Sequence Stratigraphy Analysis of the Peruvian Offshore Continental Shelf-Slope

Volume 1 of 2

Final Report
25 Figures
5 Basin Presentations
12 Appendices

Prepared for

PERUPETRO S.A.

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April 2005

"This report was funded by the U.S. Trade and Development Agency (TDA), an export promotion agency of the U.S. Government. The opinions, findings, conclusions or recommendations expressed in this document are those of the author(s) and do not necessarily represent the official position or policies of the TDA."

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EXECUTIVE SUMMARY

Exploration activity offshore Peru has been limited, particularly in recent years. Apart from exploration offsets of long-established onshore fields in the Talara basin, rank wildcats on the Peruvian shelf have been limited to the Tumbes and Trujillo basins (see Figure 1). The 19 offshore wells drilled from 1971 to 1984 in the Tumbes basin yielded several discoveries, but only brief commercial production of oil and gas from the Albacora discovery. Two wells drilled in the Trujillo basin by Occidental in 1971 and two more by Repsol in 1999 encountered interesting shows, but were dry holes. Until recently, the industry has shown little further interest beyond brief technical evaluations that produced no new seismic or drilling.

As part of a program to revitalize interest, the USTDA agreed to fund a study of the sequence stratigraphy and hydrocarbon prospectivity of the entire Peruvian offshore shelf and slope for PERUPETRO S.A. (PERUPETRO). Although there have only been two wildcat wells drilled offshore Peru in the past 20 years, by demonstrating enhanced potential in previously known plays in the Tumbes, Talara and Trujillo basins, and by identifying new plays in the Salaverry, Sechura and Pisco basins, this study suggests that further drilling activity is warranted. The Lima and Mollendo basins were not assessed due to insufficient data.

This renewed optimism for the potential of the Peruvian shelf is apparently shared by several companies that have recently acquired offshore blocks in the Tumbes, Talara, Sechura, Salaverry and Pisco basins. Figure 1 shows the location of the currently active offshore blocks, which are predominantly held by Petro-Tech Peruana S.A. (Petro-Tech), along with BPZ Energy Inc. (BPZ) and Gold Oil. From a U.S. business perspective, Petro-Tech Peruana S.A. is a Peruvian corporation that is wholly owned by Petro-Tech International, a U.S. corporation based in Houston, Texas. Near-future plans for these blocks include BPZ's Corvina and Piedra Redonda gas development project on Block Z-1 in the Tumbes basin, and Petro-Tech's plans to acquire seismic and drill on Block Z-6 in the Sechura basin and Block Z-33 in the Pisco basin.

Tumbes Basin

Production activity is heating up in the Tumbes basin, with BPZ's recent announcement of plans **for a gas-to-power project for Corvina and Piedra Redonda fields**. The remainder of Block Z-1 **west of these fields appears to be even more prospective**, but will not yield new discoveries without considerable effort in reprocessing and reinterpretation of the 2D seismic. 3D seismic will probably be needed to promote selected leads to drillable prospect status. Some limited shallow-water opportunity also exists in the open area west of Block Z-1.

The Tumbes basin has proven potential, albeit with limited prior success. However, the resurgence of activity in Block Z-1, together with the revised structural and stratigraphic interpretation provided by this study, suggests that further potential does exist.

Although the Tumbes basin has not been as prolific as the Talara basin, it has produced oil from the Zorritos field onshore and from the Albacora structure offshore (see Figure 2). As with Talara, the petroleum geology of the onshore and shallow offshore is generally well known. However, a detailed and consistent structural picture is very difficult to develop, owing to dense coverage by several different 2D seismic surveys that produce conflicting pictures of the location and orientation of the main faults. Nevertheless, a set of depth maps and depth-converted seismic sections was produced for this study.

BPZ, through its Block Z-1 license, is well positioned to explore the Neogene sub-basin in shallow water. This sub-basin reaches more than 6,000 meters in depth at its center (see Figure 3). The western boundary of Block Z-1 roughly parallels the 300 meter isobath. Once

BPZ has established gas and power production from the Corvina-Piedra Redonda project, a reasonable approach would be to shoot a tailored 3D survey west of these fields and drill an exploration test. A number of leads have already been mapped by previous operators. There is also open acreage west of Block Z-1, where another operator might explore in shallow water on the flanks of the Peru Bank, or immediately west of Block Z-1. Lastly, after having established commercial projects in the shallow-water Neogene, drilling a hole at the top of the Peru Bank would help answer the question of whether or not this large feature has hydrocarbon potential.

Talara Basin

Figure 4 summarizes the current licensing situation in the offshore Talara Basin. The open-acreage fairway west of Block Z-2B and east of the 1,000-meter isobath (see Figure 5) is probably too narrow to attract interest from a major oil company, but has been **recently licensed to Gold Oil**, a London-based independent, in February 2005. They have 15 months to evaluate the block. New interpretation from this study suggests that identifying step-outs from existing production immediately east of this block will be difficult, owing to a complicated seismic picture that one round of 3D surveys has not helped to resolve.

In contrast to the lightly explored basins to the south that have no commercial discoveries, the Talara basin is one of the oldest oil-producing provinces in the world. The petroleum geology of the onshore and shallow offshore Talara basin is well known. Petro-Tech currently operates the main producing fields in this area (Block Z-2B on Figure 4). This study focused on producing a new structural and stratigraphic framework to help assess the potential west of Block Z-2B into the deeper water offshore.

Although the data are sparse (the blue seismic lines in Figure 4), it was still possible to generate a sizable suite of depth maps and depth-converted seismic sections. This new material has highlighted the **exploration potential of the open area at the south end of the basin** (see Figure 6) that has a deep hydrocarbon kitchen overlain by a thick sedimentary section with numerous structural leads, many of which are in shallow water.

Trujillo Basin

Eocene turbidite sands throughout the Trujillo basin still contain good reservoir potential, despite four dry holes. A new facies map provides a more detailed guide to the distribution of these sands. Strong amplitude anomalies continue to show **potential for targets in the 400+ million barrel range**, but more work must be done to upgrade these leads to drillable prospects.

The Trujillo basin appears to be one of very few lightly drilled provinces left in the world with potential for giant fields. Source is proven. Good-quality sands have been drilled, and there is a strong chance that amplitude anomalies have imaged much larger turbidite reservoirs. Both structural and stratigraphic traps abound, although the integrity of the seals may be questioned, given the many oil seeps in the basin. Water depths range between 100 and 200 meters over about half of the basin, and sizable targets exist at shallow drilling depths.

Prolific oil seeps in and near the Trujillo basin (Figure 7) leave no doubt that there is at least one active petroleum system here. Nevertheless, past exploration experience has been disappointing. In 1977, Occidental drilled two dry holes, the Ballena and Delfin wells. Repsol drilled another two in 1999 – Morsa Norte and Lobos. Despite the fact that these were dry holes, there were some interesting reservoir-quality sands in the Delfin well, and hydrocarbon shows in three of the four wells.

The results of this study indicate that the potential of Eocene turbidite sands in this basin has not been condemned by these wells. If stacked high-amplitude seismic character in the Eocene is an indicator of turbidite sand (and possibly hydrocarbon-filled sand) there are numerous leads on the flanks of the deep grabens and over the tops of a variety of structural highs where this potential can be tested (see Figure 8). Recalling that a key objective of this study was to "predict the distribution of depositional sand units," Figure 9 shows how these Eocene turbidites might be distributed and is one of several maps of the Trujillo basin that map the distribution of reservoir-quality sands in the Cretaceous, Paleocene, Eocene and Miocene.

PARSEP, PERUPETRO and others have mapped several leads that are largely focused on Eocene turbidite targets (see Figure 10). The black polygons indicate leads identified in this study, which mostly confirm the previous work. It is unlikely that an oil company would drill any of these leads without considerable additional data and interpretation. This would probably include reprocessing of the existing seismic, and/or acquiring new 3D seismic to help confirm structure and enable detailed AVO work to better understand how these amplitude anomalies relate to reservoir sand bodies.

Regardless of the fact that these are leads rather than prospects, it was still possible to review their potential commerciality by considering several representative scenarios. The East Morsa Turbidite lead (highlighted in Figure 10) was chosen for this purpose in the Trujillo basin. Assuming that there is a discovery in the range of 400 million barrels, a significant positive cash flow is achievable under most development assumptions.

Salaverry and Offshore Sechura Basins

The strong possibility of **mature Cretaceous source rock in the Salaverry and offshore Sechura basins** has been newly recognized and mapped (Figure 11). This opens up a variety of new plays in these basins. The source picture has also been enhanced by the realization that the Trujillo-Salaverry High is probably a younger feature than previously thought, which allows for possible **hydrocarbon migration into the Salaverry basin from the west**.

Eocene carbonates may be an important new reservoir/stratigraphic trap facies throughout much of the Salaverry and offshore Sechura basins. Figure 12 is a good example of how these carbonate banks and pinnacles appear on seismic line 93-36. Figure 13 shows how widely the Eocene carbonate facies is distributed throughout the Salaverry and offshore Sechura basins, with the location of line 93-36 marked with a black arrow. Nevertheless, more work is needed to ensure that this Eocene sequence is not volcanic.

Several leads at the Eocene level are very large, covering areas ranging from 100 to 900 km^2 (Figure 14), which could translate to in-place **resource potential in excess of a billion barrels for the largest of these features**. Given the shallow water and shallow depths to these targets the economics of a discovery of such size would be extremely attractive.

Petro-Tech has established a dominant position in these basins. Figure 15 shows the three blocks that they control: Z-6 over the offshore Sechura basin, and Blocks Z-35 and Z-36 in the shallow-water east flank of the Salaverry basin. Petro-Tech is already making progress, having shot new seismic over Lead D in Block Z-6 (Figure 16). It is understood that drilling is planned very soon.

Pisco Basin

A newly mapped **Cretaceous source sequence** (Figure 17) and **strong possibilities for an Eocene carbonate reservoir sequence** (Figures 18 and 19) constitute important new

exploration potential in this basin, similar to that in the Salaverry and offshore Sechura basins. Figure 20 shows the location of 32 leads identified in this study, including a very large possible **pinnacle reef that appears to be more than 40 km long, and could be capable of holding more than a billion barrels of oil in place**. This group of leads also includes many more conventional structural features including wrench-related pop-ups and tilted fault blocks. These leads total more than 3,000 square kilometers of prospectivity.

The prospectivity of the northern Pisco basin would appear to have not gone unnoticed. Figure 21 shows the location of Block Z-33, which Petro-Tech licensed in September 2004. While Petro-Tech may have secured a highly prospective area in the northern Pisco basin, there is still ample opportunity left in acreage that has not been licensed to date at the southern end of the basin.

Economics and Financial Analysis

The basins studied yielded numerous play types, albeit identified opportunities can be categorized as "leads" at this time. Until future additional data becomes available that will allow further maturing of these leads to potentially drillable prospects, these leads have been volumetrically and economically assessed as "type discoveries" that are considered to be representative of the current potential exploration opportunities. For each basin, three type discoveries representing small, medium and large opportunity sizes were analyzed to determine their potential viability as commercial ventures. A full lifecycle economic/financial (cashflow) analysis was prepared for each, which assumed the drilling of an initial exploration well, followed by an appraisal period and then development and production.

Assuming exploration success, all of the type discoveries (even the low-case scenarios) resulted in financial performance that would qualify them as viable commercial ventures. A summary of the economics for the mid-cases is given below.

Table 1: Summary of Economics for Mid Cases*

	Tumbes	Talara	TSS**	Pisco
Oil (millions of barrels)	50	50	250	200
NPV at 10% ($US MM)	158	158	901	720
IRR (%)	30	30	38	41
Total Government Cashflow ($US MM)	398	398	2,571	1,949

*Assumes realized oil price of US $30/barrel

**Trujillo, Salaverry, and Sechura

Regulatory Issues

PERUPETRO has been active in recent years in modifying their petroleum laws, regulations and fiscal terms to compete more effectively for foreign capital in the global marketplace. Peru now offers one of the most investor-friendly investment environments in Latin America. The high-profile Camisea natural gas development project illustrates the ability of the Peruvian authorities to balance the interests of all stake holders in a multi-billion dollar project that has been the subject of intensive oversight not only by Peruvian society but by a

large number of multilateral financial institutions and international Non-Governmental Organizations (NGOs).

Environmental Issues

An extensive report on the environmental aspects of offshore exploration and production in Peru was undertaken as part of this study and is included as Appendix J. In this report, each basin was evaluated in terms of six aspects of environmental complexity, as listed below.

- Biodiversity
- Protected Natural Areas
- Fishery and Aquiculture
- Socio-Economic Impact
- Bathymetry
- Ocean-Bottom Sediments

A widely accepted methodology was employed to assign weights to each of these six aspects, and then to convolve them into an overall sensitivity index. Figure 22 shows the overall sensitivity index per basin.

As in most progressive countries, environmental impact studies are required before any significant operations are undertaken – especially in highly sensitive areas. However, the stringency of the laws and regulations related to these impact studies and subsequent operations are very similar to those implemented in most other mature oil and gas provinces, and are described in detail in the report (Appendix J). As with the Peruvian petroleum law and fiscal terms, these environmental rules and regulations are appropriately balanced to enable petroleum business while responsibly protecting the environment.

As practical evidence of the viability of the approval process, an EIA was approved in July 2003 for BPZ's planned 3D seismic survey over Block Z-1 in the Tumbes basin. Other EIAs have also been approved recently for Petro-Tech's seismic acquisition programs over Block Z-6 in the Sechura basin and Block Z-33 in the Pisco basin.

STUDY DELIVERABLES AND THE TERMS OF REFERENCE

The Terms of Reference (TOR) of this study are included as Appendix A. They are further discussed below in the context of describing how and where the study deliverables have addressed the TOR. Note that the headings for this section were patterned closely after those used in the TOR, to enable them to be more easily correlated with the deliverables of this study.

1. TECHNICAL ANALYSIS

(A) Project Objective

The study objective was to produce "a time-stratigraphic framework for the country's offshore sedimentary basins that can be employed to predict the distribution of depositional sand units." This new framework is reflected in most of the deliverables, in increasing levels of detail.

An overall picture is captured in five basin-specific annotated PowerPoint presentations. These Basin Presentations are designed to facilitate multi-discipline reviews of the new framework and its impact on hydrocarbon prospectivity. They begin with the conclusions, and progress through discussions of the input data, hydrocarbon sources, reservoirs, traps/leads, the exploration plan and economics.

The second level of detail is given in Appendices C-K. This material covers geology, well details, basin tectonics, depth conversion, seismic interpretation, maturation modeling, environmental issues and economics. The intended readers of these Appendices are the discipline experts who are charged with fully auditing the project results.

Lastly, the 35 GB Digital Database that is packaged on 10 DVDs with this report will enable interested parties (to whom the database is made available) to readily integrate the base data used for this study with their own data analyses. The entire body of input data and output results is provided, both in SMT workstation-ready projects as well as in industry-standard formats. More detail about the contents of the Digital Database is given in Appendix B.

(B) Project Study Area

The TOR requires that the "proposed sequence stratigraphy study will be focused on eight sedimentary basins." However, the Ribiana 1993 seismic survey, which provides the regional foundation of the new framework, does not cover the Mollendo basin at all, and covers only the southern tip of the Lima basin (see Figure 23). These two basins are not covered by any other seismic surveys. Consequently, the Mollendo basin was eliminated from the work scope, while the southern Lima basin was merged with the Pisco basin. Similarly, the offshore extent of the southern Sechura basin was merged with the Salaverry basin study. These adjustments were anticipated in the TOR by such language as, "... a detailed work scope for the project will be dependent on the relevance and quality of the above-mentioned data" (Terms of Reference, page 13, Appendix A).

(C) Project Data Base

PERUPETRO provided a large package of data on CDs and tapes soon after the project was awarded in early 2004. After initial review of this package, GCA traveled to Lima in May 2004 to gather additional data. GCA utilized the Kingdom Suite from Seismic

Micro-Technology, Inc. (SMT) as the project database and interpretation platform for this study. In order to make the SMT-generated results more accessible without the SMT software, a comprehensive Interactive Map was built with ArcView 9.0, a Geographical Information System (GIS) application from ESRI. Lastly, to comply with Clause 15 of the Contract, the SMT project database was exported into a variety of industry-standard formats that are suitable for loading into other interpretation software. These materials are part of the Digital Database that accompanies this report.

(1) Seismic Information:

As noted above, the seismic foundation for this study was the Ribiana 1993 regional survey. This was the only seismic data available in the Salaverry and Pisco basins. In the Trujillo basin, most of the lines from the Repsol 1996 survey were used to supplement the regional survey. In the Talara and Tumbes basins, selected lines from several other surveys were used to tie the regional survey to a selected set of exploration wells. Enclosures 1-5 are detailed base maps that show the precise locations of the seismic lines used in this study.

Other important seismic contributions of this study include two new regional velocity models and depth conversions of the seismic horizons, faults and trace data. The new velocity models were mainly based on stacking velocities that were manually transcribed from the paper seismic sections. Checkshots from sparse wells provided local control. The velocity data and models are provided in the Digital Database, and are explained in Appendix G.

(2) Well Information:

South of the Talara Basin only five exploration wells have been drilled. These include the Lobos, Morsa Norte, Delfin and Ballena wells in the Trujillo basin, and the onshore Pisco well. Data for these wells existed in a wide variety of sources from PERUPETRO. In order to integrate and validate these data they were compiled into a new set of composite logs that are included in the Digital Database and have been printed as Enclosures 23 and 24.

Ten more composite logs were prepared for shallow holes that were drilled in 1986 in Leg 112 of the Ocean Drilling Project (ODP). Locations for these holes are shown on the basemaps in Enclosures 3-5. High resolution images of these composite logs are also included in the Digital Database. Note that these ODP data were obtained separately from the input data provided by PERUPETRO.

Only 19 wells have been drilled in the offshore part of the Tumbes basin. Six of those were selected for preparation of the correlation panel in Enclosure 21. A high resolution image of this panel is included in the Digital Database.

Of the more than 12,000 wells that have been drilled in the Talara basin, less than 200 have been drilled offshore – and these are mainly as step-outs from existing fields in water less than 100 meters deep. Locations for these offshore wells are shown in Enclosure 2. Thirty-two wells were selected from those that were drilled into Paleocene or older sediments for preparation of six correlation panels. High resolution images of these panels are included in the Digital Database. Enclosure 22 is an example.

(3) Reports

The input database furnished by PERUPETRO contained thousands of report documents. Among these, key reports are those by Repsol and Parsep and should be among the essential reading by anyone undertaking a new exploration program, especially in the Trujillo and Salaverry basins. These selected reports are provided as a matter of convenience in the Digital Database.

(4) Geochemical, Gravity, Magnetics, Biostratigraphy, and Other Data

The geochemical data utilized in this study are described in Appendix I (Maturation Modeling). The new composite logs for the four Trujillo basin exploration wells also contain a track that shows total organic carbon content.

Grids and contours of the gravity and magnetics data supplied by PERUPETRO are contained in the ArcView Interactive Map in the Digital Database. These data were supplemented by additional satellite-based gravity obtained from the National Oceanographic and Atmospheric Administration (NOAA), which is also contained in the ArcView Interactive Map.

(D) Project Work Scope

The determination of project tasks and the detailed scope of work were intended to be dependent upon the relevance and quality of the data provided. While comments have been provided above on such quality and relevance, in general it was possible to align the interpretation with the approach set out in the original Terms of Reference, as described below.

(1) Assessment and Management of Data Base

This task began shortly after the project was awarded in January 2004, with delivery of a large package of CDs and tapes to GCA from PERUPETRO. Initial review of this package began immediately, but did not commence in earnest until the final contract was signed at the end of April, after which GCA undertook a data-gathering trip to PERUPETRO in Lima, Peru in early May. Several months of intensive recompilation and validation were necessary in order to ready the project database for interpretation – especially in manipulating and correcting the seismic navigation data. Once completed, interim results were delivered to PERUPETRO on a second trip to Lima in August 2004. Organization of the data into the Digital Database is discussed above.

(2) Development of Chronostratigraphic Framework

Production of a consistent regional framework of seismic horizons was accomplished through several complex iterations of structural and stratigraphic interpretation. The most useful compilations of these results are the three SMT projects that are provided in the Digital Database – one covering the Trujillo, Salaverry and Pisco basins, a second for the Tumbes and Talara basins, and a third that contains the composite logs and correlation panels for the whole study area. Most of the contents of these SMT projects have been extracted for ready access without the SMT software. These extractions include:

- SEG-Y exports of the seismic trace data (with embedded navigation) and interpreted horizons and faults – all in time and depth;

- Exports of well-related data in LAS and other ASCII formats;
- High resolution images of all interpreted seismic sections, in time and depth;
- An annotated presentation (Appendix H) that illustrates the key seismic sections with comments from the lead seismic interpreter;
- A complete set of structure and thickness maps, both in time and depth, as high resolution images in the Digital Database and the Basin Presentations;
- Facies, basement type and fault fabric maps as high resolution images in the Digital Database and prints in Enclosures 6-14; and,
- An ArcView Interactive Map (in the Digital Database) to display seismic locations, well locations, license block locations, basin outlines, coastlines, and all of the map-based results of the project.

(3) Analysis of Basin Tectonics

Several seismic sections at key tectonic locations were balanced and restored using a software application called LithoTect. The methodology employed for these restorations, and the conclusions reached from them are detailed in Appendix F. The data and models are contained in the Digital Database. Further background on regional basin tectonics is given in Appendix E.

(4) Development of Plays, Leads and Prospects

The TOR calls for the identification and evaluation of hydrocarbon "prospects." The industry term "prospect" properly applies only to those opportunities that are ready, or almost ready, to drill. Based on the dataset available for this study (in particular a regional seismic grid spaced typically at 10-20 kilometer intervals) it is not possible to identify opportunities that can be defined with a precision sufficient to drill. With this dataset, opportunity identification can only be classified as "leads" -- anomalies on the seismic that warrant further investigation and maturing into prospects by acquiring further seismic.

It is highly unlikely that an oil company would drill any of the leads detailed in this study without considerable additional data and interpretation. With that understanding, this report describes each basin in terms of plays and leads only. The illustrations of these plays and leads are mostly contained within the five Basin Presentations, and are drawn from selected high resolution images of seismic sections and maps in the Digital Database.

2. ECONOMIC ANALYSIS

The TOR calls for "the prospects generated by the technical study [to] be analyzed to determine their viability as commercial ventures." As noted above, it was not possible with the dataset provided to generate any "prospects." As such, the degree and rigor of economic analysis that would typically be undertaken prior to drilling a prospect was neither possible nor appropriate.

Nevertheless, in order to assess the indicative economic viability of undertaking exploration activities, several representative scenarios have been prepared in the Economic and Financial Analysis section of this report to aid in assessing the potential economic viability of the leads described in this study.

3. FINANCIAL ANALYSIS

The tasks described in this section of the TOR were combined with those in the previous section, Economic Analysis, as these two tasks are in practice part of the same analytical exercise. Discounted cash flow analysis was done for each of the representative scenarios.

4. ENVIRONMENTAL ANALYSIS

An extensive report on the environmental issues is provided as Appendix J. A brief summary of this report is included in the Executive Summary of this report.

5. REGULATORY REVIEW

PERUPETRO provides excellent access on their website to current laws and regulations governing exploration and production in Peru. A brief review of this material regarding potential impacts on offshore activity (including links to the sources) is included in the Regulatory Review section of this report.

6. PROPOSED EQUIPMENT AND SERVICES

The seismic and well-related equipment and services that will likely be required in the next five years to evaluate the prospectivity of the offshore basins are estimated in this section of this report.

7. IMPLEMENTATION PLAN

Each of the five Basin Presentations contains a section at the end that describes an exploration plan that accounts for the current operator's obligations in the context of the newly improved understanding of the basin.

8. DELIVERABLES

(A) Final Report

(1) Individual Executive Summary Reports for Each Basin

The Final Report contains an Executive Summary that covers the results of the entire study, and is followed by five Basin Presentations which focus in more detail on each of the basins.

(2) Maps Showing Sequences, Surfaces, Systems Tracts, Plays, Leads and Prospects

The Executive Summary, Basin Presentations, Enclosures, Appendices and the ArcView Interactive Map in the Digital Database thoroughly document a new structural and stratigraphic framework and detail the hydrocarbon potential contained within it.

(3) Chronostratigraphic Charts

Chronostratigraphic charts are included in each of the Basin Presentations, and are assembled together in a separate folder of the Digital Database.

(4) Economic Analyses of Commercially Viable Prospects

This deliverable appears in the Economic and Financial Analysis section of this report.

Overall, as specified in the TOR, this report was prepared in accordance with Clause I of Annex 2 of the Contract, and includes prospective U.S. sources of supply.

(5) Exploration Implementation Plans

Exploration plans are described at the end of each Basin Presentation in this report.

(B) Technical Briefing

The first presentation of the study results was delivered to an audience of over 70 geoscientists and managers at a luncheon meeting of the Geophysical Society of Houston (GSH) on November 16, 2004. Several poster sessions are also being prepared for the 2005 AAPG Annual Meeting in Calgary in June, 2005, as well as a promotional presentation in Calgary during the AAPG week. Lastly, a presentation is planned for the INGEPET meeting in Lima in November 2005.

ECONOMIC AND FINANCIAL ANALYSIS

Economic Analysis

The Economic Analysis section of this report deals with both Section 2 (Economic Analysis) and Section 3 (Financial Analysis) of the TOR, as for practical purposes these two work requirements are inseparable. A summary of the economic analysis of type discoveries, assuming exploration success, is as follows:

Table 2: Summary of Economic Cases

(All values millions of US$ unless otherwise indicated)

	Pisco			Talara			Trujillo/Salaverry/Sechura			Tumbes		
	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High
Oil (millions of barrels)	100	200	350	25	50	75	50	250	500	25	50	75
Number of Producing Wells	40	70	120	30	55	80	20	70	135	30	55	80
Gross Project Revenue (at $30 per barrel)	3,000	6,000	10,500	750	1,500	2,250	1,500	7,500	15,000	750	1,500	2,250
Royalty	221	588	1,360	39	85	142	95	966	2,465	39	85	142
Total CAPEX	285	470	770	155	225	310	155	635	1,233	155	225	310
Total OPEX	215	342	547	71	108	122	130	459	640	71	108	122
Net Cashflow Before Tax	2,279	4,600	7,823	485	1,082	1,676	1,120	5,440	10,662	485	1,082	1,676
Total Taxes	668	1,362	2,303	136	313	486	329	1,605	3,133	136	313	486
Net Cashflow After Tax	1,611	3,238	5,520	349	769	1,191	791	3,835	7,529	349	769	1,191
NPV @ 10%	358	720	1,184	69	158	259	203	901	1,674	69	158	259
IRR (%)	38	41	43	23	30	40	36	38	42	23	30	40
Total Government Cashflow	889	1,949	3,663	175	398	628	424	2,571	5,598	175	398	628

The basins studied yielded numerous plays and structural/stratigraphic features that can only be categorized as "leads" at this time. Until future additional data becomes available that will allow further maturing of these leads to potentially drillable prospects, these leads are volumetrically and economically assessed as type discoveries that are considered to be representative of the current potential exploration opportunities. For each basin three type discoveries representing low, medium and large opportunity sizes were analyzed to determine their potential viability as commercial ventures. A full cycle economic/financial (cashflow)

analysis was prepared for each, which included the drilling of an initial exploration well, followed by an appraisal period and then development and production.

(A) Volumetric determination of prospect/reservoir size

For the major basins studied low, medium and high in-place and recoverable oil volume size ranges of the type discoveries were determined. The estimate of potential recoverable volumes associated with these type discoveries were based on the available data on area from the seismic data and reservoir data based on available well log data. An example for the 100 million barrels of oil (MMbo) recoverable type discovery case is presented below.

Table 3: Parameters Used to Calculate Type Discovery of 100 MMbo Recoverable

Parameter (units)	Mean
Area of Closure (acres)	40,000
Net Reservoir Thickness (ft)	30
Porosity (%)	8
Oil Saturation (%)	60
Recovery Factor (%)	25
Oil Formation Factor (bbl/STB)	1.1
In-Place Oil (MMbo)	406
Recoverable Oil (MMbo)	100

Based on these type discovery parameters, hypothetical exploration and development scenarios were prepared in order to estimate their potential financial impact and economic reward. The table below indicates the estimated recoverable size range of the type discoveries of the respective basins for which economic analyses were carried out.

Table 4: Illustrative Ranges of Estimated Recoverable Volumes (MMbo)

Basin	Low	Medium	High
Trujillo-Salaverry-Sechura	50	250	500
Tumbes	25	50	75
Talara	25	50	75
Pisco	100	200	350

(B) Exploration, development and production costs

For each type discovery case, costs were estimated for seismic acquisition, processing and analyses, exploration, appraisal and development drilling, and associated platform and pipeline facilities needed to develop and produce the potential hydrocarbons. In developing the type discovery costs, the following general criteria were adopted:

- Per well production rate varied between 1,000 to 3,000 barrels of oil per day (bopd);
- Life of a producing well varied between 10 to 25 years;
- Production decline was set 10-15% per annum;

- Platform and Facilities costs were based on estimated field capacity which ranged between 10,000 to 200,000 bopd; and
- Average pipeline lengths were measured for each basin, and pipeline costs were applied at US $1 million per mile.

In summary, the unit costs for the major expenditure items are listed below.

Table 5: Exploration and Development Costs

2D and 3D Seismic Program ($US MM)	2
Exploration Well Cost ($US MM per well)	3 – 5
Appraisal Well Cost ($US MM per well)	3 – 4
Development Well Cost ($US MM per well)	2 – 4
Facilities / Transport - Based on Capacity (adjusted separately for each case)	50 – 425
Operating Costs* ($US per barrel)	1.60 – 2.60

* Operating costs does not include transportation and abandonment escrow charges.

(C) Deliverability or production schedule

The projected production profile for a given type discovery was based on a combination of individual well rates and projected number of wells available for production. The total production was set to match the estimated recoverable volume and the plateau rate was set to match the total capacity of the proposed facilities.

Table 6: Parameters Used to Size Development Plans

Number of Producing Wells	20 - 135
Facility Capacity (mbopd)	12 - 200

Based on this approach, a development production profile typically contains an initial build-up, followed by a period of plateau production, then followed by a period of decline.

(D) Technical and economic risk

An expected generic success probability was estimated for each basin area based on an analysis of the key geological factors that impact the generation, migration and trapping of hydrocarbon. The result ranges from approximately 1 success in 12 exploration wells to 1 success in 4 exploration wells. The Tumbes and Talara basins have the highest expected success probability due to the presence of petroleum systems that have been proven by production. No economic or political risks were considered in this analysis.

Table 7: Indicative Chance of Exploration Success

Basin	Indicative Expected Success Probability
Trujillo-Salaverry-Sechura	1 in 12
Tumbes	1 in 4
Talara	1 in 4
Pisco	1 in 10

(E) Market pricing forecast

For each type discovery economic analysis, a constant realized oil price of $30/barrel was assumed. No escalation or inflation was considered in these analyses.

Financial Analysis

An economic/financial model was developed to estimate taxes and royalties for an offshore development under the current Peruvian fiscal regime, applied as follows:

- Corporate taxes at 30%
- Royalty: Contractor's option of production based royalty on a sliding scale of 5% to 20% or economic results based royalty ranging from 5% to 25%
- No inflation of costs

Either royalty option could be more attractive than the other depending on the field characteristics. The contractor is allowed to choose the royalty option at the time of declaring commerciality. In general, the production based royalty yields more attractive economic results in small/low cost fields and the economic based royalty option is preferred in high production/high cost fields. In both cases the minimum royalty is 5%

The production based royalty starts at 5% when production is less than 5,000 b/d. As production rises, it increases proportionally up to a maximum of 20% when production reaches 100,000 b/d. The economic results based royalty is composed of fixed and variable components. The fixed component is 5%. The variable component is a function of project profitability. Supreme Decree No. 017-2003-EM (at http://mirror.perupetro.com.pe/downloads/DS017-2003-EMINGLES.doc) contains details about how the economic results based royalty is calculated.

As shown in Table 2 in the Executive Summary, these hypothetical economic/financial cashflow cases indicate that the overall economics are favorable. Tables summarizing the spending schedules, production profiles, cashflows, NPV (at 10%) and IRR for the twelve "type discoveries" are in Appendix K.

(A) Country Risk

Country risk perception is highly subjective and is often influenced by factors related to global or regional events. In the case of Peru, country risk perception is typically influenced by events in South America as a whole. A country risk assessment combines rigorous analysis of

macroeconomic performance with subjective judgment related to political outlook. Within a single country, the measurements or indexes of risk apply differently to different sectors of the economy.

Since the year 2000, Peru has maintained slow but positive economic growth, has kept inflation under control and has reduced the ratio of external debt to GDP at a time when Argentina faced a severe economic crisis and Bolivia and Venezuela experienced political disruptions. These factors help explain that, while credit rating agencies have maintained Peru's Sovereign Ratings unchanged since 1998 at BB or Ba3,[1] the Corruption Perception Index (CPI) published by Transparency International shows a slight decline in the same period. The CPI ranks countries in terms of the degree to which corruption is perceived to exist. The data is gathered through a survey of individuals and institutions in the country and around the world. The maximum possible score is 10. Finland consistently ranks as the most transparent country. In 2004, Finland was rated 9.7, while Haiti and Bangladesh shared the worst rating of 1.5 that year. A total of 106 out of 146 countries scored less than 5, with Peru ranking above the worldwide average in terms of transparency. Figure 25 shows that Peru is perceived as a peer of Mexico, Brazil and Colombia in terms of transparency.

(B) Political Risk

Since the military success against the Shining Path guerrilla movement in 1993, the perception of broad political risk in Peru has diminished substantially.

Peru will conduct presidential and congressional elections in April 2006, which are expected to bring some level of uncertainty in assessing political risk. Nevertheless, the tradition of democracy provides a framework for a relatively smooth transition. The Economist Intelligence Unit (EIU) expects a highly uncertain outcome for the election, with over 15 parties registering candidates for Congressional posts. No clear front-runner has emerged, and political parties may be forced to form alliances that could affect governability. With the economy strong (see below), the EIU is not expecting a significant shift in economic policy for the remaining term of President Toledo.

The mining sector and the Camisea natural gas project are expected to provide the driving forces for economic growth in the next decade. As such, a new government would presumably be less likely to negatively intervene in these sectors, especially after witnessing the difficulties faced by Bolivia after politically interfering with natural gas policies.

(C) Economic and Currency Risk

Peru's economy has remained relatively steady in the last five years with sustained gains in controlling inflation, reducing its current account and external debt as a percentage of GDP.

[1] Moody's Long-Term Foreign Currency Sovereign Rating is Ba3, while Standard & Poor's and Fitch Ratings use the BB nomenclature.

Table 8: Peru Economic Indicators

	1998	1999	2000	2001	2002	2003
GDP (real annual % change)	-0.7	0.9	2.9	0.2	4.9	3.8
Inflation (CPI, annual change in %)	6.0	3.7	3.7	-0.1	1.5	2.5
Current Account (as a % of GDP)	-6.4	-3.7	-3.0	-2.2	-2.0b	-1.7
Exchange Rate (Nuevo Sol/US$)	3.149	3.512	3.527	3.446	3.510	3.463
External debt (as a % of GDP)	52.1	54.4	53.0	50.7	49.3	49.0
International Reserves (US $ Million)	10,186	8.669	6,092	8.613	9,603	10,198

Source: Latin Focus

The EIU is estimating preliminary GDP growth in 2004 at a rate of slightly above 5% year-on-year.

As noted above, Peru's credit rating has remained steady at BB or Ba3, depending on the credit rating agency. However, it is important to point out that these ratings refer to international lending to the Peruvian government. The focus on this report is on offshore oil and gas exploration. If the investor is successful in finding commercial volumes of crude oil it will be able to sell that oil in the international markets and recover its investment. Depending on the volumes discovered, a gas discovery is more likely to be limited to domestic markets and potentially exposed to currency risk.

(D) Technical Development Factors

The projects considered in this study are oil and gas exploration, which are inherently risky by nature. The technical development factors associated with exploratory plays and leads are discussed elsewhere in this study.

(E) Location and Access

Access to offshore exploration locations will be simple compared to the logistical complexities encountered in the jungles and mountains of onshore Peru. Offshore weather and sea state are also comparatively benign (fewer violent storms) than in other offshore operating areas like the North Sea or the Gulf of Mexico. Furthermore, initial drilling efforts in offshore Peru will likely be concentrated in water depths and drilling depths far less than those currently faced in most other offshore provinces.

ENVIRONMENTAL ISSUES

The environmental aspects of offshore exploration and production operations in offshore Peru are summarized in the Executive Summary, and are fully documented in the study provided as Appendix J.

REGULATORY REVIEW

Peru offers one of the most investor-friendly investment environments in Latin America. The high profile Camisea natural gas development project, located in the Eastern side of the Andes Mountain Range, illustrates the ability of the Peruvian authorities to balance the interests of all stake holders in a multi-billion dollar project that has been subject of intensive oversight not only by the Peruvian society but by a large number of multilateral financial institutions and international NGOs.

Law 26221 (The Organic Hydrocarbons Law[2]) sets forth the legal framework governing Peru's petroleum industry. It was conceived as an "investment promotion" piece of legislation, creating PERUPETRO as an independent commercial entity charged with promoting investment and administering the State's interest in the development of hydrocarbons in Peru. Because PERUPETRO was created as a commercial entity any contract it enters into is subject to the provisions of Article 62 of Peru's Constitution which protects "both parties to the contract" by providing that any contract modification signed by commercial entities has to be agreed by both parties in writing thus granting judicial stability to contracts.

A survey of a broad cross section of current, past and potential oil and gas investors in Peru conducted by GCA in 2003 concluded that the regulatory and contractual regime was not considered an impediment to investment in Peru. Some of the surveyed companies indicated that, while the fiscal regime in force at the time was by no means onerous once a discovery is made, it was nevertheless not properly aligned with the risk-reward opportunities available elsewhere. The fiscal regime has since been modified resulting in renewed interest in exploration in Peru. Supreme Decree 017-2003 EM[3] provides fiscal stability and guarantees access to foreign exchange.

Another result of the survey indicated that existing oil and gas producers found overlap in the jurisdiction of PERUPETRO S. A., the Instituto Nacional de Recursos Naturales (INRENA) and the Organismo Supervisor de la Inversión en la Energía (OSINERG[4]) and Consejo Nacional del Ambiente (CONAE), creating unnecessary red-tape. PERUPETRO therefore decided, as a matter of internal policy, to clarify the role it plays vis-à-vis other key government agencies involved in exploration and production of hydrocarbons. The Ministry of Mines and Energy formulates policy guidelines and regulations; OSINERG enforces such regulations; and PERUPETRO limits its role to supervising the contractual obligations acquired by oil and gas investors. Key regulations issued by the Ministry of Energy & Mines are in Supreme Decree[5] 032-2004. The main function of INRENA, a decentralized entity reporting to the Ministry of Agriculture, is related to the protection and sustainable use of natural resources with a focus on wildlife and its habitat, and it has jurisdiction over national parks. CONAE, a policy formulation body charged with coordinating and supervising environmental policy carried out by different Federal entities, reports to the Ministers Council.

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[2] The Organic Hydrocarbons Law can be found at:
http://mirror.PERUPETRO.com.pe/downloads/Legislation.doc

[3] The text of Supreme Decree 017-2003 EM can be found at:
http://mirror.PERUPETRO.com.pe/downloads/DS017-2003-EMINGLES.doc

[4] www.osinerg.gob.pe

[5] The text of Supreme Decree 032-2004 can be found at:
http://www.osinerg.gob.pe/osinerg/transparencia/normas/hidro/DS-032-2004.pdf

Table 9: Entities with Jurisdiction over Environmental Policy, Regulations and Enforcement

Entity	Policy	Regulation	Enforcement
Ministry of Energy & Mines Office of Energy Environmental Issues	X		
Ministry of Agriculture INRENA	X	X	
OSINERG (Fiscalization/enforcement)		X	X
CONAE	X		
PERUPETRO (Contractual issues)			X

In the last three years PERUPETRO has reviewed certain contractual policies in order to encourage investors to explore in Peru. It has made work commitments more flexible and accommodated, after negotiation, block definition input from potential investors and relaxed relinquishment requirements.

In terms of access to acreage, the Qualification Requirements[6] for company participation in exploration in Peru allow a broad range of company sizes to qualify to engage in exploration activities.

Table 10: Key Elements of Peru's Contractual and Fiscal Regime

1	Concession-type contract (Tax & Royalty)
2	No NOC carried interest or back-in rights
3	Contractor to chose between two royalty regimes at time of declaring commerciality: a) Production-based b) Fixed + Variable Royalty
4	Income tax
5	Exploration Phase -- VAT exemption
6	Fiscal Stability Provision applies

Qualification: Companies wishing to apply to PERUPETRO as operator for a hydrocarbon exploration and exploitation license must demonstrate oil and or gas production experience for the three years previous to the application. Companies that do not meet these qualifications can still participate in a license as long as they are associated with a qualified operator.

Access: PERUPETRO operates an "open door" application system for licenses. Companies can propose the location and size of a block in which they are

[6] Qualification requirements can be found at:
http://www.systemdigital.com/peru/pdf/Contractor%20Qual%20Eng.pdf

interested. Negotiations will then take place over the work commitment that would apply. If agreed, the award will follow. Occasionally, PERUPETRO offers internally selected blocks and launches a promotional campaign to interest potential investors in exploring these blocks. These "promotional blocks" are awarded to interested parties on a first-come-first-served basis. If more than one party is interested in these promotional blocks, the final award is based on the best work program offered.

Contract Term: Total contract duration is 30 years for crude oil and 40 years for natural gas, plus any applicable retention period. The normal exploration period is up to 7 years, is divided into three phases, and is extendable under specific conditions. In the event of a natural gas discovery, a retention period of 10 years may be granted in order to establish a market. The exploitation period is the balance of the contract duration following the exploration period (excluding any retention period).

Relinquishment: During the exploration period, the contractor may relinquish 100% of the contract area after the fulfillment of the first phase of the work commitment. The contractor must relinquish 25% of the original area after the conclusion of the second exploration phase and 50% of the original contract area after the conclusion of the third exploration phase.

Work Commitment: During the first and second exploration phases the contractor will agree with PERUPETRO on the amount of work units per 10,000 hectares. After the third exploration period and any extension thereof, the work program requires a minimum of 4 work units per each 10 hectares remaining in the contract area, or the drilling of one exploratory well. Each work unit is equivalent to US$ 5,000.

Training Obligation: US$ 50,000 per year until the first calendar year of production, and then it increases based on the production level, and is capped at $180,000 per year if production exceeds 50,000 bopd.

Arbitration: International Arbitration (International Chamber of Commerce) is allowed after exhausting remedies provided in the contract.

Local Content: Peru has no local content requirements.

Value Added Taxes: Do not apply during the exploration phase. This provision facilitates temporary imports of equipment used in exploration activities, and removes what has proven to be a significant problem in a number of other countries.

PROPOSED EQUIPMENT AND SERVICES

Figure 1 shows the seven offshore blocks that are either currently licensed or are pending government approval. They cover most of the shallow-water high-prospectivity fairways in these basins, although potential exists for additional blocks in the western part of the Tumbes basin, the southern part of the Talara basin, the southern part of the Pisco basin and the eastern part of the Trujillo basin. However, offshore activities in the next five years will likely be focused on seismic acquisition and exploration drilling in fulfillment of work requirements on the current blocks.

Table 11 summarizes these work programs, which are largely estimates based on public announcements and industry reports. The five-year total for the seven current blocks is US$ 178 million, including US$ 33 million for seismic, and US$ 120 million for wells. The remaining US$ 25 million would be spent on overhead and other exploration-related programs, including non-seismic surveys and field work.

Table 11: Estimated 5-Year Work Programs for the Current Offshore Blocks

Basins	Block	Type	Status	Operator	Contract Length (years)	Total Work Plan (Million US$)	Comment	Seismic (Million US$)	Number of Wells	Cost of Wells (Million US$)
Tumbes and Talara	Z-1	E&P	Confirmed	BPZ Energy	30	26	"planned"	5	4	20
Talara	Z-34	TEA	Confirmed	Gold Oil	2	15	estimated	3	2	10
Talara	Z-2B	E&P	Confirmed	Petro-Tech	30	30	estimated	4	5	25
Talara and Sechura	Z-6	E&P	Confirmed	Petro-Tech	30	40	MM US$ 40 "planned" MM US$8	7	5	25
Salaverry	Z-35	E&P	Pending	Petro-Tech	30	25	estimated	5	3	15
Salaverry	Z-36	TEA	Pending	Petro-Tech	2	20	estimated	4	3	15
Pisco	Z-33	E&P	Confirmed	Petro-Tech	30	22	"planned"	5	2	10
					Totals	178		33	24	120

The three operating companies who hold the current blocks are all small independents with limited working capital. The volume and pace of their activity will largely depend on securing partners and other sources of capital. The newly described potential of these basins should aid them in attracting partners, but sustained interest will undoubtedly depend on the results of the first few wells. A significant discovery would likely change this picture radically, but it is assumed that it will take at least five years and 20-30 exploration wells to fully test the exploration concepts described in this report.

Petro-Tech currently holds a dominant position. Not only do they hold five of the seven offshore blocks, they are also the major provider of exploration and production services in this province, as they leverage off of their production operations on Block Z-2B. They are an experienced provider of production platforms and other surface facilities. They also have their own seismic boat in the area, with which they acquire their own 2D data, and will soon be acquiring 3D data as well. From a U.S. business perspective, Petro-Tech Peruana S.A. is a Peruvian corporation that is wholly owned by Petro-Tech International, a U.S. corporation based in Houston, Texas.

IDENTIFICATION OF PROSPECTIVE U.S. SOURCES OF SUPPLY

In November 2004, the USTDA released a Definitional Mission Report by Merkelin and Associates, Inc. entitled, "Advisory and Assistance Services by Non-Governmental Sources for Hydrocarbon Exploration Projects in Peru -- USTDA 04-Q-5-211." Appendix A of that report is entitled, "US Suppliers with Potential Interest in Peru's Petroleum Industry." The suppliers listed there are precisely those who would be potentially interested in providing the equipment and services for exploration and production projects in the offshore basins of Peru. That list of suppliers is reproduced below.

One important addition was made to this list – that of Petro-Tech International. As mentioned in the Proposed Equipment and Services section, they are already established as a key operator in offshore Peru, and are a major provider of exploration and production goods and services in that province. Nevertheless, any of the following providers could compete for this business.

Business Name	Point of Contact	Address	Tel / Fax	Product / Service	Web page / Email
Amercable	Marine Cable Sales	350 Bailey Road El Dorado, AK 71730	800-506-9473 870-862-9613	Flexible electric power and control cables	www.amercable .com
Ameron International	Industrial Market National Sales Office	5900 Clinton Drive Houston, TX 77020	713-672-8140 713-672-7174	Industrial coatings and finishes	www.ameroncoatings .com
BJ Services International	J.C. Mondelli	5500 Northwest Central Dr. Houston, TX 77027	713-462-4239 713-895-5851	Pumping, pipeline, well completion services	jmondelli@bjservices .com
Baker Hughes	Trevor Burgess VP, Mktg & Technology	3900 Essex lane Houston, TX 77027	713-439-8600	Oil tools, drill bits, drilling fluids, deep-water drilling	www.bakerhughes .com
Bluewater Offshore Production Systems (U.S.A.) Inc.	Max Krekel	8554 Katy Freeway Suite 327 Houston, TX 77024	713-722-8131	Offshore production and storage facilities	mkrekel@bluewater-offshore.com
C&C Technologies	Jake Klara, Dept. Manager	730 E. Kaliste Saloom Rd. Lafayette, LA 70508	337-261-0660 337-261-0192	Geophysical survey services	Jake.klara@cctechnl .com
Danos & Curole	International Business	13083 Highway 308 Larose, LA 70373	985-693-3313 985-693-4698	Marine contractor in energy field	international@dano .com
Delmar Systems, Inc.	Sales Dept.	12000 Richmond Ave, Suite 170 Houston, TX 77082	281-596-9000 281-596-9001	Mooring and subsea installation services	sales@delmarus.com
Diamond Offshore Drilling, Inc.	John L. Gabriel, Sr. VP Contracts & Mktg	15415 Katy Freeway Suite 100 Houston, TX 77094	281-492-5300 281-492-5378	A leading deep-water drilling contractor	www.diamondoffshore .com
Drilling & Production Resources	Sales Dept.	Houston, TX	713-996-7600 713-996-7676	Land and offshore installation services	sales@dprhou.com or services@dprhou.com
ENSCO International Incorporated	Marketing Dept.	500 N. Akard, Suite 4300 Dallas, TX 75201	214-397-3041 214-397-3370	Offshore oil and gas drilling contractor	marketing.hdqrs@ enscous.com
FIKE Corp.	Sales Corporate	704 S. 10th Street Blue Spring, MO 64105	816-229-3405 816-228-9277	Fire detection explosion prevention	fpssales@fike.com

Business Name	Point of Contact	Address	Tel / Fax	Product / Service	Web page / Email
FIGRP-LTC INC.	David Schwartz	6100 Hillcroft, 5th Floor Houston, TX	713-369-6100 713-369-6110	Scanning paper documents (seismic)	fugro-lct.com
Geophysical Research Corp.	Paul Conway	6540 E. Apache Tulsa, OK 74115	918-834-9600 918-838-8846	Geophysical research corporation	sales@grcamerada .com
Global Industries	Craig Broussard, VP – Business Dev.	5151 San Felipe Houston, TX 77056	713-479-7979 713-479-7810	Pipeline and platform construction	craig@globalind.com
Halliburton Worldwide Services		2135 Hiway 6 South Suite 201 Houston, TX 77077	281-496-8100	Oil and gas services worldwide	www.halliburton.com
Hofer Flow Control	Deborah Rauschenbach – International Sales	107 Kitty Hawk Lane Elizabeth City, N. Carolina 27909	252-331-1997 252-331-2886	Flow controls, onshore and offshore	rausch@hofferflow .com
Honeywell	General Inquiries	16404 N. Black Canyon Hiway MS2S18 Phoenix, AZ 85053	602-313-6409 602-313-4040	Control systems in refineries and oil production facilities	msscuspctr@ honeywell.com
Hydrill Company	Sales Office, Field Service, Manufacturing Plant	3300 N. Sam Houston Parkway East Houston, TX 77032-3411	281-449-2000 281-985-2828	Wide range of petroleum drilling and production products	www.hydril.com
International Marine Systems	Ted Smith, IMS Manager	2845 Hiway 311 Shriever, LA 70395	875-972-9002 875-972-9004	Offshore oil and gas supply vessels	www.chouest.com/ims. html
Landmark Graphics Corporation	Customer Support	Building 1, Suite 200 2101 City West Blvd Houston, TX 77042-2827	713-839-2000 713-839-2015	Software and services for upstream oil and gas industry	http://www.lgc.com/
Lone Star Steel Company	International Sales	15660 N. Dallas Pkwy Suite 500 Dallas, TX 75248	972-770-6434 972-770-6335	Tubular products for the oil and gas industry	www.lonestarsteel.com
LYNX Information Systems, inc.	Joe Winston	16420 Park Ten Suite 150 Houston, TX 77084	281-599-7226 282-599-7790	Recovery, digital reconstruction geological geophysical data	jwinston@lynx-info.com
McDermott International, Inc.	Corporate Communications	757 N. Eldridge Parkway Houston, TX 77079	281-870-5011 281-870-5095	Engineering, fabrication, installation oil equipment	www.mcdermott.com
Mercer Valve Company	Outside Sales	6218 Long Drive Houston, TX 77087	405-440-2630	Relieve valves and related products	Mvsales1 @mercervalve.net
NavCom Technology, Inc.	Ron Hatch	123 W. Torrence Blvd, Suite 101 Redondo Beach, CA 90277	310-937-7460 310-937-7464	GPS and wireless communication	www.navcomtech.com
Neuralog	Cesar A. Bolivar	4800 Sugar Grove Blvd. Suite 410 Houston, TX 77477	281-240-2525 281-240-2526	Data scanning and digitizing	Neuralog.com
Oceaneering International	Stephen E. Bradshaw, VP Business Dev.	11911 FM 529 Houston, TX 77041	713-329-4500 713-329-4541	Subsea and remotely controlled products	www.oceaneering.com
Paragon Engineering Services, Inc.	J. Augustine, Business Dev.	10777 Clay Road Houston, TX	713-570-1000 713-570-8910	Production facilities, platforms	jaugustine@paraengr .com

Business Name	Point of Contact	Address	Tel / Fax	Product / Service	Web page / Email
Petroleum Geo-Services (PGS)	Sales Department	738 Highway 6 South Suite 500 Houston, TX 77079	281-589-8818 281-589-1482	Seismic survey and oil & gas production services	www.pgs.com
Petro-Tech International	Paul Doyle President	9800 Northwest Freeway Suite 500 Houston, TX 77092	713-622-3492 713-622-3474	Seismic acquisition and processing, platforms, production facilities	pdoyle@osfi-fw.com
Rowan Companies	Mark Keller, Sr. VP Mktg.	2800 Post Oak Blvd., Suite 5450 Houston, TX	713-960-7575	Drilling and steel manufacturing	www.rowancompanies .com
Smith Services	Earl M. Springer, VP Business Dev.	16470 Hardy Street Houston, TX 77032	281-443-3370 281-233-5336	Products and services, oil & gas production and exploration	info@smith.com
Sperry Sun Drilling Services	Christine Howe	14103 Interdrive West Houston, TX 77032	281-871-6059	Surface logging, directional drilling, etc.	Christine.how@ halliburton.com www.sperry-sun.com
Stolt Offshore (USA), Inc.	NA	900 Town & Country Lane, Suite 400 Houston, TX 77024	713-430-1100 713-461-0039	Subsea pipelines and risers	Gom-info@ stoltoffshore.com
Superior Energy Services	Lee Faw	523 N. Sam Houston Parkway E, Suite 200 Houston, TX 77060	281-999-0047 281-999-6505	Well services and oil & gas rental tools	Lee.faw@ superiorenergy.com
Tenaris	Ronad Ballkenende	Siderca Corporation 4511 Britmoore Rd. Houston, TX 77041	713-767-4400 713-767-4444	Oil field and pipeline services; built Camisea pipeline	www.tenaris.com
Tidewater	Monty Orr, VP Int'l Sales	2500 Wilcrest Drive Suite 300 Houston, TX 77042	713-954-4875 713-334-4563	Information technology, networks	morr@tdw.com
Varco International	Haynes B. Smith, III President, Varco Services	2000 W. Sam Houston Parkway South Houston, TX 77042	281-953-2200 713-953-2400	Drilling equipment, tubular services	info@varco.com
Western Geco	Maurice Nessim	10001 Richmond Houston, TX 77042	713-789-9600 713-789-0172	Data processing and seismic acquisitions	www.westerngeco.com

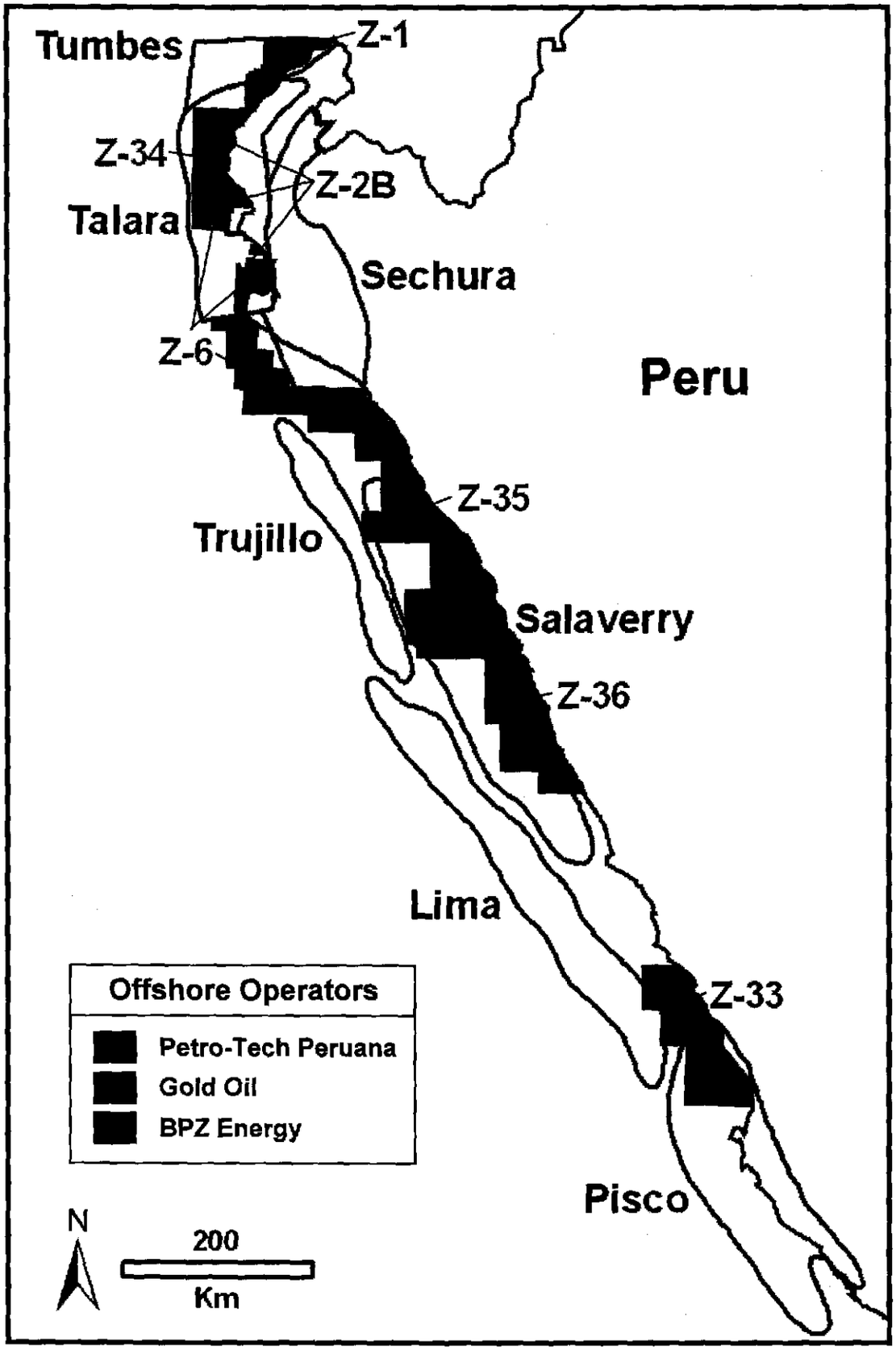


Figure 1: Peru Offshore Basins and Currently Licensed Blocks

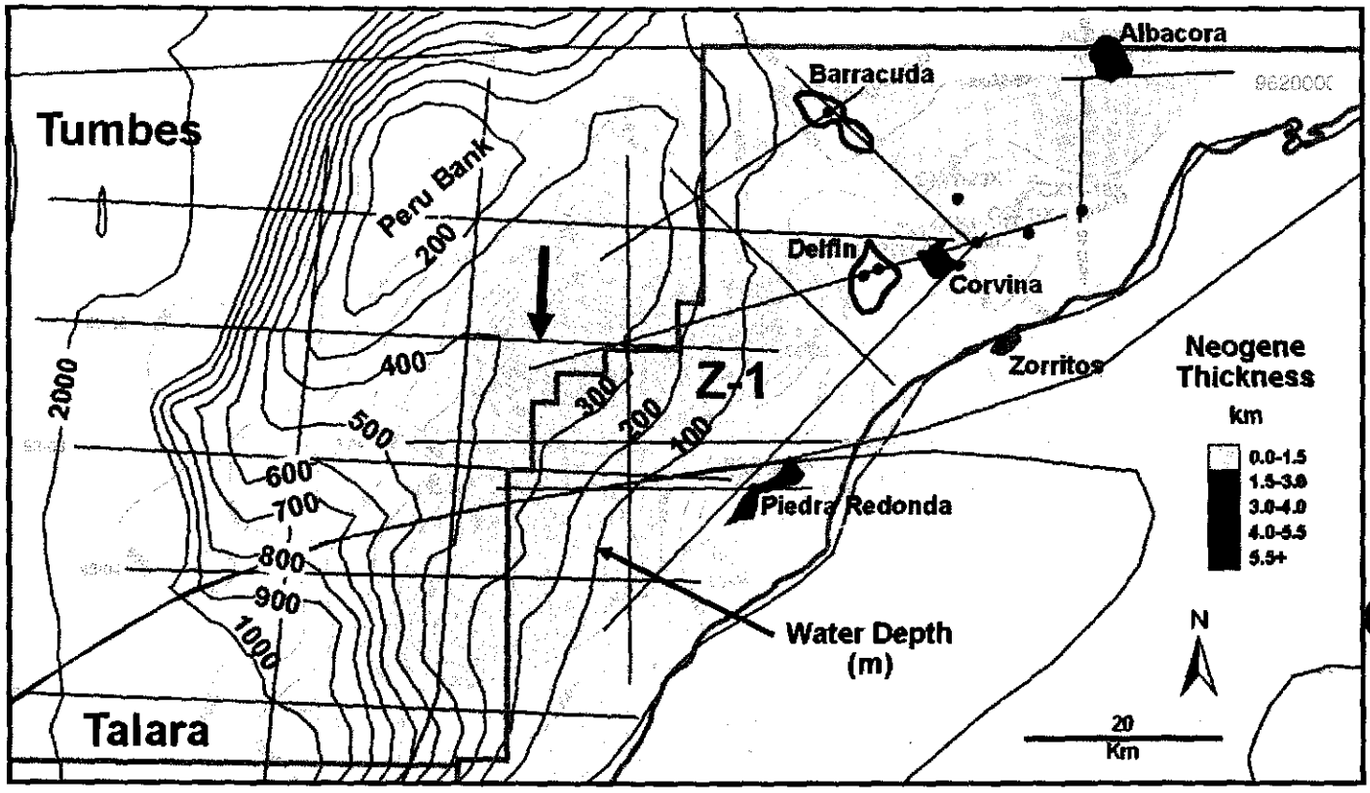


Figure 2: Tumbes Basin Exploration Fairways

The Tumbes shallow-water Neogene fairway lies mostly within BPZ's Block Z-1. However, there are relatively shallow-water areas left in open acreage immediately west of Block Z-1, especially east of the Peru Bank. The black arrow marks the location of the segment of Line 93-02 that is shown in Figure 3.

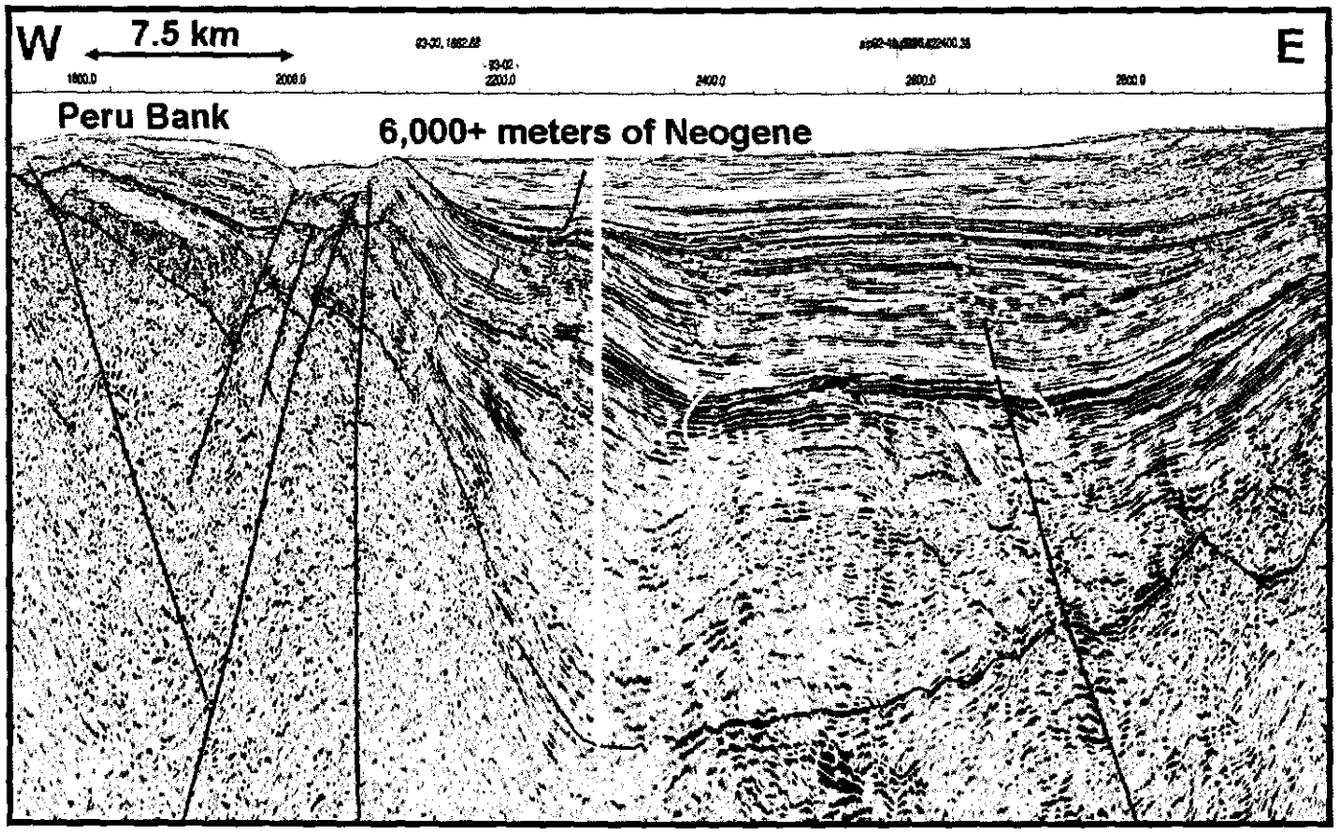


Figure 3: Example Line through the Neogene Sub-Basin in Tumbes Basin

6,000+ meters of Neogene sediment in the sub-basin east of the Peru Bank. A broad inversion at the Top Miocene horizon is marked in the white oval.

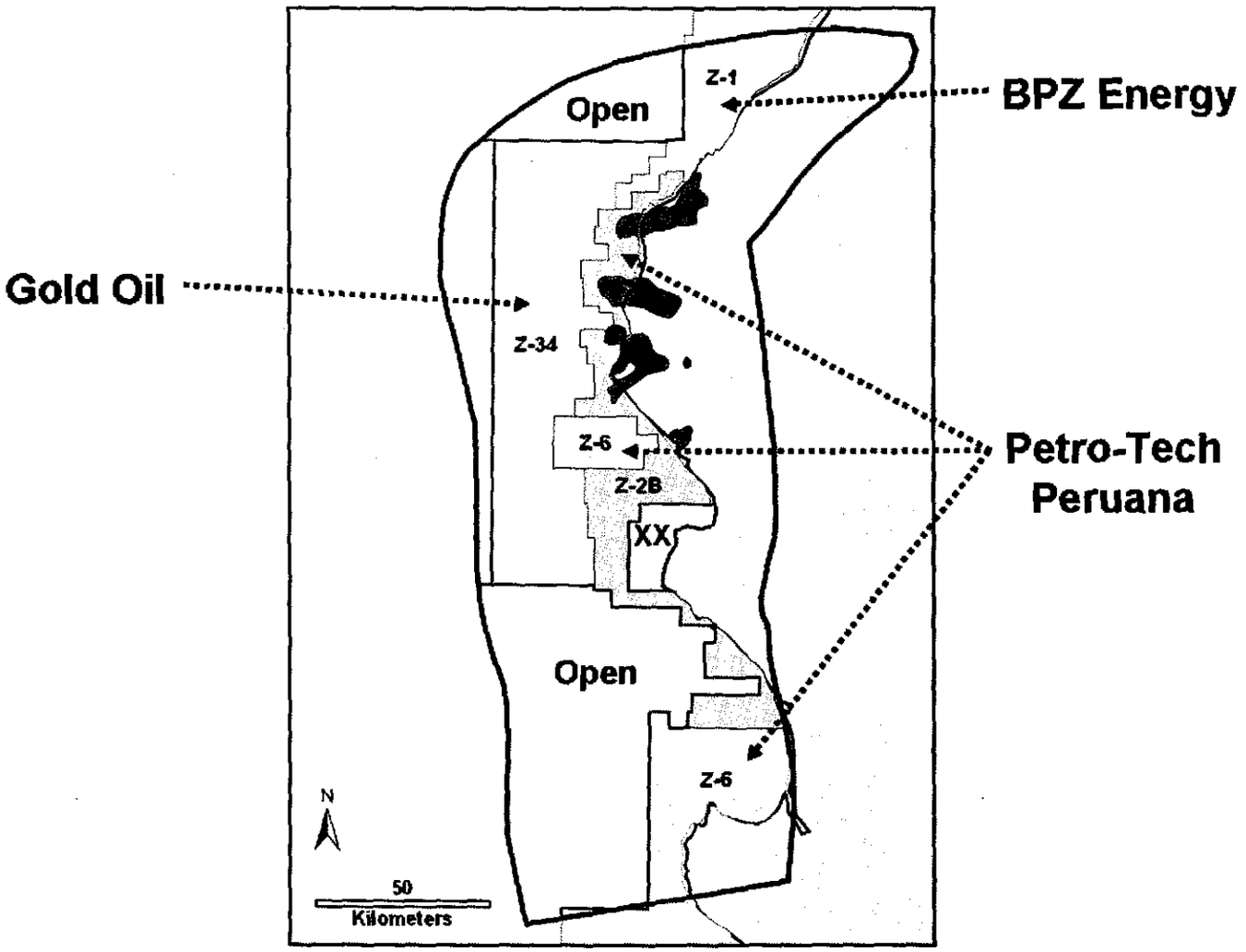


Figure 4: Offshore Licensing Summary Map of the Talara Basin

Petro-Tech is the operator of the long-standing onshore and shallow offshore production, and has a commanding exploration acreage position in Blocks Z-2B and Z-6. BPZ Energy and Gold Oil are other players. Open areas to the north and south may attract others. The area marked XX is the offshore extension of the Paita High. It has been heavily eroded and is likely not prospective.

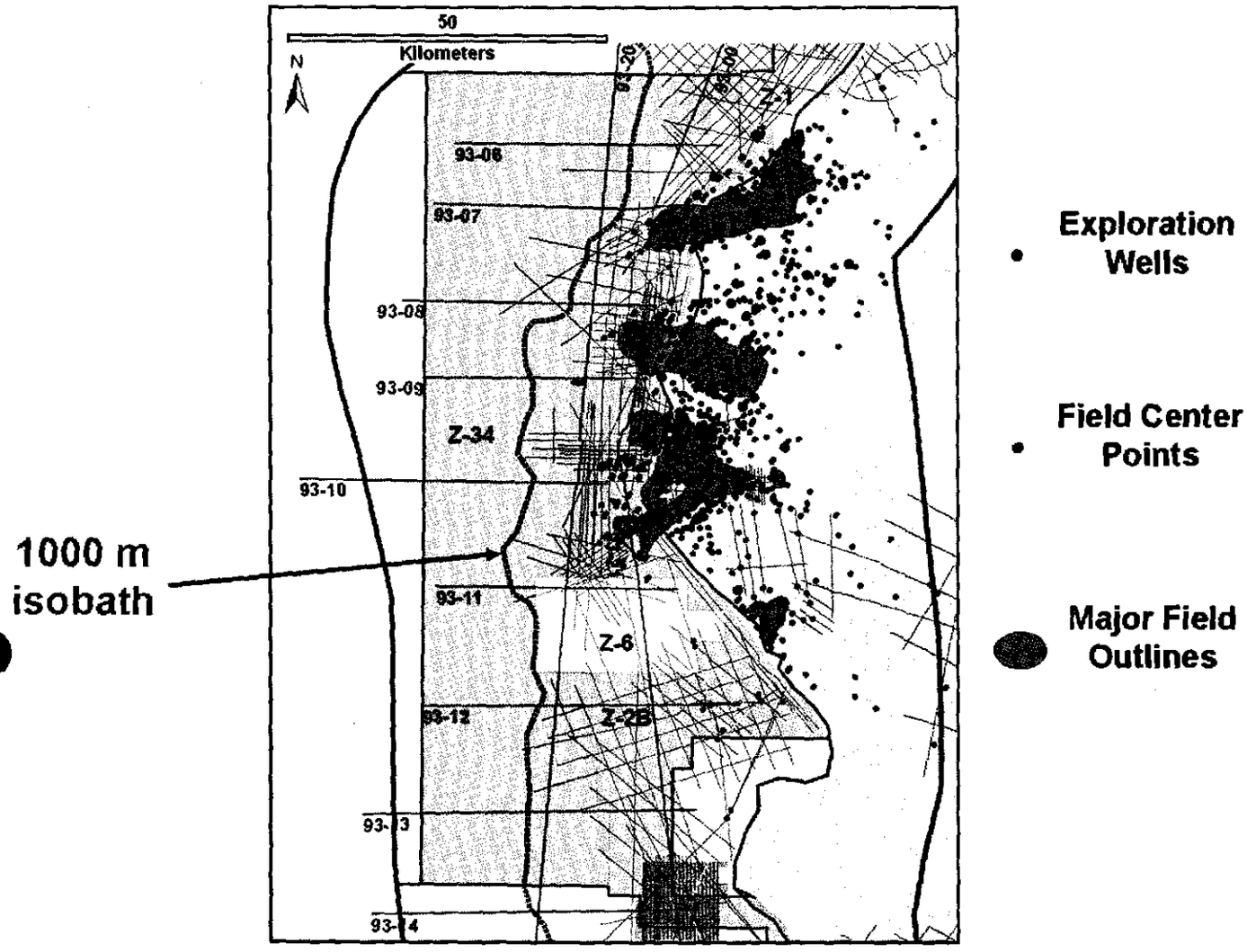


Figure 5: Talara Basin Exploration Fairway Map

The fairway between the proven production and the 1000-meter isobath is very narrow and is structurally complex. A swath of offshore 3D seismic surveys has only further confused the structural picture.

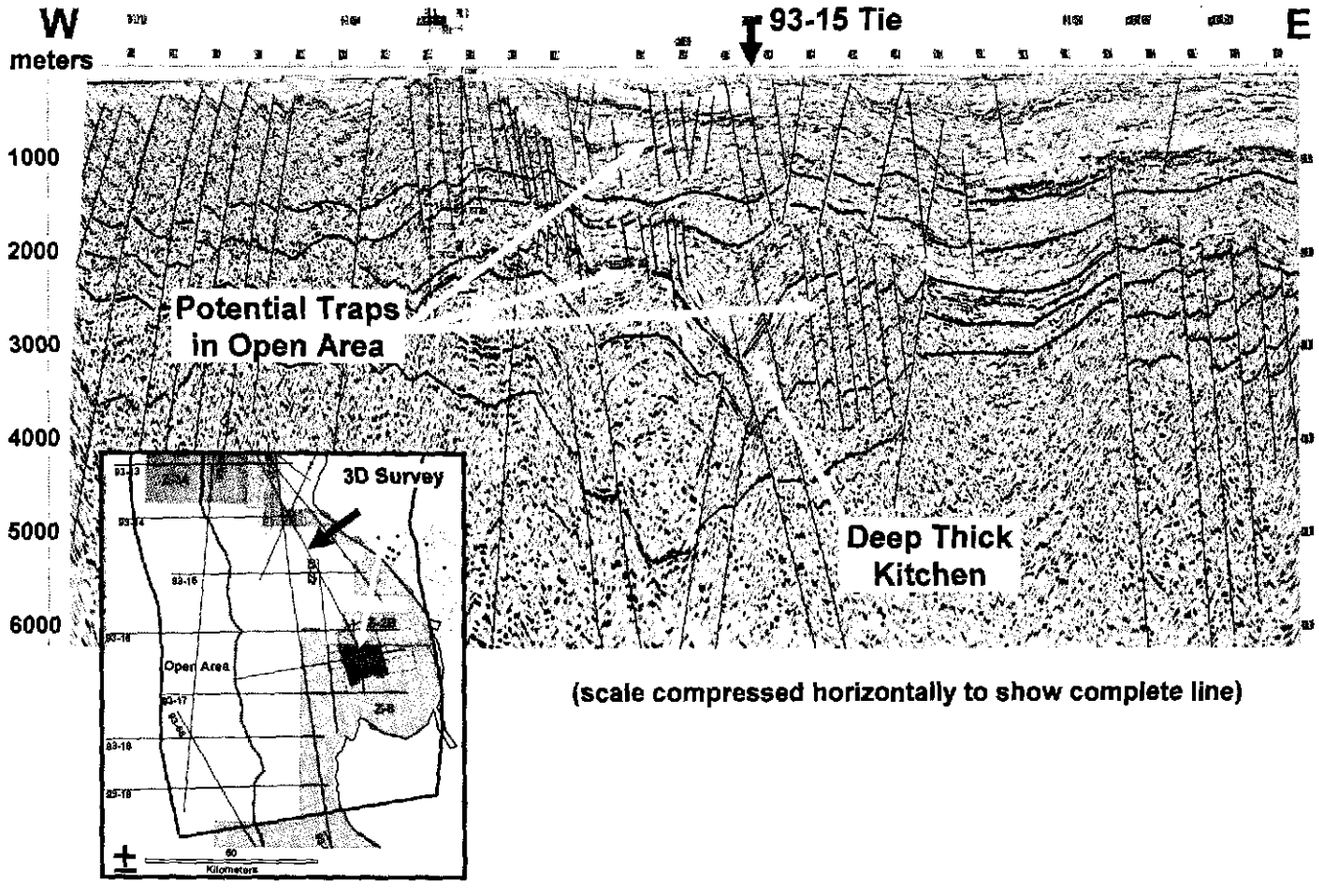


Figure 6: Example Line through the Southern Prospective Area in the Talara Basin

The open area at the south end of the Talara basin is very attractive. A thick kitchen area is overlain by many potential structures in shallow water and reasonable drilling depths.

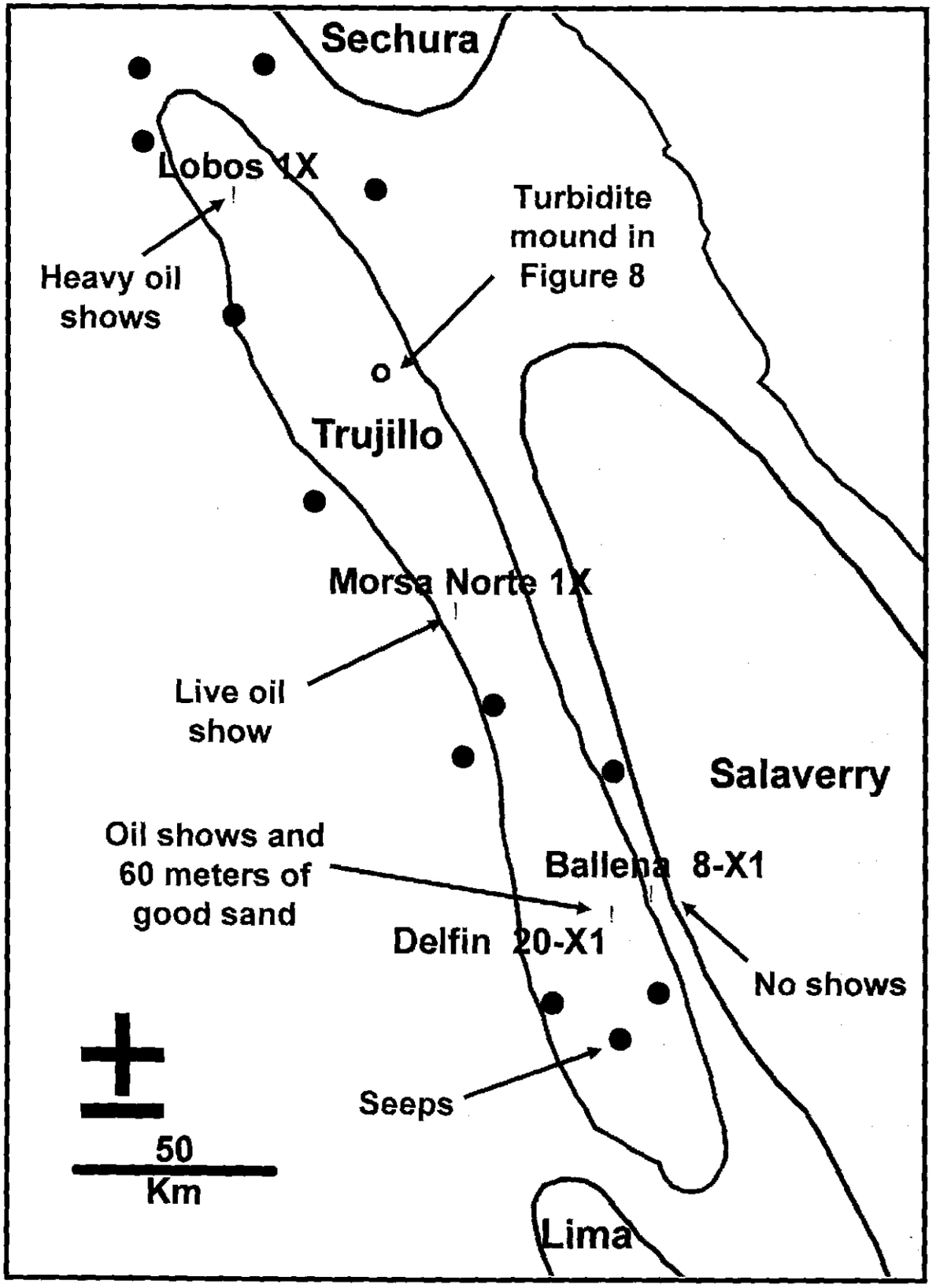


Figure 7: Locations of Oil Seeps and Exploration Wells in the Trujillo Basin

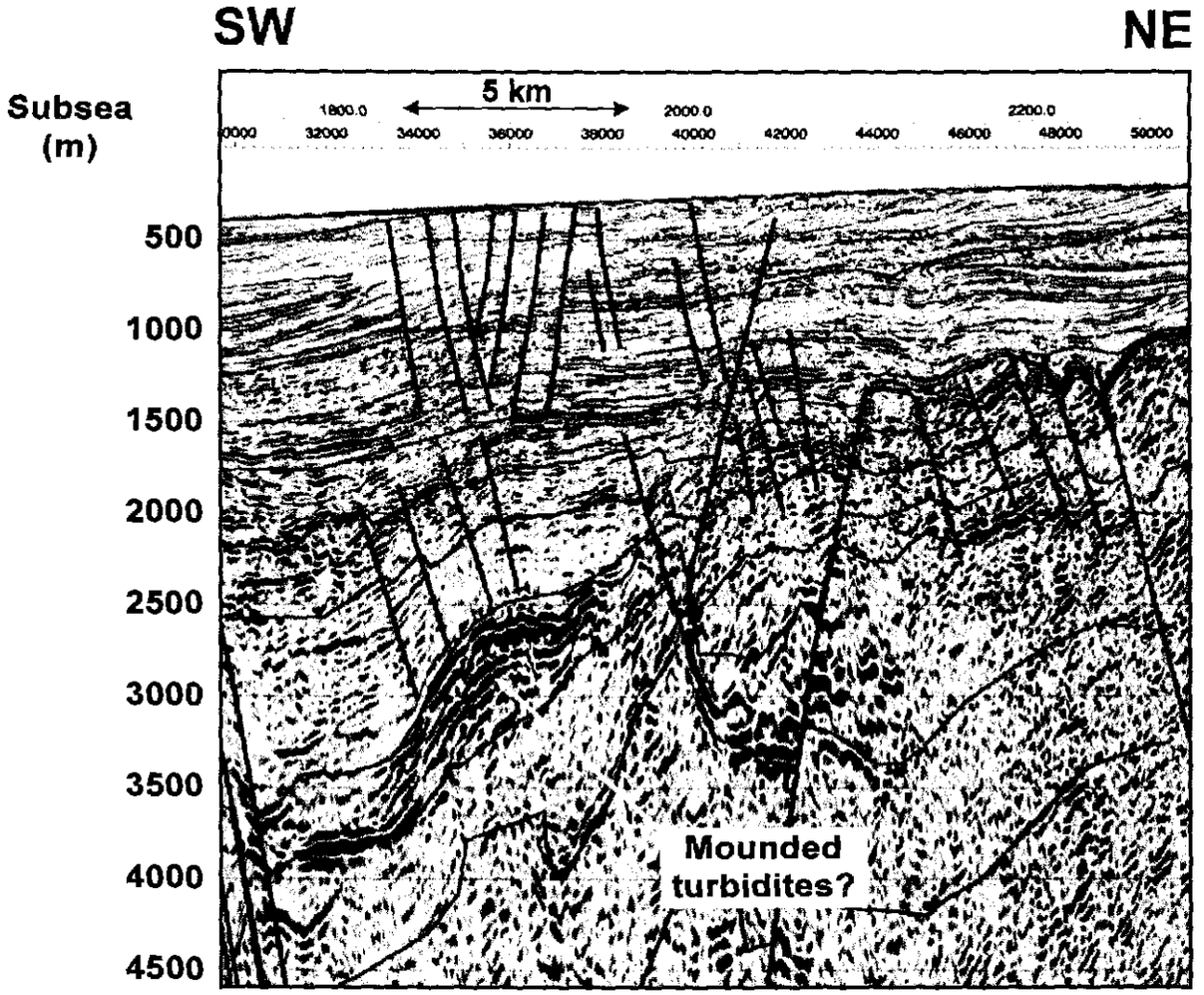


Figure 8: Possible Mounded Turbidites in the Trujillo Basin

Good example of stacked high-amplitude anomaly that might be mounded Eocene turbidite sand on Line 93-35 (see Figure 7 for location)

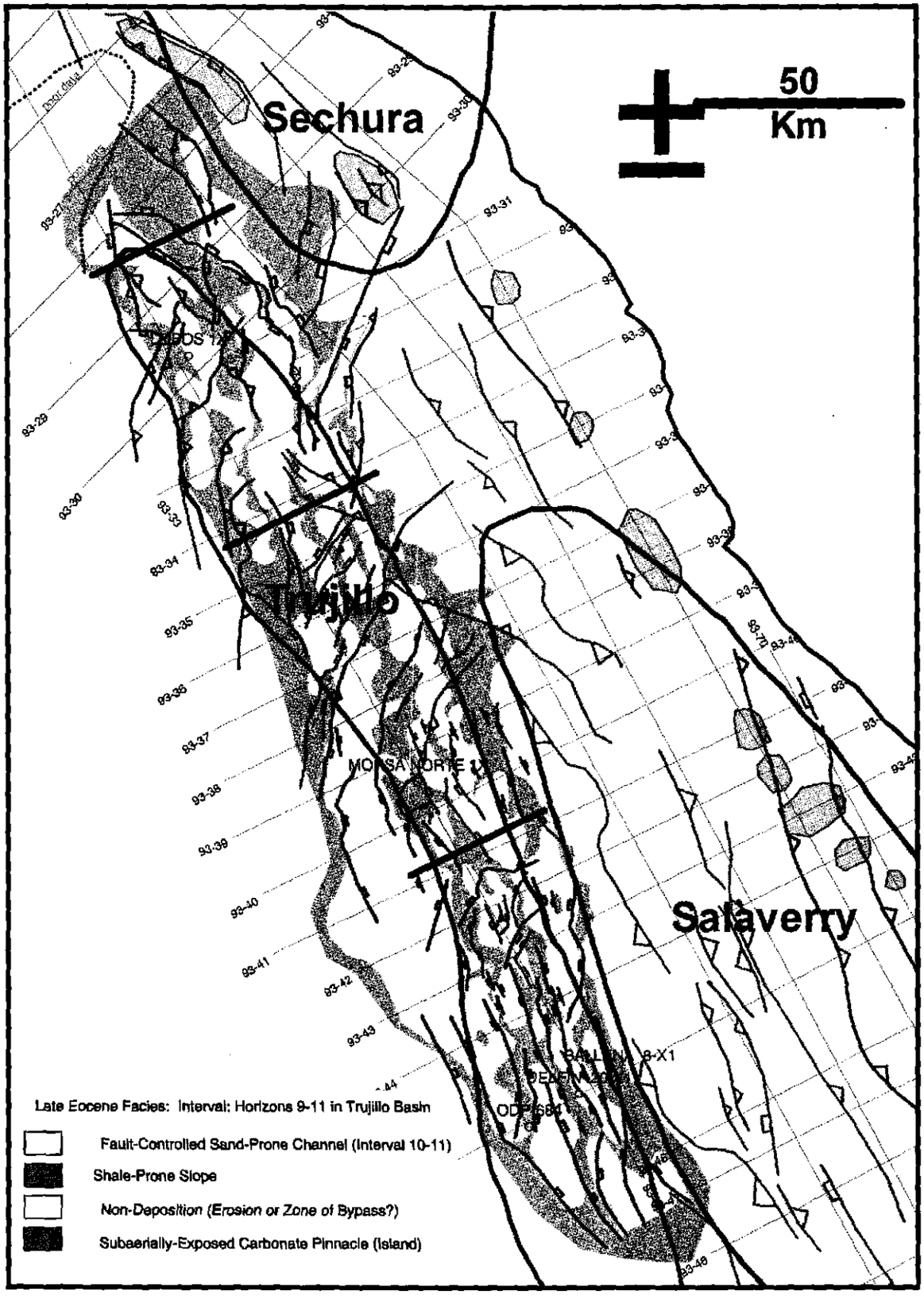


Figure 9: Distribution of Late Eocene Turbidite Channels in the Trujillo Basin

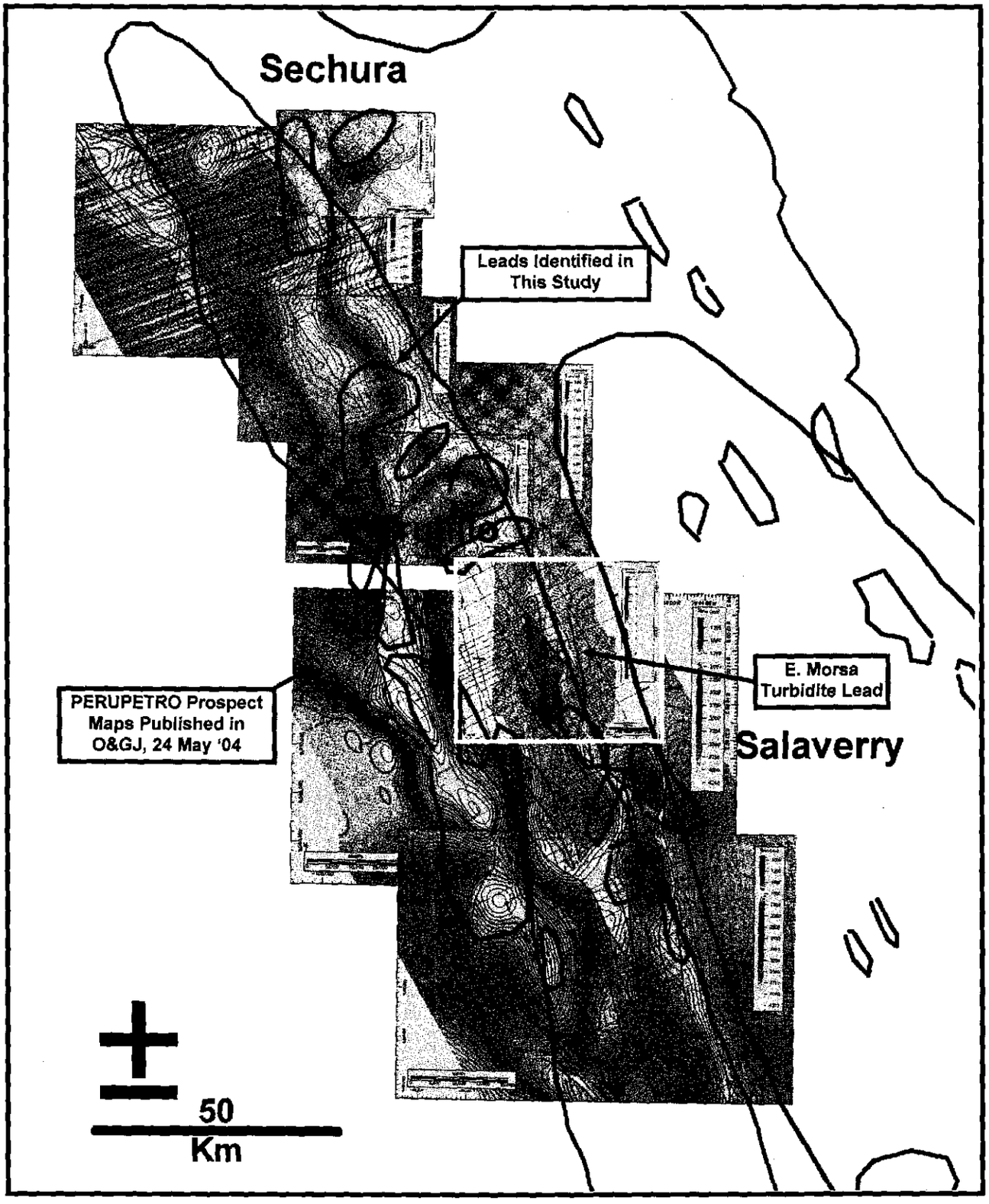


Figure 10: Leads in the Trujillo Basin

Location of eight leads mapped by previous workers and confirmed in this study

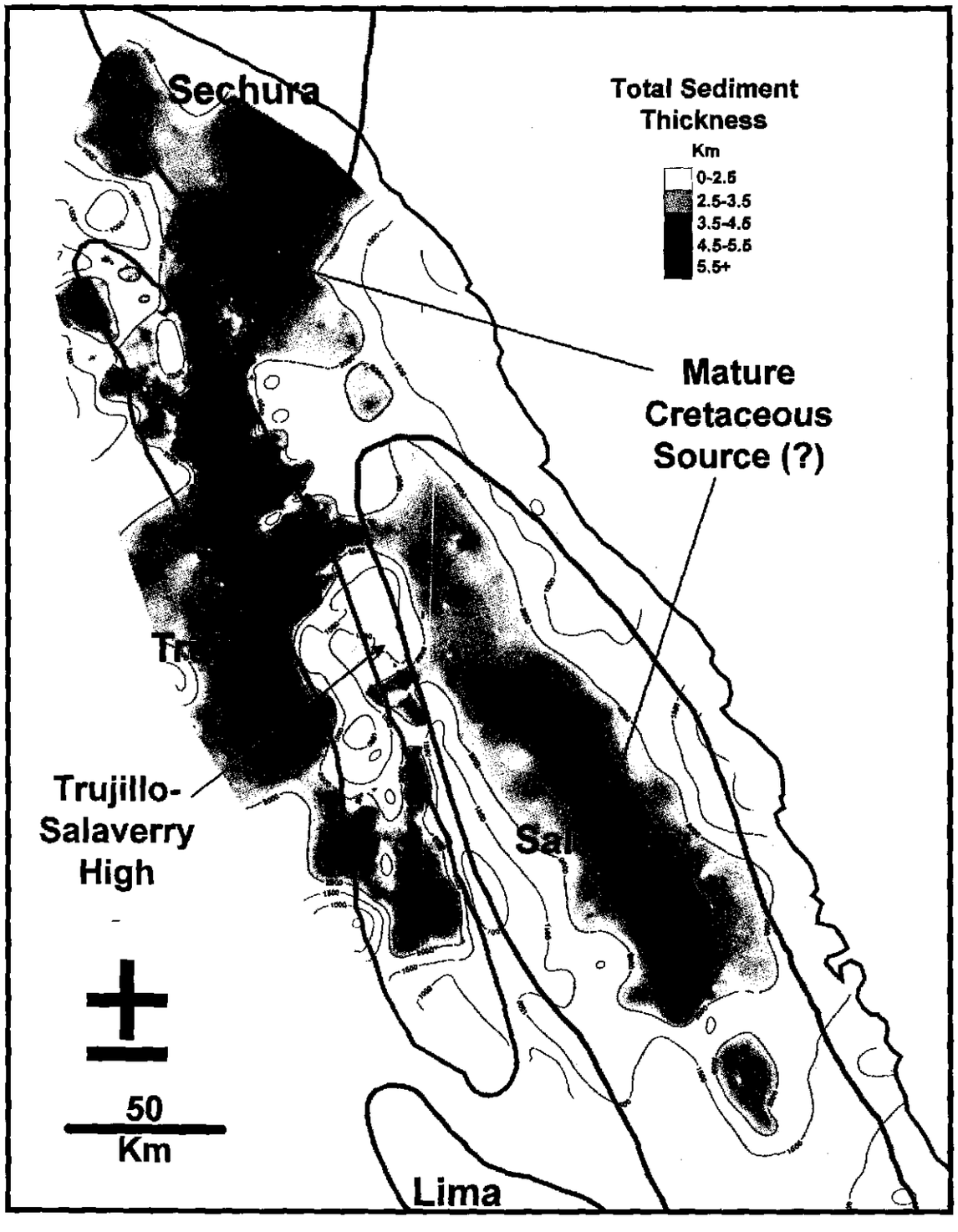


Figure 11: Strong possibility of mature Cretaceous source rock in the Salaverry and offshore Sechura basins

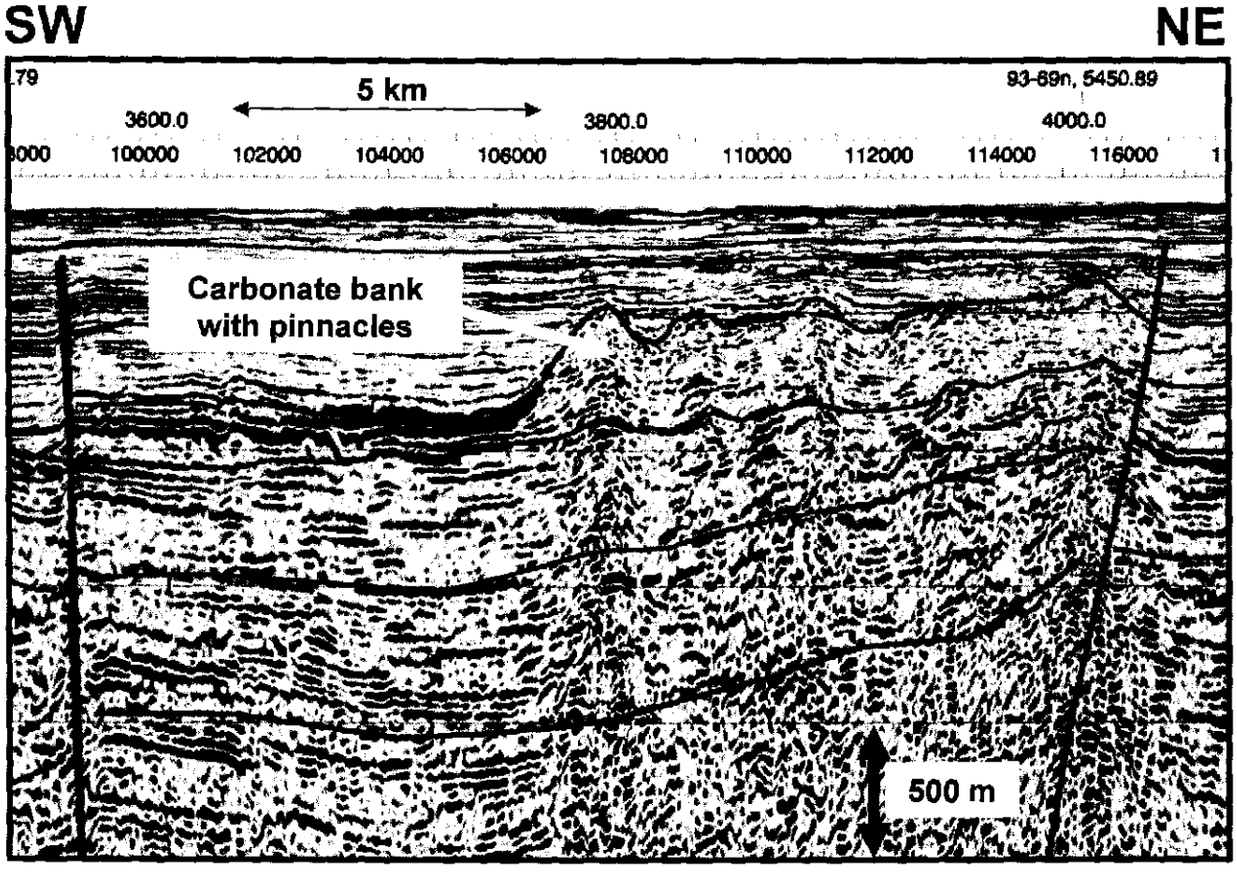


Figure 12: Possible Eocene Carbonates in the Salaverry and Offshore Sechura Basins

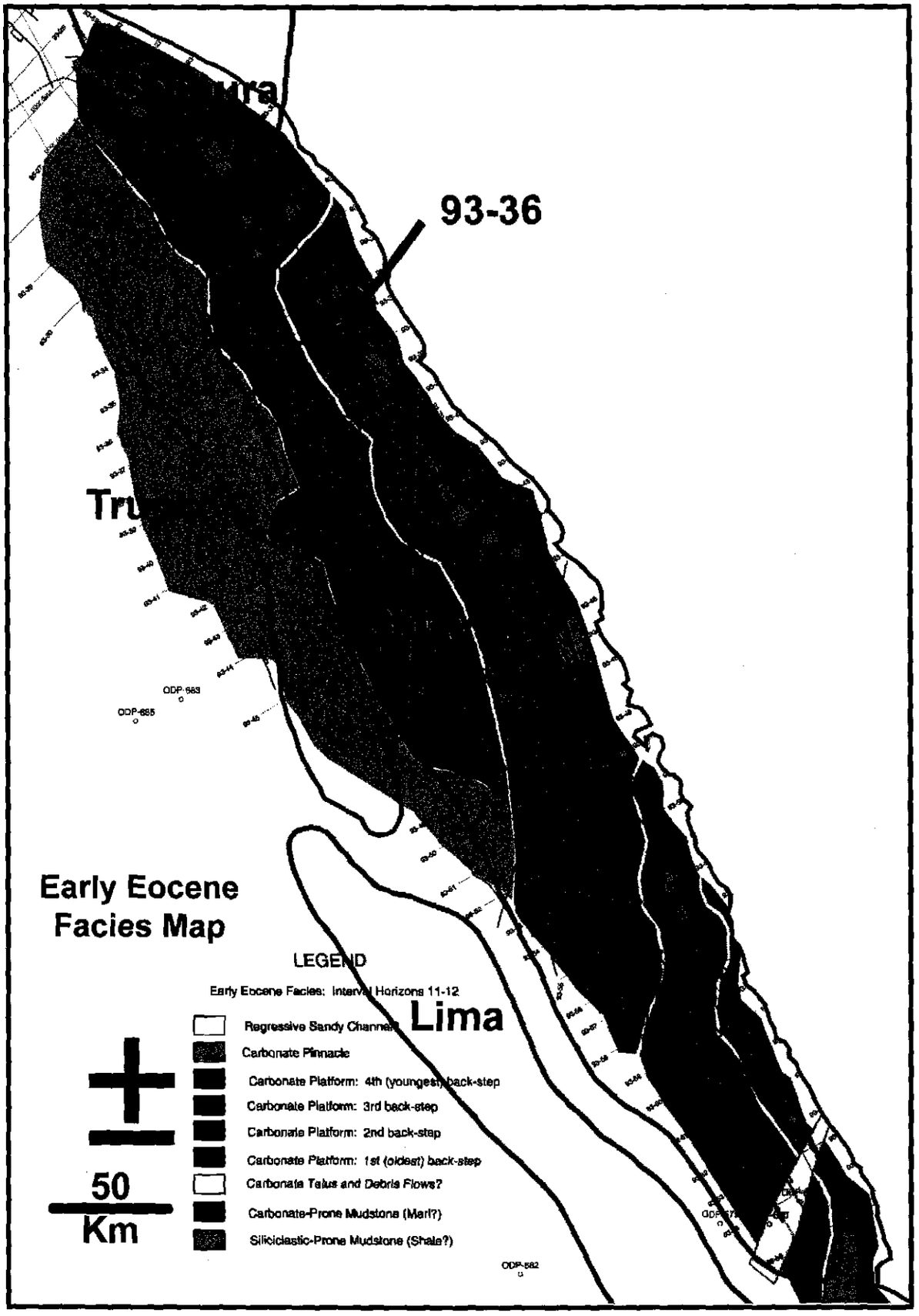


Figure 13: Map of Early Eocene carbonate platforms (in blues) and pinnacles (pink). Location of Line 93-36 (Figure 12) shown with black arrow

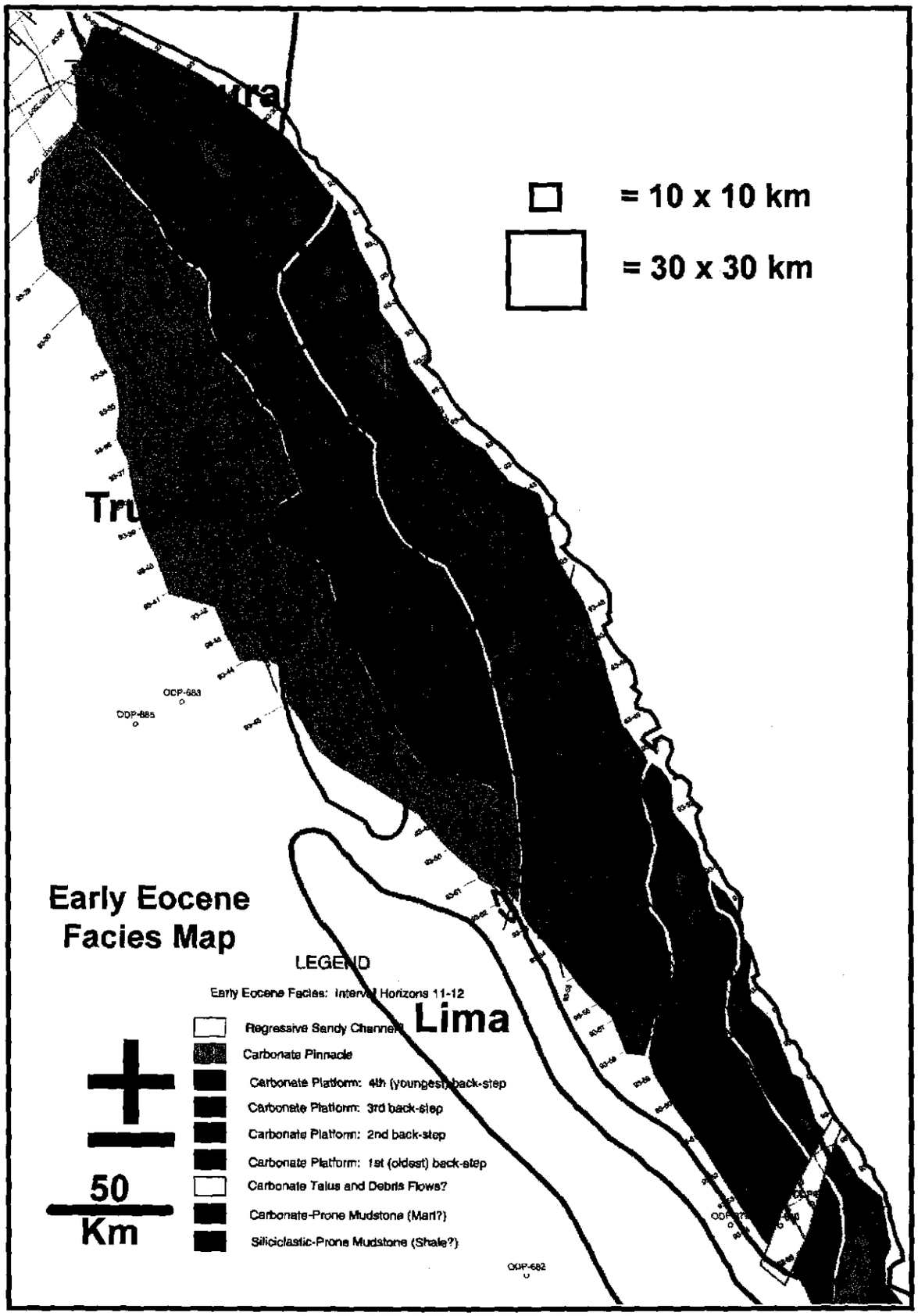


Figure 14: Wide variety of structural and stratigraphic leads – some with giant potential

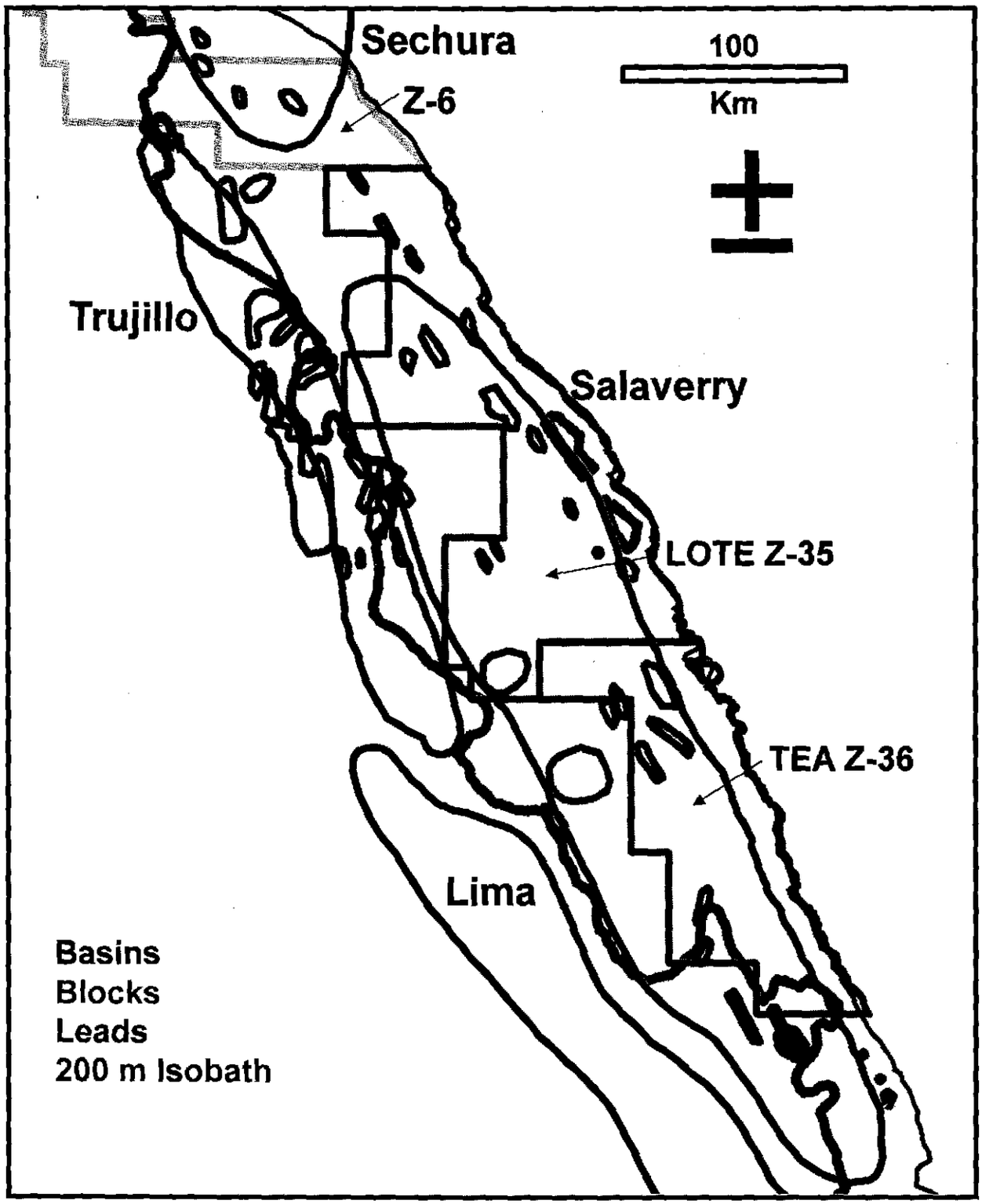


Figure 15: Petro-Tech Acreage Position in the Salaverry and Offshore Sechura Basins

Petro-Tech Peruana currently holds Block Z-6, and is awaiting government approval of a contract on Block Z-35 and an evaluation agreement for Block Z-36. These blocks encompass most of the leads identified in this study, which are all in less than 200 meters of water, with a few exceptions.

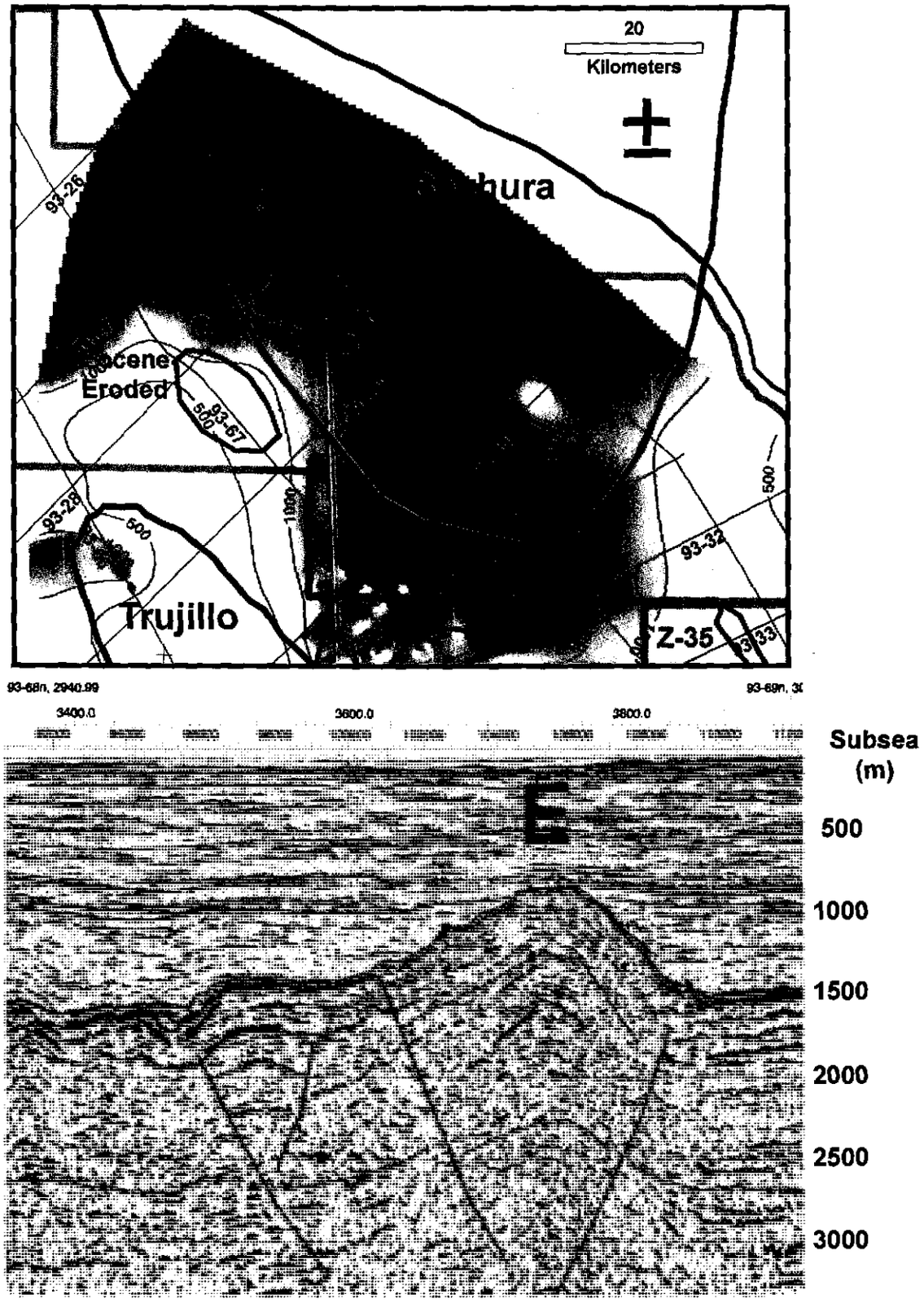


Figure 16: Petro-Tech is set to drill Lead E above in 2005. There are at least four others on their Block Z-6.

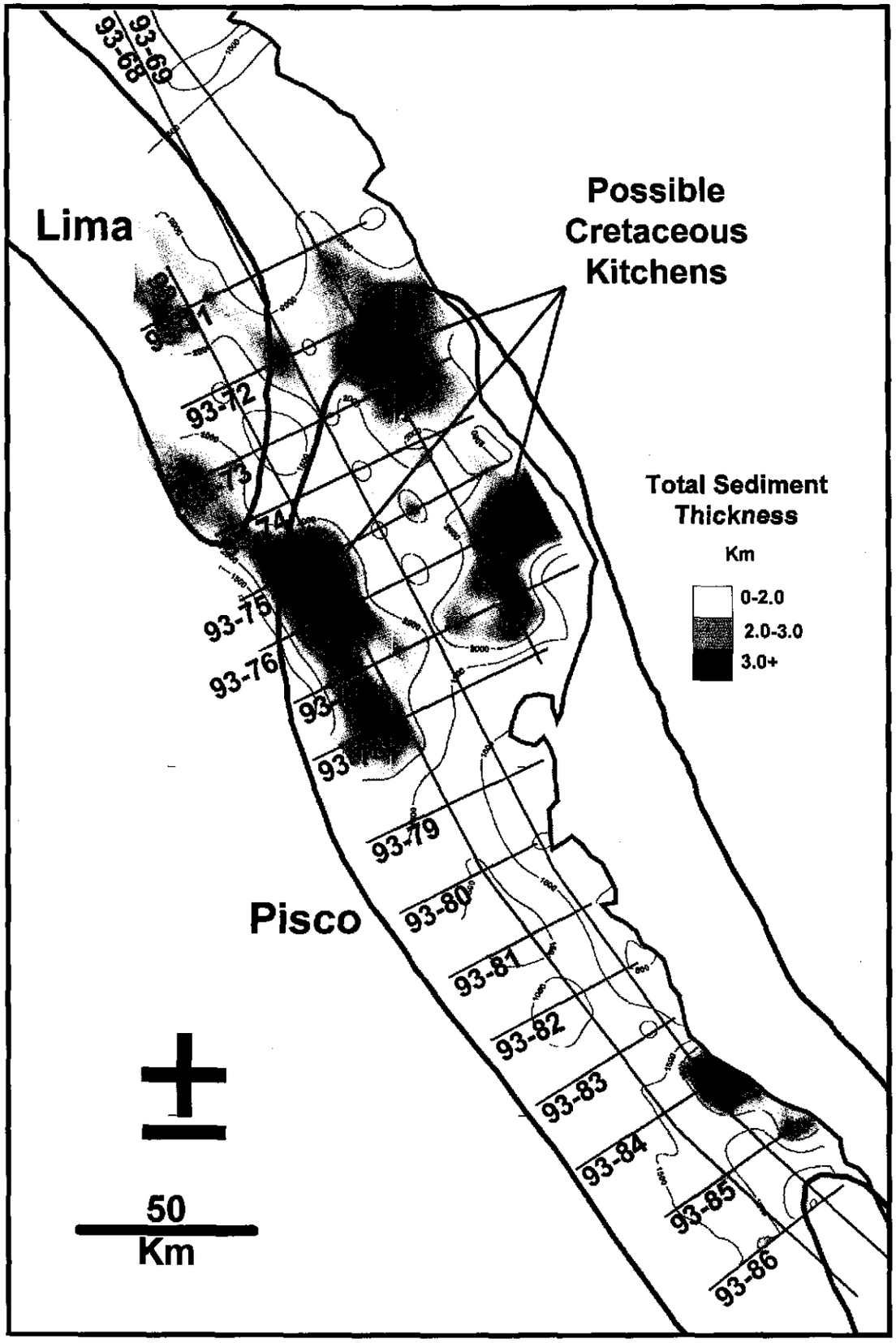


Figure 17: Map of Possible Mature Cretaceous Source Rock in the Pisco Basin

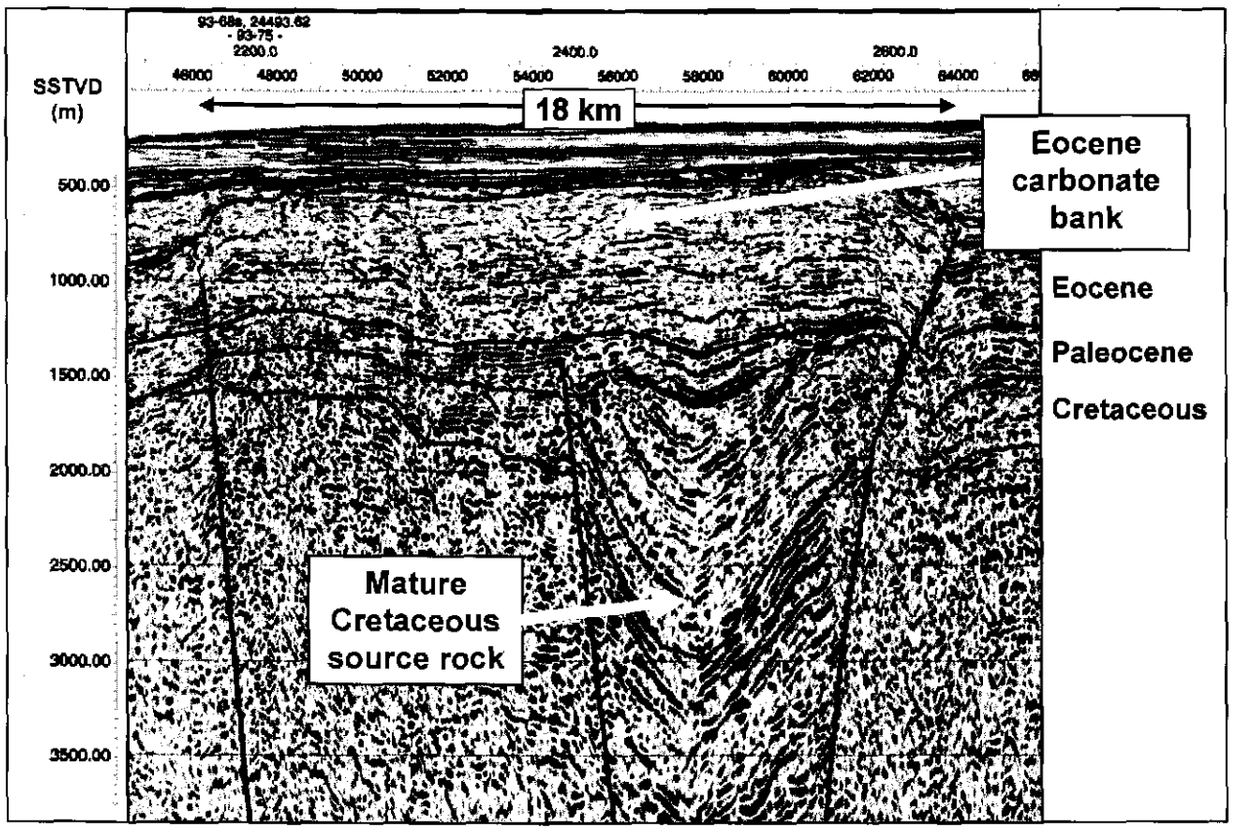


Figure 18: Example Line through Possible Cretaceous Source Rocks in the Pisco Basin

Line 93-75 in the Pisco basin, showing location of possibly mature Cretaceous source rocks below a possible Eocene carbonate bank reservoir

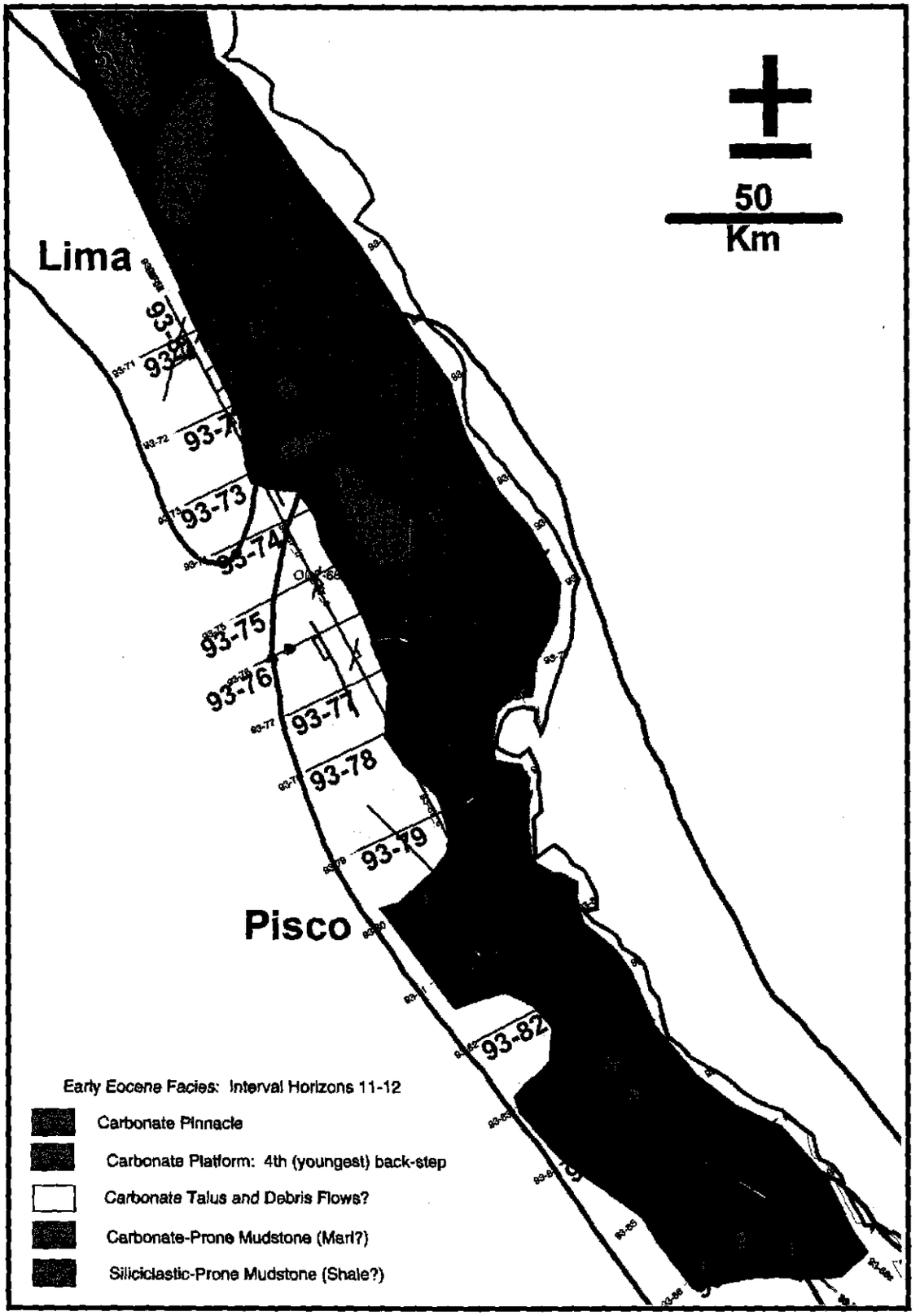


Figure 19: Distribution of Possible Eocene Carbonate Platform (light blue) and Pinnacle (pink) Reservoir Facies

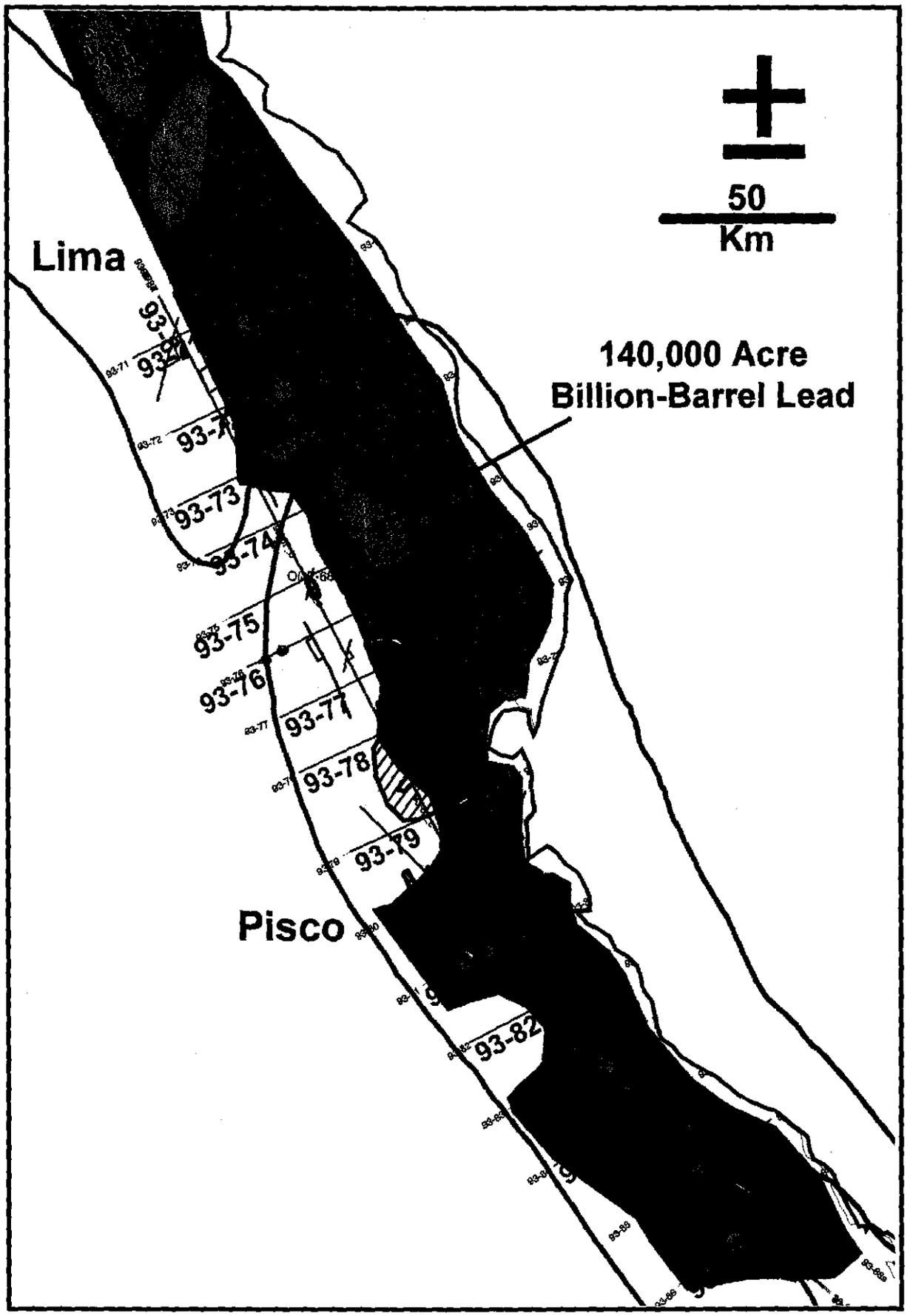


Figure 20: A Billion-Barrel Lead in the Northern Part of the Pisco Basin

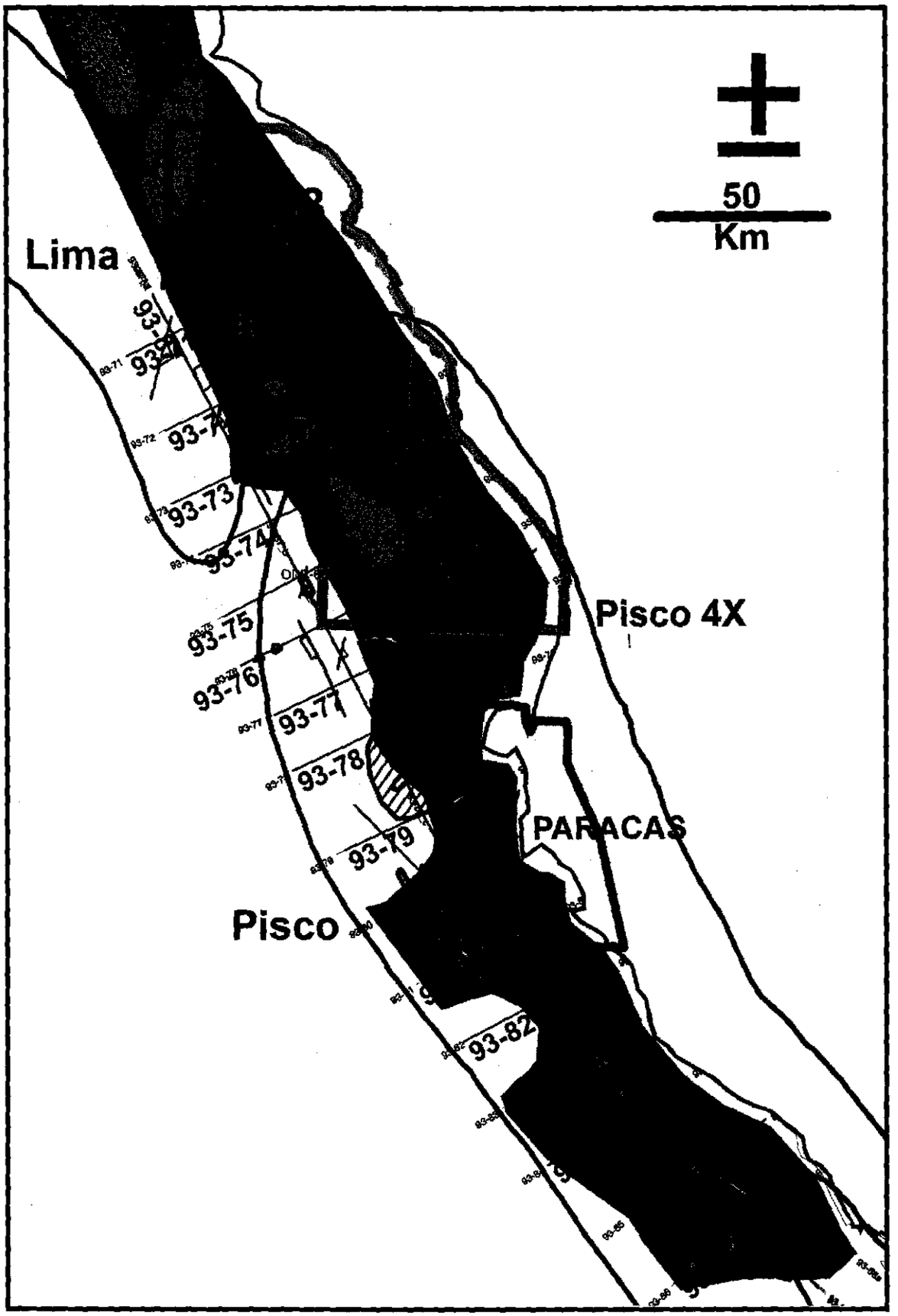


Figure 21: Block Z-33 – Licensed by Petro-Tech Peruana on September 1, 2004

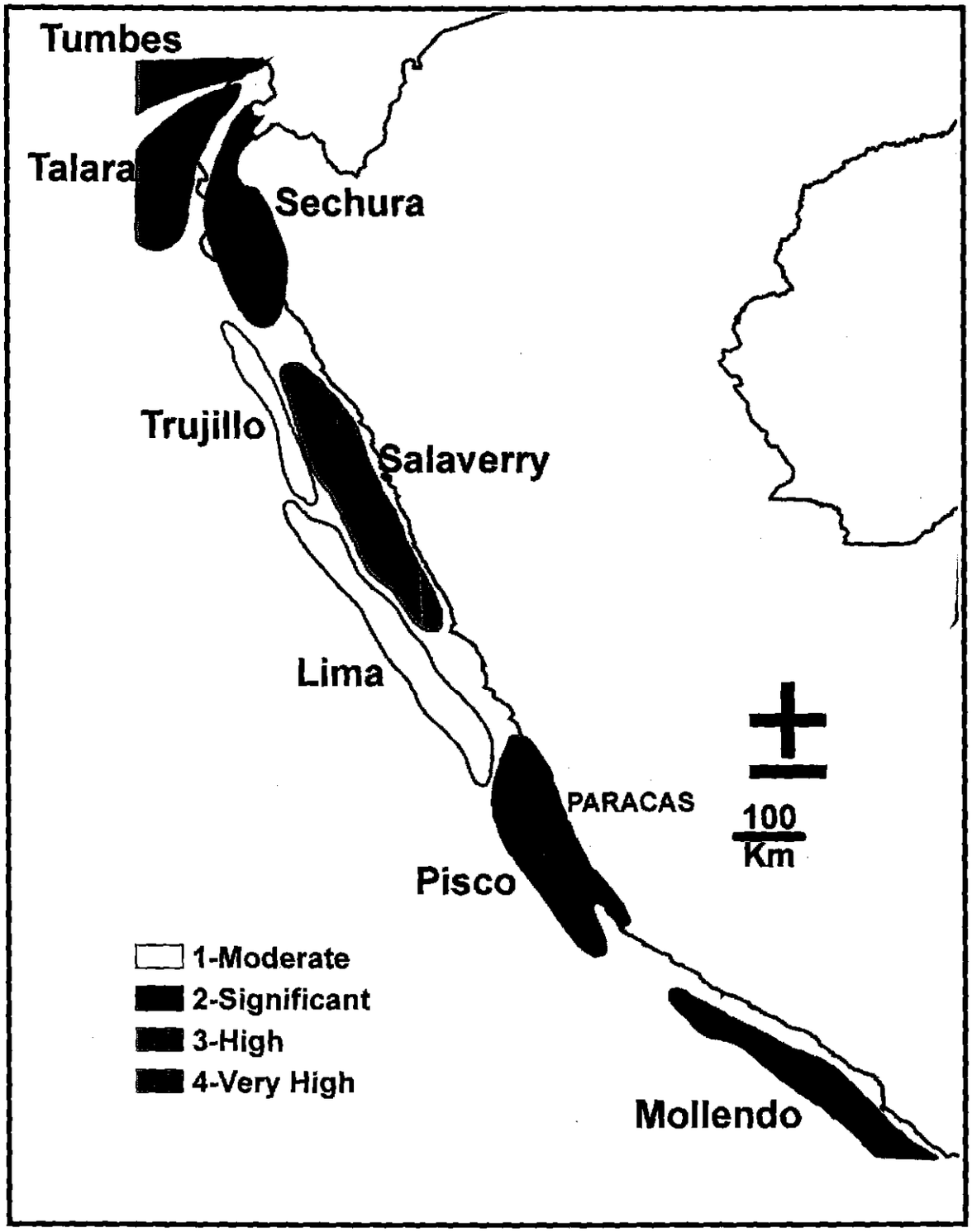


Figure 22: Summary Map of Offshore Environmental Sensitivity

Overall environmental sensitivity rating per basin. Pisco is very high because of the National Reserve of Paracas – an environmentally protected area.

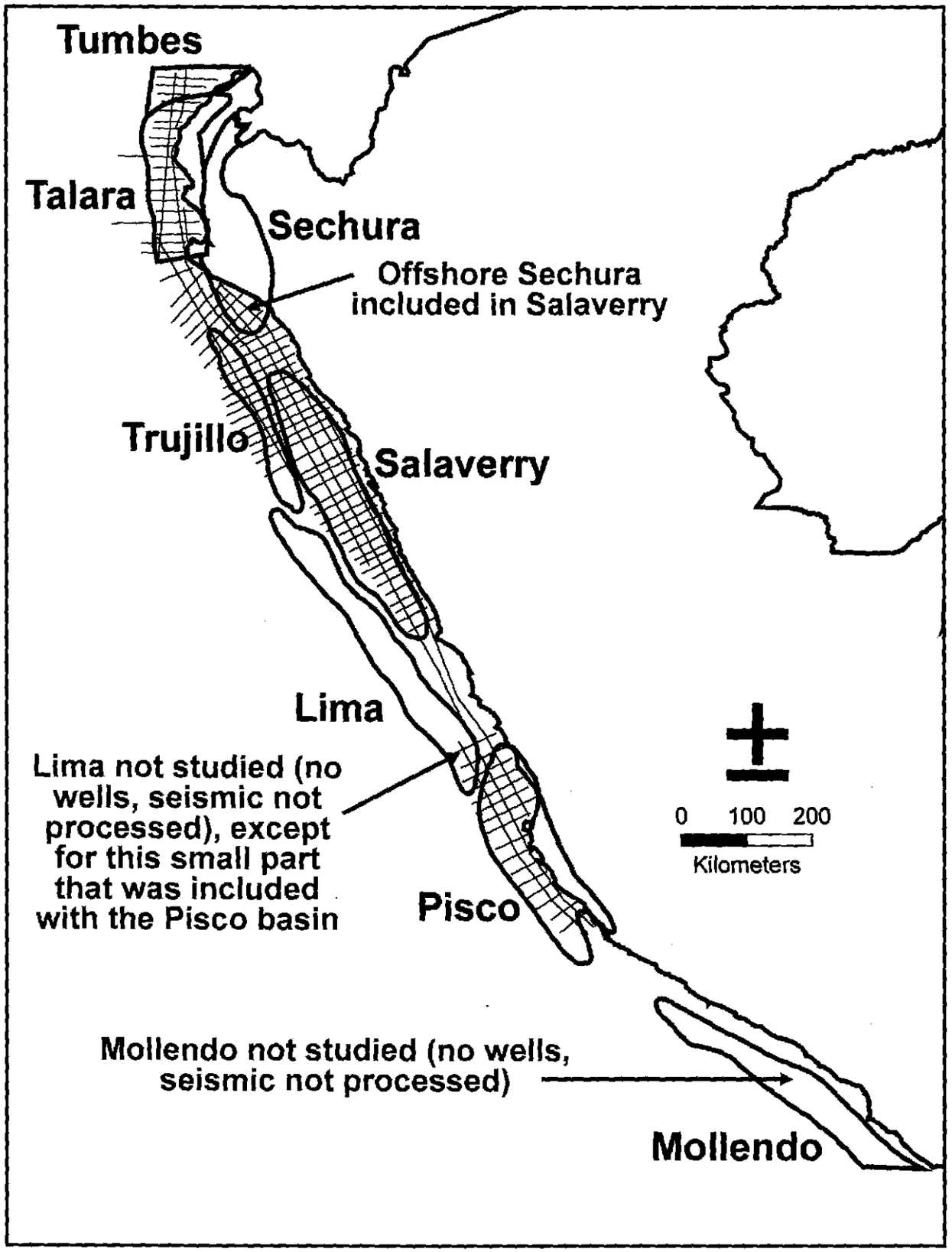


Figure 23: Regional Seismic Coverage of the Offshore Basins

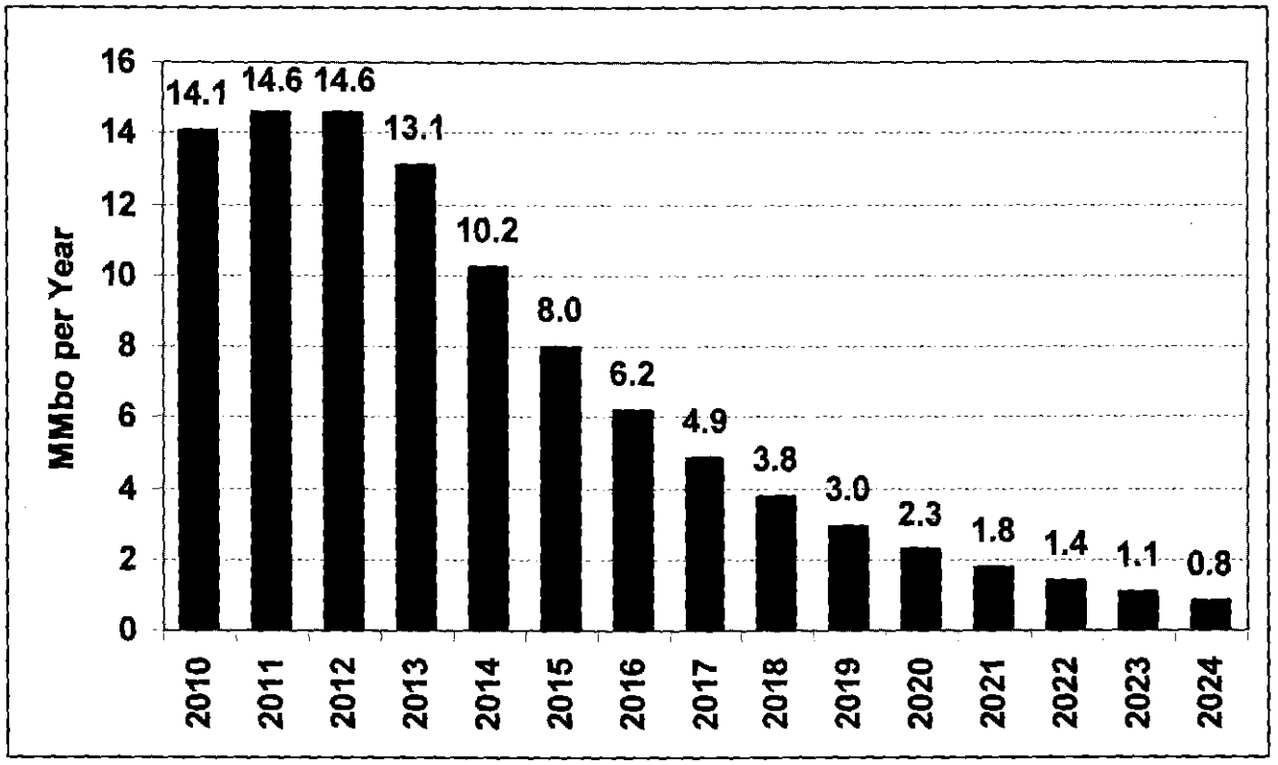


Figure 24: 100 MMbo Typical Discovery Production Profile

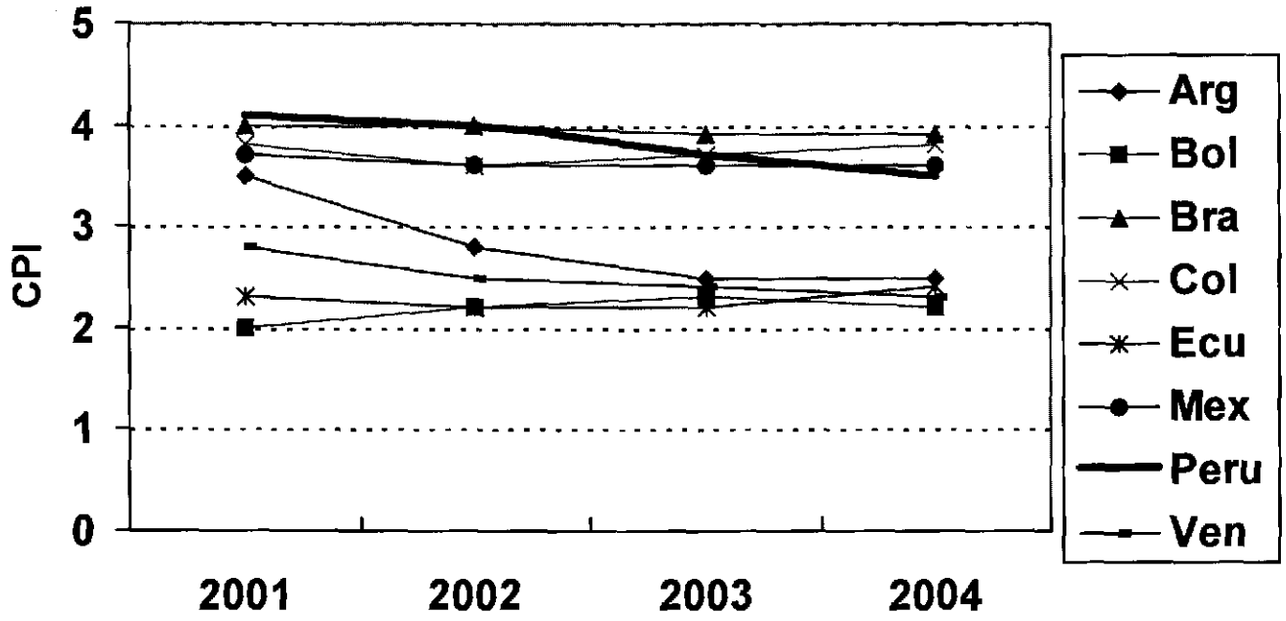
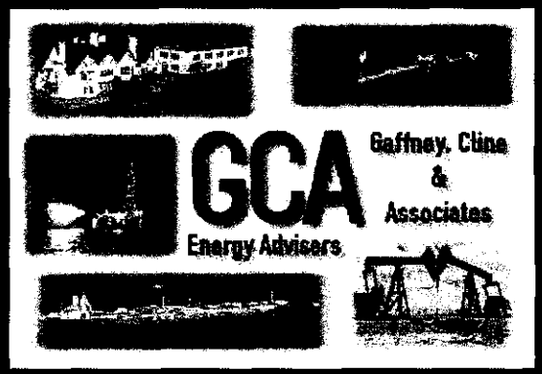


Figure 25: Transparency International Corruption Perception Index (CPI)

Gaffney, Cline & Associates

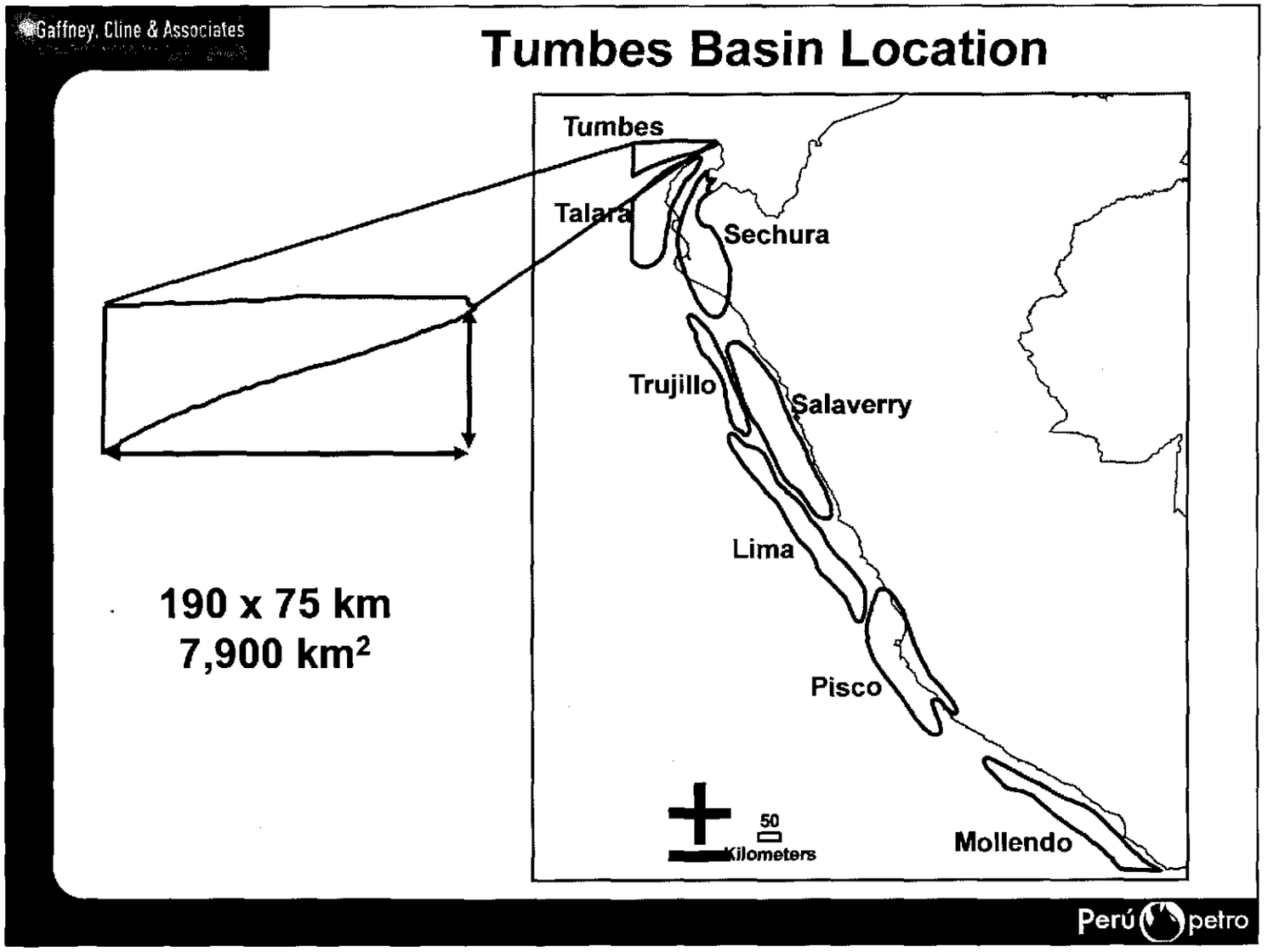
April 2005

Hydrocarbon Prospectivity of the Tumbes Basin



Perú petro

This Basin Presentation is part of the Final Report for the larger study entitled, "Sequence Stratigraphy Analysis of the Peruvian Offshore Continental Shelf-Slope." This study was funded by the USTDA, and was executed by Gaffney, Cline & Associates for PERUPETRO.



The Tumbes basin is the northern-most basin in the study area. It is actually part of the greater Tumbes-Progreso basin which extends into Ecuador to the north. However, only the Tumbes part on the Peruvian side was included in this study.

Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

This presentation begins with the conclusions and a quick review of the data, which is followed by discussion of possible hydrocarbon source rocks, reservoirs and leads. It finishes with a brief discussion of exploration plans and several economic scenarios.

Gaffney, Cline & Associates

Tumbes Conclusions

- Proven Neogene petroleum system with oil and gas production from the Zorritos field onshore and the Albacora discovery offshore
- Possible Cretaceous-Paleogene petroleum system
- Numerous Neogene leads in shallow to moderate water depths and reasonable drilling depths, but will likely require careful reprocessing of 2D seismic plus targeted 3D seismic to resolve complex structures
- Reservoir is key uncertainty
- BPZ Energy has a dominant acreage position (Block Z-1) and has scheduled their first commercial offshore project (Corvina gas production), but workable area is still available in the western half of the basin, albeit in deeper water

Perú petro

Overall, the Tumbes basin is rich in potential, and is poised to see the implementation of a new offshore commercial project – gas production from BPZ Energy's Corvina and Piedra Redonda fields in Block Z-1. Although much of the shallow-water fairway is covered by Block Z-1, there is still workable open acreage in the western half of the basin.

Gaffney, Cline & Associates

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Perú petro

PERUPETRO furnished unlimited access to their data archives. The gross volume of data available for this study was therefore extremely large, requiring considerable effort in organizing and distilling it into a useable project database.

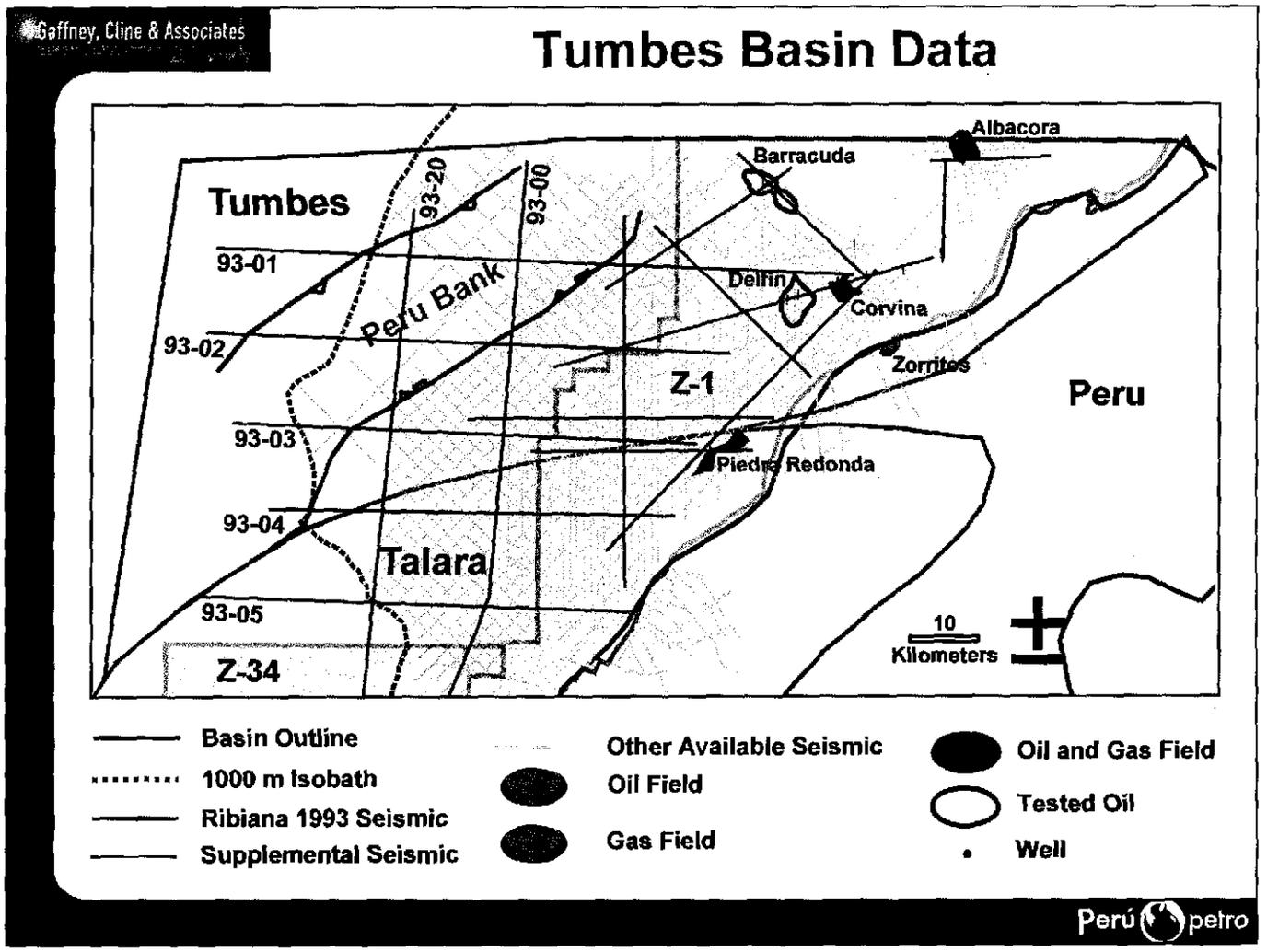
Gaffney, Cline & Associates

The Project Database

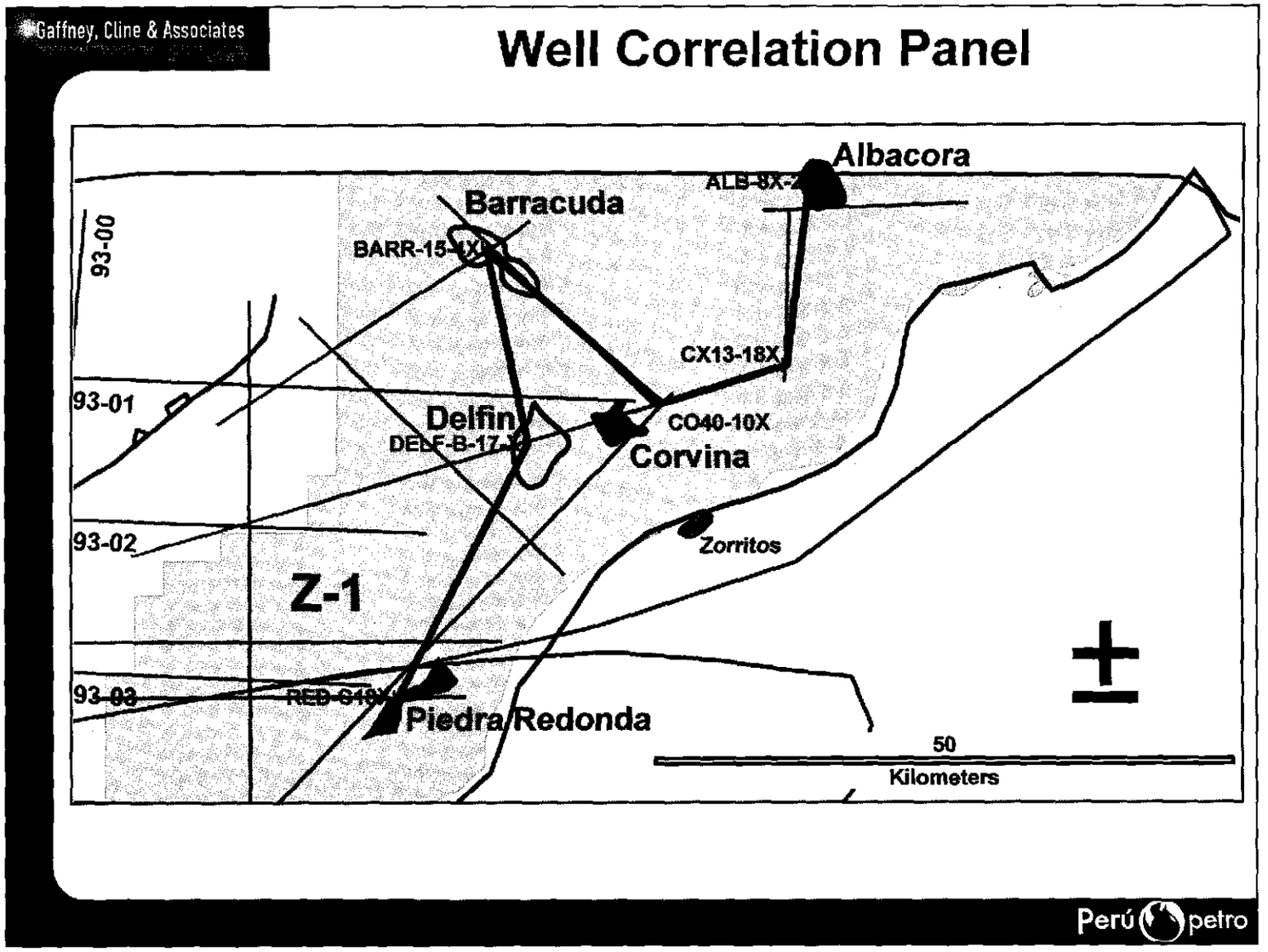
- **Final Report (paper)**
  - **Executive Summary**
  - **Basin Presentations**
  - **Other Required Sections**
    - Economics, Regulatory, Environmental and others
  - **Enclosures**
    - Selected maps, logs and cross sections
- **Digital Database (DVDs)**
  - **Final Report**
  - **ArcView Interactive Map**
  - **3 SMT Kingdom Suite Projects**
  - **Standard-format Exports**
  - **Detailed Appendices**
    - Geology, Wells, Seismic Interpretation, Tectonics, Depth Conversion, Maturation, Environmental

Perú petro

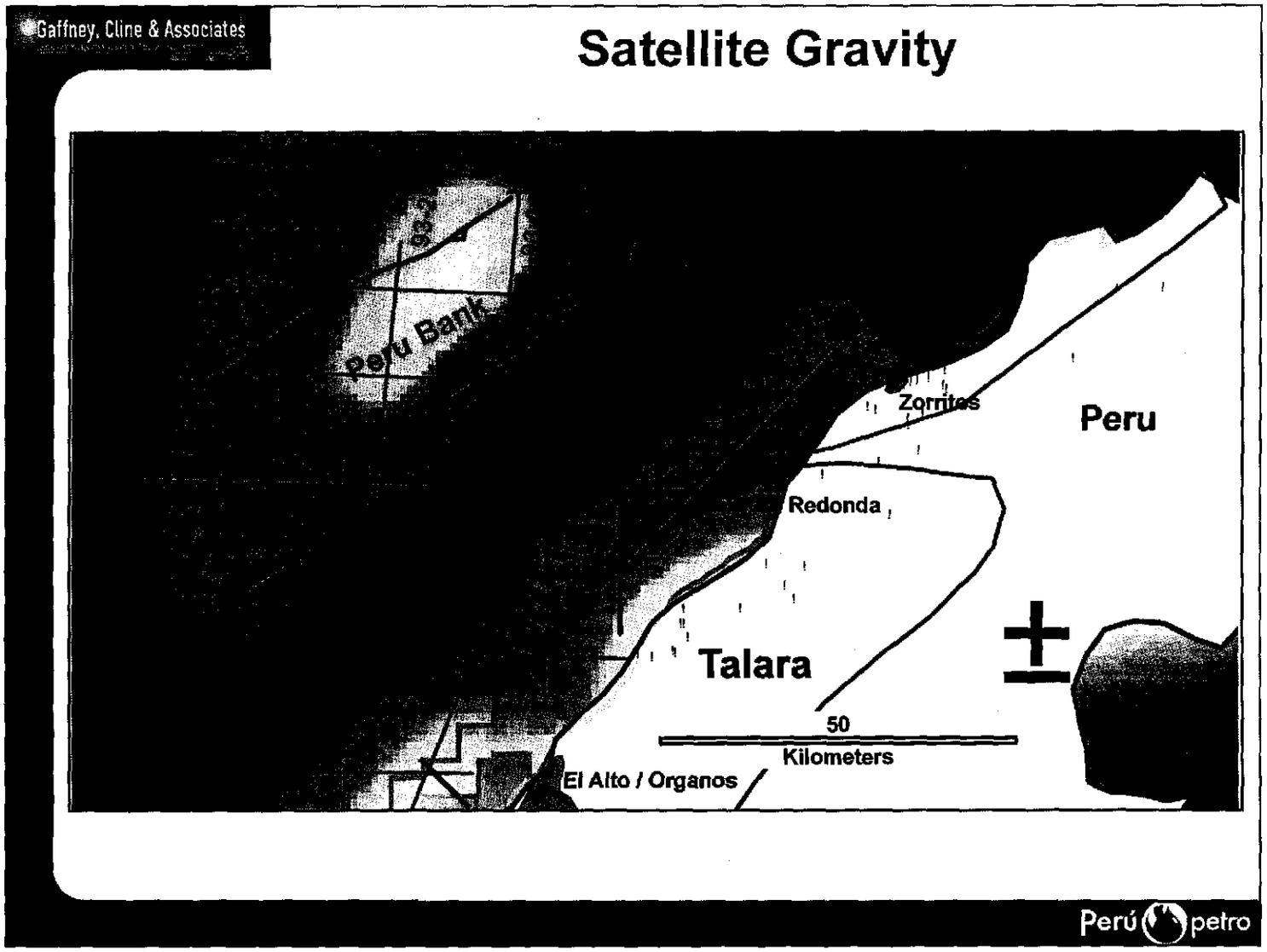
The project database for the Tumbes basin exists in several forms. First, there is an SMT Kingdom Suite project that covers both the Tumbes and Talara basins. This integrated project is available as part of the Digital Database that is packaged on DVDs with this report. The contents of this project were also exported into SEG-Y, LAS and other standard formats for loading into other workstation software. The Digital Database also contains an ArcView Interactive Map that was used to produce the map-based graphics in this presentation. It contains surface location data for wells and seismic, gravity and magnetics, geo-registered images of all of the maps produced in this study and a wide variety of other useful map-based data. Selected maps and cross sections are included in the Enclosures. Lastly, the Final Report contains several Appendices that contain discipline-specific detailed discussions as listed above.



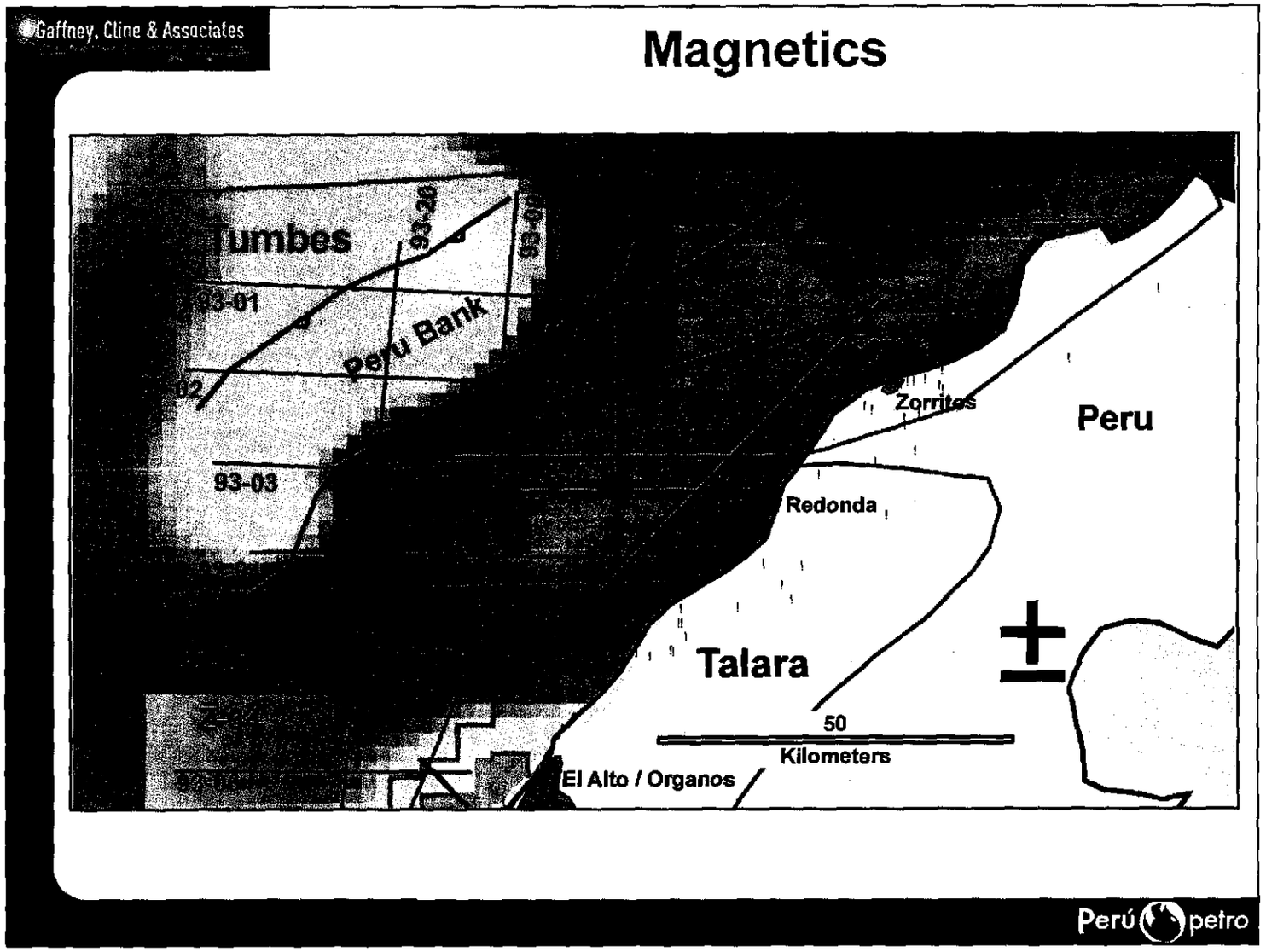
The Ribiana 1993 seismic survey (in blue) formed the main basis for the new structural and stratigraphic framework throughout the study area. Supplemental lines (in red) were added to the Tumbes project database to enable ties to the known fields and wells. This was sufficient to build the regional framework. Additional seismic is available (in grey), which will have to be reprocessed to work at the prospect level (see slide 38). Reprocessing was beyond the scope of this study. There are also 19 wells in the project database – 8 in the Albacora field, 1 in the Barracuda prospect, 6 in the Corvina gas field area, 2 in the Delfin prospect and 2 in the Piedra Redonda gas field. These are all of the wells that have been drilled in the offshore Tumbes basin. This map also marks the location of the Z-1 block, which is held by BPZ Energy, and the northernmost part of the Z-34 block, which is held by Gold Oil.



A correlation panel was constructed to show details about the wells connected by the red line in this map. This helped facilitate building the new regional framework in this area. It was captured in a high-resolution TIF image, which is included in the Digital Database DVDs with this study.



The project database also includes several sources of gravity and magnetics data. This map of satellite-measured gravity clearly shows the limits of the Peru Bank, which is a prominent offshore structural feature in this basin.



The magnetics data also shows the Peru Bank and was used to delineate the limits of three basement crustal types, as shown later in this presentation.

Gaffney, Cline & Associates

Outline

- Conclusions
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- Reservoirs
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Perú petro

There is one proven petroleum system in the Neogene sub-basin in the eastern part of the Tumbes basin. There may be a second petroleum system in the Cretaceous-Paleogene section beneath the Peru Bank, with possible extension beneath the Neogene sub-basin. Therefore, hydrocarbon sources and reservoirs are relatively well-known, as compared to studied basins with no proven systems (Salaverry and Pisco). The USGS has recently published a useful summary of current knowledge of the petroleum systems in the Tumbes-Progreso basin, which is available at http://pubs.usgs.gov/bul/b2206-b/. Several of the figures from that report have been used here to introduce the maps and sections in the new framework produced in this study. Overall, GCA's analysis appears to be generally similar to the USGS view as shown in these figures, except as noted on individual slides below.

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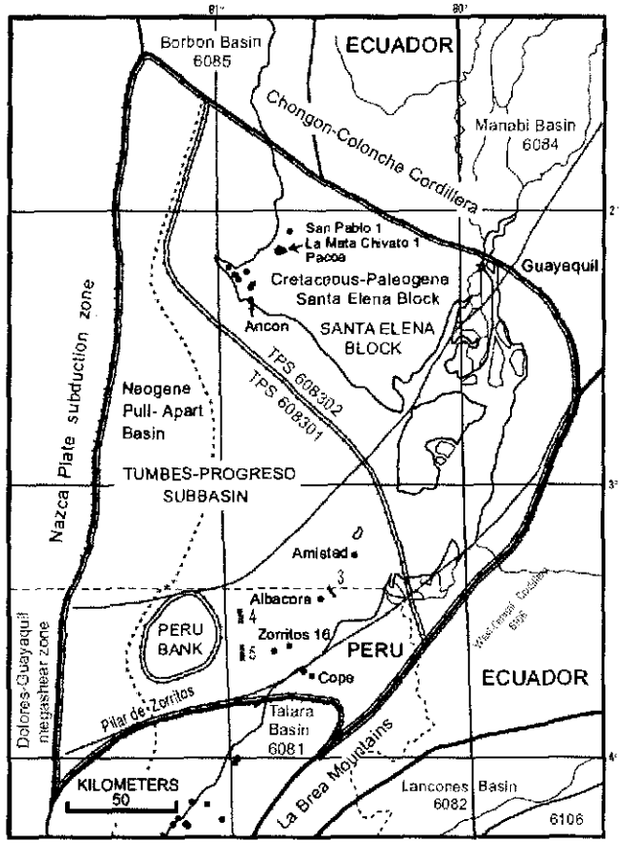
Regional Structural Setting



Source: Higley (2004) at http://pubs.usgs.gov/bul/b2206-b/, fig. 1

Perú petro

The USGS has recently summarized current thinking about the greater Tumbes-Progreso basin. They divide the basin into three blocks -- the Santa Elena Block in Ecuador, the Tumbes-Progreso sub-basin and the Peru Bank. They also recognize two petroleum systems – the Cretaceous-Paleogene petroleum system, which includes the Santa Elena Block and the Peru Bank, and the Neogene petroleum system in the Tumbes-Progreso sub-basin. As mentioned previously, GCA believes that the Cretaceous-Paleogene system may also extend beneath the Neogene Tumbes-Progreso sub-basin. Other workers (Zúñiga-Rivero and Hay-Roe) have suggested a different regional break-out that assigns the Peru Bank as part of the Talara basin. For the purpose of this study, the "Tumbes basin" includes the Peru Bank and that part of the Tumbes-Progreso sub-basin that lies on the Peruvian side of the border.

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Cretaceous-Paleogene Petroleum System Events Chart

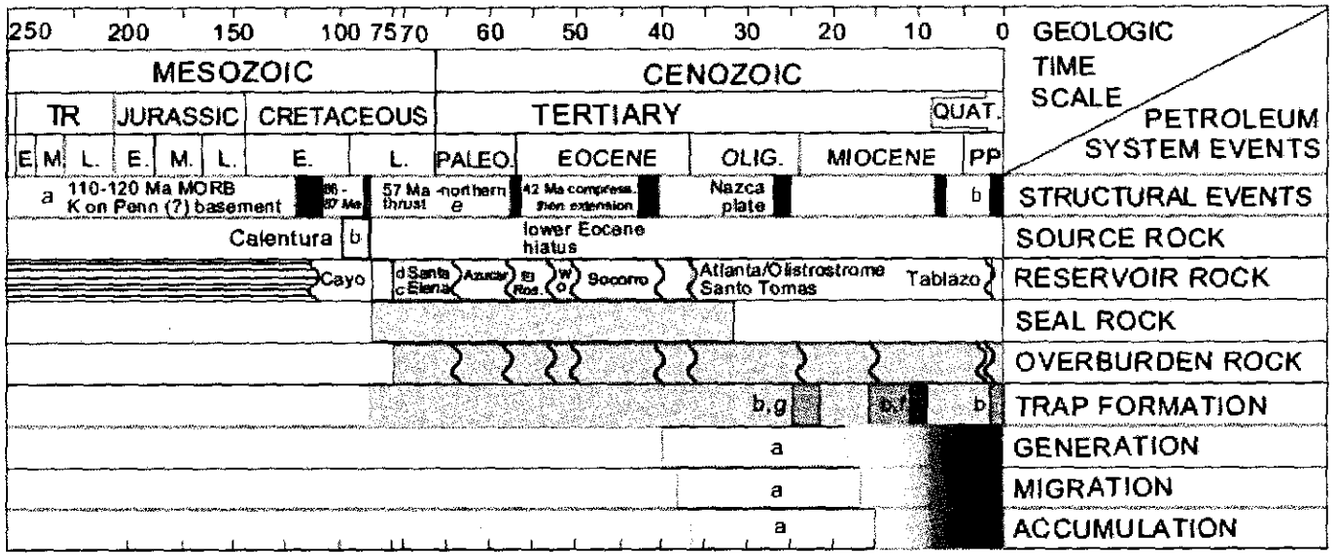


Figure 5. Events chart for the Cretaceous-Paleogene Total Petroleum System (608302) and Assessment Unit (60830201), *Santa Elena block of the Progreso Basin province.* Dark gray and blue mark the time sequences of primary events. Oceanic crust formed during the *Aptian-Albian* (Jaillard and others, 1995). MORB is Cretaceous (K) mid-oceanic ridge basalt on Pennsylvanian (Penn) age basement rocks. Eocene (42 Ma) compressional tectonism of the Andes was followed in Oligocene time by partition of the Farallon Plate into the Cocos and Nazca Plates (Handschumacher, 1976; Marocco and others, 1995; Pilger, 1984). Events include (1) Santa Elena block early Paleocene (Santa Elena Formation) to late Eocene (Socorro Formation and Wildflysch Olistrostrome [WO]) and Quaternary Tablazo Formation, and (2) Tumbes-Progreso subbasin early to middle Miocene Zorritos, Heath, and Cardalitos (Subibaje) Formations. Time periods of unconformities (wavy black lines) were determined from American International Petroleum Corporation (no date), Gonzales (1999), Kingston (1994), Kraemer and others (1999), Perupetro (1999), Petroconsultants (1996), and Seranne (1987). Letter codes refer to the following references: a, Kingston (1994); b, Jaillard and others (1995); c, GeoMark (1998); d, Petroconsultants (1996); e, Haq and others (1987); f, Pindell and Tabbutt (1995); and g, Shepherd and Moberly (1981).

Source: Higley (2004) at http://pubs.usgs.gov/bul/b2206-b/, fig. 5

Perú petro

This chart summarizes current thinking about the Cretaceous-Paleogene Petroleum System in the greater Tumbes-Progreso basin. Although the USGS limits this System to the Santa Elena block and the Peru Bank, the maps produced in this new study suggest that thick Cretaceous-Paleogene sediments may be present in the study area east and south of the Peru Bank. If these are not Cretaceous-Paleogene sediments, then they may be a thick sequence of organic-rich anoxic marine shale at the floor of the pull-apart basin that opened along the Dolores-Quayaquil megashear zone during the Neogene.

Gaffney, Cline & Associates

Neogene Petroleum System Events Chart

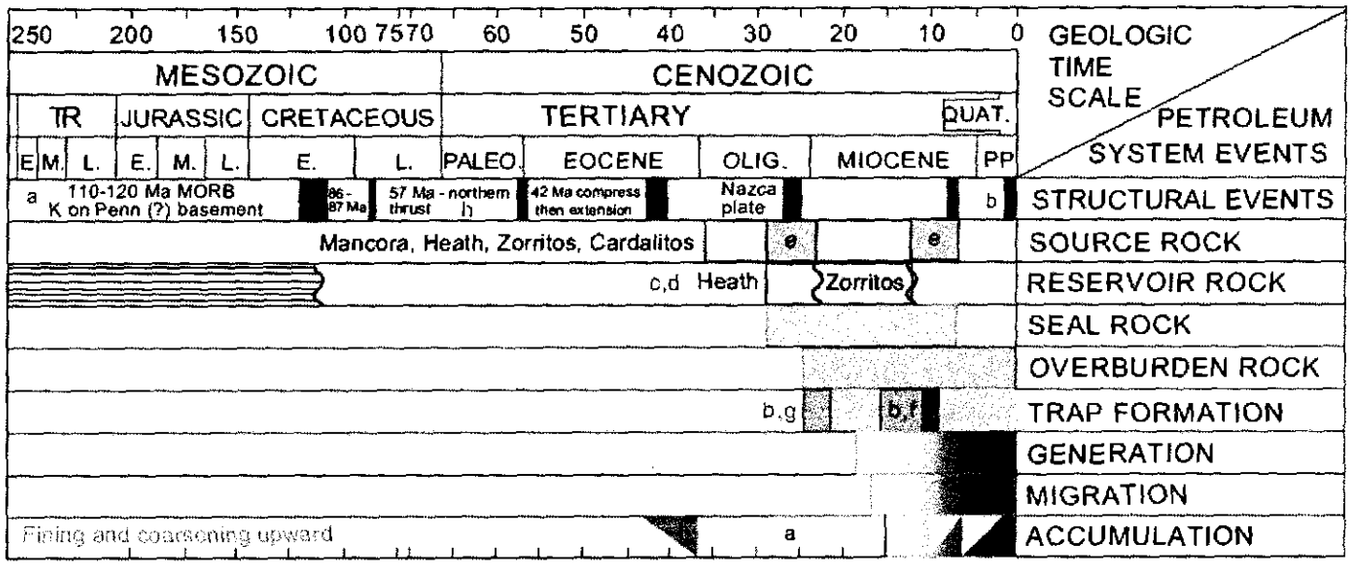
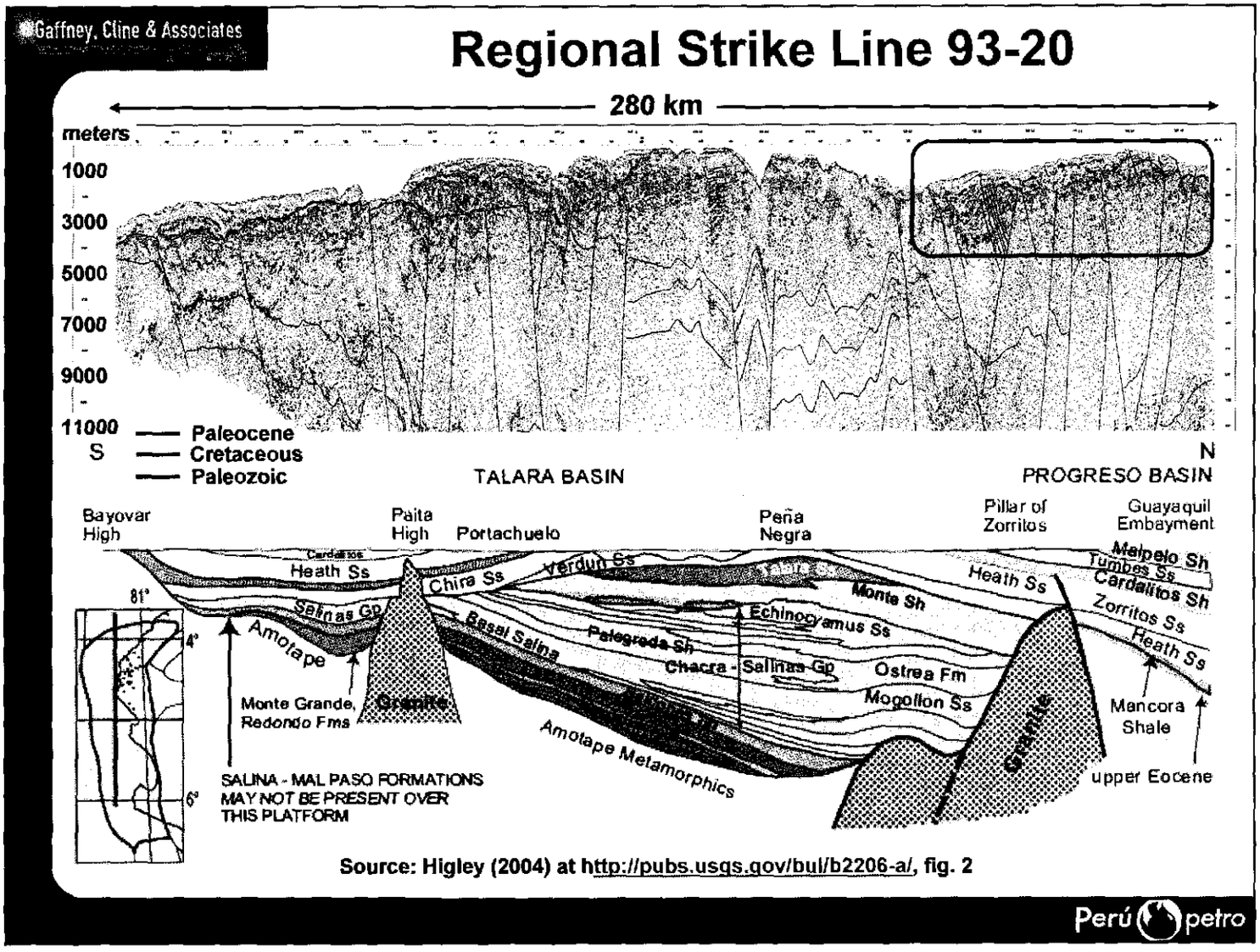


Figure 4. Events chart for the Neogene Total Petroleum System (608301) and the Neogene Pull-Apart Basin Assessment Unit (60830101) of the Progreso Basin province. Dark gray and blue shading mark the time intervals of primary events. Oceanic crust formed during the Aptian-Albian (Jaillard and others, 1995). MORB is Cretaceous (K) midoceanic ridge basalt on Pennsylvanian (Penn) basement rocks. Eocene (42 Ma) compressional tectonism of the Andes was followed in Oligocene time by partitioning of the Farallon Plate into the Cocos and Nazca Plates (Handschumacher, 1976; Marocco and others, 1995; Pilger, 1984). Events include (1) Santa Elena block lower Paleocene (Santa Elena Formation) to upper Eocene (Socorro Formation and Wildflysch Olistrostrome) and Quaternary Tablazo Formation, and (2) Tumbes-Progreso subbasin early to middle Miocene Zorritos, Heath, and Cardalitos (Subibaja) Formations. There is no documented information on hydrocarbon source rocks or on the timing of generation and migration. Time periods of unconformities (wavy black lines) were determined from American International Petroleum Corporation (no date), Gonzales (1999), Kingston (1994), Kraemer and others (1999), Perupetro (1999), Petroconsultants (1996), and Seranne (1987). Letter codes refer to references: a, Baldock (1982) and Egüez and others (1991); b, Jaillard and others (1995); c, GeoMark (1998); d, Petroconsultants (1996); e, Zúñiga-Rivero, Keeling, and Hay-Roe (1998a); f, Pindell and Tabbutt (1995); g, Shepherd and Moberly (1981); and h, Haq and others (1987).

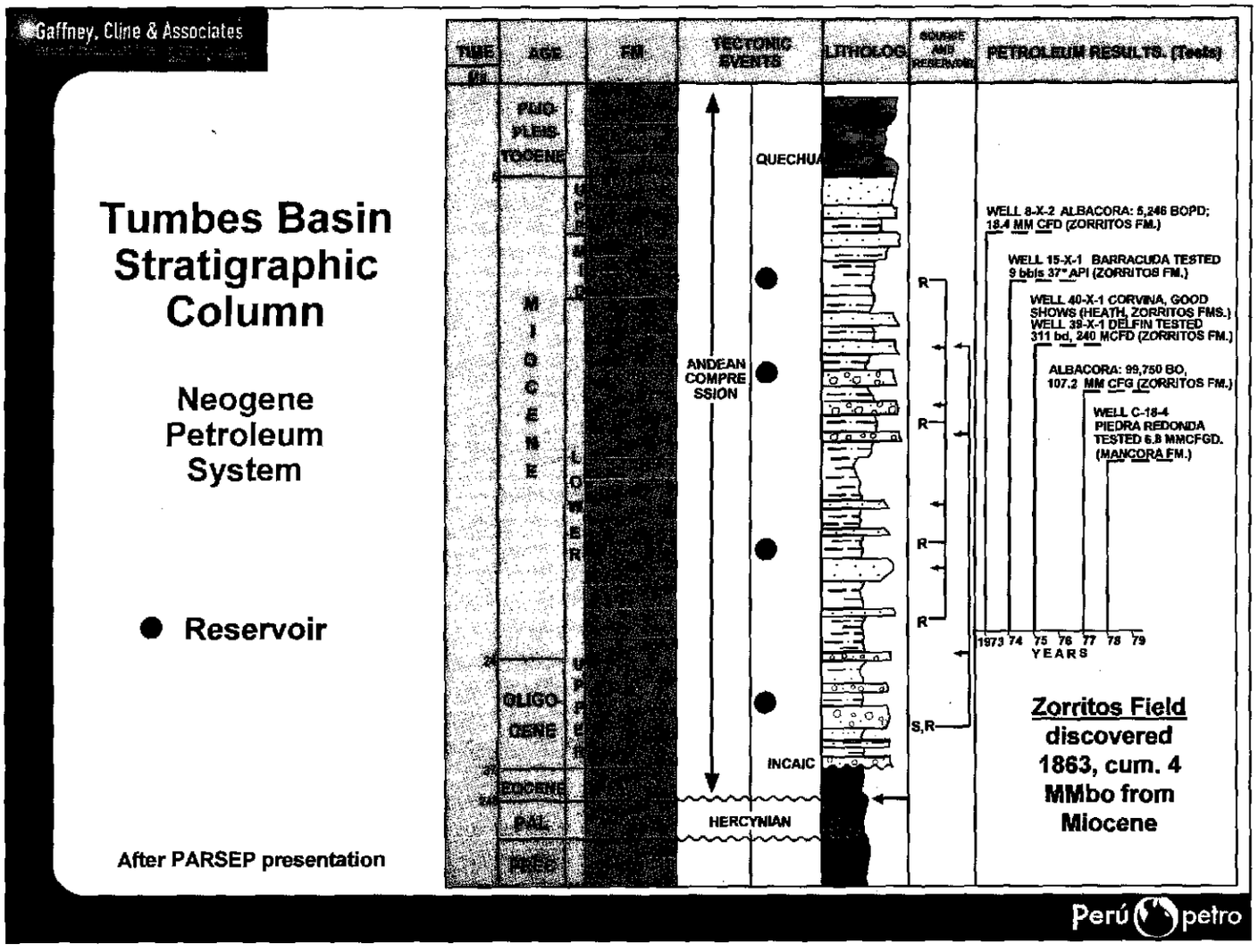
Source: Higley (2004) at http://pubs.usgs.gov/bul/b2206-b/, fig. 4

Perú petro

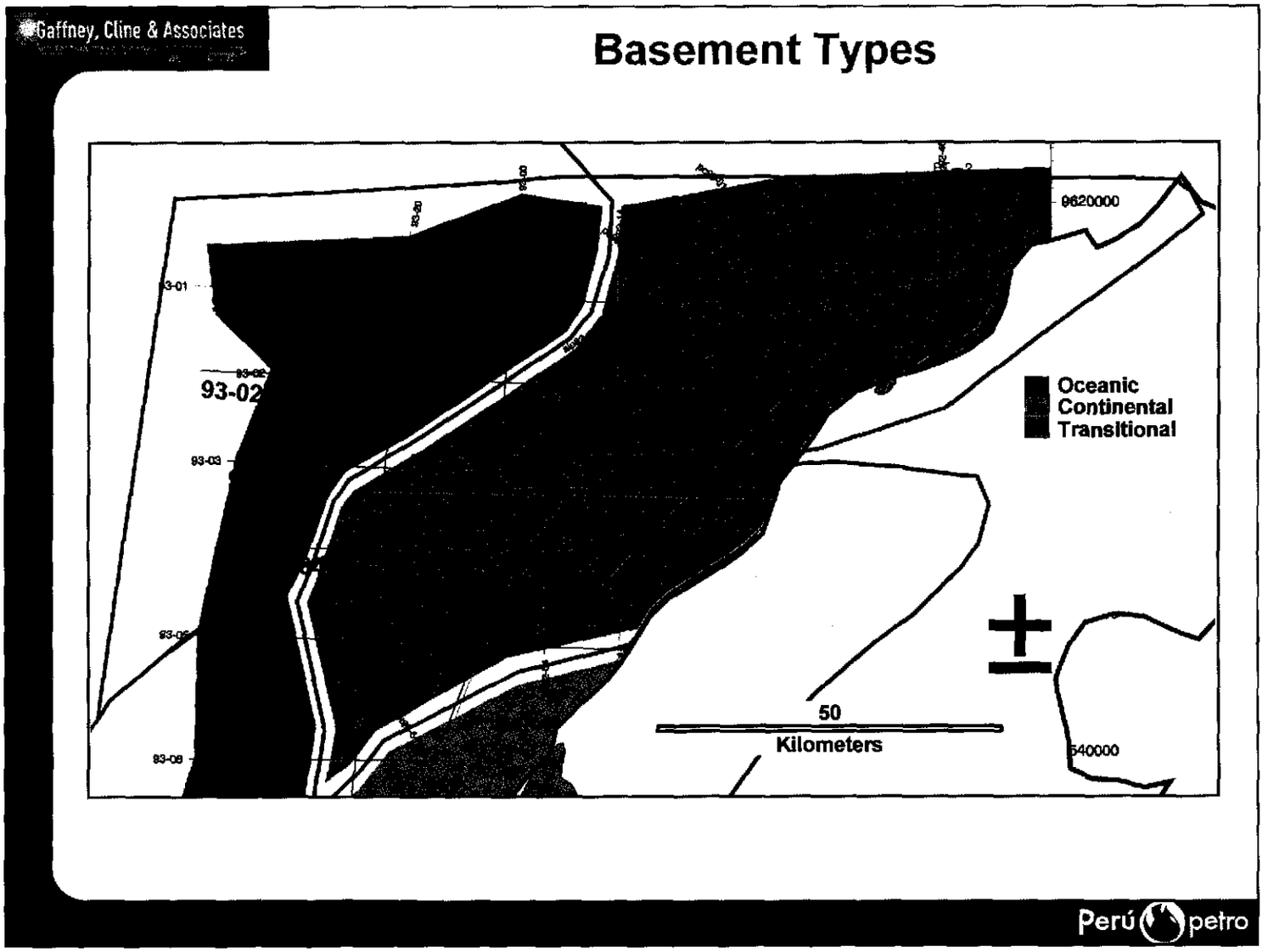
This chart summarizes current knowledge of the Neogene Petroleum System. As mentioned in the previous slide, the extent of the Cretaceous-Paleogene Petroleum System into the study area is conjectural. The Neogene sub-basin, on the other hand, is clearly apparent on the seismic (see next slide), and has been divided into Miocene, Pliocene and Quaternary sequences in the map set that appears later in this presentation.



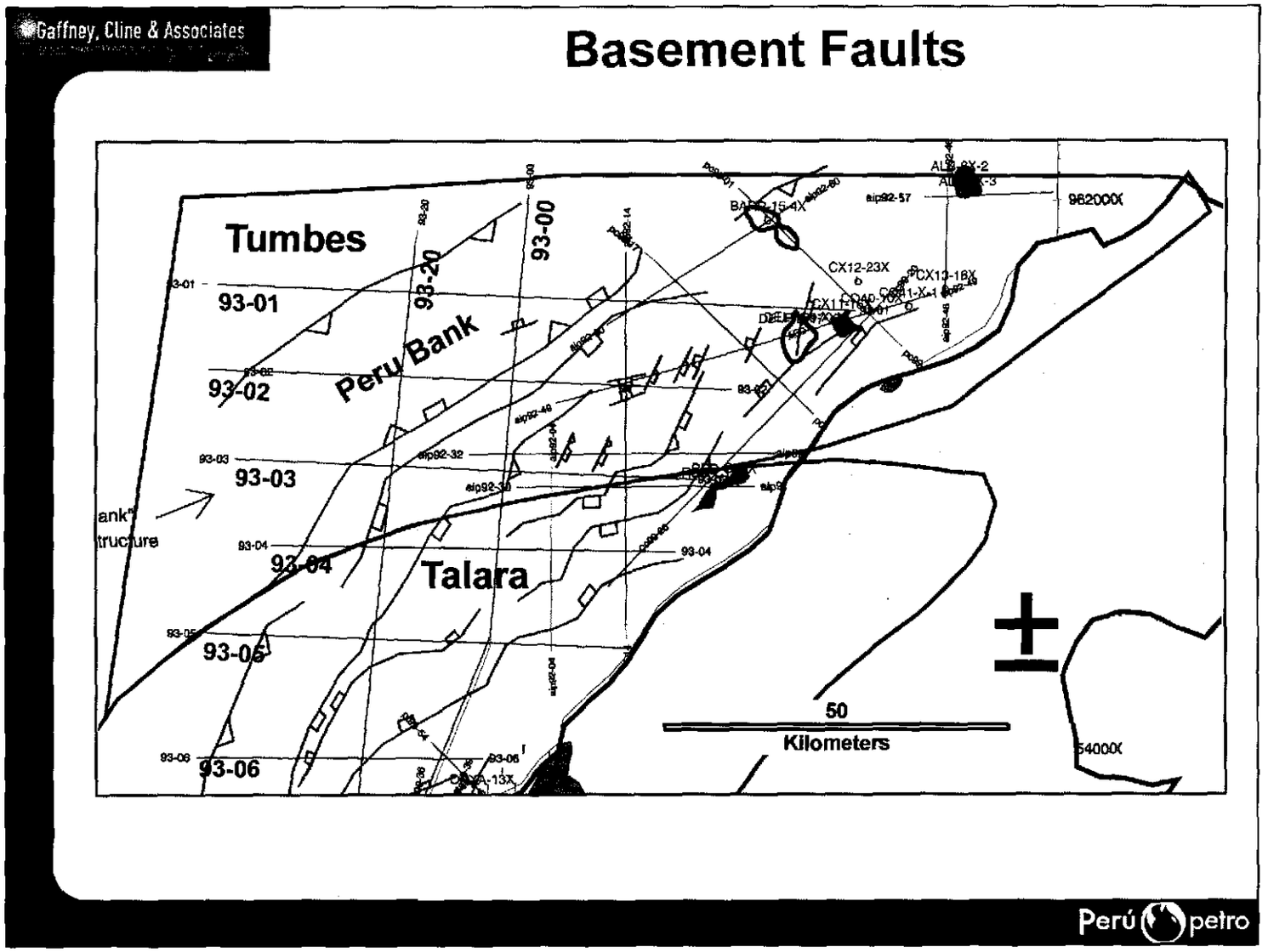
The USGS figure at the bottom is a general geoseismic section that roughly coincides with seismic line 93-20, which is shown at the top of the slide. In contrast with the Talara basin to the south, where the post-Paleocene section is relatively featureless, the Neogene section in the Tumbes basin (circled in red) had enough seismic character to differentiate Miocene, Pliocene and Quaternary sequences.



This chart summarizes the local stratigraphy and known petroleum occurrences in the Tumbes basin, which are presumably all in the Neogene Petroleum System. The onshore Zorritos field was discovered in 1863, and has produced 4 million barrels of oil. Although initial production rates from the Albacora discovery in 1973 were promising, it produced only 100 thousand barrels of oil and 107 million cubic feet of gas. The Corvina gas discovery in 1975, and the Piedra Redonda gas discovery in 1978, awaited a gas market that only matured recently. BPZ Energy is currently implementing a development plan for these two fields, in which they will pipe the gas to shore and generate electricity for sale into the Peruvian energy grid. Contingent on a successful appraisal program, they may also export gas and/or power to Ecuador.



The new depth-converted framework of horizons, faults, maps and sections produced in this study begins with an interpretation of three crustal types that form the floor of the Tumbes basin. This interpretation was drawn mainly from the magnetics and satellite gravity data shown in slides 9 and 10 of this presentation. The main significance of this map is that it confirms the pull-apart nature of this basin, which is also reflected into an overall structural style that is a complex combination of extension, compression and wrenching.



This map shows the basement fault fabric that emerged from the new regional interpretation. The main faults trend northeast, roughly parallel to the Peru Bank and the boundaries between the three different crustal blocks.

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Tumbes Horizon Legend

- 1_ts_a_1_Quaternary_Waterbottom (pae)
- 1_ts_b_2_Pliocene_Mal_Pelo (pae)
- 1_ts_c_3_Late_Miocene_Tumbes (pae)
- 1_ts_i_9_Latest_Eoc_Oligocene_Heath (pae)
- 1_ts_m_13_Paleocene (pae)
- 1_ts_m_13_Paleocene_overthrust (pae)
- 1_ts_n_14_Cretaceous (pae)
- 1_ts_n_14_Cretaceous_overthrust (pae)
- 1_ts_o_15_Cretaceous_Muerto? (pae)
- 1_ts_o_15_Cretaceous_Muerto?_overthrust (pae)
- 1_ts_p_16_Paleozoic (pae)
- 1_ts_p_16_Paleozoic_overthrust (pae)
- 1_ts_q_17_Crystalline_Bsmt (pae)
- 1_ts_r_18_intra-continental_bsmt_1 (pae)
- 1_ts_s_19_intra-continental_bsmt_2 (pae)
- 1_ts_t_20_top_oceanic_crust (pae)
- 1_ts_t_20_top_oceanic_crust_overthrust (pae)
- 1_ts_t_21_base_upper_oceanic_crust (pae)
- 1_ts_t_21_base_upper_oceanic_crust_overthrust (pae)
- 1_ts_u_22_top_transitional_crust (pae)

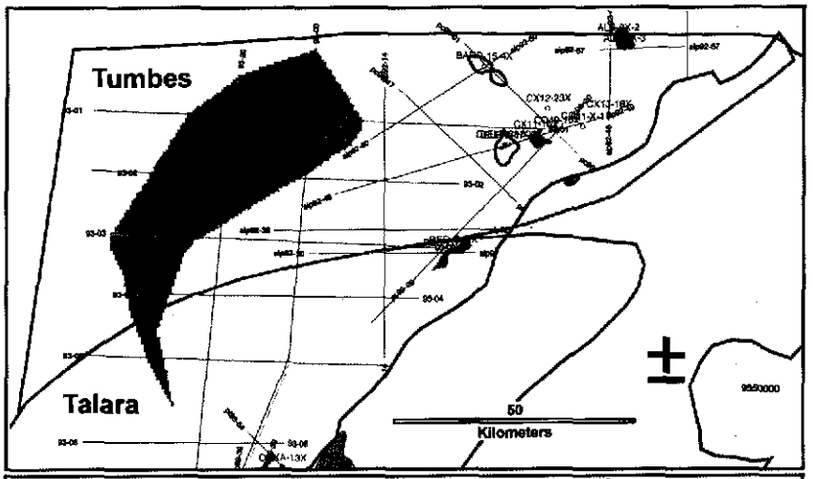
Perú petro

Refer to this chart to identify the interpreted depth horizons in the seismic sections and the maps in this presentation. In general for the horizons, pink is Crystalline Basement, green is Cretaceous, red is Paleocene, and orange is Latest Eocene or Oligocene (Heath). Note that some of the horizons were entered twice to facilitate picking vertically repeated sections (due to overthrusting). The depth structure maps that follow are labeled with the same numbers that appear above, beginning with the top Transitional Crust as horizon number 22.

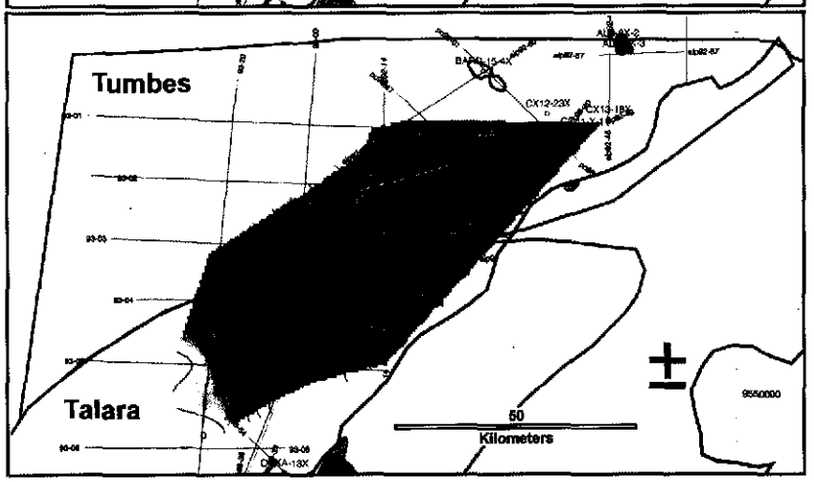
Gaffney, Cline & Associates

Depth Structure Maps

Oceanic Crust (20)

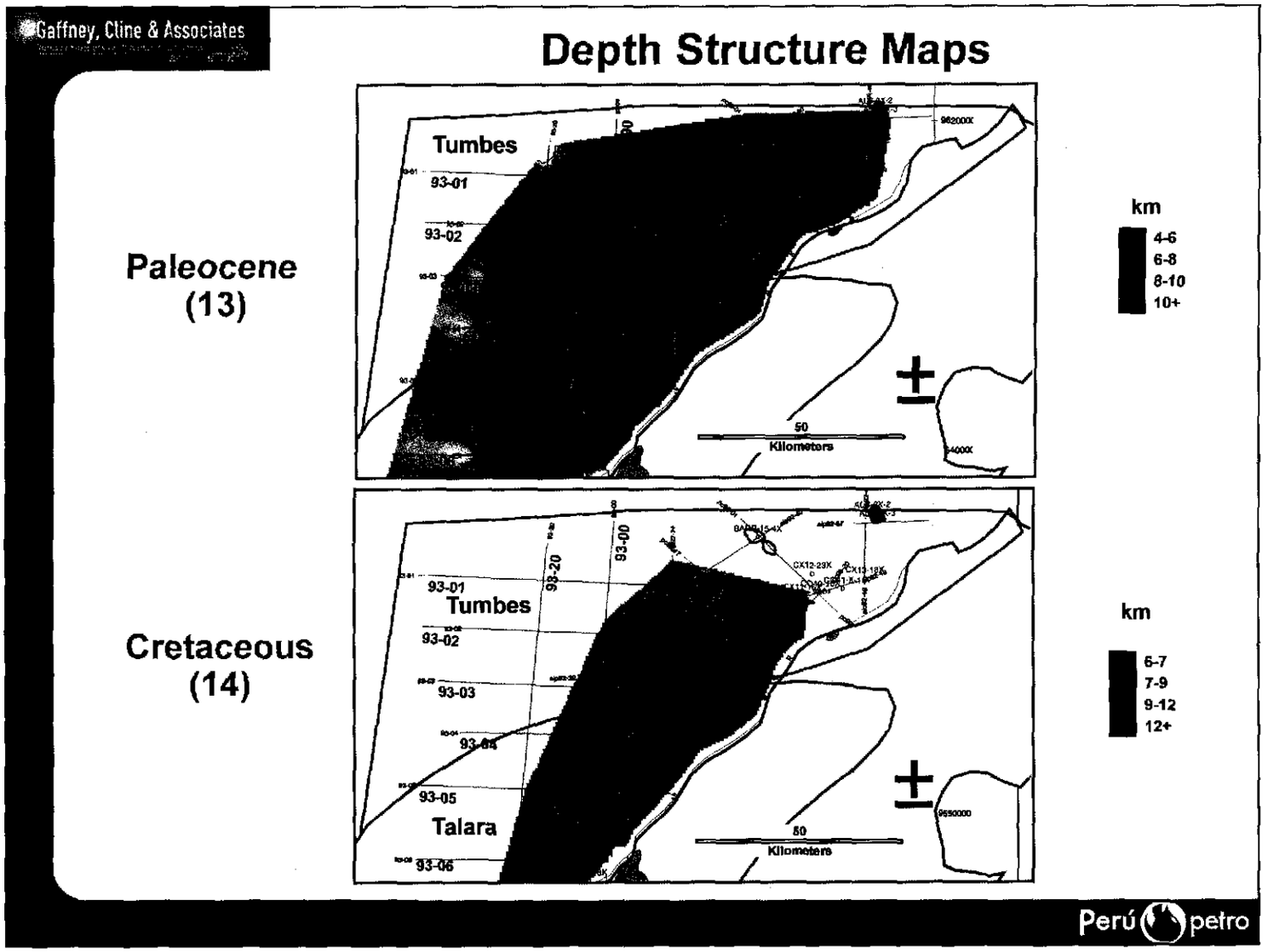


Transitional Crust (22)



Perú petro

This slide begins the series of depth structure maps in the new framework. The map at the top shows the depth to oceanic crust, which exceeds 16,000 meters at the eastern end of this crustal block. The map on the bottom shows the depth to transitional crust, which may be as much as 18,000 meters or more. Interpretation of seismic horizons at this depth is admittedly speculative, but does suggest much deeper potential than has been previously mapped.



As previously mentioned, the interpretation of a Cretaceous horizon is speculative. The limits of this map (bottom of slide) are more suggestive of the confidence limit of the interpretation, rather than the actual limits of this horizon, which may well extend north into Ecuador. The Paleocene map was drawn with more confidence, and starts to give regional form to the main basin axes, which extend south and east of the Peru Bank.

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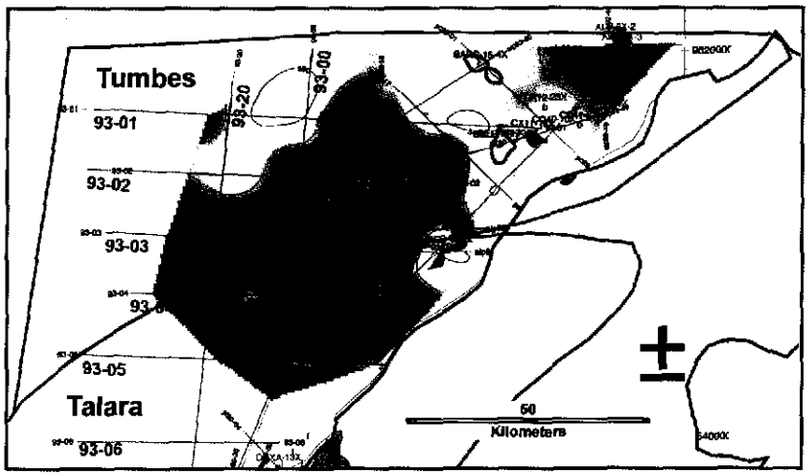
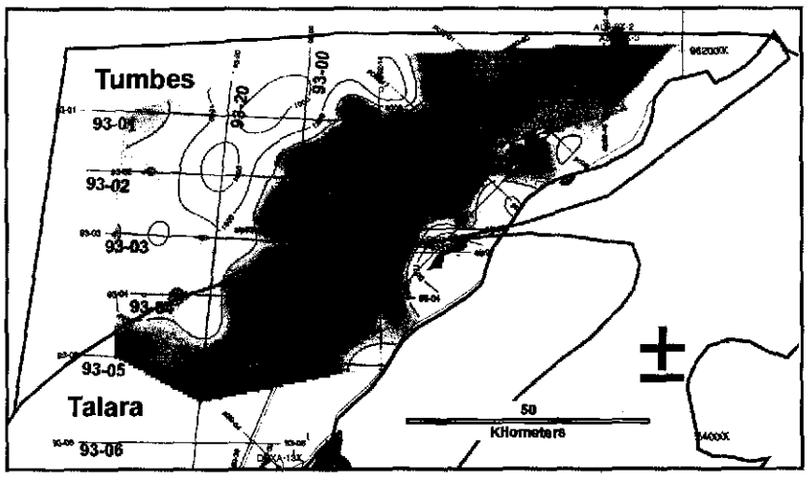
Depth Structure Maps

Late Miocene (3)

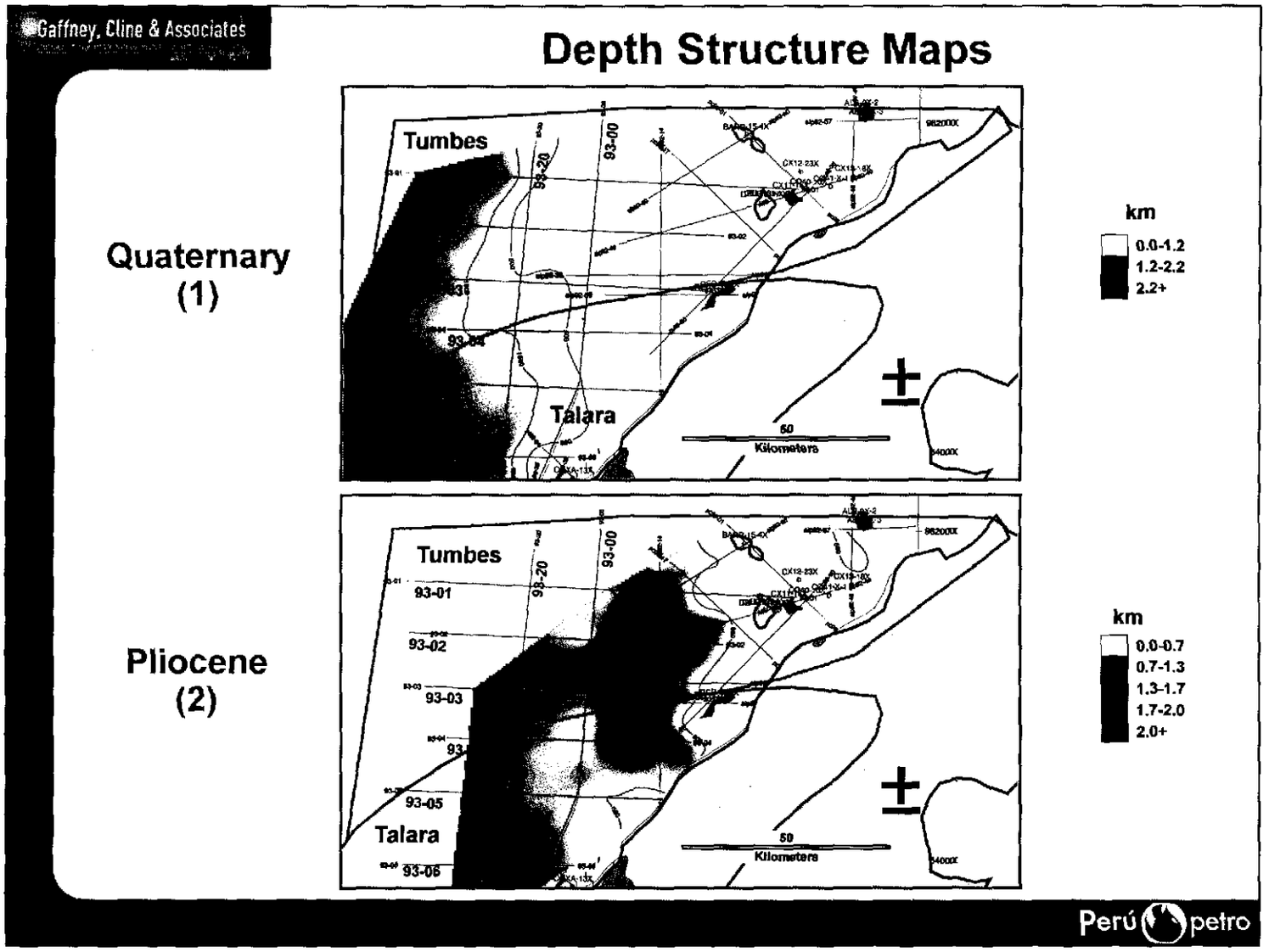


Late Eocene Oligocene (9)



Perú petro

The horizon in the bottom map marks the base of the Neogene Petroleum System, which reaches a depth of at least 7,000 meters east of the Peru Bank. This area is full of interesting structural leads, as are illustrated in the following section of this presentation. By the same token, this area is highly faulted, which makes detailed correlation difficult.



The Pliocene and Quaternary maps complete the set. The Quaternary map was used as an approximate water bottom surface in the depth conversion process.

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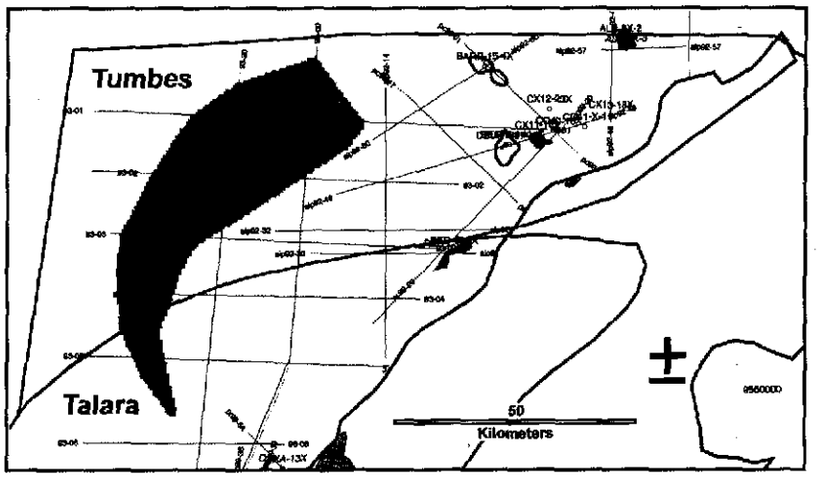
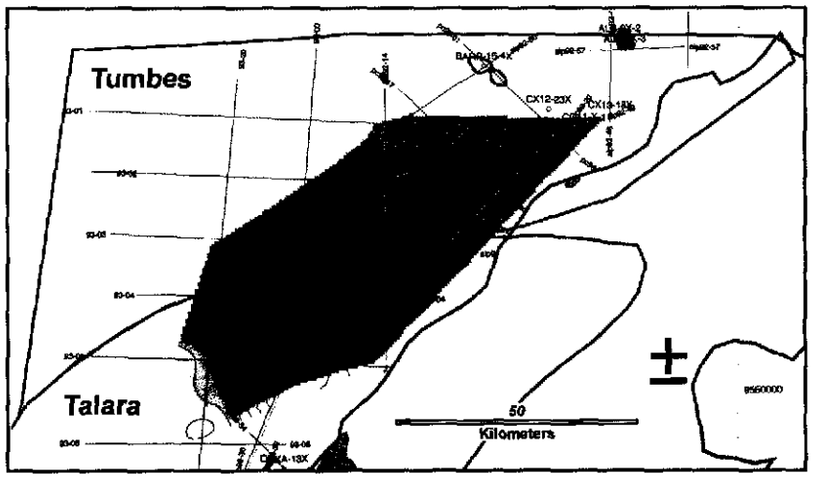
Isopach Maps

Quaternary to Oceanic Crust (1-20)



Quaternary to Transitional Crust (1-22)



Perú petro

These two maps indicate the total possible sedimentary thickness in the Tumbes basin, which may range up to 18,000 meters or more. If there are Cretaceous source rocks near the base of this thick sediment pile, they would very likely be overmature and have generated gas. The shallower Neogene petroleum system would most likely be the oil producer. Regardless of which system generated it, the fact is that this basin has produced both oil and gas.

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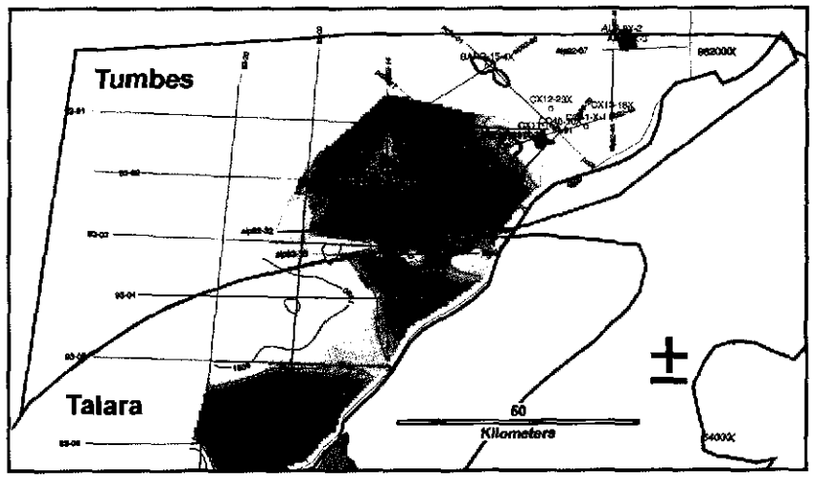
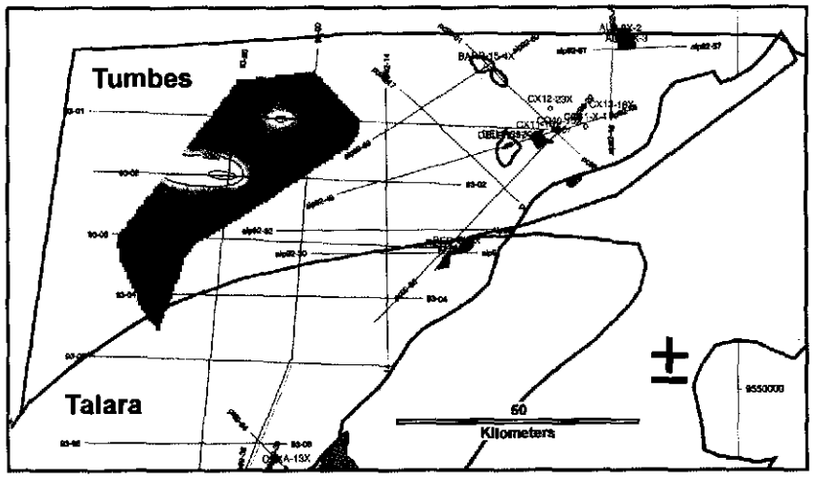
Isopach Maps

Paleocene to Cretaceous (13-14)



Paleocene to Oceanic Crust (13-20)



Perú petro

The USGS contends that Neogene sediments rest on basement east of the Peru Bank. However, as previously mentioned, this study shows potential for Paleocene and older sediments in this area. These two maps show the thickness of potential Paleocene sediments, which lie above oceanic crust beneath the Peru Bank and above conjectural Cretaceous east of the Peru Bank.

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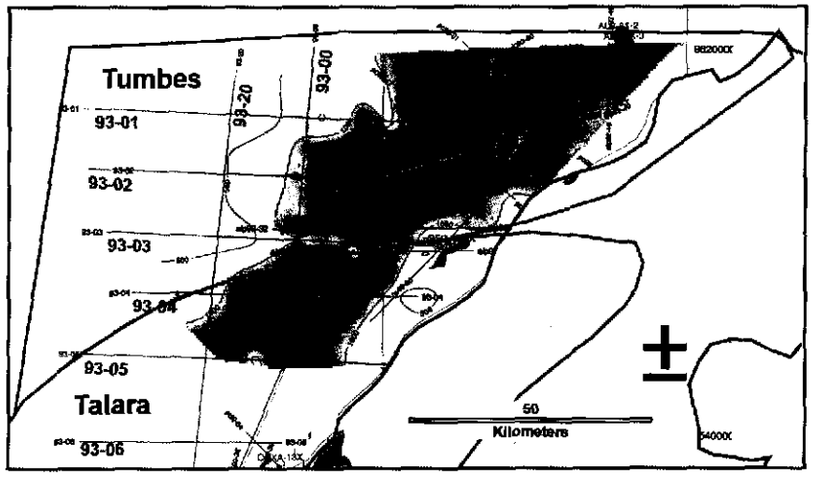
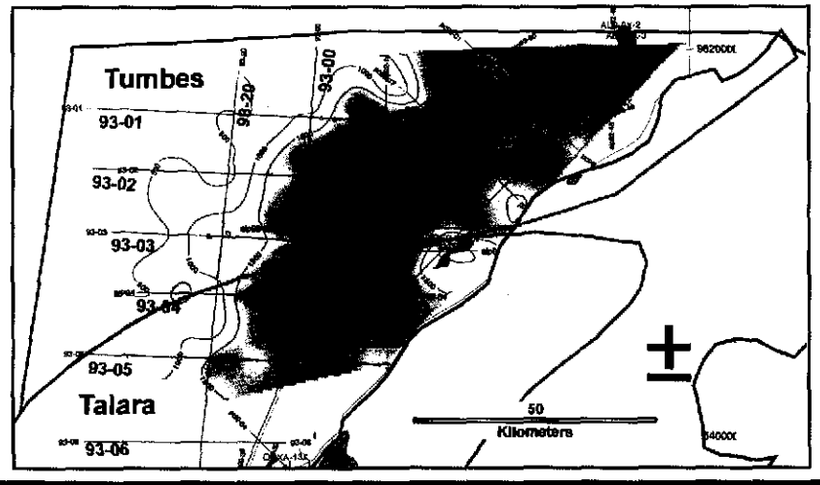
Isopach Maps

Late Miocene to Late Eocene-Oligocene (3-9)



Quaternary to Late Eocene-Oligocene (1-9)



Perú petro

The bottom map shows the total thickness of Neogene (Miocene+Pliocene) and Quaternary sediments. This interval is very clear on the seismic, and shows abundant opportunities for a variety of structural traps. The map above shows the interpreted thickness of the Miocene sequence, the first of three into which the Neogene+Quaternary interval has been divided.

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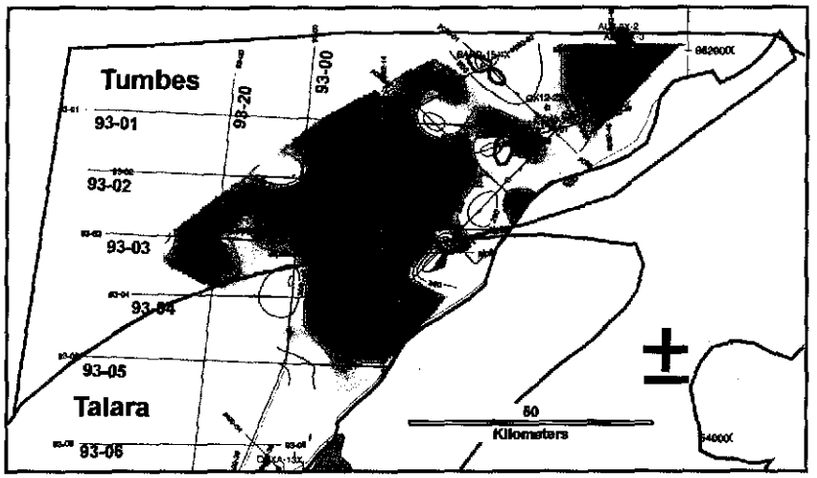
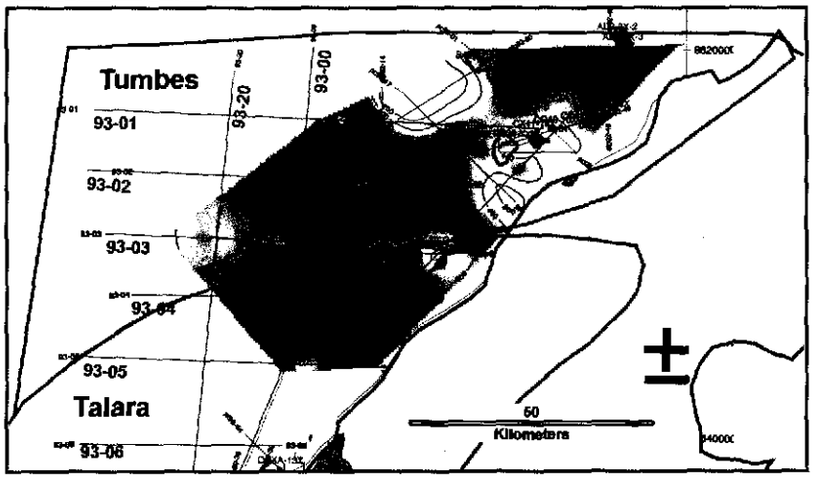
Isopach Maps

Quaternary to Pliocene (1-2)



Pliocene to Late Miocene (2-3)



Perú petro

These two maps complete the set with the Pliocene and Quaternary thickness maps. There are no wells in these offshore Neogene thicks. However, the seismic character of the Neogene in the Tumbes basin is somewhat similar to the seismic character of the Eocene turbidite sequences in the Trujillo basin. It is possible that similar Neogene turbidites might extend into the deeper water westward from the proven reservoirs on the shallow shelf on the eastern side of the basin.

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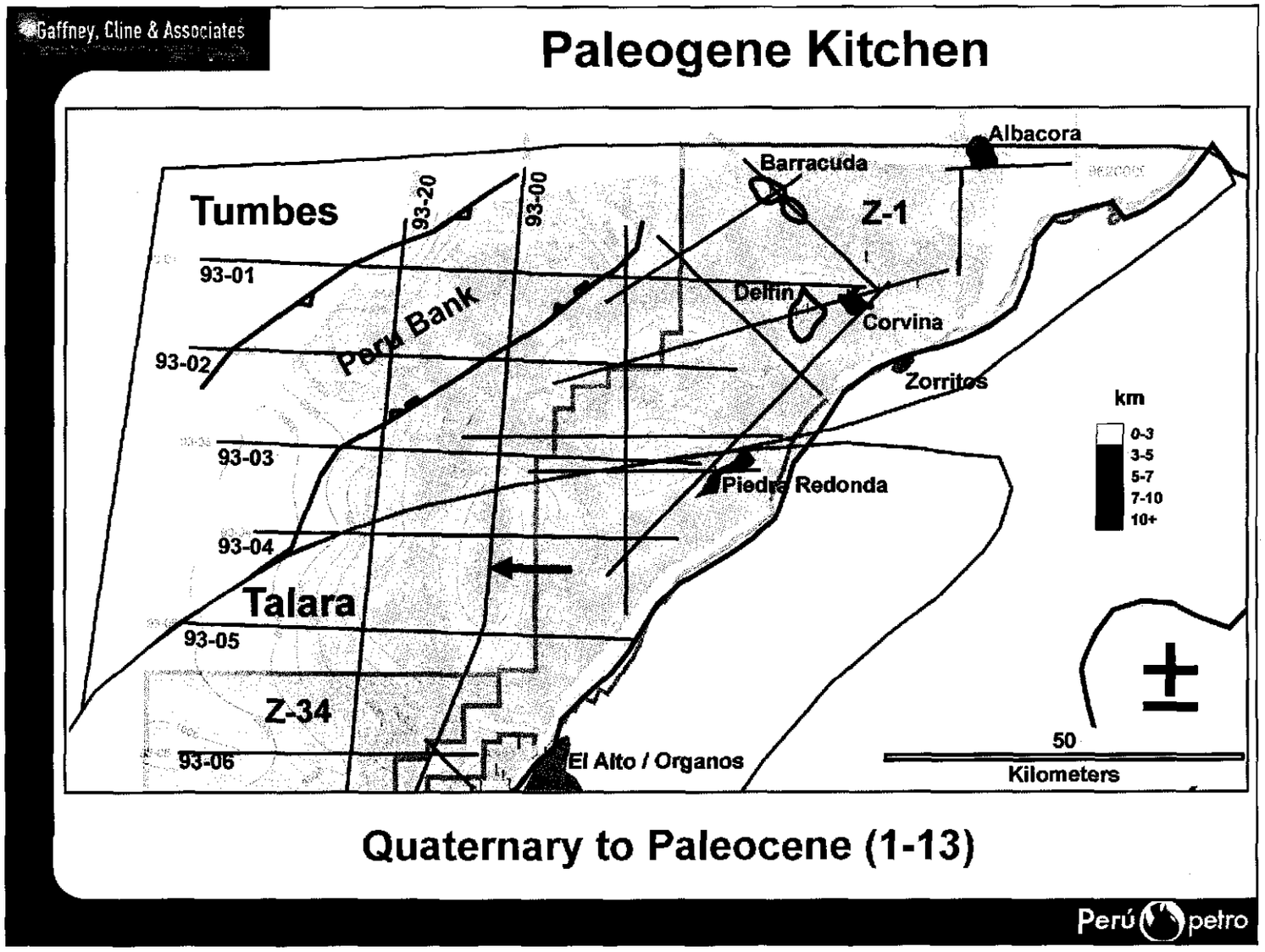
Outline

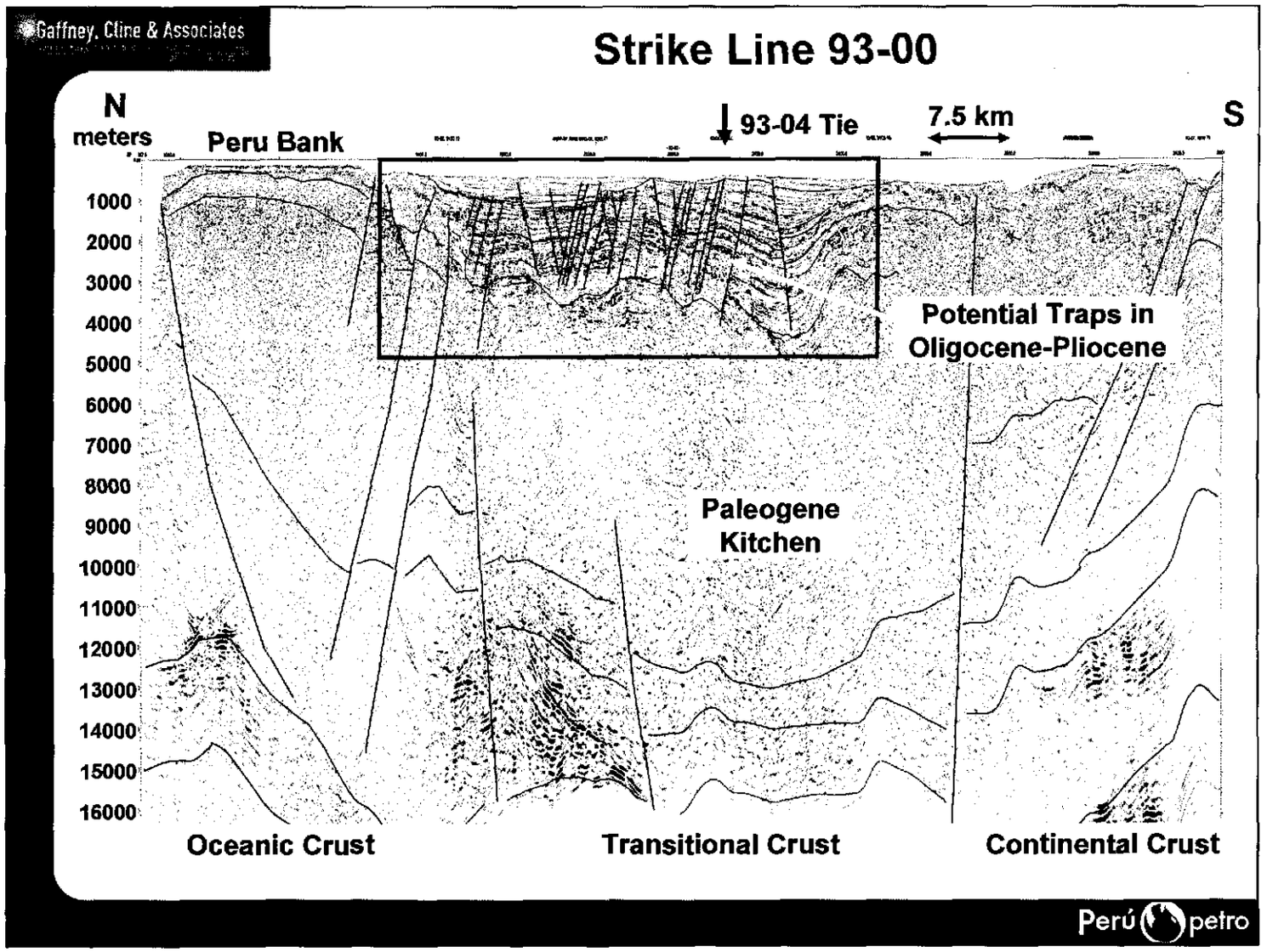
- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

BPZ Energy controls Block Z-1, which includes much of the shallow-water fairway in this basin. Nevertheless, there is considerable potential in open acreage west of this block. However, water depth quickly becomes an issue.



The Quaternary to Paleocene isopach map is one of two maps that are key to understanding the potential of the Tumbes basin. Line 93-00 runs north-south through the axis of the thickest part of this unit (10,000 meters +), and is shown in the slide after next. Another thick axis runs east from the Peru Bank.



This line begins at the Peru Bank in the north (Tumbes basin), and traverses south to the Pena Negra offshore field in the Talara basin. It runs down the axis of the deep Paleogene kitchen, and shows the overlying Neogene basin with an abundance of potential folded and faulted traps. A detailed blow-up of the section in the red box appears in the next slide.

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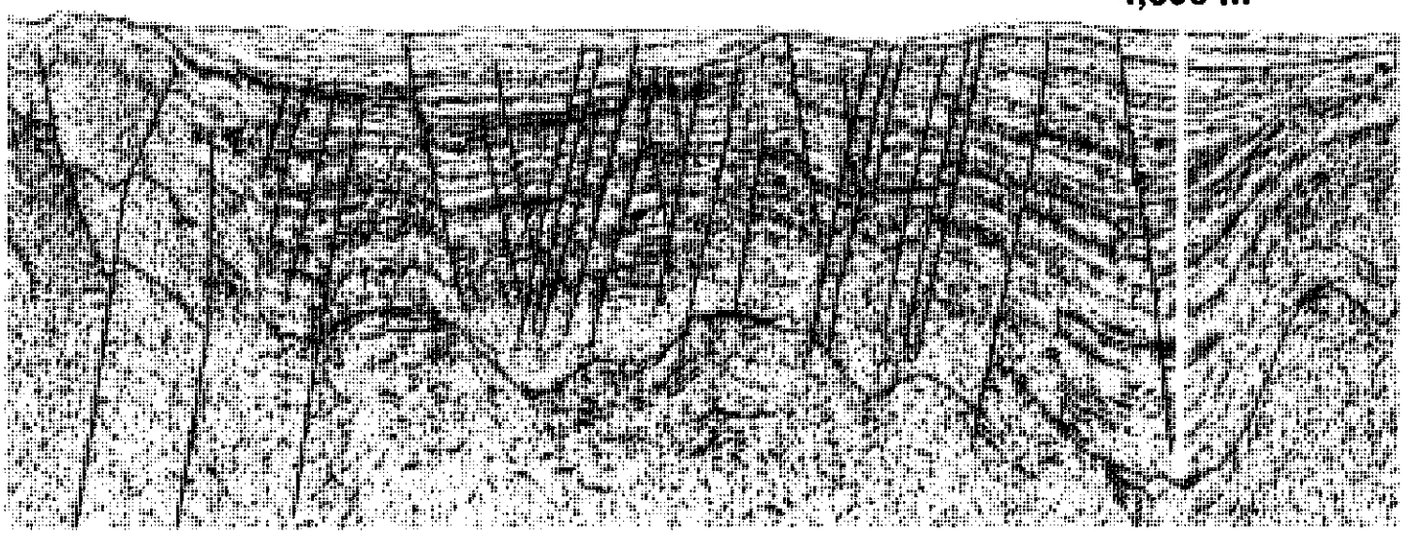
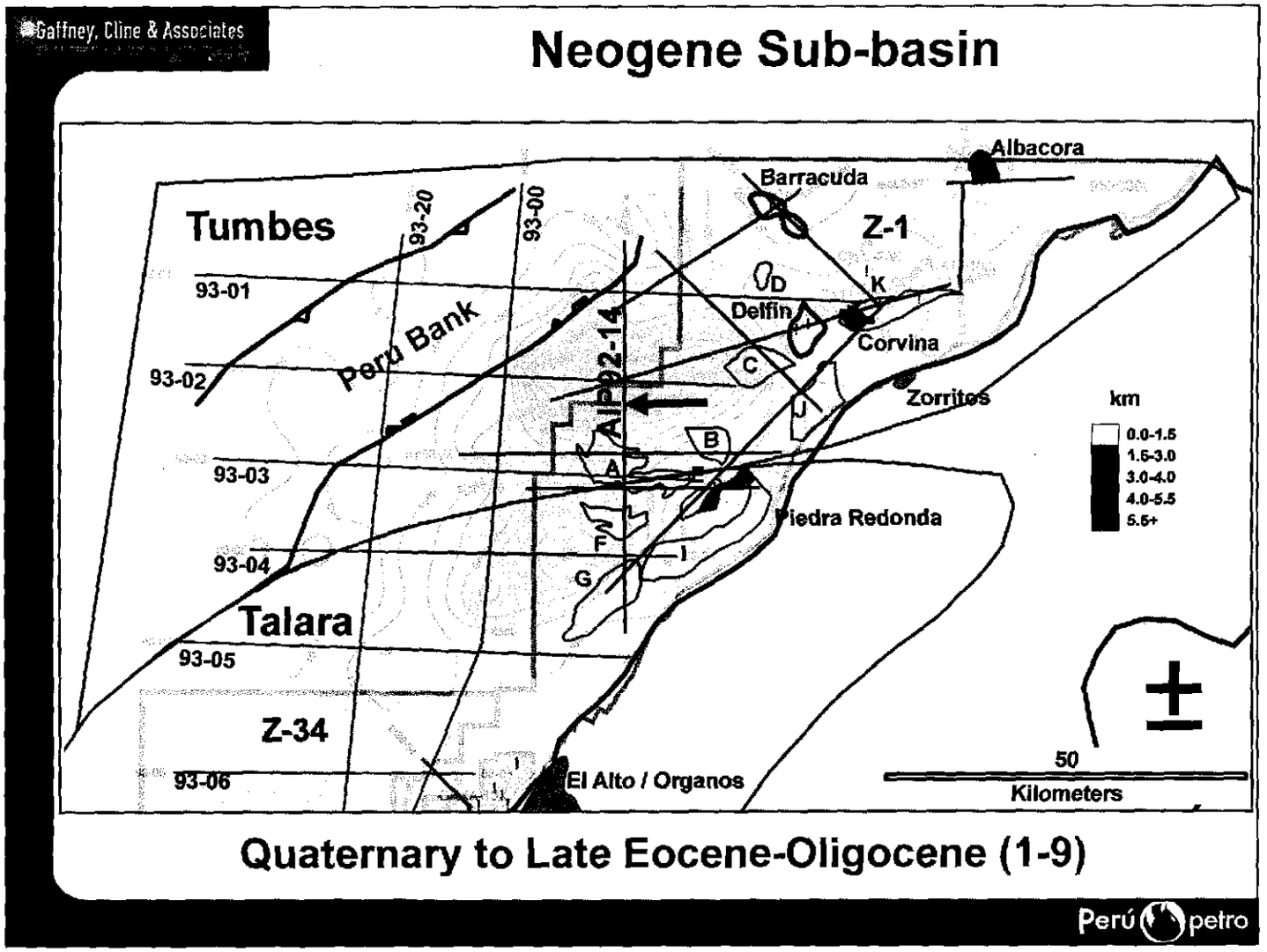
93-00 Detail

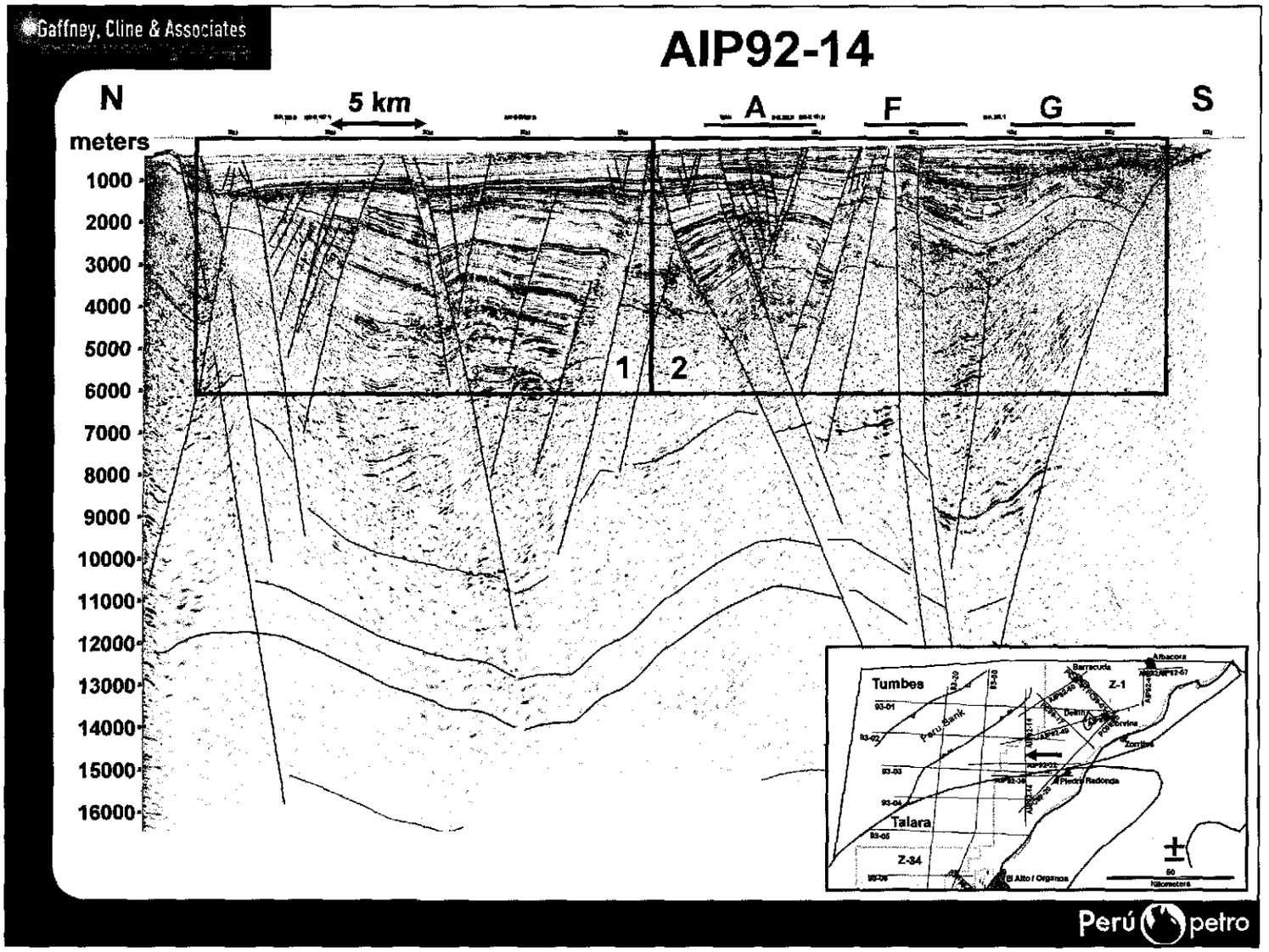


Perú petro

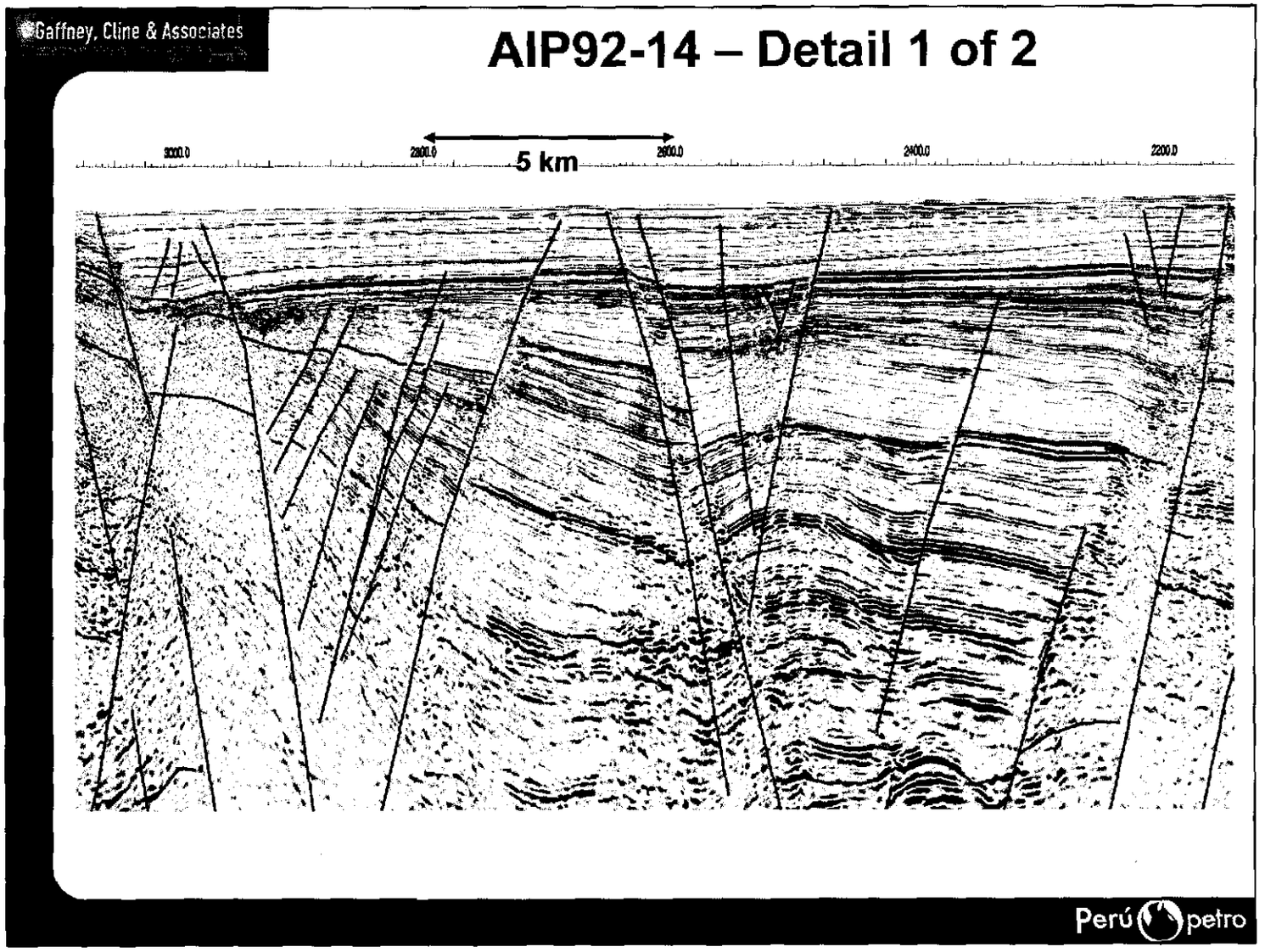
Multiple episodes of compression and extension have generated many folds and faults in this sub-basin, which ranges up to 4,500 meters thick in the deepest part along this line. Also note that there are some amplitude anomalies that are similar to those that are attributed to Eocene turbidite sands in the Trujillo basin. It might reasonably be expected that channelization of deeper-water sands might be controlled by the faults in this basin too.



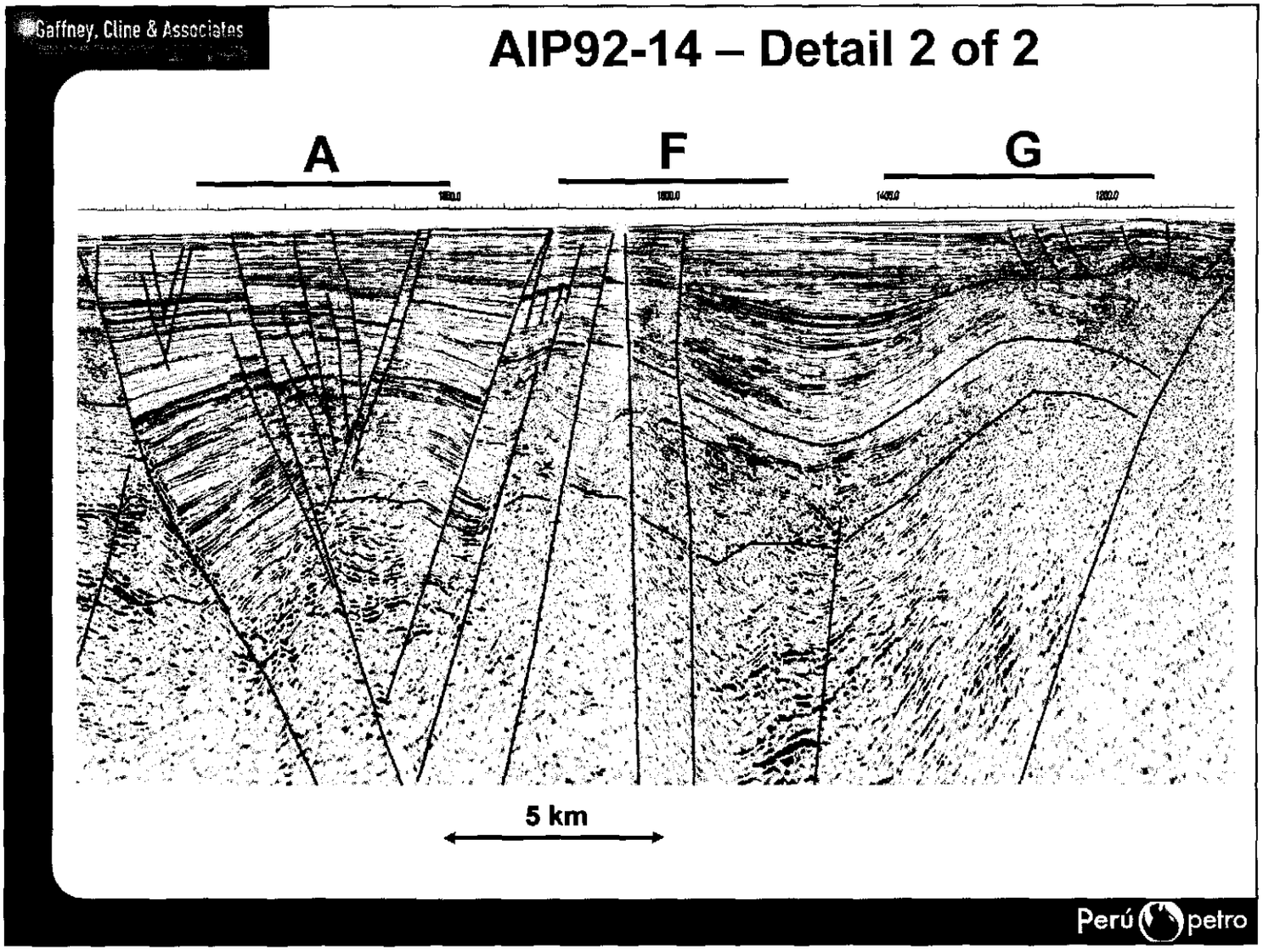
The second map that is key to understanding the exploration potential of the Tumbes basin is the Quaternary to Late Eocene-Oligocene isopach map, which illustrates the total thickness of the Neogene sub-basin that hosts the potential reservoir facies and traps that were shown in the previous slide. Line AIP92-14 (marked with a black arrow) shows the considerable thickness and structural richness of the Neogene along this line. Also note the set of exploration leads (in blue, labeled A-K) that a previous operator of this block mapped. Some of these leads are easy to see in the supplementary seismic lines in the project database (in red), but some are not. The places where the seismic lines cross over these leads are marked in red on the seismic sections.



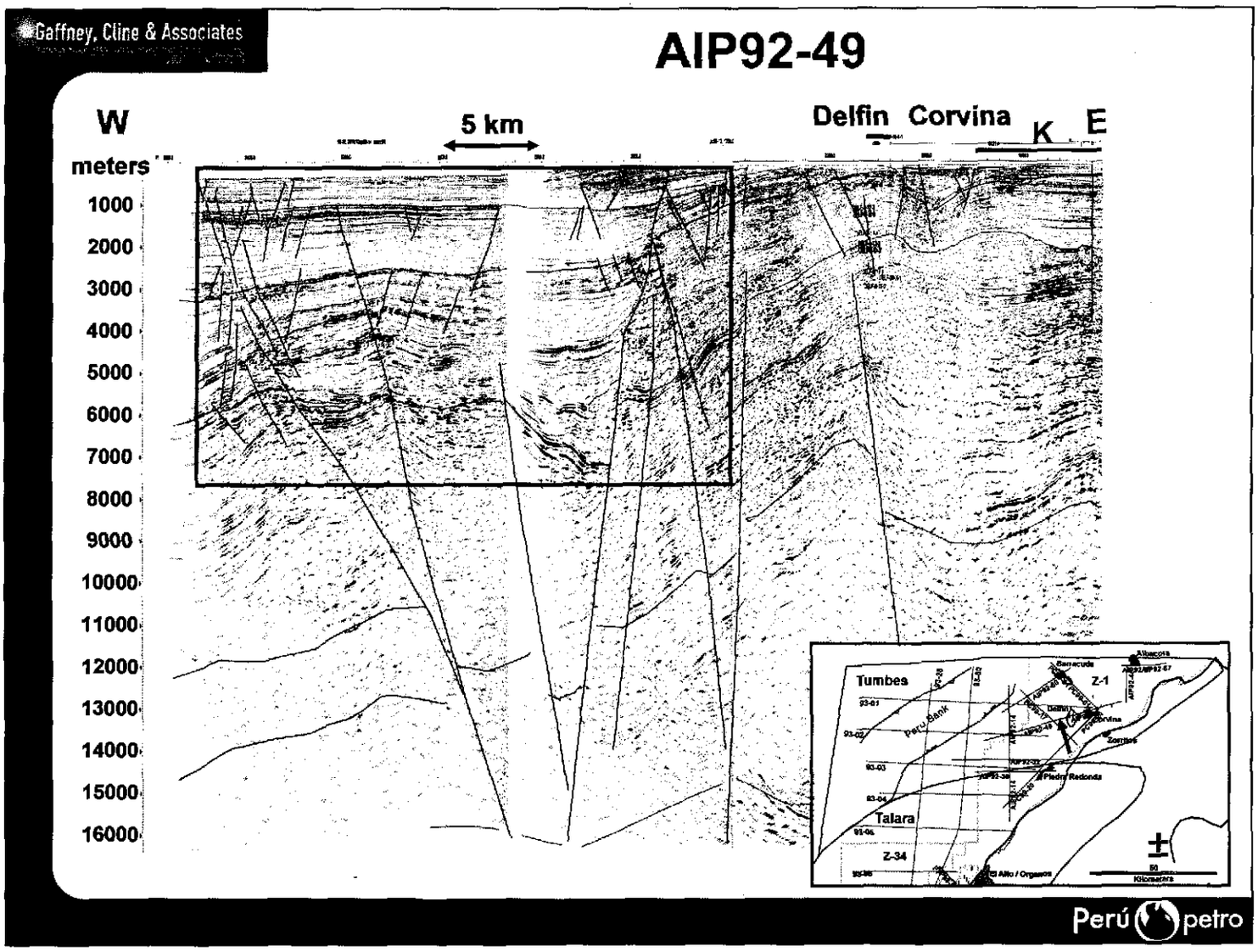
The Neogene section (from the orange horizon to the surface) reaches almost 6,000 meters thick along this line, which would be more than thick enough to bring source rocks in this interval to maturity, assuming similar heatflows to those used to model the Trujillo, Salaverry and Pisco basins. The red boxes indicate the locations of the two detail slides that follow. Lastly, note the location of three of the leads (A, F and G) from the previous map. In all three cases, the structure of the lead is clear.



This detail clearly shows both extensional faults as well as compressional inversion horst blocks and folds. This detail also gives a clearer view of the amplitude anomalies that might indicate fault-controlled turbidite channeling. A cluster of two or three of these structures would constitute a substantial oil and/or gas field.



This second detail shows more of the wrench-related faulting and folding. Here again, the broader of these structures, or clusters of two or three, could easily host enough oil to make a commercial field (see Economics section at the end).

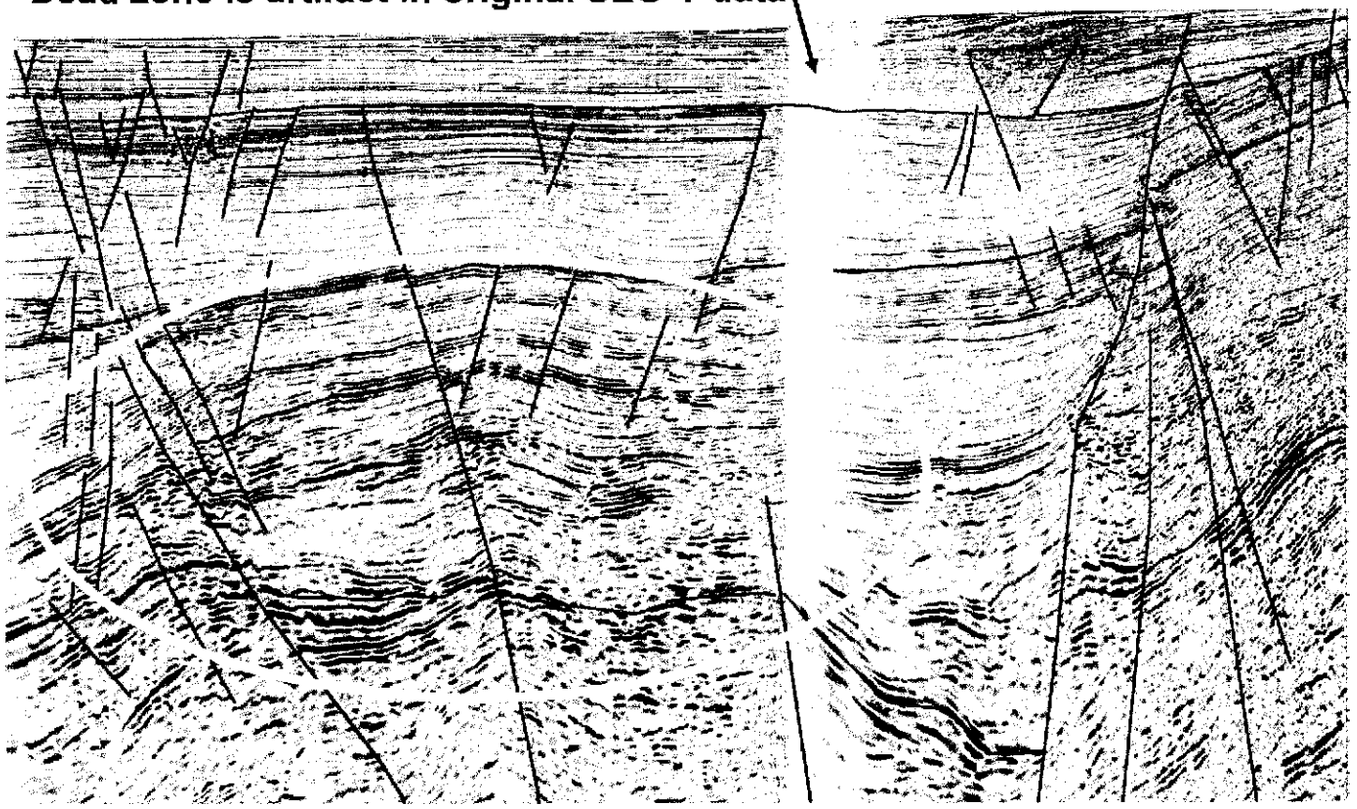


This extends from the middle of the Neogene sub-basin to the Delfin prospect and the Corvina gas field. The Delfin well tested gas. Corvina will soon become a commercial venture for BPZ Energy, as they pipe gas to shore to generate power to sell into the local grid. Note that the seismic is relatively featureless around Delfin and Corvina, which is an indication of how difficult it is to correlate horizons on this shallow shelf than it is in the thick of the basin.

Gaffney, Cline & Associates

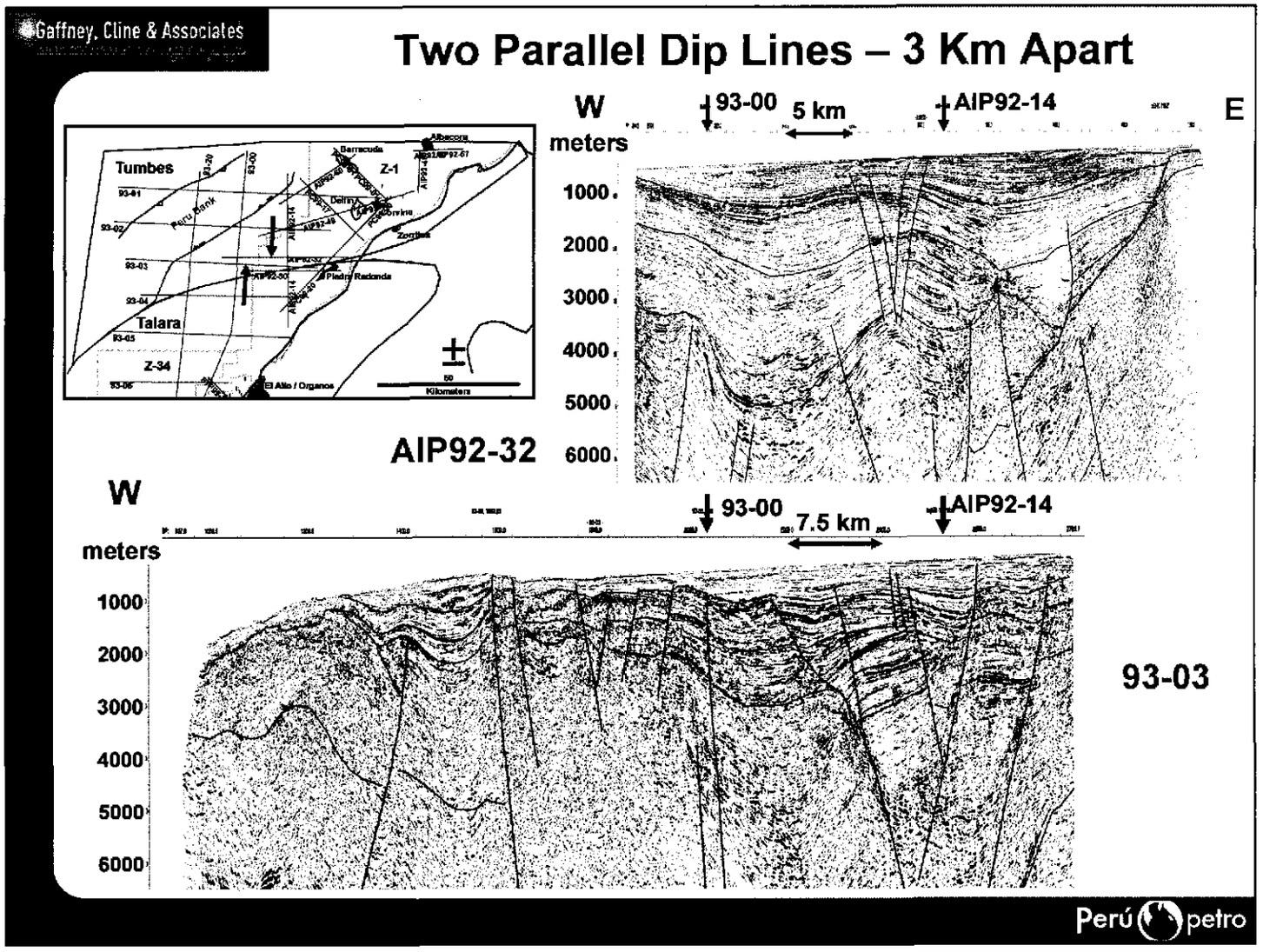
AIP92-49 Detail

Dead zone is artifact in original SEG-Y data

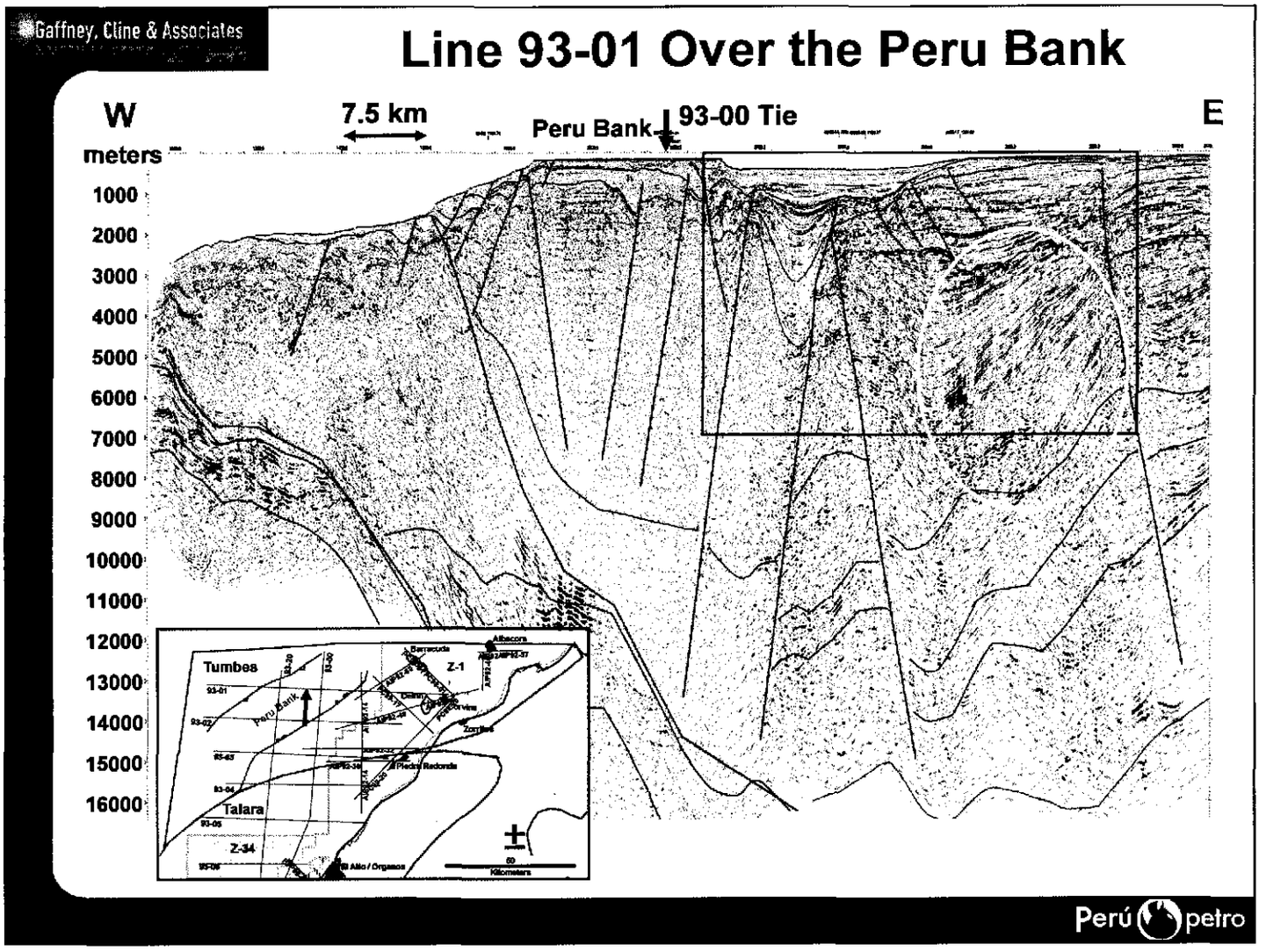


Perú petro

This detail from the previous line shows one of several broadly folded and faulted anticlines that may have several levels of stacked pay.



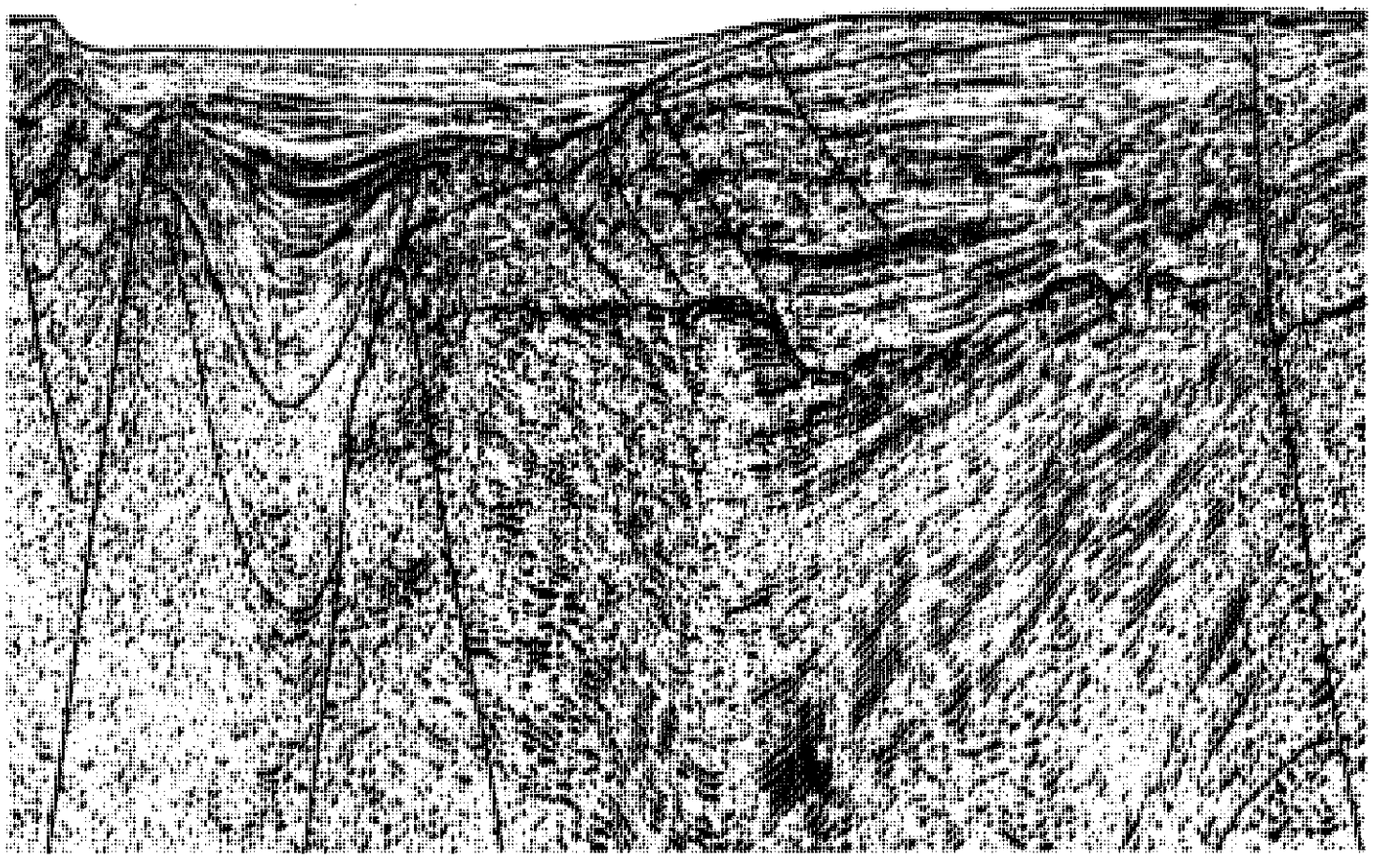
While these one-line structural features are very interesting, the challenge of promoting any of them into drillable prospects lies in correlating from line to line. The two parallel lines above illustrate the problem. They are 3 kilometers apart and are generally similar structurally, but are quite different in detail. Considerable effort was invested during this study in detailed correlations like this. It is possible to establish a detailed framework using lines from one survey with a particular orientation, only to have it fall apart in trying to extend it to a different survey with a different orientation. Reprocessing of the 2D seismic and/or 3D seismic will definitely be necessary to solve this 3-dimensional problem.



The next series of 10 slides captures a set of five parallel lines that cover most of the prospective area in the Tumbes basin. This series begins with Line 93-01, which extends across the Peru Bank and images both the subduction zone to the west and the Neogene sub-basin to the east. The Peru Bank appears to be a former basin (thick) during the Eocene that has been inverted through reactivation of the main bounding faults, and then beveled flat at the top by wave action. The detail area marked with the red box is shown in the next slide. Also note that the Eocene section in the white oval may be gravity slide, which would make the Paleocene "horizon" (in red) a fault instead.

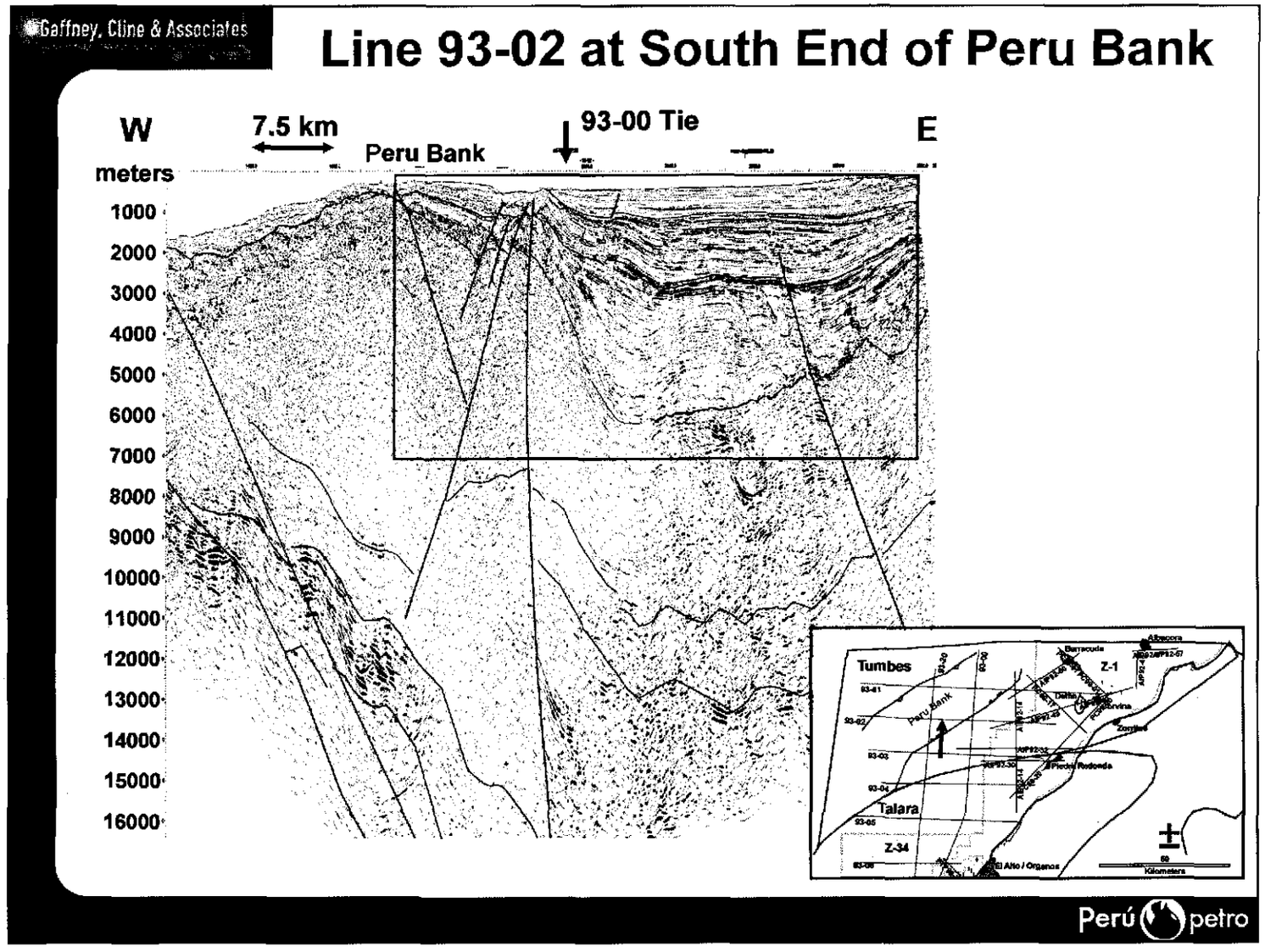
Gaffney, Cline & Associates

93-01 Detail

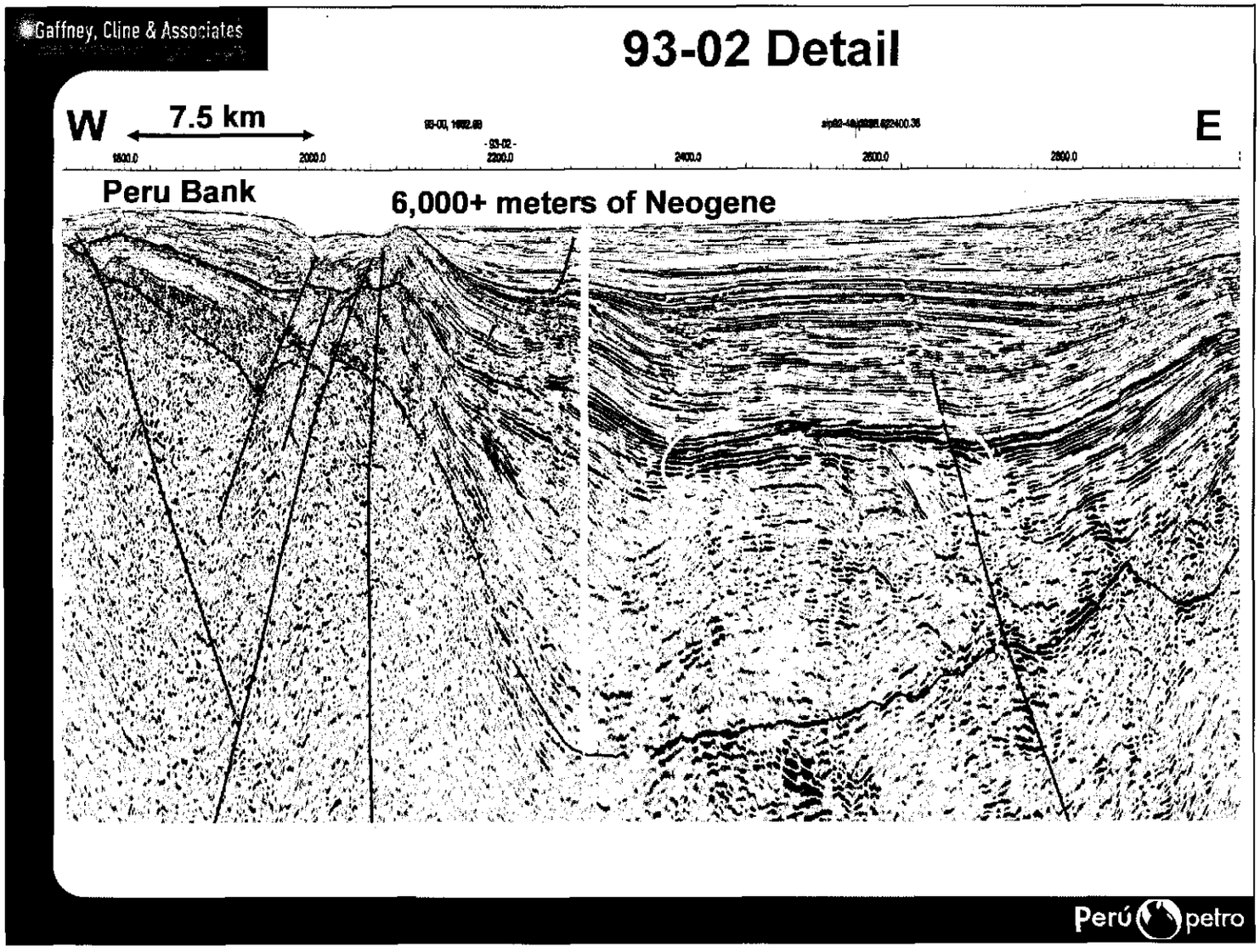


Perú petro

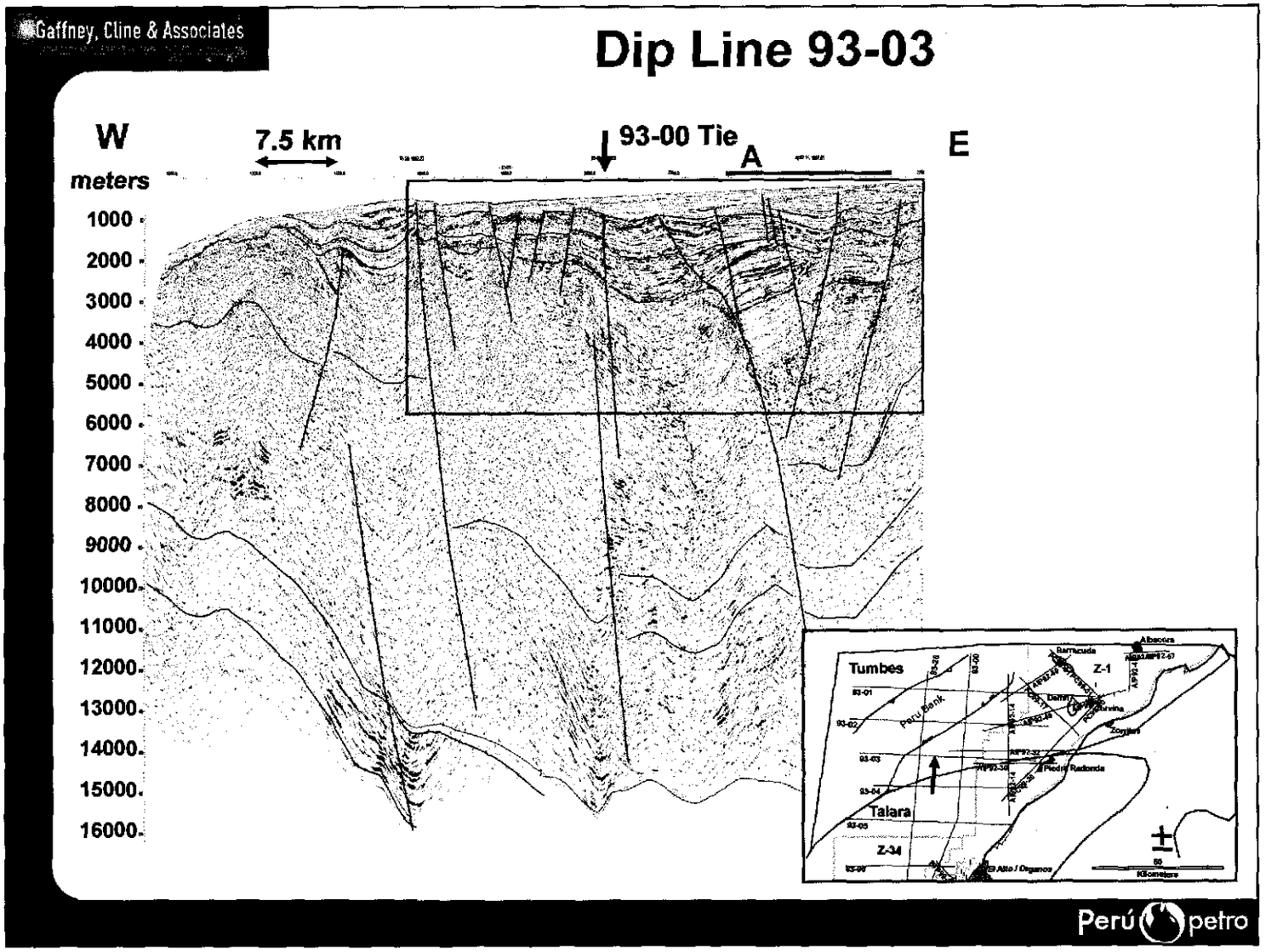
This is a closer look at the Neogene sub-basin and shows more of the same faulting, folding and seismic amplitudes as the previous sections through this sub-basin.



This is the next line south of 93-01, and shows more of the Peru Bank high, underlain by thick Eocene and oceanic crust. The Neogene sub-basin is particularly thick (6,000 meters) along this line.



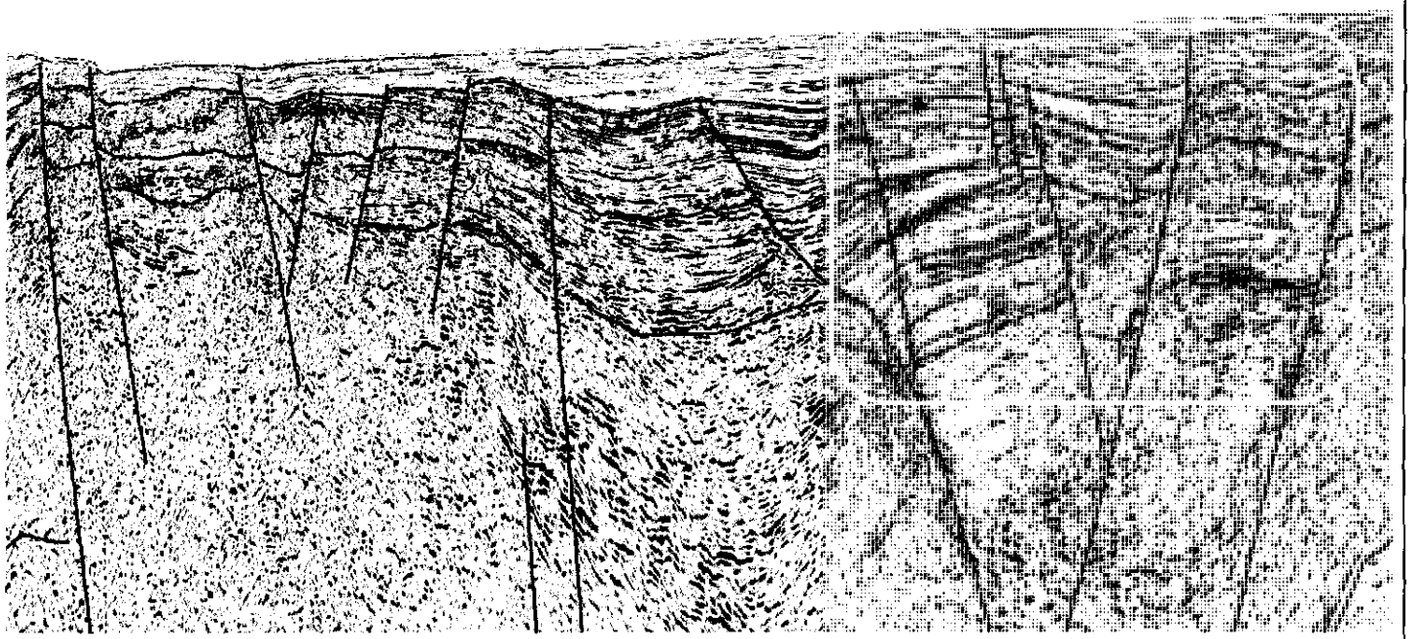
This detail shows a relatively broad inversion (white oval) bounded by a fault on the east, and probably another fault to the west which is not shown in the interpretation.



Continuing south one more line, the Peru Bank gives way to 1,500 meters of Neogene sediments and more of the reactivated faults that are seen north of this line. The eastern end of this line transects Lead A (see slide 33 for location). In this case, it's fairly easy to see the structural character of this lead on this section and the detail in the following slide.

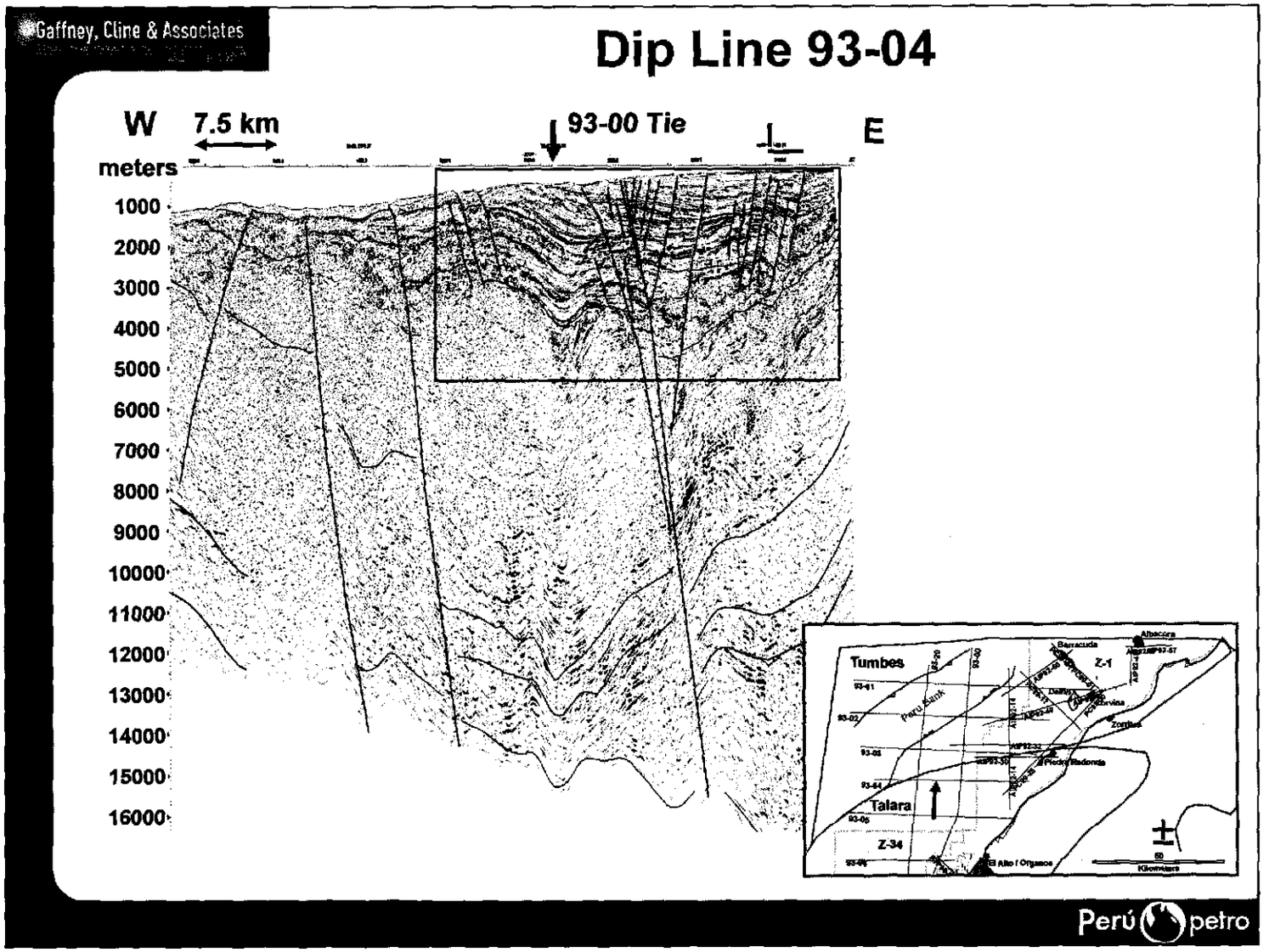
Gaffney, Cline & Associates

93-03 Detail



Perú petro

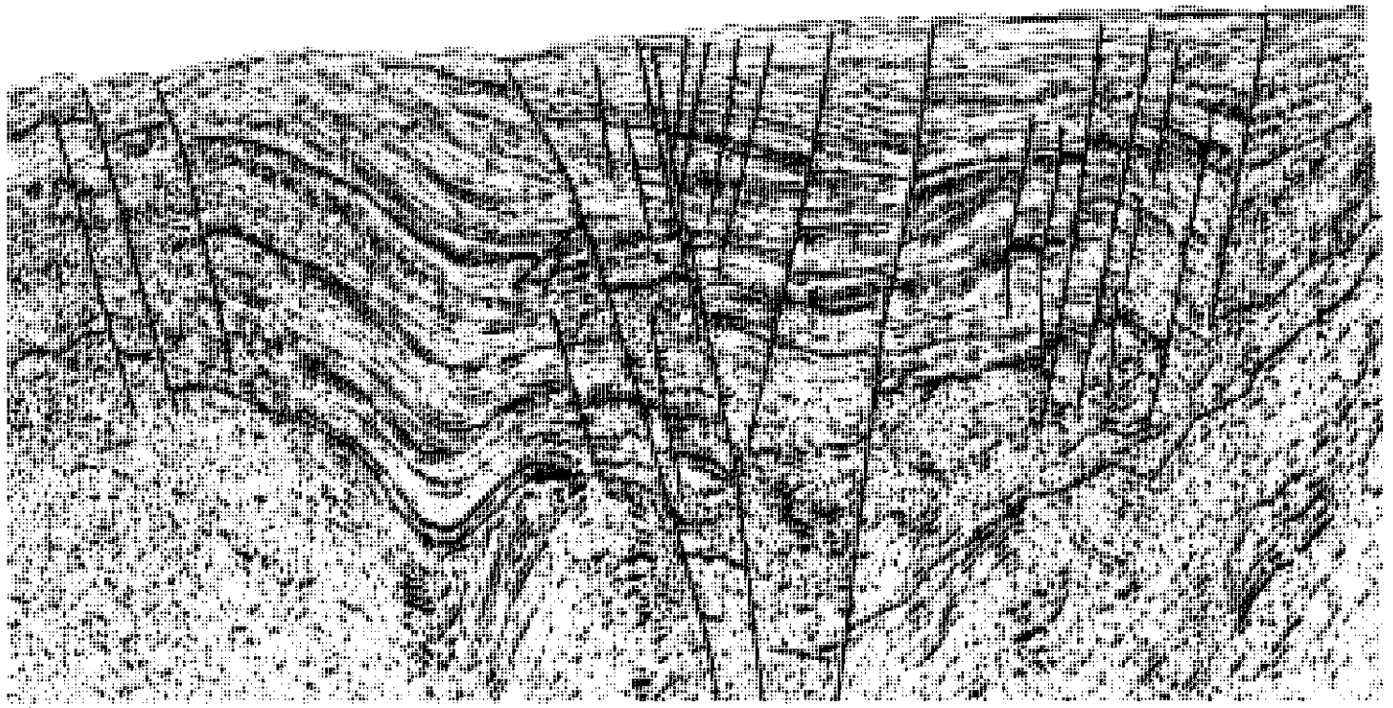
The white box is the approximate location of Lead A from slide 32. There are other tilted fault blocks on this line with trapping potential.



This line shows that the Neogene sub-basin actually extends seamlessly into the Talara basin to the south. The extreme eastern end of this line also transects Lead I, which appears to be a highly faulted anticline.

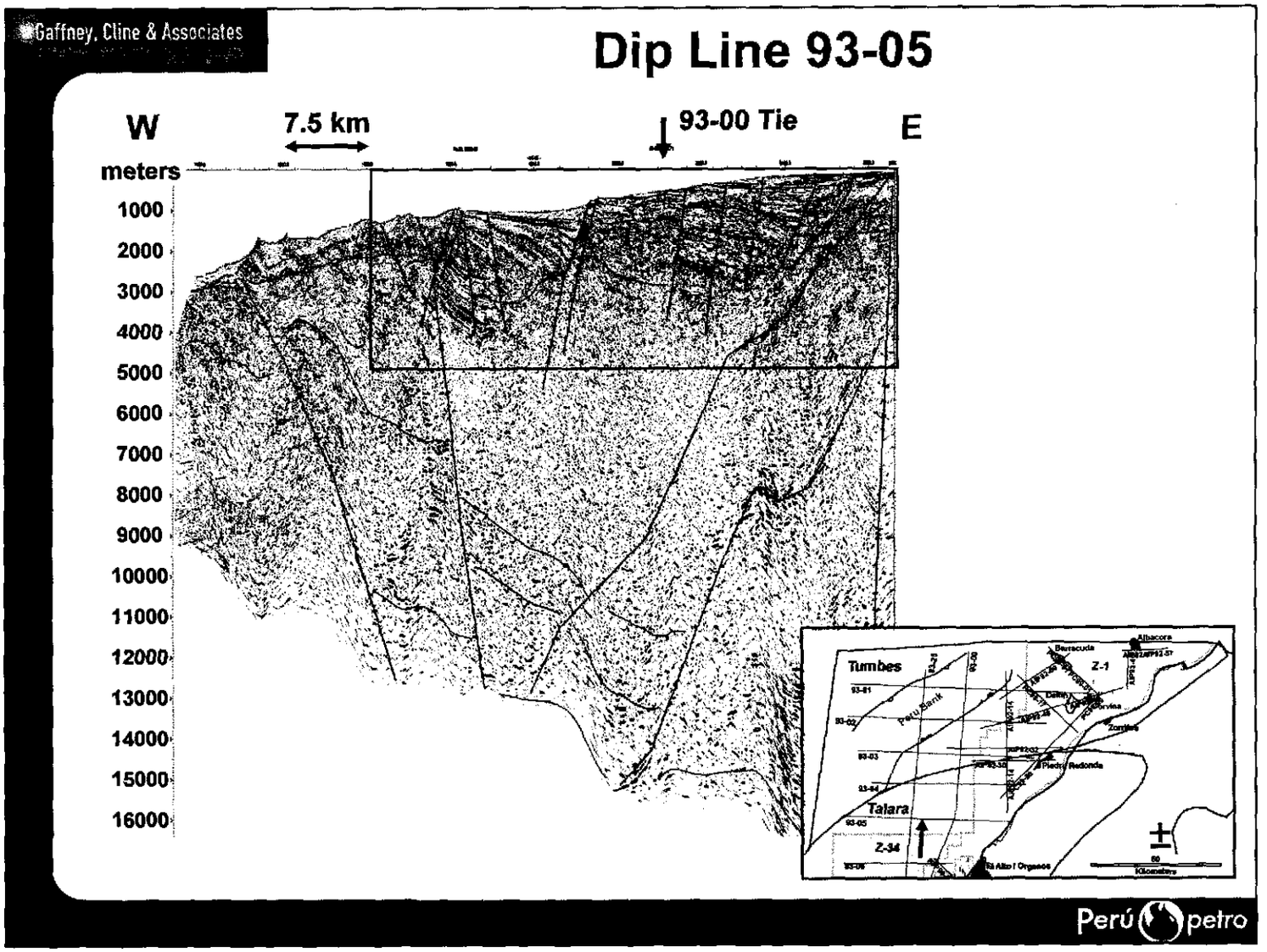
Gaffney, Cline & Associates

93-04 Detail

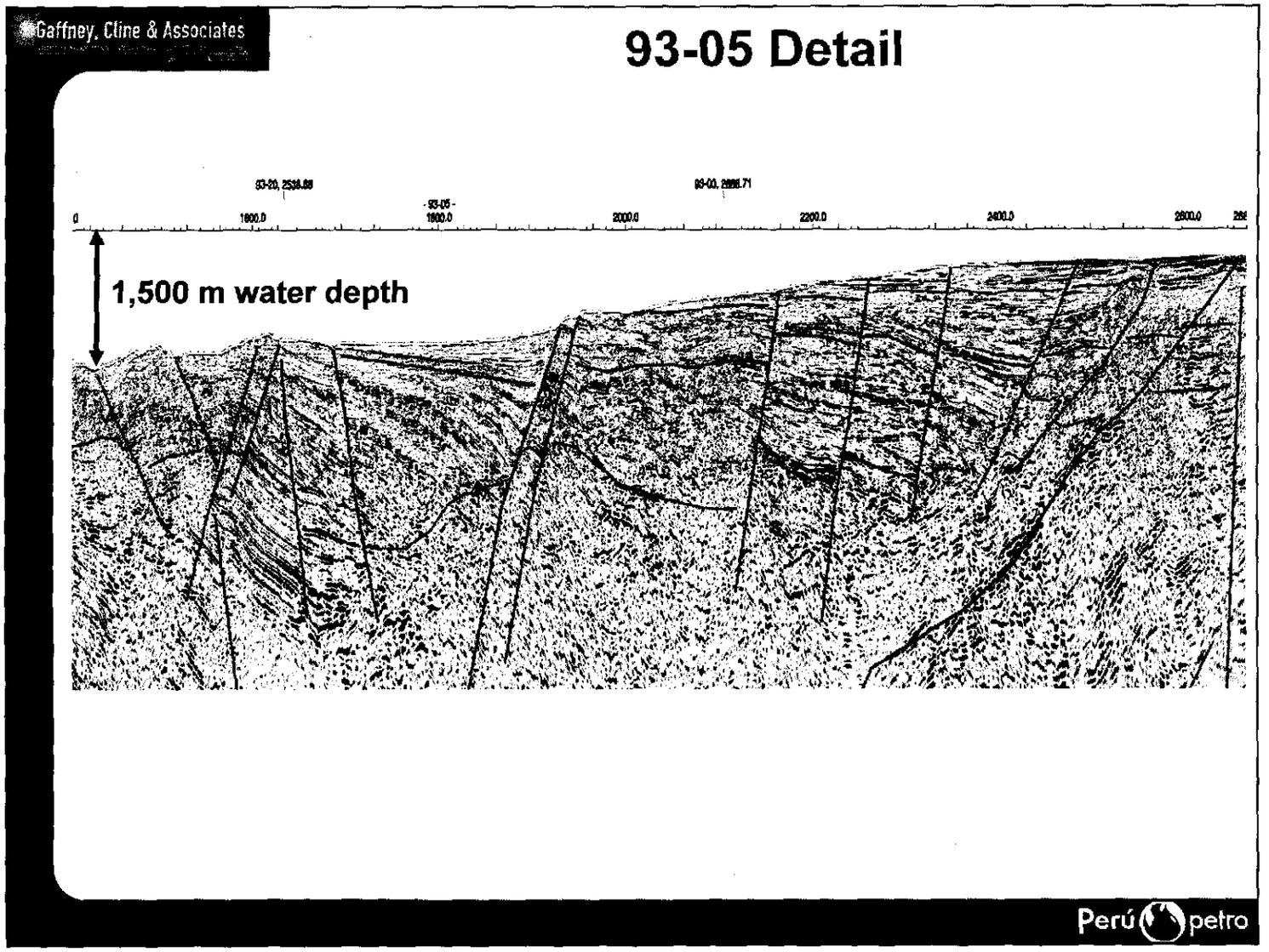


Perú petro

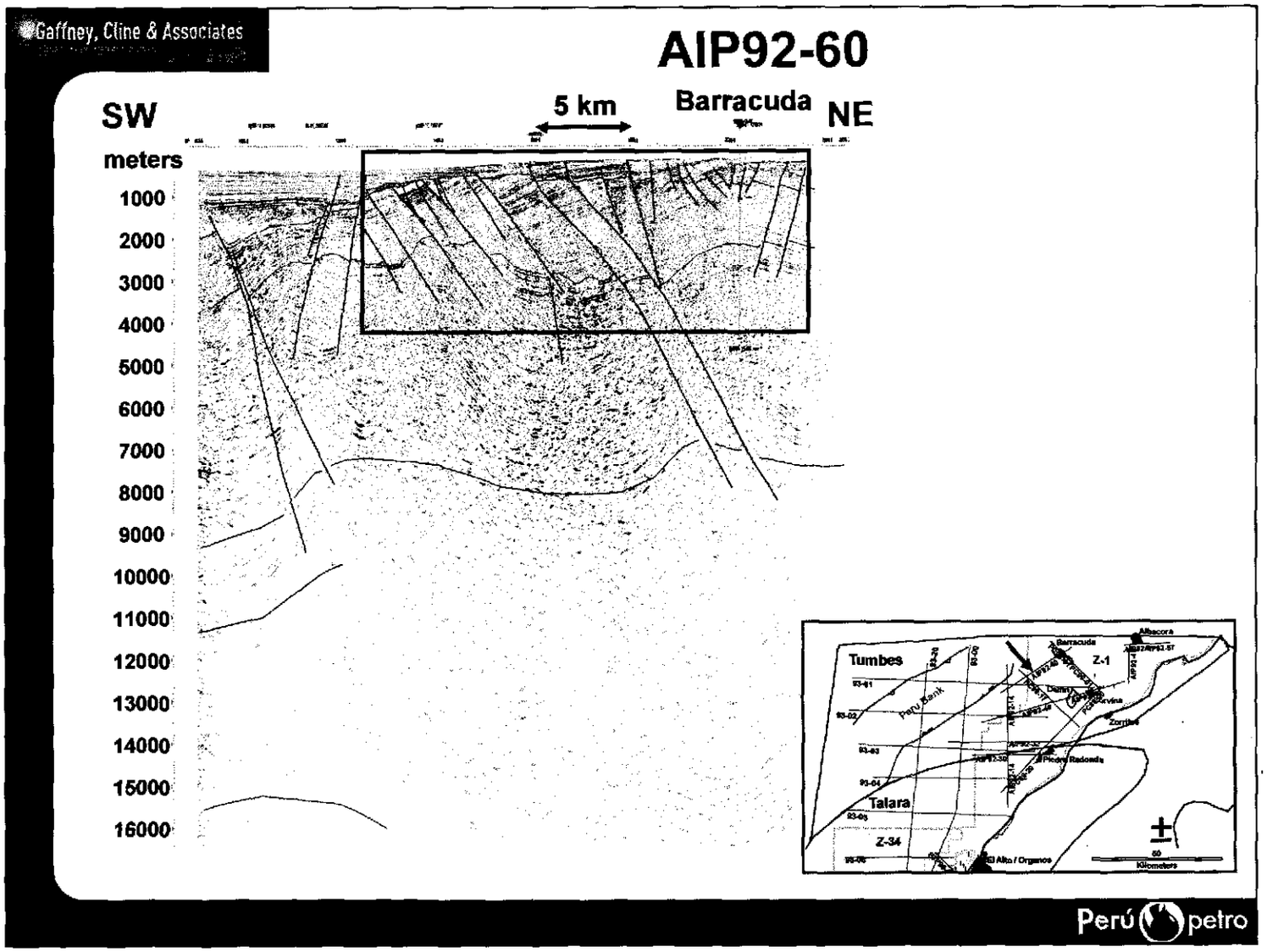
This detail shows how heavily faulted this sub-basin can be, and how difficult it is to correlate detailed chronostratigraphic sequences laterally.



The last line of this series of parallel lines lies entirely in the Talara basin, and mostly in open acreage. Here again, the Neogene sub-basin appears continuous at least this far south. Although it exhibits the same structural and stratigraphic style as the four other lines in this series, the water depth is 1,000 meters or more over much of this line, especially in the open acreage to the west. Drilling in deep water like this will likely be contingent on initial exploration success in shallower water.



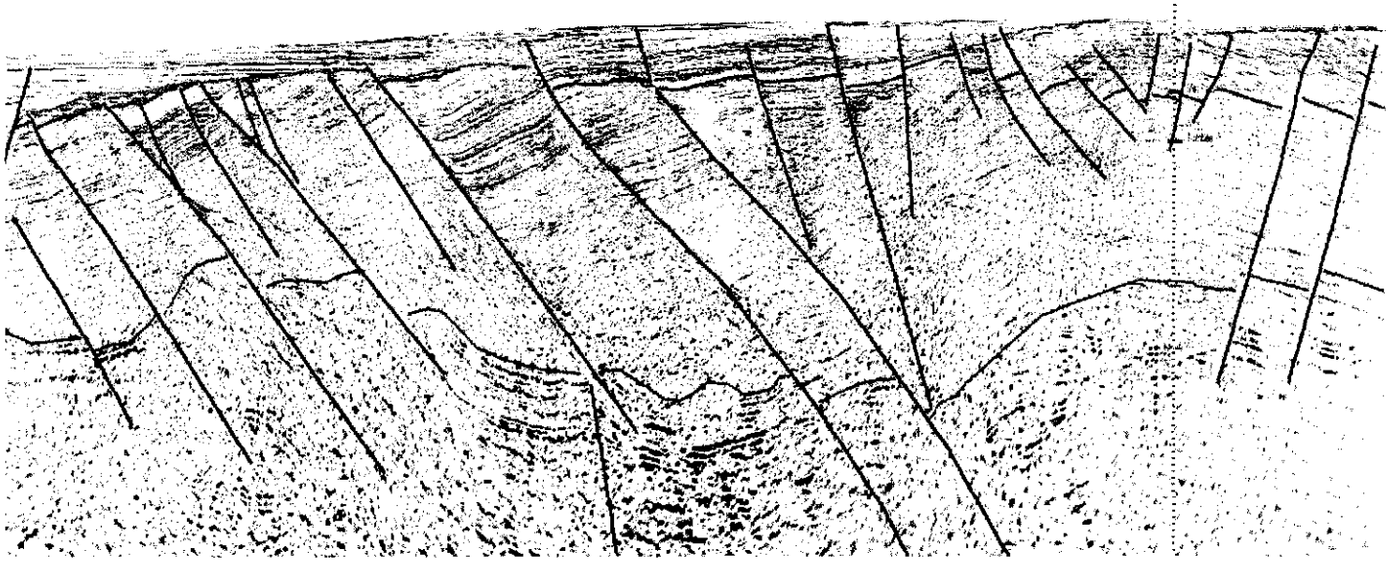
Although water depths reach over 1,500 meters at the western end of this detail, there are still some interesting fault blocks in the shallow water over BPZ Energy's Block Z-1.



The next series of eight slides illustrates four more seismic lines that show how the Neogene sub-basin appears further onshore in the shallow-water area of BPZ Energy's Block Z-1. Previous slides 33-37 are also part of this shallow-water seismic grid that supplements the Ribiana 1993 lines shown previously. This line AIP92-60 ties the Barracuda wells into the regional framework, and shows that the overall faulted and folded structural style persists into this area.

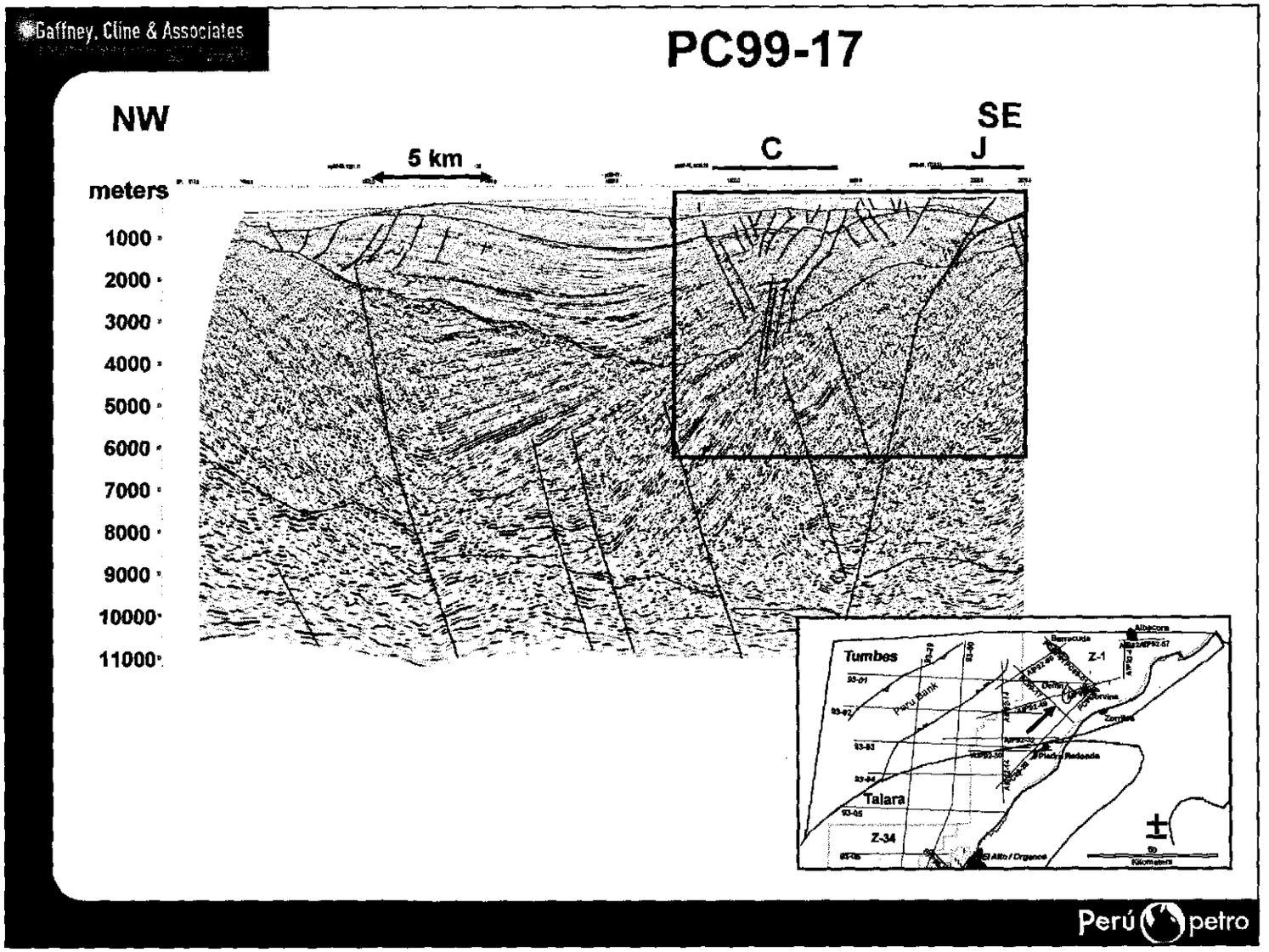
Gaffney, Cline & Associates

AIP92-60 Detail

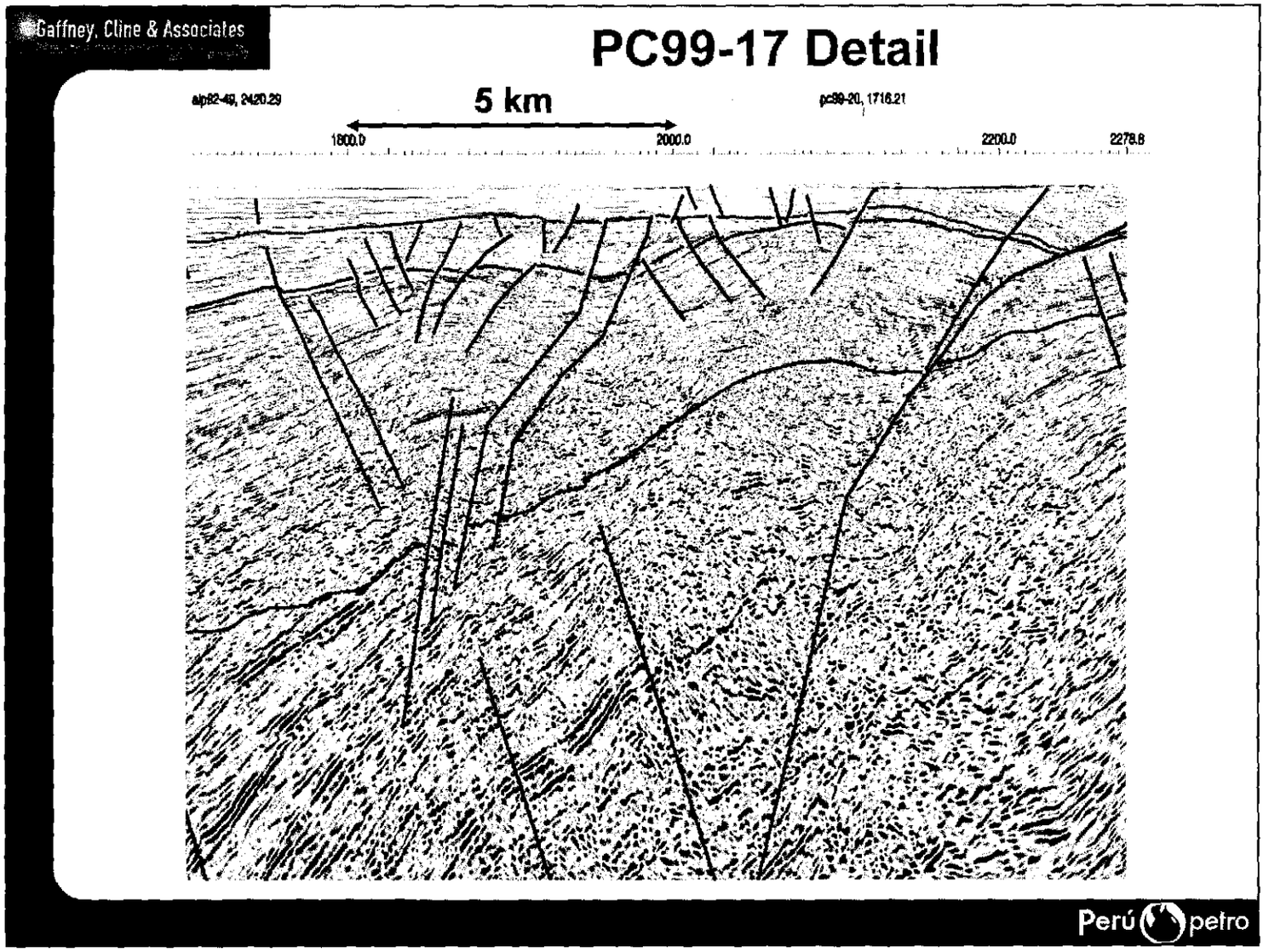


Perú petro

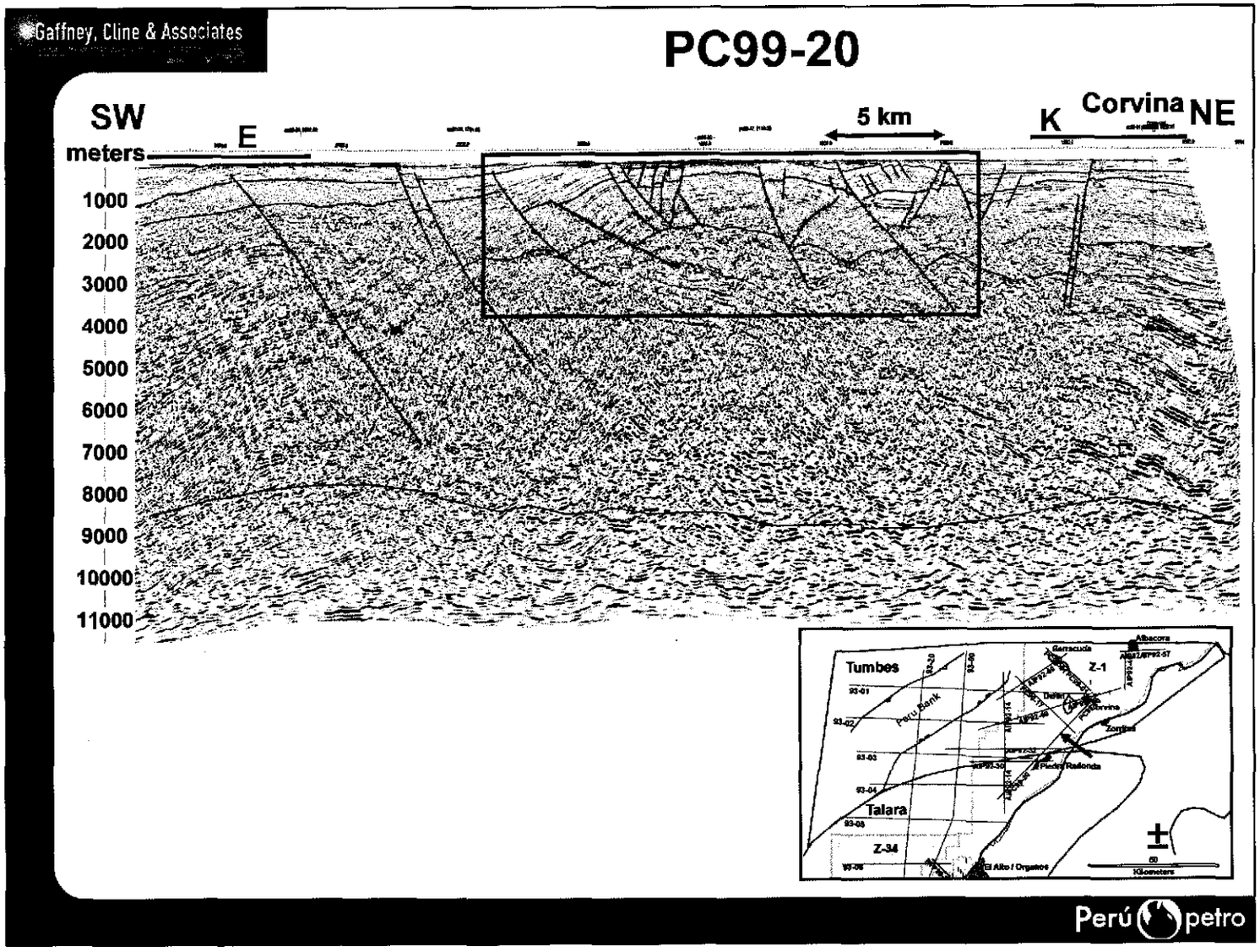
This detail suggests that there may be a thicker prospective reservoir section in the series of tilted fault blocks west of the Barracuda prospect.



This line ties the previous one at approximately a right angle and heads southeast to shore. It transects Leads C and J at the southeastern end, which are better seen in the detail on the next slide.



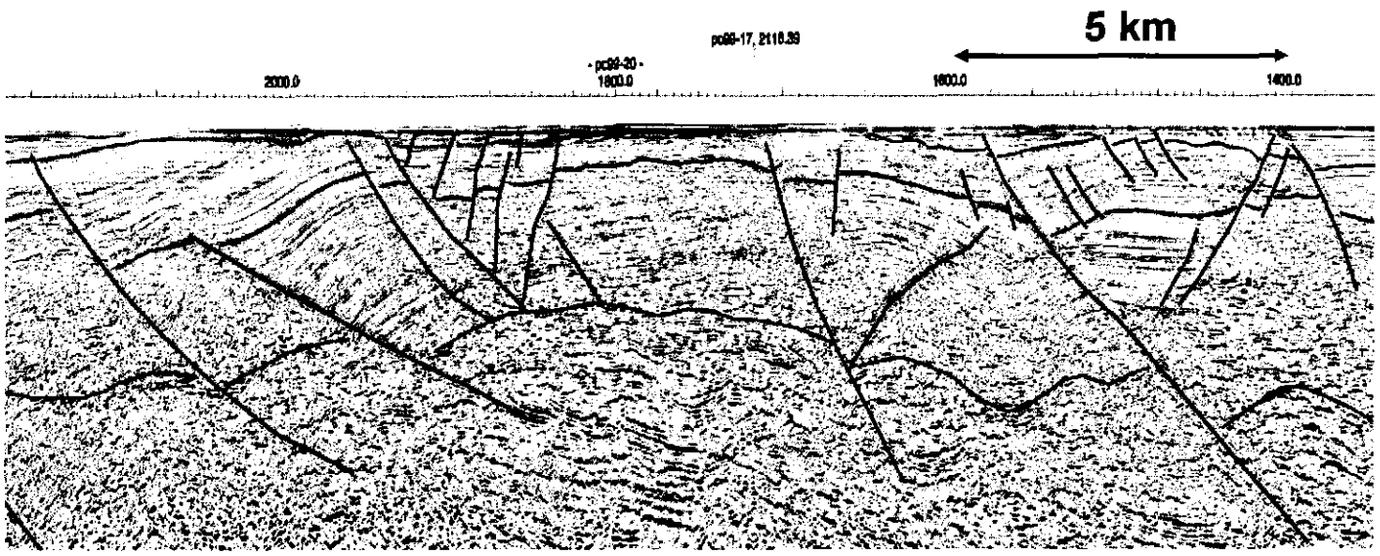
These two rather broadly folded and faulted structures are near shore and are at reasonable drilling depths. The density of faulting may present a seal risk, especially for the one on the right.



This line intersects the previous line almost at a right angle and runs parallel to the shore. It ties with the Corvina wells at the northeast end and shows the same sort of faulted anticline as the previous section, but with more lateral extent in this direction – almost 15 kilometers.

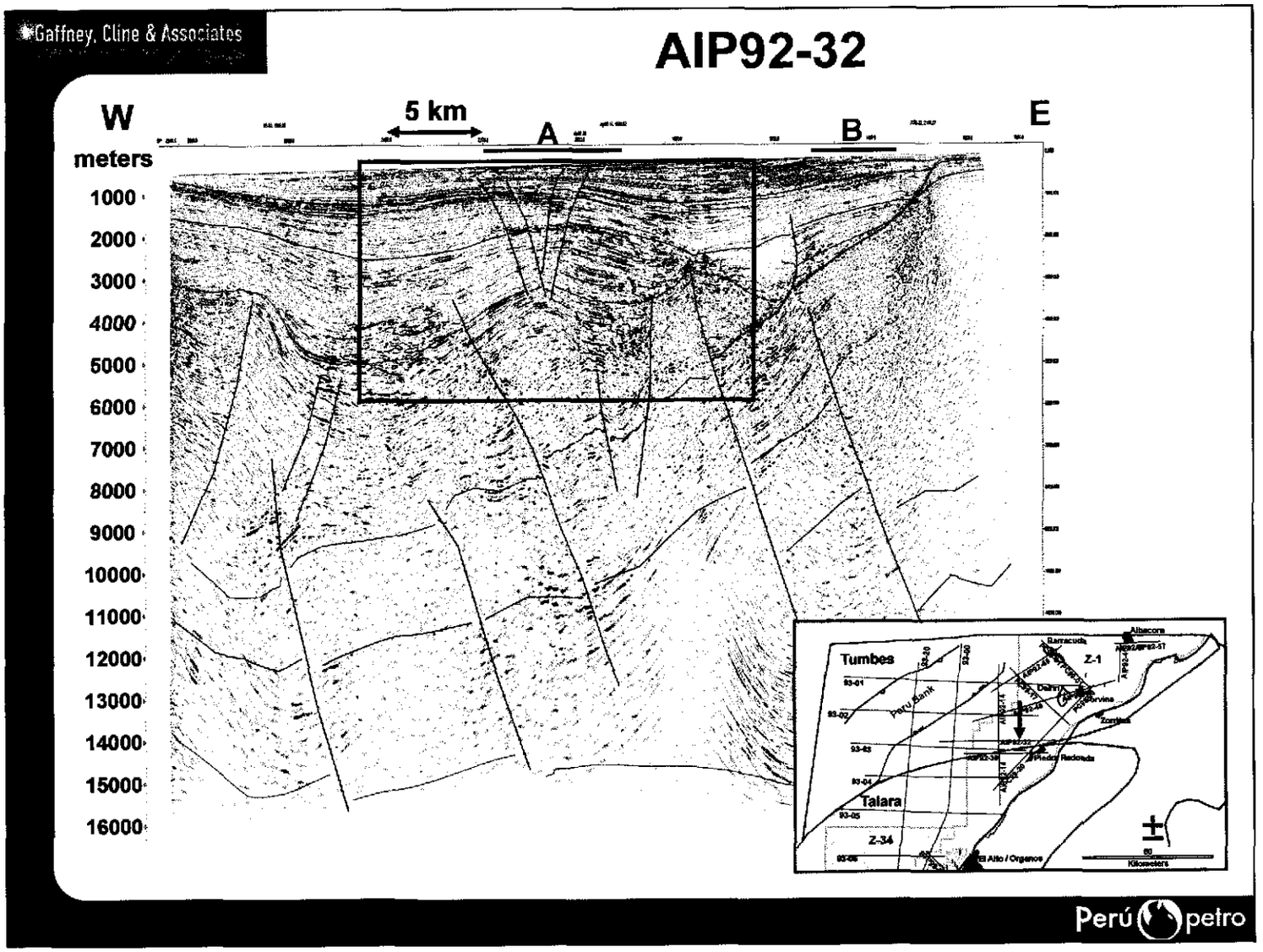
Gaffney, Cline & Associates

PC99-20 Detail



Perú petro

This detail of the previous slide better illustrates the stratigraphic character of the Miocene interval (blue-to-orange).



This last line in this series intersects the previous line obliquely, and transects Leads A and B. Lead A is another of these faulted anticlines that grew in response to compression with a strike-slip component. The structural basis for Lead B is not as clear.

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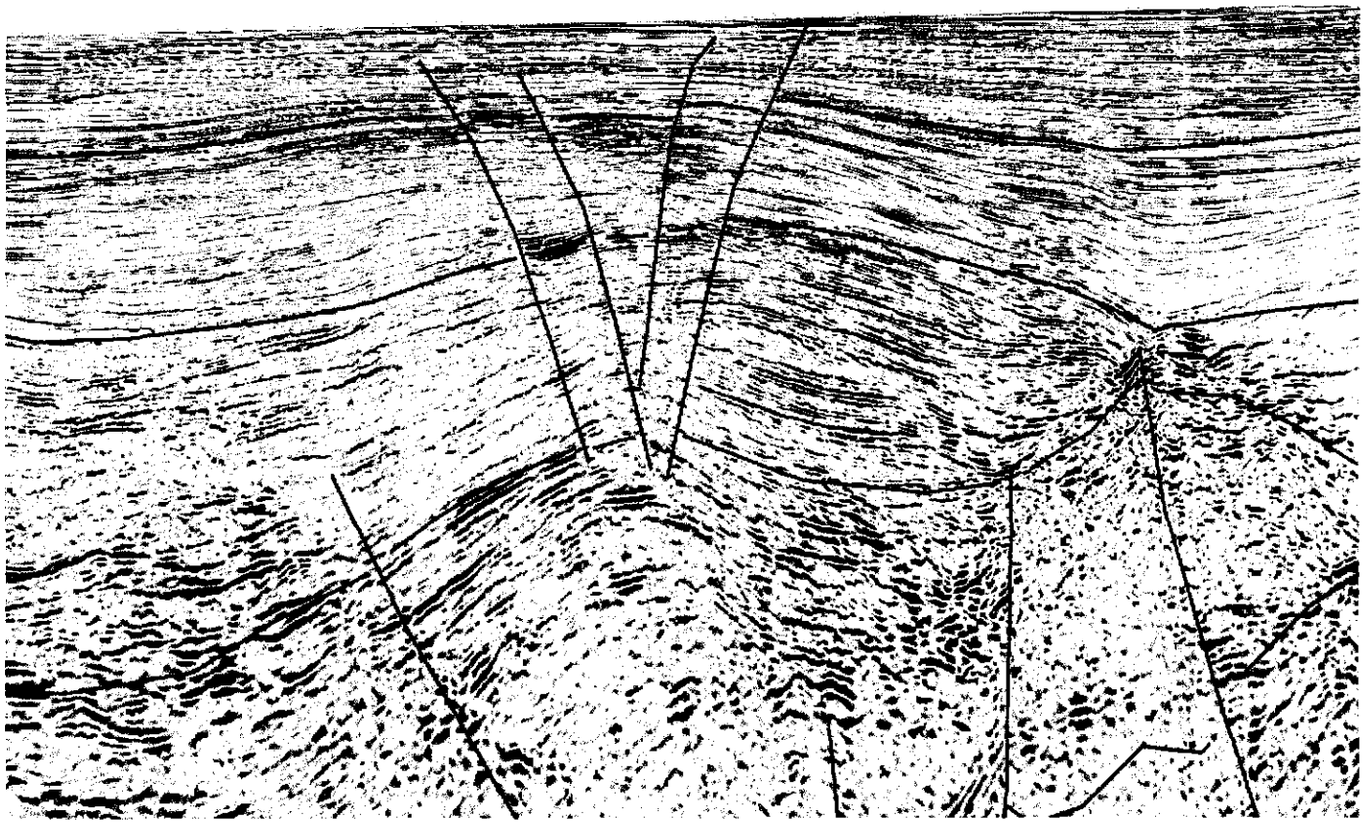
AIP92-32 Detail



Perú petro

This detail shows a distinctly sedimentary character beneath the Lower Eocene-Oligocene horizon (in orange), which further supports the possibility that this is not basement. The remaining supplementary seismic lines are available at the end of this presentation. They also show how difficult it is to tie the existing wells to the relatively featureless near-shore seismic.

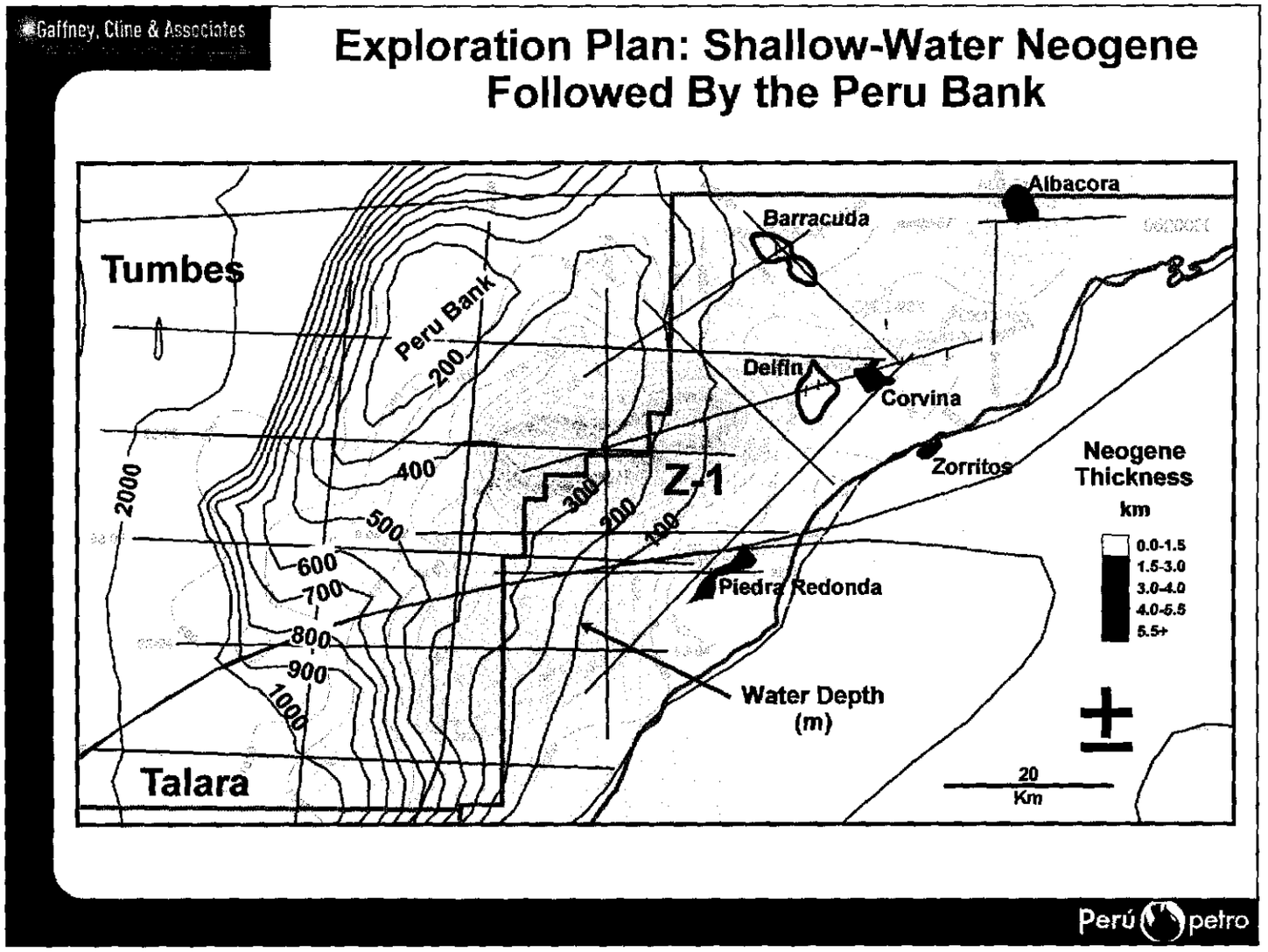
Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

BPZ Energy has tied up most of the prime shallow-water acreage with their contract on Block Z-1. Any near-term exploration in the Tumbes basin will likely derive from their plan for the block.



BPZ Energy is well positioned to economically explore the Neogene sub-basin in shallow water. The western boundary of their Block Z-1 roughly parallels the 300 meter isobath. Once they have established gas and power production from the Corvina-Piedra Redonda project, a reasonable approach would be to shoot a tailored 3D survey west of these fields in advance of drilling a first test. Another operator might also take the open acreage west of Block Z-1 and explore on the flanks of the Peru Bank, or immediately west of Block Z-1. Lastly, after having established commercial projects in the shallow-water Neogene, drilling a slim hole at the top of the Peru Bank would help answer the question of whether or not this impressive structure has hydrocarbon potential.

Gaffney, Cline & Associates

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Perú petro

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Three Scenarios Show Overall Favorable Economic Potential

(US$ million unless otherwise noted)	Low	Mid	High
Oil (millions of barrels)	25	50	75
Producing Wells	30	55	80
Gross Project Revenue	750	1,500	2,250
Royalty	39	85	142
CAPEX	155	225	310
OPEX	71	108	122
Net Cashflow Before Tax	485	1,082	1,676
Tax	136	313	486
Net Cashflow After Tax	349	769	1,191
NPV (Discount 10%)	69	158	259
IRR (%)	23	30	40

Perú petro

There is no doubt that the new chronostratigraphic framework produced in this study has documented a substantial amount of exploration potential in the Tumbes basin. However, there is considerable doubt about how much of that potential will be realized, and when. Therefore, the economic analysis was based on a simple three-scenario approach – a low case, a mid case and a high case. Given the structural complexity of the Neogene sub-basin where most of the potential lies, the range between the low case and the high case was purposely modest. The exploration and development costs were based on information in the public domain and advice from PERUPETRO. In general, because oil prices are high and costs are low in this shallow-water, close-to-shore environment, even the low case delivers a sizable rate of return.

Gaffney, Cline & Associates

Conclusions Revisited

- Proven Neogene petroleum system with oil and gas production from the Zorritos field onshore and the Albacora discovery offshore
- Possible Cretaceous-Paleogene petroleum system
- Numerous Neogene leads in shallow to moderate water depths and reasonable drilling depths, but will likely require careful reprocessing of 2D seismic plus targeted 3D seismic to resolve complex structures
- Reservoir is key uncertainty
- BPZ Energy has a dominant acreage position (Block Z-1) and has scheduled their first commercial offshore project (Corvina gas production), but workable area is still available in the western half of the basin, albeit in deeper water

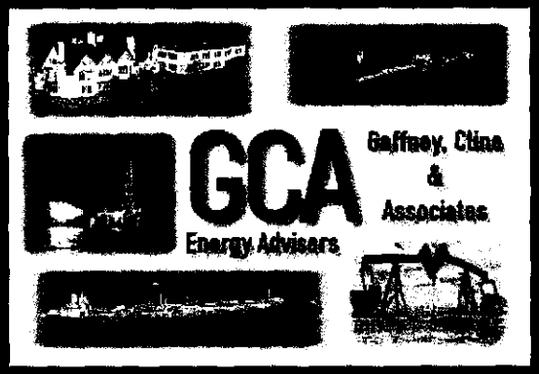
Perú petro

Overall, the Tumbes basin is rich in potential, and is poised to see the implementation of a new offshore commercial project – gas production from BPZ Energy's Corvina and Piedra Redonda fields in Block Z-1. Although much of the shallow-water fairway is covered by Block Z-1, there is still workable open acreage in the western half of the basin.

Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Tumbes Basin



Perú petro

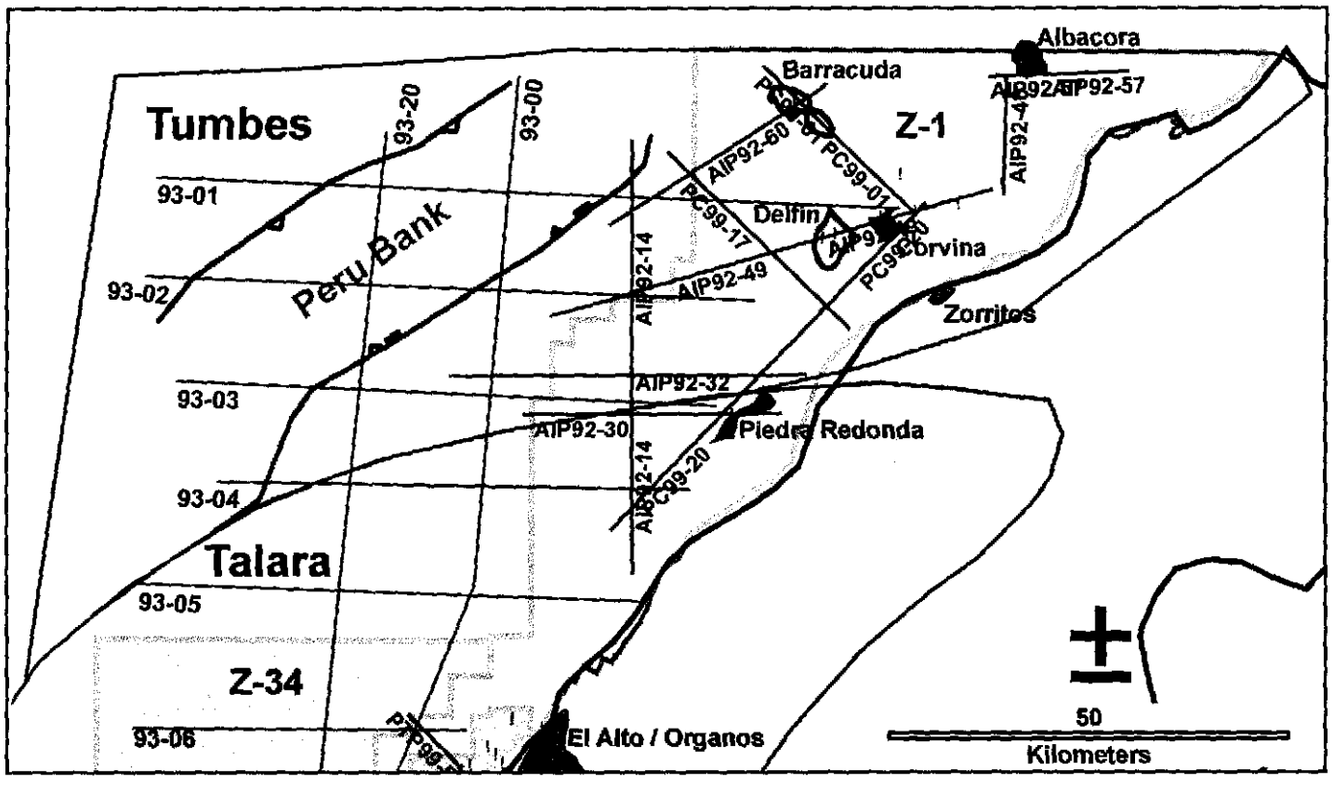
Gaffney, Cline & Associates

The following are the remaining Tumbes basin seismic lines that were not incorporated into the main Tumbes basin presentation.

Perú petro

Gaffney, Cline & Associates

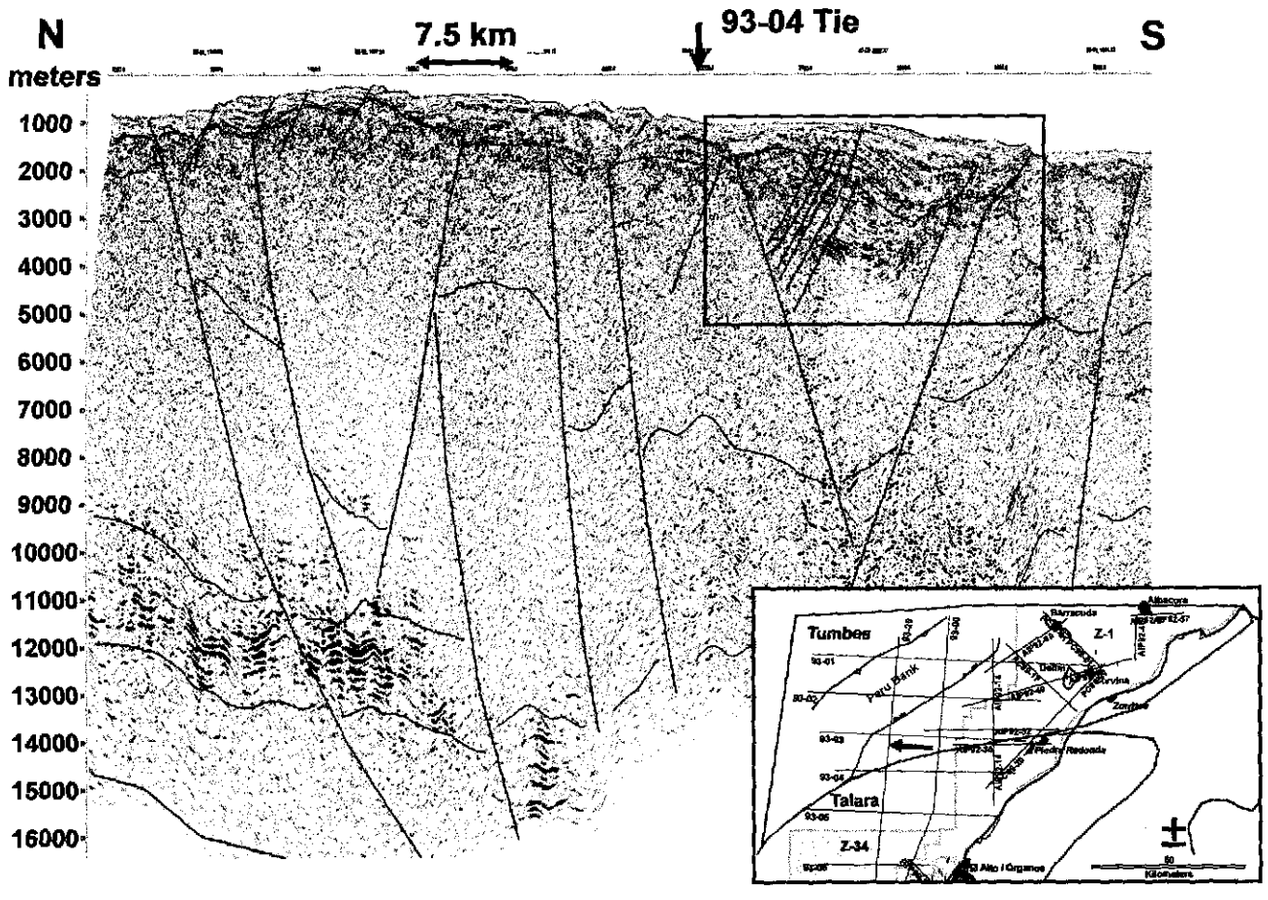
Seismic Index Map



Perú petro

Gaffney, Cline & Associates

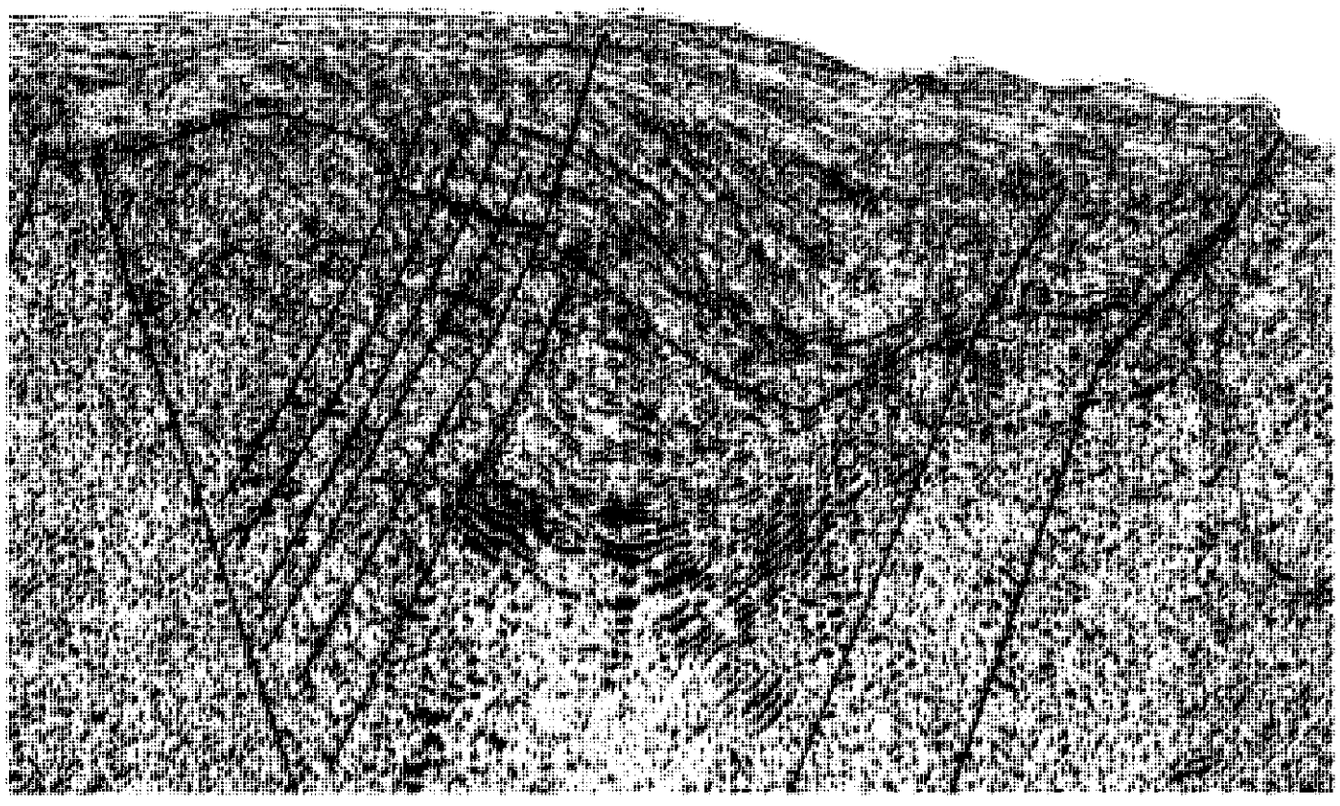
Strike Line 93-20



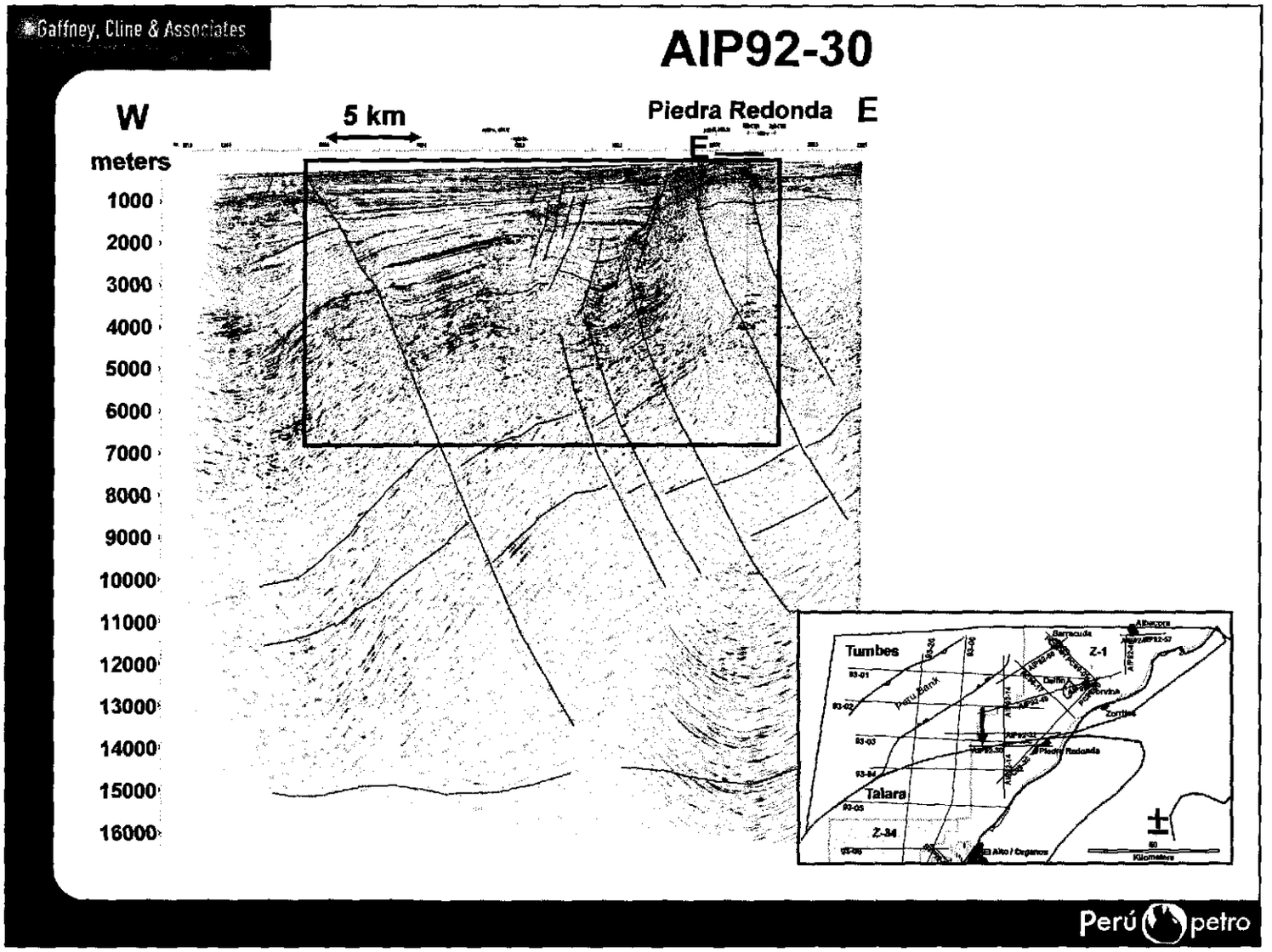
Perú petro

Gaffney, Cline & Associates

Line 93-20 Detail

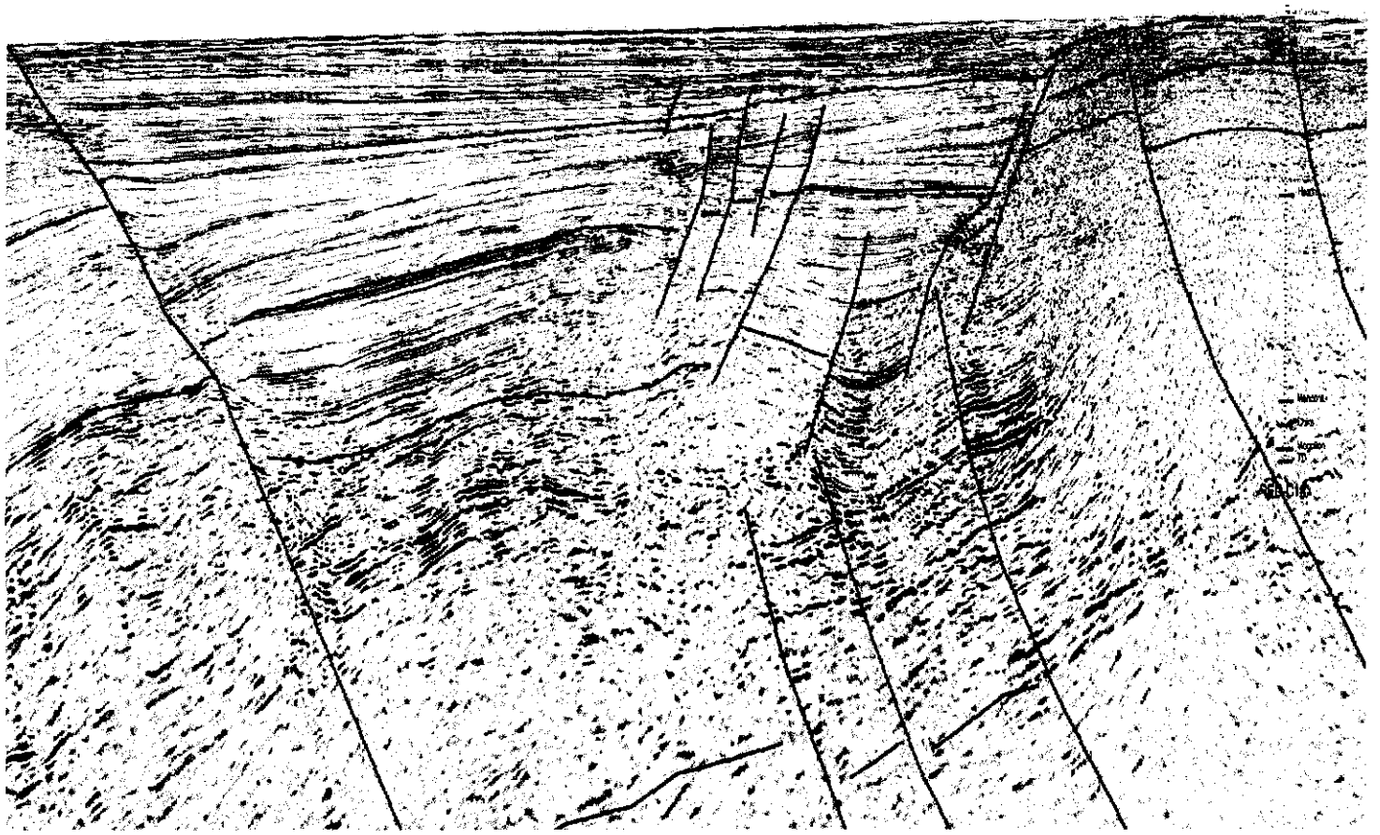


Perú petro


Gaffney, Cline & Associates
AIP92-30
W
5 km
Piedra Redonda
E
meters
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
Tumbes
Z-1
Talara
Z-34
Perú petro

Gaffney, Cline & Associates

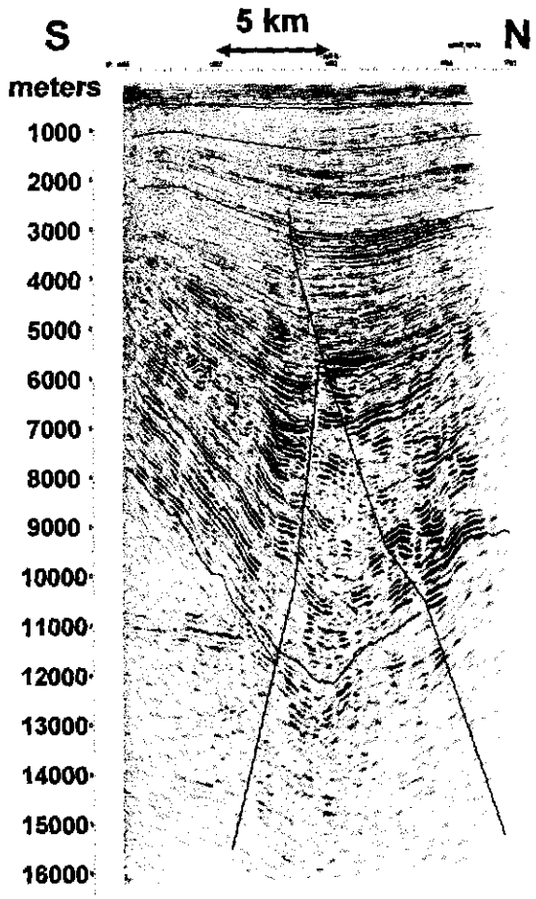
AIP92-30 Detail

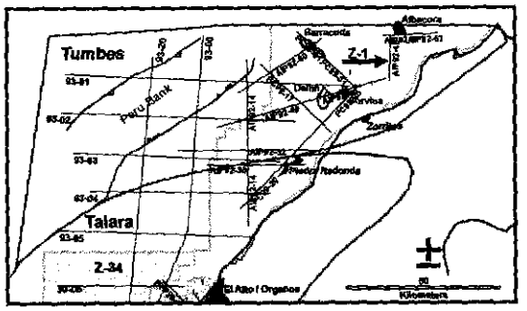


Perú petro

Gaffney, Cline & Associates

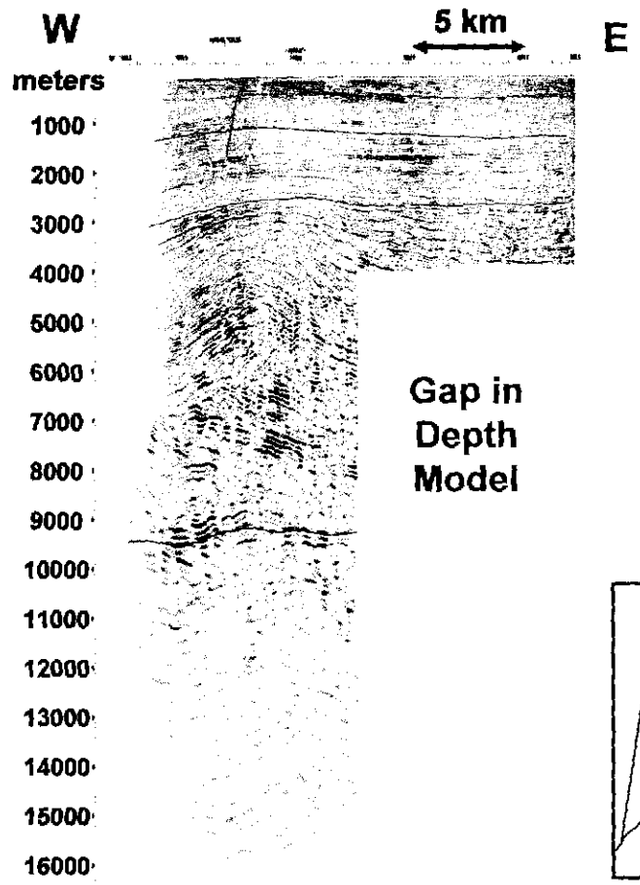
AIP92-46

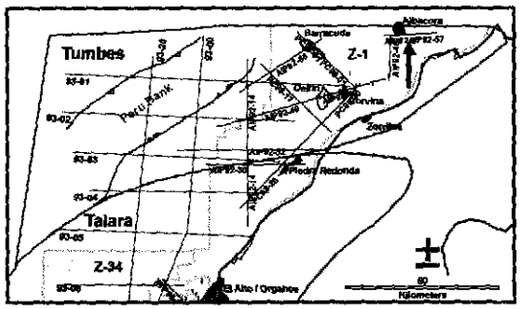




Gaffney, Cline & Associates

AIP92-57

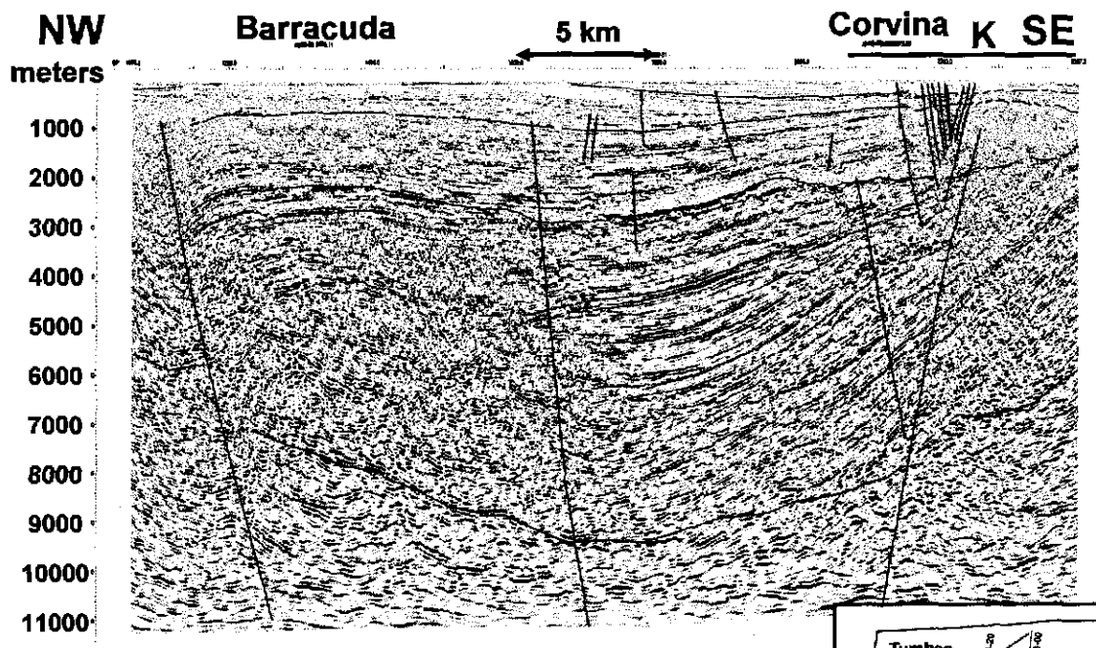


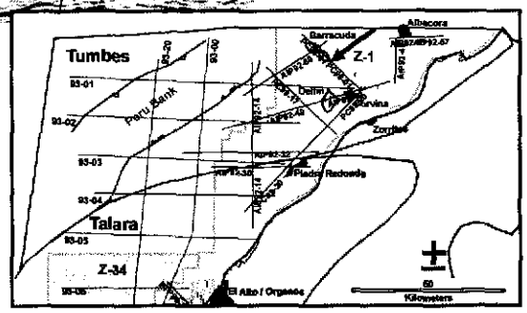


Perú petro

Gaffney, Cline & Associates

PC99-01





Perú petro

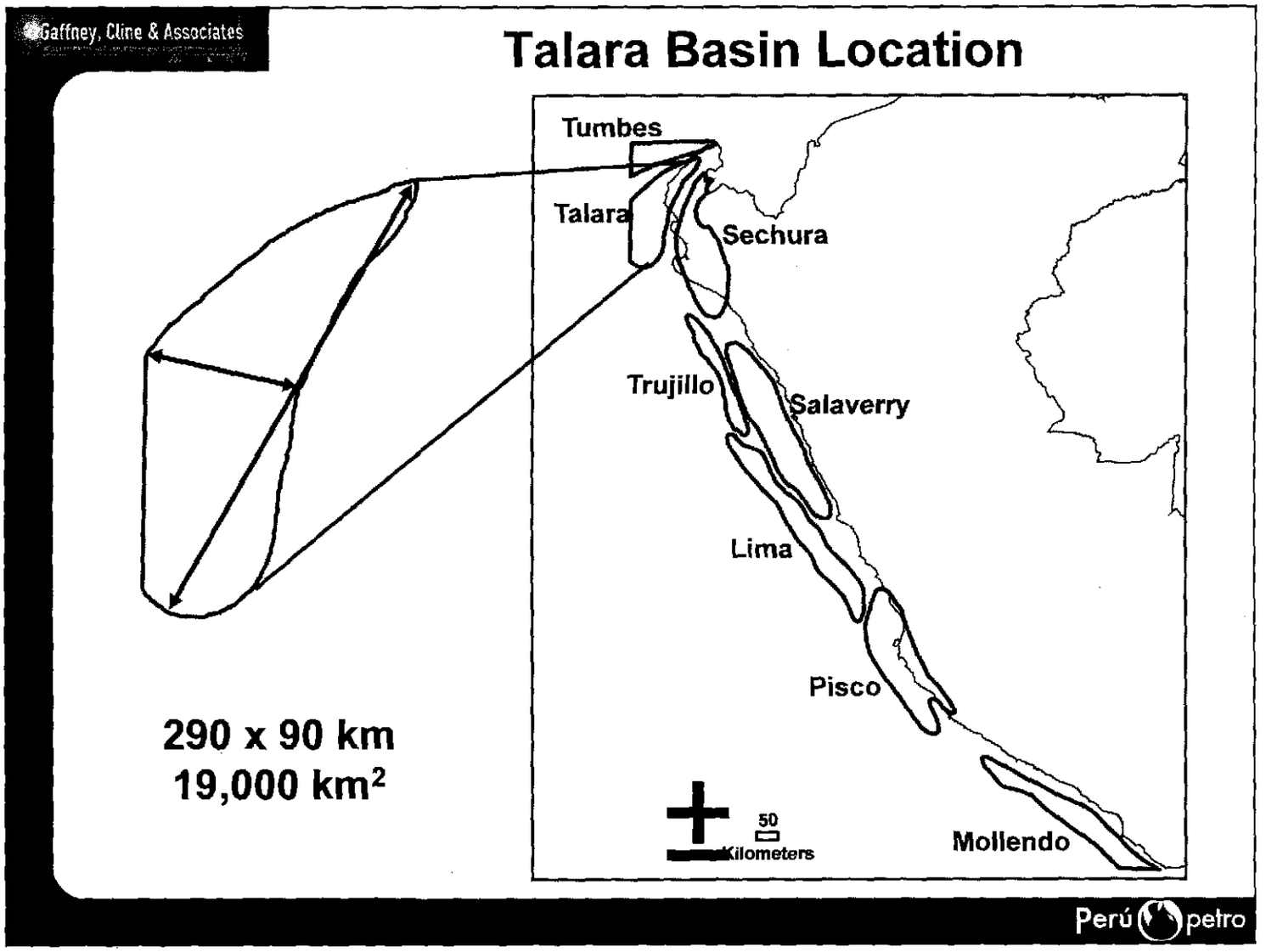
Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Talara Basin

Perú petro

This Basin Presentation is part of the Final Report for the larger study entitled, "Sequence Stratigraphy Analysis of the Peruvian Offshore Continental Shelf-Slope." This study was funded by the USTDA, and was executed by Gaffney, Cline & Associates for PERUPETRO.



The Talara basin outline as originally furnished by PERUPETRO extends 100 km offshore and includes the Peru Trench in over 5,000 meters of water. Later in this presentation, a case is made for modifying this outline to represent a genetically and practically more workable limit for this basin.

Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

This presentation begins with the conclusions and a quick review of the data, and is followed by discussion of possible hydrocarbon source rocks, reservoirs and leads (including expected water depths and drilling depths). It finishes with recommended exploration plans and several economic scenarios.

Gaffney, Cline & Associates

Talara Conclusions

- Long-standing petroleum system proved with first onshore discovery in 1869
- Thick offshore Cretaceous and Tertiary section with abundant source and reservoir potential
- Numerous undrilled leads in shallow to moderate water depths and reasonable drilling depths
- Reservoir location and quality are risks, especially offshore from established production, where 2D seismic is poor
- Petro-Tech has a dominant acreage position, and Gold Oil has secured Block Z-34 recently, but attractive areas are still available at the north and south ends of the basin

Perú petro

Talara is a basin of contrasts. On the one hand, at least one petroleum system has produced oil for more than 130 years, from many reservoirs that have been penetrated by thousands of wells. On the other hand, very little offshore exploration has been done in water depths greater than 200 meters. Despite the proximity of the Peru Trench to the west, there are still significant areas of relatively broad shallow shelf, especially at the northern and southern extremities of the basin, where the chances for source and reservoirs are favorable and where abundant structural leads exist. Petro-Tech is the dominant player, but attractive open areas to the north and south are still available.

Gaffney, Cline & Associates

Outline

- Conclusions
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Perú petro

PERUPETRO furnished unlimited access to their data archives. The gross volume of data available for this study was therefore extremely large, requiring considerable effort in organizing and distilling it into a useable project database.

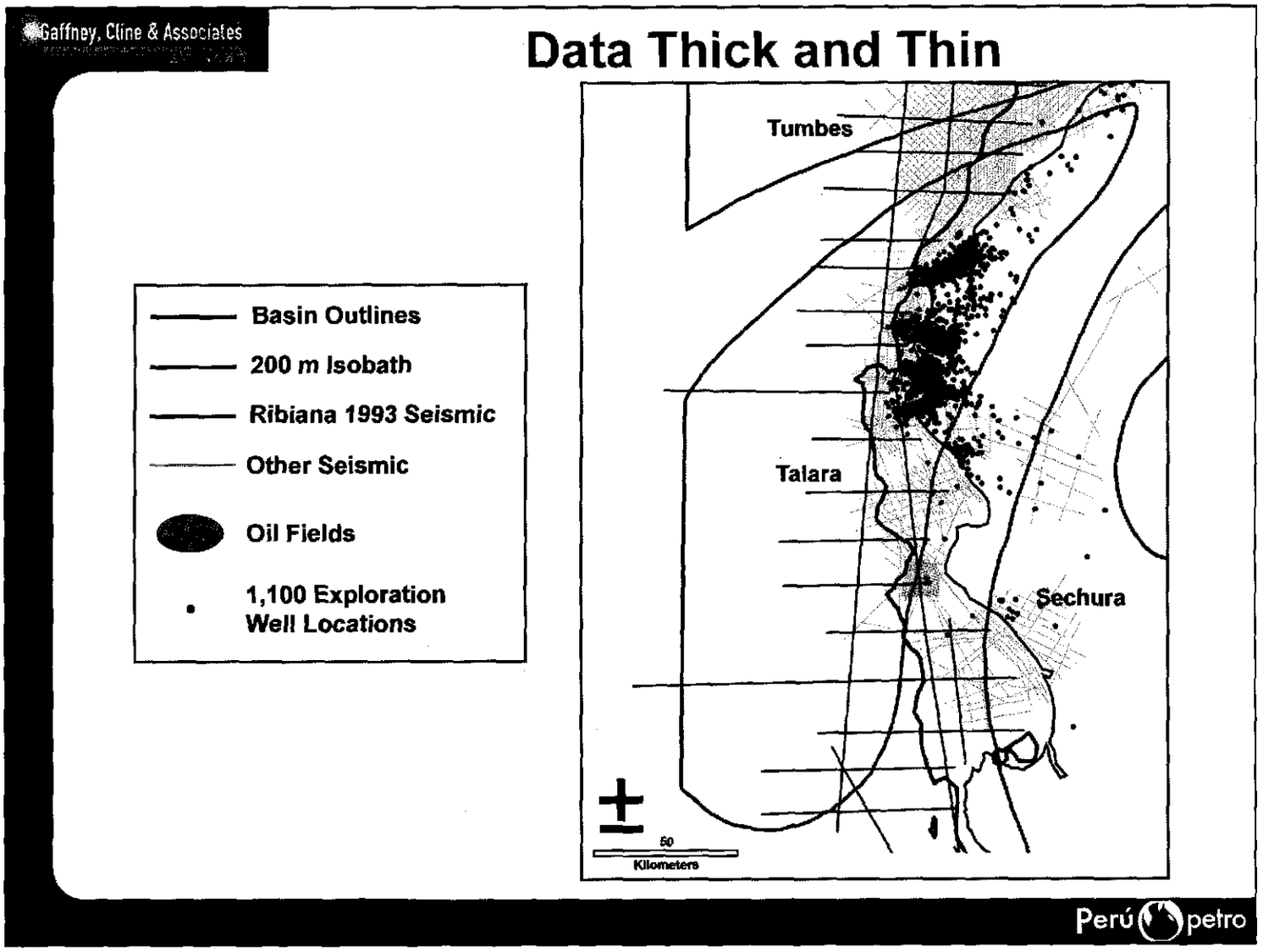
Gaffney, Cline & Associates

The Project Database

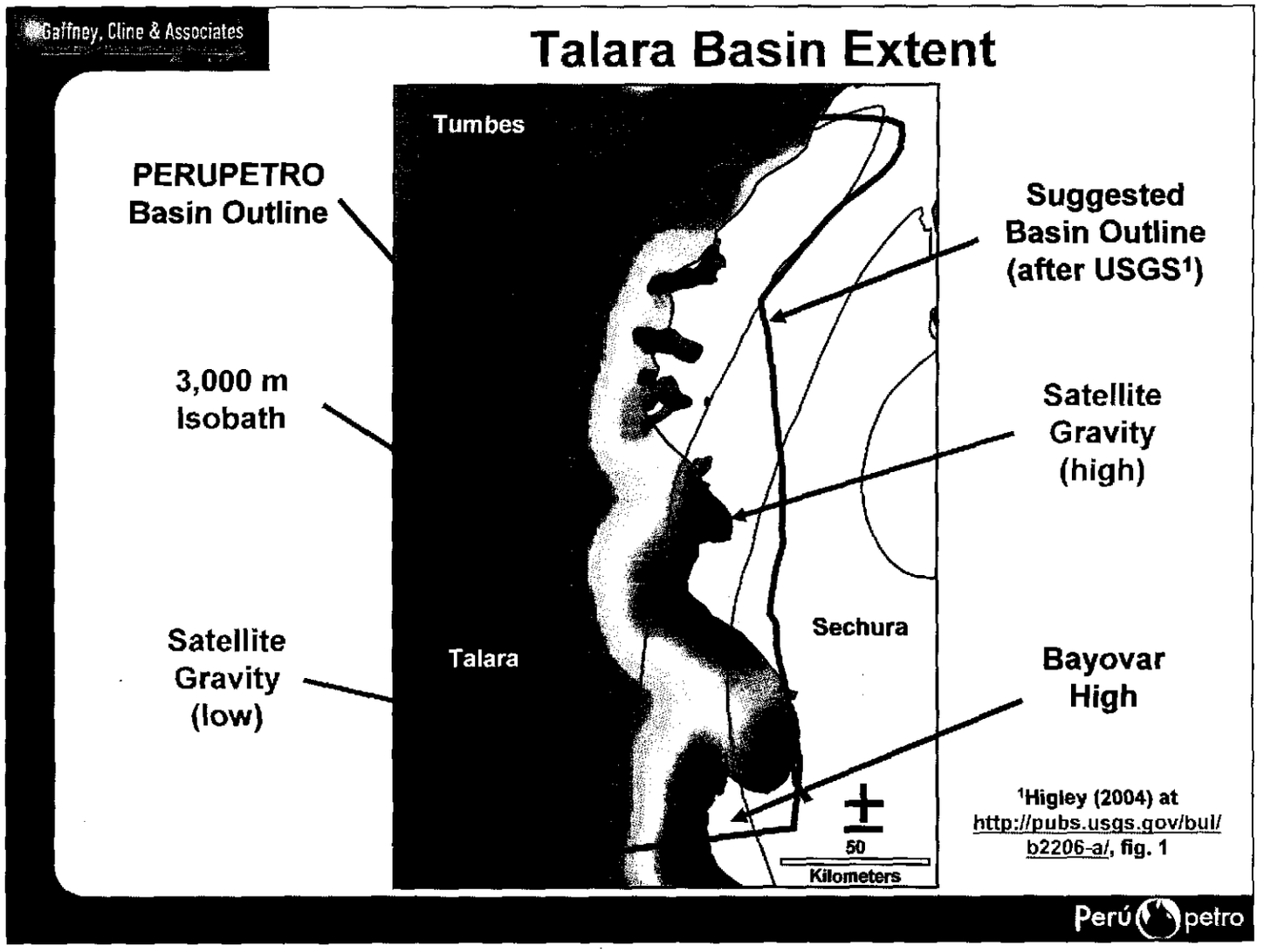
- **Final Report (paper)**
  - **Executive Summary**
  - **Basin Presentations**
  - **Other Required Sections**
    - Economics, Regulatory, Environmental and others
  - **Enclosures**
    - Selected maps, logs and cross sections
- **Digital Database (DVDs)**
  - **Final Report**
  - **ArcView Interactive Map**
  - **3 SMT Kingdom Suite Projects**
  - **Standard-format Exports**
  - **Detailed Appendices**
    - Geology, Wells, Seismic Interpretation, Tectonics, Depth Conversion, Maturation, Environmental

Perú petro

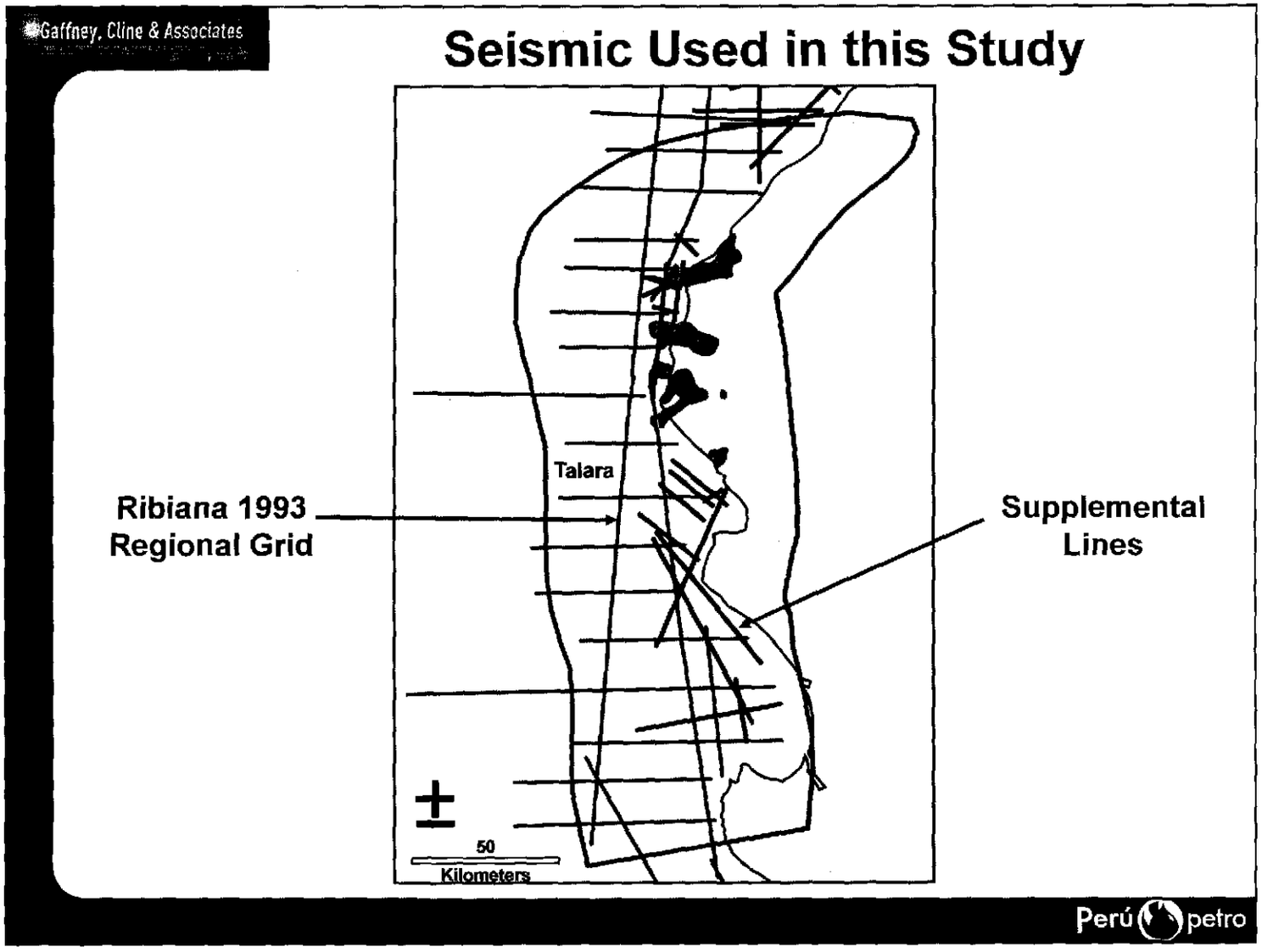
The project database for the Talara basin exists in several forms. First, there is an SMT Kingdom Suite project that covers both the Tumbes and Talara basins. This integrated project is available as part of the Digital Database that is packaged on DVDs with this report. The contents of this project were also exported into SEG-Y, LAS and other standard formats for loading into other workstation software. The Digital Database also contains an ArcView Interactive Map that was used to produce the map-based graphics in this presentation. It contains surface location data for wells and seismic, gravity and magnetics, geo-registered images of all of the maps produced in this study and a wide variety of other useful map-based data. Selected maps and cross sections are included in the Enclosures. Lastly, the Final Report contains several Appendices that contain discipline-specific detailed discussions as listed above.



More than 12,000 exploration and development wells have been drilled in the Talara basin, but most of those are onshore. Petro-Tech Peruana reports that their offshore Z-2B block contains 1,350 wells – again, mostly development. Less than 150 exploration wells have been drilled offshore, most as step-outs from existing fields, very few of which have been in greater than 100 meters of water. This map shows a subset of 1,100 locations, as provided by PERUPETRO, that are classed as exploration wells, both offshore and onshore. The seismic picture is similarly thick in the shallow offshore, and thin in deeper water.



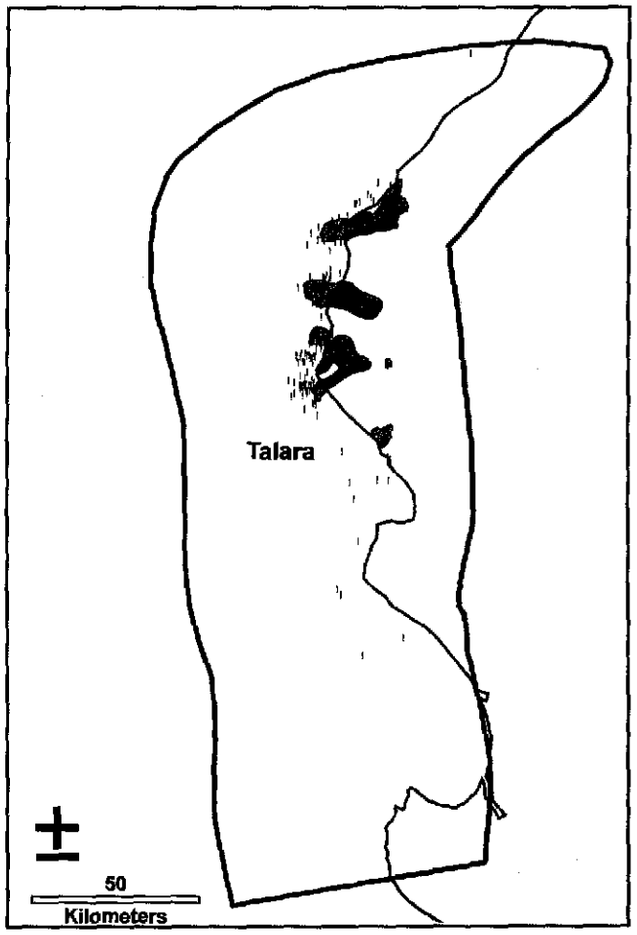
For this study, a modification of the Talara basin outline was used. It follows the basin limit used by the United States Geological Survey (USGS), except for the straight-line cut at the south over the Bayovar High. It was impossible to correlate Talara stratigraphy south of this limit. This new outline encompasses the entire continental shelf in this area, including the area that was formerly attributed to the Sechura basin. The extent of the shelf is seen clearly in the satellite gravity data. The western margin of the new outline roughly coincides with the 3,000 meter isobath, which marks what will likely be a practical drilling limit for the foreseeable future. The eastern limit is based on surface geology. The northern limit is somewhat arbitrary, as the sequences identified at the northern end of the Talara basin continue uninterrupted into the Tumbes basin.



The main basis for the new regional framework was the Ribiana 1993 seismic survey, which is shown in blue on the map. Supplemental lines (in red) were added to help tie the offshore well information to the regional grid. All of these lines in the project database were converted to depth. The depth traces, as well as the depth-converted horizons and faults are available in the SMT project and in exported SEG-Y and ASCII files in the Digital Database DVDs with this study.

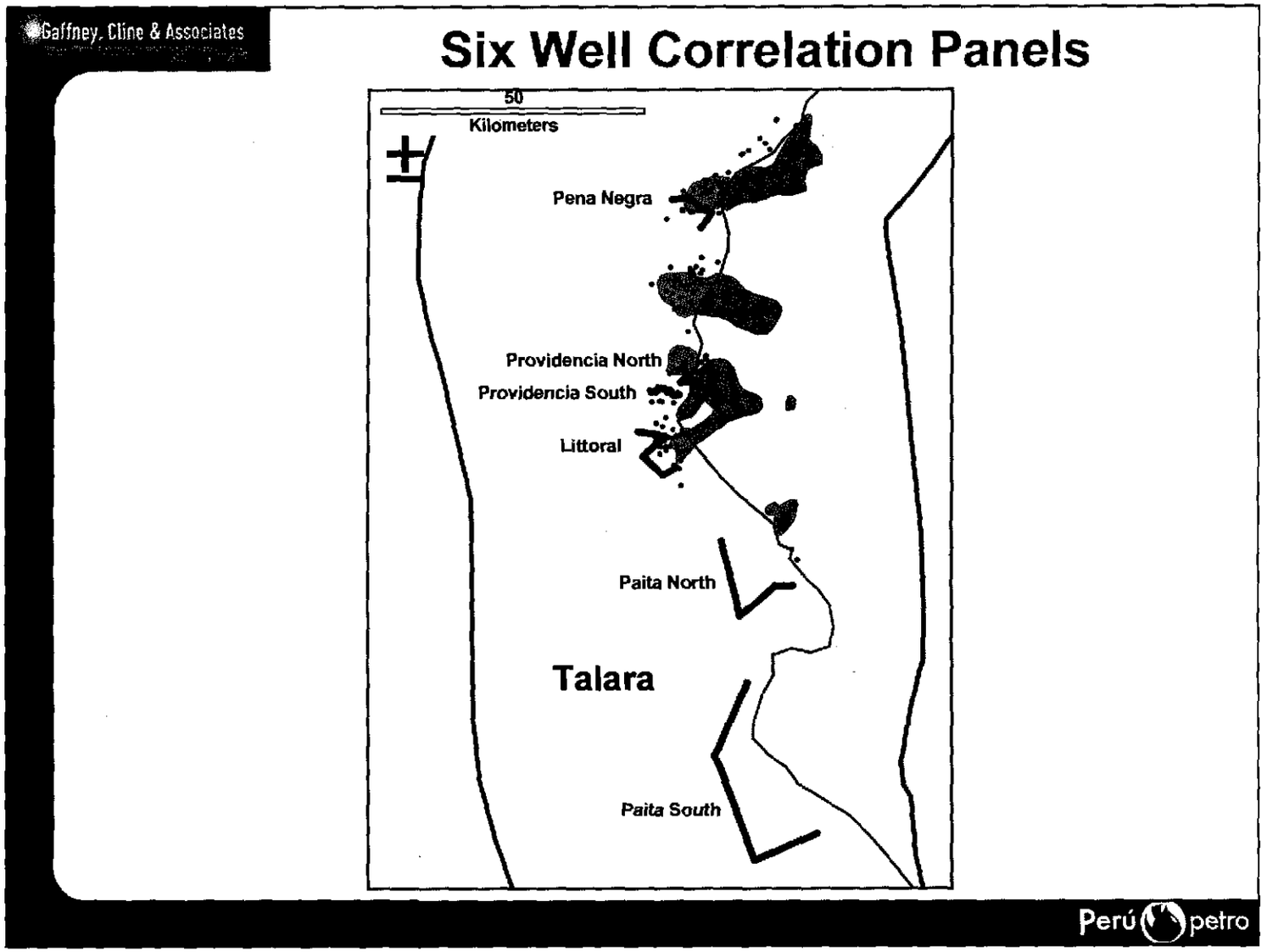
Gaffney, Cline & Associates

Wells in the Project Database



Perú petro

The project database was loaded with headers, tops and/or log data for the 220 well locations shown here. These 220 represent all of those wells from PERUPETRO for which additional data beyond name and location were available. Naturally, these wells were clustered in and near the old producing fields, with only a handful scattered elsewhere in the offshore. Once verified and re-interpreted, these data were exported from the SMT project database into an ASCII file. Both the SMT project and the ASCII file are provided in the Digital Database DVDs with this study.



Six detailed correlation panels were constructed to facilitate building the new regional framework. These panels were captured in high-resolution TIF images, which are included in the Digital Database DVDs with this study. A paper print of an example panel is also included as Enclosure 21.

Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

Hydrocarbon sources and potential reservoirs are relatively well-known in the Talara basin when compared to the other basins in the study area. The USGS has recently published a useful summary of current knowledge, which is available at http://pubs.usgs.gov/bul/b2206-a/. Several of the figures from this report have been used here to introduce the maps and sections in the new framework produced as part of this study.

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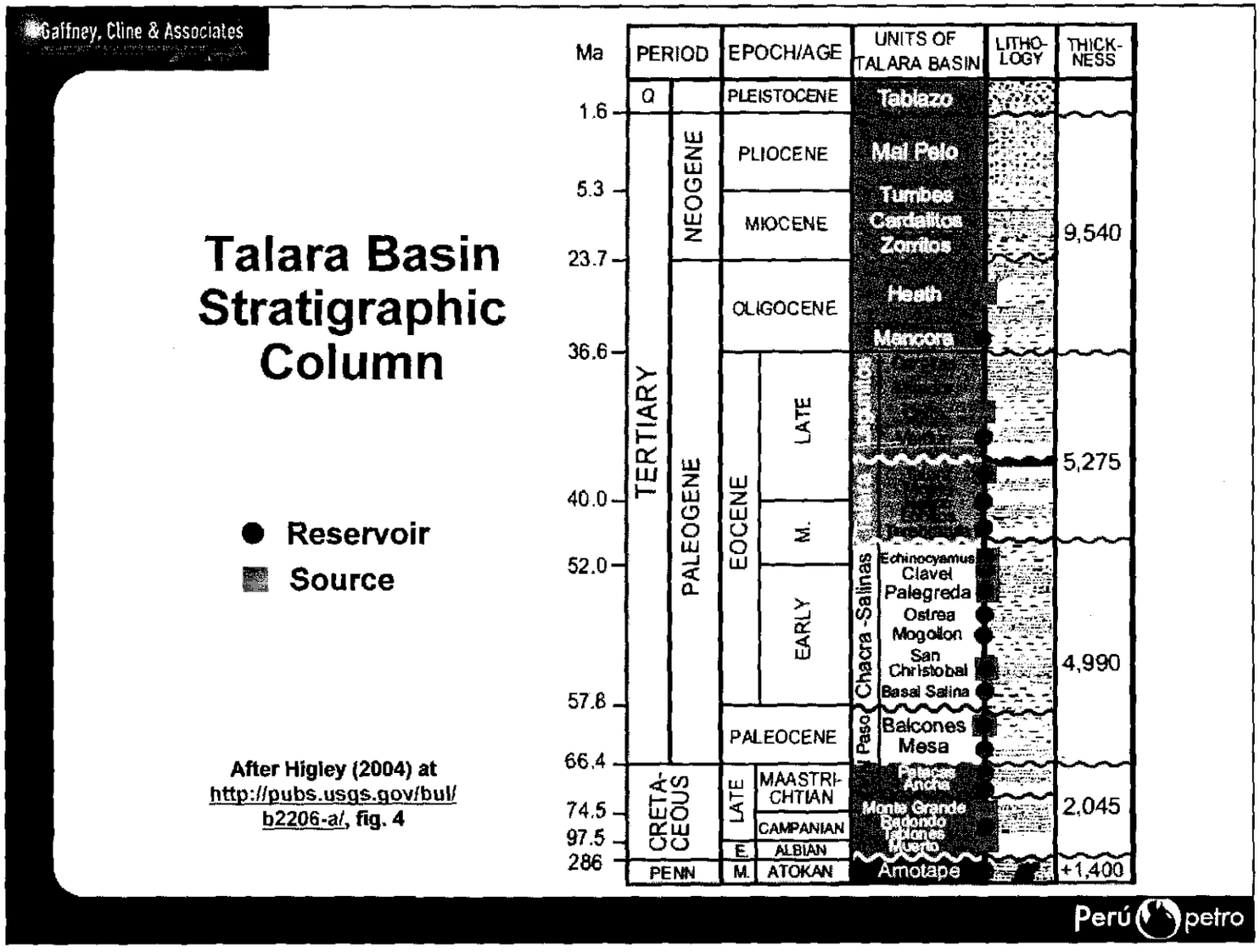
Proven Oil Province

- Oldest oil-producing region in Peru (first discovery in 1869)
- >1.8 BBO produced to date, 85% onshore
- USGS estimate ~1.6 BBO left (USGS), 85% offshore
- Very little published on source rocks, but mature Cretaceous source is likely
- Deeply buried Paleocene and Eocene also contain potential source rocks
- High-quality proven reservoirs from Cretaceous to Oligocene (+ Late Paleozoic fractured quartzite)

Perú petro

The Talara basin is one of the oldest oil-producing provinces in the world, having produced nearly 2 billion barrels of oil since the first discovery in 1869. The USGS estimates that there are 1.6 billion more barrels left to produce, with 85% of that potential existing in the offshore. In spite of this level of activity, little has been published on source rocks, although conventional wisdom points to the Cretaceous Muerto Formation as one of the likely sources, in addition to source potential in the Paleocene and Eocene. Proven reservoirs are distributed widely through the Cretaceous-to-Oligocene interval.



This is a useful summary of the local formation names for the suspected Cretaceous-to-Oligocene source rocks and proven reservoirs in the Talara basin.

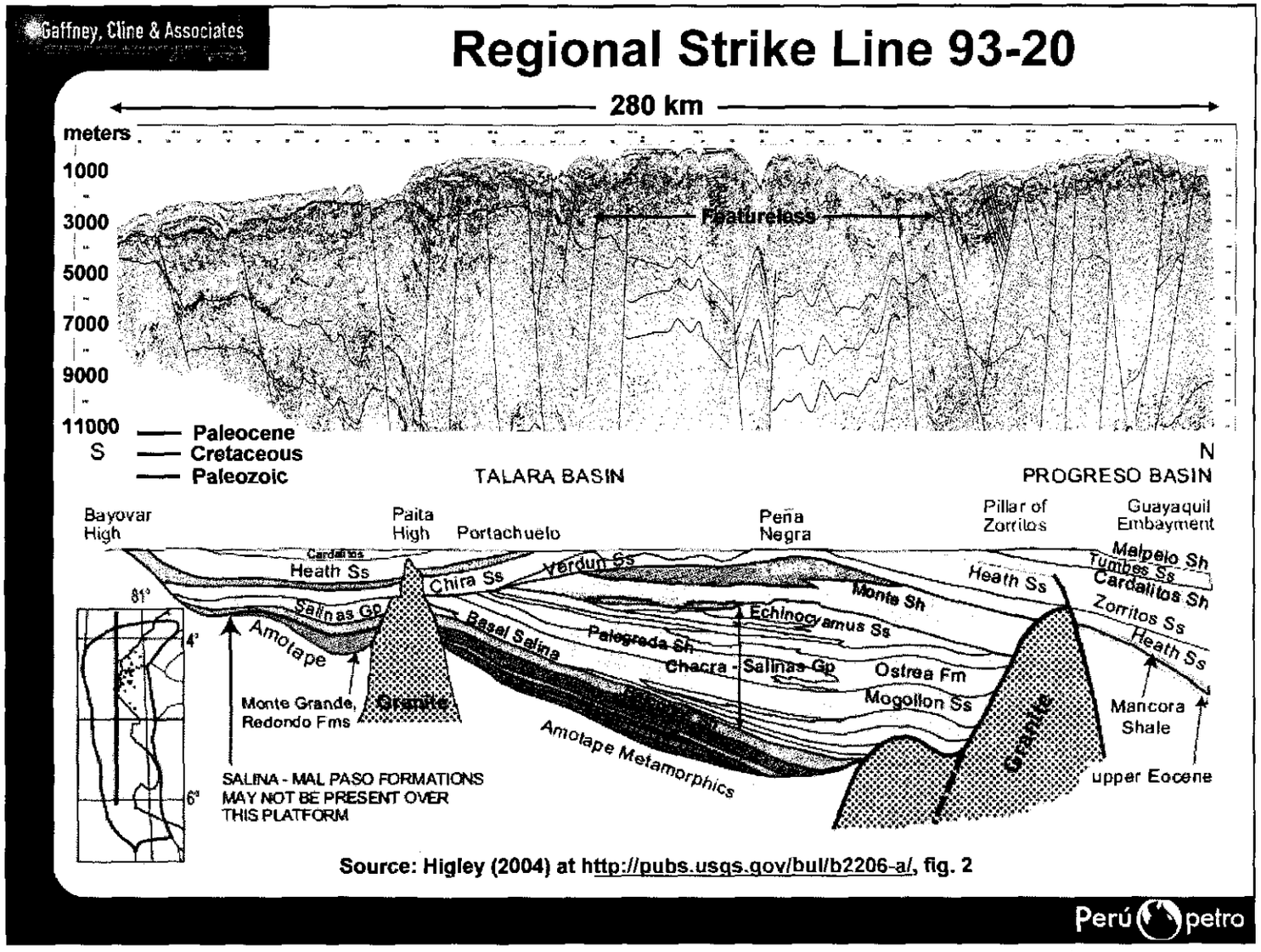
Gaffney, Cline & Associates

Talara Seismic Horizon Legend

- 1_ts_a_1_Quaternary_Waterbottom (pae)
- 1_ts_b_2_Pliocene_Mal_Pelo (pae)
- 1_ts_c_3_Late_Miocene_Tumbes (pae)
- 1_ts_j_9_Latest_Eoc_Oligocene_Heath (pae)
- 1_ts_m_13_Paleocene (pae)
- 1_ts_m_13_Paleocene_overthrust (pae)
- 1_ts_n_14_Cretaceous (pae)
- 1_ts_n_14_Cretaceous_overthrust (pae)
- 1_ts_o_15_Cretaceous_Muerto? (pae)
- 1_ts_o_15_Cretaceous_Muerto?_overthrust (pae)
- 1_ts_p_16_Paleozoic (pae)
- 1_ts_p_16_Paleozoic_overthrust (pae)
- 1_ts_q_17_Crystalline_Bsmt (pae)
- 1_ts_r_18_intra-continental_bsmt_1 (pae)
- 1_ts_s_19_intra-continental_bsmt_2 (pae)
- 1_ts_t_20_top_oceanic_crust (pae)
- 1_ts_t_20_top_oceanic_crust_overthrust (pae)
- 1_ts_t_21_base_upper_oceanic_crust (pae)
- 1_ts_t_21_base_upper_oceanic_crust_overthrust (pae)
- 1_ts_u_22_top_transitional_crust (pae)

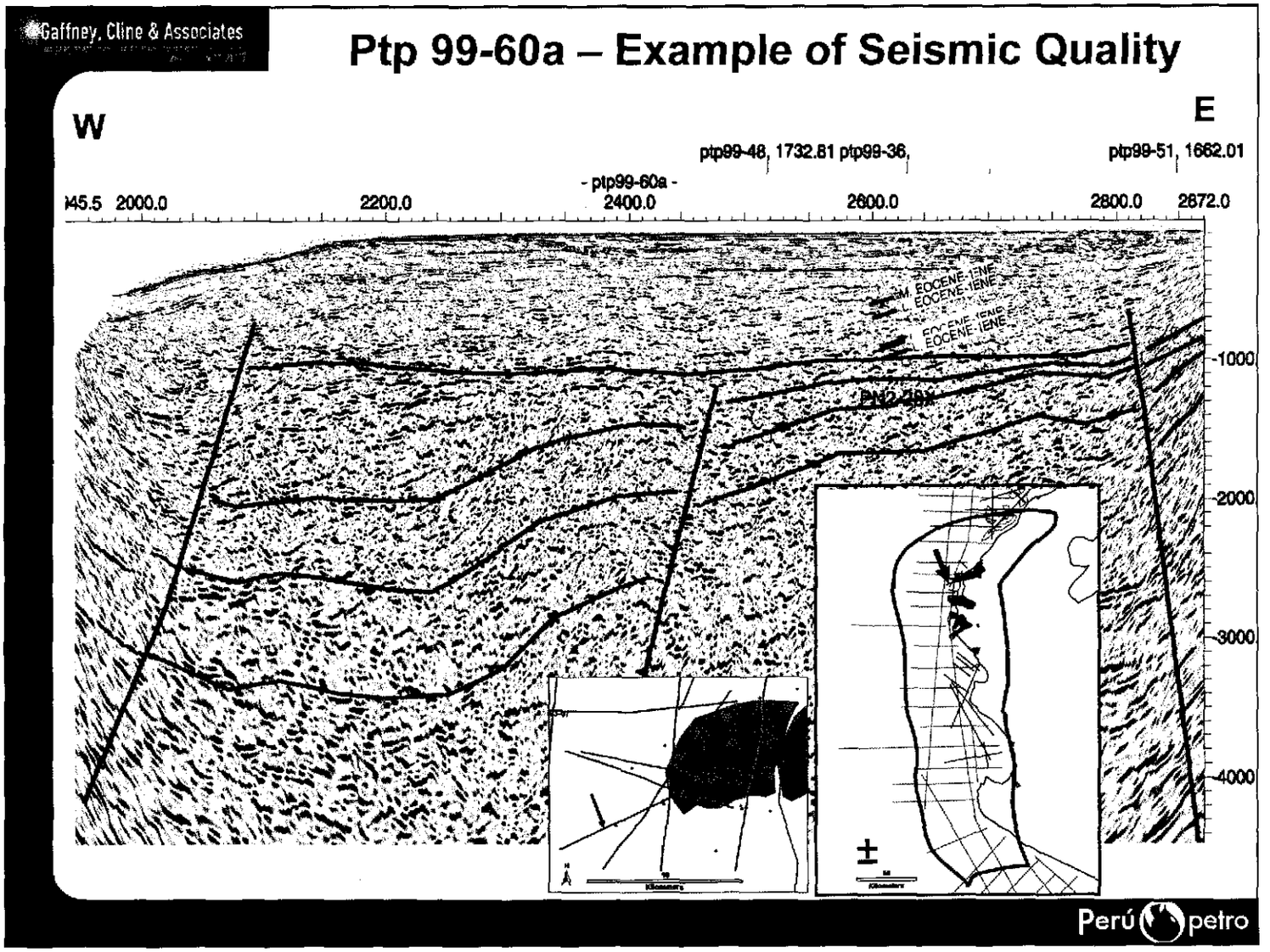
Perú petro

Numerous depth-converted seismic sections are included in this presentation. Refer to this chart to identify the interpreted horizons. In general, pink is Crystalline Basement, green is Cretaceous, red is Paleocene, and orange is Latest Eocene or Oligocene (Heath). Note that some of the horizons were entered twice to facilitate picking vertically repeated sections (due to overthrusting).

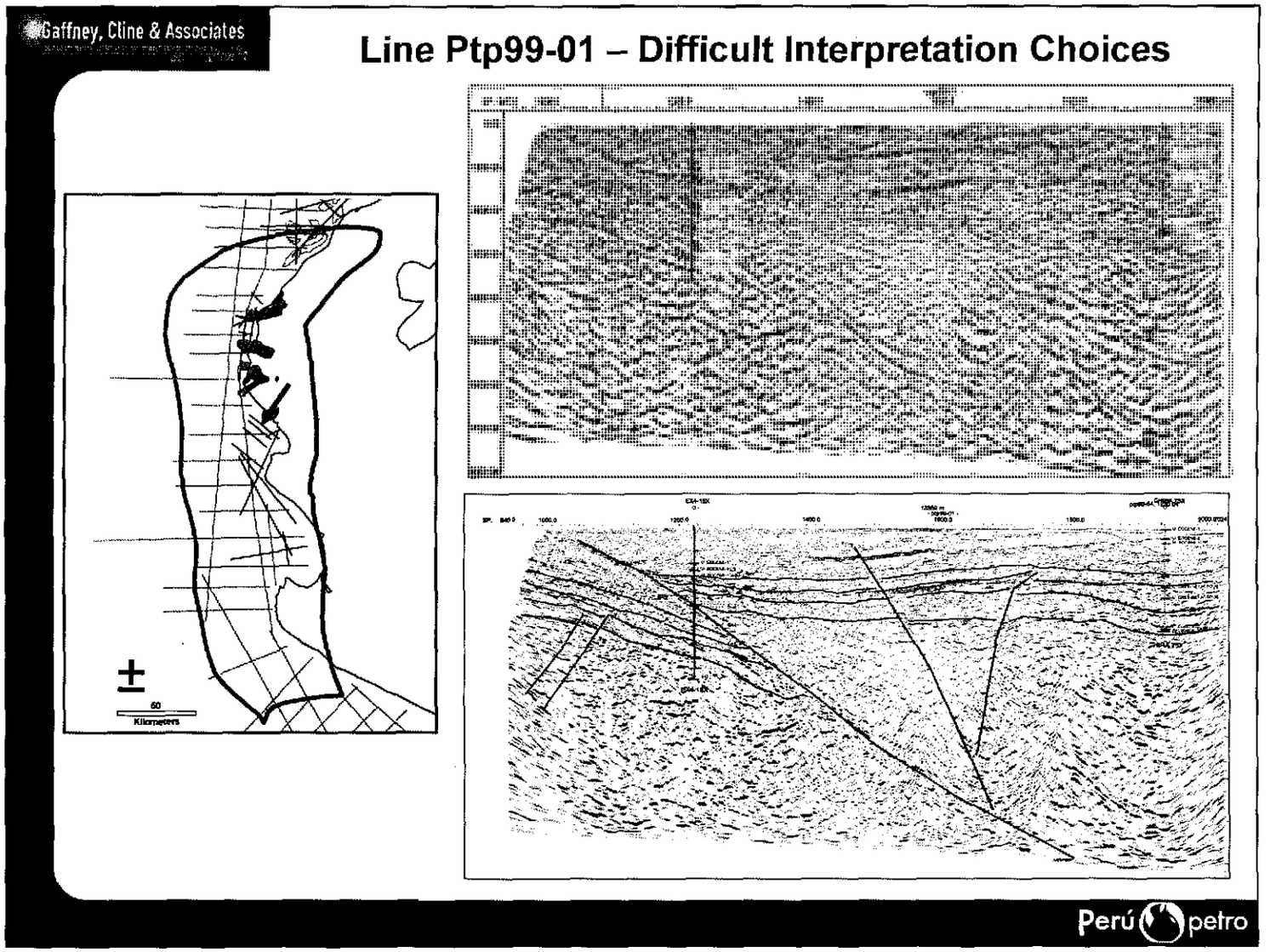


Source: Higley (2004) at http://pubs.usgs.gov/bul/b2206-a/, fig. 2

The USGS figure at the bottom is a general geoseismic section that roughly coincides with seismic line 93-20, which is shown at the top of the slide. While the subdivision of the post-Paleocene section in the geoseismic section is schematically useful, this level of detail is very difficult to see in the relatively featureless seismic. This featureless seismic character is typical of the Ribiana 1993 lines and the supplemental seismic lines near the known fields. The new framework was therefore limited to a few speculative horizons that correspond to the main sequences in this area. These speculative horizons include the top Paleozoic, Cretaceous, Paleocene and Quaternary (for water depth control).



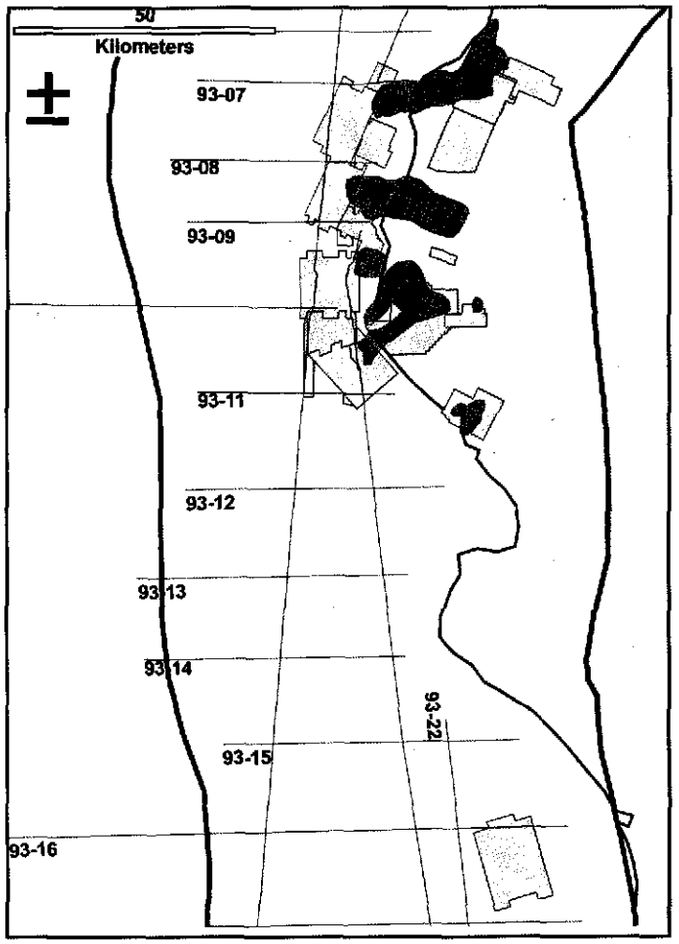
Here is a more detailed example of the challenge that faces anyone attempting detailed chronostratigraphy with the 2D seismic data on the shallow shelf immediately offshore from the known fields. This line ties into the offshore Pena Negra field, and again shows the featureless nature of these lines.



The well data did not make this correlation task any easier. In this example, the interpreter can either honor the well picks and draw correlation lines that cross this especially clear seismic horizon, or the seismic horizons can be honored and a thrust fault and repeated section interpreted, which was not reported in the left-hand well.

Gaffney, Cline & Associates

3D Surveys Available



Perú petro

Ideally, 3D seismic would be more helpful in sorting out the detailed structure and stratigraphy in this area. These are the available 3D surveys, as reported by PERUPETRO. However, an experienced operator in this area recently mentioned that this is one of those rare cases where the 3D confused the structural interpretation more than the 2D. In any case, these 3D surveys were not included in the Terms of Reference for this study, nor were they made available by PERUPETRO.

Gaffney, Cline & Associates

Talara Petroleum Systems Events Chart

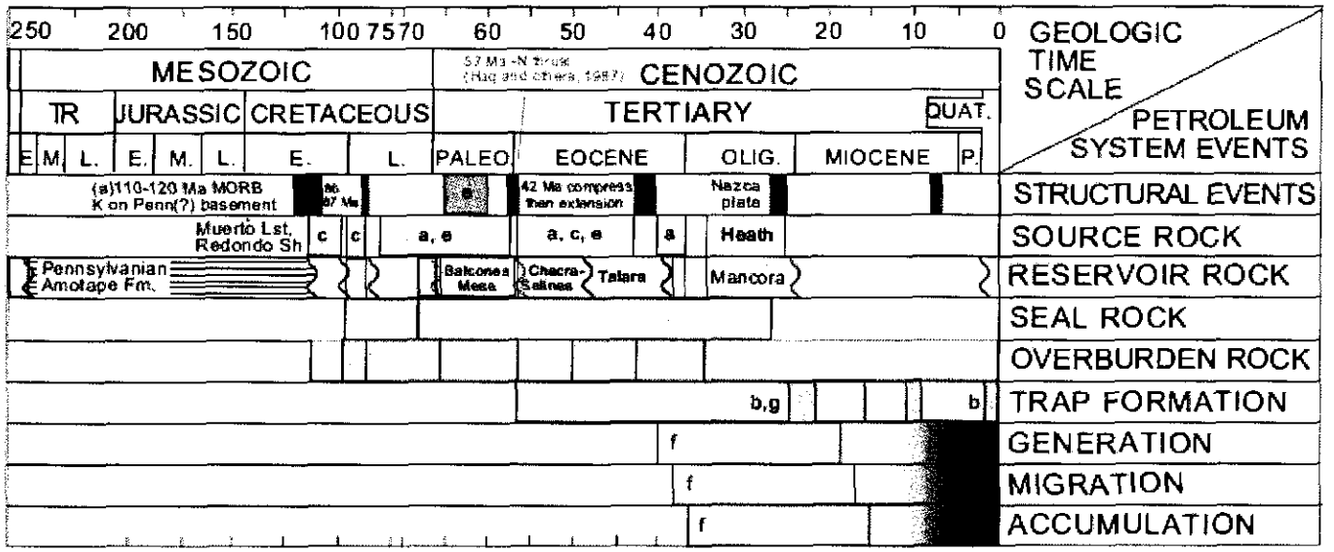
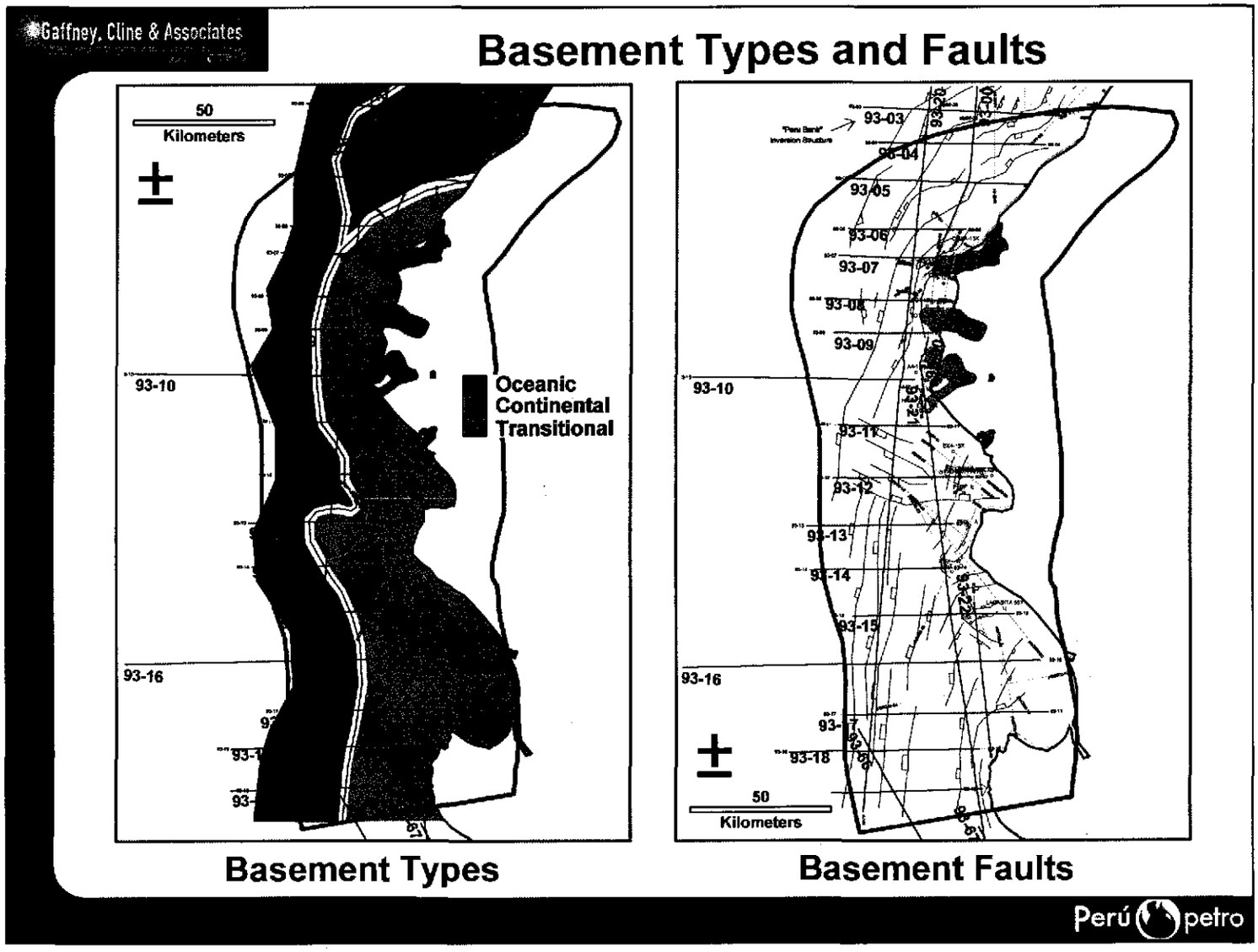


Figure 5. Total petroleum system events chart for the Cretaceous-Paleogene Assessment Unit 60810101, Talara Basin province. Gray and turquoise rectangles mark the time sequences of primary events. "P" in the geologic time scale is Pliocene time. MORB is Cretaceous (K) mid-oceanic ridge basalt on Pennsylvanian (Penn) basement rocks. Compression tectonism of the Andes Mountains during Eocene time (42 million years ago) was followed in Oligocene time by partitioning of the Farallon continental plate into the Cocos and Nazca Plates (Handschumacher, 1976; Marocco and others, 1995; Pilger, 1984). There is no published information available on hydrocarbon source rocks or timing of petroleum generation and migration; these interpretations are speculative. Ages of unconformities (wavy black lines) were determined from Sebrier and others (1988), Seranne (1987) and the sources (a) through (d) listed below. Letters (a) through (g) refer to the following sources: (a) AIPC (no author or date), (b) Jaillard and others (1995), (c) Perupetro (1999), (d) Petroconsultants (through 1996), (e) Zúñiga-Rivero and Hay-Roe (1998), and Zúñiga-Rivero and others (1998a), (f) Kingston (1994), (g) Shepherd and Moberly (1981).

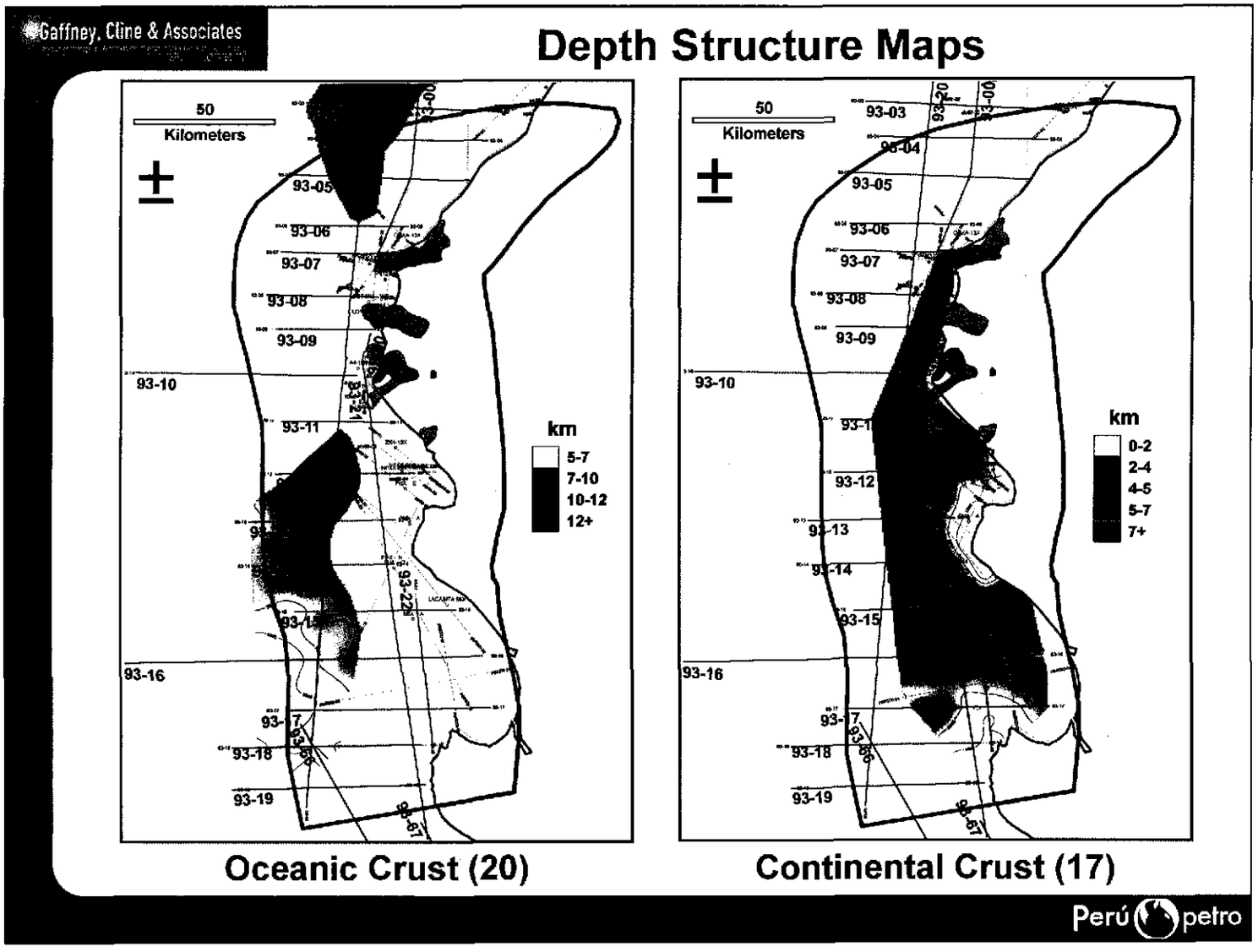
Source: Higley (2004) at http://pubs.usgs.gov/bul/b2206-a/, fig. 5

Perú petro

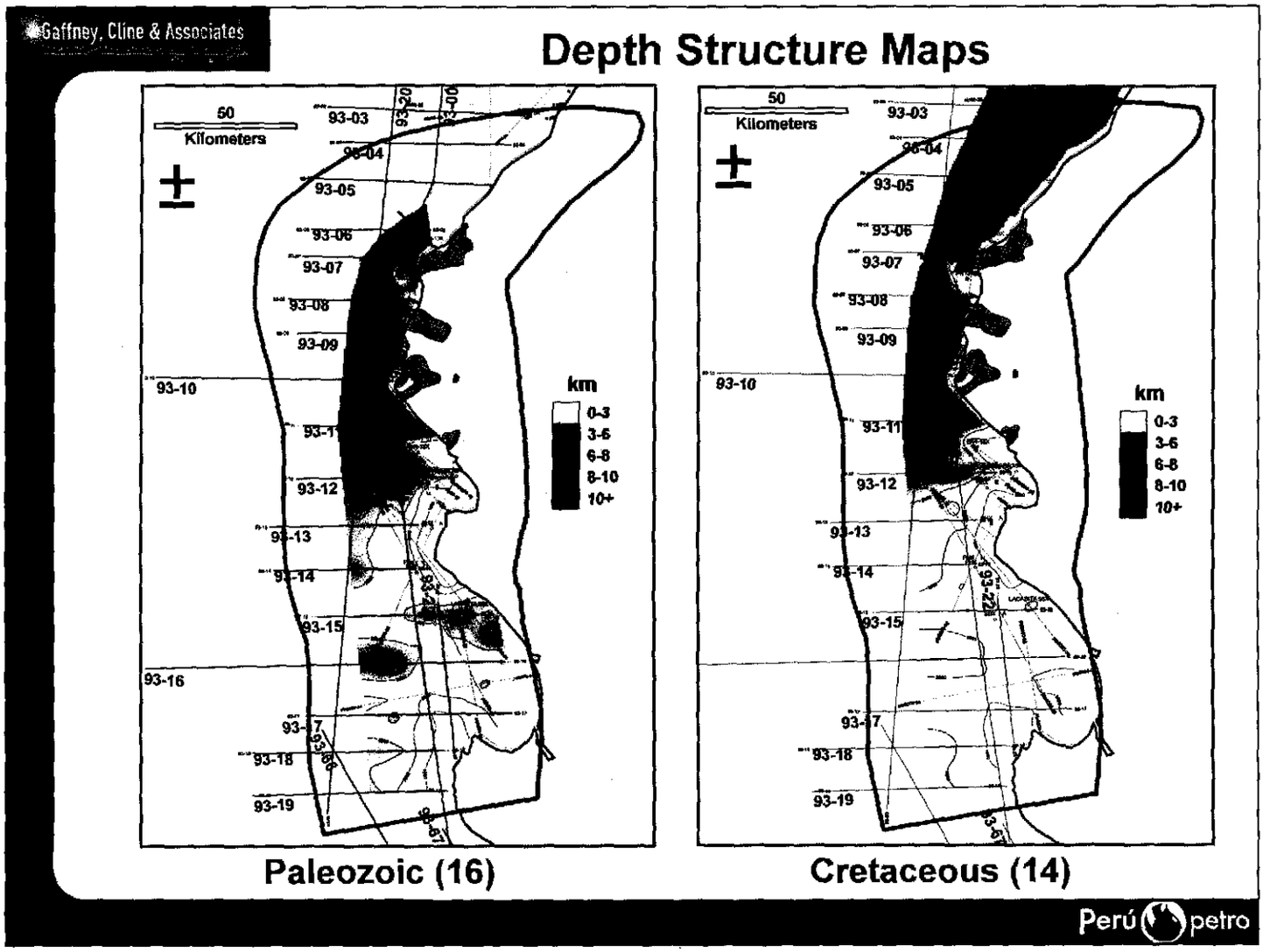
This USGS chart summarizes current thinking about the timing of key petroleum system events, based on the many sources listed in the figure caption. The new framework in this study is consistent with this view of multiple episodes of extension, compression and wrenching from Early Cretaceous through Pliocene time.



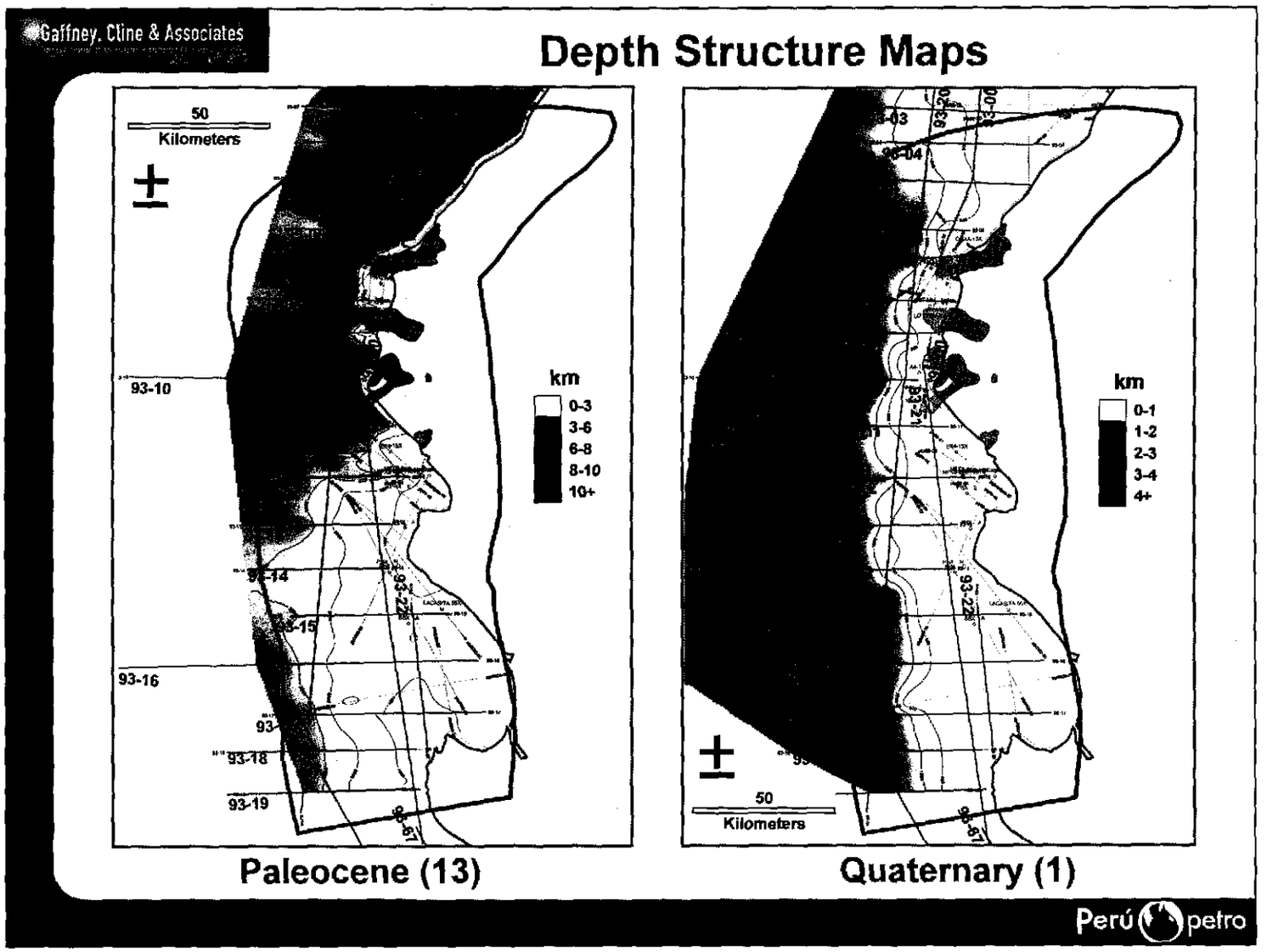
In spite of these data limitations, a new depth-converted framework of horizons, faults, maps and sections was produced. The first of the new map series shows the subcrop pattern for three different basement types, which corresponds closely with the satellite gravity data in slide 8 of this presentation. The second map shows the basement fault fabric that emerged from the new regional interpretation. The main set of faults trend north-northeast, with a second set at nearly right angles to the first.



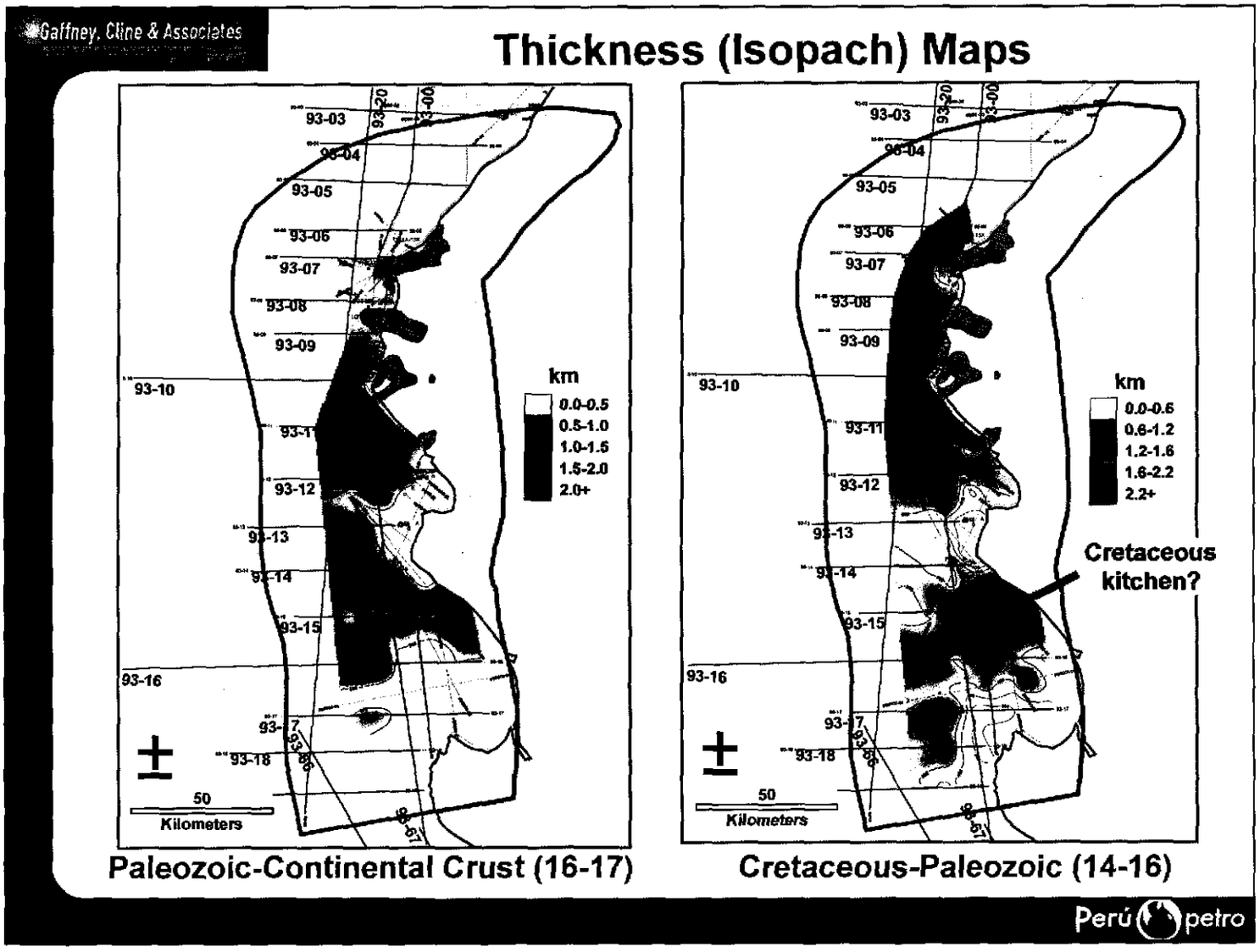
This slide begins the series of depth structure maps in the new framework. The numbers following the horizon names correspond to the legend in slide 15. The map on the left shows the depth to oceanic crust in two pods. Oceanic crust could not be seen on the seismic in the area between these pods. The map on the right shows the depth to continental crust. It is similarly limited to the area where continental crust could be identified on the seismic, although the limitation is not as pronounced as with the oceanic crust map. Both maps suggest that the total sediment column in the offshore may range up to more than 10 kilometers thick.



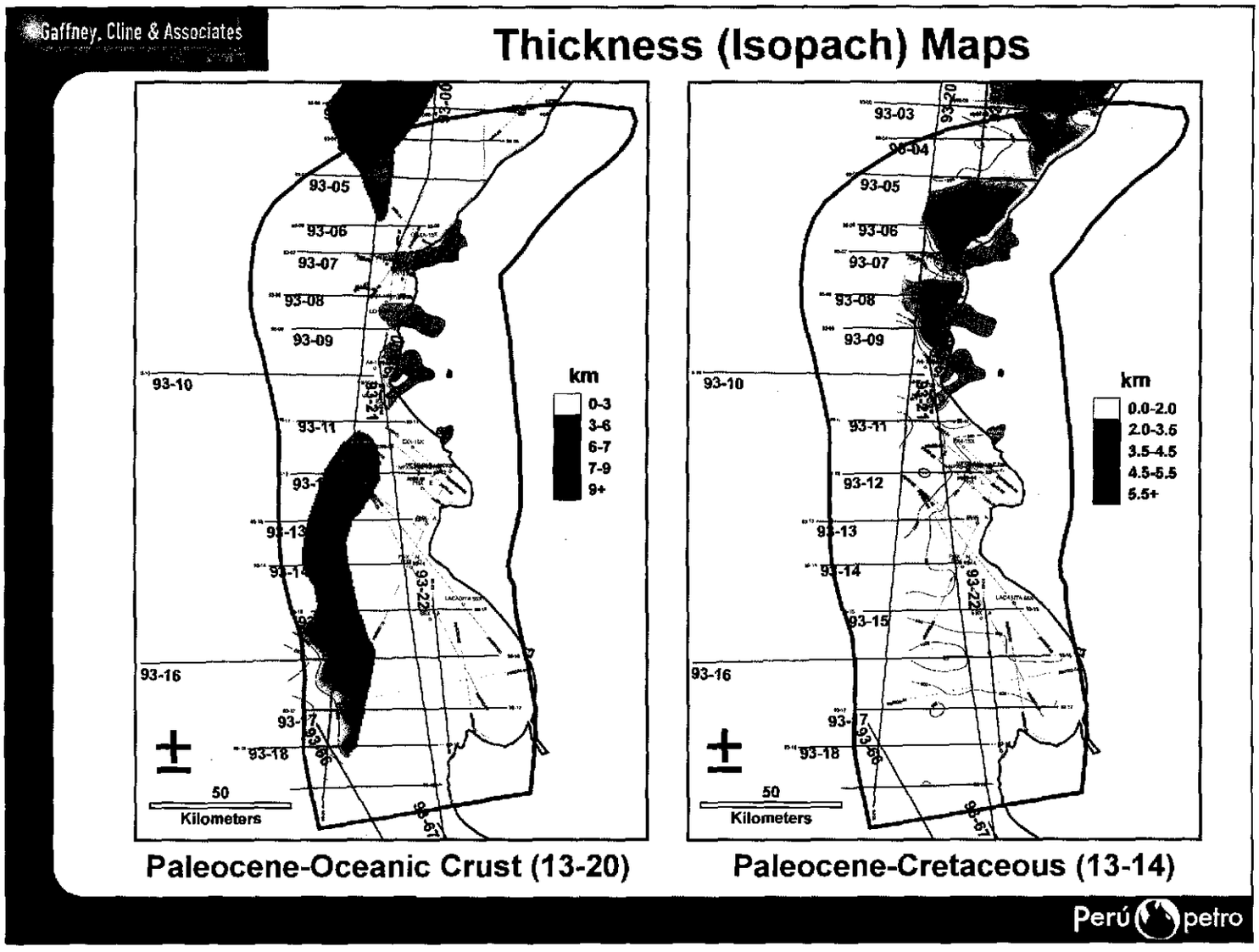
The left map shows depth to top Paleozoic over continental crust. Water depth in this area is less than 1 km, which suggests that the total post-Paleozoic sediment column is in the 9 km range. These thicknesses are confirmed later in the isopach maps in this presentation. Note the particularly deep Paleozoic offshore from the known fields, which may be an indication of the hydrocarbon kitchens that fed these structures. The Cretaceous horizon has the same general shape as the Paleozoic one. However, the extension of thick Cretaceous over the transitional crust into the Tumbes basin to the north is highly speculative. If it is not Cretaceous, then the Paleocene section would be particularly thick in this area.



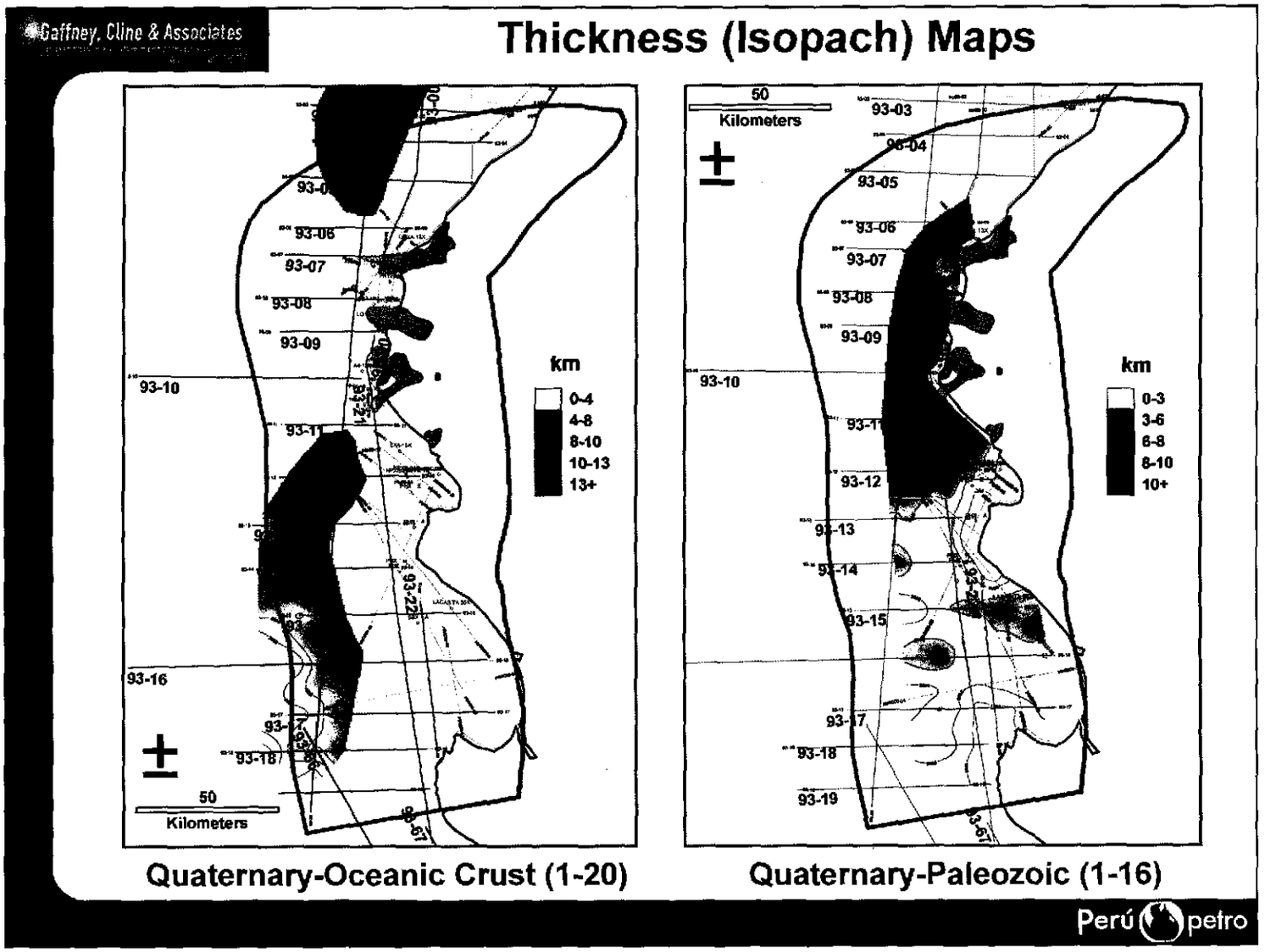
The Paleocene map shows the same depth trend, with a deep hole in the north that extends into the Tumbes basin. Lastly, the Quaternary map is essentially a map of water depth. The two deep (blue) holes on the west are a reflection of the Peru Trench, which is more continuous north-south than the grid indicates. The bull's-eyes are merely a function of the gridding process between these two widely-spaced lines (93-10 and 93-16).



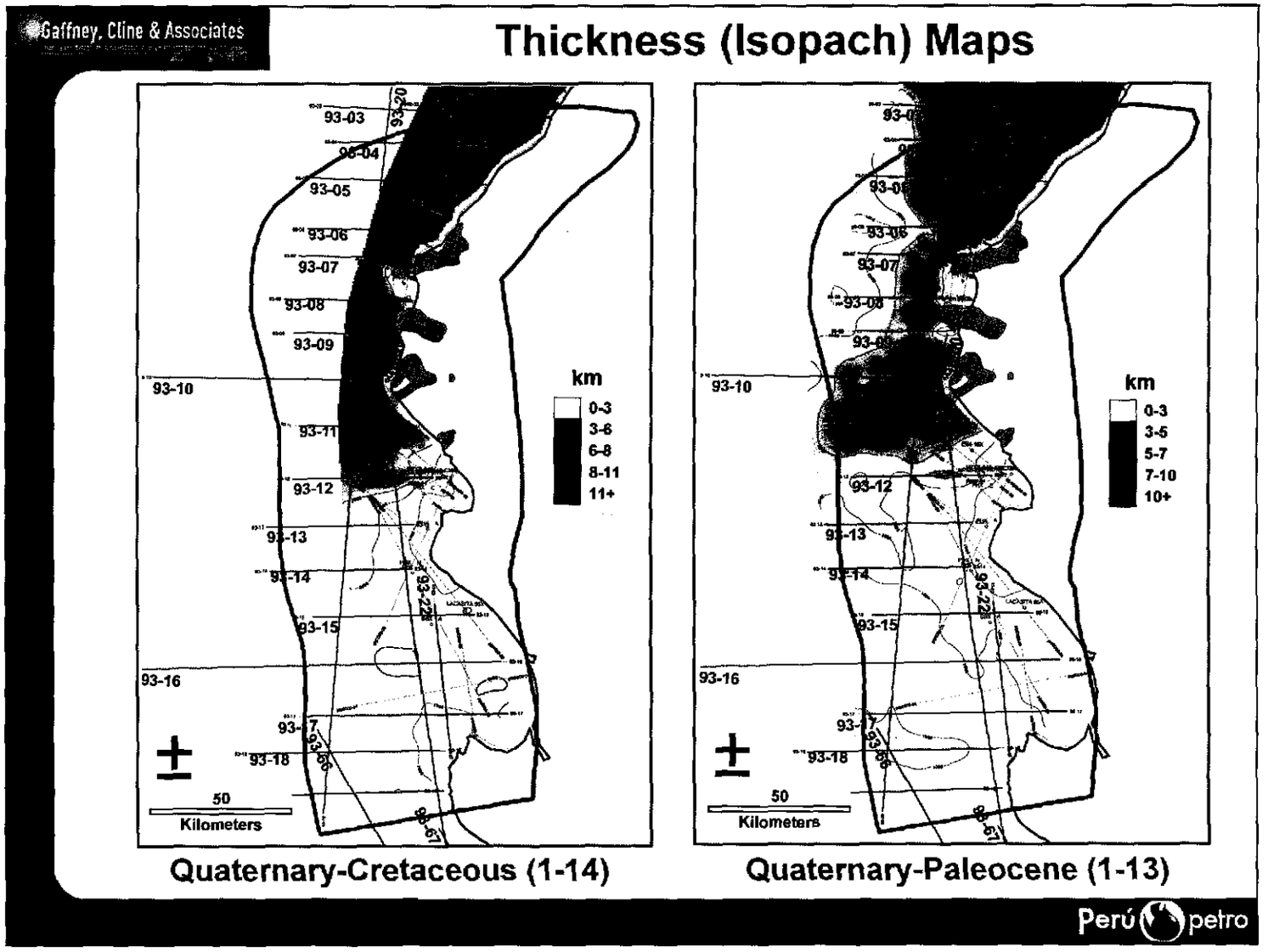
This next series of maps were generated from the previous set of depth structure maps. The first map represents the thickness of Paleozoic sediments. The oldest known reservoirs in the Talara basin are Paleozoic in age. The next map shows the thickness of Cretaceous sediments. Current thinking strongly suggests that the Early Cretaceous Muerto Formation is a likely hydrocarbon source in this basin. The Cretaceous is over 2,000 meters thick west of the known fields, and occurs at depths below 3,000 meters (see the Cretaceous Depth Structure Map in slide 23). This would likely be deep and hot enough for long enough to have generated both oil and gas. Also notice another Cretaceous thick in the southeast corner of the basin (marked with black arrow). This may be another Cretaceous kitchen.



These two maps together show the thickness of Paleocene sediments – both where they are deposited on oceanic crust and where they overly the Cretaceous. Conspicuous thicks are situated offshore from the known fields and north into the Tumbes basin. The Paleocene Mesa and Balcones formations host source and reservoir rock onshore. The deeper-water equivalents of these formations might be even more prolific in the offshore.



These maps show the total thickness of sediments in the Talara basin, which ranges up to more than 13,000 meters overlying oceanic crust to the west. The total thickness over continental crust to the east is in the same range, when the thickness in the right-hand map is added to the Paleozoic-Continental Crust (16-17) thickness map in slide 25.



These two maps complete the isopach map set by illustrating total post-Cretaceous sediment thickness and total post-Paleocene thickness. Both maps show the same thicker-to-the-north trend of the previous maps, as well as pronounced thicks immediately offshore of the known fields.

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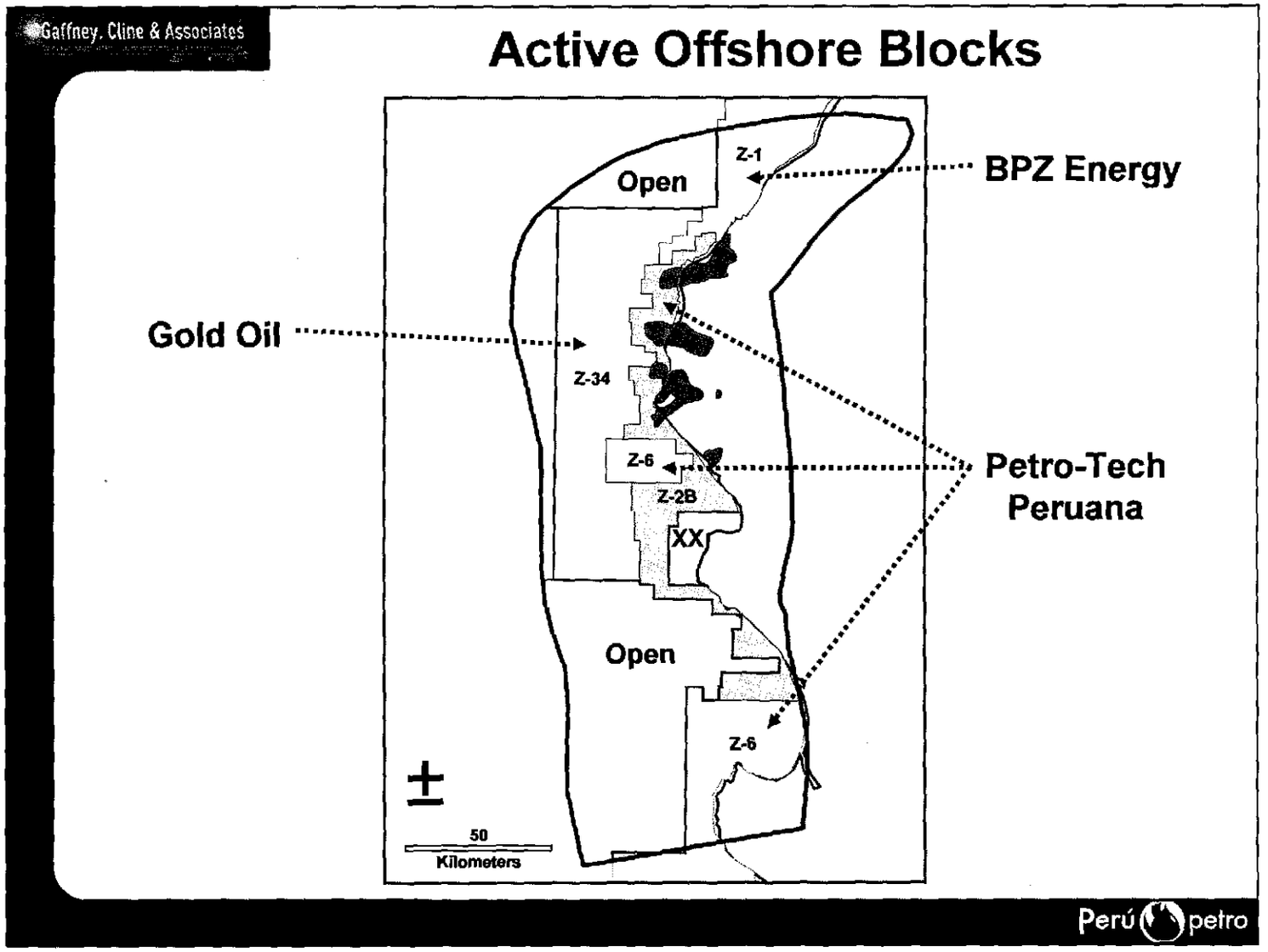
Outline

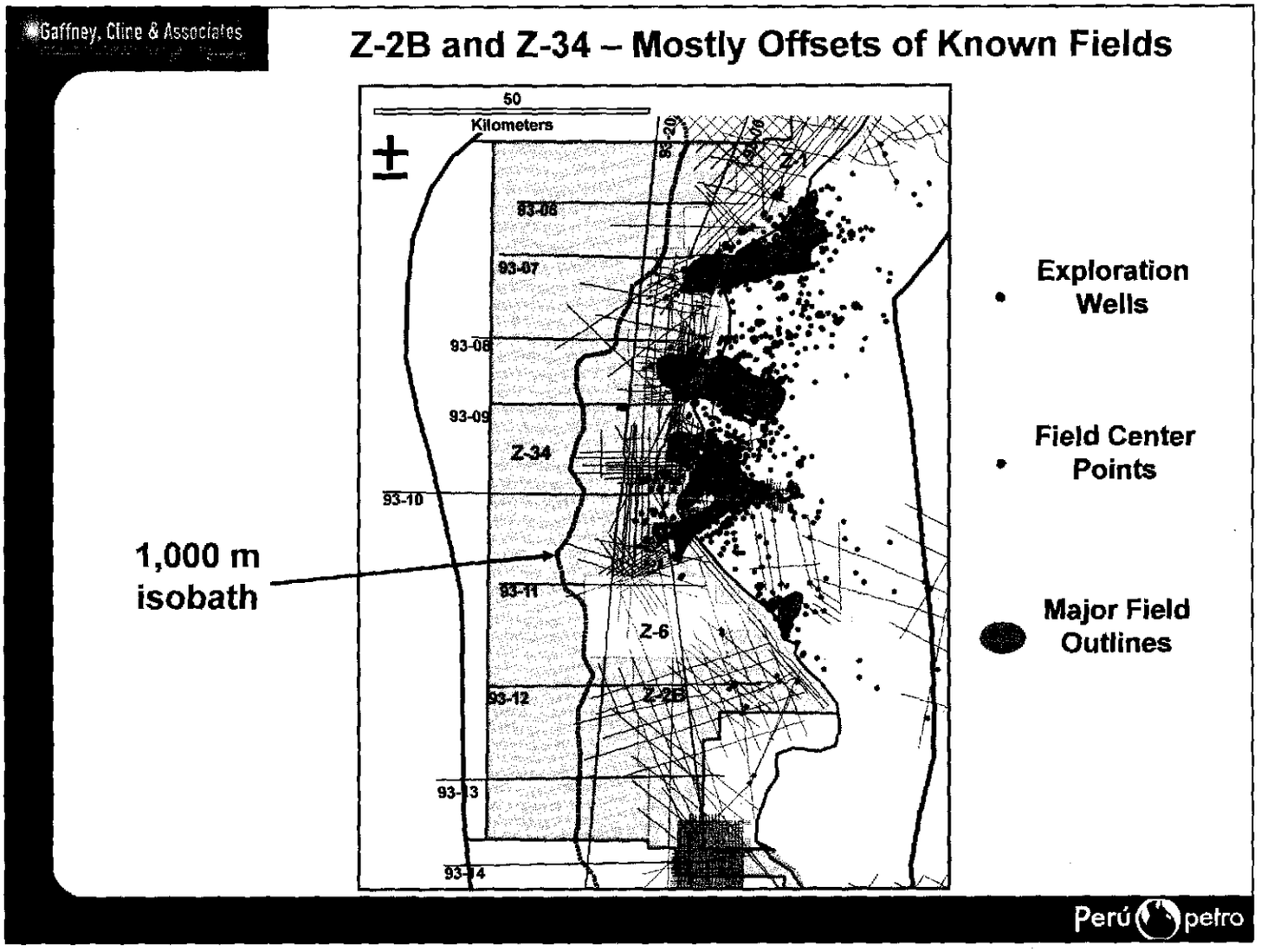
- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

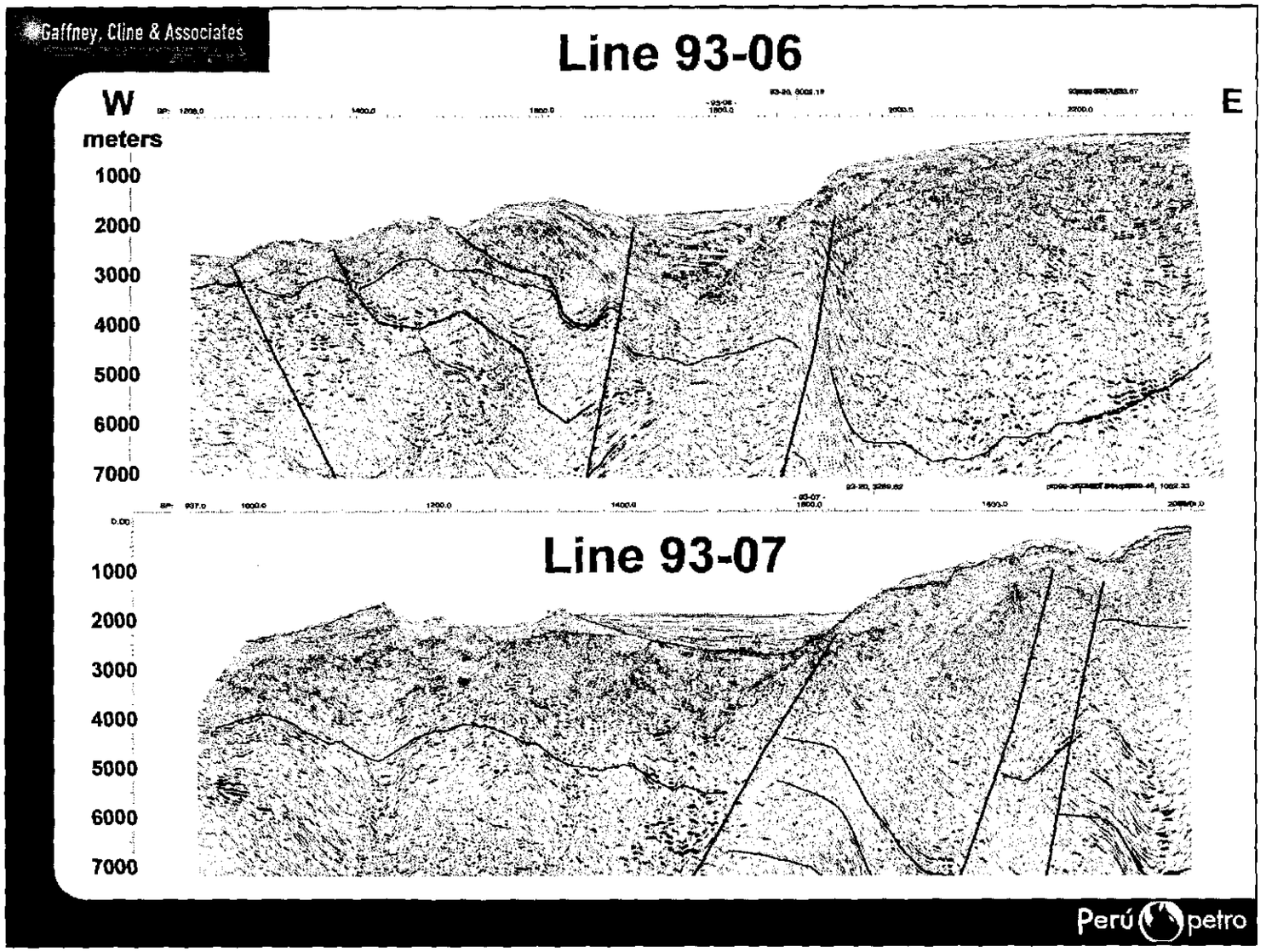
Much of the prospective offshore area in the Talara basin is already under license. The following section of this presentation reviews the relative prospectivity of these various areas, and the exploration plans that will likely be implemented.



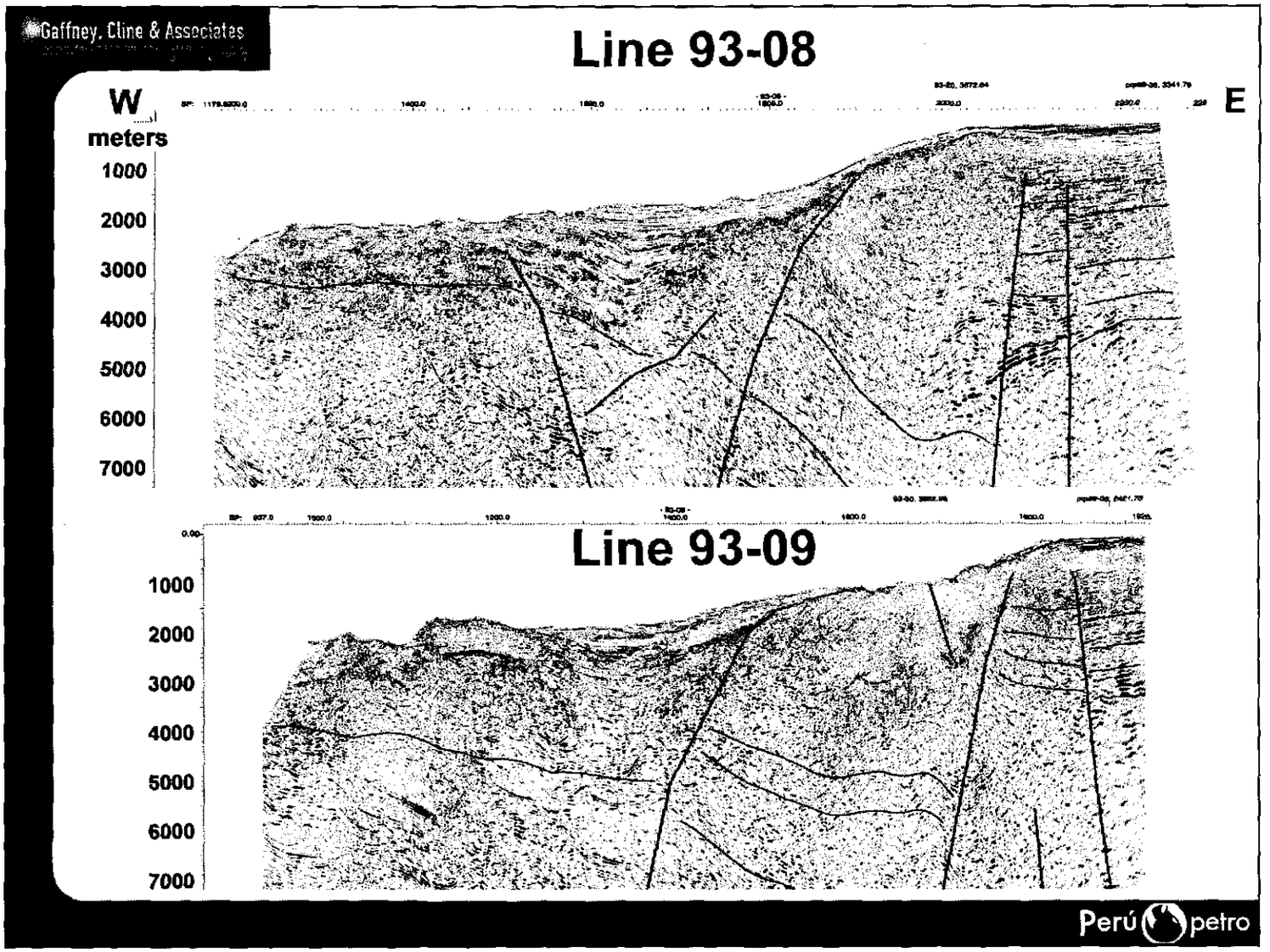
This map illustrates the current offshore licensing situation in the Talara basin. Petro-Tech Peruana is the long-time operator of the Z-2B block. They also hold the two Z-6 blocks on the shallow-water shelf. Gold Oil, a London-based independent, recently took an evaluation license on block Z-34. The terms of this license include technical evaluation only, with no commitment for new seismic or drilling on the block. Agreements such as these generally run for two years. Lastly, the area marked with the XX is the non-prospective Paita High, over which most of the sediment column has been eroded.



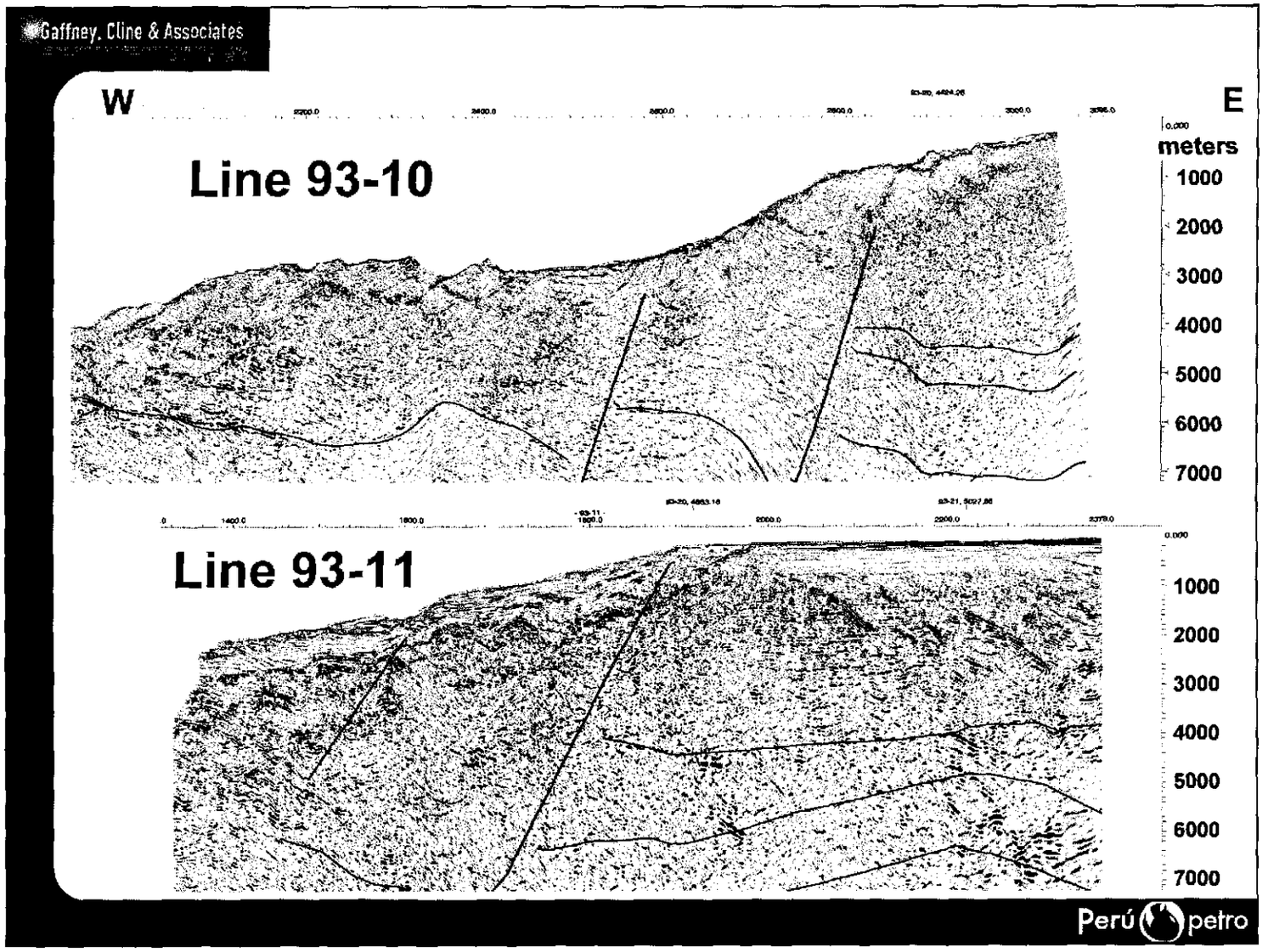
Offshore exploration plans for the Z-2B block and the new Z-34 block will likely focus on offsets of the known production. This map shows the 2D seismic and the exploration well information that is available to Petro-Tech to support this offset work. The 3D seismic surveys (see slide 19) will also be essential in picking new locations well inboard of the 1000 m isobath shown on this map. Gold Oil, a small independent, will also likely focus on shallow-water offsets of the known production, especially where the eastern "saw teeth" of their block penetrate into the inter-field offshore areas. It is unlikely that either company will mount a major drilling campaign anytime soon, given the structural complexity that has yet to be resolved despite the 3D seismic coverage.



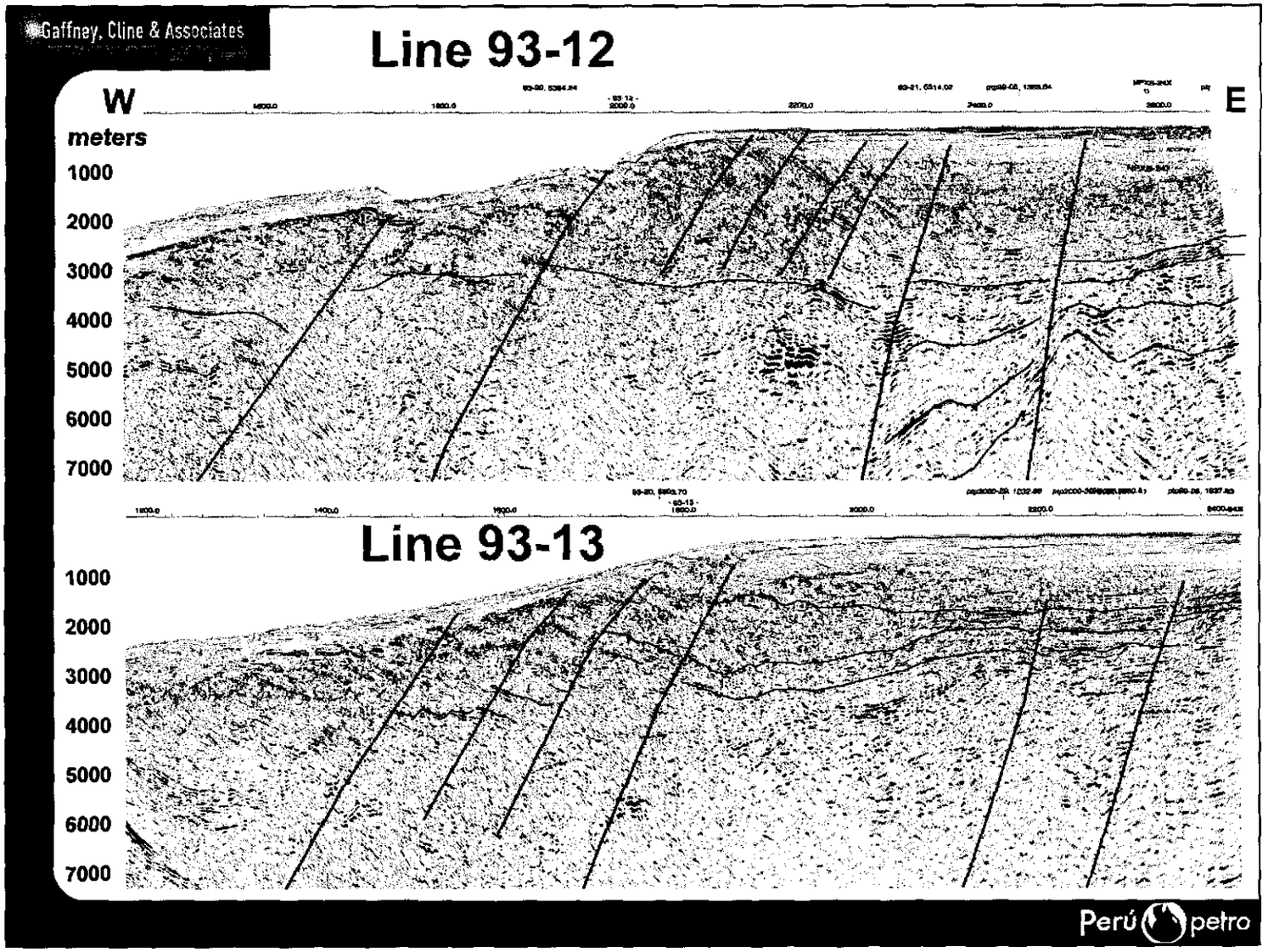
Beyond the shallow-water offset opportunities in Gold Oil's Block Z-34, there exist suggestions of deeper-water fault-bounded sub-basins in 2,000 meters of water. Note the thrust-inverted basin at the center of the northern-most line (93-06). There is other deeper potential in the fault blocks at the east end of Line 93-07, but the interpreted faults and horizons are tenuous at best, owing to the relatively featureless character of the seismic in this area.



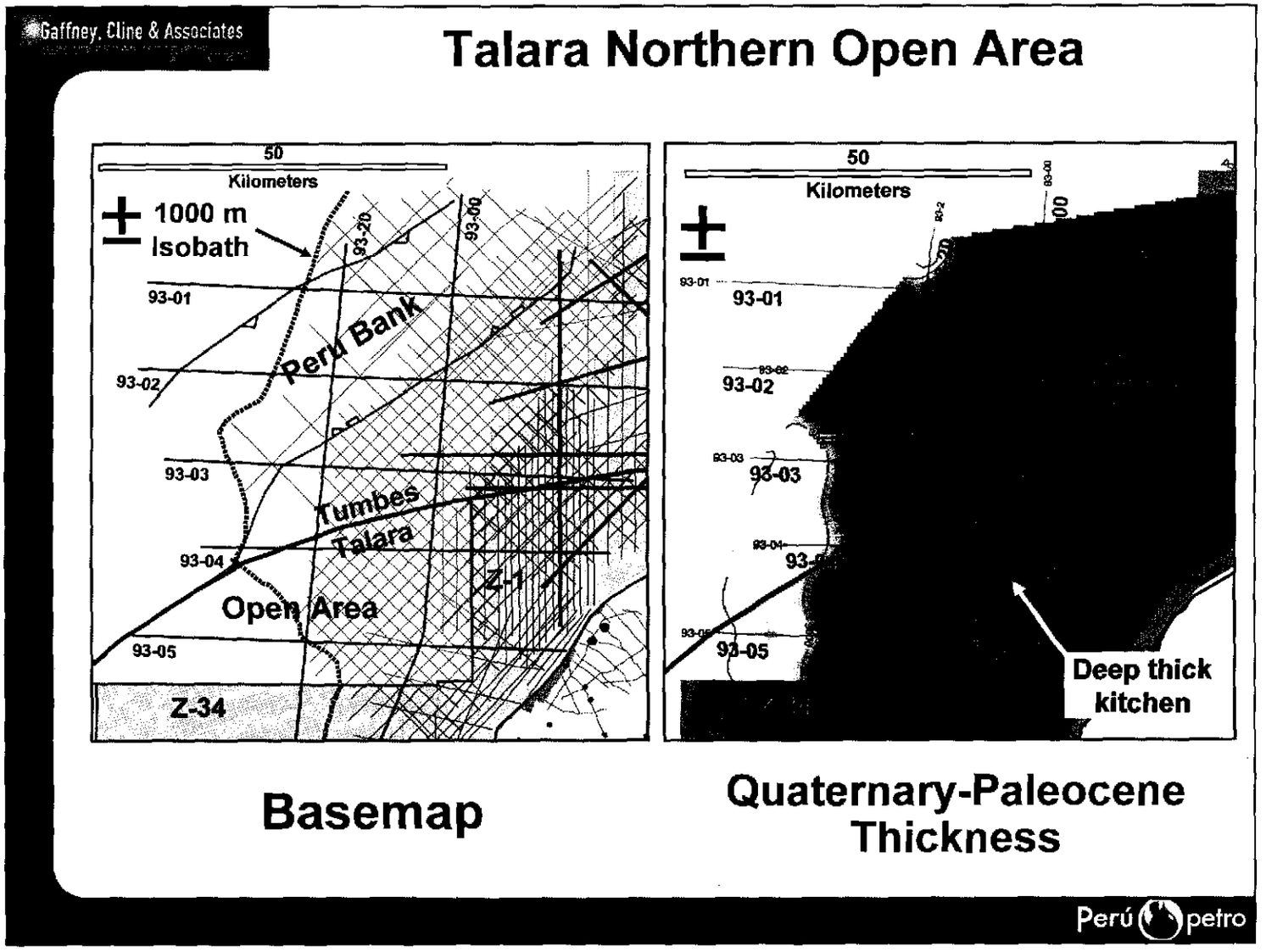
Progressing further south in the Gold Oil block Z-34, there is more evidence of deeper-water sub-basins and tilted fault blocks. The amplitude anomalies at the east end of both of these lines (on Block Z-2B) appear reminiscent of the anomalies that are attributed to turbidite sand accumulation in the Trujillo basin.



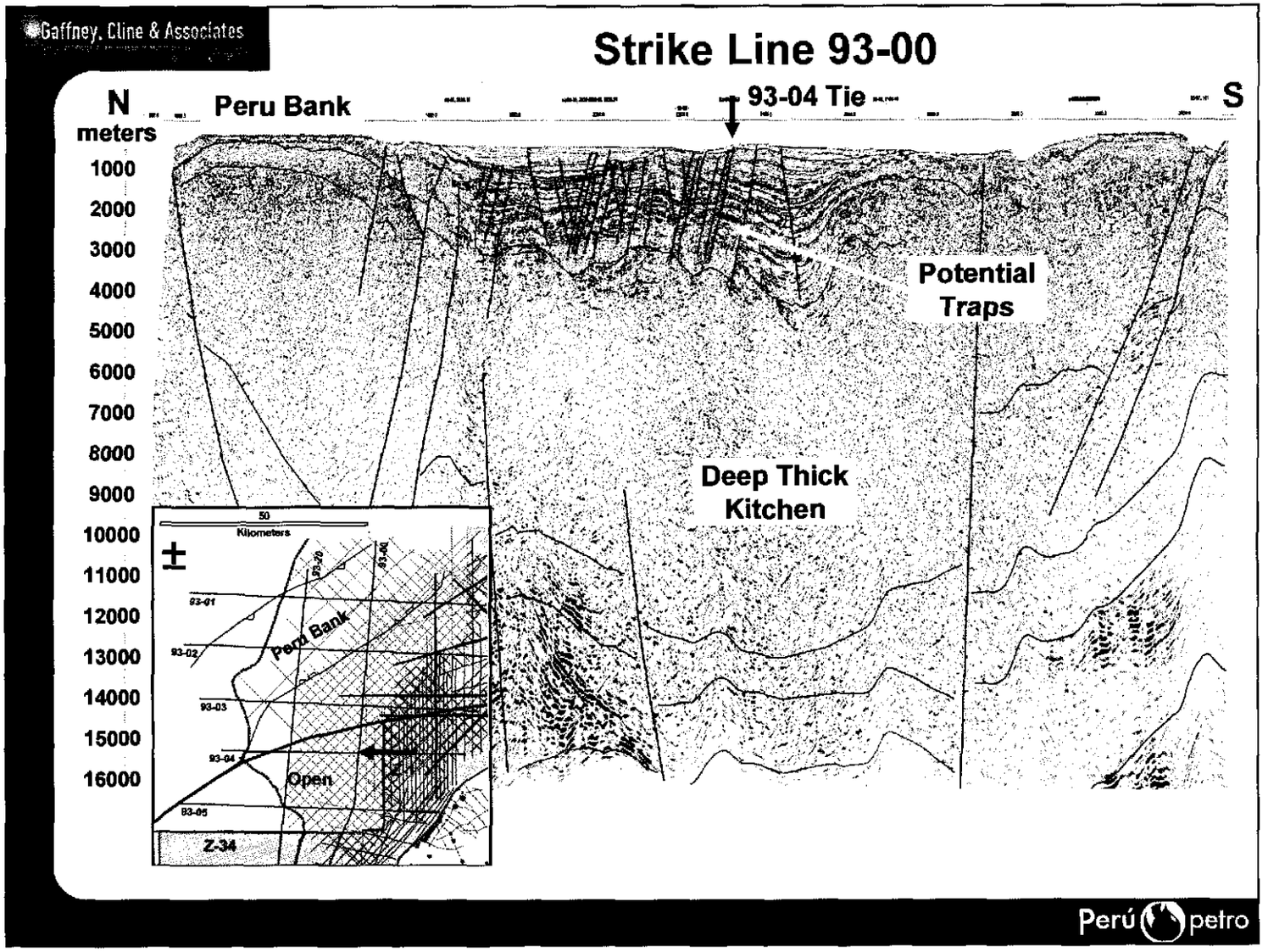
Progressing yet further southward, the water gets deeper and the seismic harder to interpret on Line 93-10. The character of Line 93-11 is even more chaotic, with isolated high amplitudes that suggest complex faulting and slumping. The eastern shallow-water half of this line lies over Petro-Tech's Z-6 block.



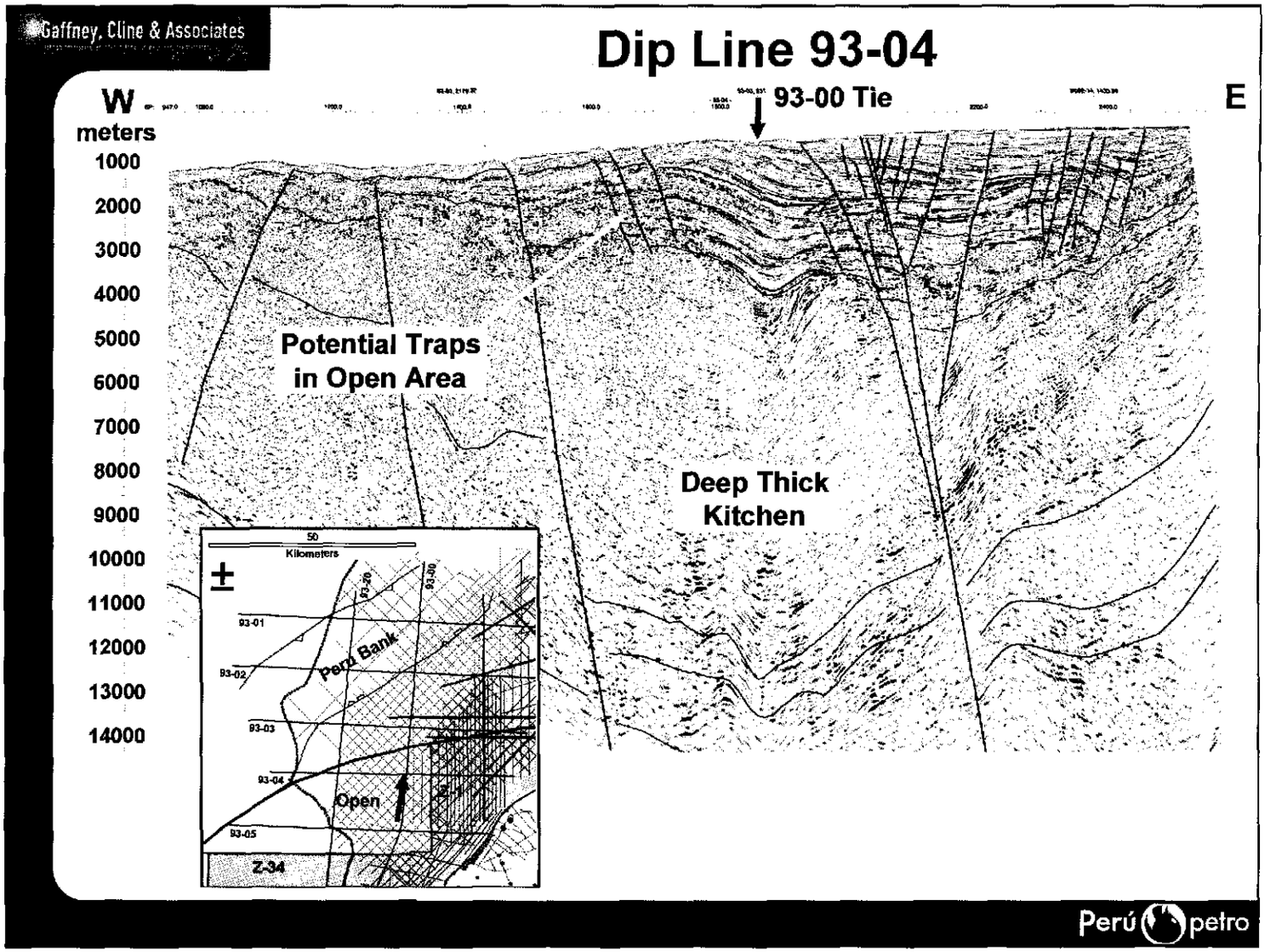
Line 93-12 illustrates the tilted fault blocks more clearly than the previous line. Here again, the shallow-water eastern half of the line lies in Petro-Tech territory (Block Z-2B). Line 93-13 is the southern-most line in Block Z-34, and provides further evidence for the north-south continuity of this belt of potential tilted fault block traps.



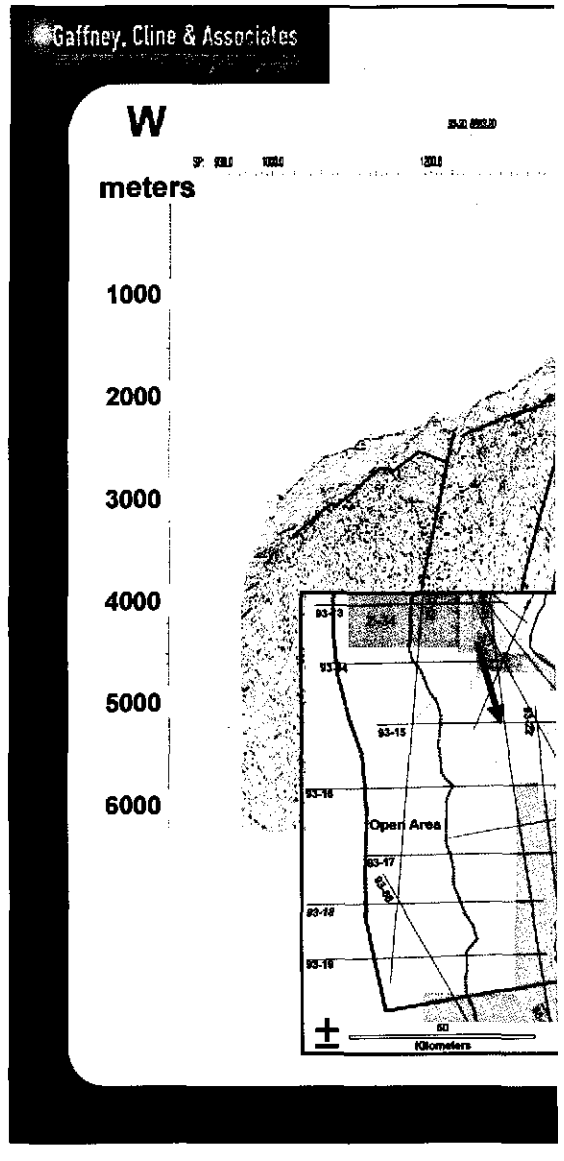
Aside from the central blocks that are already under license (Z-2B and Z-34), there are two open areas that may have even better potential. The open area to the north, which continues into the Tumbes basin, is underlain by an especially thick potential hydrocarbon kitchen, as shown in the isopach map at the right. This deep kitchen appears to be overlain by a Miocene-Pliocene (Neogene) basin with abundant structural leads that are pictured in the following three slides.



Strike line 93-00 begins at the Peru Bank in the north (Tumbes basin), and traverses south to the Pena Negra offshore field in the Talara basin. It runs down the axis of the deep thick Cretaceous-Paleogene kitchen, and shows the overlying Neogene basin with an abundance of potential folded and faulted traps.

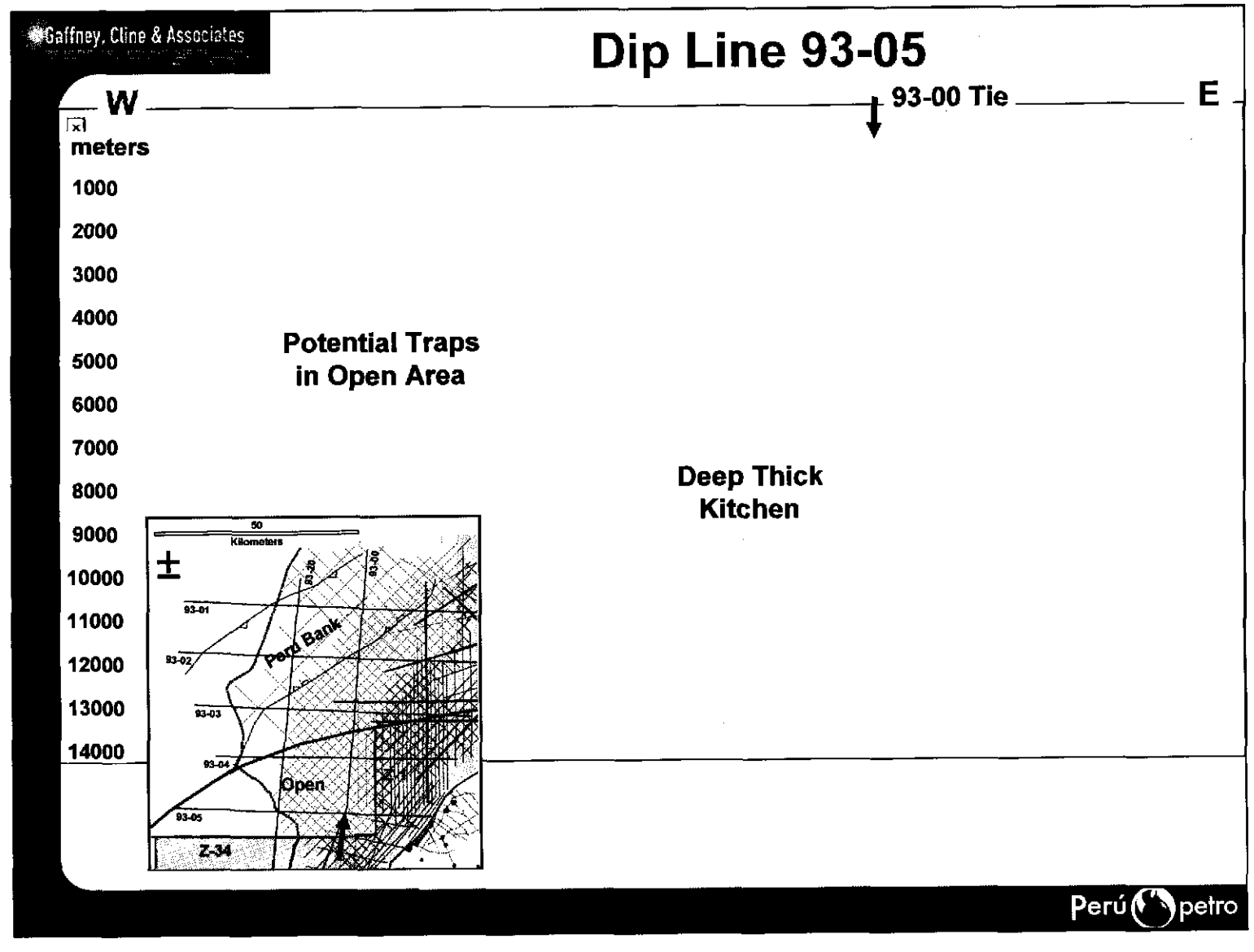


Dip line 93-04 intersects the strike line in the previous slide just west of BPZ's Z-1 block. The basemap shows that this area is covered by multiple 2D seismic surveys with different orientations. Faults interpreted on lines in one survey do not readily tie with faults interpreted on intersecting lines from another survey. A 3D survey over this area and the continuation of this open area into the Tumbes basin is recommended to address this.

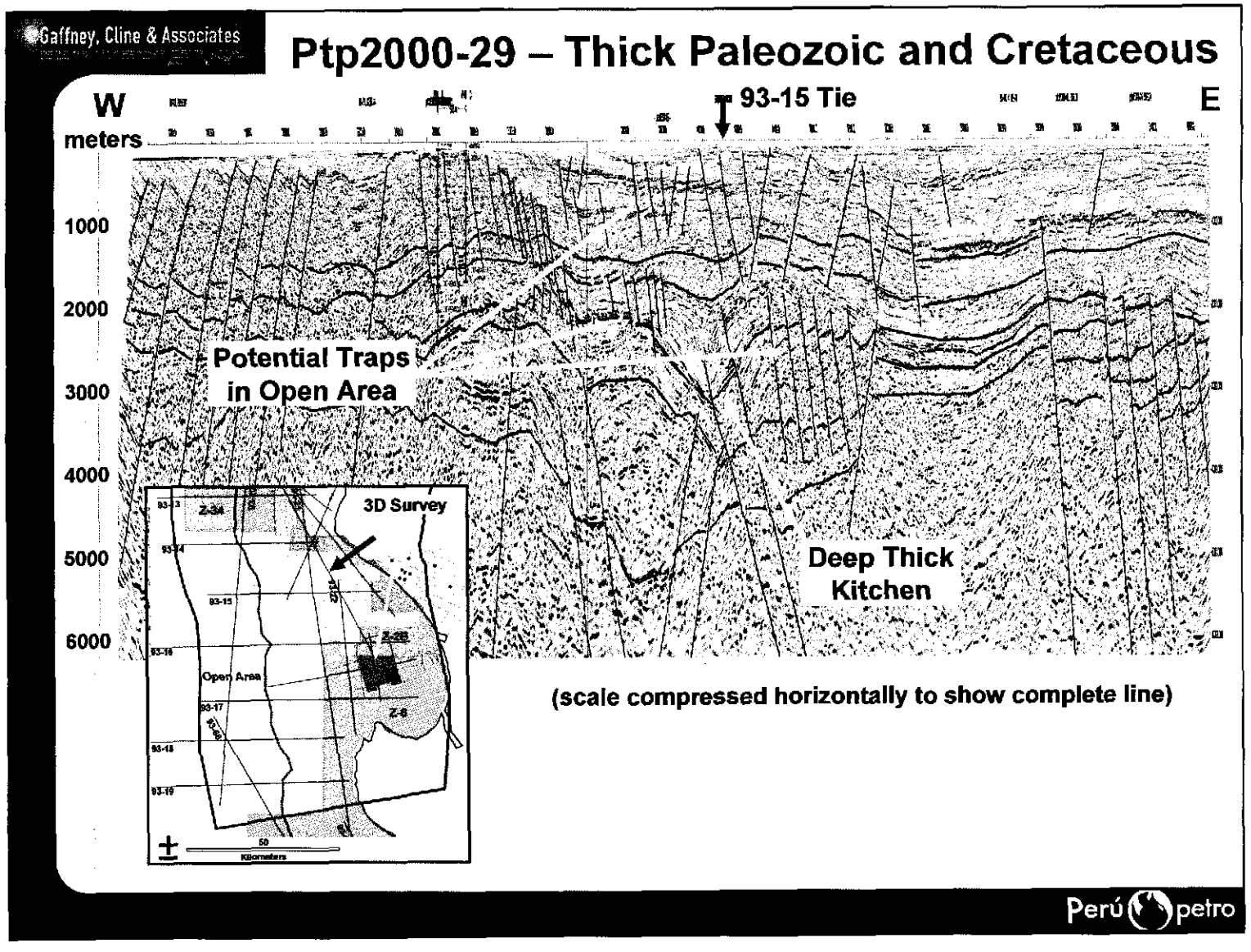


Dip line 93-15 runs right through the heart of the ki
folded trap opportunities, many of which are marked

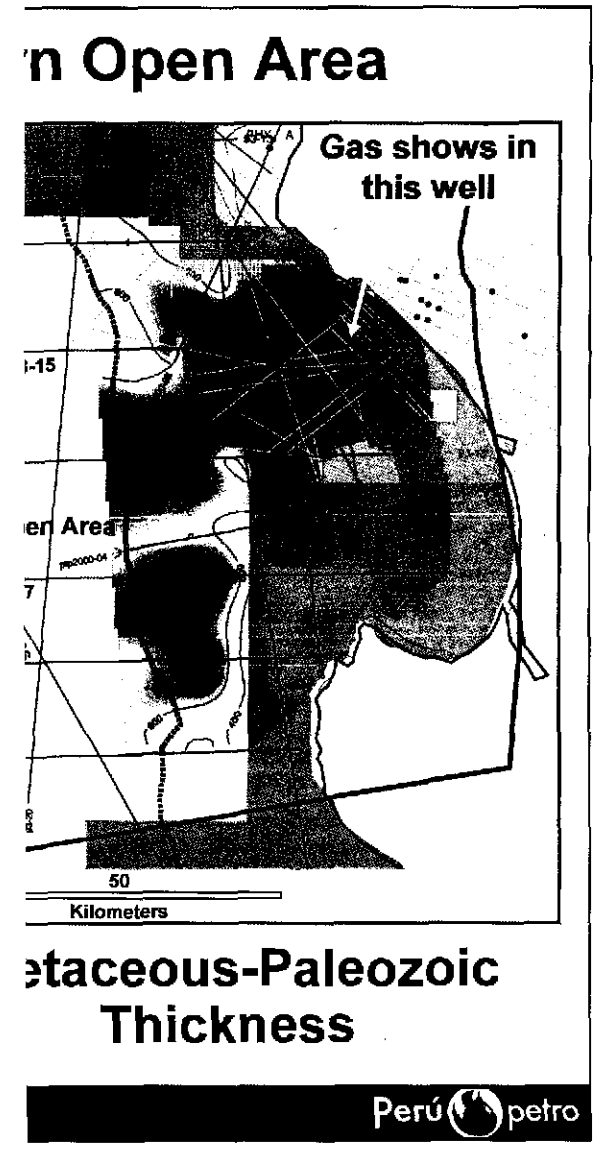
Hydrocarbon Prospectivity of the Talara Basin



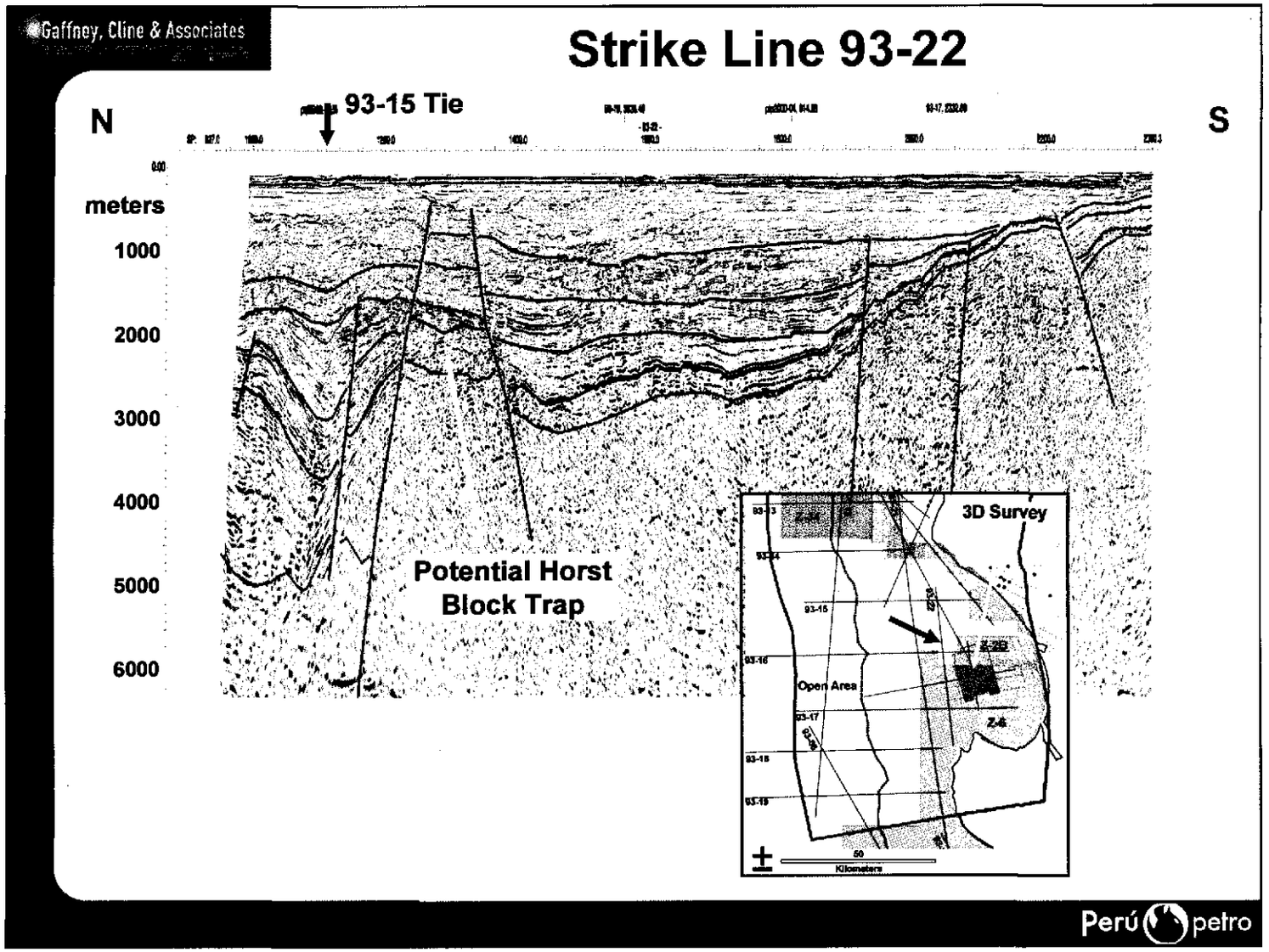
Dip line 93-05 lies 13 km south of line 93-04, and shows the potential for some of these faulted anticlines to cover the entire extent of this open area. This area has not yet been drilled.



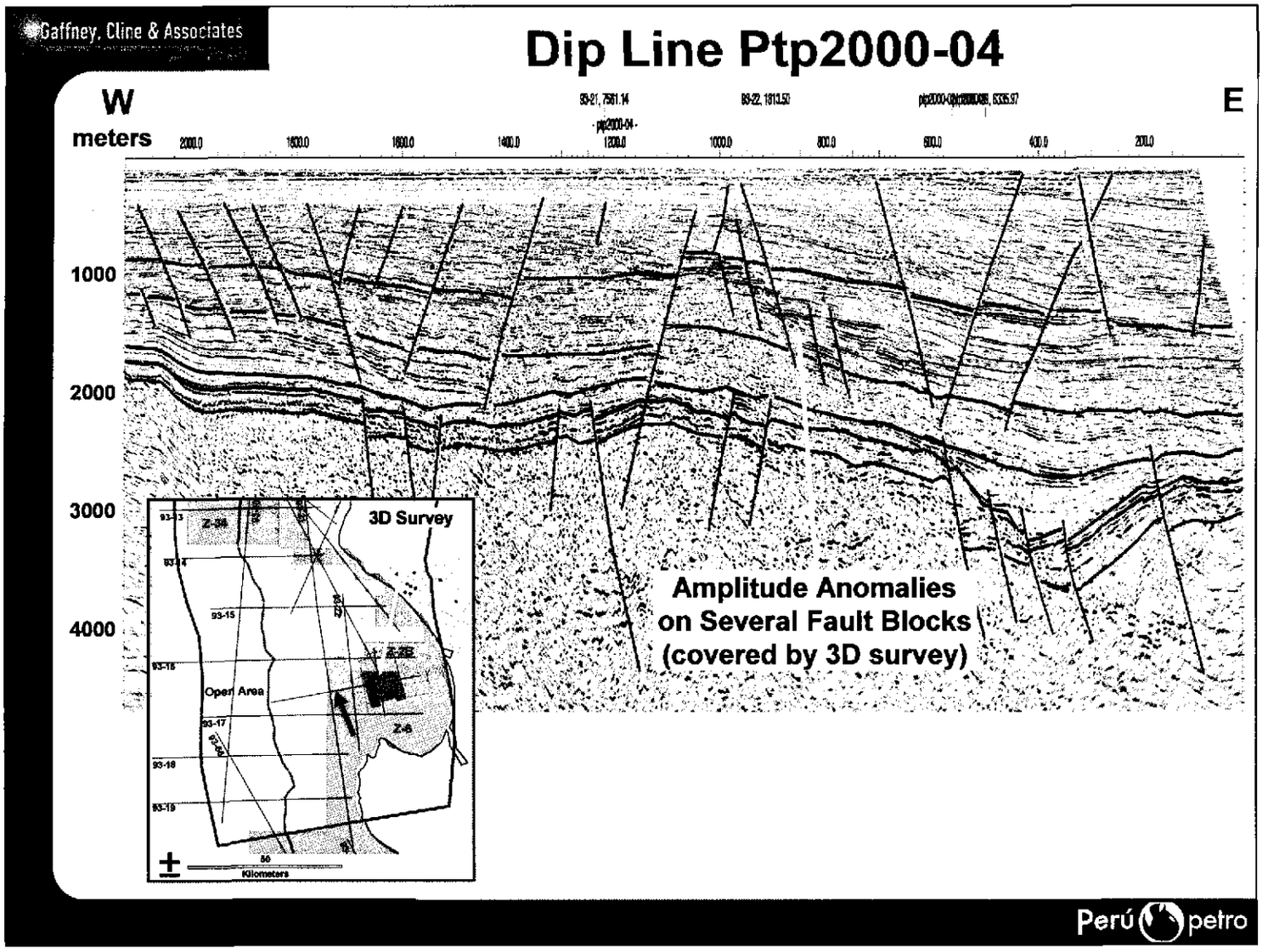
This is a particularly long strike line that has been horizontally compressed to show it all on one slide. It confirms the depth, lateral extent and structural complexity of the sub-basin illustrated in the previous slide. The tie location with dip line 93-15 is also shown.



Talara basin. It is attractive for many of the same
ntial. The La Cassita well, which lies very near one of



This strike line provides additional confirmation of the lateral extent of this sub-basin, and images a potential horst-block trap.



This last example line has captured several interesting seismic amplitude anomalies associated with several fault blocks that are located on Petro-Tech's block Z-6. The basemap also shows the location of a 3D survey that covers this area. It has apparently not yet been drilled.

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Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

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Three Scenarios Show Overall Favorable Economic Potential

(US$ million unless otherwise noted)	Low	Mid	High
Oil (millions of barrels)	25	50	75
Producing Wells	30	55	80
Gross Project Revenue	750	1,500	2,250
Royalty	39	85	142
CAPEX	155	225	310
OPEX	71	108	122
Net Cashflow Before Tax	485	1,082	1,676
Tax	136	313	486
Net Cashflow After Tax	349	769	1,191
NPV (Discount 10%)	69	158	259
IRR (%)	23	30	40

Perú petro

There is no doubt that the new chronostratigraphic framework produced in this study has documented a substantial amount of exploration potential in the Talara basin, especially in the southern open area. However, there is considerable doubt about how much of that potential will be realized, and when. Therefore, the economic analysis was based on a simple three-scenario approach – a low case, a mid case and a high case. Given the structural complexity of this basin, the range between the low case and the high case was purposely modest. The exploration and development costs were based on information in the public domain and advice from PERUPETRO. In general, because oil prices are high and costs are low in this shallow-water, close-to-shore environment, even the low case delivers a sizable rate of return. Drilling in the deep water was not considered, as it is likely that exploration drilling will be limited to the shallow water for the foreseeable future.

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Conclusions Revisited

- Long-standing petroleum system proved with first onshore discovery in 1869
- Thick offshore Cretaceous and Tertiary section with abundant source and reservoir potential
- Numerous undrilled leads in shallow to moderate water depths and reasonable drilling depths
- Reservoir location and quality are risks, especially offshore from established production, where 2D seismic is poor
- Petro-Tech has a dominant acreage position, and Gold Oil has secured Block Z-34 recently, but attractive areas are still available at the north and south ends of the basin

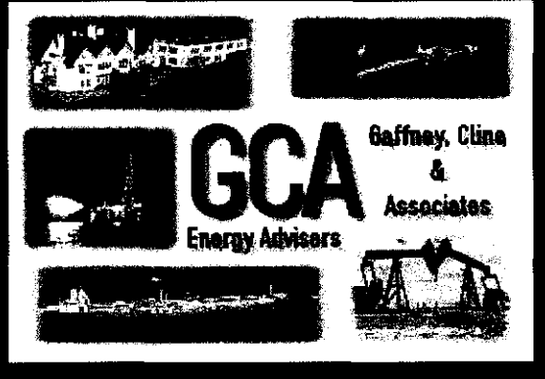
Perú petro

Talara is a basin of contrasts. On the one hand, at least one petroleum system has produced oil for more than 130 years, from many reservoirs that have been penetrated by thousands of wells. On the other hand, very little offshore exploration has been done in water depths greater than 200 meters. Despite the proximity of the Peru Trench to the west, there are still significant areas of relatively broad shallow shelf, especially at the northern and southern extremities of the basin, where the chances for source and reservoirs are favorable and where abundant structural leads exist. Petro-Tech is the dominant player, but attractive open areas to the north and south are still available.

Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Talara Basin



Perú petro

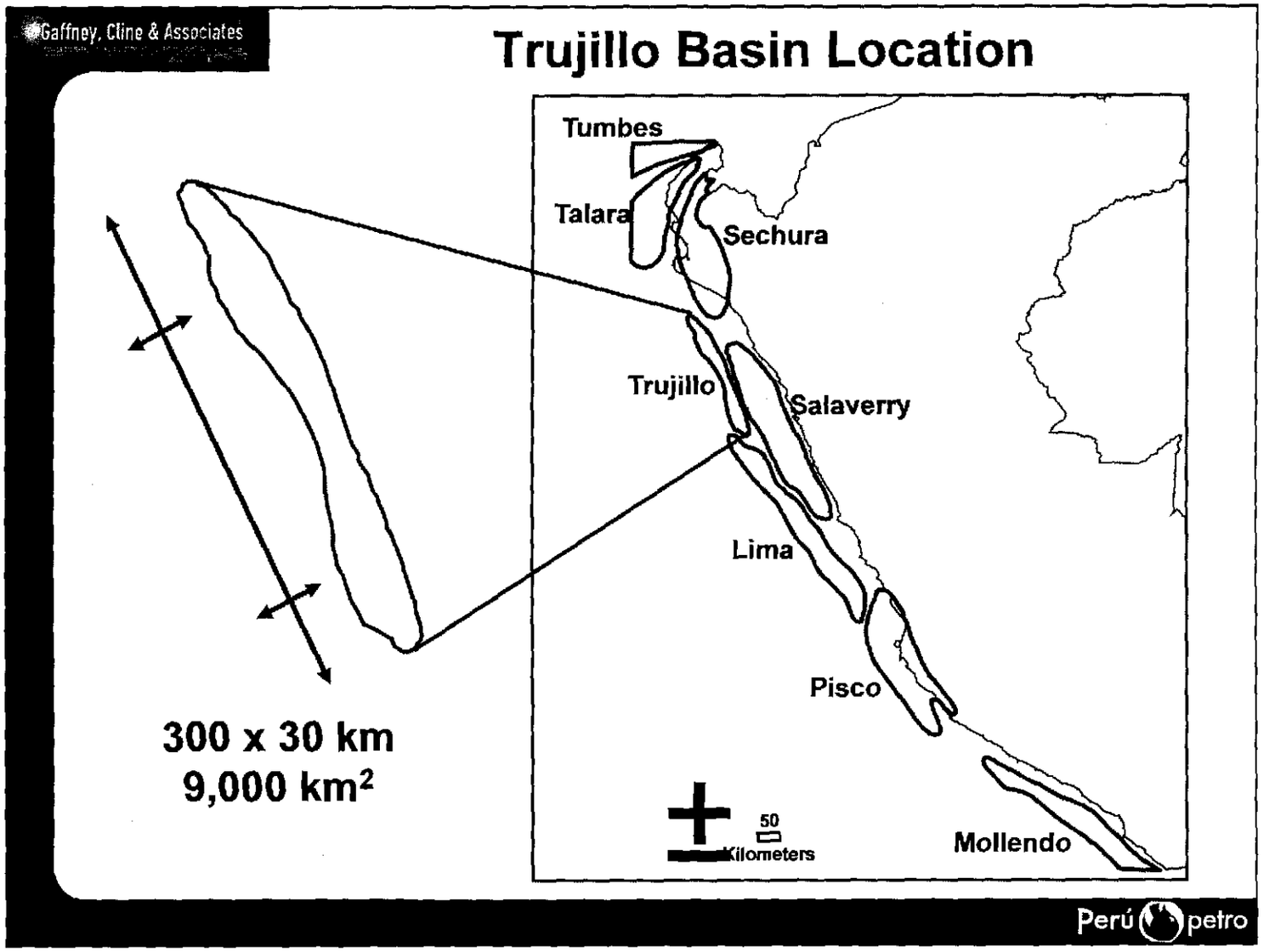
Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Trujillo Basin

Perú petro

This Basin Presentation is part of the Final Report for the larger study entitled, "Sequence Stratigraphy Analysis of the Peruvian Offshore Continental Shelf-Slope." This study was funded by the USTDA, and was executed by Gaffney, Cline & Associates for PERUPETRO.



The Trujillo basin is located south of the Sechura and west of the Salaverry basin. Although it looks small on this map, the basin covers 9,000 km² and has been the main focus of offshore exploration interest in Peru since the 1970's.

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Outline

- Conclusions
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- Leads
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- Economics

Perú petro

This presentation begins with the conclusions and a quick review of the data, and is followed by discussion of possible hydrocarbon source rocks, reservoirs and leads (including expected water depths and drilling depths). It finishes with recommended exploration plans and several economic scenarios.

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Past Failures, But a Bright Future

- Source is proven
- Much better regional framework to chase Eocene turbidite reservoirs
- Most potential in reasonable water and drilling depths
- Leads over amplitude anomalies have giant potential
- Will require careful 3D seismic and a multi-well program to overcome past failures and thoroughly explore this tectonically complex area

Perú petro

Four dry holes do not make a dry basin. Oil companies large and small are hungry for exploration provinces with remaining potential for giant discoveries. The Trujillo basin still qualifies as one of these high-potential provinces.

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Perú petro

PERUPETRO furnished unlimited access to their data archives. The gross volume of data available for this study was therefore extremely large, requiring considerable effort in organizing and distilling it into a useable project database.

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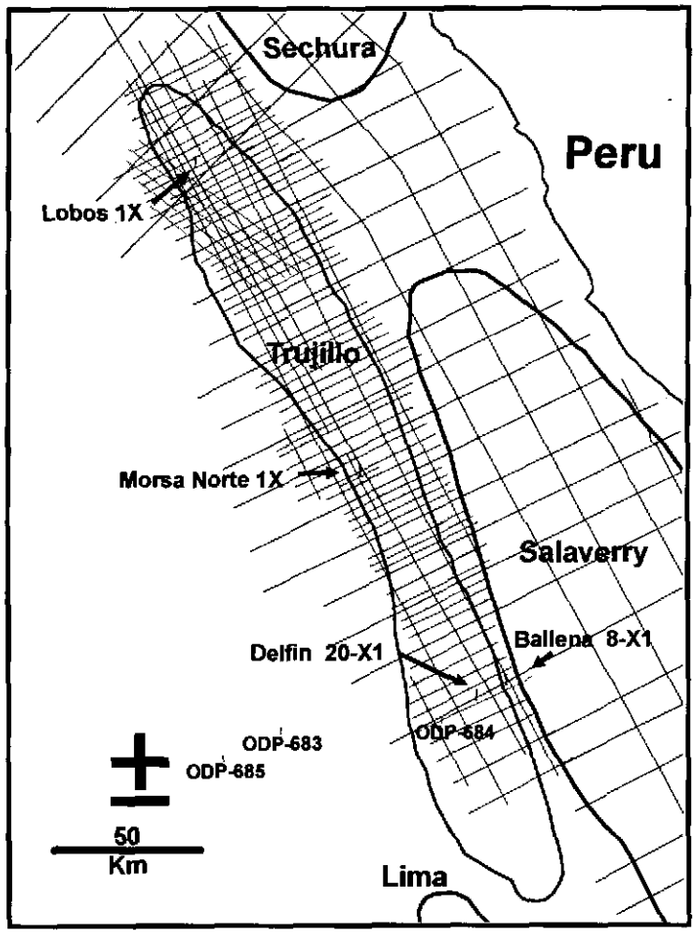
Trujillo Seismic and Four Wells

Repsol 1996 Seismic (in red)

Total 4,019 km
Used 3,660 km



Ribiana 1993 Seismic (in blue)

Total 10,548 km

Perú petro

The seismic grid included in this study for the Trujillo basin included all of the Ribiana 1993 lines (in blue). It also included most of the in-fill Repsol 1996 survey (in red). Only a few lines (the diagonal ones in grey near the Lobos well) were not interpreted. Lastly, a short strike line from the Ribiana 1998 survey (lo98-10b) was added to help tie the Lobos well to the interpretation grid. The Trujillo basin also contains four exploration wells. The first two, Delfin and Ballena, were drilled by Occidental in 1971. The Morsa Norte and Lobos wells were drilled by Repsol in 1999. Although all four were dry holes, they contained encouraging shows and evidence of reasonable reservoir potential. Further detail about these wells appears throughout this presentation.

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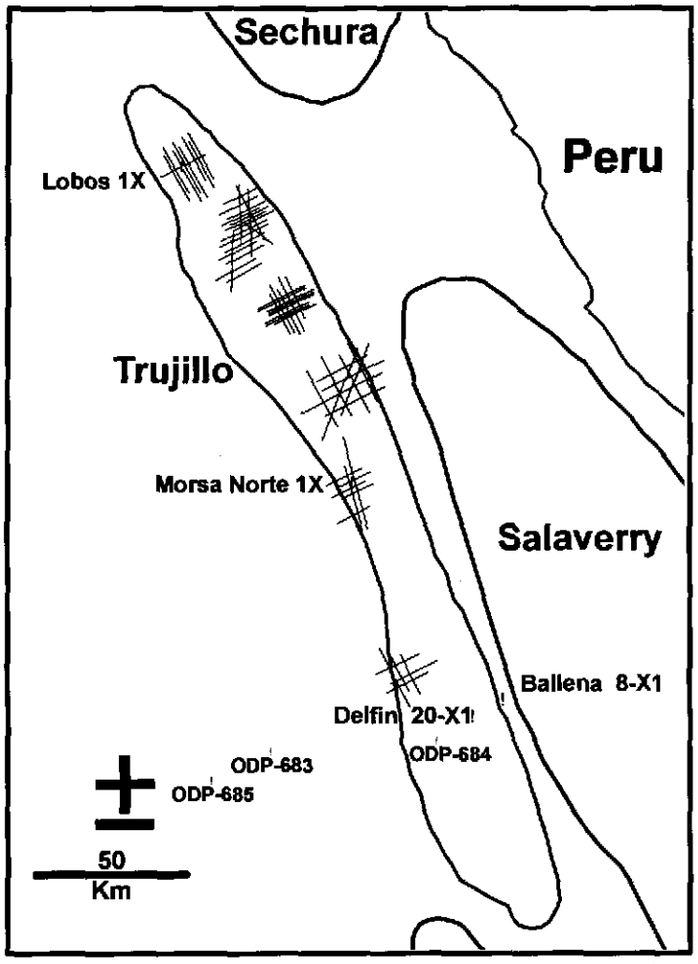
Repsol 1998 Surveys Not Needed



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This map illustrates the coverage of the Repsol 1998 seismic surveys (in red). They were not needed for the regional interpretation, except for the strike line lo98-10b which passes through the Lobos well location and helped tie it to the regional framework.

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The Project Database

- **Final Report (paper)**
  - **Executive Summary**
  - **Basin Presentations**
  - **Other Required Sections**
    - Economics, Regulatory, Environmental and others
  - **Enclosures**
    - Selected maps, logs and cross sections
- **Digital Database (DVDs)**
  - **Final Report**
  - **ArcView Interactive Map**
  - **3 SMT Kingdom Suite Projects**
  - **Standard-format Exports**
  - **Detailed Appendices**
    - Geology, Wells, Seismic Interpretation, Tectonics, Depth Conversion, Maturation, Environmental

Perú petro

The project database for the Trujillo basin exists in several forms. First, there is an SMT Kingdom Suite project that covers the Trujillo, Salaverry, offshore Sechura and Pisco basins. This integrated project is available as part of the Digital Database that is packaged on DVDs with this report. The contents of this project were also exported into SEG-Y, LAS and other standard formats for loading into other workstation software. The Digital Database also contains an ArcView Interactive Map that was used to produce the map-based graphics in this presentation. It contains surface location data for wells and seismic, gravity and magnetics, geo-registered images of all of the maps produced in this study and a wide variety of other useful map-based data. Selected maps and cross sections are included in the Enclosures. Lastly, the Final Report contains several Appendices that contain discipline-specific detailed discussions as listed above.

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Outline

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Although there have been no successful tests or commercial production from this basin, there is enough evidence from the hydrocarbon shows in the wells and the numerous surface seeps that there is at least one active petroleum system in this basin.

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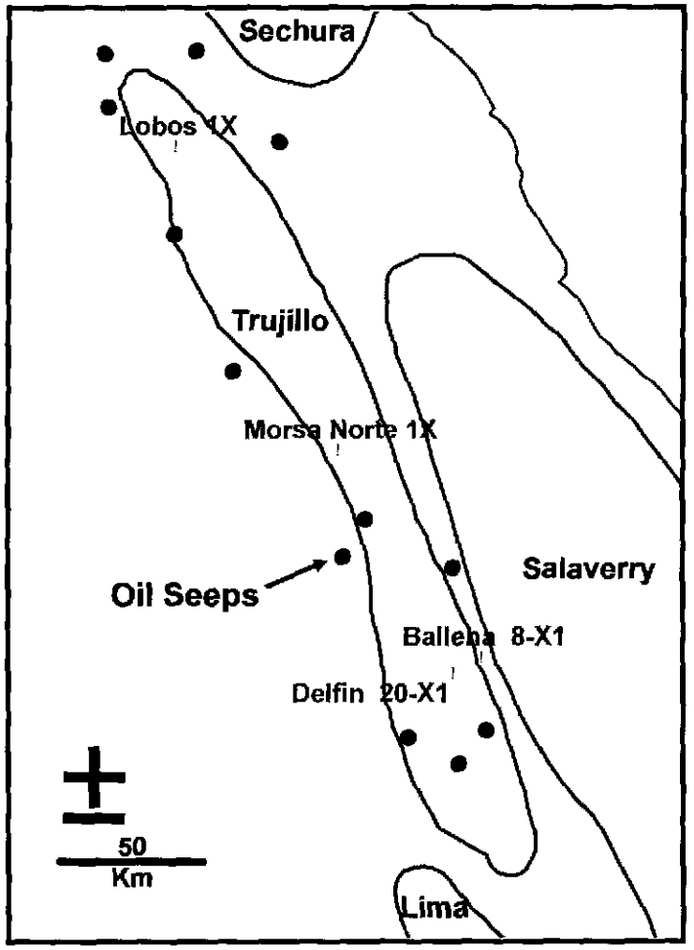
Oil Seeps Obvious Evidence of Source



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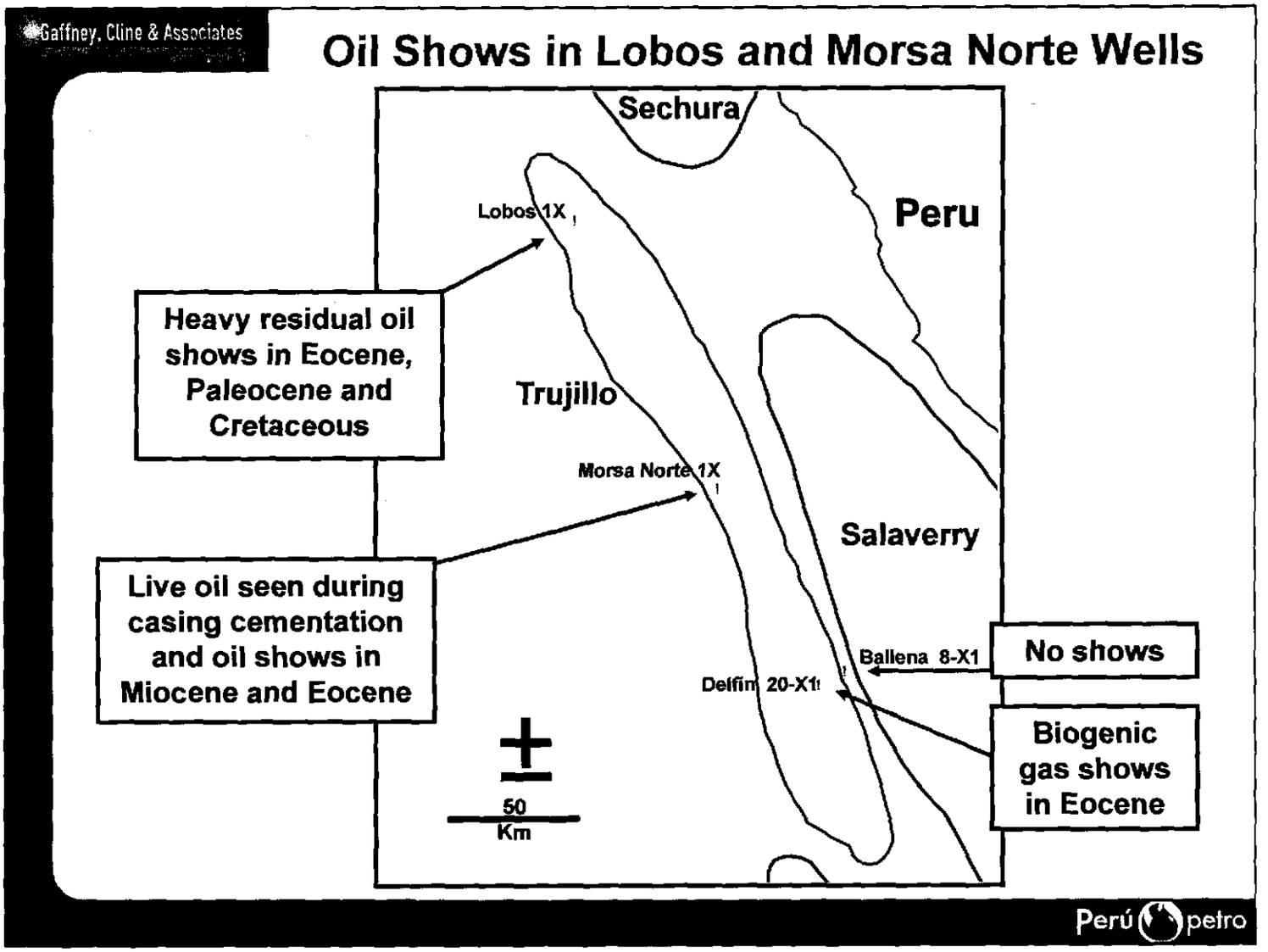
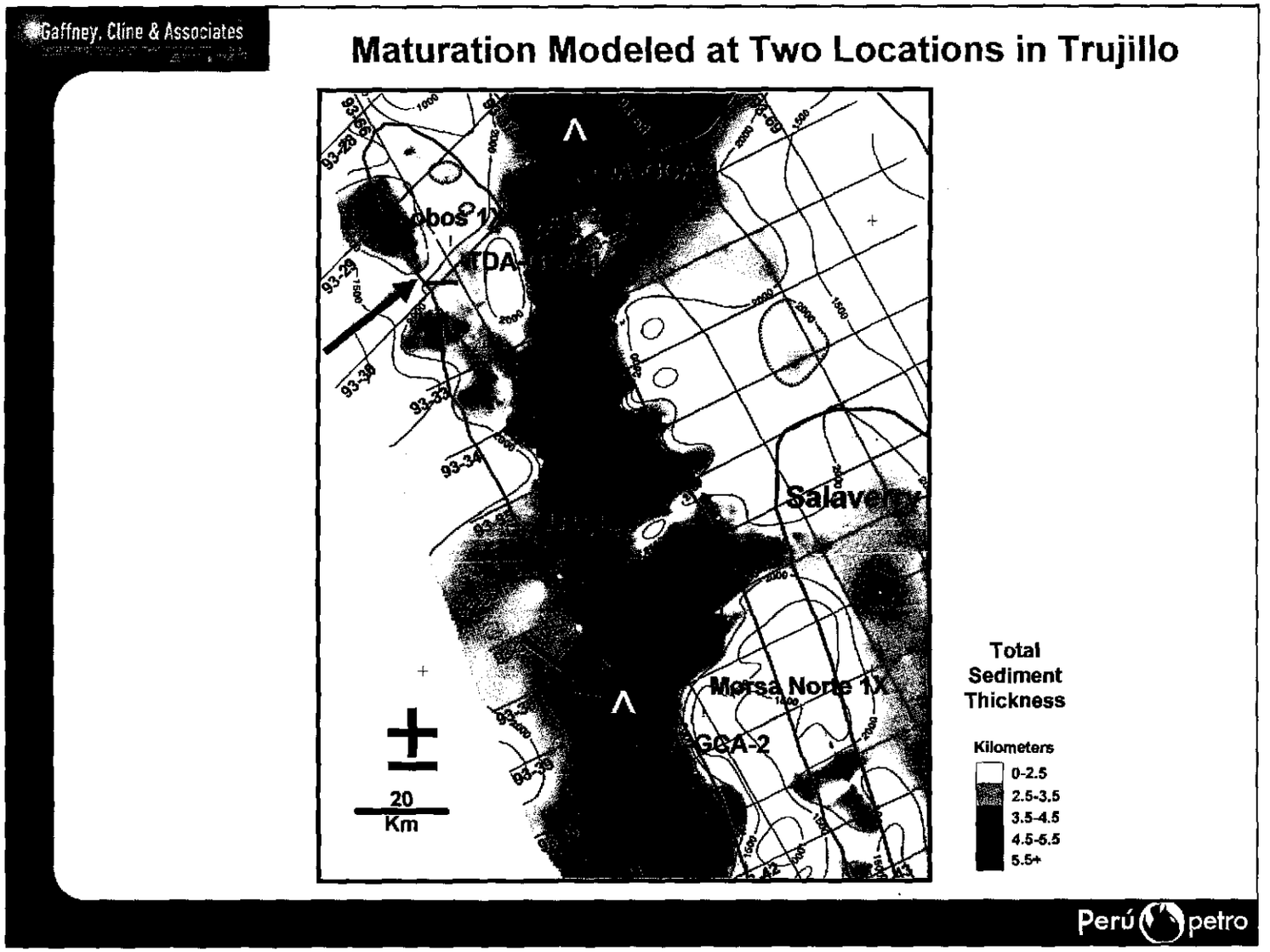
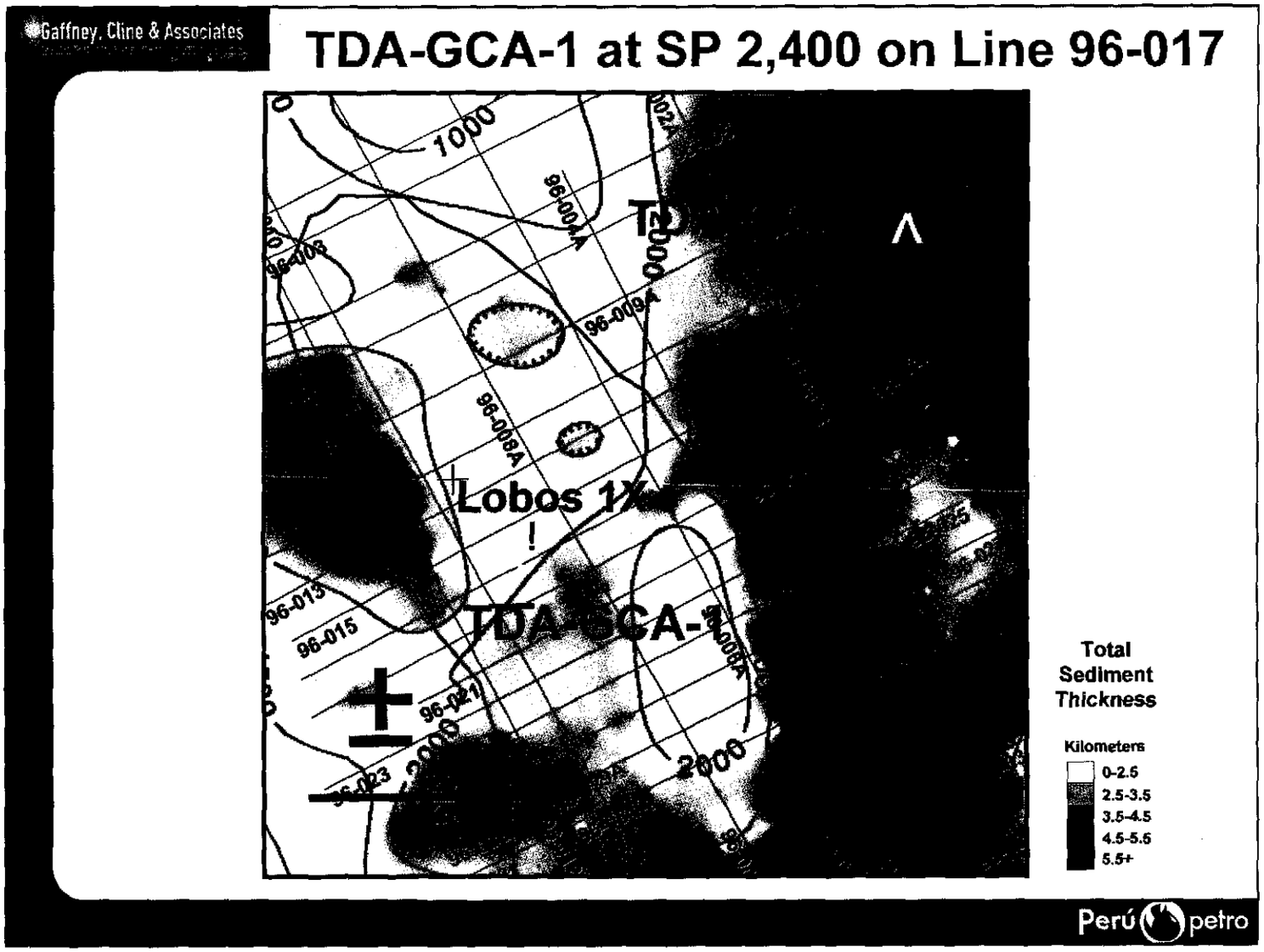
Here are the locations of 12 of the most prominent hydrocarbon seeps in and near the Trujillo basin.



In spite of the fact that the four exploration wells in the Trujillo basin were dry holes, two of them (Lobos and Morsa Norte) encountered significant oil shows. Furthermore, live oil was observed in the Morsa Norte well during the cementation of the 20" casing. The biogenic gas in the Delfin well was likely derived from oil biodegradation. Along with the oil seeps, these shows provide further evidence of at least one active petroleum system in the Trujillo basin.



To better quantify source, maturation modeling was conducted at two locations in the Trujillo basin (yellow stars at black arrows). The first location was chosen near the Lobos well, because this well was very important to most aspects of the regional interpretation. The second location was chosen in the axis of the deep graben to the west of the Morsa Norte well to quantify the maturity of this potential oil kitchen.



Here is a more detailed look at the modeling location near the Lobos well, along the 96-017 seismic line. The total sediment column (the contour map) is about 2,000 meters thick at this location.

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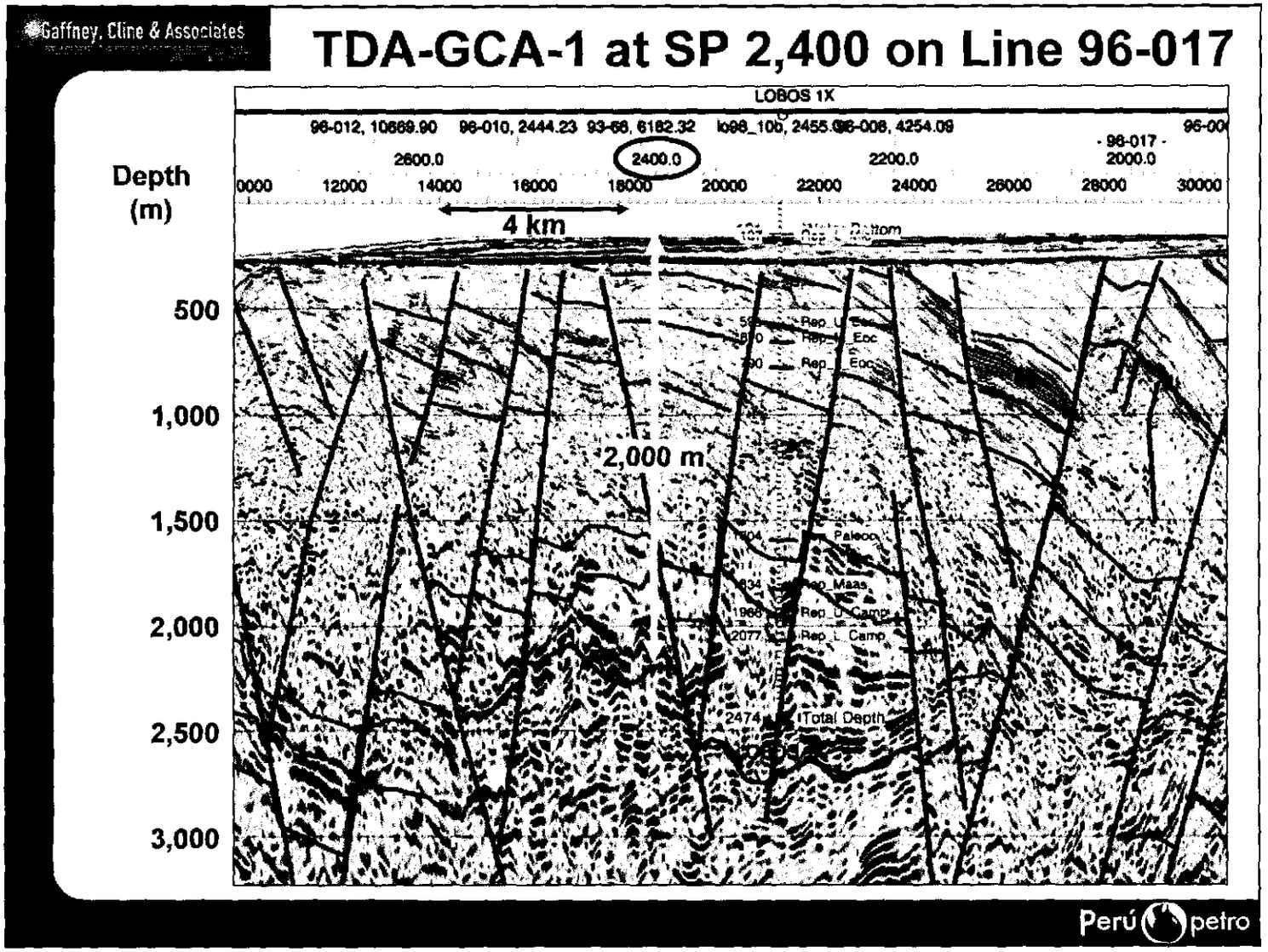
Seismic Horizon Legend

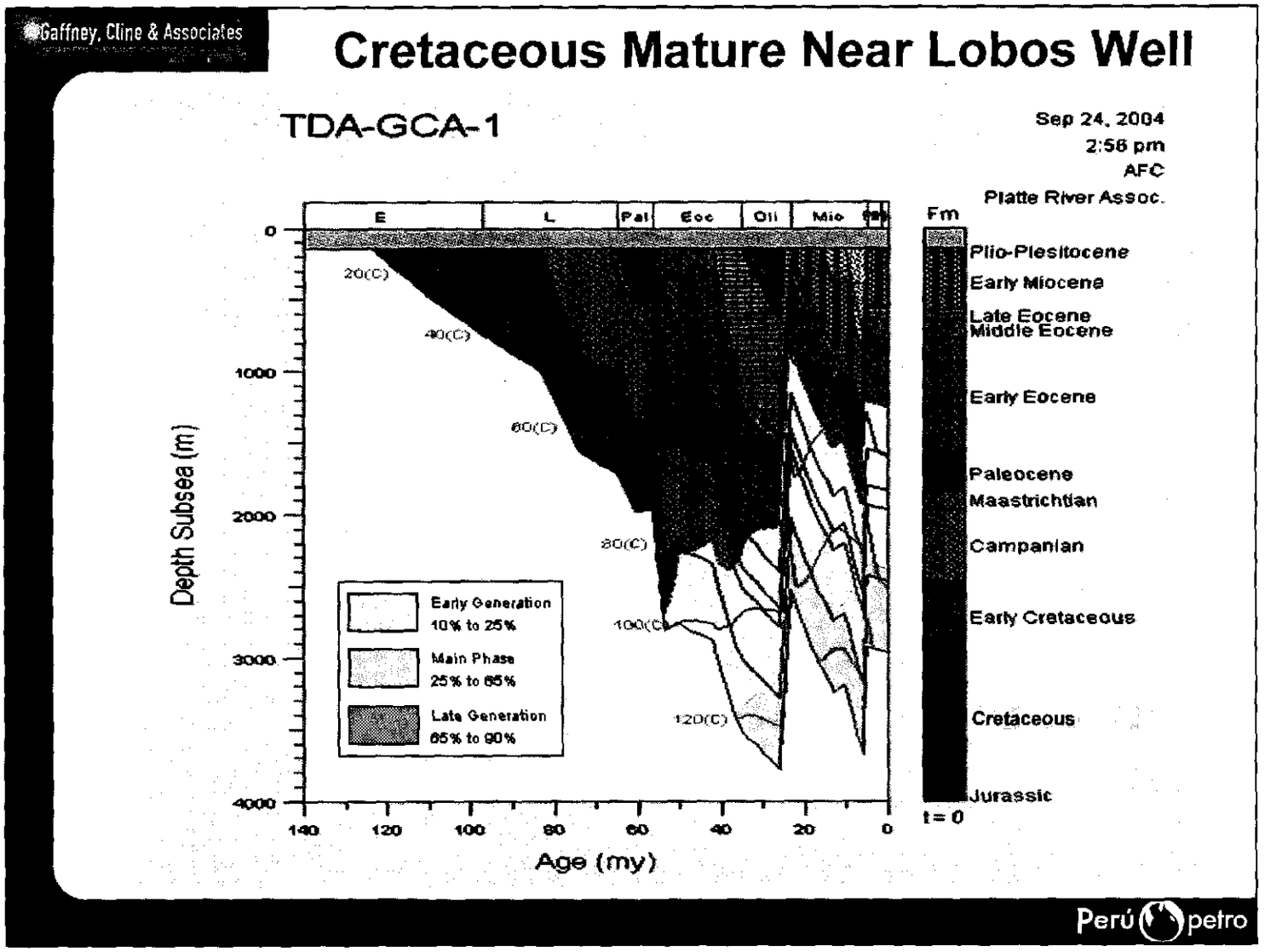
- 1_ts_a_1_Quaternary (pae)
- 1_ts_b_2_Pliocene (pae)
- 1_ts_c_3_Late_Miocene (pae)
- 1_ts_c_3_Late_Miocene_overthrust (pae)
- 1_ts_d_4_Middle_Miocene (pae)
- 1_ts_d_4_Middle_Miocene_overthrust (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_a (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_b (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_c (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_d (pae)
- 1_ts_f_6_incised_channels_intra-mid_Miocene (pae)
- 1_ts_g_7_Early_Miocene (pae)
- 1_ts_h_8_small_channels_Early_Miocene (pae)
- 1_ts_i_9_Latest_Eocene_Oligocene (pae)
- 1_ts_i_9-13_mrg_Eoc_Oligo-Mid_Eoc_carb (pae)
- 1_ts_i_9-13_mrg_Eoc_Oligo-Mid_Eoc_carb_new (pae)
- 1_ts_j_10_Middle_Eocene (pae)
- 1_ts_k_11_Middle_Eocene_carbonates? (pae)
- 1_ts_k_11_Middle_Eocene_carbonates?_overthrust (pae)
- 1_ts_l_12_Early_Eocene_carbonates? (pae)
- 1_ts_l_12_Early_Eocene_carbonates?_overthrust (pae)
- 1_ts_m_13_Paleocene_Base_Eoc (pae)
- 1_ts_m_13_Paleocene_Base_Eoc_overthrust (pae)
- 1_ts_n_14_Cretaceous (pae)
- 1_ts_n_14_Cretaceous_overthrust (pae)
- 1_ts_o_15_Intra-Cretaceous_Muerto? (pae)
- 1_ts_p_16_Paleozoic_meta (pae)
- 1_ts_p_16_Paleozoic_meta_overthrust (pae)
- 1_ts_q_17_Precambrian_Crystalline_Bsmt (pae)

Perú petro

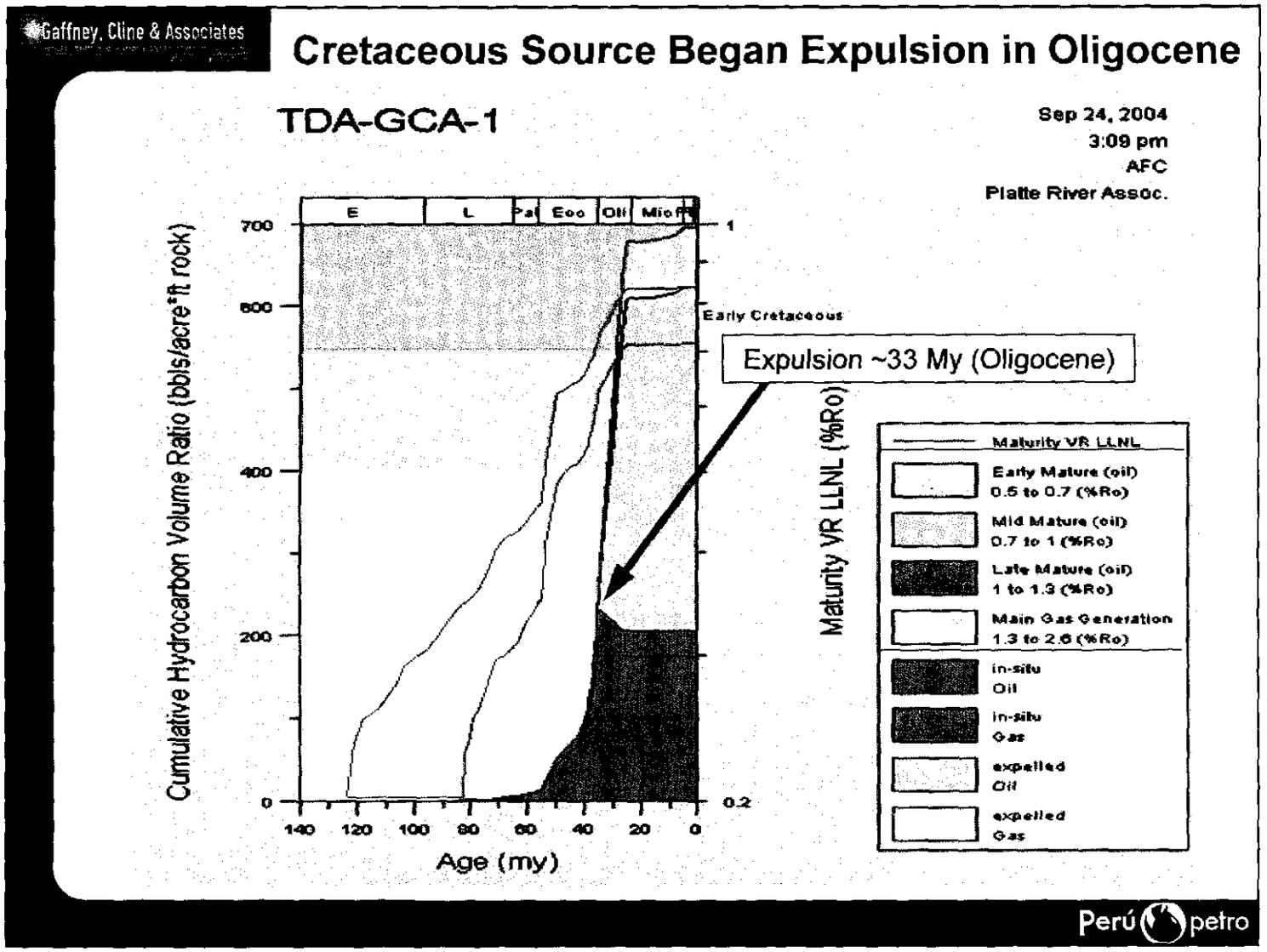
Use this legend to understand the age of the interpreted horizons in the seismic lines that follow in this presentation. Overall, blue marks Paleozoic metamorphic basement, green is top Cretaceous, and red is top Paleocene. The Eocene is broken into several intervals as shown. The Oligocene has been largely eroded throughout the area. The Miocene is complicated by several episodes of channel cut and fill, which is represented by several horizons in the interpretation. Finally, the section is capped off by Pliocene and Quaternary horizons.



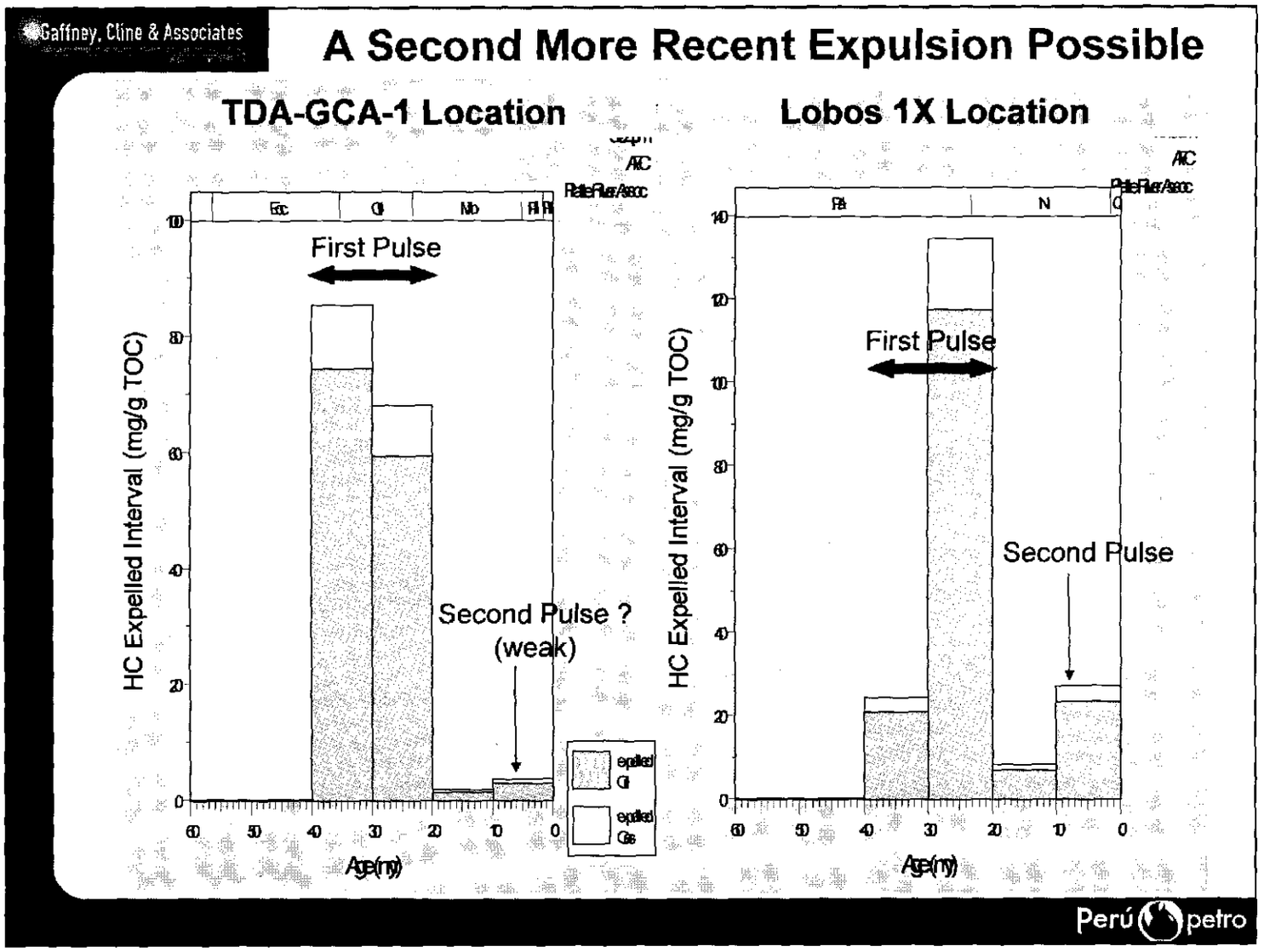
A look at the depth-converted seismic line 96-017 confirms that the total sediment thickness is about 2,000 meters at the TDA-GCA-1 location. This line segment also illustrates the seismic tie to the Lobos well. The tops do not tie this line precisely because the Lobos well is actually projected into this line from 3 kilometers to the northeast.



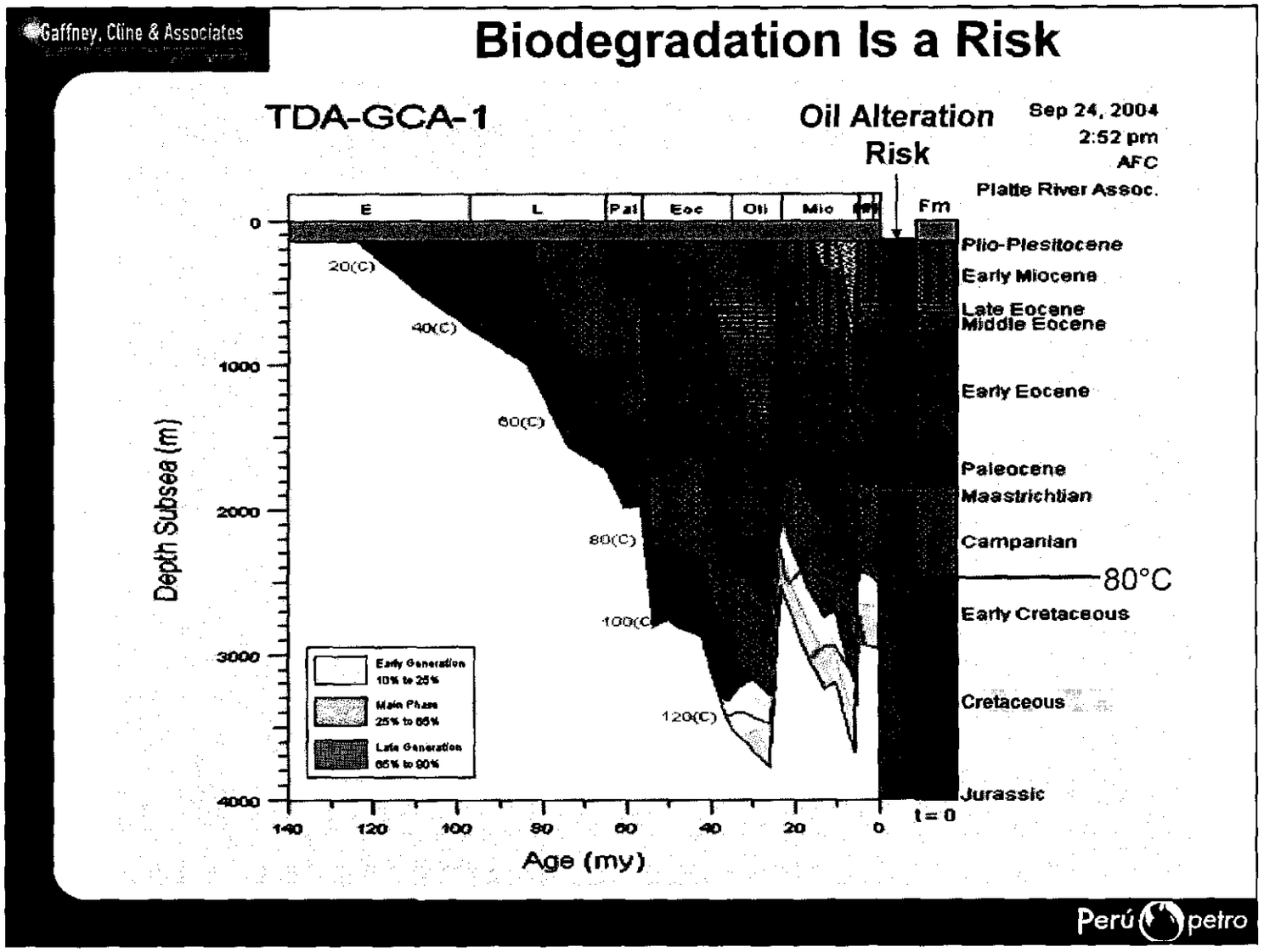
This location is near the Lobos well, which had heavy oil shows in the sandier intervals in the Lower Eocene, Paleocene and Cretaceous. Notice that the Tertiary section above the Early Eocene in this location is not mature enough to generate and expel hydrocarbons. The Cretaceous is mostly in the main phase of hydrocarbon generation.



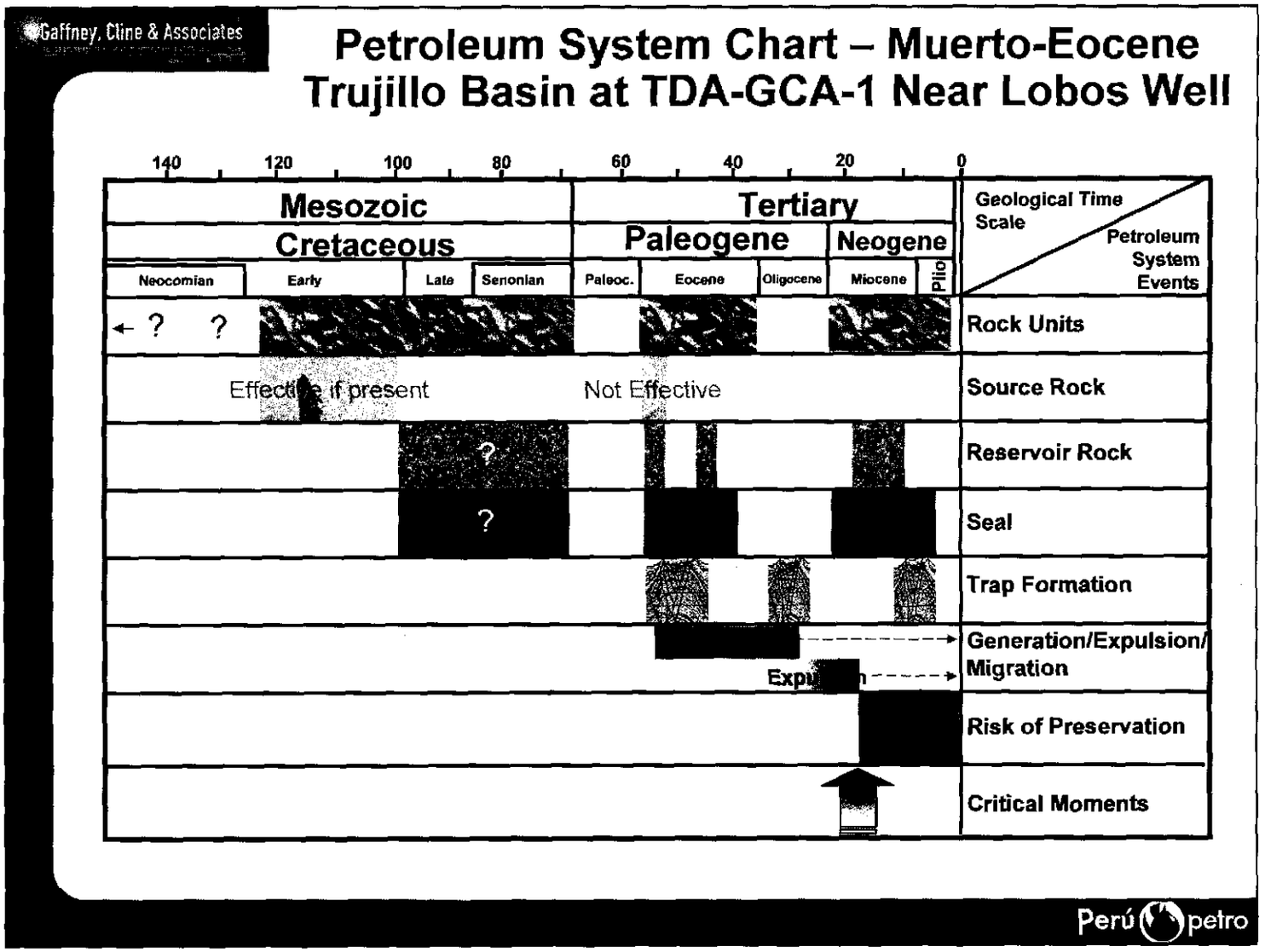
Based on the thickness of at least 1,000 meters of Cretaceous section (around 600 m penetrated in the Lobos 1X well), oil expulsion began around Oligocene time from the Muerto formation or its equivalent Cretaceous source rock at this location. Today, this interval may still be generating and expelling oil. Sensitivity analysis with variations of +/- 5 milliwatts per square meter (mW/m2) in heat flow does not drastically affect the interpretation of the oil generation history.



Based on the expulsion evolution from the Muerto formation, it is possible to infer a main pulse of oil migration between 40 and 20 million years ago (My), and a second smaller pulse in recent time. This recent pulse is more pronounced at the Lobos 1X well location, where the Cretaceous is somewhat thicker and deeper than at the modeled location.



All of the oil in Tertiary and Late Cretaceous reservoirs is in the zone of potential biodegradation. Any oil potentially trapped in the source rock Cretaceous section would be preserved from biodegradation.



Cretaceous source rock generation and expulsion of hydrocarbons varies in time, depending on the thickness of the Cretaceous section in the seismic interpretation. Almost certainly by Middle Eocene time, but possibly as early as Late Eocene, source rock may have been generating and expelling hydrocarbons. A critical moment was assigned to the entry of the main Eocene reservoir into the biodegradation window occurring below 80° C. Another critical moment was assigned based on the end of the oil expulsion available to migrate to the potential traps in the area.

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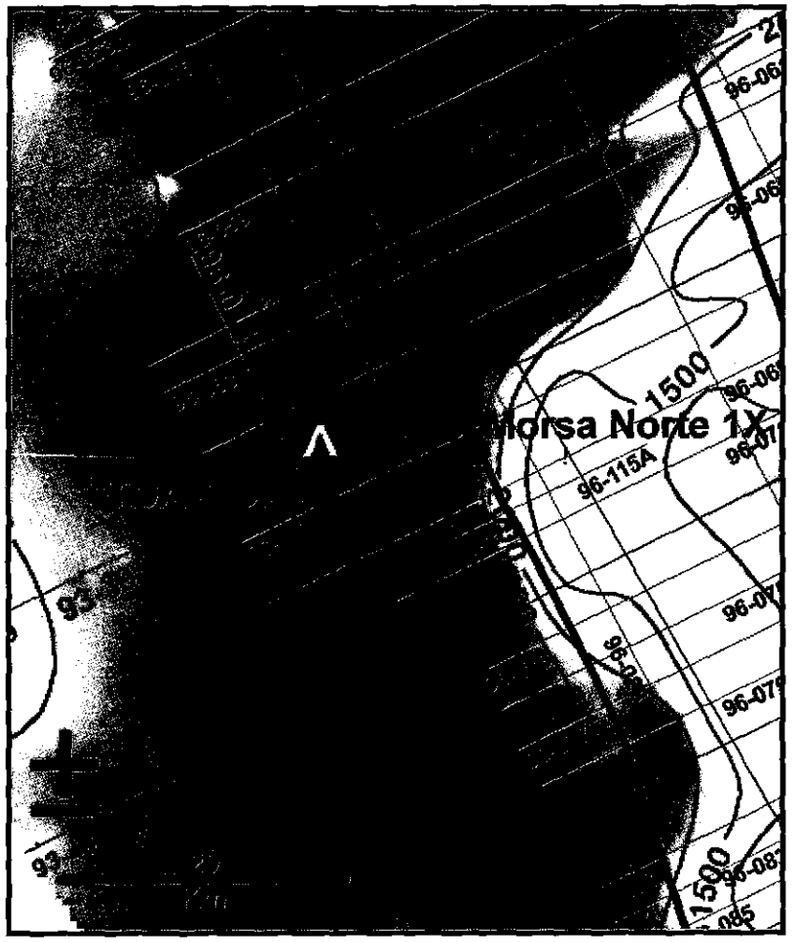
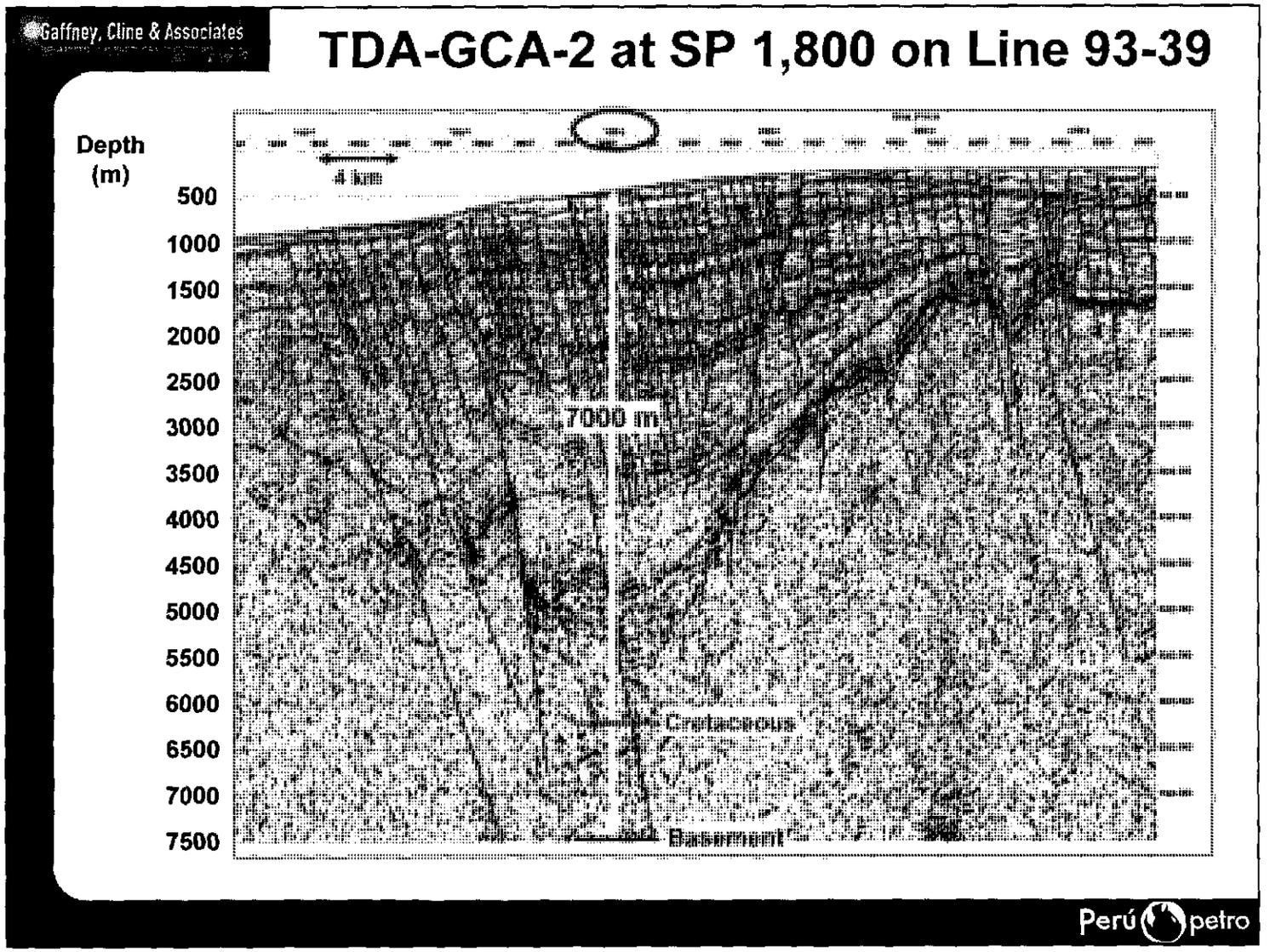
TDA-GCA-2 at SP 1,800 on Line 93-39

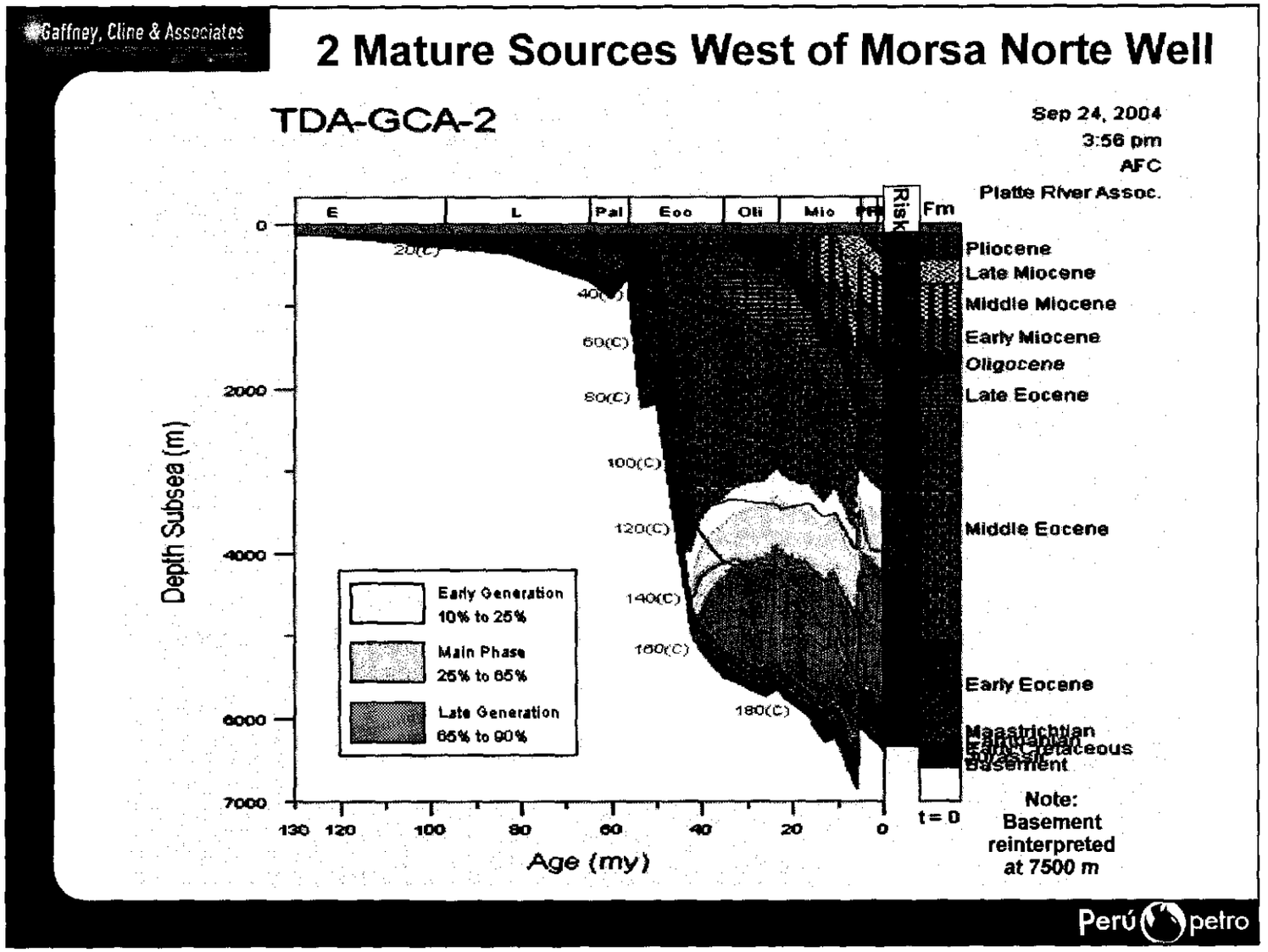


Perú petro

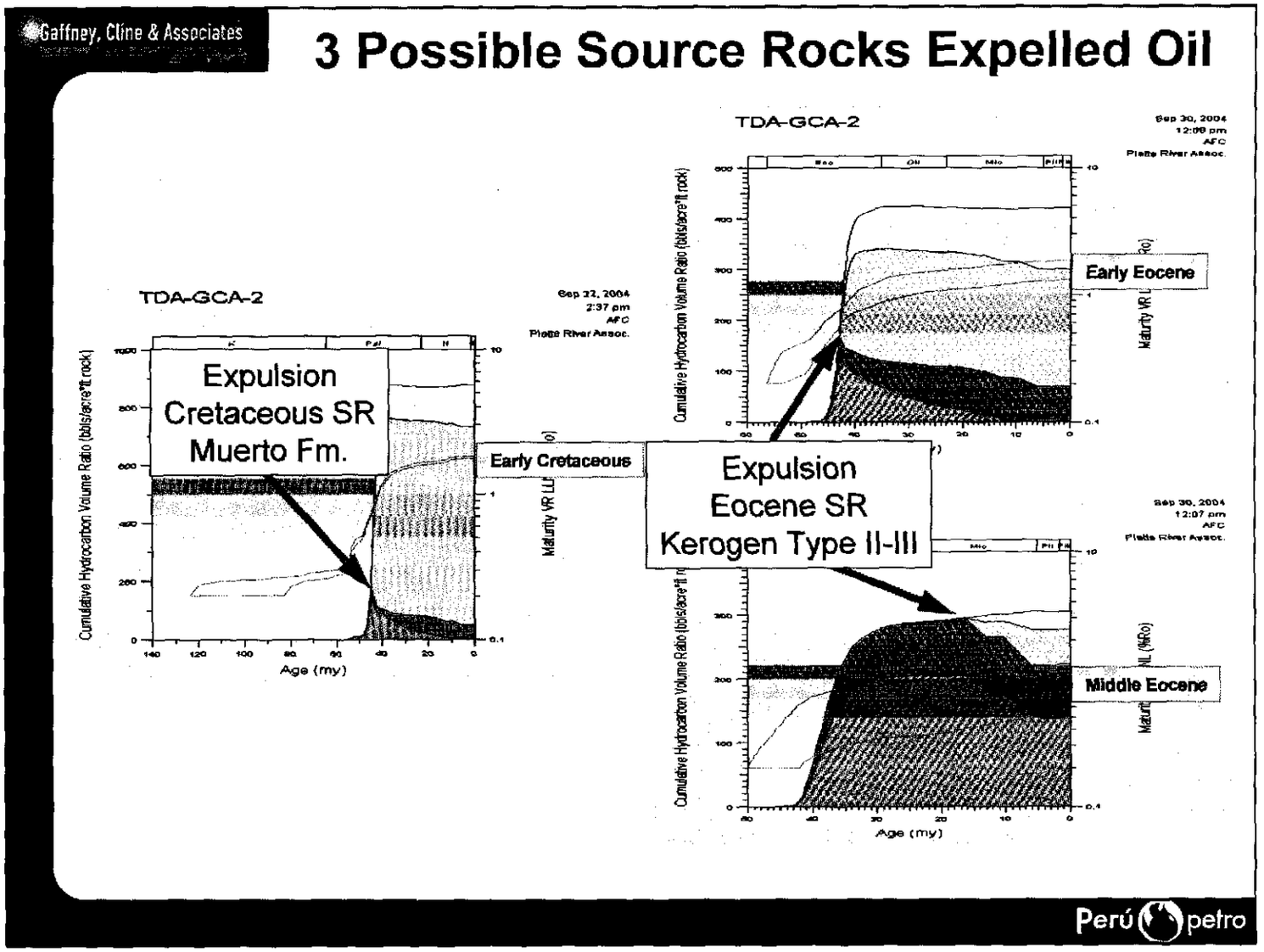
Here is a detailed look at the TDA-GCA-2 maturation modeling location. It shows a much thicker section of total sediments. The actual thickness interpreted at this location is 7,000 meters (see next slide), but the gridding interval for this map was too large to show contours in the narrowest part of this trough.



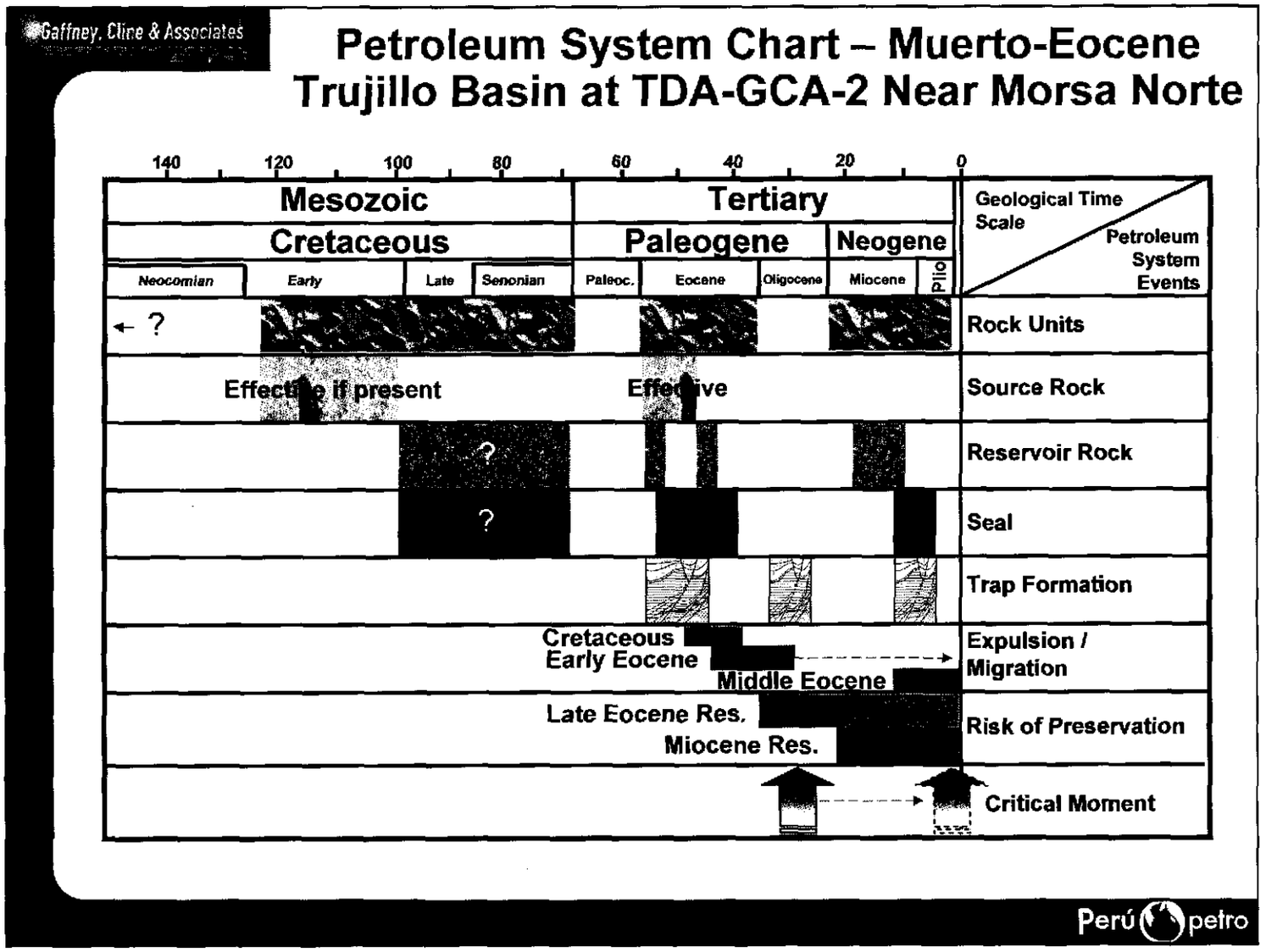
The Cretaceous and Basement tops at the modeled location were not interpreted in this section. They were projected in from the 96-014 strike line two kilometers to the southwest.



Thick Tertiary deposition at the TDA-GCA-2 modeled location enabled potential Eocene and Cretaceous source rocks to generate oil as early as the Eocene. Note that the seismic was reinterpreted subsequent to this analysis, putting basement another 1000 meters deeper, which only enhances the maturation picture.



A typical mixed type II-III kerogen as Eocene source rock would have expelled hydrocarbons under the modeled thermal conditions. The Cretaceous and Early Eocene source rocks were likely rapidly exhausted. Any oil might have migrated to traps at that time, otherwise it was lost. Middle Eocene expulsion is better timed to charge the younger traps.



The Cretaceous source rock generated and expelled hydrocarbons almost instantly at Middle Eocene time, but the Middle Eocene source rock may have generated and expelled hydrocarbons as late as Pliocene, if adequate source rock were present. Critical moments are assigned to the end of oil generation from the Cretaceous/Early Eocene source rock pair, but if a source is present in the Middle Eocene interval, fresh oil might have been available to younger traps.

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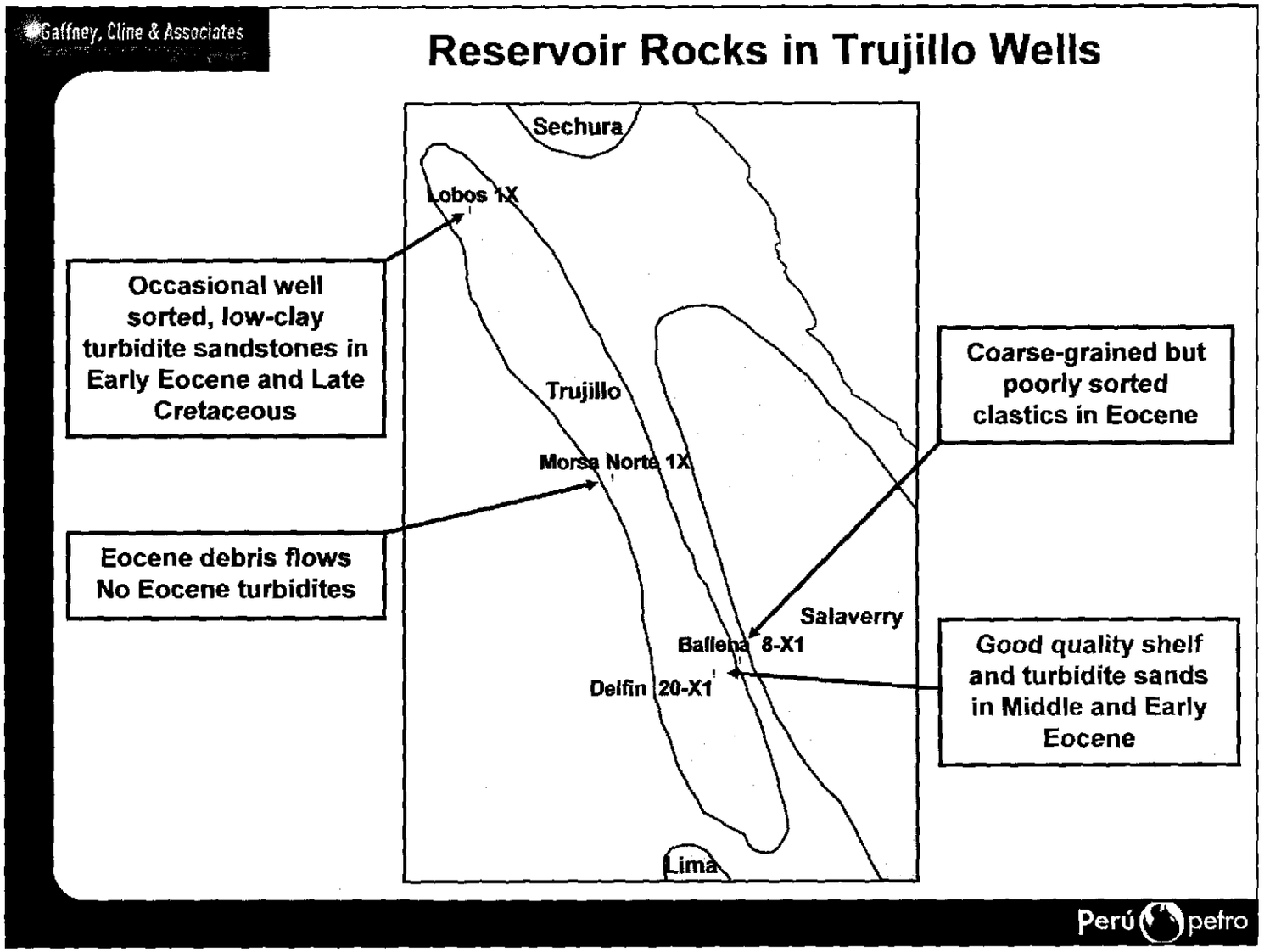
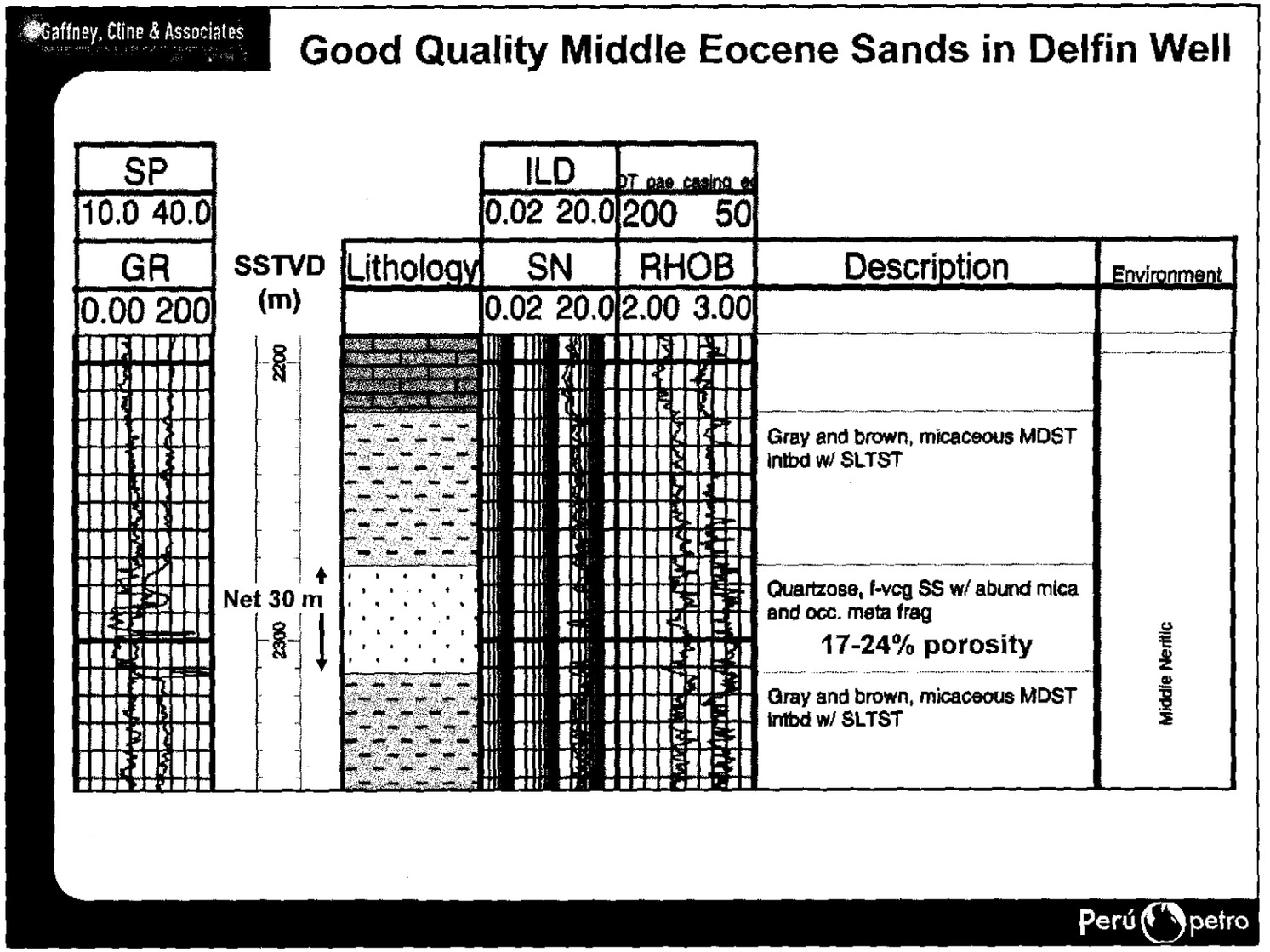
Perú petro

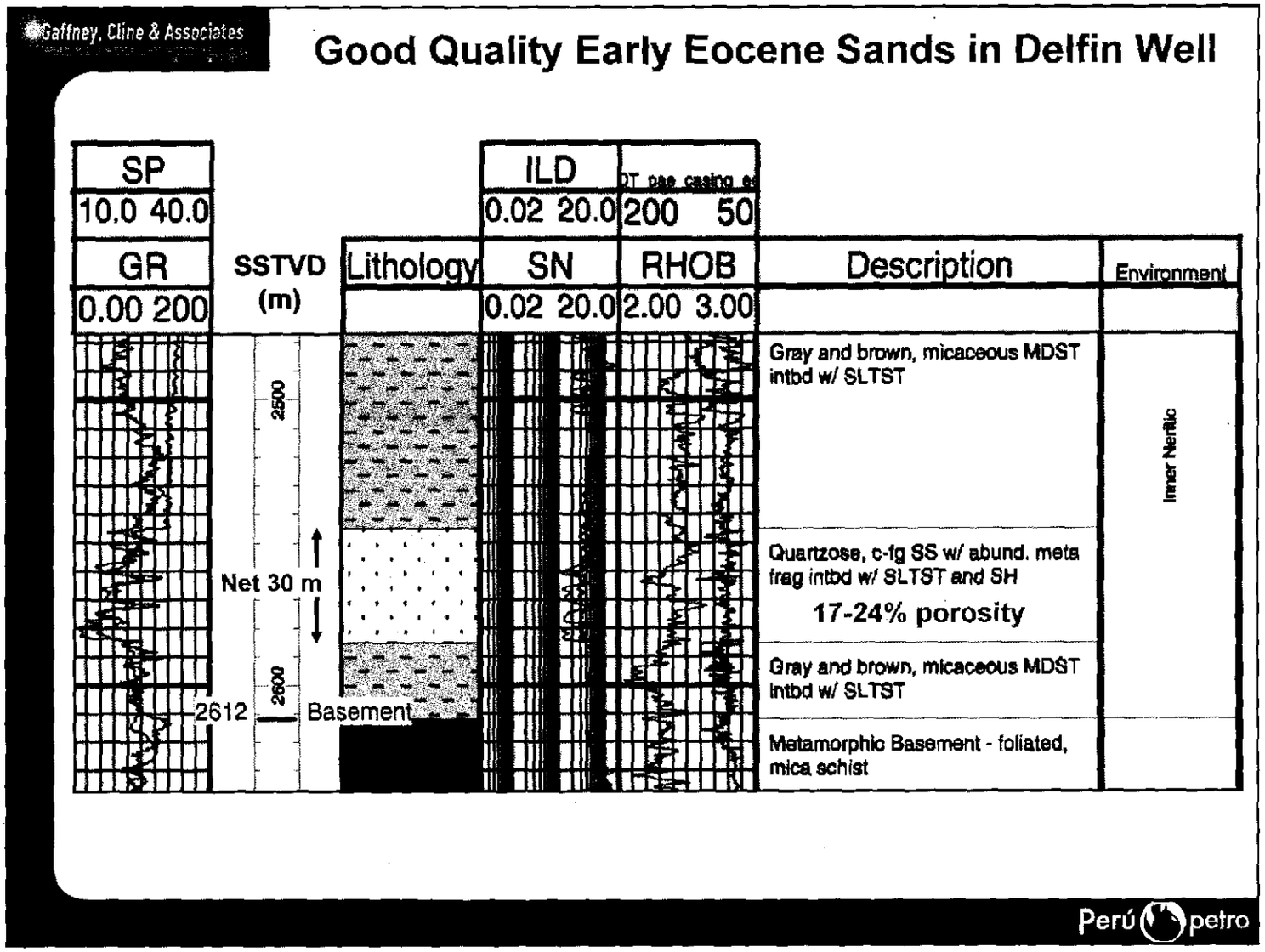
Source is clearly not a key risk in the Trujillo basin. Reservoir has been more problematic. However, the new structural and stratigraphic framework presented in this study has illuminated several new clastic and possible carbonate fairways.



Overall, the four exploration wells encountered poor-to-fair quality reservoir rocks, with the exception of the Delfin well. This well encountered two 30-meter packages of good quality sand in the Eocene. They are illustrated in the following two slides.



The first good-quality reservoir sand interval in the Delfin well occurs at approximately 2,275 meters (sub-sea true vertical depth = SSTVD) in the Middle Eocene. The net interval averaged 17-24% porosity.



A similar 30-meter net interval occurs in the Delfin well at approximately 2,545 meters SSTVD in the Lower Eocene.

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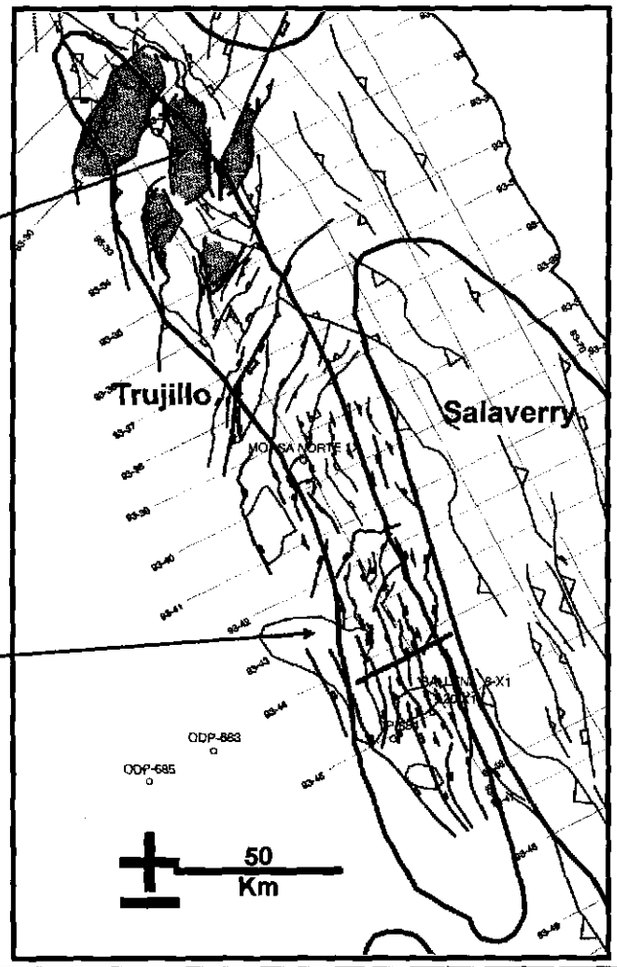
Early Eocene Channels/Turbidites

Conglomerate-Prone Fault-Bounded Extensional Basins

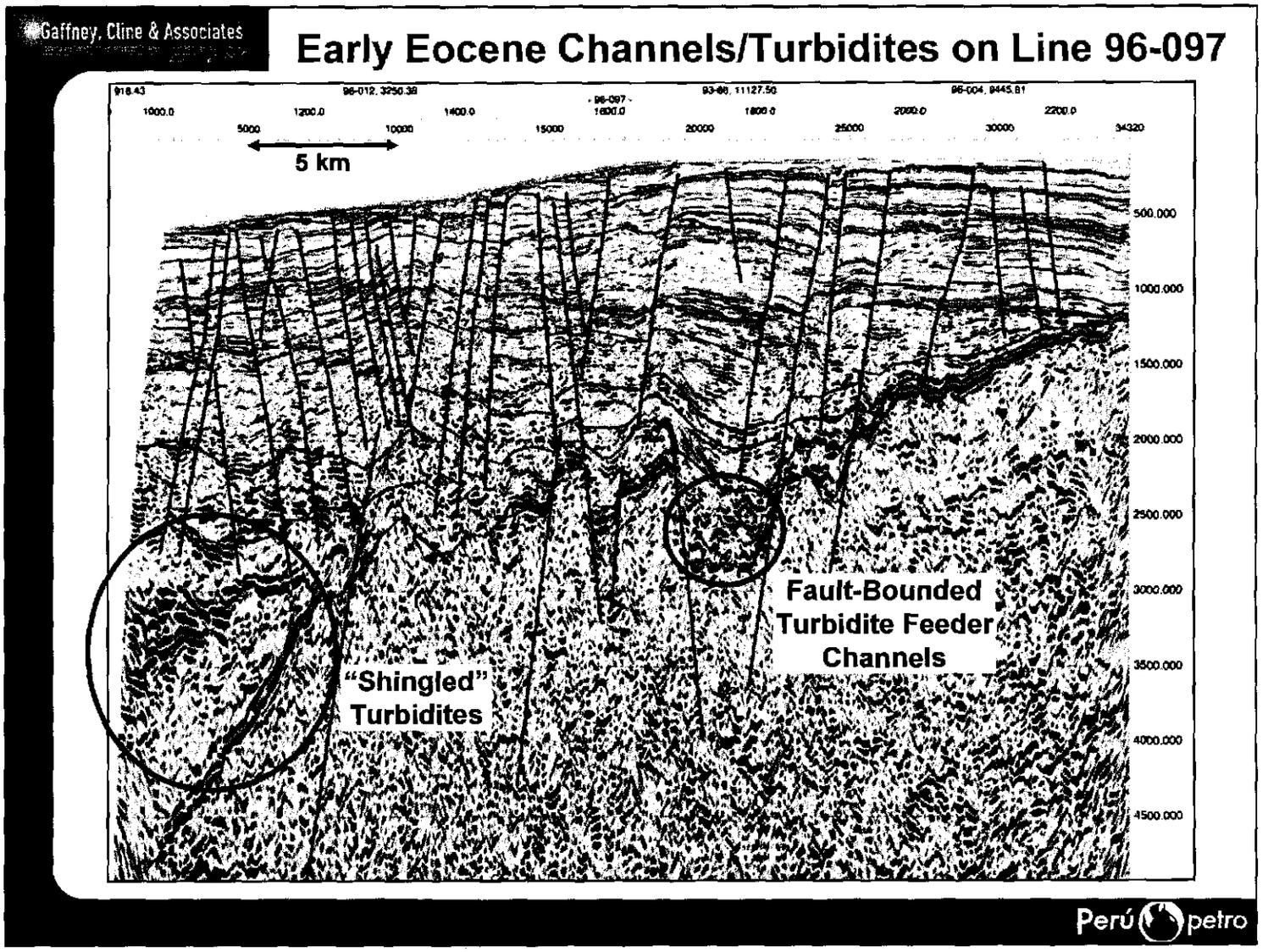
Sand-Prone Fault-Bounded Basins and Basin-Floor Fans



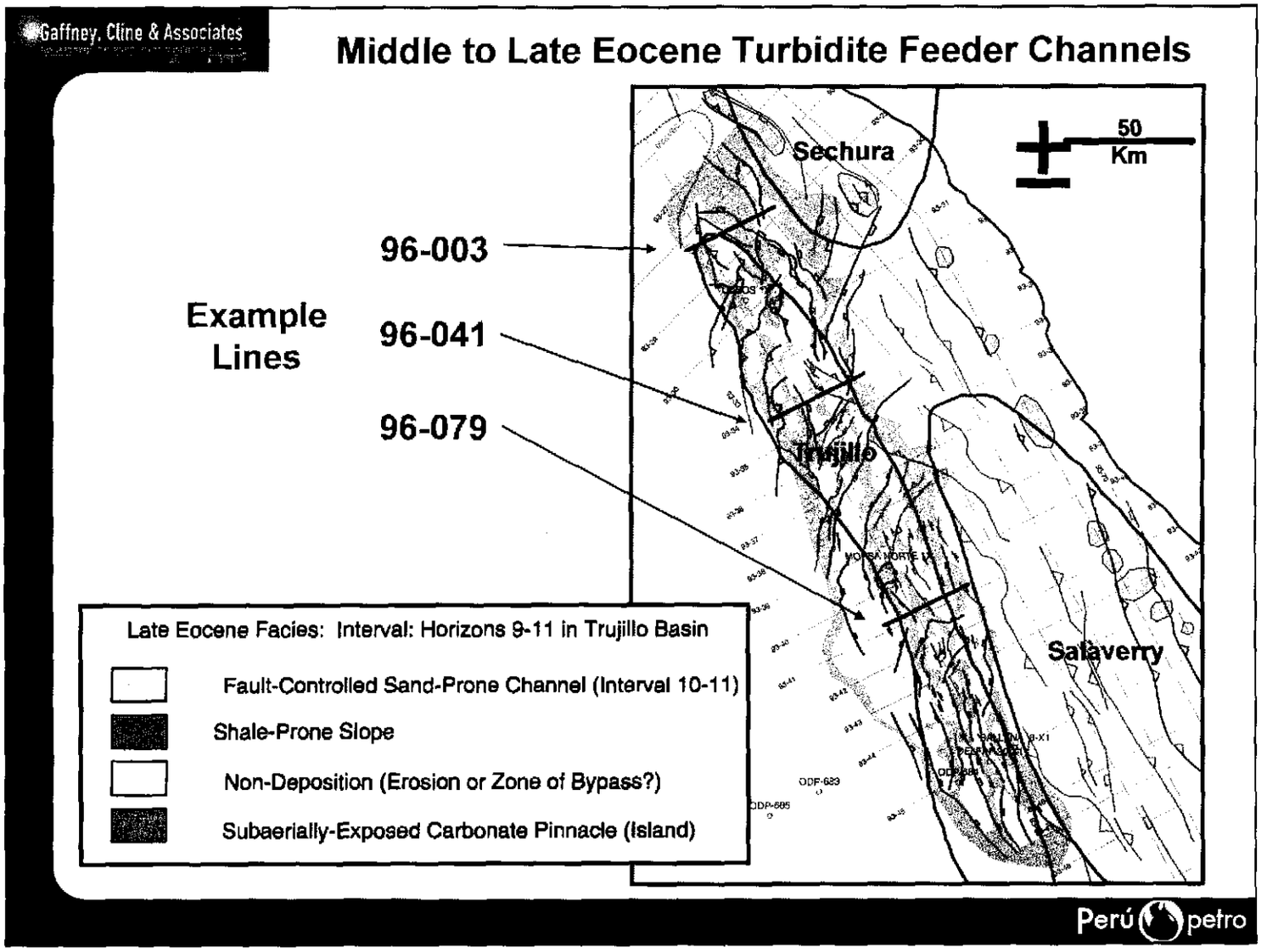
Line 96-097 in red

Perú petro

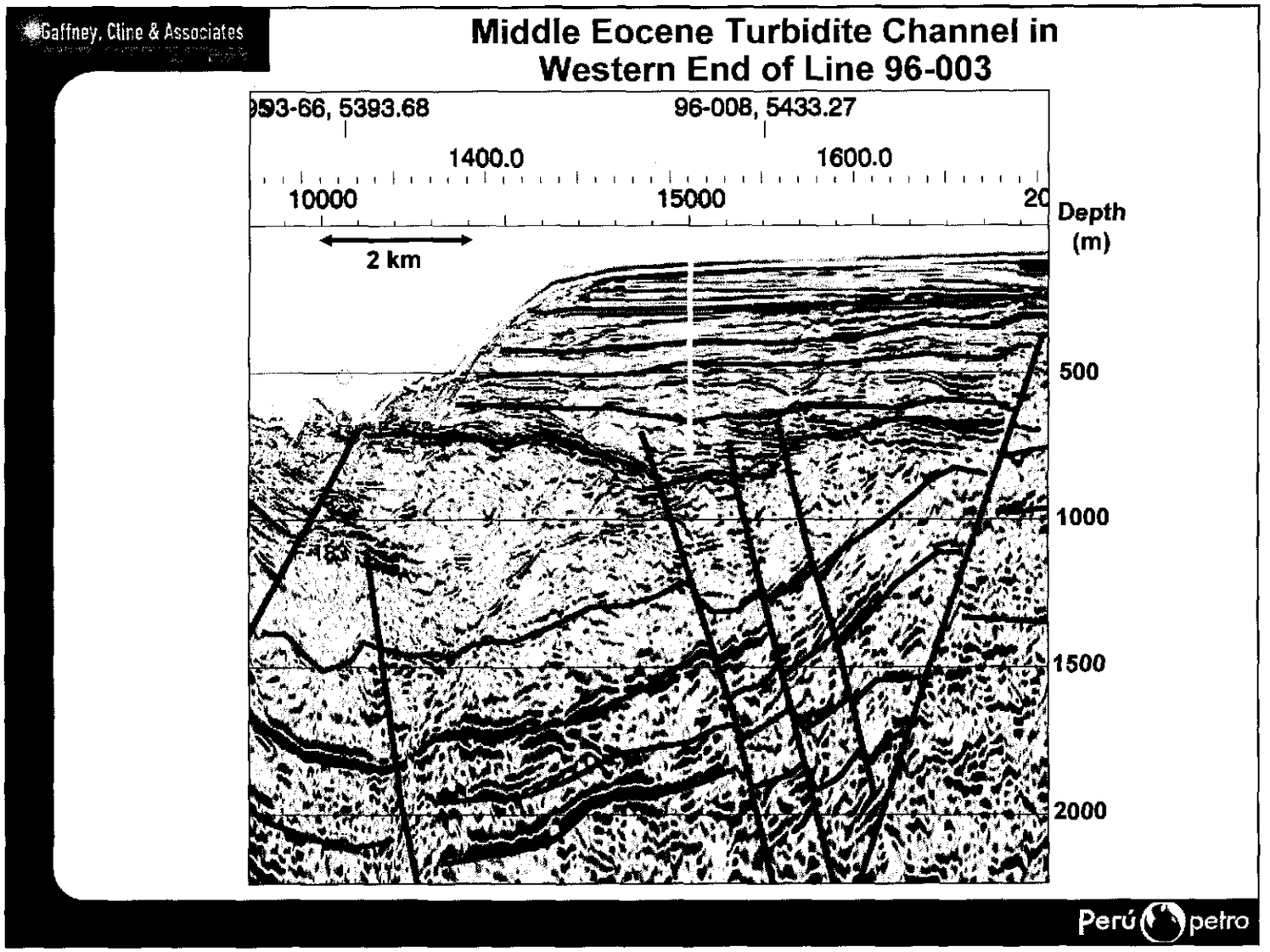
A major deliverable of this study was a set of paleogeographic/facies distribution maps. Here is the one for the Lower Eocene. It suggests that the Lower Eocene sand in the Delfin well might have been deposited in a fault-bounded basin floor fan. Line 96-097 illustrates the seismic character of this interval in the next slide.



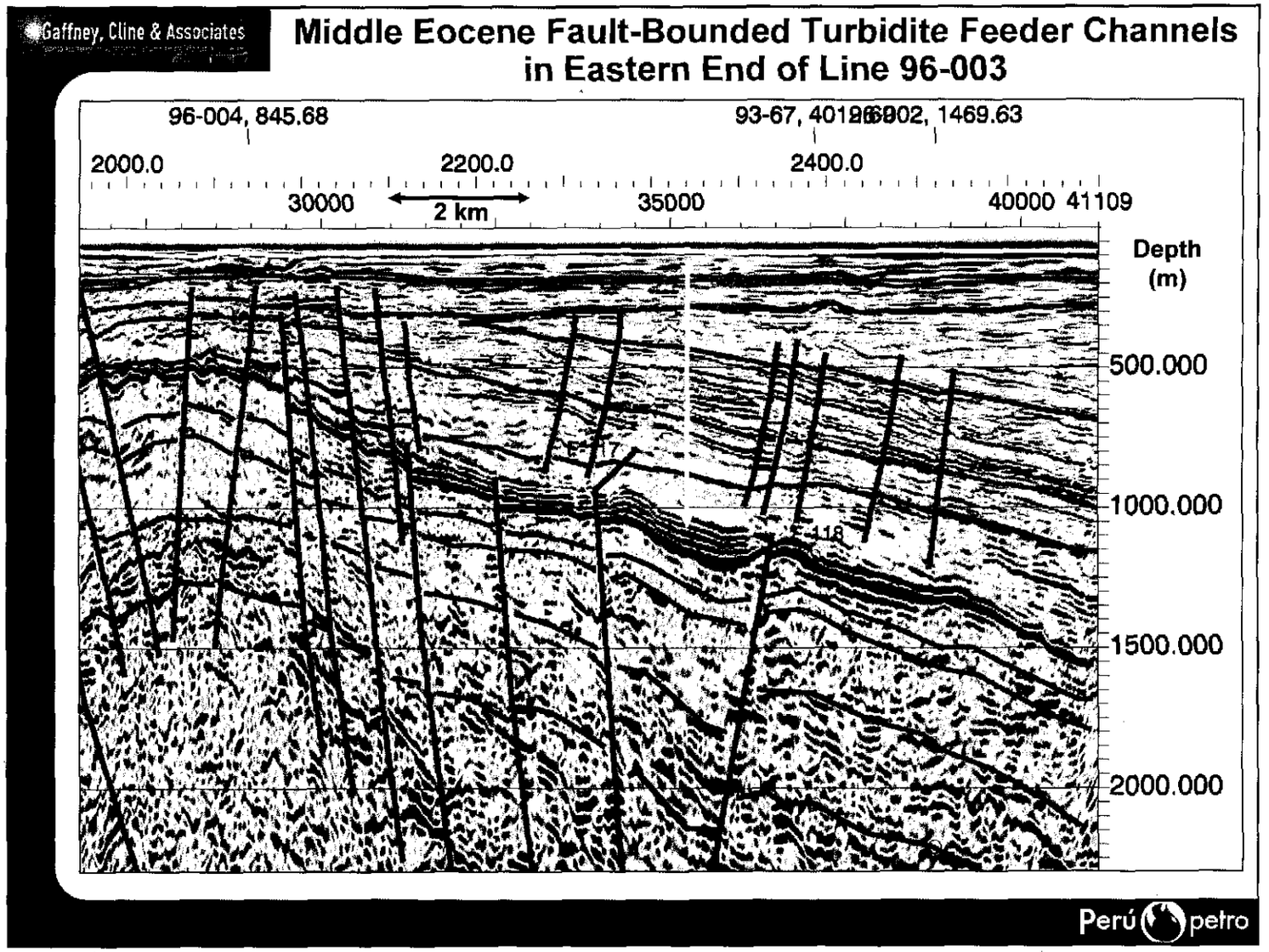
There are actually two different sand morphologies in this section. One represents a possible turbidite feeder channel that is bounded by normal faults. The other shingled geometry is more characteristic of stacked basin-floor turbidite fans.



Moving higher in the stratigraphic column, this facies map shows how Middle to Late Eocene turbidite channels may have been regionally controlled by a family of normal and reverse (thrust) faults that may have resulted in an overall strike orientation to these feeder channels, rather than a dip orientation, which is more often the case for this type of depositional system. The three seismic lines shown in red were chosen to illustrate the sequence stratigraphic character of this interval in the following slides.



Note the overall brighter seismic amplitudes of what has been interpreted as turbidite sand. This possible association of sand with seismic amplitude anomalies has made this interval an especially interesting target. Repsol tested this hypothesis with the Morsa Norte and Lobos wells, but failed to position those wells in the deeper, more sand-prospective parts of the sub-basins near those well locations. The seismic lines that illustrate these failures, and the potential success nearby, are included later in this presentation.



Here is another example at the eastern end of Line 96-003. Notice how the fault F-118 has influenced the downdip extent of the high-amplitude stack in the fault block marked with the white arrow.

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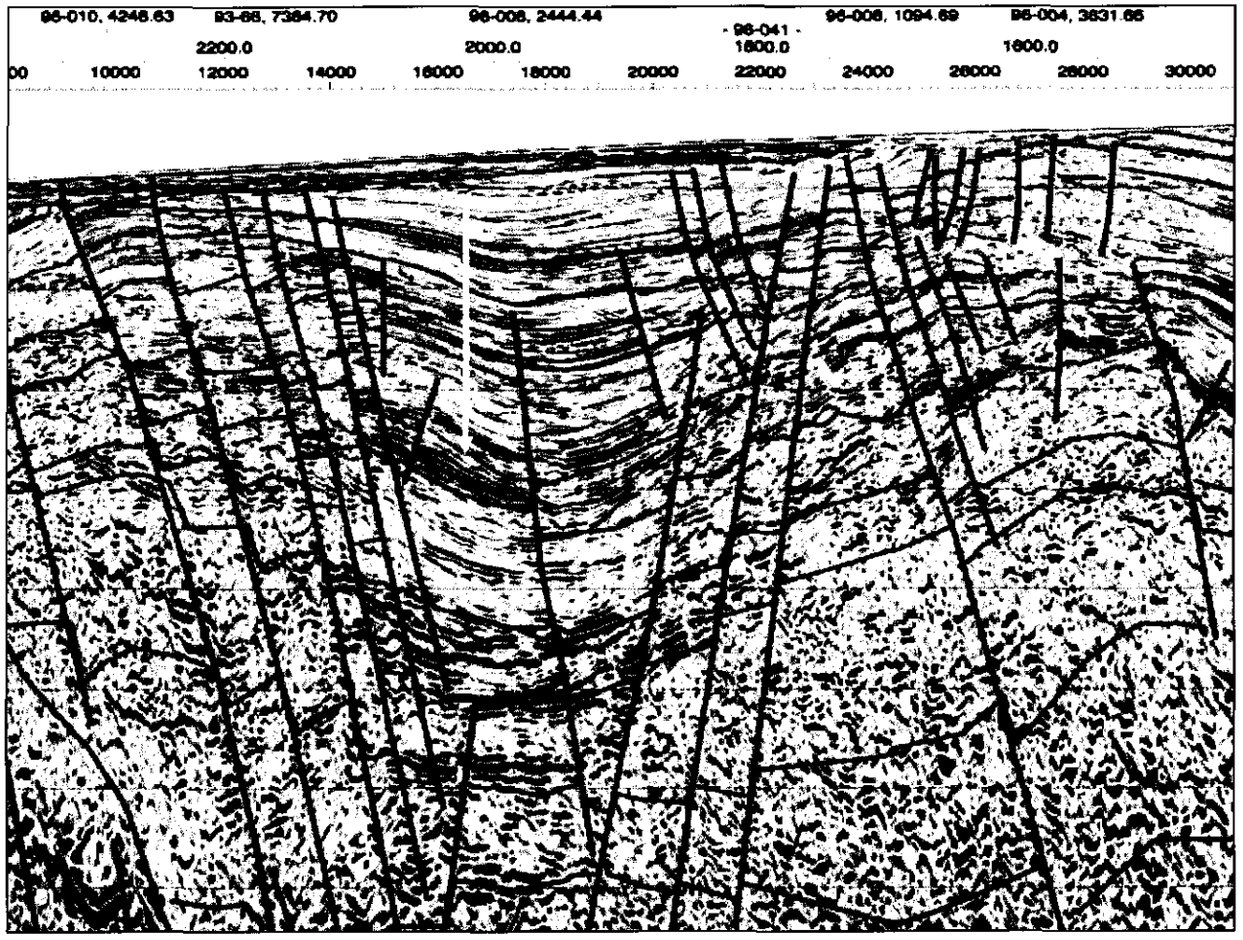
Turbidite Feeder Channels in Line 96-041

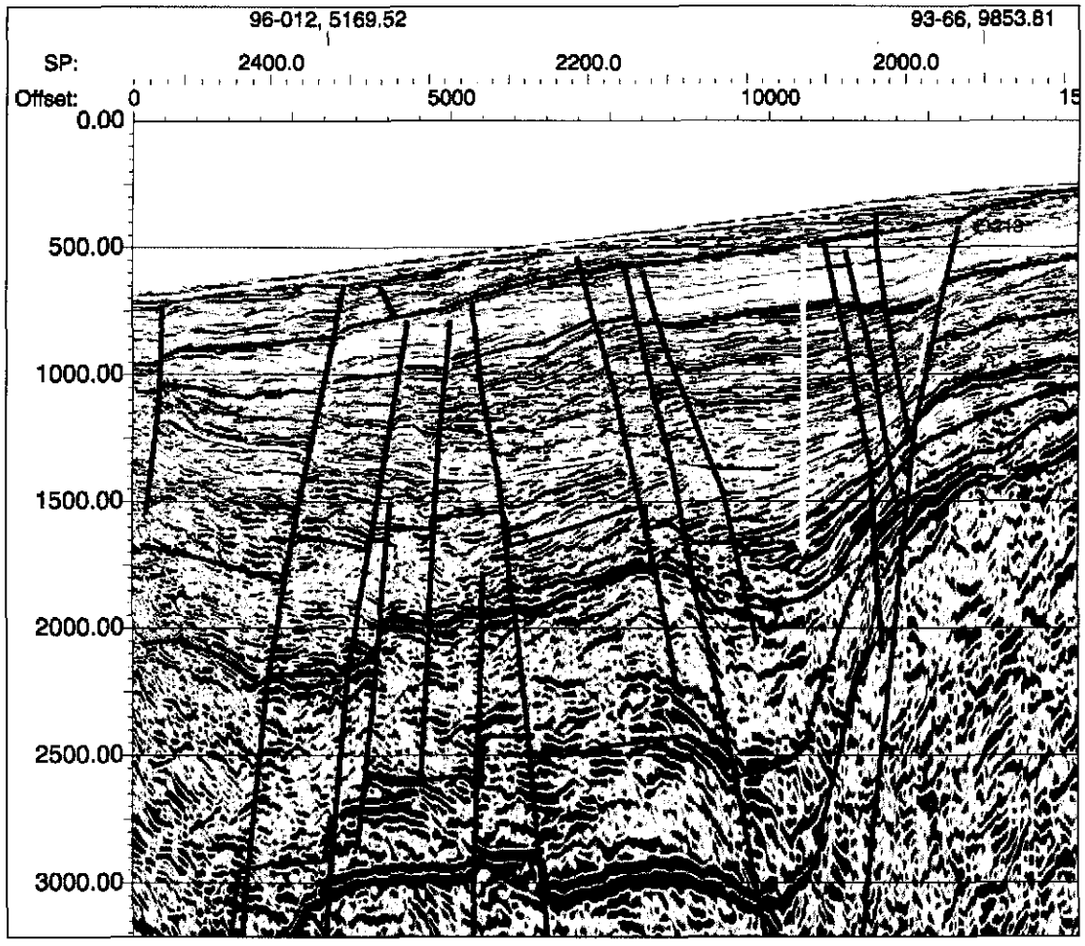


Perú petro

Here is another example of a high-amplitude stack (at the white arrow) that is bounded by high-angle faults.

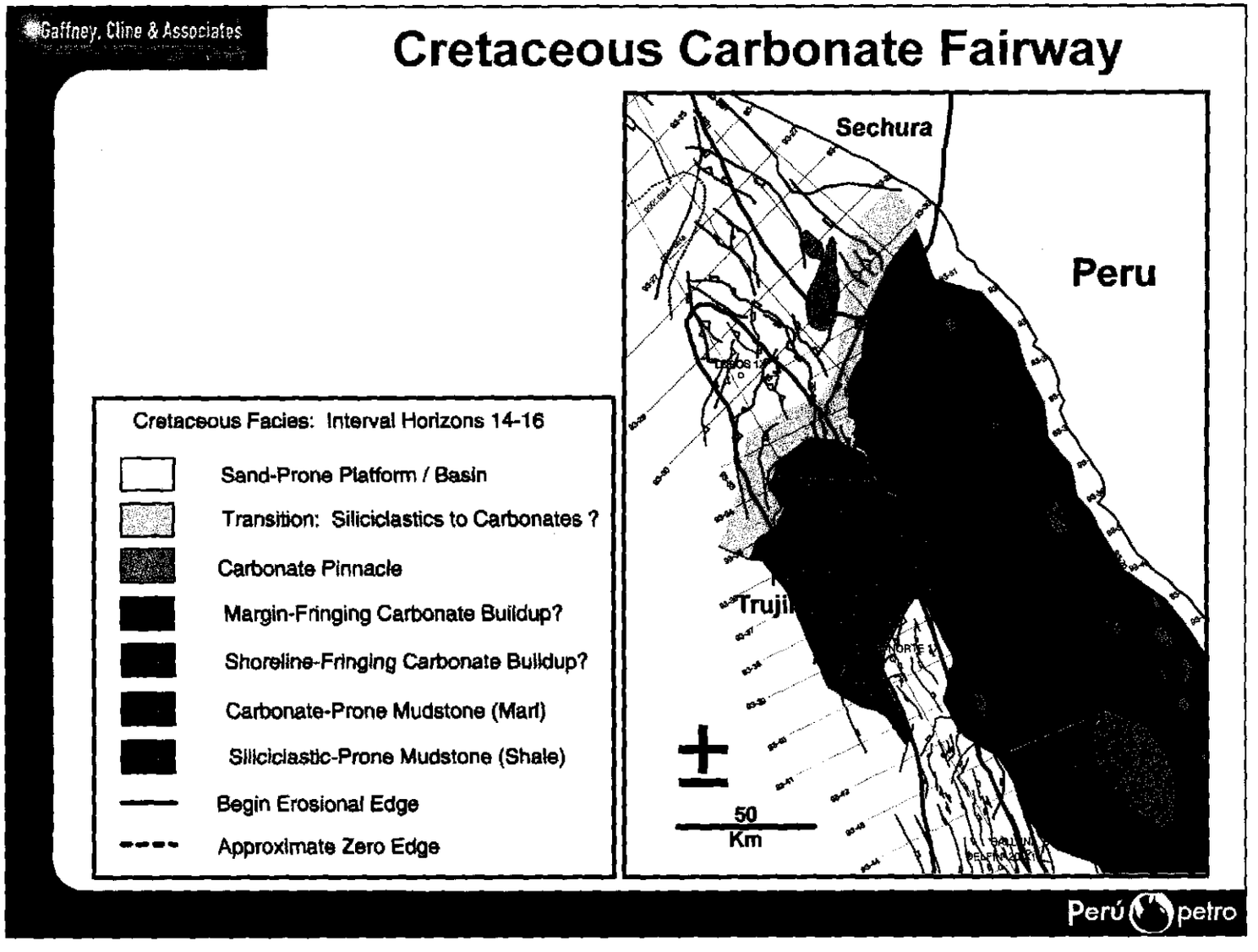
Gaffney, Cline & Associates

Turbidite Feeder Channels in Line 96-079



Perú petro

Here is a last example of fault-bounded turbidite feeder channels.



There is also reservoir potential in the Cretaceous in the northern part of the Trujillo basin, where carbonate-prone deposits northwest of the Morsa Norte well eventually transition to sand-prone sediments around and north of the Lobos well. These potential reservoirs are less attractive than the Eocene turbidites, because reservoir quality is more uncertain.

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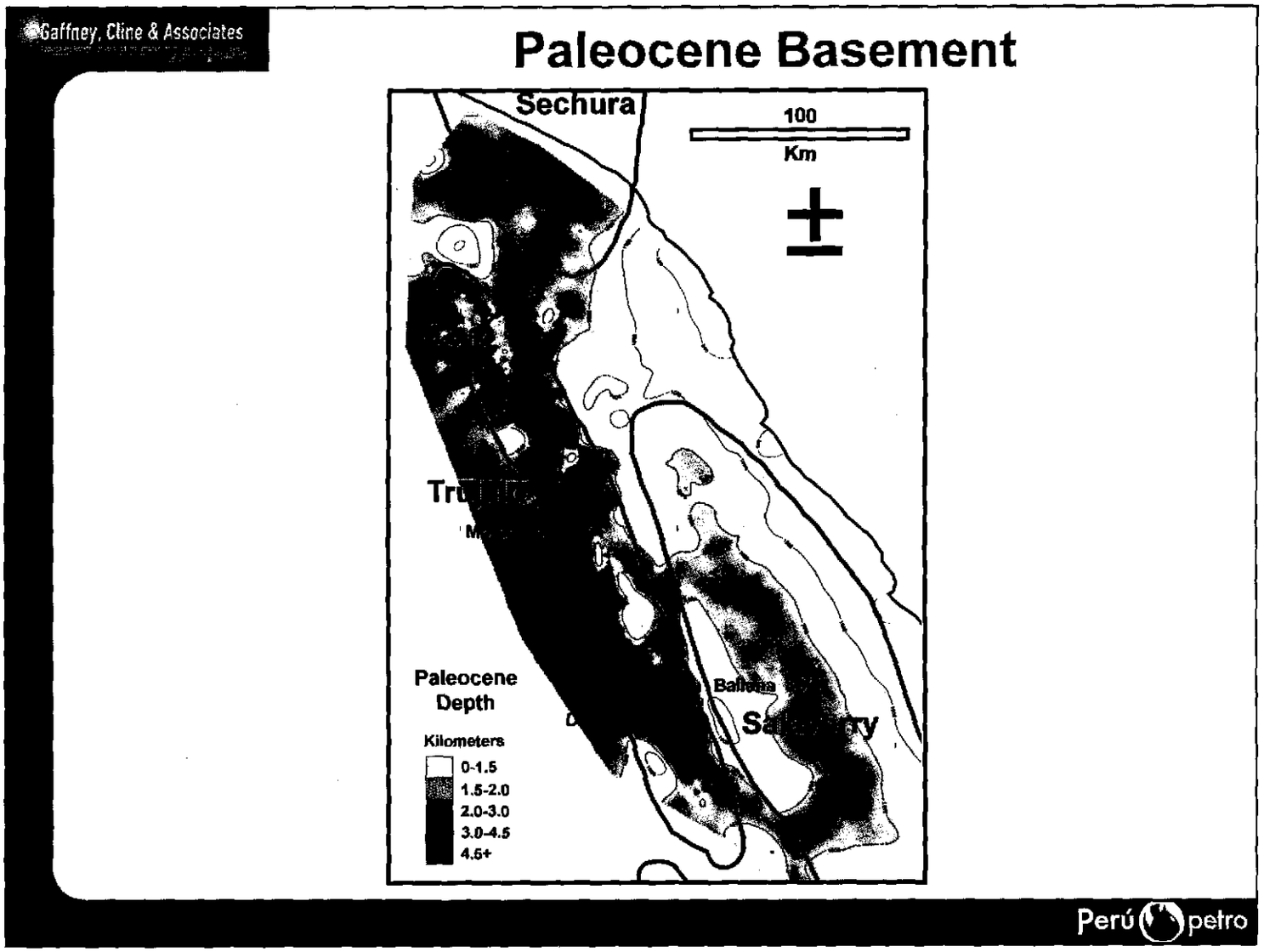
Outline

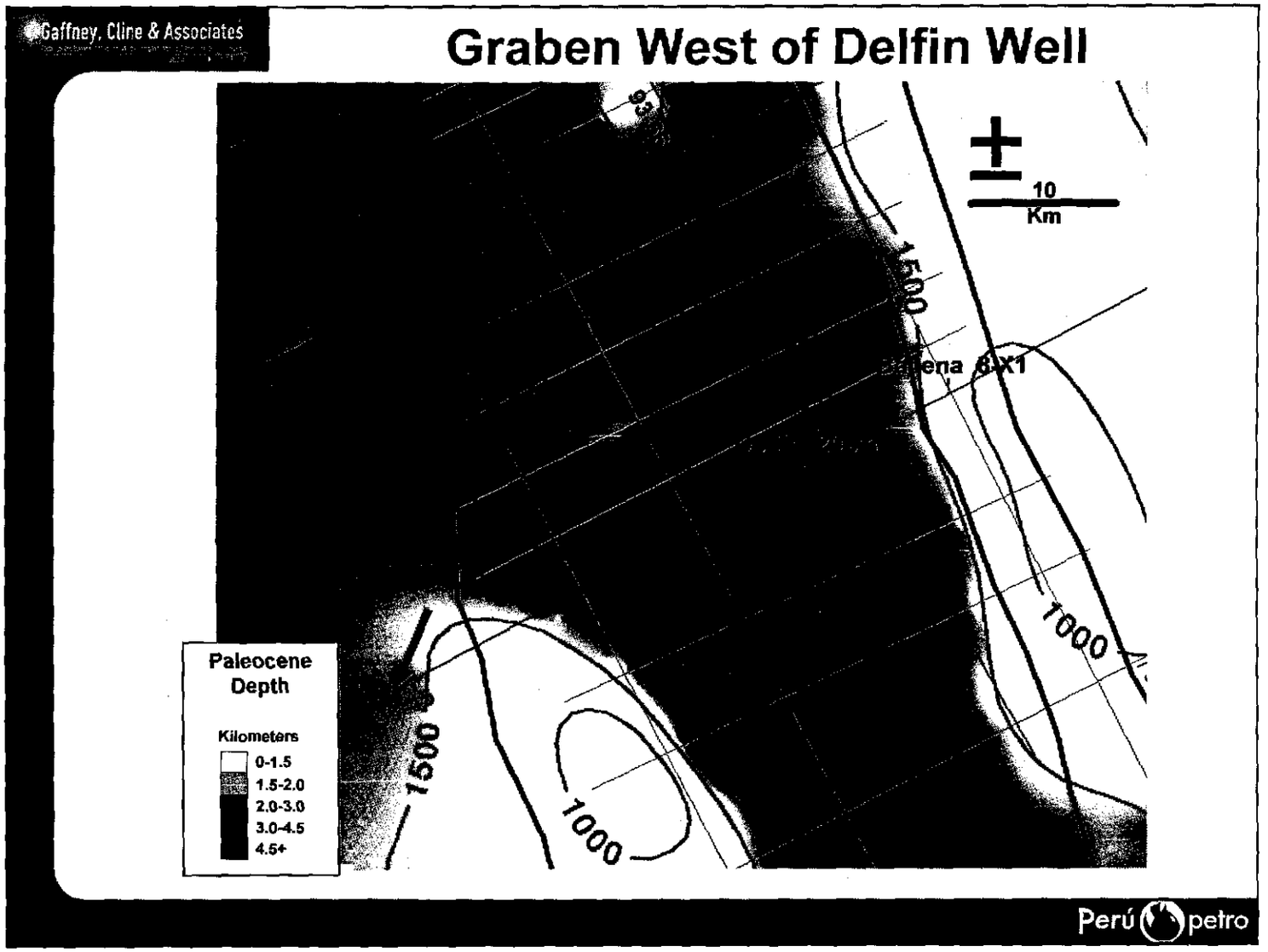
- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

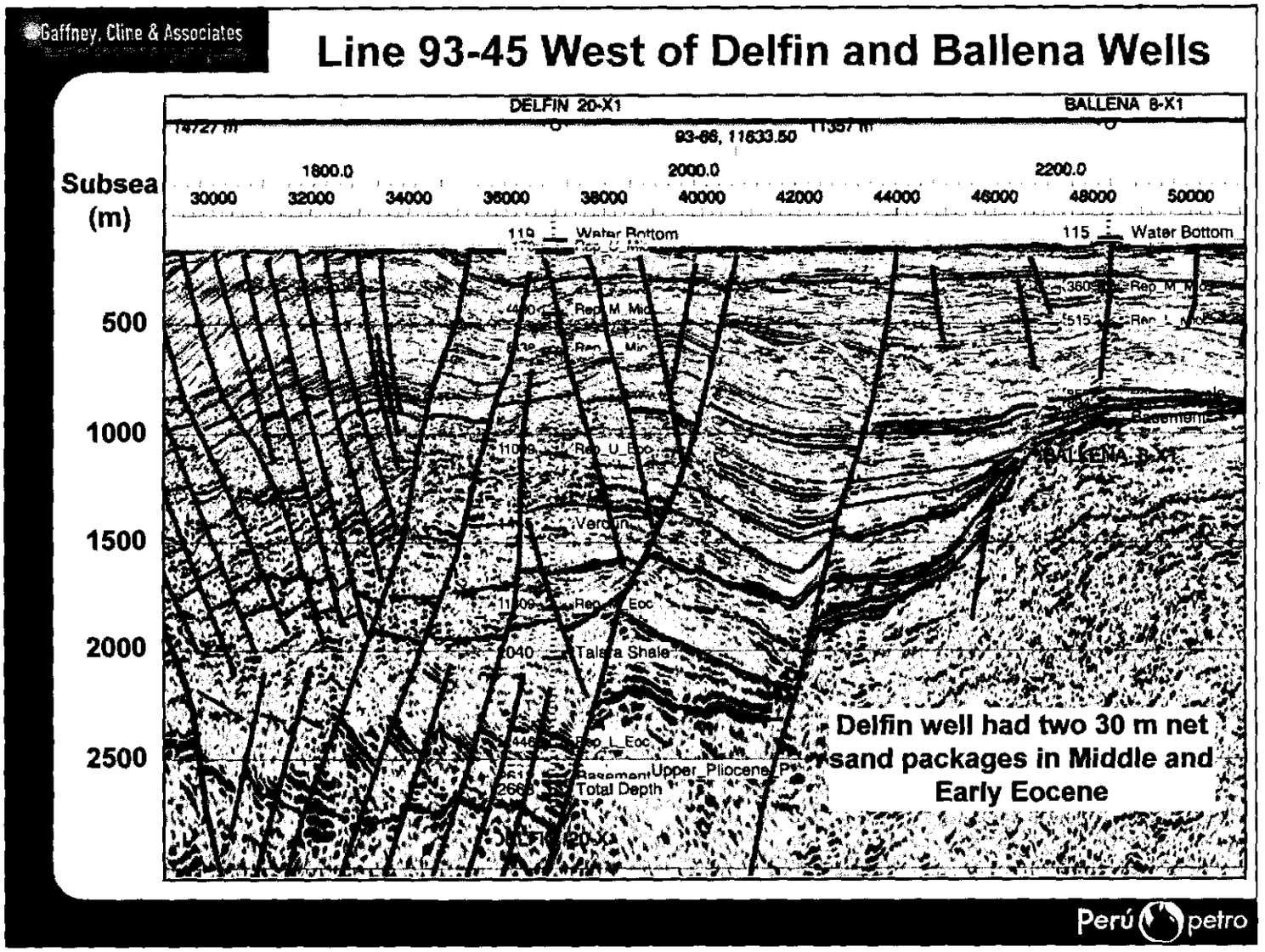
Possible traps in the Trujillo basin fall into two categories – stratigraphic traps along basement lows, and conventional tilted fault blocks and horsts defining basement highs. In both cases, basement geometry (shown in the next slide) defines the fairway.



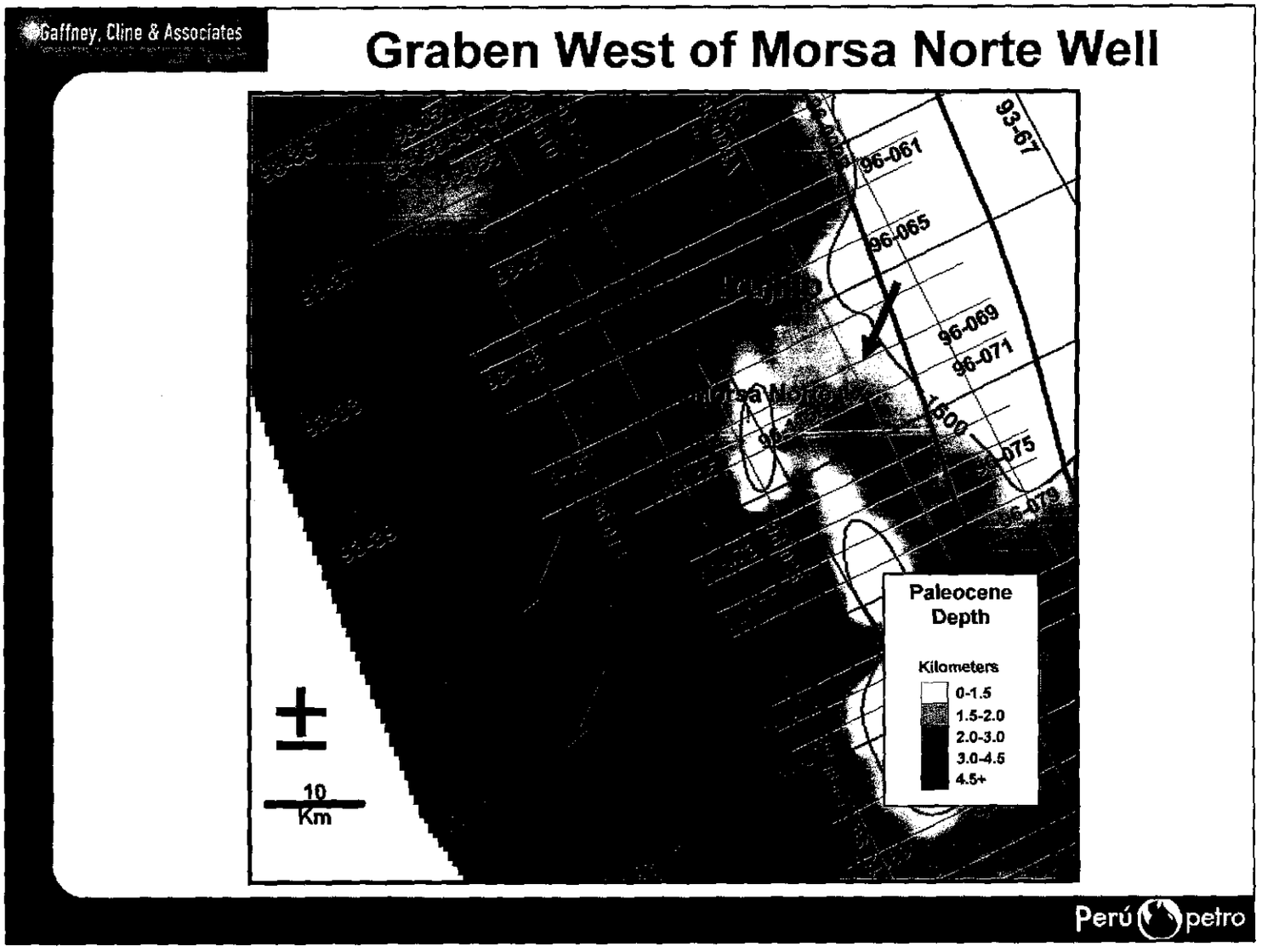
Note that three of the four Trujillo wells were drilled over basement highs. The only one that was not drilled over a basement high was the Delfin well, and it was only in this well that good-quality reservoir rocks were found.



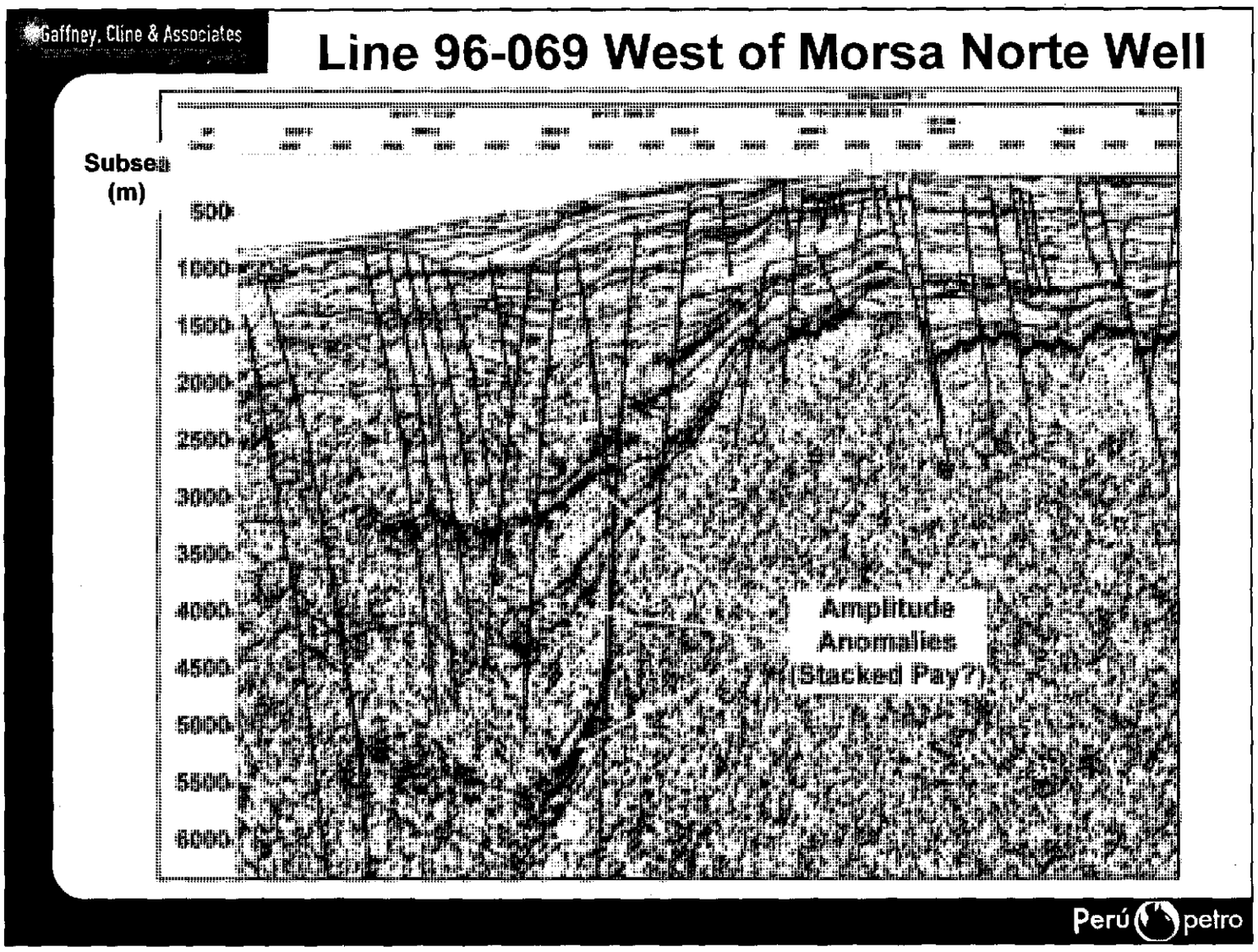
Line 93-45 (marked with the black arrow) is key to understanding how to explore in the Trujillo Basin. It ties both the Ballena and Delfin wells, and extends southwest into a deeper sub-basin.



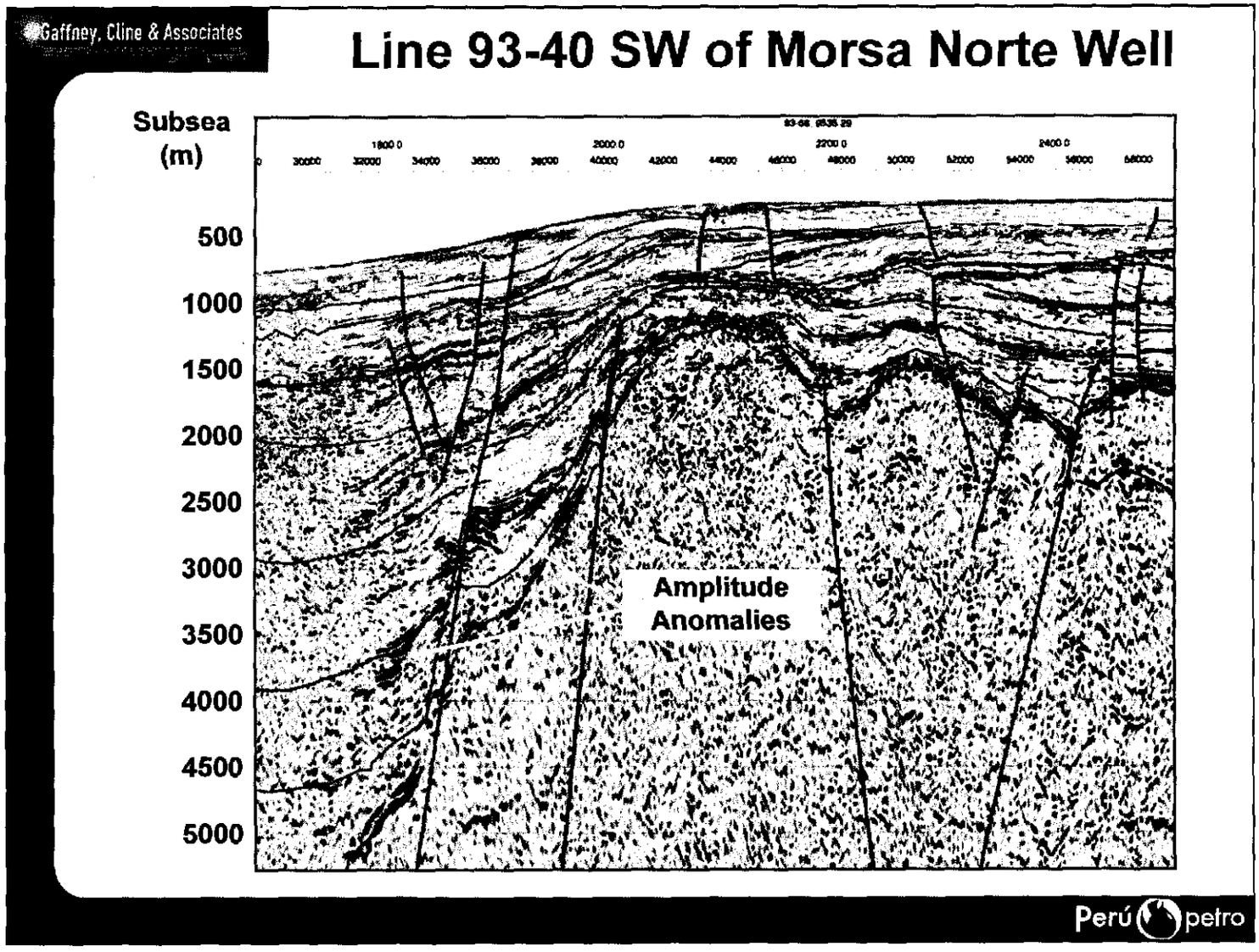
Here is a segment of that line, which helps illustrate the seismic character that is associated with good reservoir sand in the Delfin well. Unfortunately, the posted well tops partially obscure the seismic character of the Middle and Early Eocene, but the stacking of higher amplitudes can still be seen.



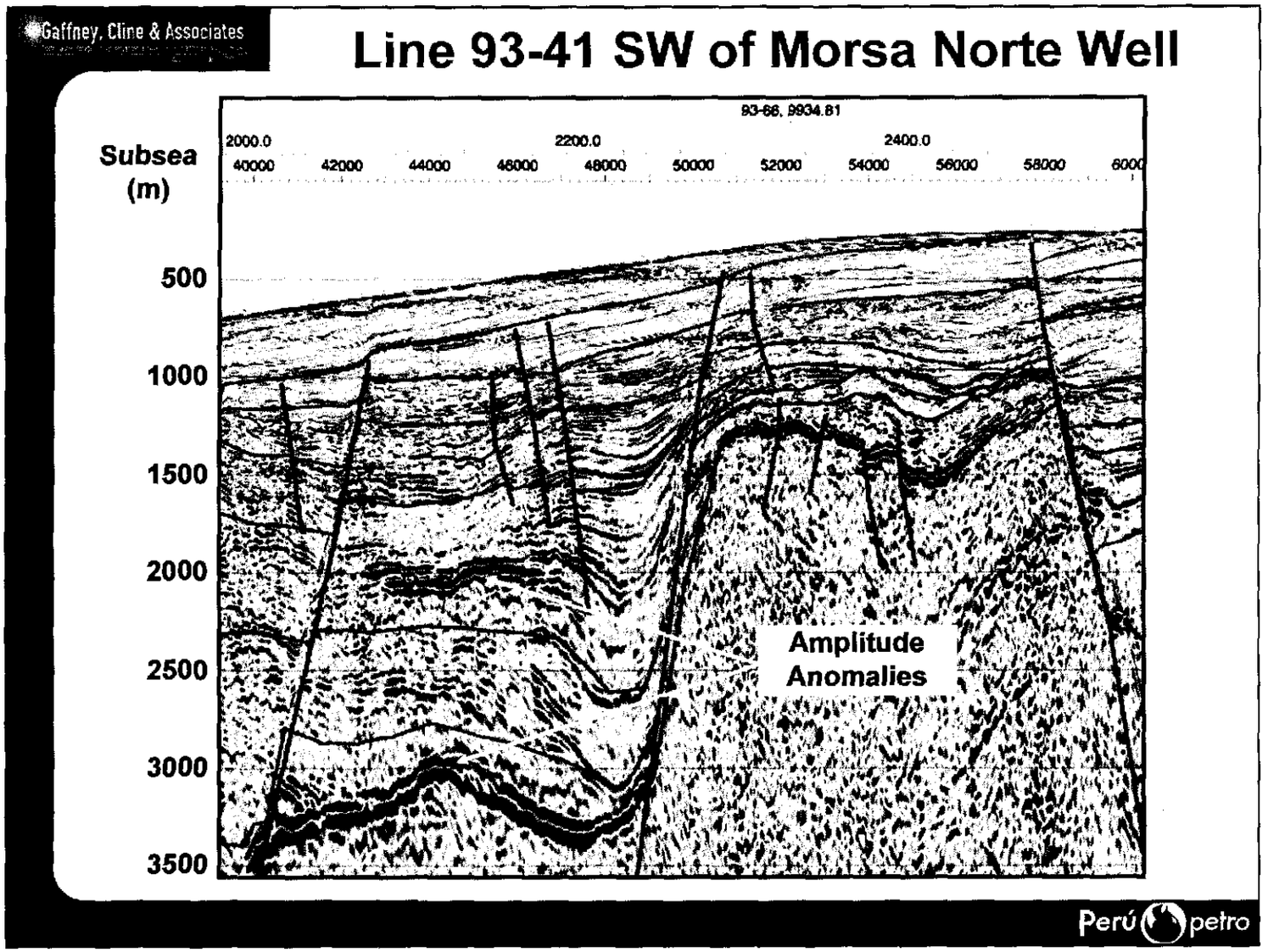
Moving about 90 km to the northwest to the vicinity of the Morsa Norte well, this slide shows the location of three lines (96-069, 93-40 and 93-41) that were chosen to illustrate the potential of the deep graben that lies west of this well.



The northern-most line ties the Morsa Norte well, and clearly illustrates the potential for stacked pay for a well that might be drilled on the eastern flank of the graben, and not on the basement high.



This line is eight kilometers southeast of the previous line, and shows very similar vertical character, and demonstrates that there is potential for significant lateral continuity of these potentially stacked slope/basin floor turbidites.



This line is 15 kilometers southeast of the previous line, and again illustrates the tempting nature of these stacked high amplitudes.

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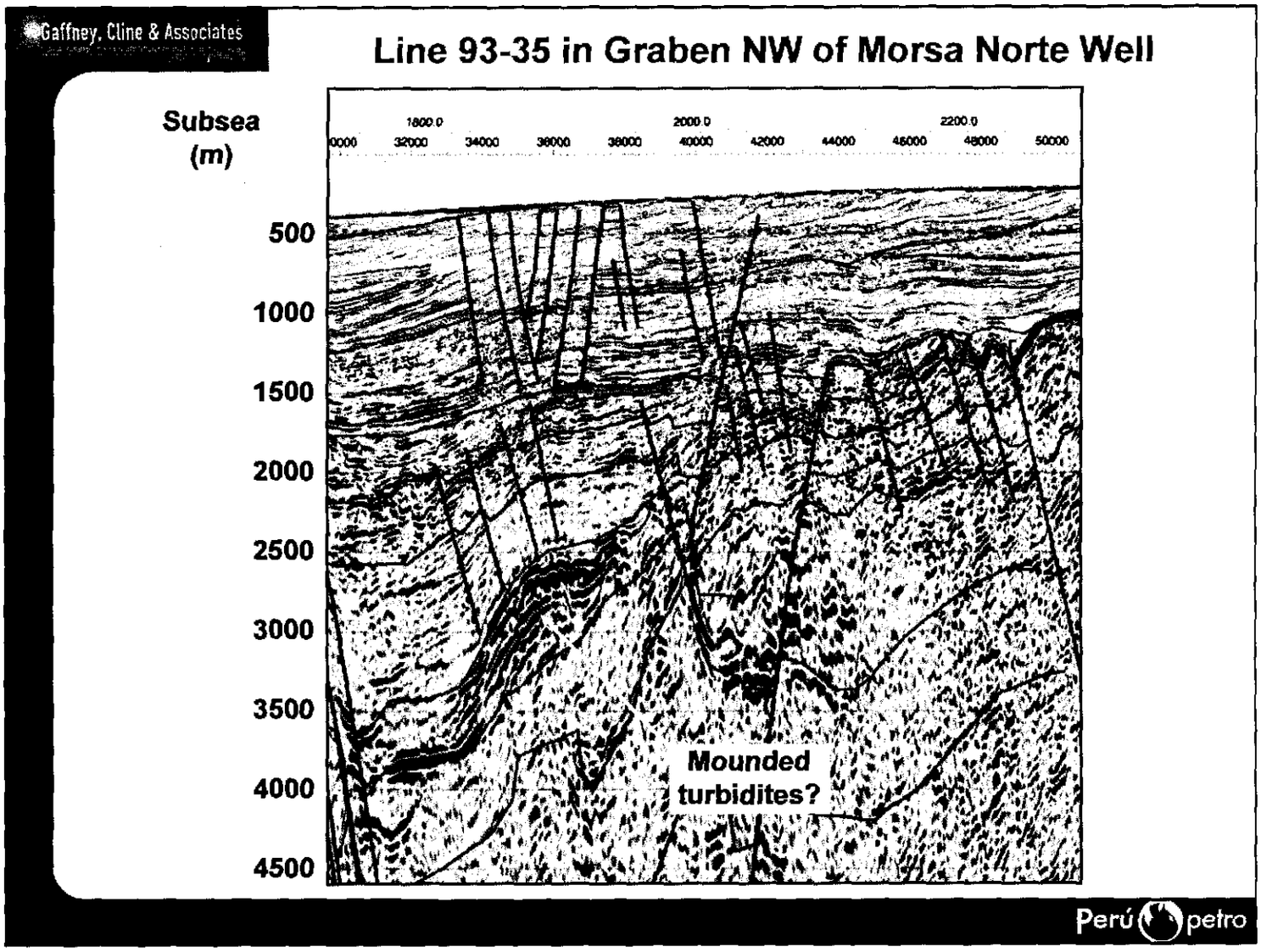
Grabens Between Morsa Norte and Lobos Wells

Perú petro

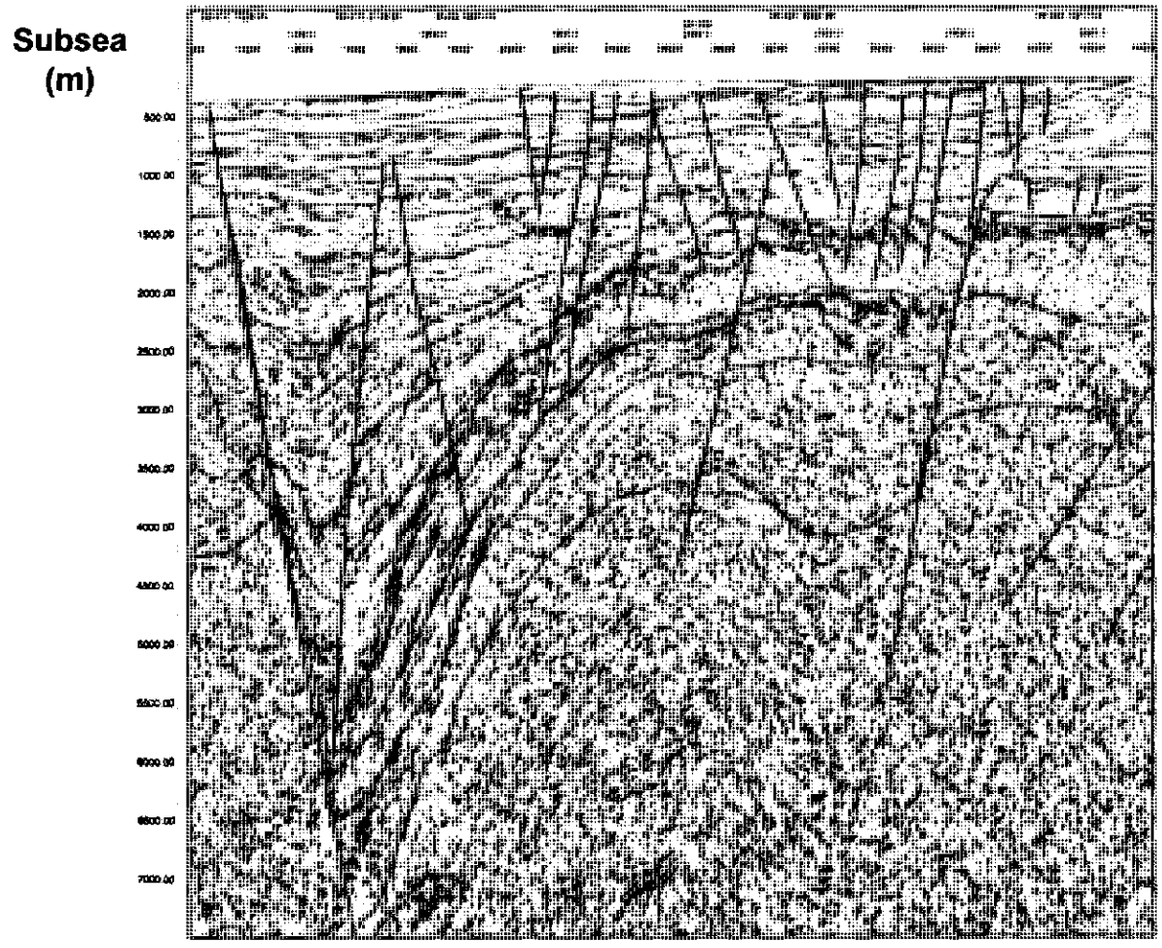
These two example lines are about 45 kilometers northwest of the Morsa Norte well, and 70 kilometers southeast of the Lobos well.



This is perhaps the best example of mounding of these potential turbidites. The gross thickness of this interval is more than 500 meters. Even at a conservative net-to-gross ratio of 0.2, that would still yield 100 meters of stacked pay.

Gaffney, Cline & Associates

96-059 Northwest of Morsa Norte Well

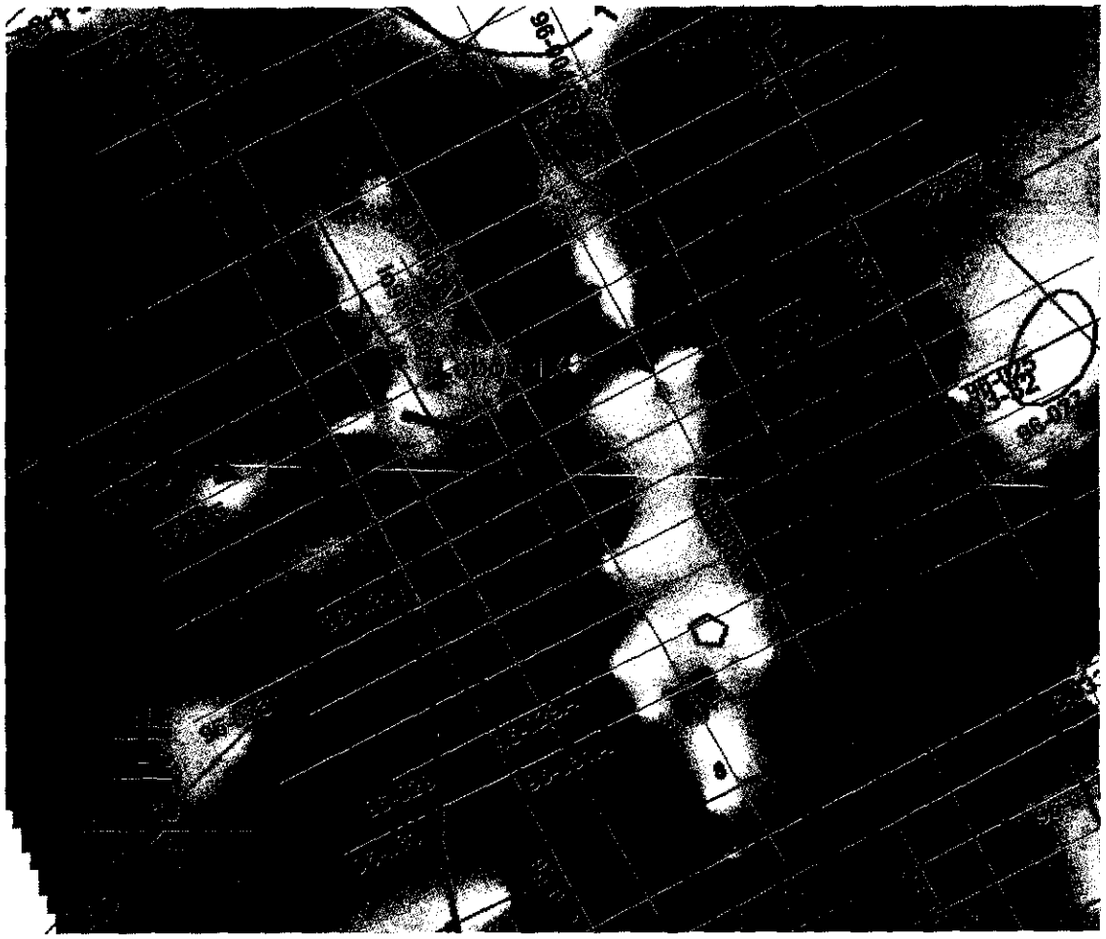


Perú petro

This section is the best example of lateral continuity of the stacked high amplitudes that may be turbidite sand.

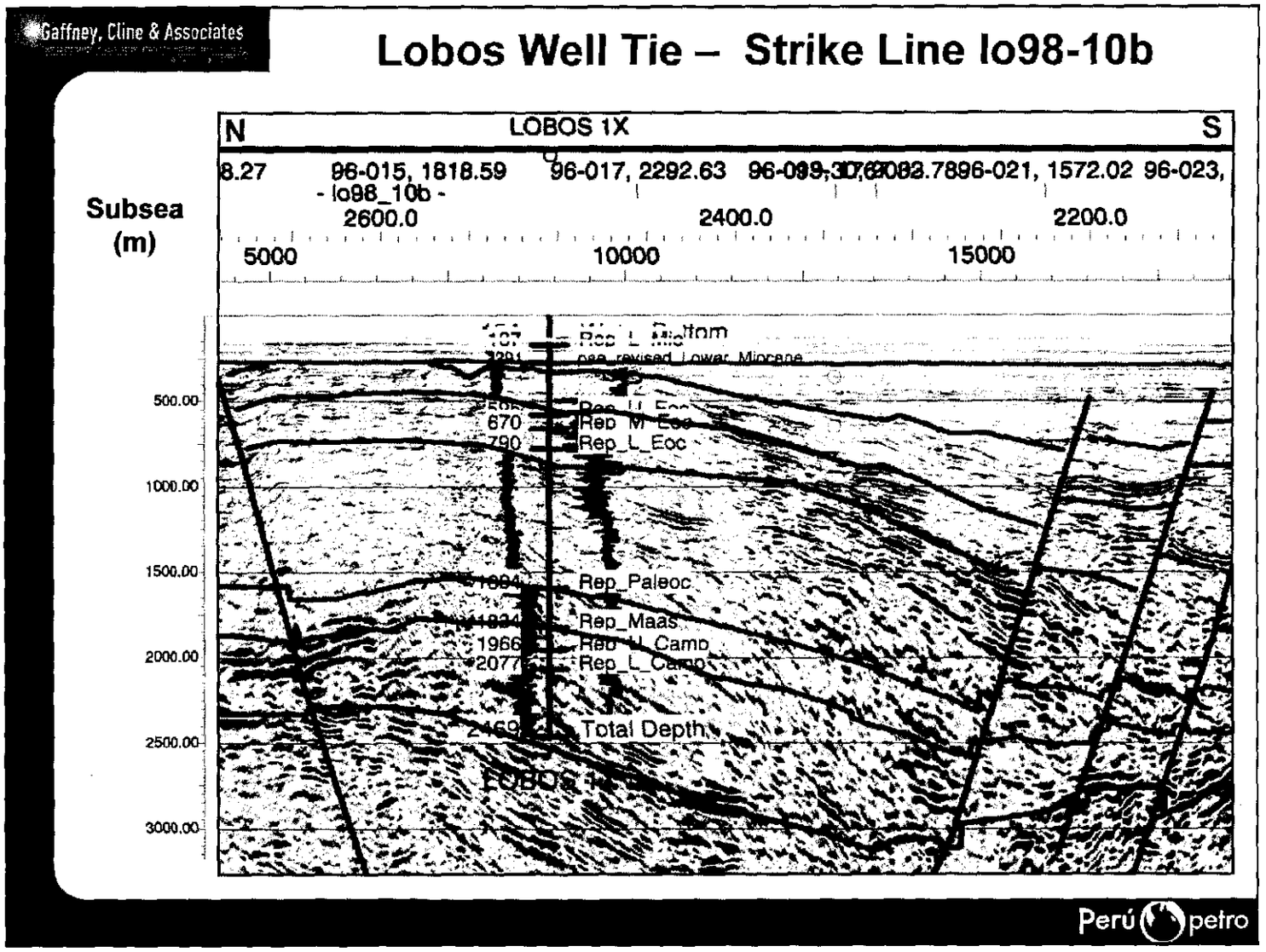
Gaffney, Cline & Associates

High Area Around Lobos Well

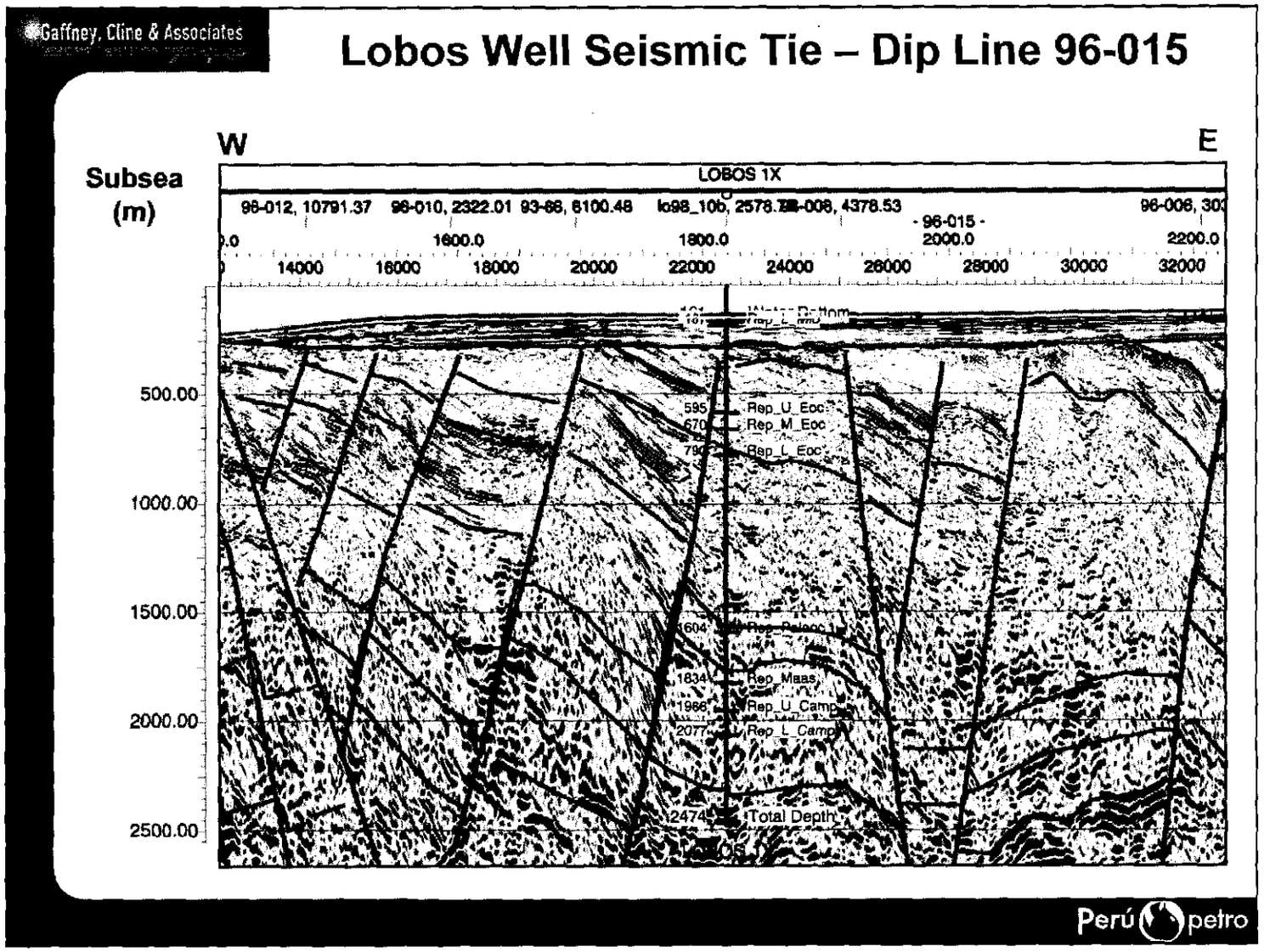


Perú petro

Potential for good-quality reservoir may also exist in the structural highs at shallower drilling depths. The following two sections, marked with black arrows on the map, illustrate why the area around the Lobos well may still be prospective, in spite of past failure.



This section shows how the Eocene interval penetrated by the Lobos well is seismically rather transparent – lacking the stacked high-amplitudes that might indicate turbidite sand accumulation.



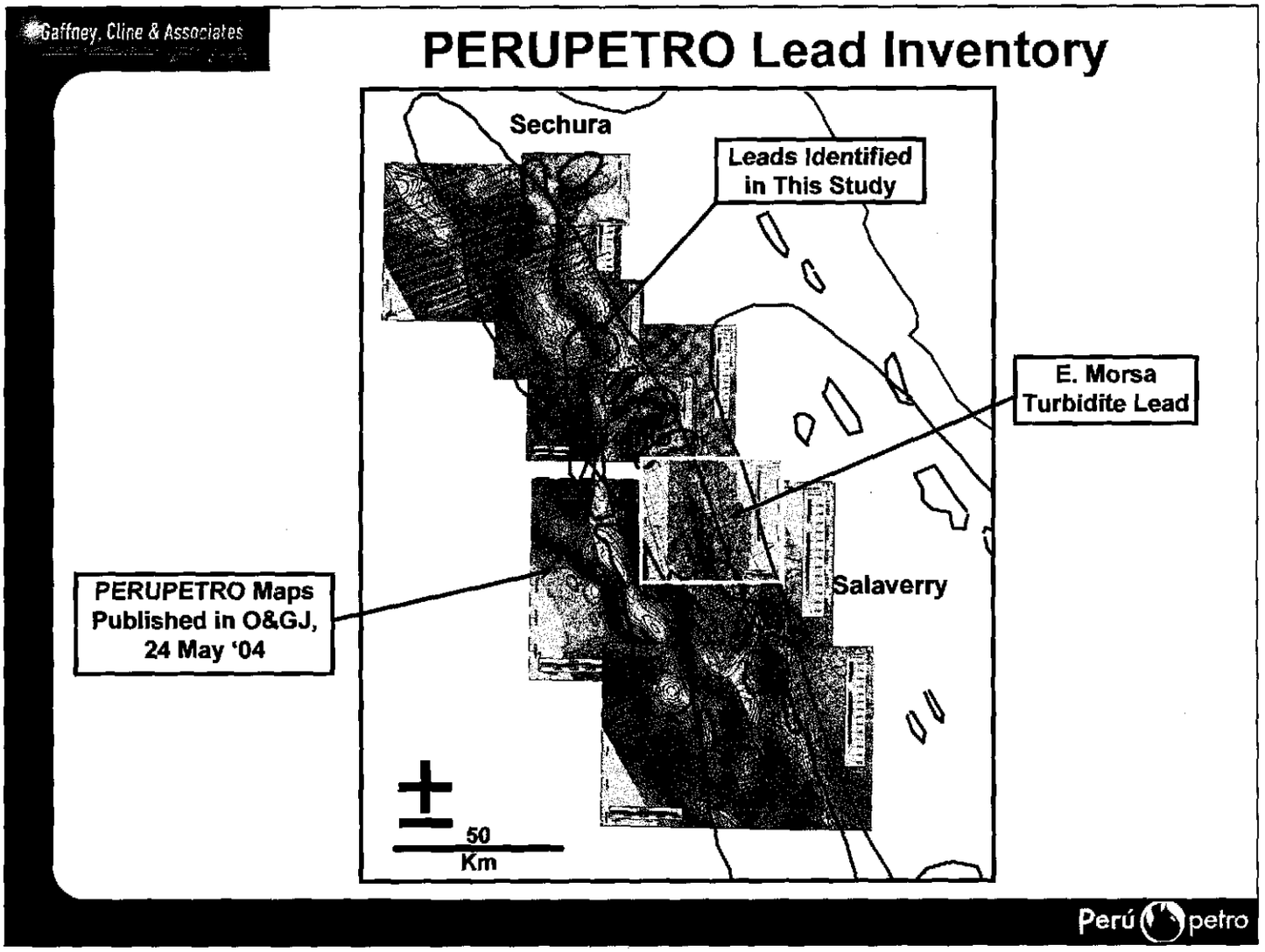
Here again, the Eocene shows none of the stacked high-amplitude character at the Lobos location on this dip line. However, the tilted fault blocks east and west of this well do have seismic high amplitudes that might be better places for a shallow test.

Gaffney, Cline & Associates

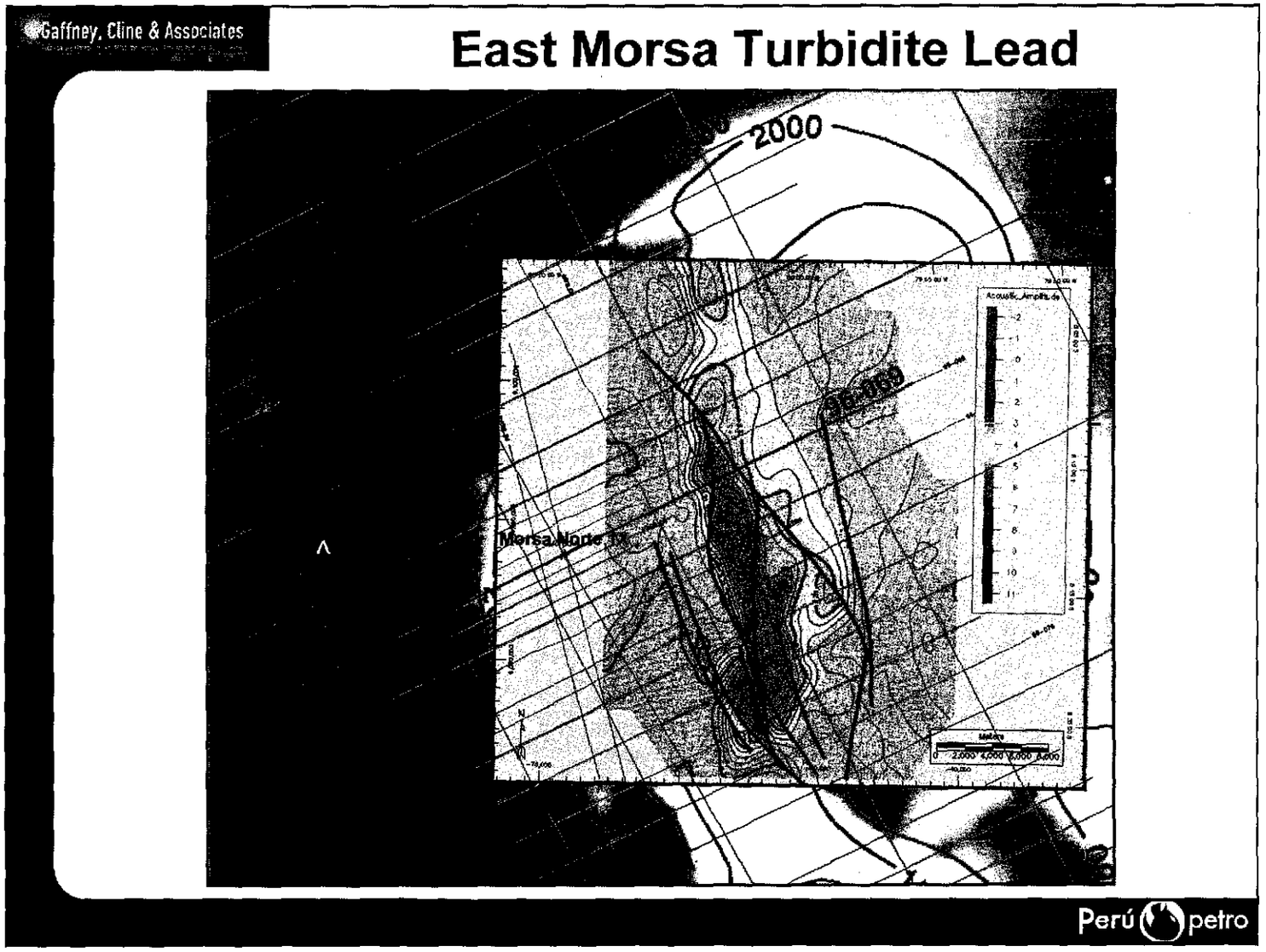
Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

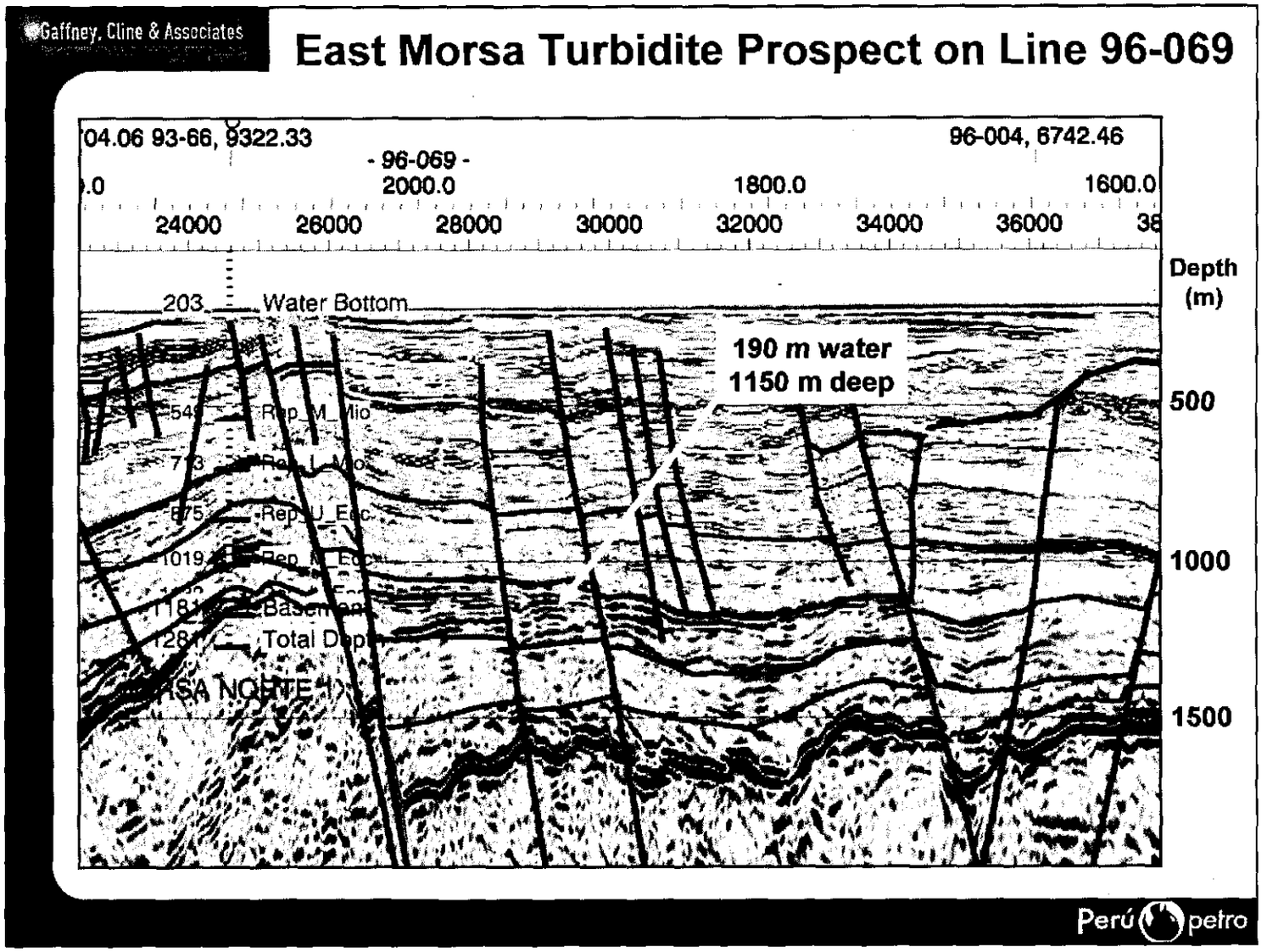
Perú petro



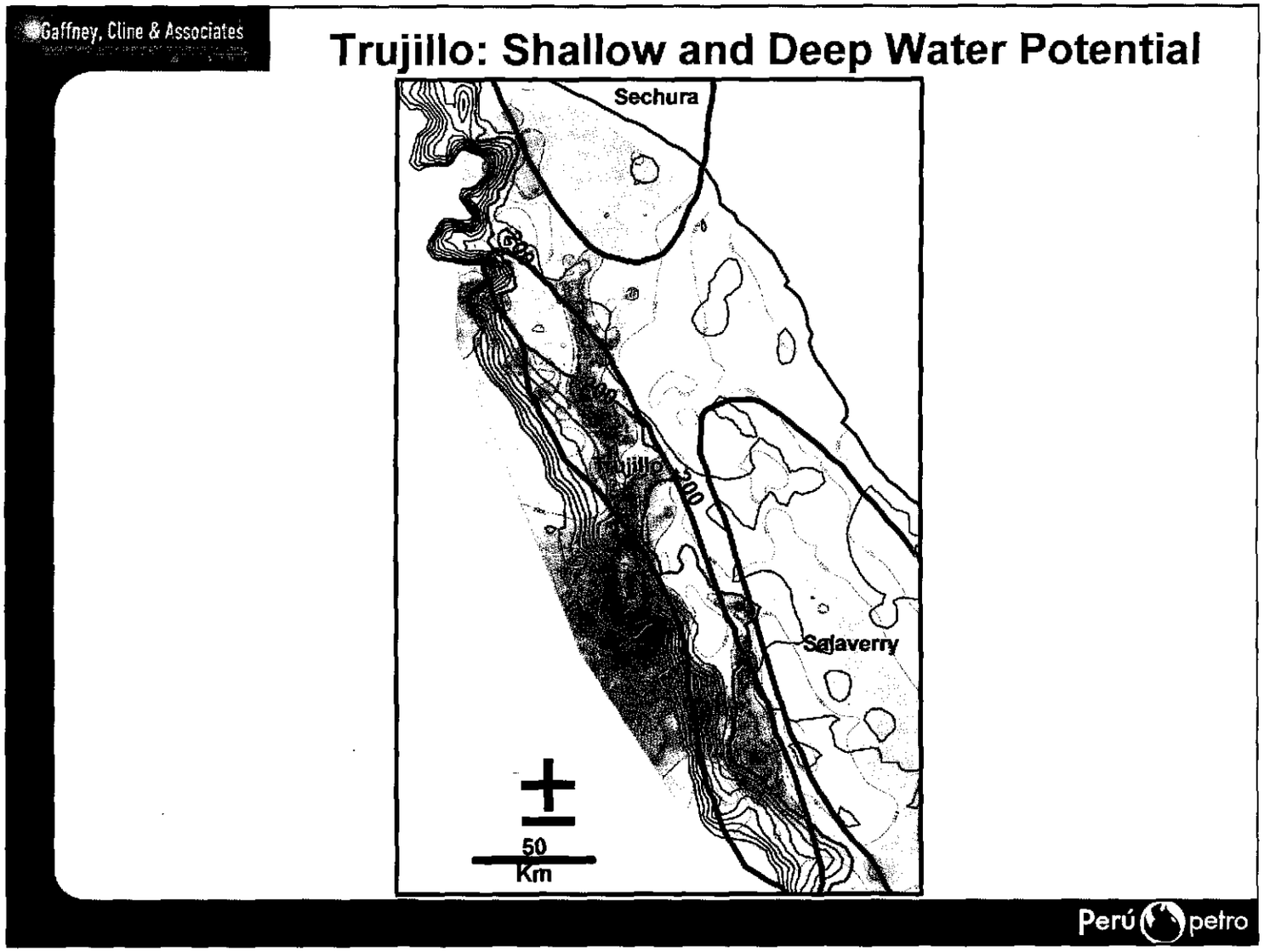
PERUPETRO published an article in the May 24, 2004 issue of the Oil and Gas Journal, in which they presented eight prospect maps over the Trujillo basin. Although referred to as "prospects," they are probably not "drill ready" – at least not without a localized 3D seismic surveys. On that basis, GCA recommends classifying them as leads, rather than prospects. The regional maps and lead identification (the black polygons) produced in this study are consistent with these PERUPETRO maps. The next two slides show the East Morsa Turbidite lead in more detail.



The amplitude anomalies in the graben west of the Morsa Norte have been illustrated earlier in this presentation. PERUPETRO has mapped a similar anomaly east of Morsa Norte. It can be easily seen on Line 96-069 in the next slide. The length of the mapped anomaly is about 25 kilometers. The width is about 6 kilometers.



This amplitude anomaly is typical of those illustrated in the previous slides. PERUPETRO has just taken it one step further by mapping the anomaly as seen on the previous slide. It is likely that future exploration in the Trujillo basin will be focused on this set of mapped leads.



This map shows 100-meter isobaths from 100 meters to 1,000 meters deep. As these isobath contours illustrate, most of the prospective area in the Trujillo basin lies in water depths between 200 and 500 meters. Drilling targets exist at depths as shallow as 1,000 meters, and as deep as 5,000+ meters. In general these are not prohibitive depths. However, another round of exploration activity in the Trujillo basin will likely be contingent on proven offshore exploration success in the Sechura, Salaverry and/or the Pisco basins, where the shallow-water shelf fairway is broader.

Gaffney, Cline & Associates

Outline

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Perú petro

Gaffney, Cline & Associates

Indicative Potential for E. Morsa

Volumetric Parameters

- Area: 30,000 acres
- Net Pay: 65 feet
- Porosity: 20%
- Oil Saturation: 65%
- Formation Volume Factor: 1.1 RB/STB
- Recovery Factor: 25%

450 MM Barrels Recoverable

Perú petro

This represents a quick calculation of the potential for this lead, given a successful discovery well, representing more than enough potential to justify a substantial exploration effort.

Gaffney, Cline & Associates

Three Scenarios Show Overall Favorable Economic Potential

(US$ million unless otherwise noted)	Low	Mid	High
Oil (millions of barrels)	50	250	500
Producing Wells	20	70	135
Gross Project Revenue	1,500	7,500	15,000
Royalty	95	966	2,465
CAPEX	155	635	1,233
OPEX	130	459	640
Net Cashflow Before Tax	1,120	5,440	10,662
Tax	329	1,605	3,133
Net Cashflow After Tax	791	3,835	7,529
NPV (Discount 10%)	203	901	1,674
IRR (%)	36	38	42

Perú petro

There is no doubt that the new chronostratigraphic framework produced in this study has documented a substantial amount of exploration potential in the Trujillo basin. However, there is considerable doubt about how much of that potential will be realized, and when. Therefore, the economic analysis was based on a simple three-scenario approach – a low case, a mid case and a high case. The range between the low case and the high case was chosen to capture the general size range of the leads that PERUPETRO has already documented. The exploration and development costs were based on information in the public domain and advice from PERUPETRO. In general, because oil prices are high and costs are low in this shallow-water, close-to-shore environment, even the low case delivers a sizable rate of return. Drilling in the deep water was not considered, as it is likely that exploration drilling will be limited to the shallow water for the foreseeable future.

Gaffney, Cline & Associates

Conclusions Revisited

- Source is proven
- Much better regional framework to chase Eocene turbidite reservoirs
- Most potential in reasonable water and drilling depths
- Leads over amplitude anomalies have giant potential
- Will require careful 3D seismic and a multi-well program to overcome past failures and thoroughly explore this tectonically complex area

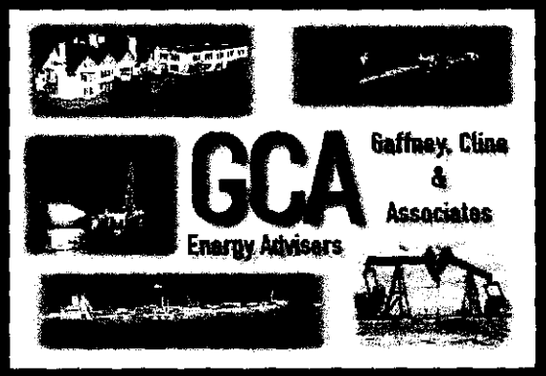
Perú petro

Four dry holes do not make a dry basin. Oil companies large and small are hungry for exploration provinces with remaining potential for giant discoveries. The Trujillo basin still qualifies as one of these high-potential provinces.

Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Trujillo Basin



Perú petro

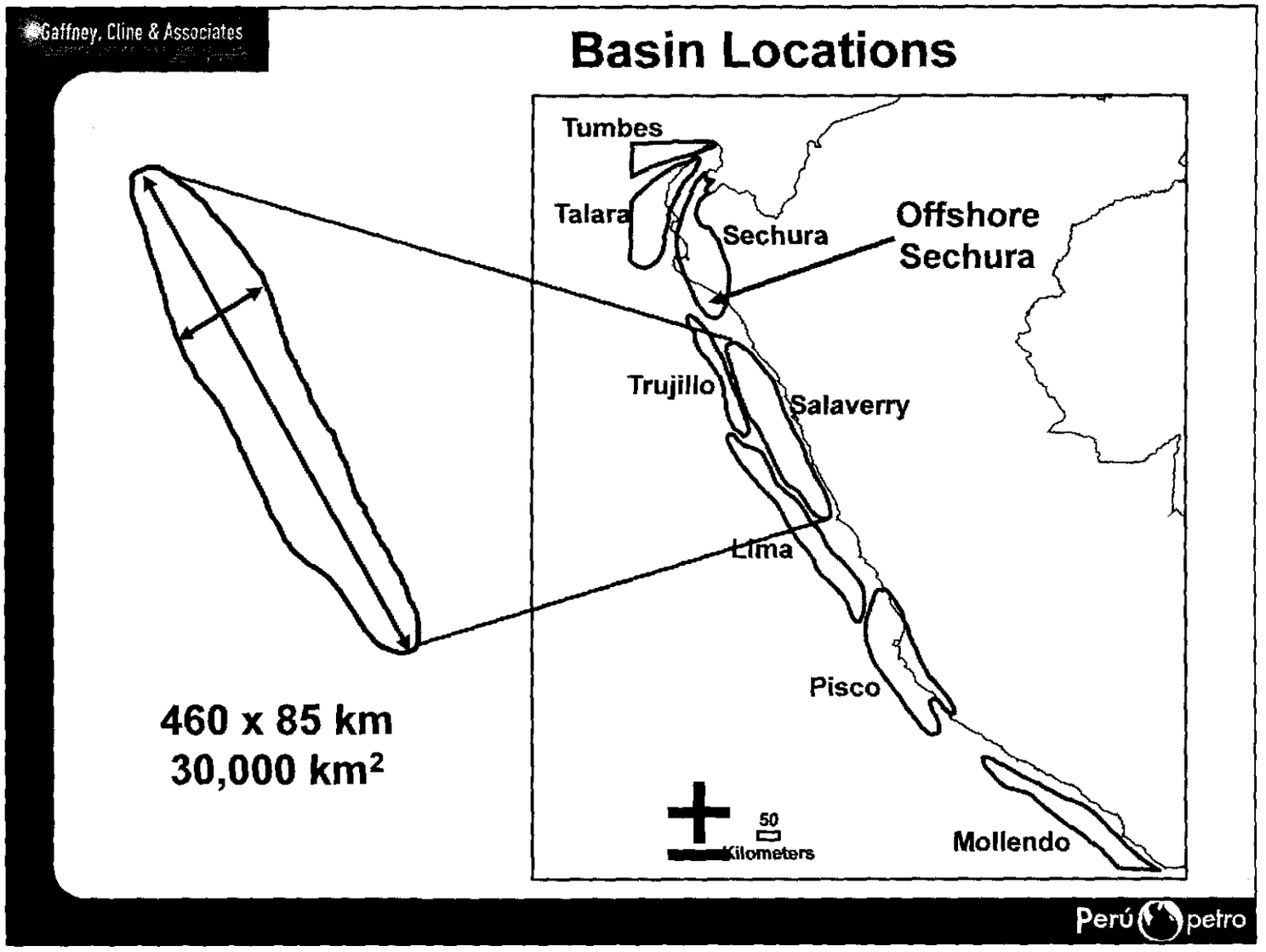
Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Salaverry and Offshore Sechura Basins

Perú petro

This Basin Presentation is part of the Final Report for the larger study entitled, "Sequence Stratigraphy Analysis of the Peruvian Offshore Continental Shelf-Slope." This study was funded by the USTDA, and was executed by Gaffney, Cline & Associates for PERUPETRO.



The Salaverry basin is located east of the Trujillo and Lima basins on the shallow-water Peruvian continental shelf. The Sechura basin is located mostly onshore. For the purpose of this study, the southernmost (offshore) part of the Sechura basin (at red arrow on map) has been combined with the Salaverry basin into this single Basin Presentation.

Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

This presentation begins with the conclusions and a quick review of the data, and is followed by discussion of possible hydrocarbon source rocks, reservoirs and leads (including expected water depths and drilling depths). It finishes with recommended exploration plans and several economic scenarios.

Gaffney, Cline & Associates

This is Potentially "Elephant Country"

- Possible mature source in thick along Salaverry basin axis and at south end of Sechura basin
- Charging from the west into the Salaverry basin also possible
- Possible Eocene (and Cretaceous) carbonate reservoirs/traps in both basins
- Large structures with giant potential, one of which Petro-Tech Peruana plans to drill on Block Z-6 in the offshore Sechura basin later this year
- Shallow water and shallow drilling over both basins
- Petro-Tech in process of contracting two blocks (Z-35 and Z-36 on the eastern flank of the Salaverry basin

Perú petro

In summary, in a time of shrinking exploration opportunities, the Salaverry and offshore Sechura basins are potential "elephant country." They have good possibilities for mature source rocks, effective reservoirs and large potential traps. However, it should be noted that most of these assumptions have been built up from a regional seismic grid with no wells. There is still a lot of basic exploration work to do before any prospect can be matured and made ready to drill. 3D seismic will be particularly useful in defining drillable structures and estimating the nature of the fluids that fill them. Petro-Tech Peruana has already started an aggressive campaign of acreage acquisition over the Salaverry basin, and has already acquired new 2D seismic data over one lead in the offshore Sechura basin.

Gaffney, Cline & Associates

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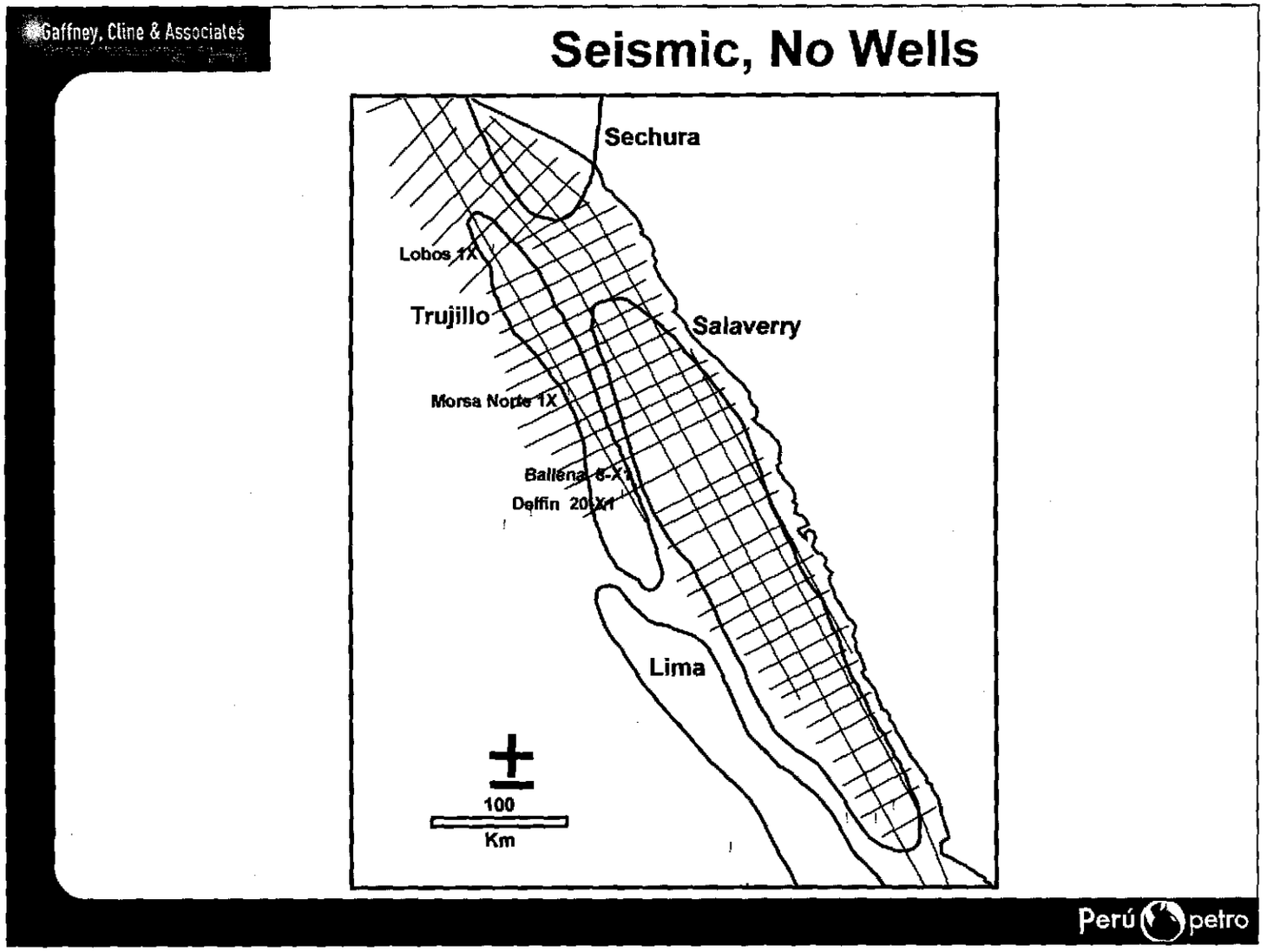
Perú petro

PERUPETRO furnished unlimited access to their data archives. The gross volume of data available for this study was therefore extremely large, requiring considerable effort in organizing and distilling it into a useable project database.



The Ribiana 1993 seismic grid, combined with regional gravity and magnetics data, formed the main basis for the new structural and stratigraphic framework in the Salaverry and offshore Sechura basins. The entire Ribiana 1993 survey was depth converted – both the horizons and the SEG-Y traces. The only wells actually situated in the Salaverry basin are the two ODP shallow well locations at the extreme south (in red), which yielded very little useful information, aside from heat flow data for the maturation modeling work. The four wells in the Trujillo basin (in black) were useful in forming analogies.

Gaffney, Cline & Associates

The Project Database

- **Final Report (paper)**
  - **Executive Summary**
  - **Basin Presentations**
  - **Other Required Sections**
    - Economics, Regulatory, Environmental and others
  - **Enclosures**
    - Selected maps, logs and cross sections
- **Digital Database (DVDs)**
  - **Final Report**
  - **ArcView Interactive Map**
  - **3 SMT Kingdom Suite Projects**
  - **Standard-format Exports**
  - **Detailed Appendices**
    - Geology, Wells, Seismic Interpretation, Tectonics, Depth Conversion, Maturation, Environmental

Perú petro

The project database for the Salaverry and offshore Sechura basins exists in several forms. First, there is an SMT Kingdom Suite project that covers the Trujillo, Salaverry, offshore Sechura and Pisco basins. This integrated project is available as part of the Digital Database that is packaged on DVDs with this report. The contents of this project were also exported into SEG-Y, LAS and other standard formats for loading into other workstation software. The Digital Database also contains an ArcView Interactive Map that was used to produce the map-based graphics in this presentation. It contains surface location data for wells and seismic, gravity and magnetics, geo-registered images of all of the maps produced in this study and a wide variety of other useful map-based data. Selected maps and cross sections are included in the Enclosures. Lastly, the Final Report contains several Appendices that contain discipline-specific detailed discussions as listed above.

Gaffney, Cline & Associates

Outline

- Conclusions
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Perú petro

As opposed to the Tumbes, Talara and Trujillo basins, where either production or seeps have proven the existence of at least one active petroleum system in each of these basins, there is no direct evidence of an active source rock in either the Salaverry or the offshore Sechura basins. However, new isopach mapping and maturation modeling indicate that conditions are conducive to the generation, expulsion and migration of hydrocarbons.

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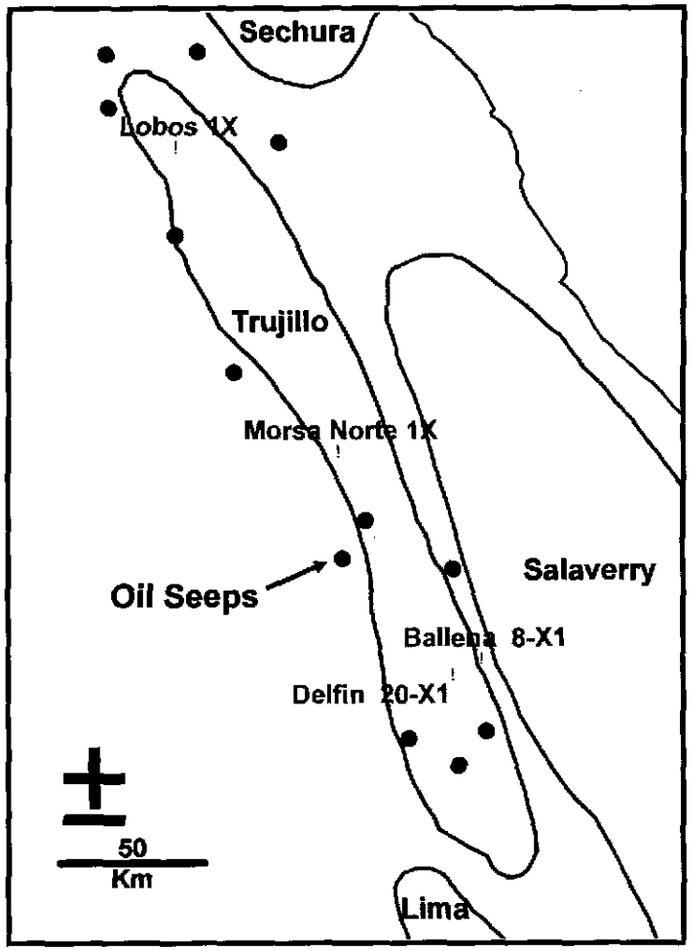
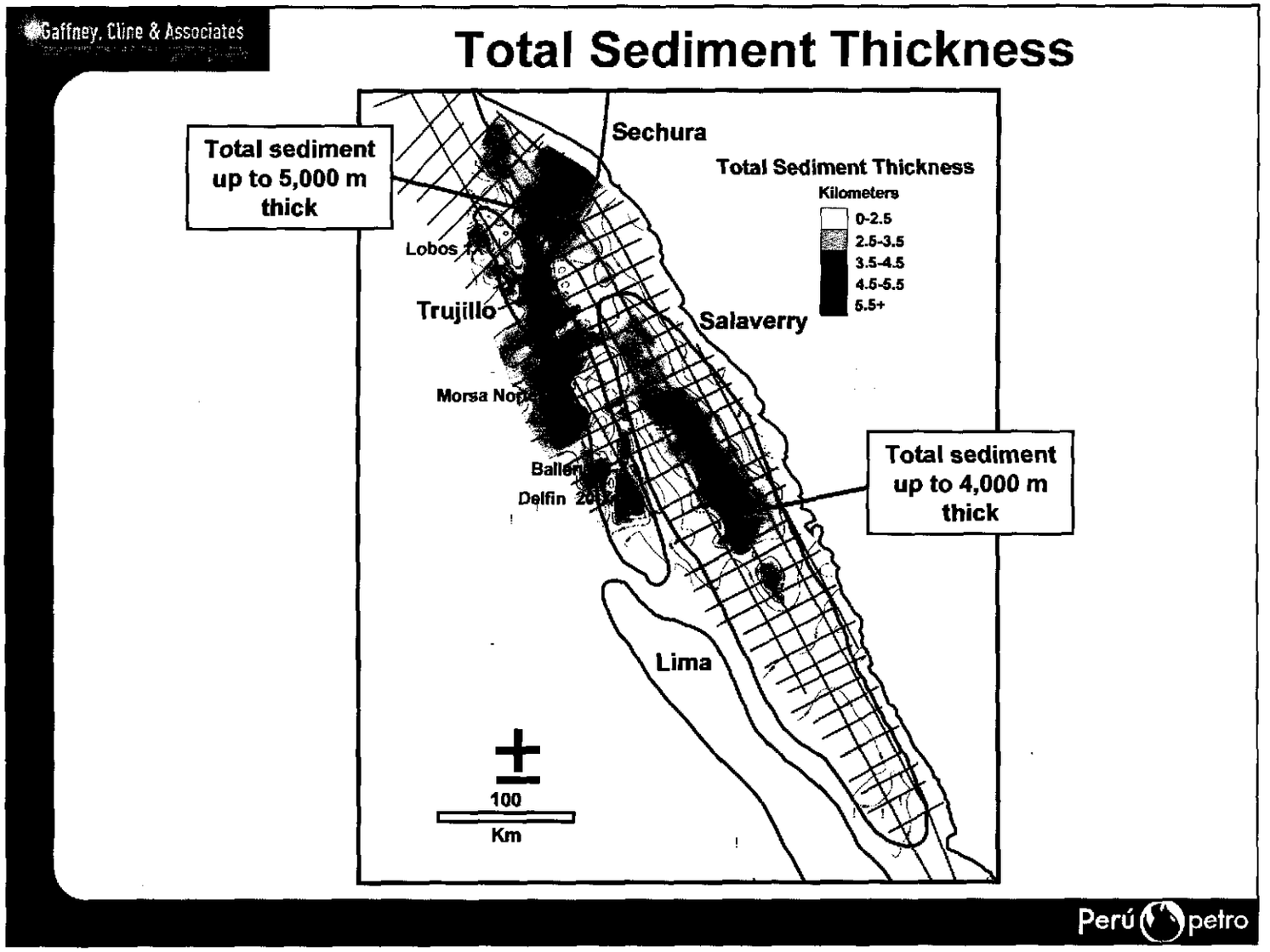
Oil Seeps Near (But Not In) the Basins

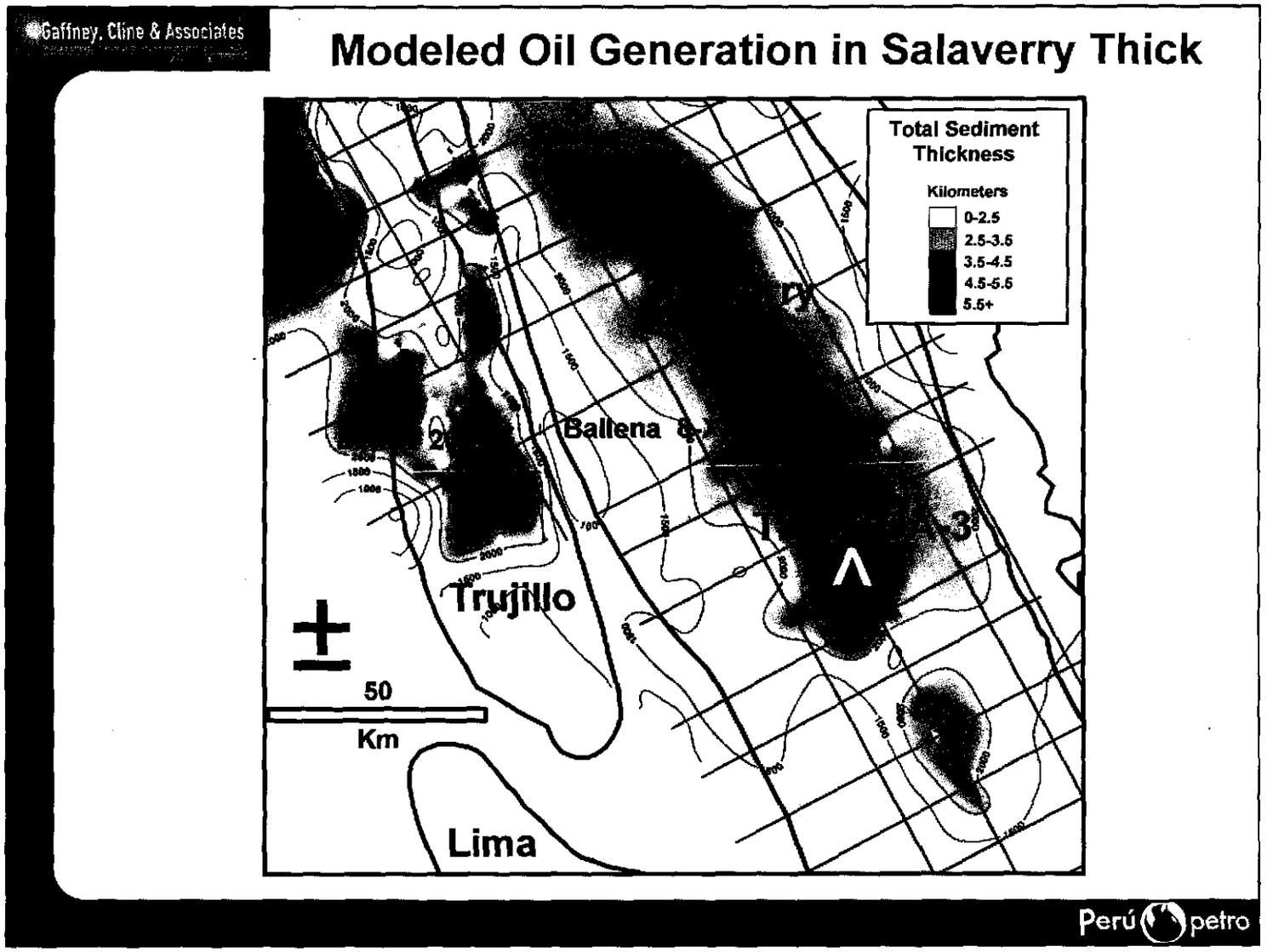


Perú petro

There are numerous oil seeps in and around the Trujillo basin, which probably emanate from a mature Cretaceous source rock similar to the prolific Muerto Formation in the Talara Basin. By analogy, a thick possibly Cretaceous sediment accumulation at the center of the Salaverry basin may contain a similar source rock, although seeps have not been documented over the Salaverry basin. This may be because this basin has a simple saucer shape with fewer faults that may be the conduits for the seeps in the Talara basin. There is an even thicker analogous section at the southernmost extreme of the offshore Sechura basin.



One of the main results of this study was to recognize and map Cretaceous sediments in most of the offshore basins, including most notably the Salaverry and offshore Sechura basins. Including the newly interpreted Cretaceous, the total sediment thickness in these basins ranges up to 5,000 meters (in dark red on the map). As shown in the next slides, this is potentially thick enough to have generated hydrocarbons.



Assuming that a Muerto Formation equivalent Cretaceous source rock is present in the Salaverry basin (there are no wells to confirm it), the oil generating potential was modeled at this location (the yellow star) using BasinMod software from Platte River Associates.

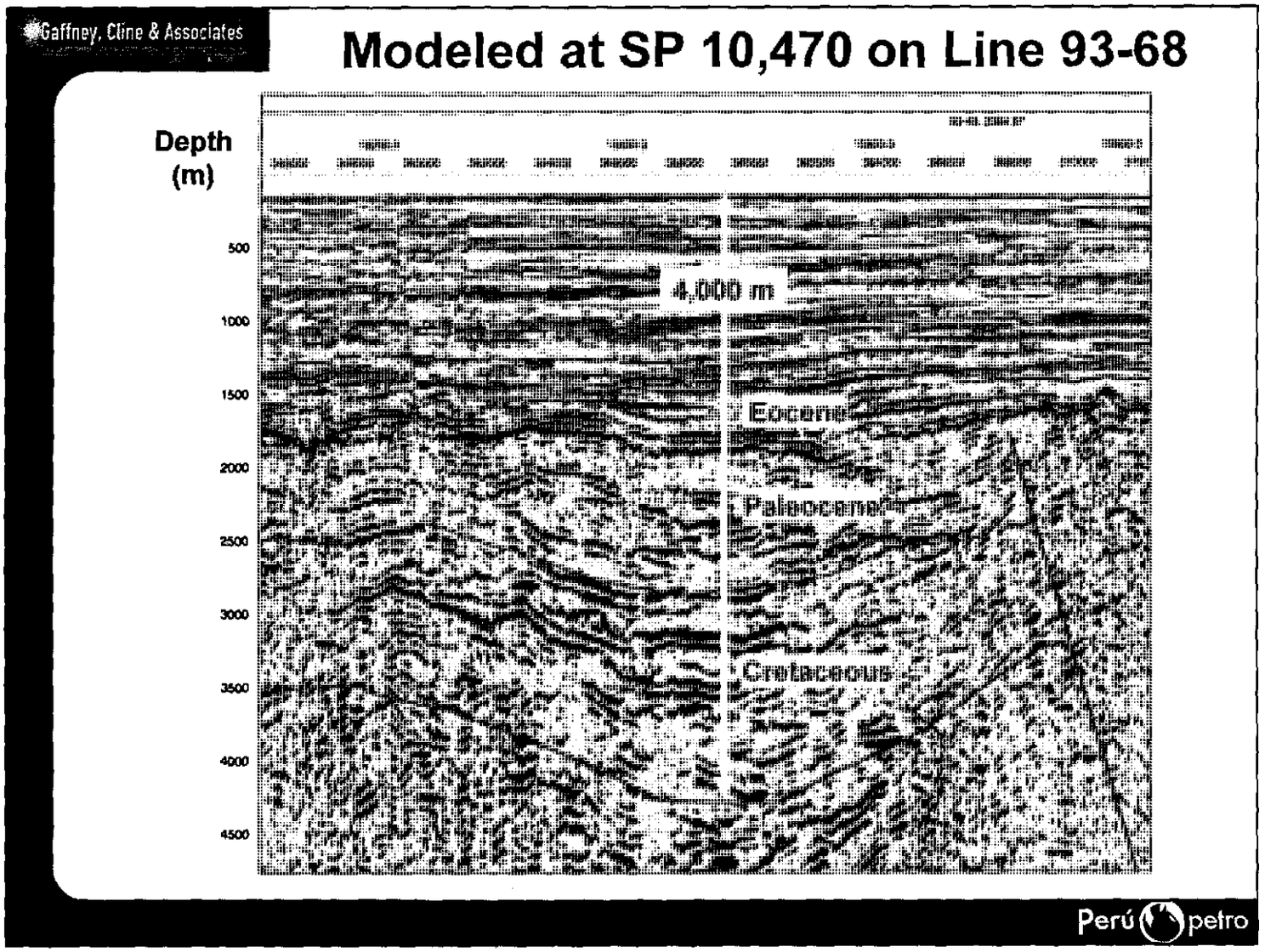
Gaffney, Cline & Associates

Seismic Horizon Legend

- 1_ts_a_1_Quaternary (pae)
- 1_ts_b_2_Pliocene (pae)
- 1_ts_c_3_Late_Miocene (pae)
- 1_ts_c_3_Late_Miocene_overthrust (pae)
- 1_ts_d_4_Middle_Miocene (pae)
- 1_ts_d_4_Middle_Miocene_overthrust (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_a (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_b (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_c (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_d (pae)
- 1_ts_f_6_incised_channels_intra-mid_Miocene (pae)
- 1_ts_g_7_Early_Miocene (pae)
- 1_ts_h_8_small_channels_Early_Miocene (pae)
- 1_ts_j_9_Latest_Eocene_Oligocene (pae)
- 1_ts_j_9-13_mrg_Eoc_Oligo-Mid_Eoc_carb (pae)
- 1_ts_j_9-13_mrg_Eoc_Oligo-Mid_Eoc_carb_new (pae)
- 1_ts_j_10_Middle_Eocene (pae)
- 1_ts_k_11_Middle_Eocene_carbonates? (pae)
- 1_ts_k_11_Middle_Eocene_carbonates?_overthrust (pae)
- 1_ts_l_12_Early_Eocene_carbonates? (pae)
- 1_ts_l_12_Early_Eocene_carbonates?_overthrust (pae)
- 1_ts_m_13_Paleocene_Base_Eoc (pae)
- 1_ts_m_13_Paleocene_Base_Eoc_overthrust (pae)
- 1_ts_n_14_Cretaceous (pae)
- 1_ts_n_14_Cretaceous_overthrust (pae)
- 1_ts_o_15_Intra-Cretaceous_Muerto? (pae)
- 1_ts_p_16_Paleozoic_meta (pae)
- 1_ts_p_16_Paleozoic_meta_overthrust (pae)
- 1_ts_q_17_Precambrian_Crystalline_Bsmt (pae)

Perú petro

Use this legend to understand the age of the interpreted horizons in the seismic lines that follow in this presentation. Overall, blue marks Paleozoic metamorphic basement, green is top Cretaceous, and red is top Paleocene. The Eocene is broken into several intervals as shown. The Oligocene has been largely eroded throughout the area. The Miocene is complicated by several episodes of channel cut and fill, which is represented by several horizons in the interpretation. The section is capped off by Pliocene and Quaternary sediments.



Here is the partial line that illustrates the thickness and seismic character of the sedimentary sequences at the modeled location in the Salaverry basin (TDA-GCA-3).

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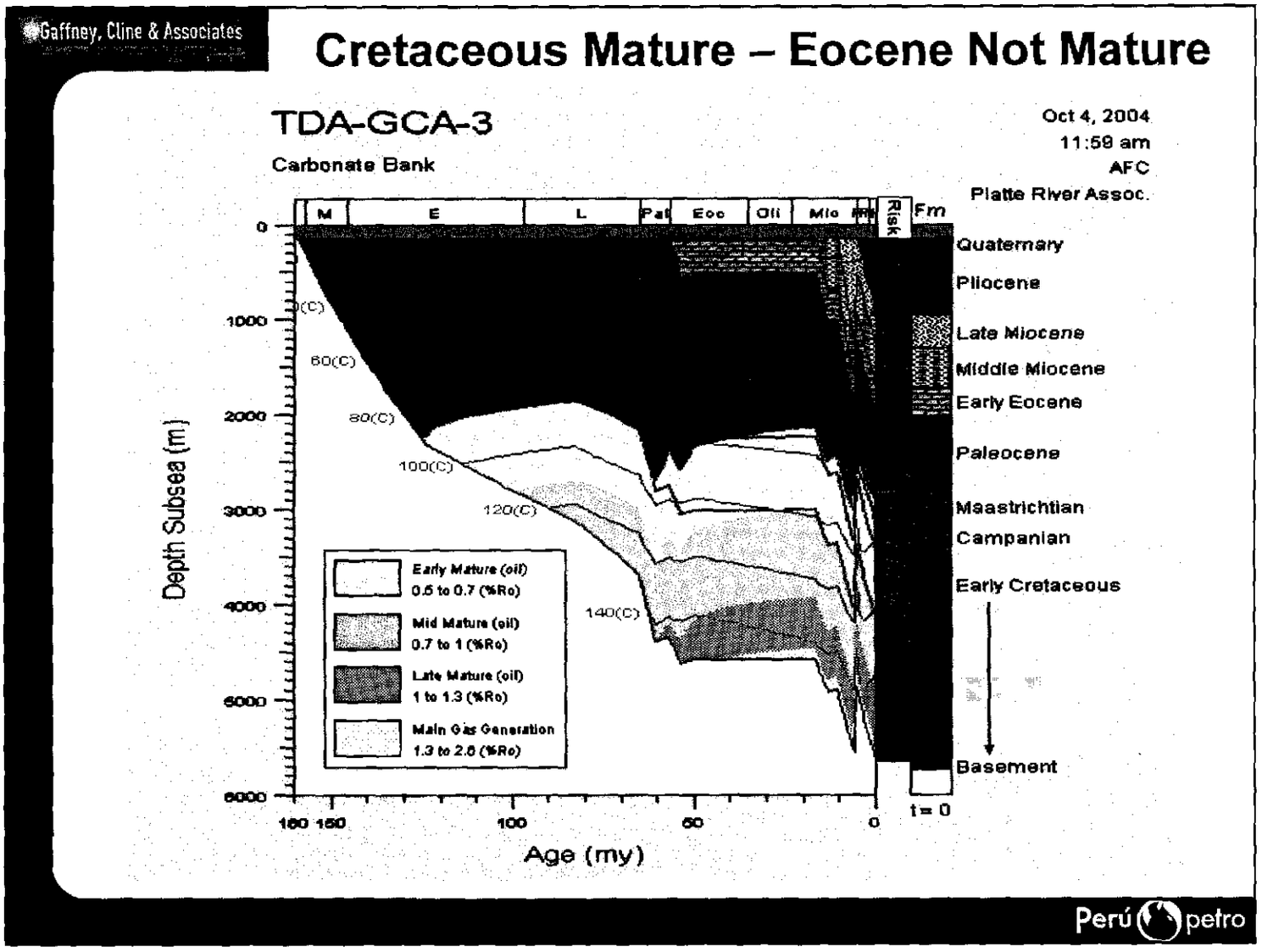
Oil Generation Modeling in the Salaverry and Sechura Basins

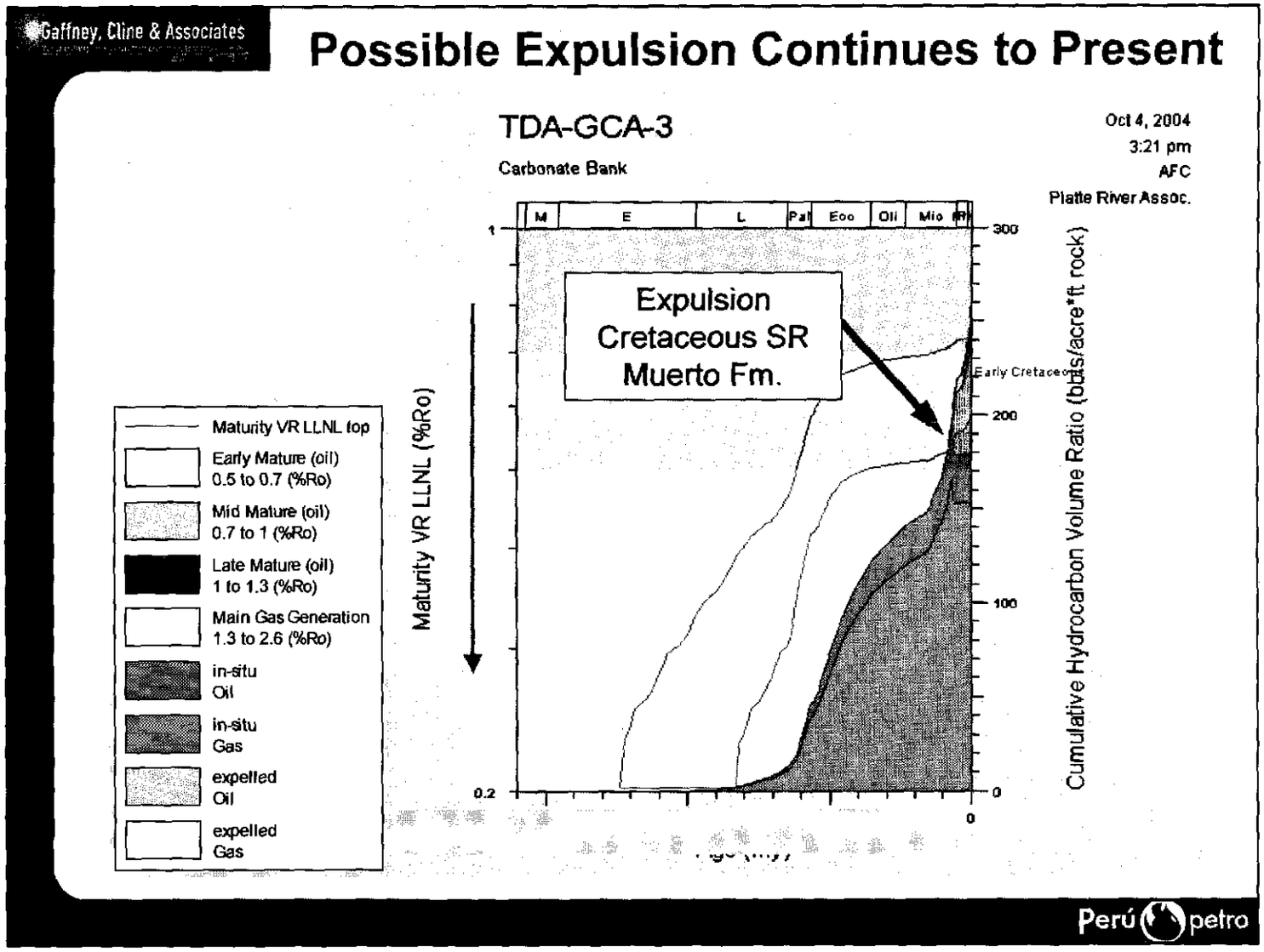
- These models include three source rocks:
  - Early Cretaceous (Muerto Fm.): Kerogen Type II (Cretaceous of South America)
  - Early and Late Eocene: Kerogen Type II-III (marine with strong influence of terrigenous organic matter)

Perú petro

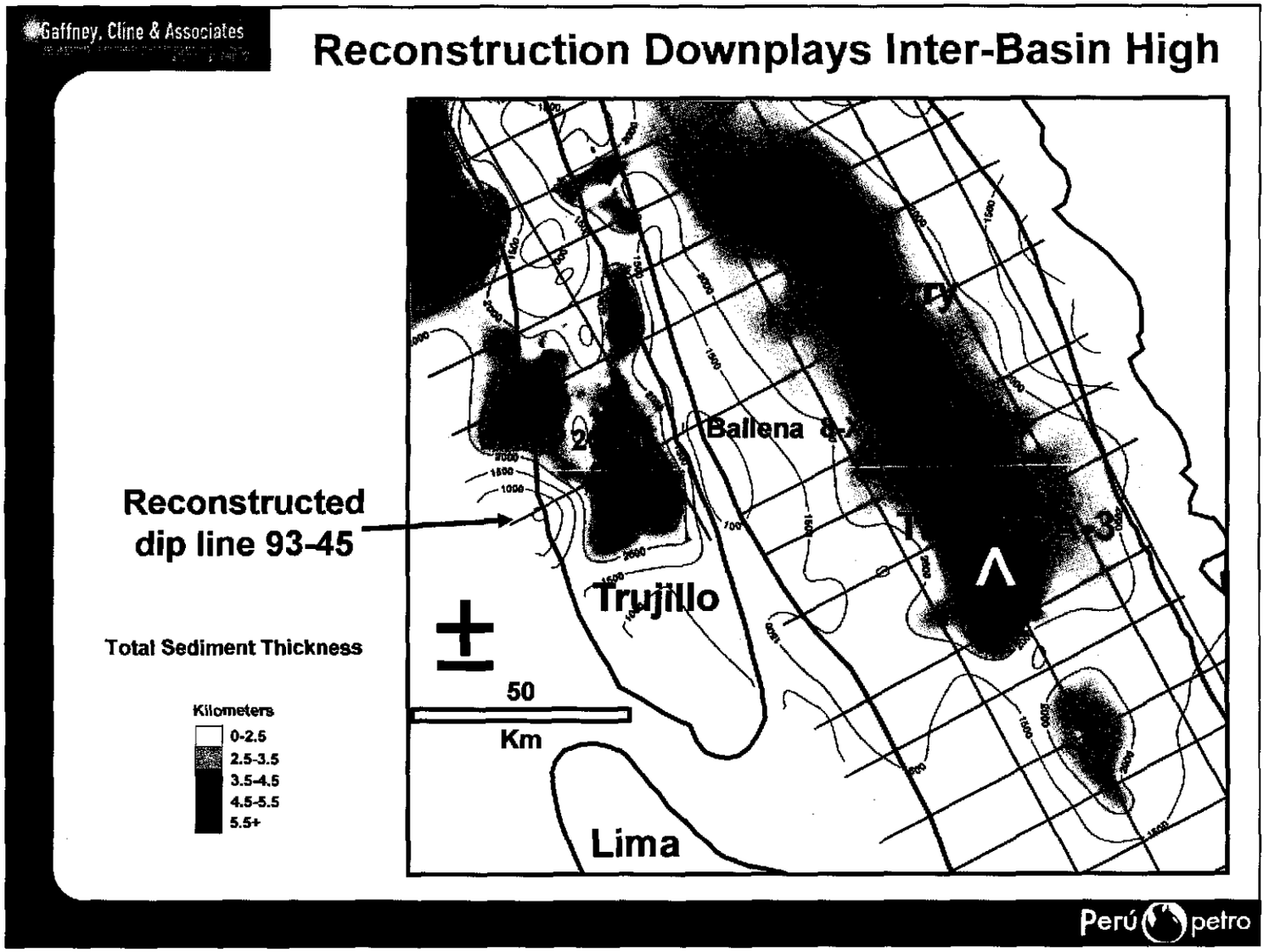
For the sake of completeness, the possibility of Eocene source rocks was also modeled, along with the Cretaceous, in both basins.



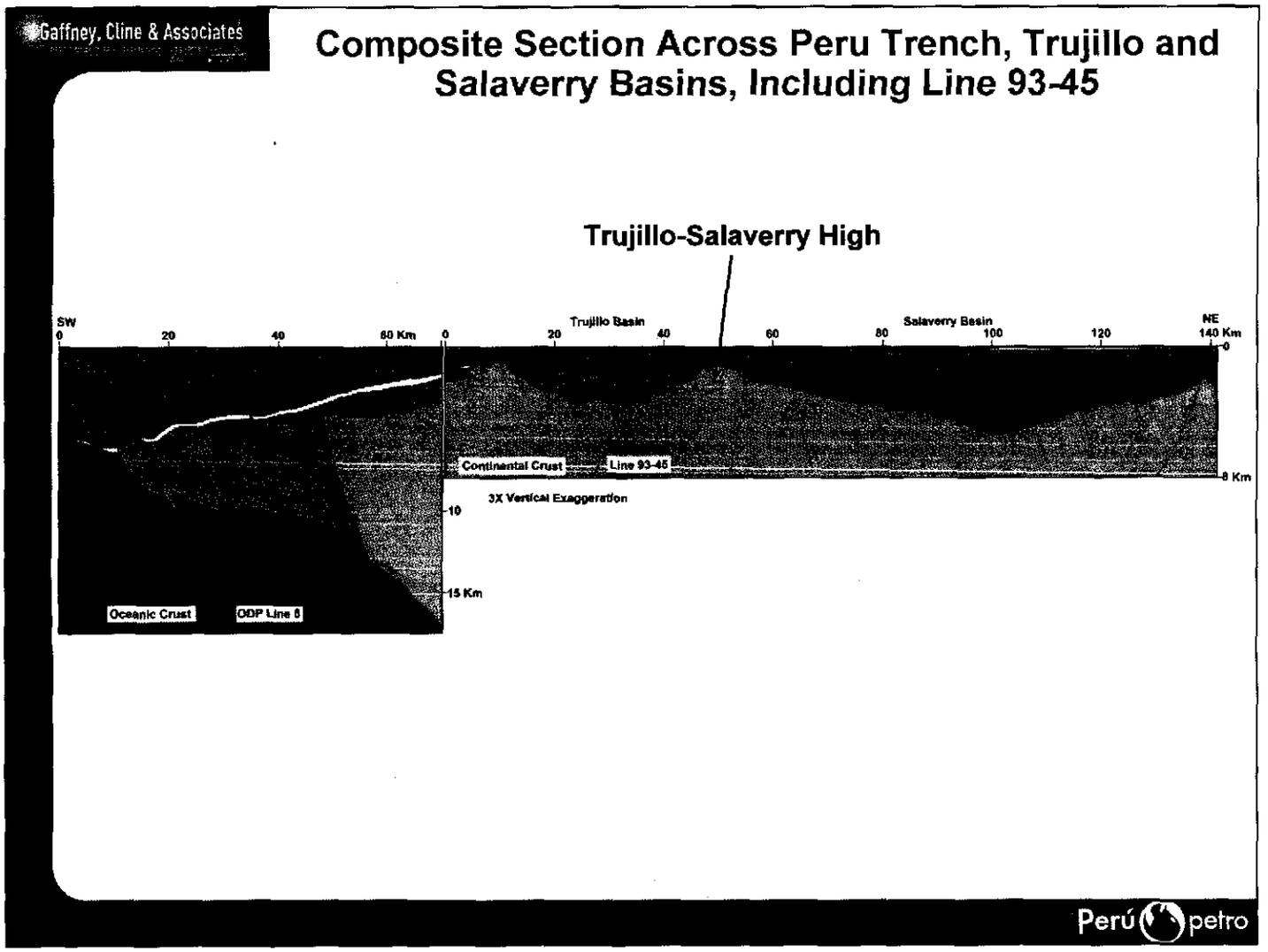
The 4000-meter total sediment thickness at this location was sufficient to push the possible Early Cretaceous source into early maturity in Eocene time. Late Cretaceous and Eocene possible source intervals did not likely achieve maturity.



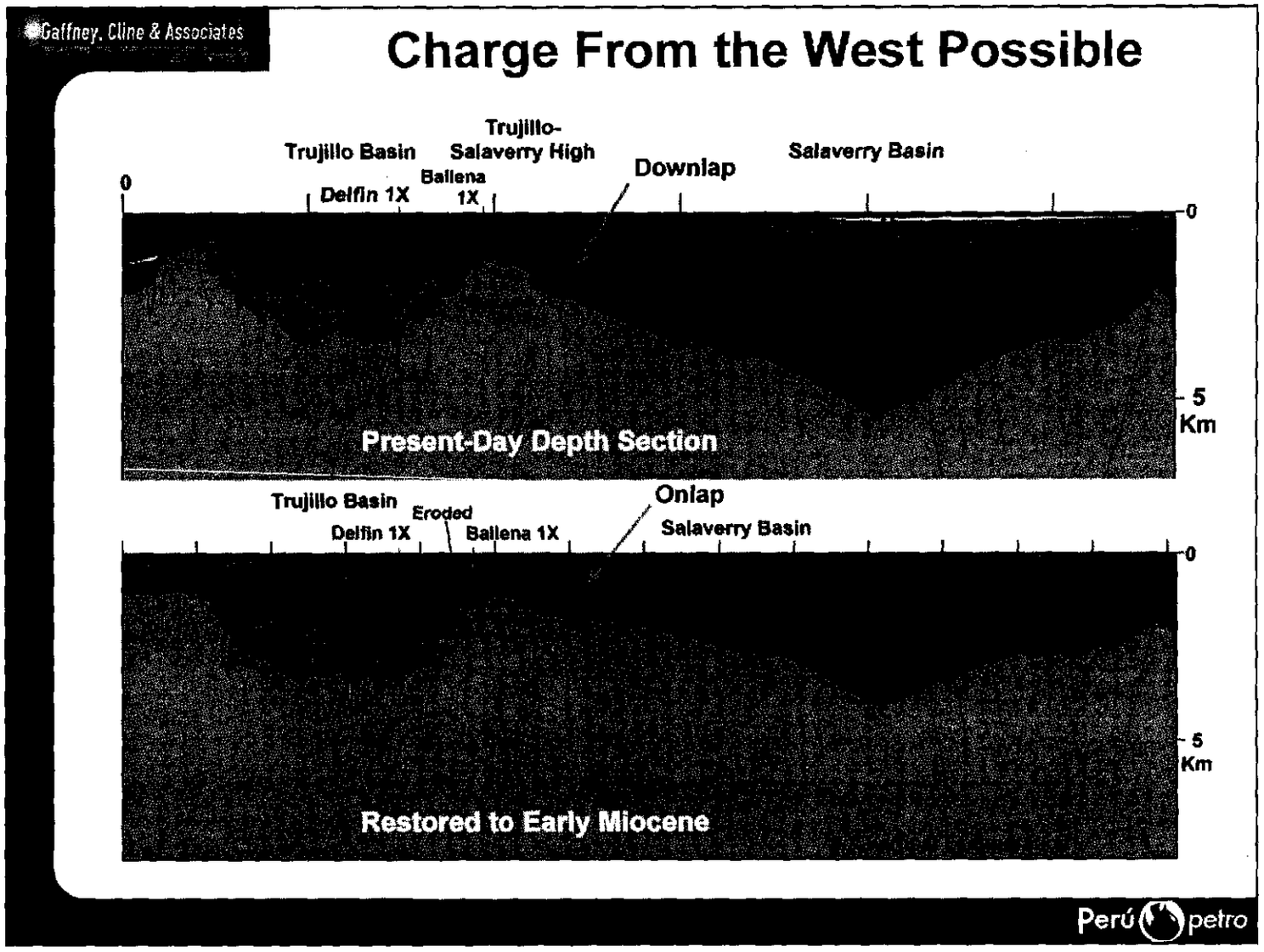
After attaining maturity in the Eocene, oil expulsion may have started in Late Miocene time. Cretaceous source rock may still be generating and expelling hydrocarbons today.



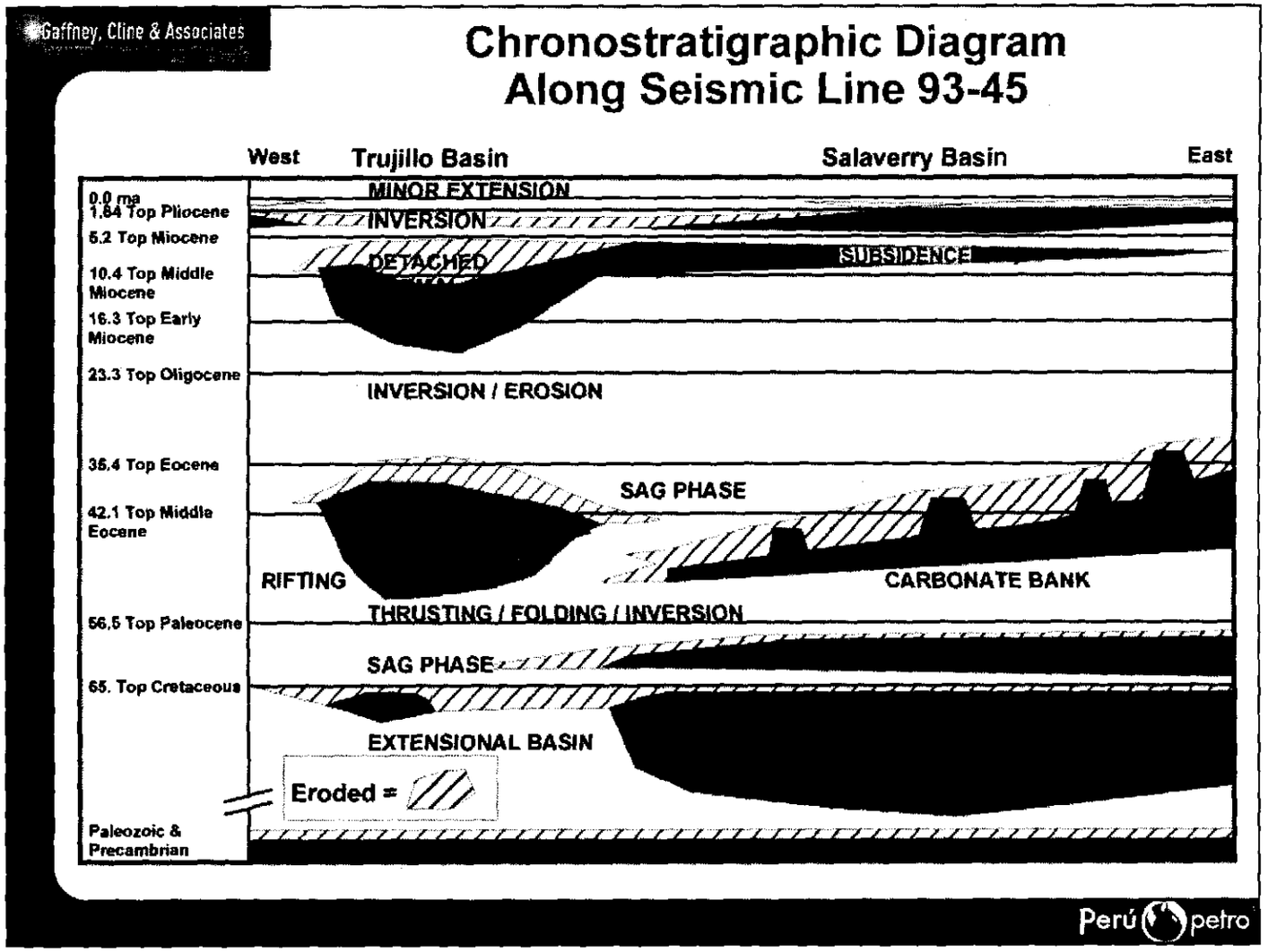
Another important part of this study involved reconstructing the main tectonic events that shaped these offshore basins into their present complex forms. The dip line 93-45 was crucial in understanding the timing of the Trujillo-Salaverry High, and the influence it may have had in controlling the possible flow of hydrocarbons from the Trujillo basin into the Salaverry basin.



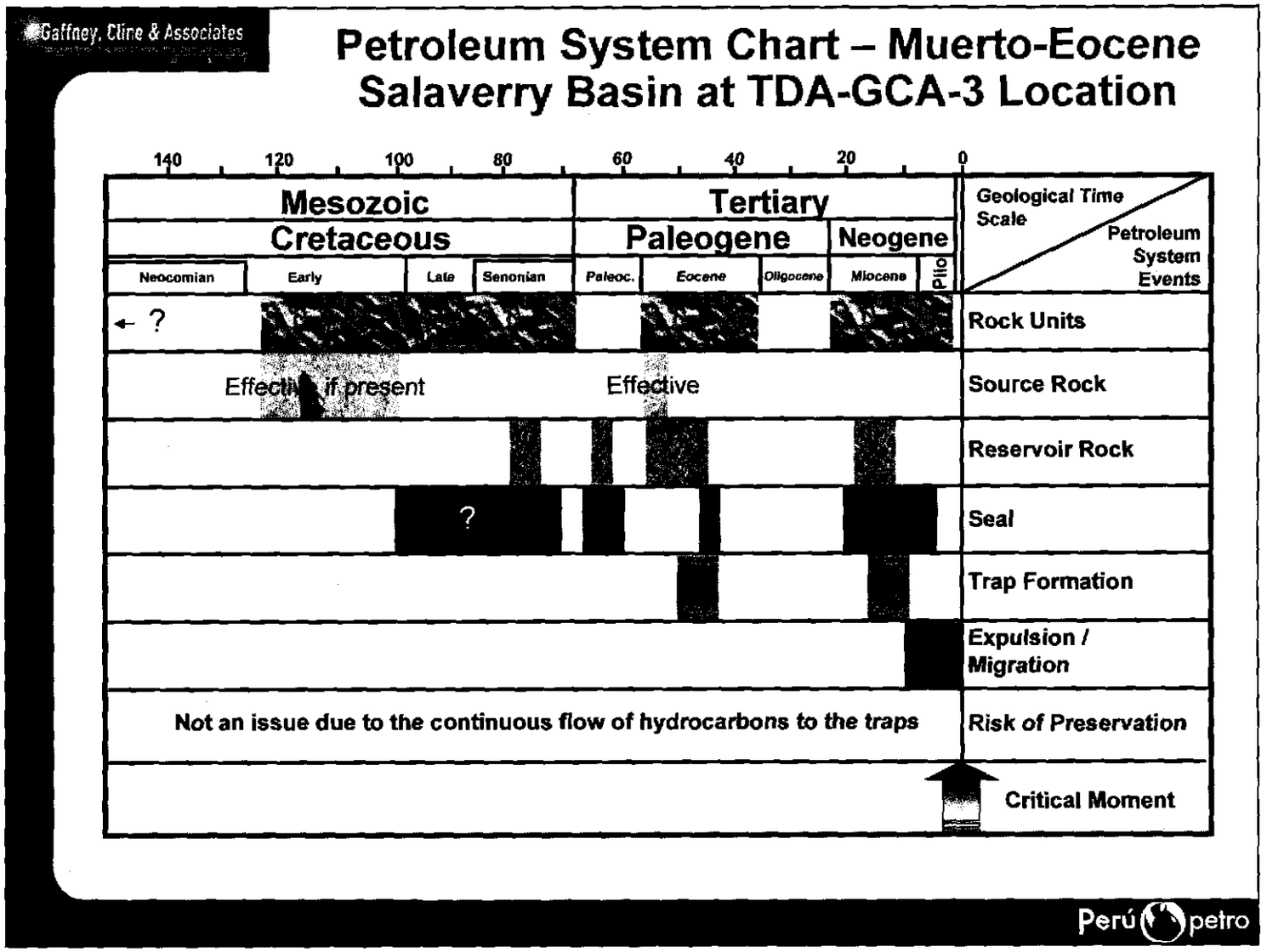
This is a 3:1 present-day depth section based on ODP line 5 and seismic line 93-45. The Trujillo and Salaverry basins overlie continental crystalline crust. The accretionary wedge is small and confined to the area beneath the outer continental slope. There is good agreement between the regional gravity profile and this composite section based on seismic data. Conventional wisdom holds that the Trujillo-Salaverry High has been in place long enough to obstruct the flow of hydrocarbons from the Trujillo basin eastward into the Salaverry basin. That assumption was tested by restoring Line 93-45 back to key geologic times and observing the resulting paleogeometries.



Notice that the downlapping bed terminations in the western Salaverry basin in the present-day section actually become onlapping terminations when restored back to the Early Miocene. This provides evidence that the Trujillo-Salaverry High was probably not in place until later, and that hydrocarbons might have migrated eastward into the Salaverry basin. Of course, the volume of Trujillo-sourced hydrocarbons that might have migrated into the Salaverry basin is purely a matter of conjecture at this point.



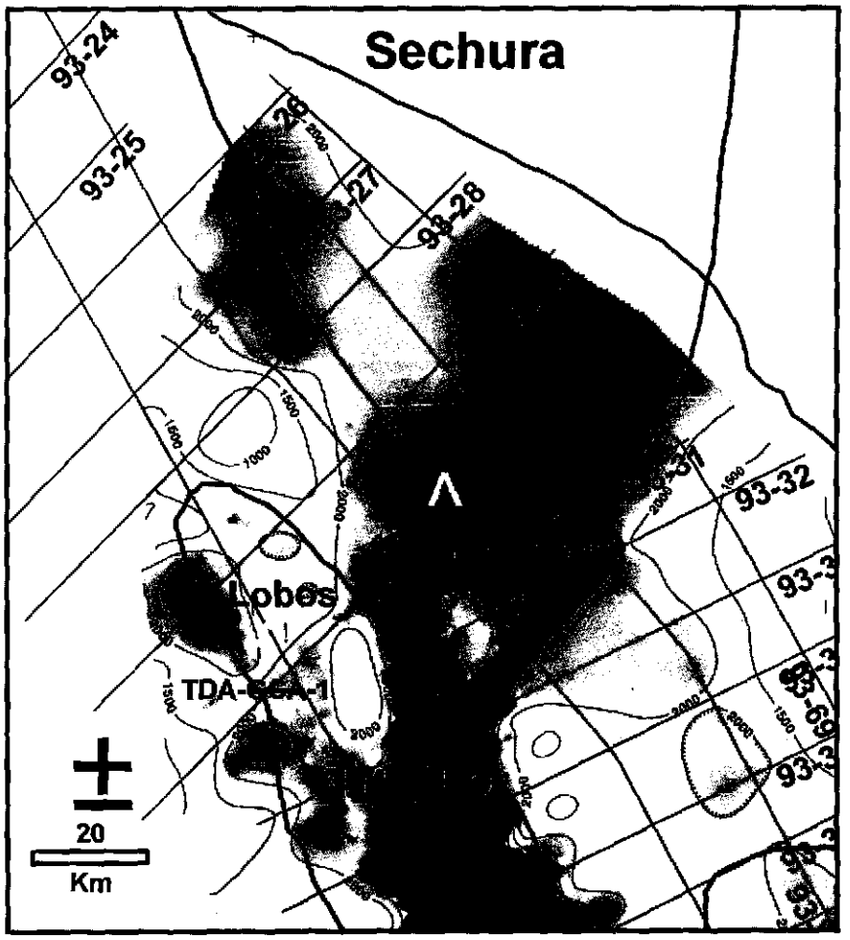
Additional lines were restored in a similar manner to help complete a fresh interpretation of the regional structural and stratigraphic history of the Trujillo and Salaverry basins. This chart summarizes that history. Erosion is shown by hatching. Non-deposition is indicated by white space. In summary, this history includes three episodes of rift/sag basin-building deposition (in the Cretaceous, Eocene and Miocene) and three episodes of thrusting, wrenching and inversion that caused significant structuring and erosion in the Paleocene, Oligocene and Pliocene. A possible period of carbonate bank and pinnacle build-ups in the Eocene is particularly significant as a possible source of carbonate reservoir rocks. Opposing thought holds that these "build-ups" are actually volcanics. Ground truth can be tested in several areas where these build-ups are very near the surface.



This slide summarizes the newly interpreted (but unconfirmed by the drill) petroleum system for the Salaverry basin. The main source rock is Cretaceous. Potential reservoirs exist in the Cretaceous, Paleocene, Eocene and Miocene. Thick shales provide seals throughout the sedimentary section. Traps were formed and reshaped in response to multiple episodes of extension, compression/inversion and wrenching. Expulsion likely began after most of these structures were in place.

Gaffney, Cline & Associates

Modeled Generation in Sechura on Line 93-30

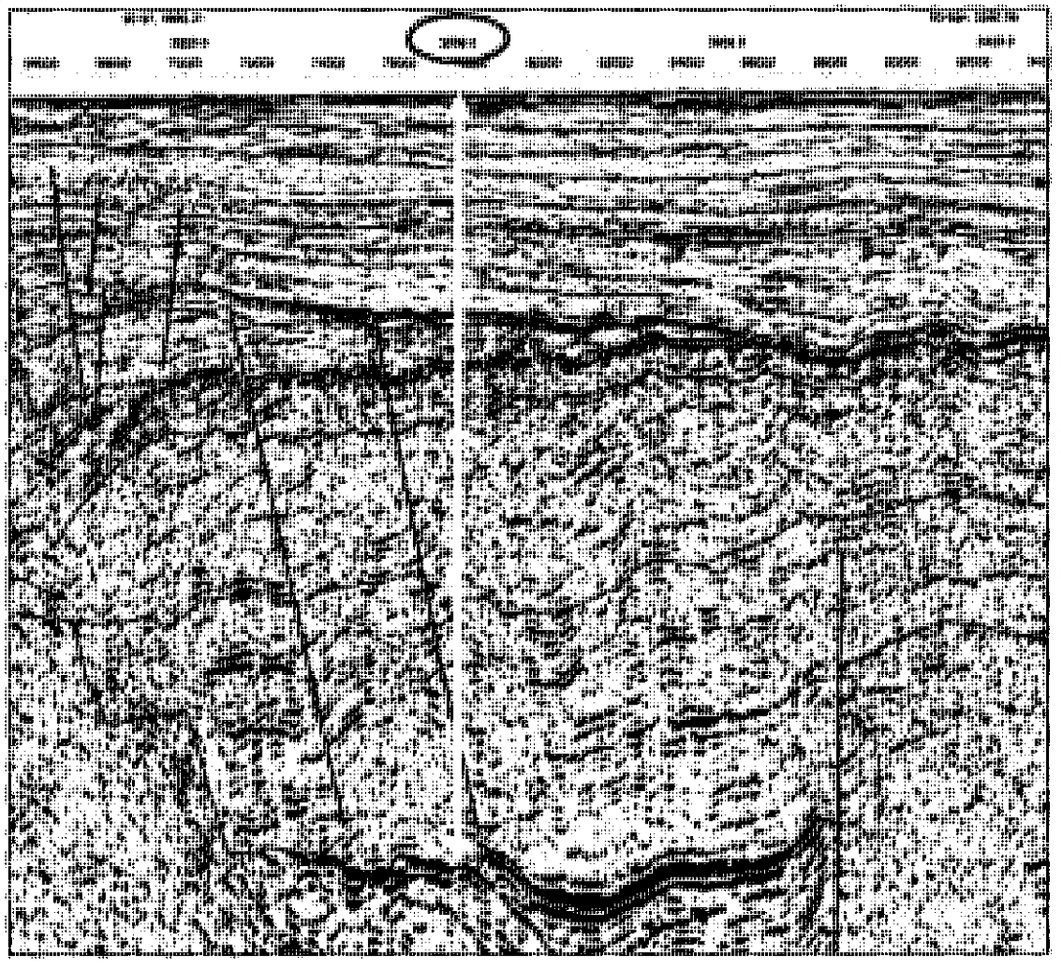


Perú petro

Maturation modeling was also performed at this location in the offshore Sechura basin. The conclusions reached were as good or better than those reached for the Salaverry basin.

Gaffney, Cline & Associates

TDA-GCA-4 at SP 3,000 on Line 93-30



Almost 5,000 meters of sediment at shotpoint 3,000

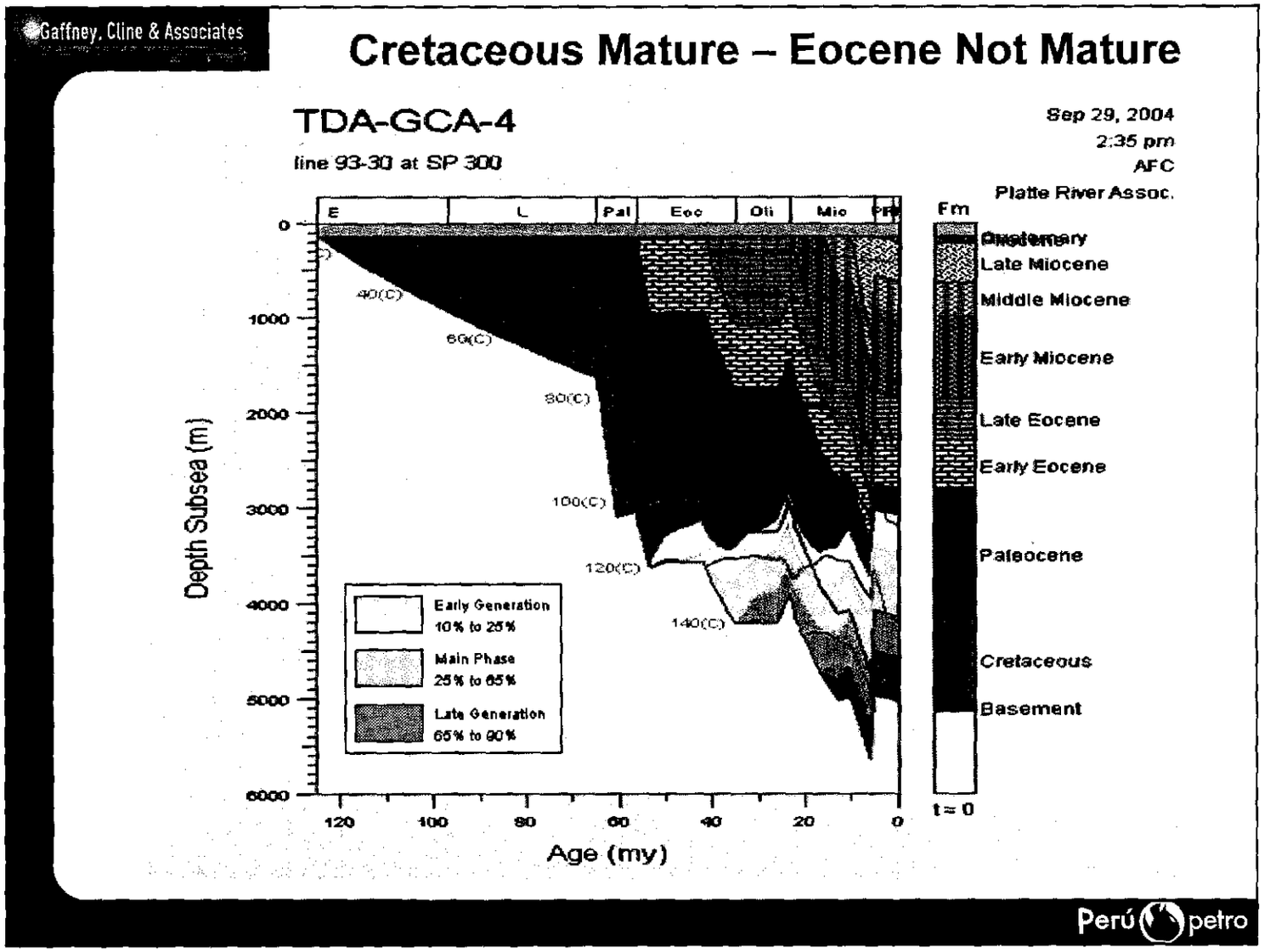
Eocene

Paleocene

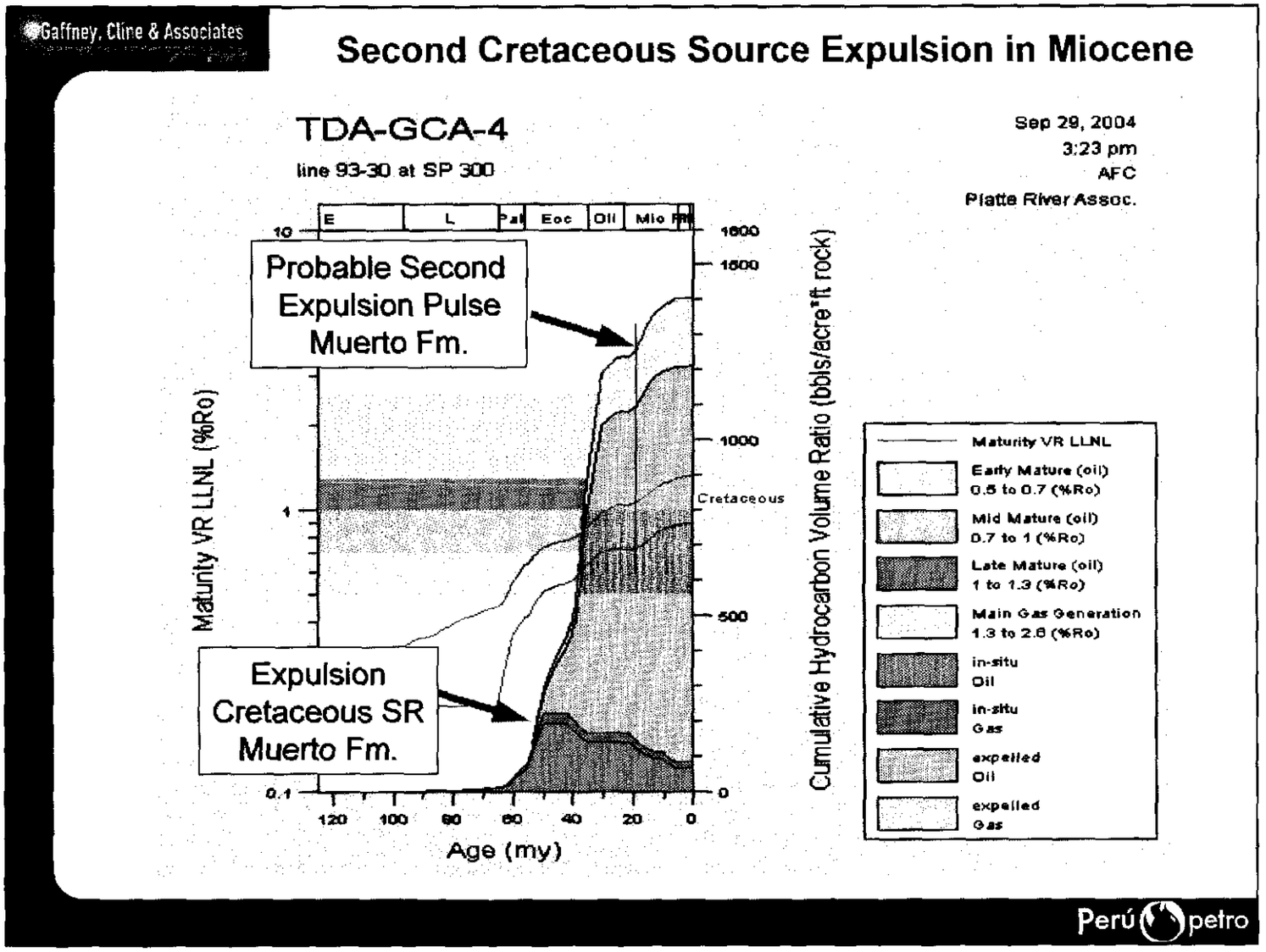
Cretaceous

Perú petro

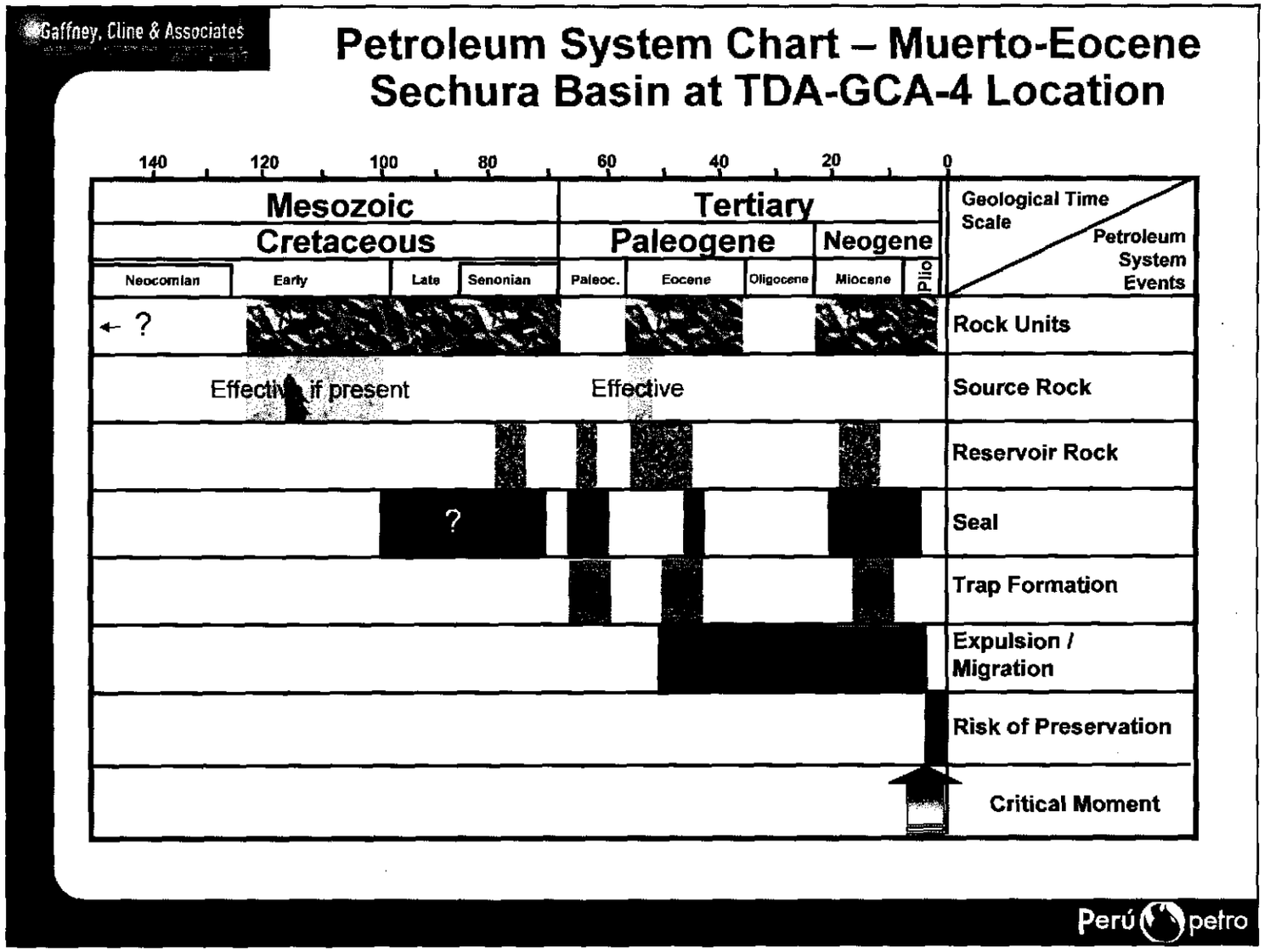
The total sediment column at this location is about 1,000 meters thicker than at the location modeled in the Salaverry basin, which improves the chance for adequate maturation.



A possible Cretaceous source rock moved into the oil window in Eocene time, and would now be over-mature. Owing to the thick Paleocene section, the Eocene is not close to the necessary maturation level in order to be considered a potential source rock for the offshore Sechura basin.



Oil expulsion began at Eocene time. A reactivation and second expulsion pulse may have occurred during Miocene time from a mature source rock that can be associated with the phenomenon observed in Lobos 1X of a second pulse of light oil/condensate.



Because the sediment column is thicker at this location than in the Salaverry basin, the onset of maturation was earlier. There is still a risk of biodegradation in this basin.

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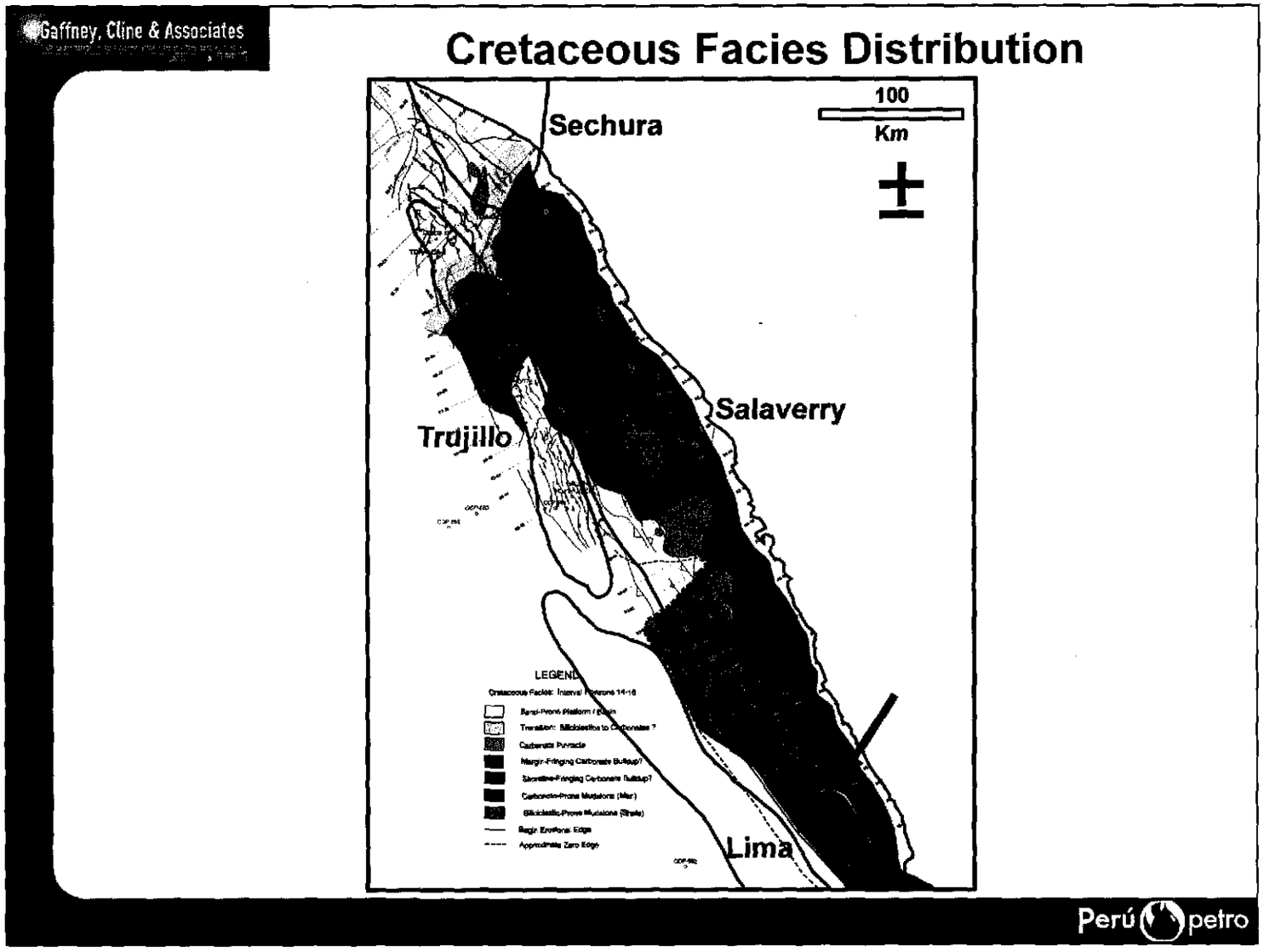
Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro



A set of subcrop and facies maps was prepared as a supplement to the conventional structure and isopach maps for this study. These maps aid understanding of the distribution of potential source rocks and reservoirs. For example, the sequence stratigraphic character of the Cretaceous suggests that it is carbonate-prone, as is illustrated in Line 93-62 (next slide) at the location marked with the black arrow.

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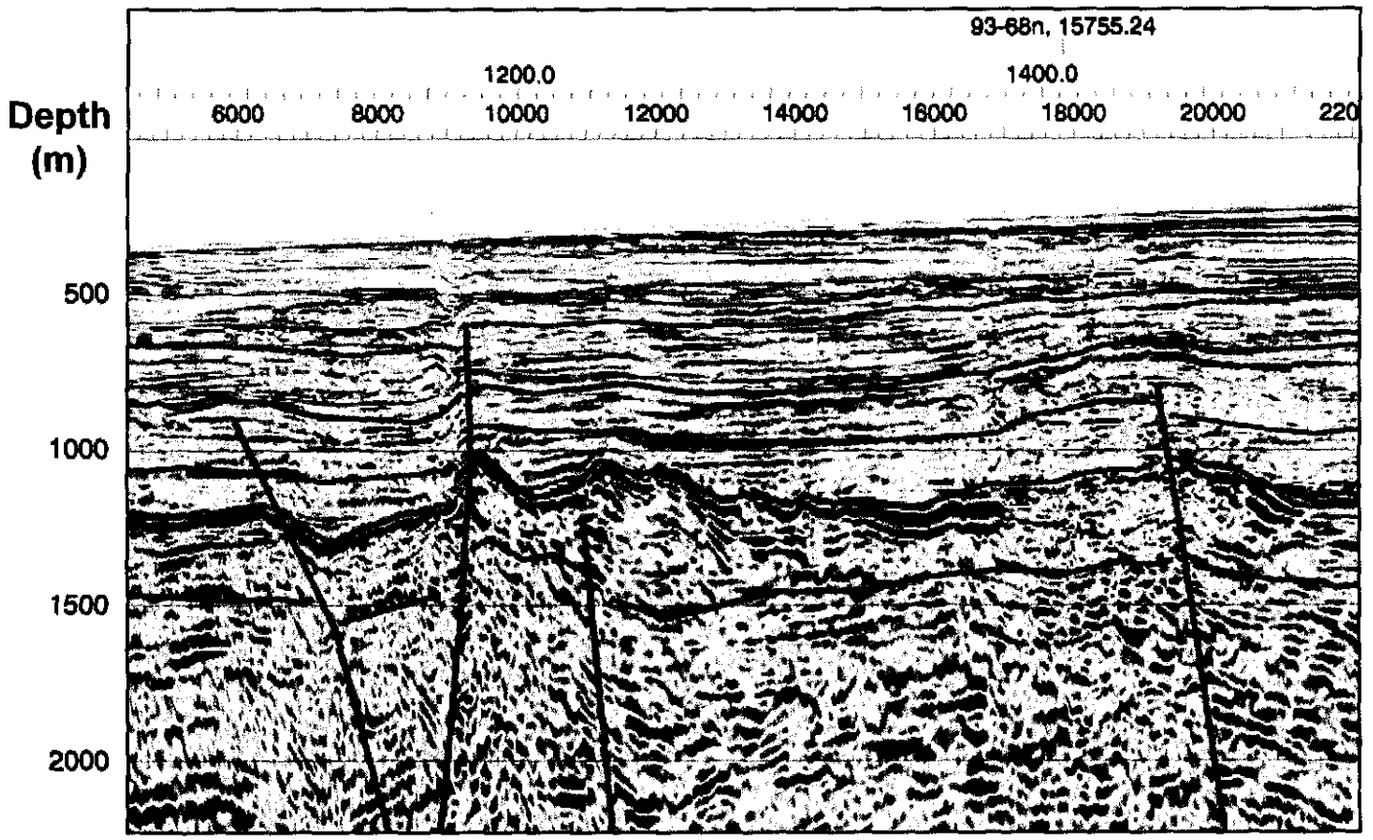
Line 93-62 – Example of Cretaceous Build-Ups



Perú petro

This segment of Line 93-62 is a good illustration of the "build-up character" of the seismic below the Top Cretaceous interpreted horizon. Notice how the location of the build-ups appears to be fault-controlled.

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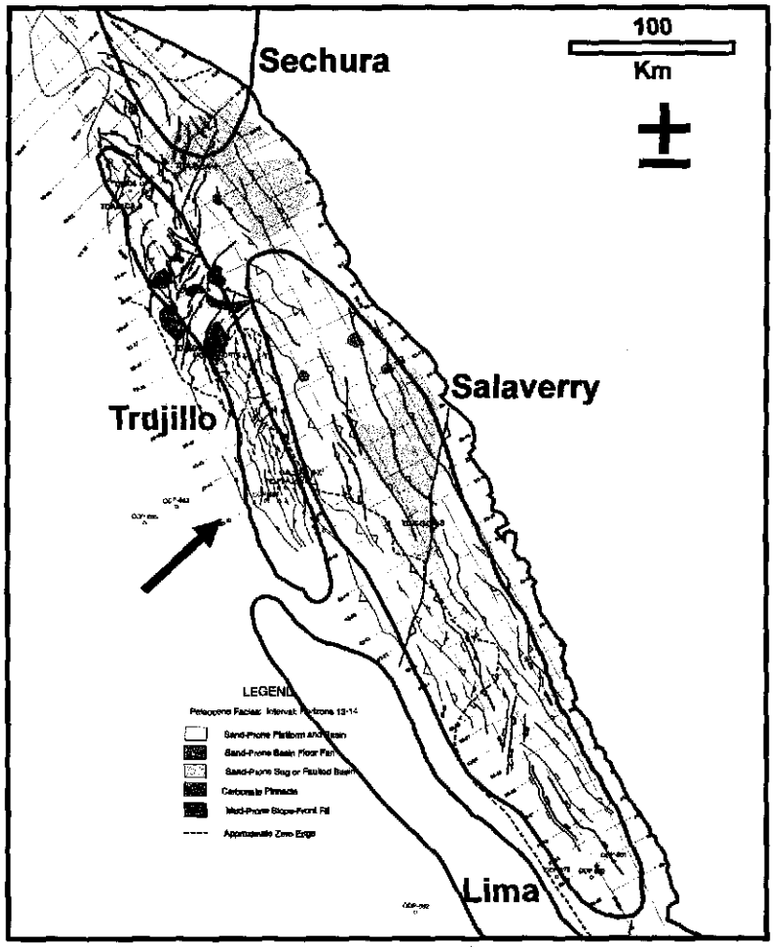
Paleocene Facies Distribution



Perú petro

Moving up into the Paleocene, this facies was interpreted to be largely sand-prone, especially in the vicinity of the sag basins that are shaded grey on the map. Line 93-45 (that ties the Delfin and Ballena well locations) is a good illustration of this sand-prone character in the following slide.

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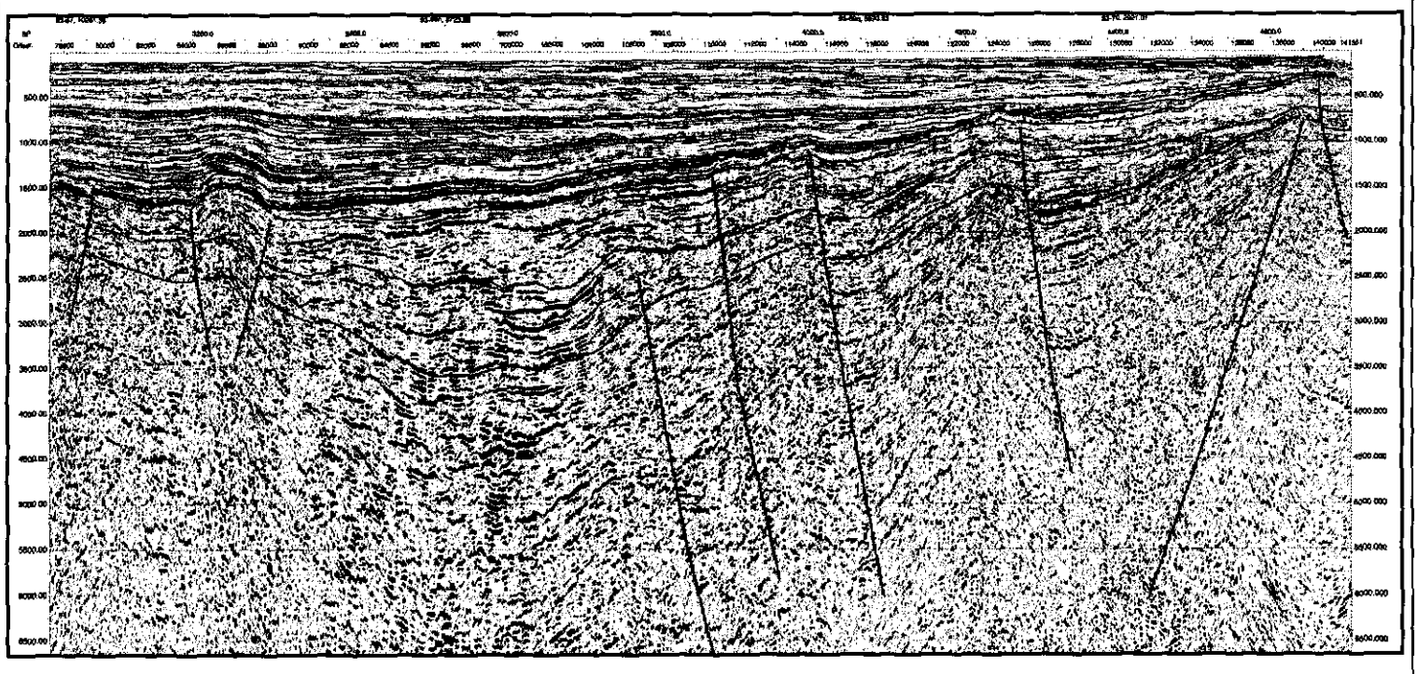
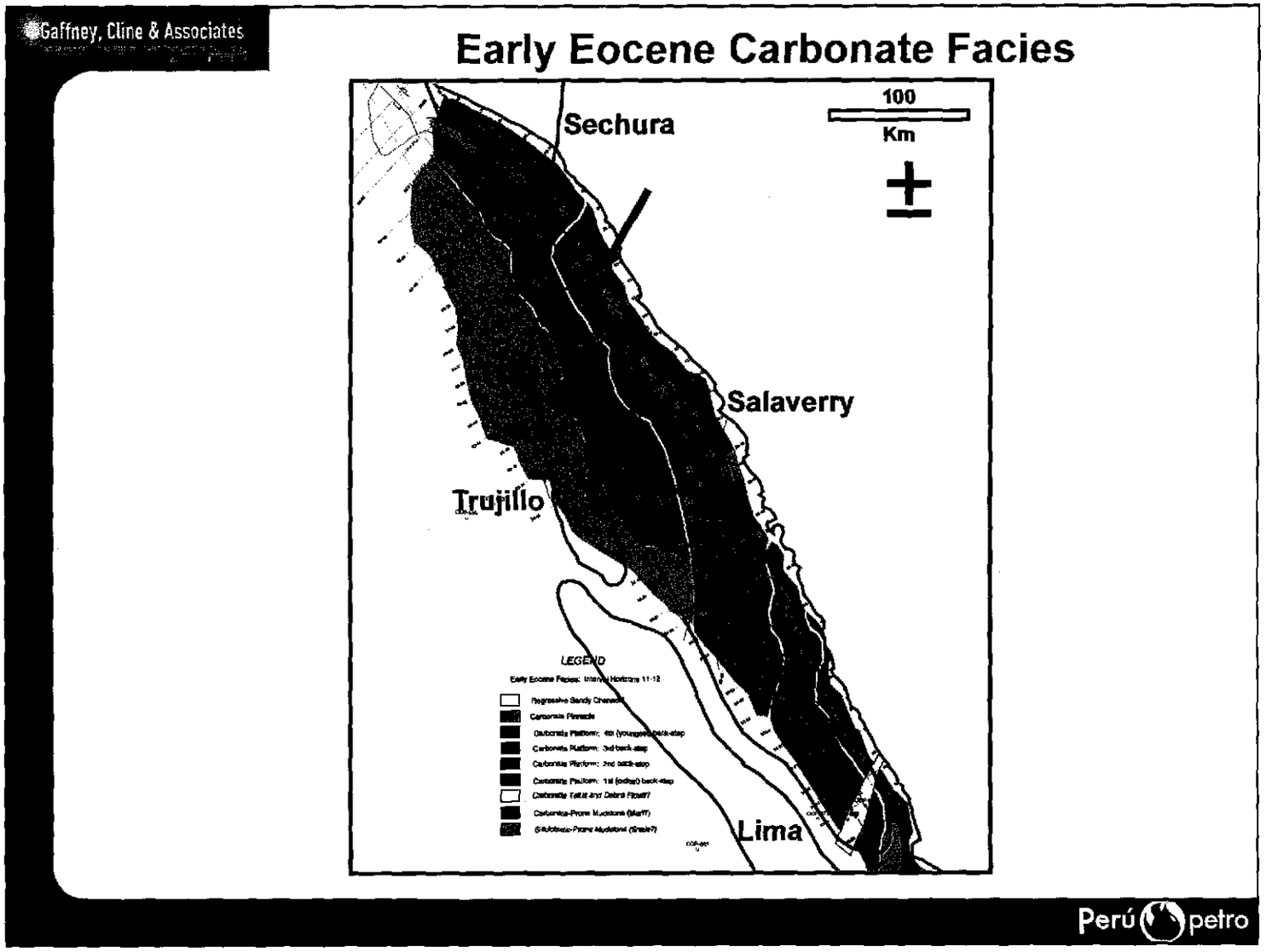
Line 93-45 Sand-Prone Cretaceous / Paleocene Sag Basin

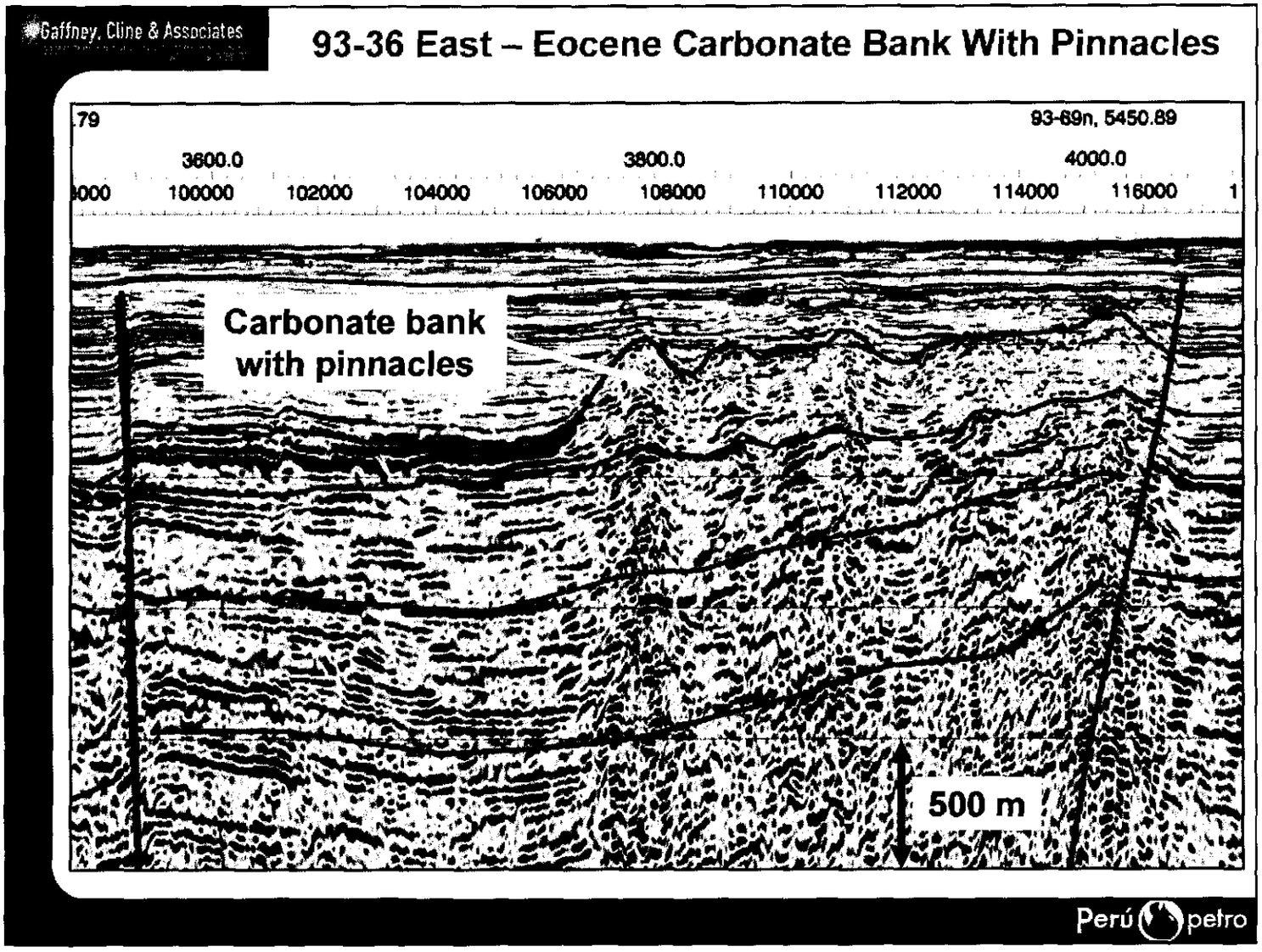


Perú petro

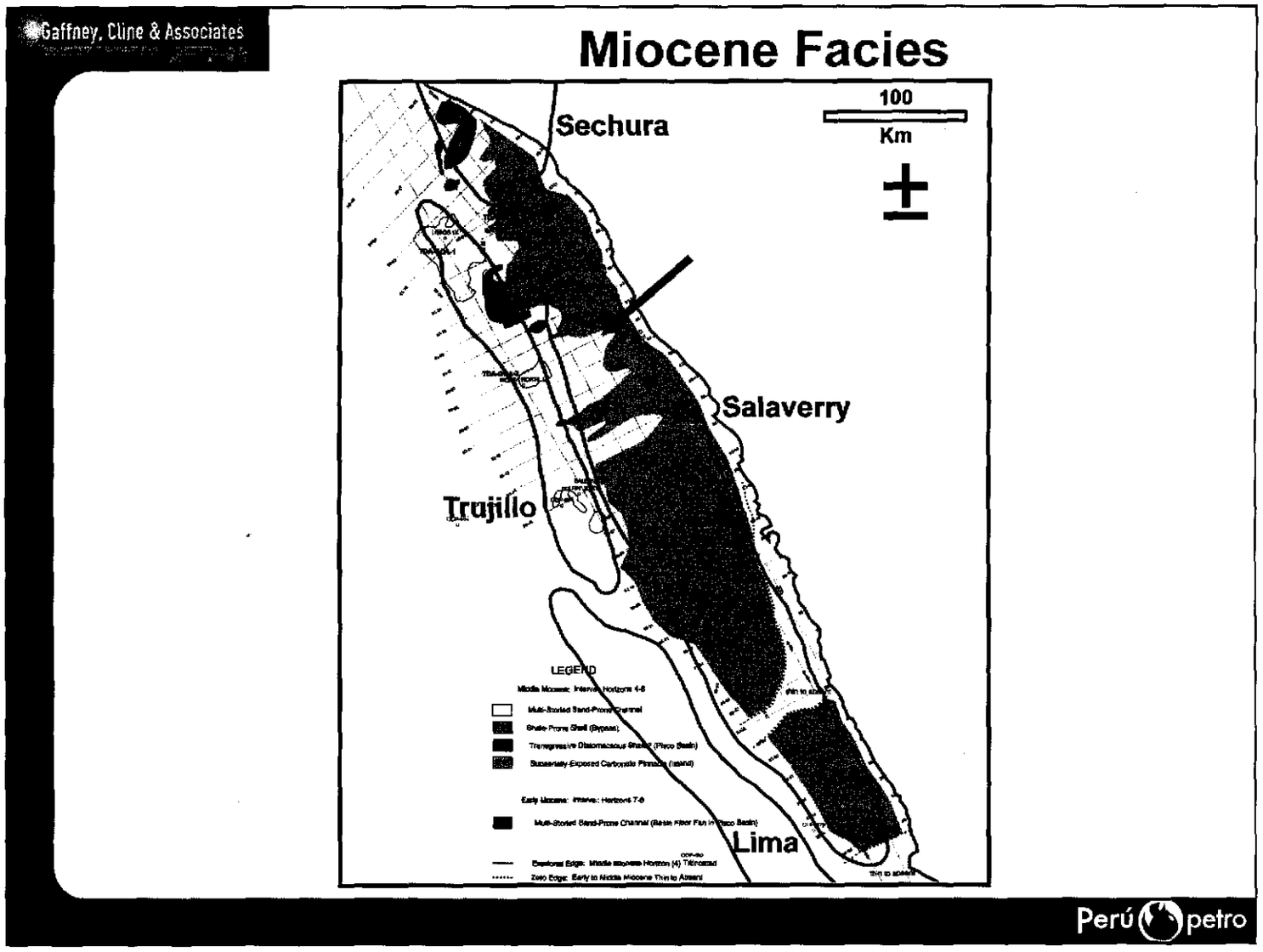
Note the wrench-related pop-up structure at the western end of this line, and the tilted fault blocks at the eastern end. In most cases, the regional spacing of the Ribiana 1993 survey (around 15 x 15 kilometers) is too wide to map the lateral limits of these one-line structures. Also note that these structures are ideally positioned to catch hydrocarbons that may have migrated out of the sag basin.



This regional facies map captures several phases of "backstepping" of carbonate platforms over the Salaverry basin in the Eocene. Note the abundance of the "pinnacles" (in pink), which may be very attractive exploration targets. The arrow shows the location of Line 93-36, which appears in the next slide as a good example of the carbonate-prone character of this Eocene interval.



This is perhaps the best example of the sequence stratigraphic character that led to the interpretation of carbonates in the Eocene. Of course, these may be volcanics, but there is little evidence of a deep root for most of these structures. Moreover, the seismic character at the edges of these banks is more suggestive of organic build-ups.



The last of the series of facies maps shows the maximum extent of a multi-storied Miocene channel complex. Line 93-39, marked with the black arrow, is a good example of the multiple levels of channelized erosion and deposition. A segment of that section is shown in the next slide.

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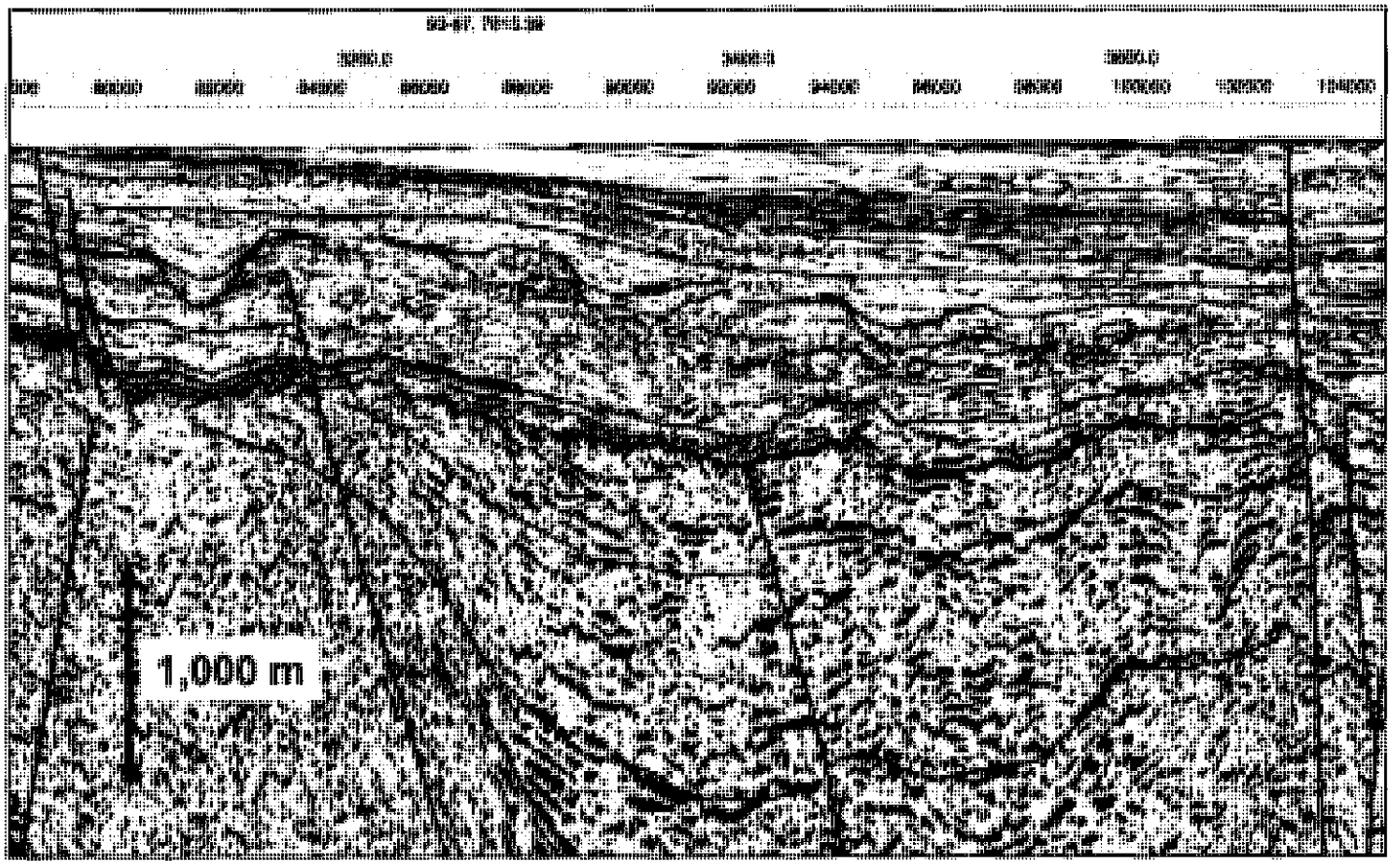
Line 93-39 – Miocene Channels



Perú petro

These Miocene channels are also well situated over the Paleocene/Cretaceous sag basin that may have been a local hydrocarbon kitchen.

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Outline

- Conclusions
- Data
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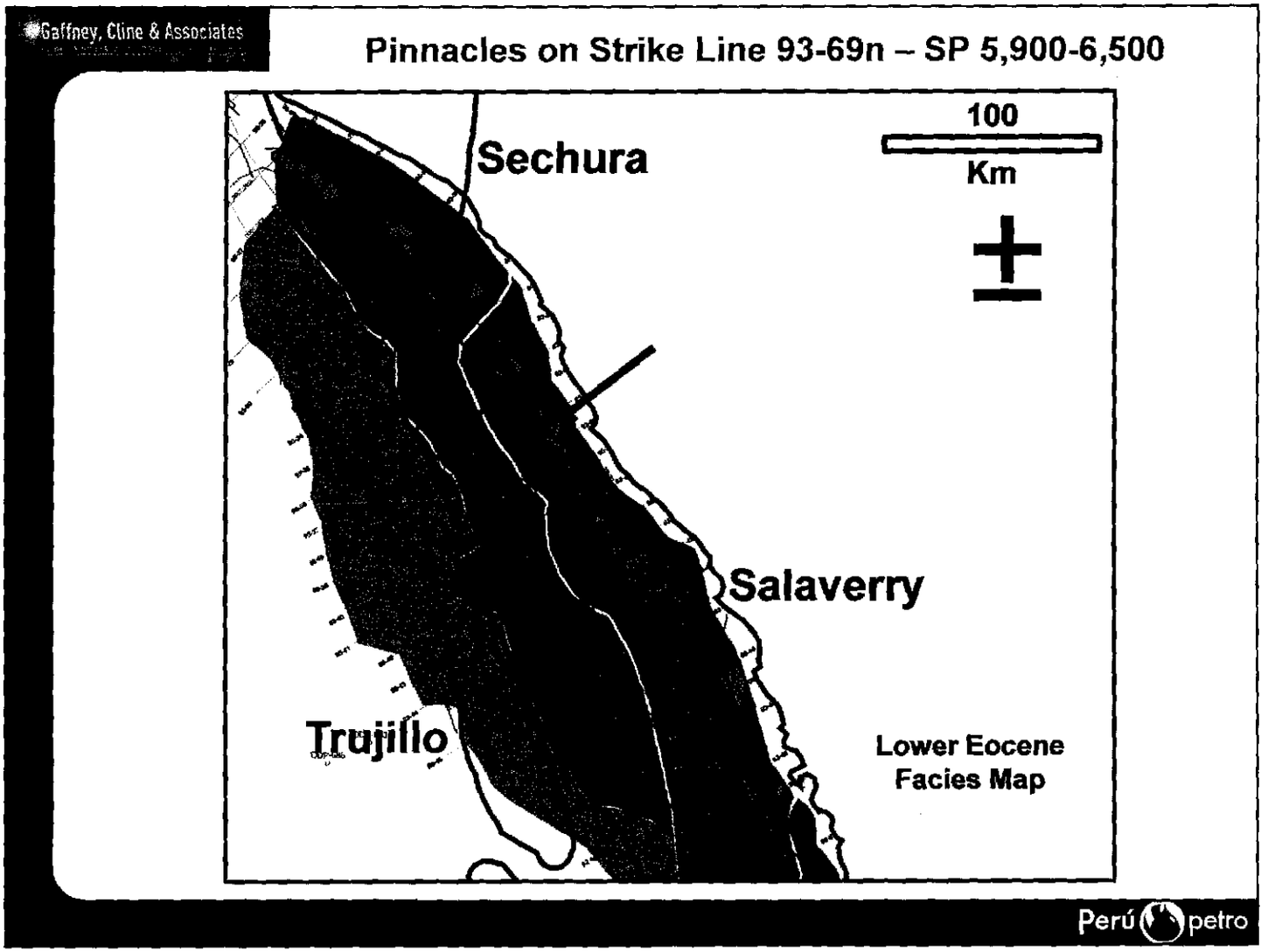
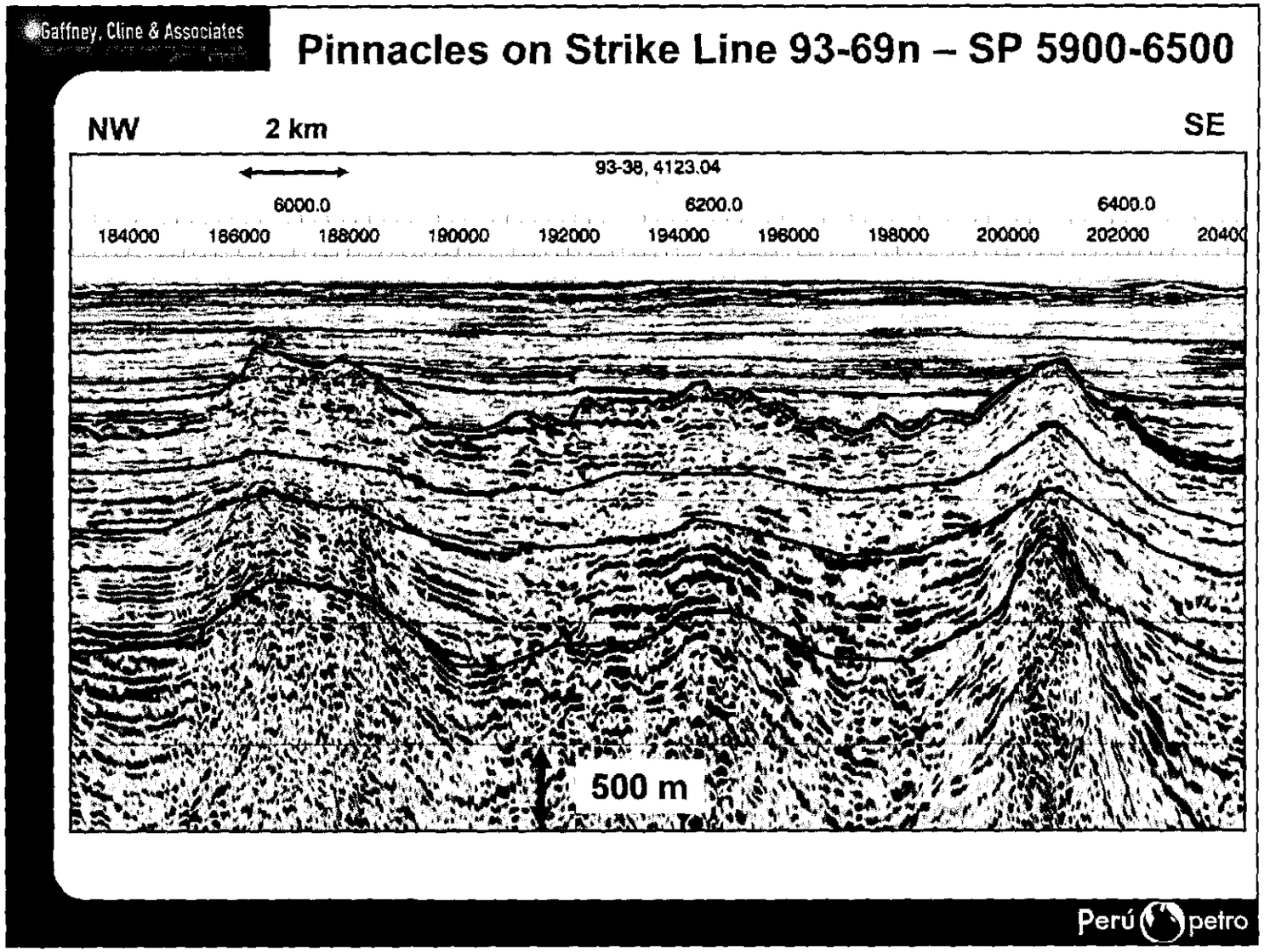
- Economics

Perú petro

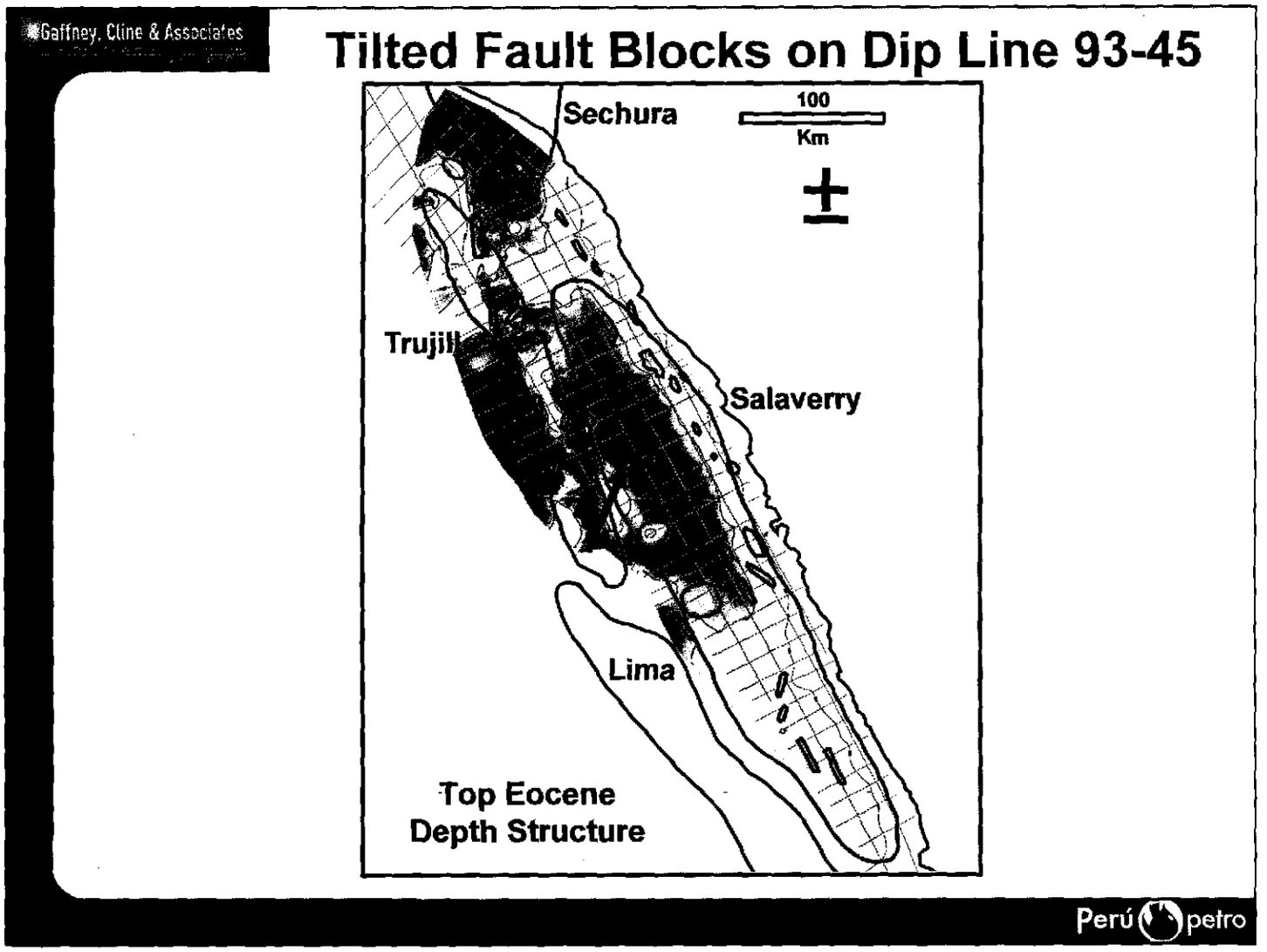
The most interesting leads in the Salaverry and offshore Sechura basins are wrench-related pop-up structures. Eocene carbonate pinnacles also have high potential, although the actual existence of carbonates in these basins has yet to be confirmed with drilling.



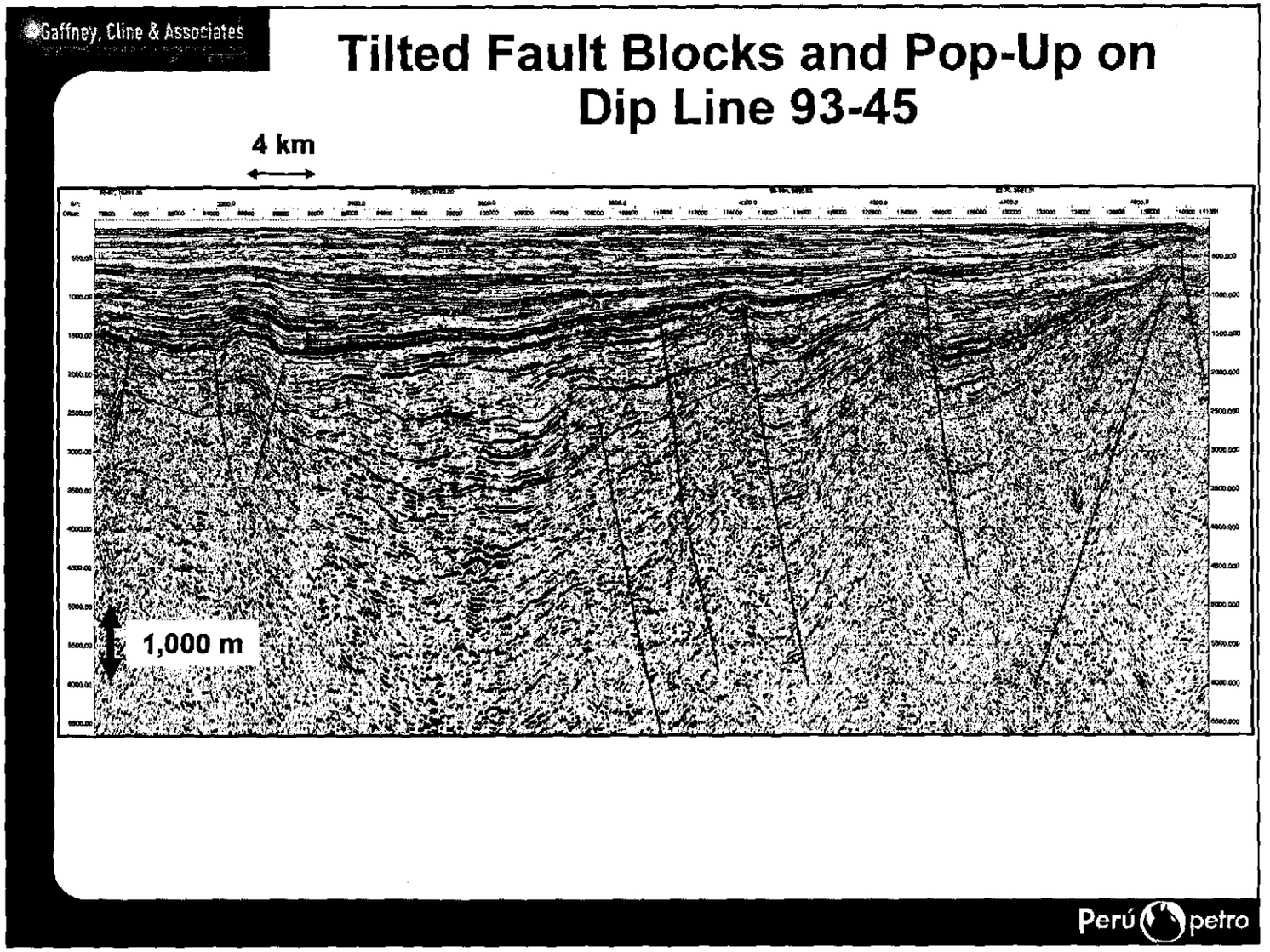
Many promising traps in the Salaverry and offshore Sechura basins appear to be largely stratigraphic in nature, and are associated with what may be pinnacle-shaped carbonate build-ups in the Early Eocene. The following slide is a particularly good example of these pinnacles, and is marked with a black arrow on the map. It should be noted that this "Eocene carbonate" interpretation runs counter to conventional wisdom that maintains that these pinnacles are actually volcanic in nature. Fortunately, this controversy can be resolved relatively easily, as the subject facies occurs very near the surface and could be drilled inexpensively at several locations (see Pisco Basin Presentation, slide 30).



In some cases, there is evidence here for a deep root to the "pinnacles" at either end of this line segment. The velocity data available for this study were not of sufficient volume or quality to distinguish these features as carbonate build-ups instead of volcanics. In addition to the shallow drilling mentioned in the previous slide, new 2D and 3D surveys should be carefully engineered to help resolve this issue.



In addition to the carbonate-related stratigraphic traps described in the previous slides, there are other important leads that are more structural in nature. Some of these are shown in black on this map. Dip line 93-45 in the next slide (located at the black arrow on the map) is a good example . Note that the Top Eocene depth structure map shown is actually a merge of several Eocene surfaces, depending upon how much of the Eocene section is preserved in a given area.



In most cases, the regional spacing of the Ribiana 1993 survey (around 15 x 15 kilometers) is too wide to map the lateral limits of these one-line features. For example, the wrench-related pop-up feature at the western end of this line is about four kilometers wide in the dip direction, and is probably not more than twice this width in the strike direction.

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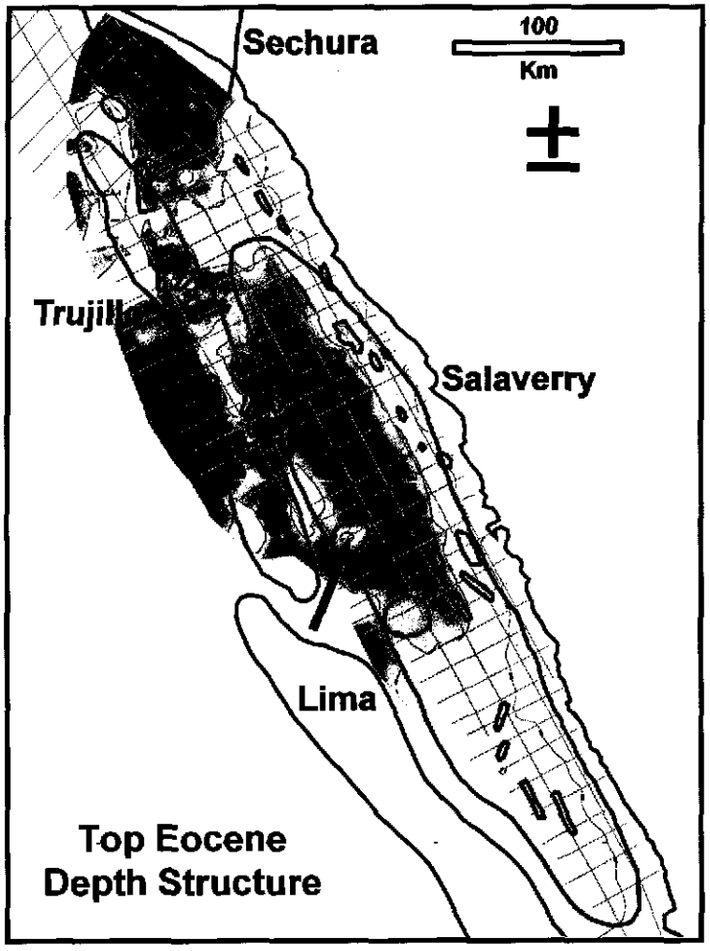
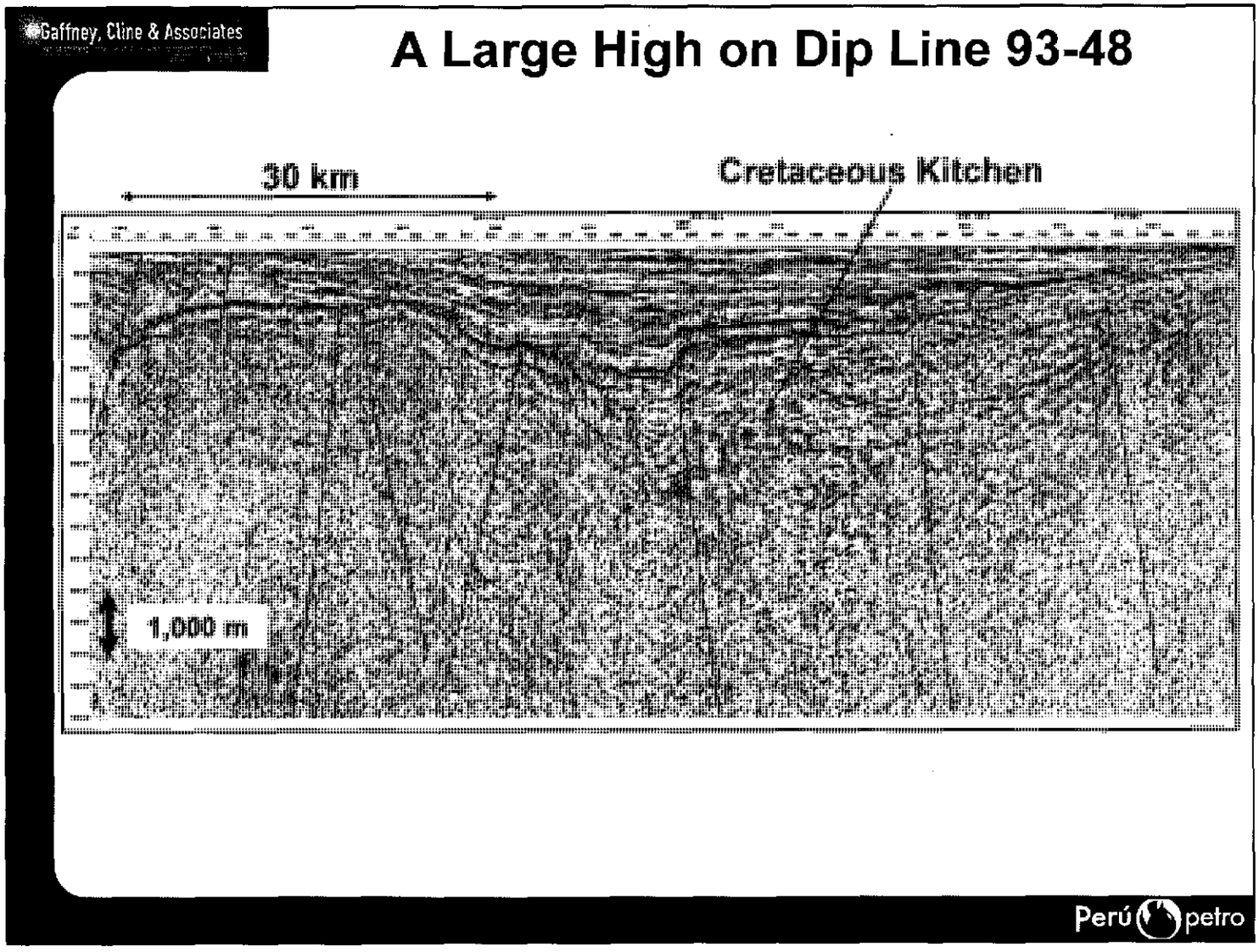
A Large High on Dip Line 93-48

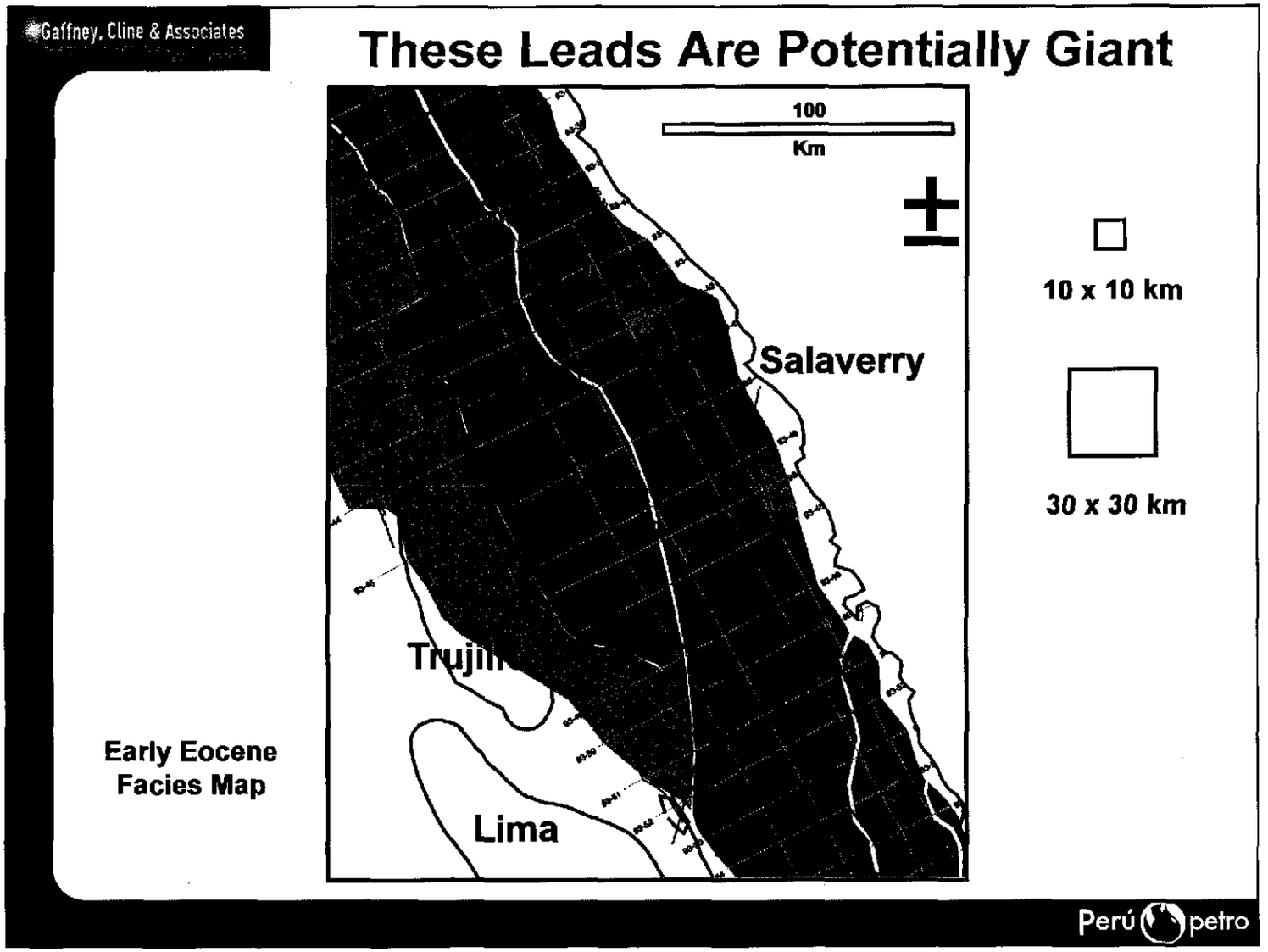


Perú petro

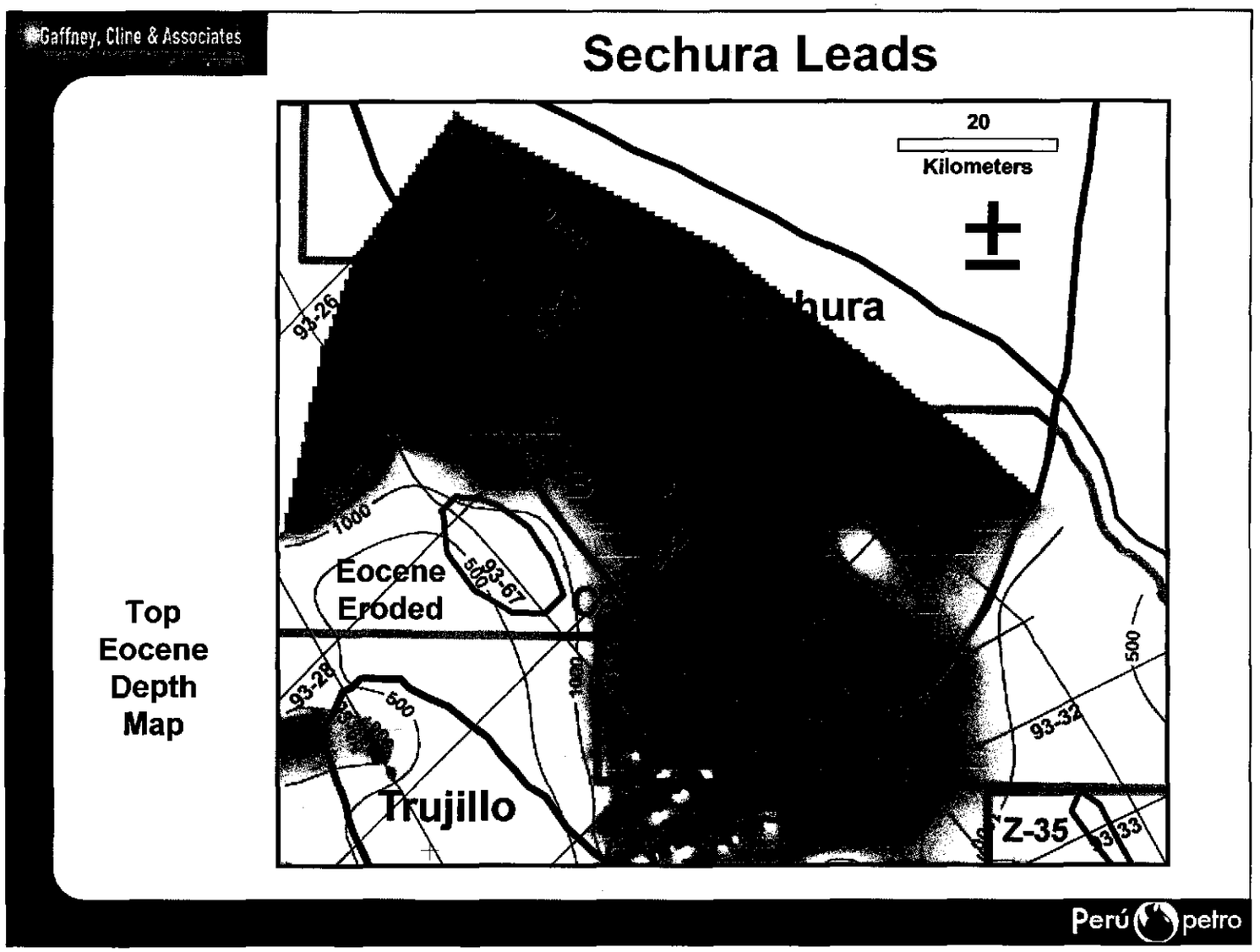
This is one of the largest of the one-line structural anomalies, which extends for 30+ kilometers along this line.



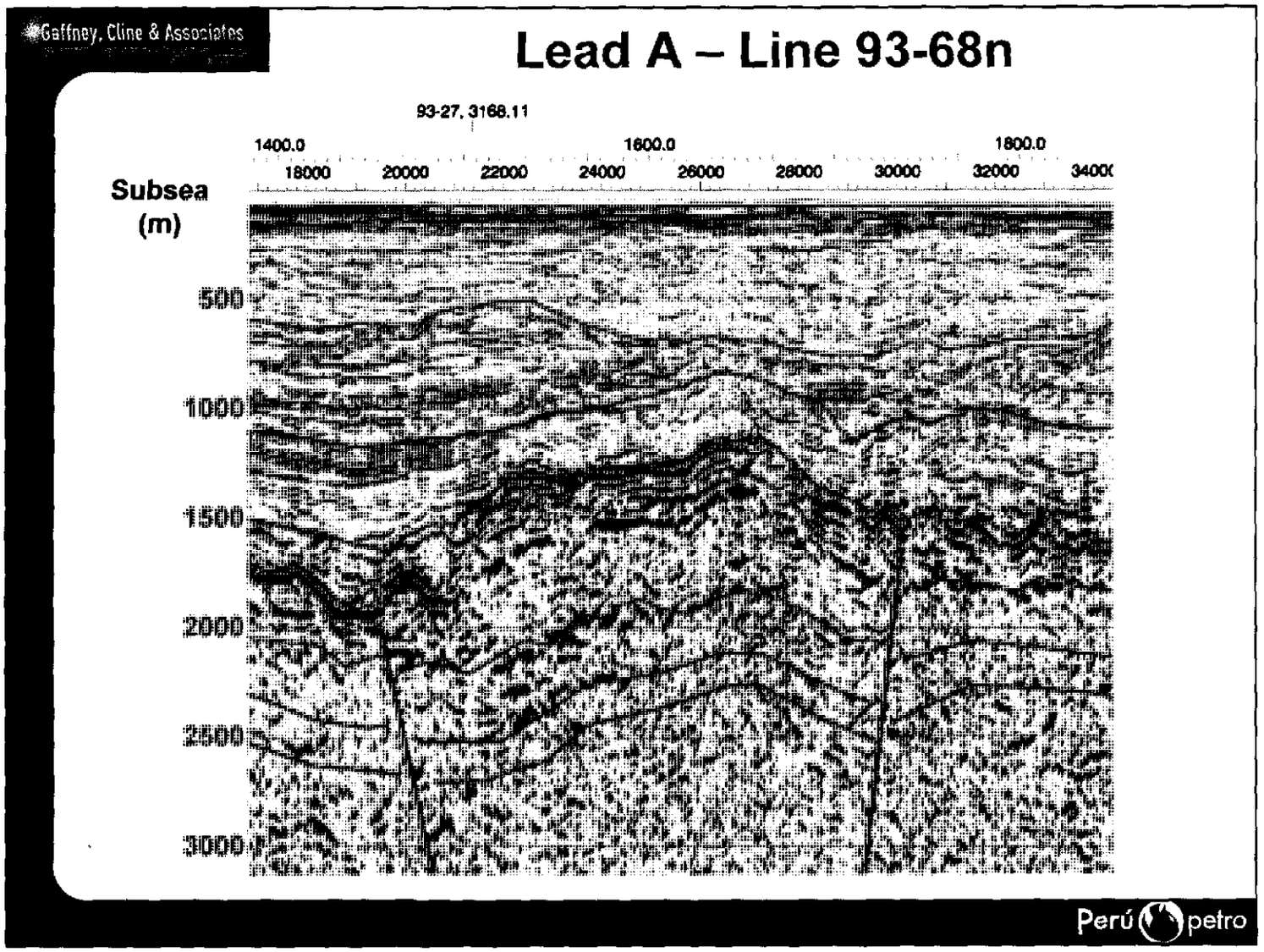
Eocene is interpreted to be thin over the crest of this structure. Nevertheless, there is substantial potential for reservoir over the crest, as well as combined structural and stratigraphic traps around the flanks of this high.



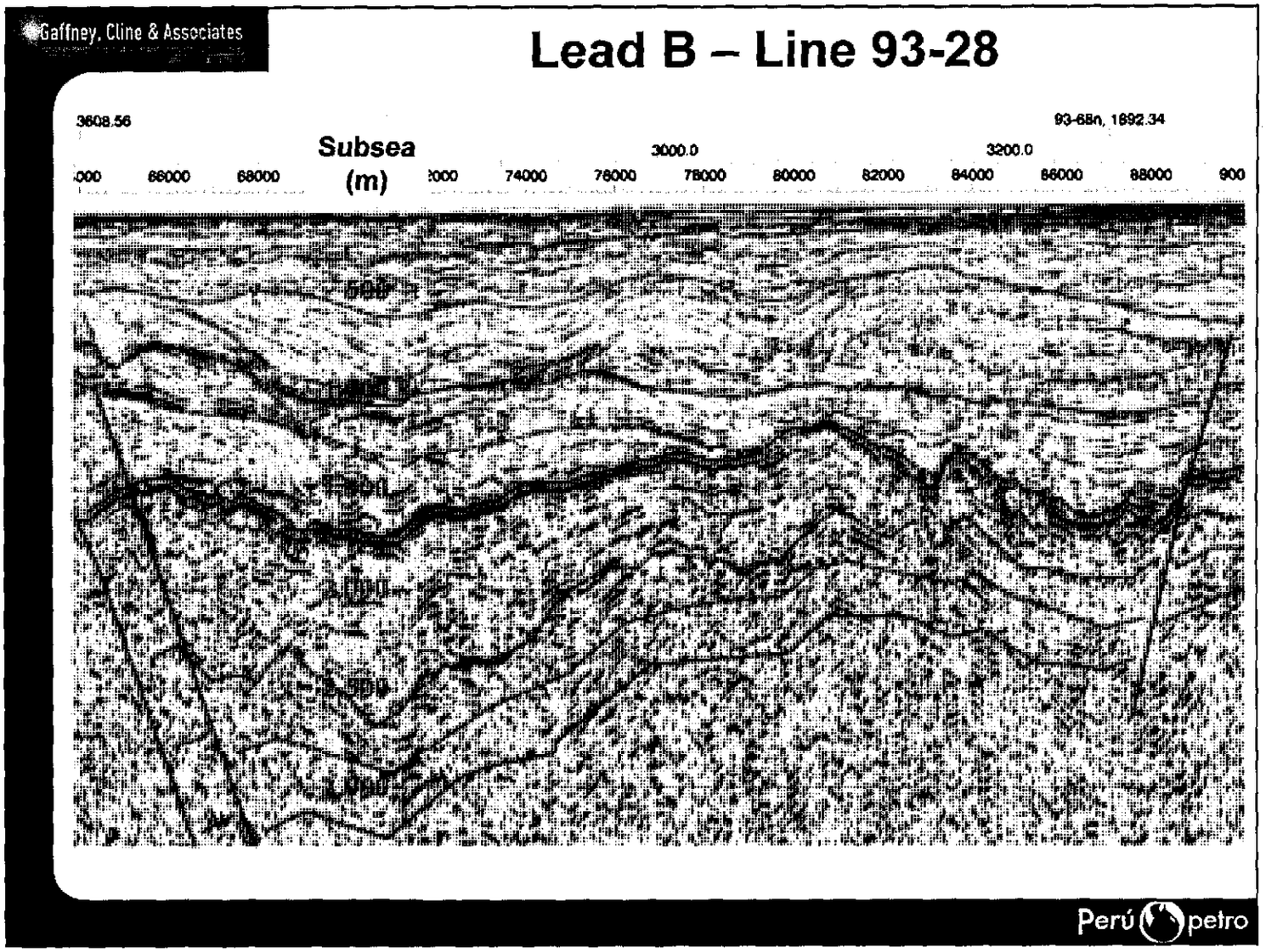
Combining the Eocene carbonate map with the structural leads map gives an overall impression that a middle-sized lead might be 100 square kilometers in size, albeit the limitations of the regional seismic grid must not be forgotten, even though these are not all one-line features. With that limitation in mind, it is possible to approximate in-place resource potential for a range of lead sizes as is illustrated in the economics section of this presentation.



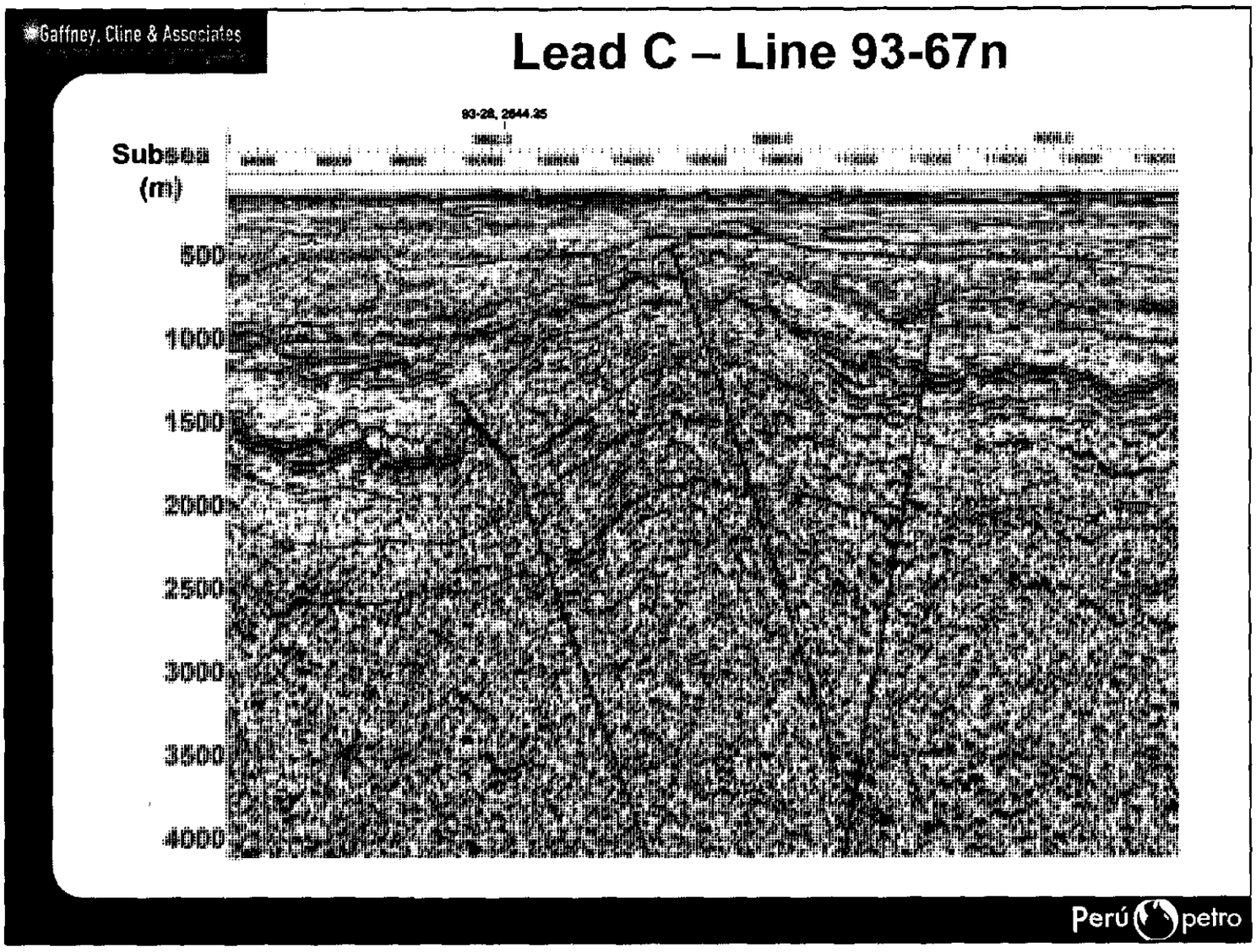
Although the offshore part of the Sechura is much smaller than the Salaverry basin, it lies mostly within Petro-Tech Peruana's Block Z-6, and contains at least five leads as shown (A-E) on this map. Segments of seismic lines illustrating these five leads are shown in the following slides.



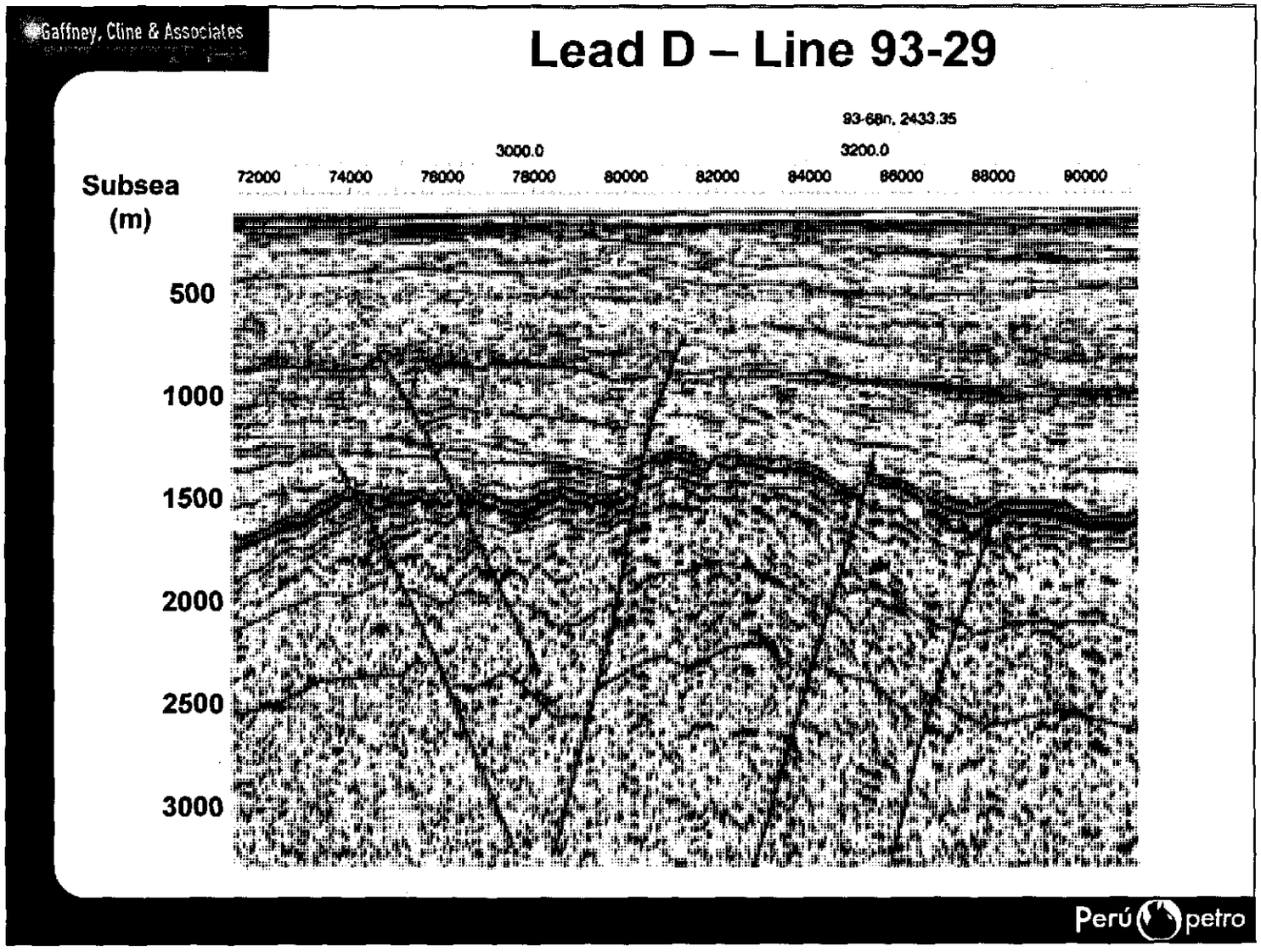
Lead A appears to be a wrench-related pop-up feature. The Eocene carbonate section is thicker over the crest, suggesting that it might be an inverted graben. In any case, the rugose character and high seismic amplitudes over the top of this structure suggest that if these are carbonates, they might have been subaerially exposed, which may have enhanced their porosity.



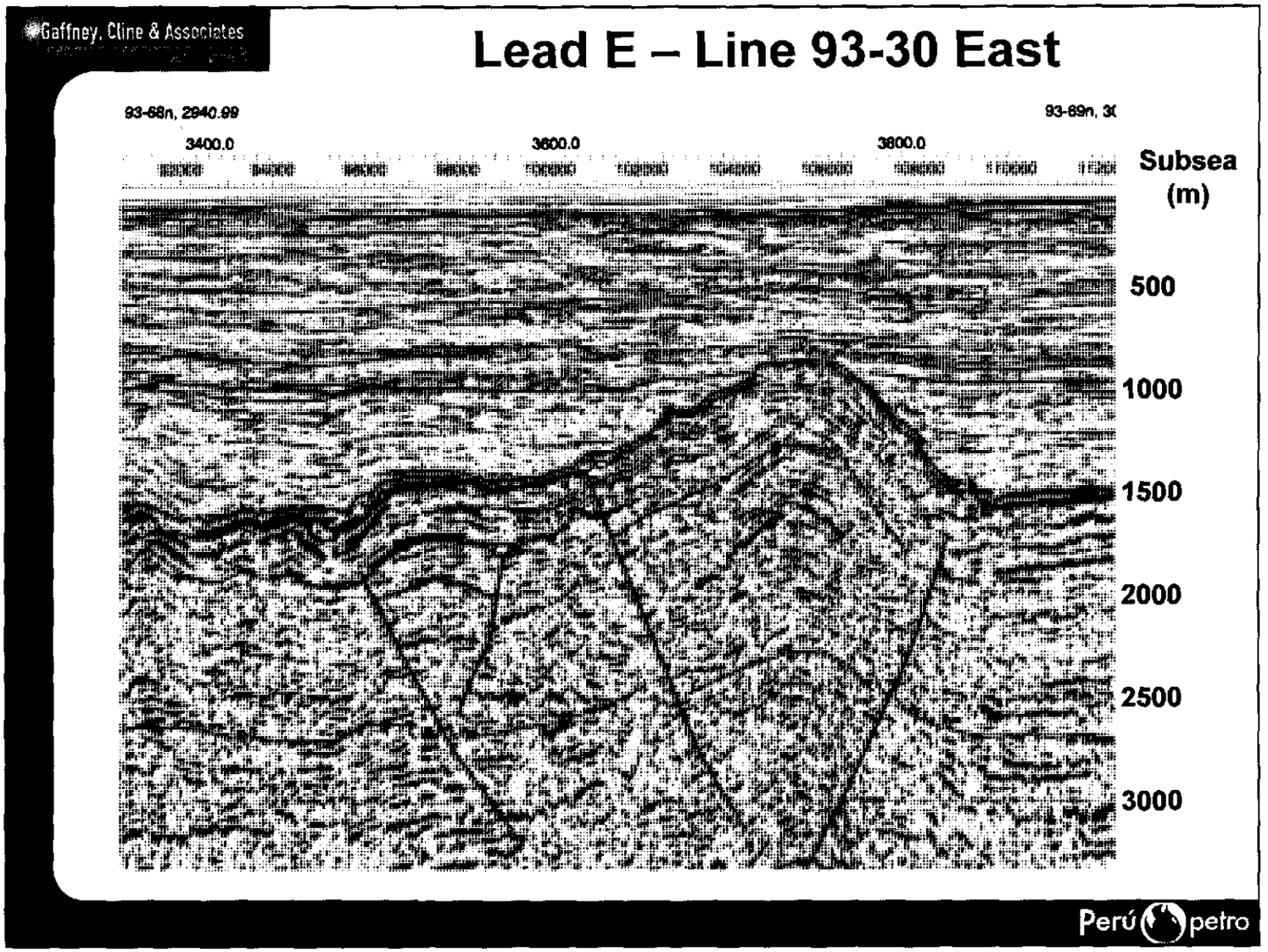
Lead B is very similar to Lead A.



Lead C appears to be another pop-up feature, which is adjacent to a significant high over which the Eocene section has been at least partially eroded. The strong reflectors on the flanks of this feature disappear over the crest. Some would argue that this is evidence for a volcanic intrusion here. This location would be another good place to resolve the carbonates vs. volcanics alternative interpretations.



Lead D is more of a faulted anticline, with clear smaller-scale faulting.



Lead E is the most impressive of these features. Petro-Tech Peruana has already shot new 2D seismic over this feature, and GCA understands that it may be drilled later this year (2005).

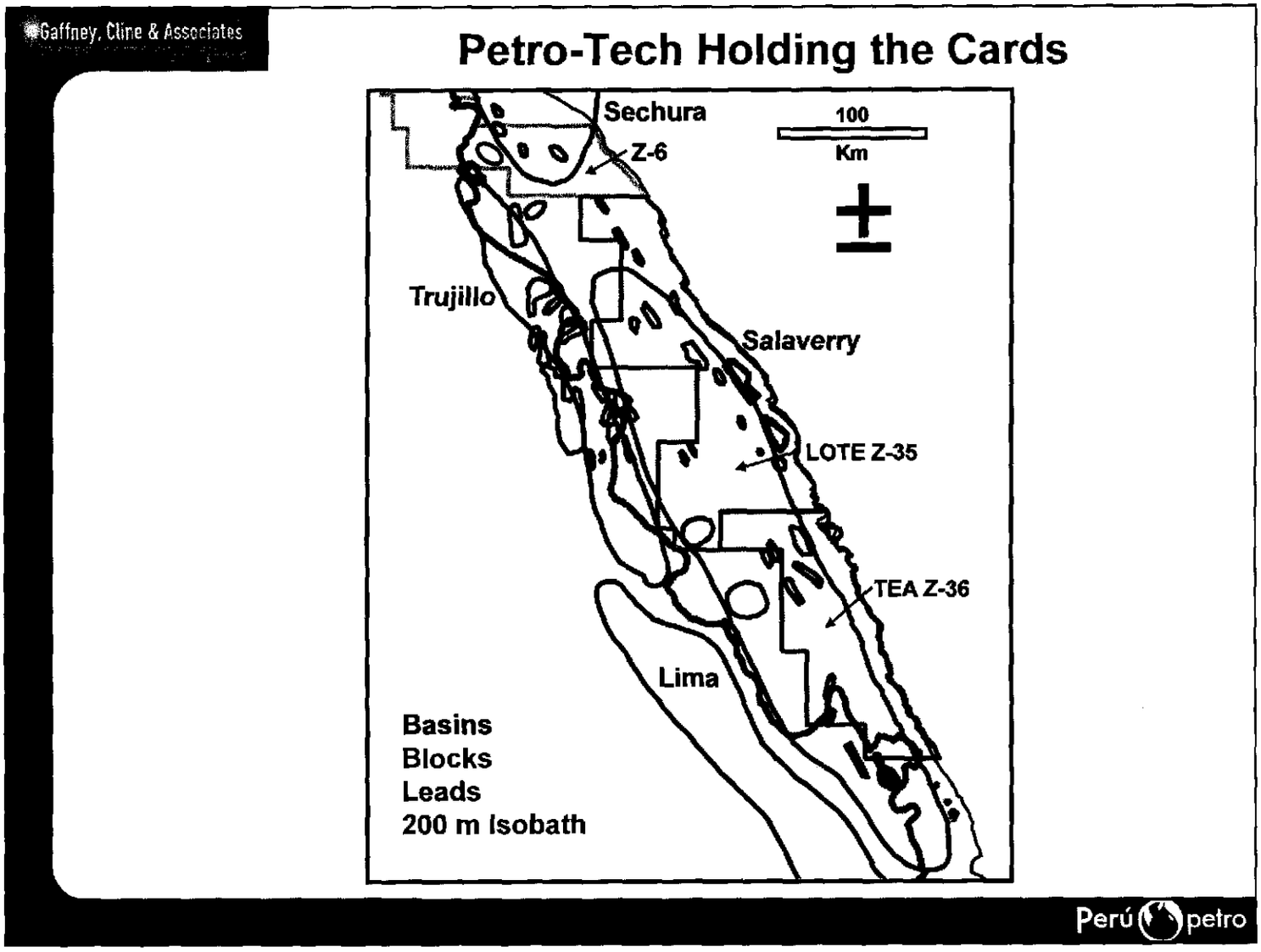
Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Sources
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

Petro-Tech Peruana has recently made aggressive moves to tie up much of the prospective acreage in both the Salaverry and offshore Sechura basins. The exploration plan for this area will depend largely on their schedule.



This map shows the dominant acreage position of Petro-Tech Peruana in the heart of the shallow-water fairway in these basins. Their 30-year license on Block Z-6 was signed in 2002. It requires seven years of exploration, and provides a royalty discount if a discovery is made within the first four years of exploration. Petro-Tech has advised that it plans to invest a total of $40 million on this offshore block. A contract on Block Z-35 and a Technical Evaluation Agreement (TEA) for Block Z-36 are awaiting government approval.

Gaffney, Cline & Associates

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Perú petro

Gaffney, Cline & Associates

10 x 10 km Lead Size

Volumetric Parameters

- Area: 100 km^2 = 24,710 acres
- Net Pay: 30 feet
- Porosity: 8%
- Oil Saturation: 60%
- Formation Volume Factor: 1.1 RB/STB

250 MM Barrels in Place

Perú petro

There are several leads identified that appear to be around 100 km^2 in size. If confirmed, prospects this size clearly offer attractive drilling opportunities for the industry.

Gaffney, Cline & Associates

30 x 30 km Lead Size

Volumetric Parameters

- Area: 900 km^2 = 222,390 acres
- Net Pay: 30 feet
- Porosity: 8%
- Oil Saturation: 60%
- Formation Volume Factor: 1.1 RB/STB

2.2 Billion Barrels in Place

Perú petro

The largest of the leads documented in this study range up to 30 x 30 km in area, which could easily reservoir in the order of 2 billion barrels of oil.

Gaffney, Cline & Associates

Three Scenarios Show Overall Favorable Economic Potential

(US$ million unless otherwise noted)	Low	Mid	High
Oil (millions of barrels)	50	250	500
Producing Wells	20	70	135
Gross Project Revenue	1,500	7,500	15,000
Royalty	95	966	2,465
CAPEX	155	635	1,233
OPEX	130	459	640
Net Cashflow Before Tax	1,120	5,440	10,662
Tax	329	1,605	3,133
Net Cashflow After Tax	791	3,835	7,529
NPV (Discount 10%)	203	901	1,674
IRR (%)	36	38	42

Perú petro

There is no doubt that the new chronostratigraphic framework produced in this study has documented a substantial amount of exploration potential in the Salaverry and offshore Sechura basins. However, there is considerable doubt about how much of that potential will be realized, and when. Therefore, the economic analysis was based on a simple three-scenario approach – a low case, a mid case and a high case. The range between the low case and the high case was chosen to roughly match the range of the hypothetical prospects in the previous two slides. The exploration and development costs were based on information in the public domain and advice from PERUPETRO. In general, because oil prices are high and costs are low in this shallow-water, close-to-shore environment, even the low case delivers a sizable rate of return.

Gaffney, Cline & Associates

Conclusions Revisited

- Possible mature source in thick along Salaverry basin axis and at south end of Sechura basin
- Charging from the west into the Salaverry basin also possible
- Possible Eocene (and Cretaceous) carbonate reservoirs/traps in both basins
- Large structures with giant potential, one of which Petro-Tech Peruana plans to drill on Block Z-6 in the offshore Sechura basin later this year
- Shallow water and shallow drilling over both basins
- Petro-Tech in process of contracting two blocks (Z-35 and Z-36 on the eastern flank of the Salaverry basin

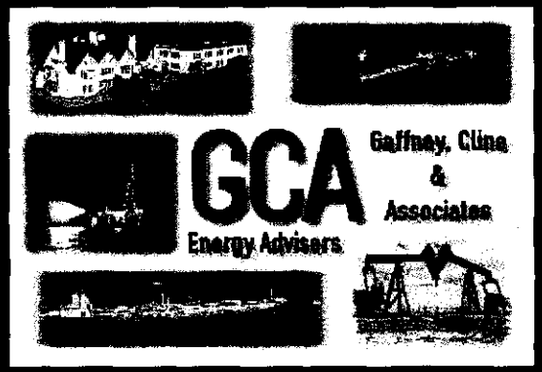
Perú petro

In summary, in a time of shrinking exploration opportunities, the Salaverry and offshore Sechura basins are potential "elephant country." They have good possibilities for mature source rocks, effective reservoirs and large potential traps. However, it should be noted that most of these assumptions have been built up from a regional seismic grid with no wells. There is still a lot of basic exploration work to do before any prospect can be matured and made ready to drill. 3D seismic will be particularly useful in defining drillable structures and estimating the nature of the fluids that fill them. Petro-Tech Peruana has already started an aggressive campaign of acreage acquisition over the Salaverry basin, and has already acquired new 2D seismic data over one lead in the offshore Sechura basin.

Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Salaverry Basin



Perú petro

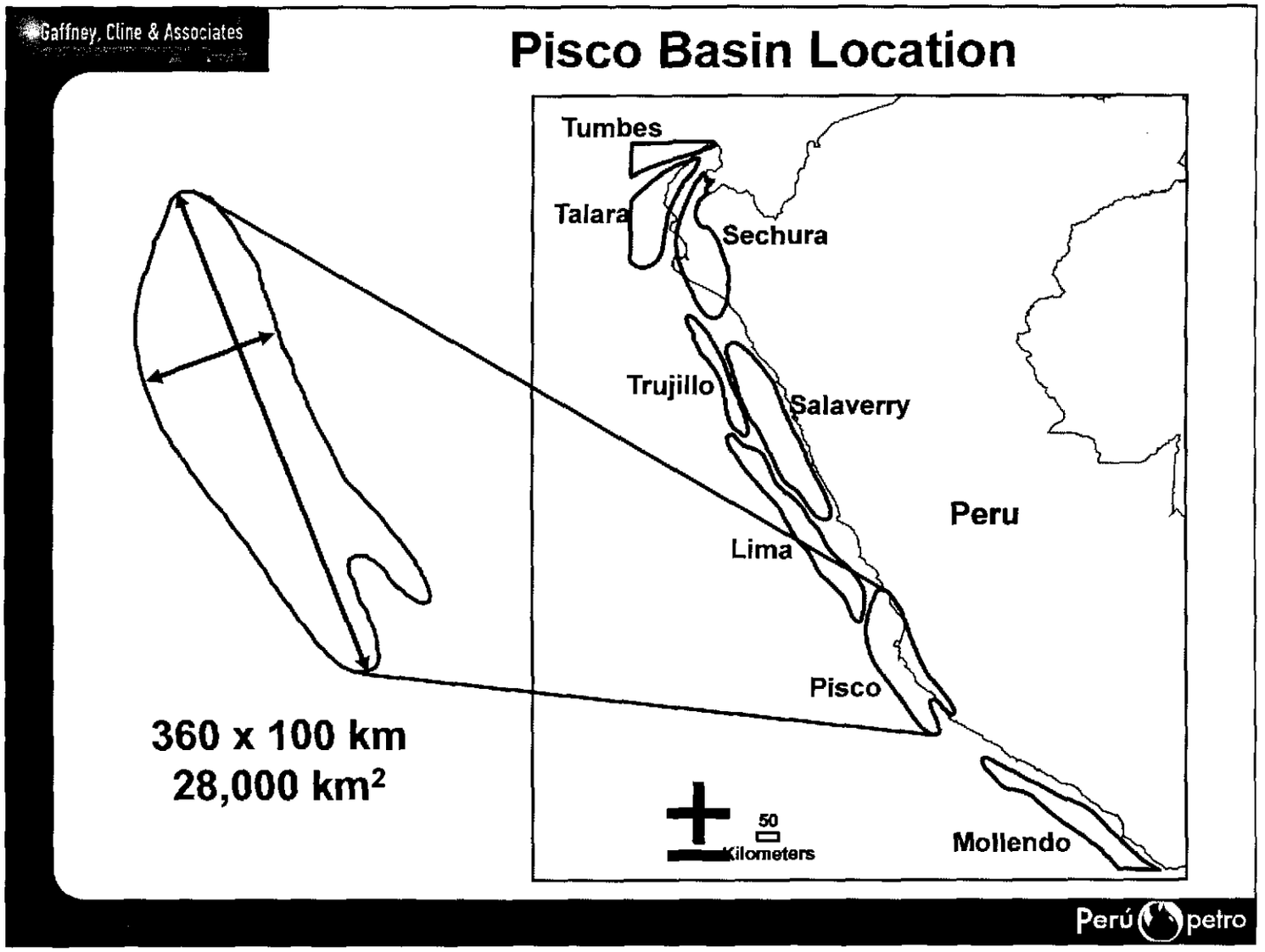
Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Pisco Basin

Perú petro

This Basin Presentation is part of the Final Report for a larger study entitled, "Sequence Stratigraphy Analysis of the Peruvian Offshore Continental Shelf-Slope." This study was funded by the USTDA, and was executed by Gaffney, Cline & Associates for PERUPETRO.



The Pisco basin is located south of the Lima basin, partially on the shallow-water Peruvian continental shelf and partially onshore.

Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Sources
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- Leads
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- Economics

Perú petro

This presentation begins with the conclusions and a quick review of the data, and is followed by discussion of possible hydrocarbon source rocks, reservoirs and leads (including expected water depths and drilling depths). It finishes with recommended exploration plans and several economic scenarios.

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Pisco Basin Conclusions

- Strong possibility of several Cretaceous source kitchens in the northern part of the basin
- Possible Eocene/Cretaceous carbonate reservoirs/traps – also deep-water sands in Cretaceous, Eocene and Miocene
- Wide variety of large-potential traps with attractive economics
- Shallow water and shallow drilling over half of the offshore part of the basin
- Petro-Tech Peruana secured block Z-33 and has committed to an initial $8 million exploration program
- Additional attractive exploration fairway remains, south of the National Reserve of Paracas

Perú petro

GCA's evaluation of the Pisco basin potential includes identification of the strong possibility of a viable Cretaceous source, several new possibilities for good-quality reservoirs, and a wide variety of new leads with large potential and attractive economics, owing to shallow water and shallow drilling depths. In September 2004, Petro-Tech secured the Z-33 block, which covers the heart of the Pisco exploration fairway. They plan an initial $8 million exploration campaign, with seismic acquisition commencing very soon. Petro-Tech's parent company owns a seismic boat that is in Peruvian waters, which will greatly facilitate Petro-Tech's progress in exploring this and other offshore blocks in the Talara, Sechura and Salaverry basins. Additional shallow-water fairway remains, with substantial leads identified south of the National Reserve of Paracas that may attract other operators into this basin.

Gaffney, Cline & Associates

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Perú petro

PERUPETRO furnished unlimited access to their data archives. The gross volume of data available for this study was therefore extremely large, requiring considerable effort in organizing and distilling it into a useable project database.

Gaffney, Cline & Associates

The Project Database

- **Final Report (paper)**
  - **Executive Summary**
  - **Basin Presentations**
  - **Other Required Sections**
    - Economics, Regulatory, Environmental and others
  - **Enclosures**
    - Selected maps, logs and cross sections
- **Digital Database (DVDs)**
  - **Final Report**
  - **ArcView Interactive Map**
  - **3 SMT Kingdom Suite Projects**
  - **Standard-format Exports**
  - **Detailed Appendices**
    - Geology, Wells, Seismic Interpretation, Tectonics, Depth Conversion, Maturation, Environmental

Perú petro

The project database for the Pisco basin exists in several forms. First, there is an SMT Kingdom Suite project that covers the Trujillo, Salaverry, offshore Sechura and Pisco basins. This integrated project is available as part of the Digital Database that is packaged on DVDs with this report. The contents of this project were also exported into SEG-Y, LAS and other standard formats for loading into other workstation software. The Digital Database also contains an ArcView Interactive Map that was used to produce the map-based graphics in this presentation. It contains surface location data for wells and seismic, gravity and magnetics, geo-registered images of all of the maps produced in this study and a wide variety of other useful map-based data. Selected maps and cross sections are included in the Enclosures. Lastly, the Final Report contains several Appendices that contain discipline-specific detailed discussions as listed above.

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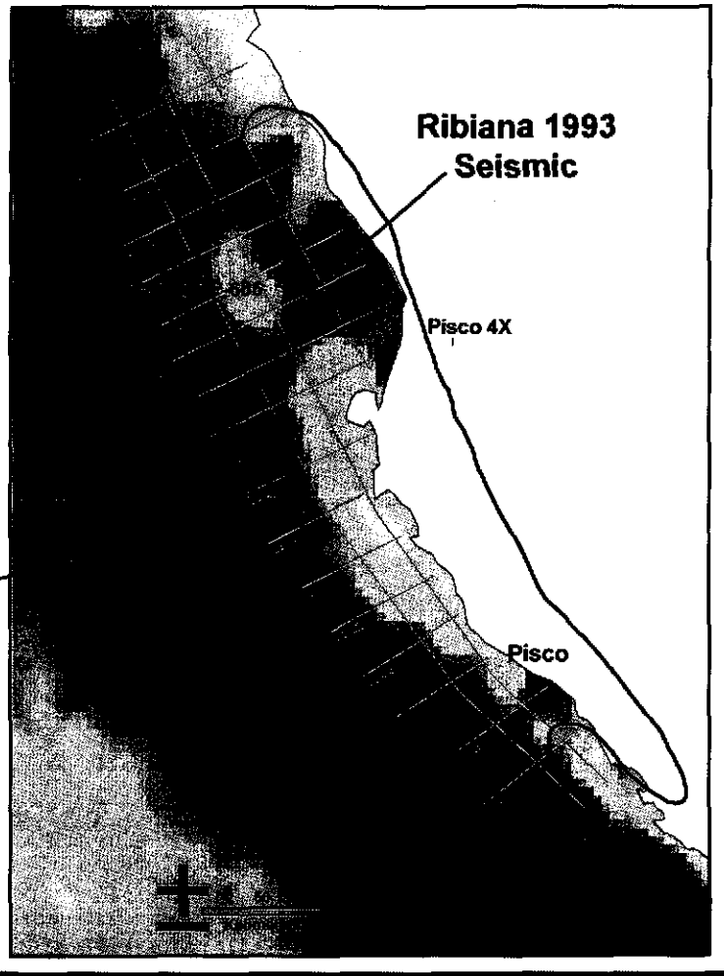
Pisco Data – Gravity, 1993 Seismic, 1 Well



Perú petro

The Ribiana 1993 seismic grid, combined with regional gravity and magnetics data, formed the main basis for the new structural and stratigraphic framework in the Pisco basin. The entire Ribiana 1993 survey was depth converted – both the horizons and the SEG-Y traces. The only wells in the basin are the onshore Pisco 4X well and the two ODP shallow well locations at the north end of the basin (in red), which yielded very little useful information, aside from heat flow data for the maturation modeling work.

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PISCO-4X History

- Only exploration well drilled in Pisco Basin
- Drilled by International Petroleum Company (IPC)
- Status: P&A October 1955
- Drilled on onshore seismic prospect, supported by gravity and magnetics – no surface expression of structure
- Pre-drill target: Eocene and possible Oligocene and Miocene sandstones

Drill Results

- 425 m of Pliocene diatomaceous and tuffaceous shales
- 359 m of Miocene diatomaceous and tuffaceous shales
  - poor source potential
- 67 m of Miocene shallow marine sands
  - fair to good reservoir quality
  - good permeability on test, but recovered fresh water only
- 65 m of Cretaceous(?) conglomerates and hydrothermally-altered quartzites and shales

Perú petro

The highlight of the Pisco-4X well was a test of a 67 m thick interval of fair-to-good reservoir quality Miocene sand that showed good permeability on test, but produced only water.

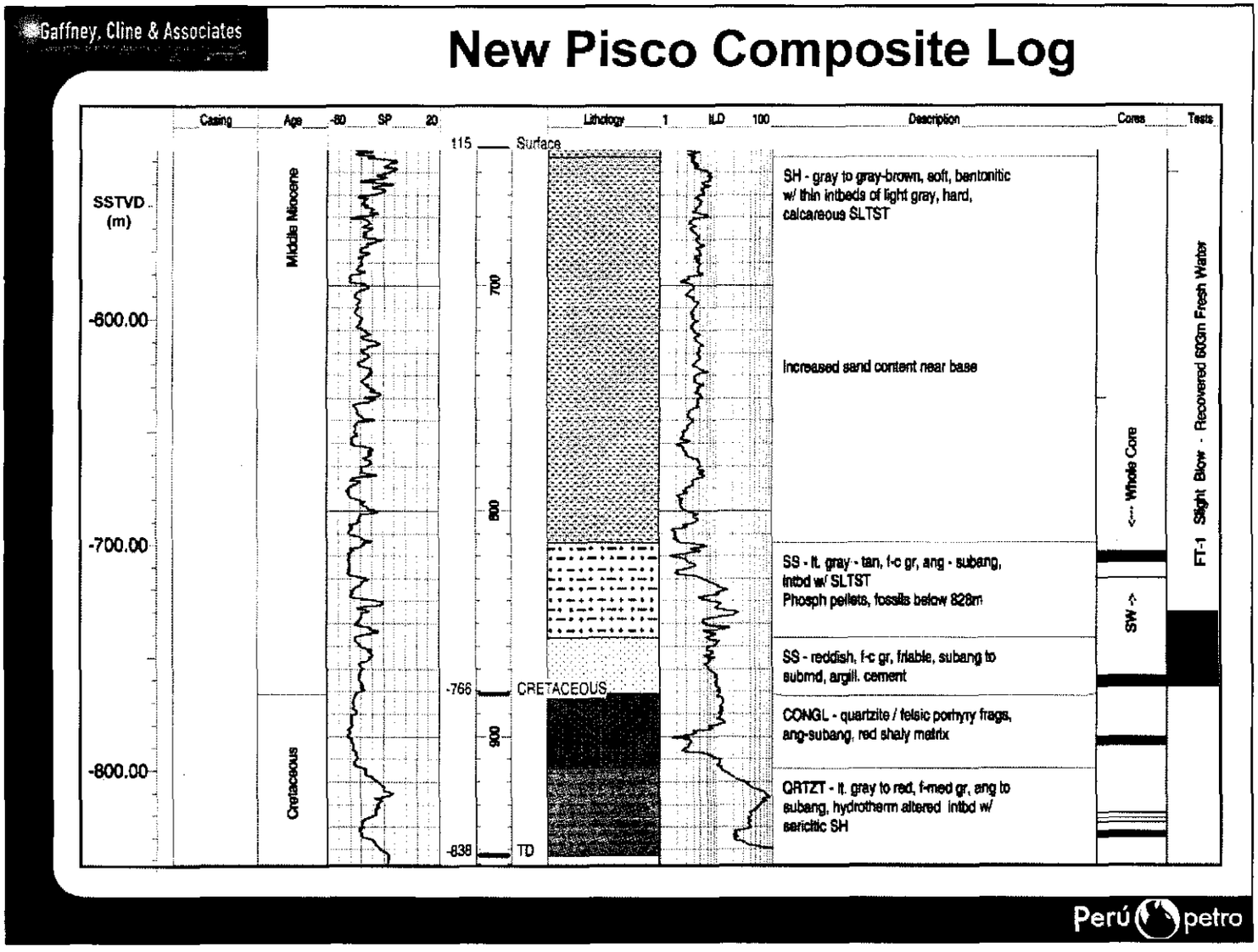
Gaffney, Cline & Associates

PISCO-4X Conclusions

- No indication of hydrocarbons in the well
- Eocene – Oligocene not recognized in well, but Eocene to early Oligocene outcrops are present in basin
- Good quality Miocene reservoirs were flow tested in well (good permeability, but water-bearing)
- Source potential is problematic at well location - better indications in outcrop
- Cretaceous identified in well
  - based on lithology change – not paleontology
  - not corroborated by surface geology
  - potential Cretaceous thickness (if any) unknown in basin
- Onshore portion of Pisco basin considered non-prospective, and thick mature sediments not likely

Perú petro

Based upon this well and other studies of the onshore, IPC concluded that the onshore part of the Pisco Basin was not prospective. Hunt recently completed a technical evaluation of the onshore Pisco basin with similar conclusions.



Details about this well were difficult to assemble during the course of this study. To help future workers avoid replicating this effort, a new composite log was constructed. This slide shows only the lowermost section of the new log, where the Miocene sand is described. The full composite log is available on paper as Enclosure 5, and digitally on the Digital Database DVDs.

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Outline

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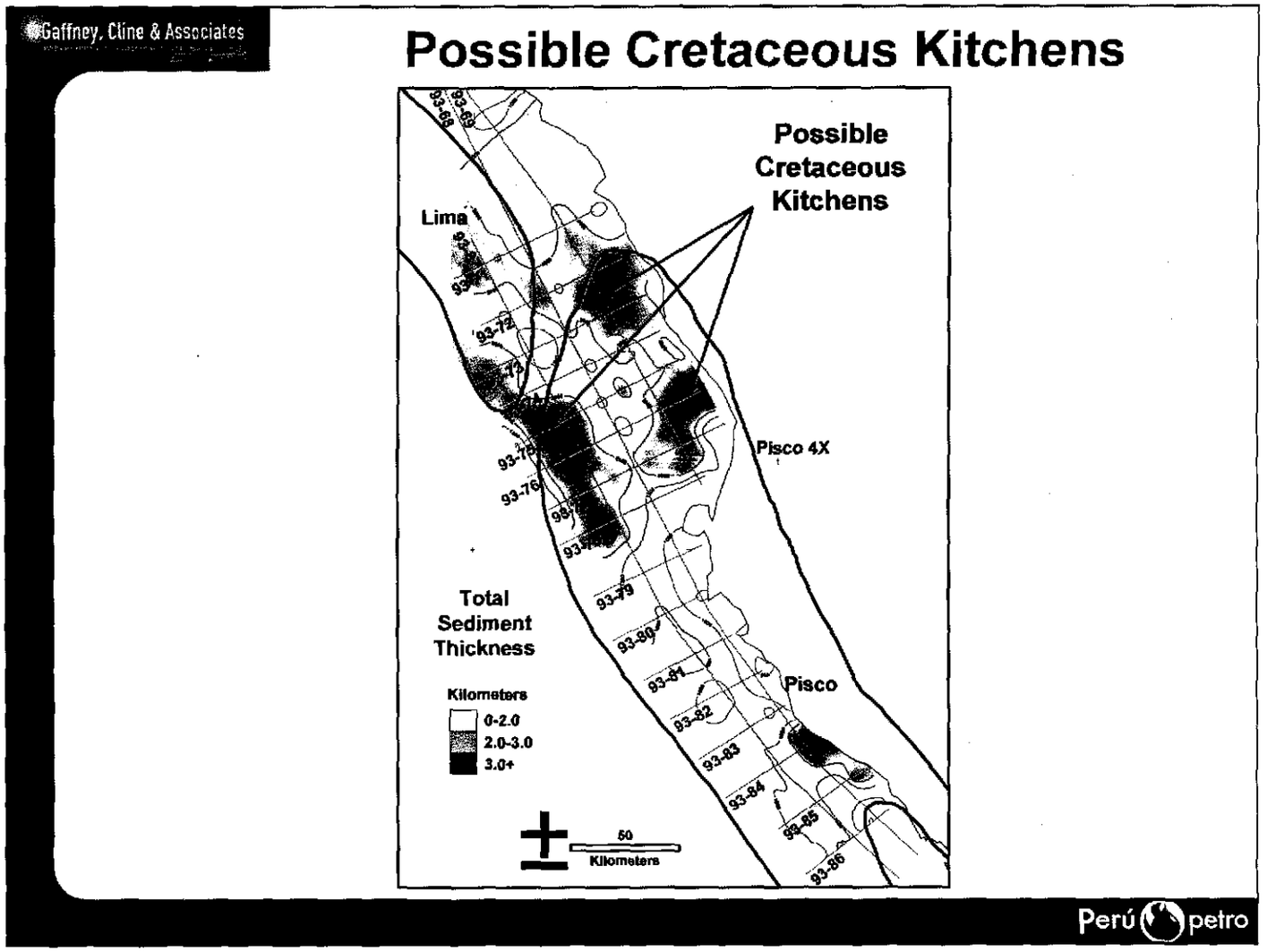
Perú petro

With no wells offshore, no seeps and no evidence of hydrocarbons in the onshore Pisco-4X well, there is no direct evidence of an effective source rock in the offshore Pisco basin. However, maturation modeling showed encouraging results.



One of the main results of this study was to recognize and map Cretaceous sediments in most of the offshore basins. Extending this Cretaceous interpretation into the Pisco basin was tenuous, considering that there are only two long strike lines (93-68 and 93-69) in the Ribiana 1993 seismic survey that connect the Pisco basin into the new framework in the Trujillo and Salaverry basins to the north. Including this newly interpreted Cretaceous section, the resulting Total Sediment Thickness map shows maximum thickness up to 4,000 meters, which is sufficient to bring the Cretaceous to maturity, as is illustrated in the following slides.

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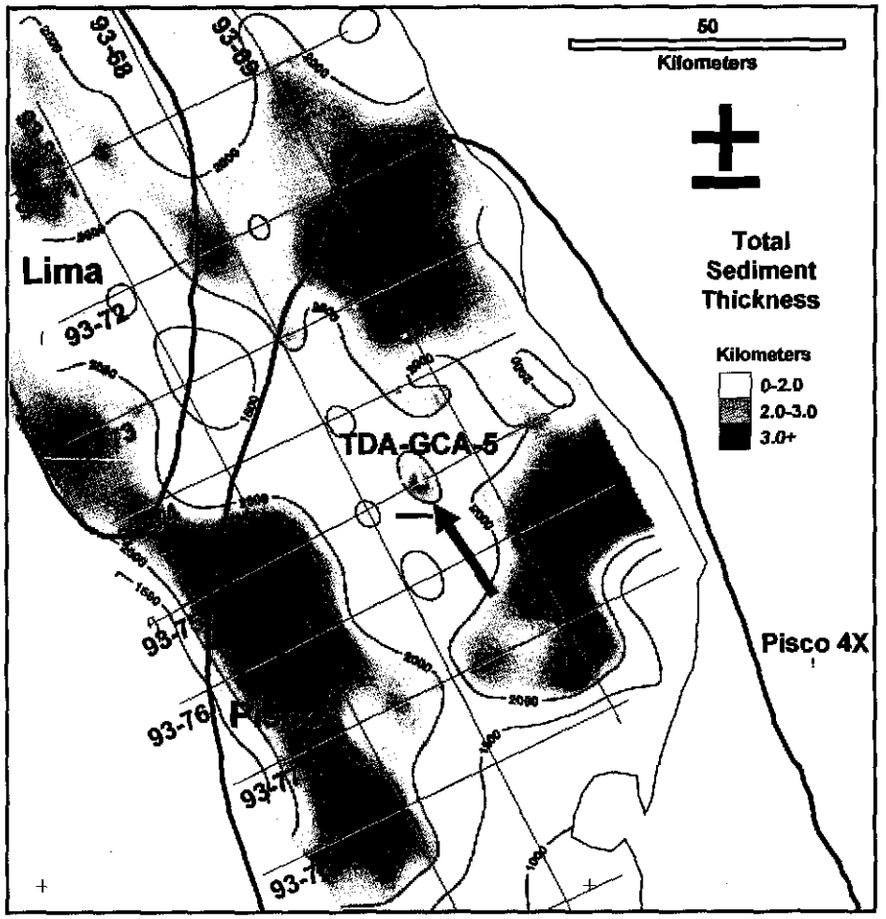
Maturation Modeling on Line 93-75



Perú petro

This is the location on line 93-75 that was chosen for maturation modeling. The total sediment thickness at this location is approximately 2,750 meters. Maturation modeling in the thicker intervals to the west, north and east would produce an even more encouraging maturation, expulsion and migration picture.

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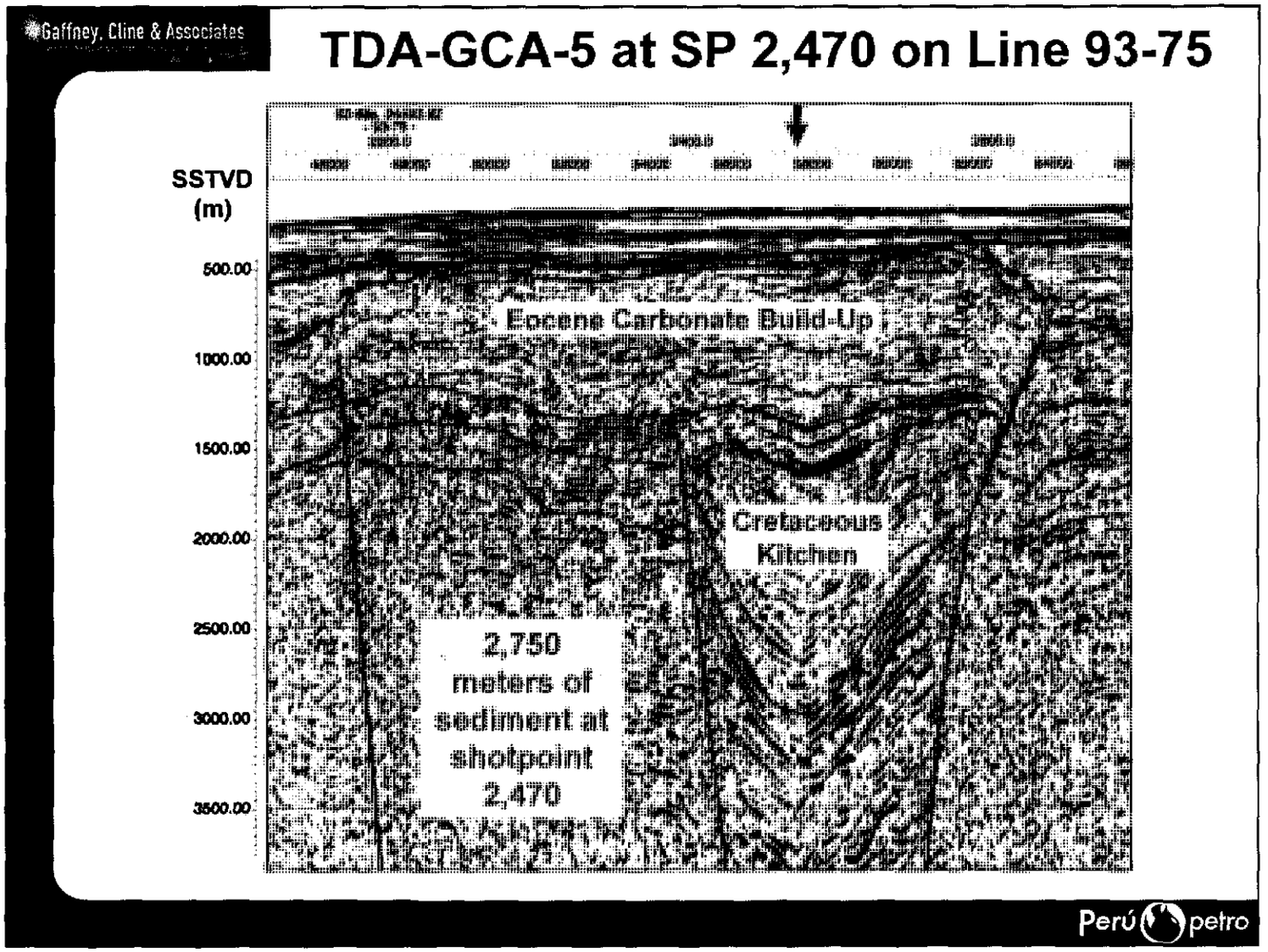
Seismic Horizon Legend

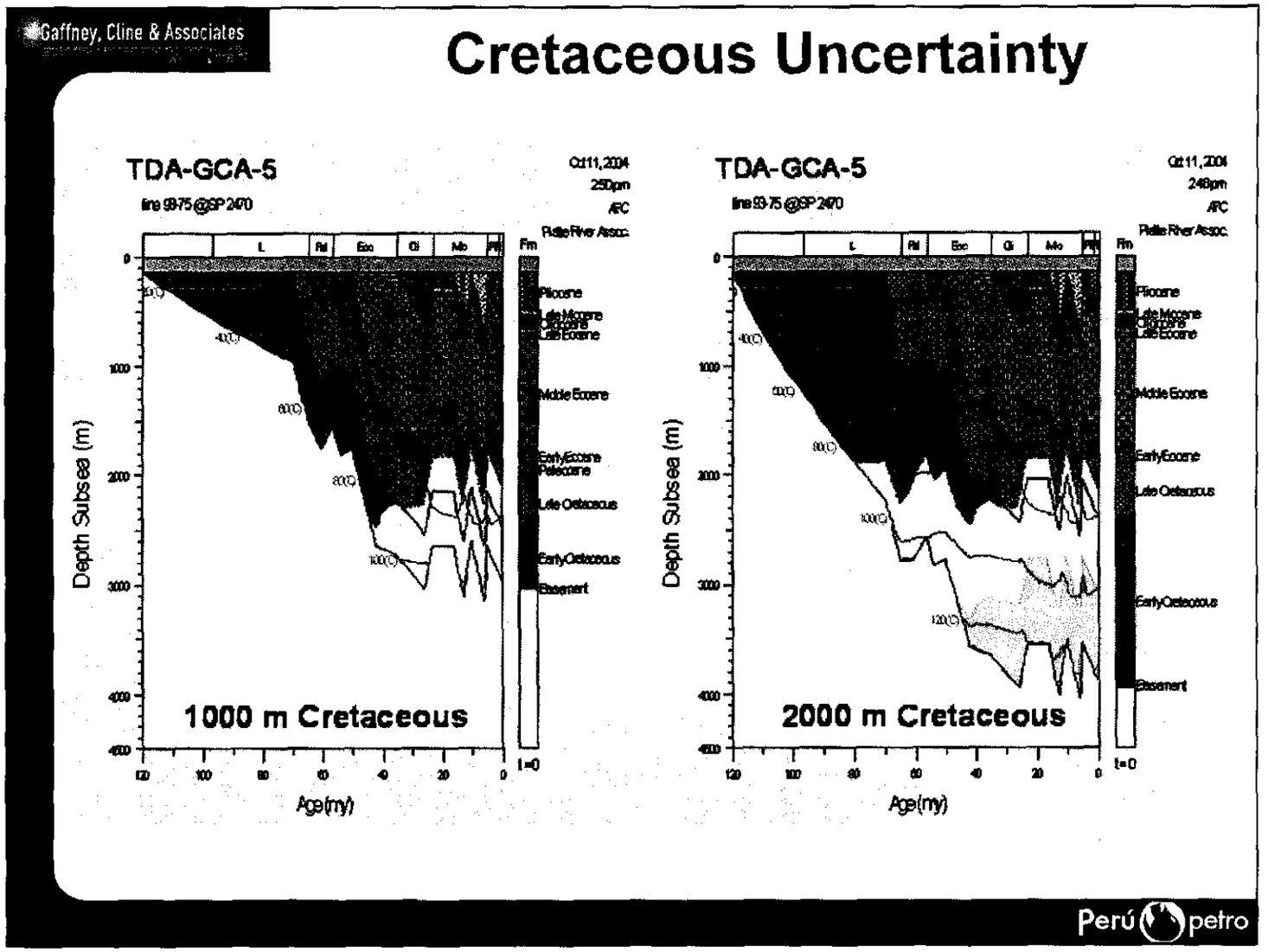
- 1_ts_a_1_Quaternary (pae)
- 1_ts_b_2_Pliocene (pae)
- 1_ts_c_3_Late_Miocene (pae)
- 1_ts_c_3_Late_Miocene_overthrust (pae)
- 1_ts_d_4_Middle_Miocene (pae)
- 1_ts_d_4_Middle_Miocene_overthrust (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_a (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_b (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_c (pae)
- 1_ts_e_5_undif_channel_cut_&_fill_Miocene_d (pae)
- 1_ts_f_6_incised_channels_intra-mid_Miocene (pae)
- 1_ts_g_7_Early_Miocene (pae)
- 1_ts_h_8_small_channels_Early_Miocene (pae)
- 1_ts_i_9_Latest_Eocene_Oligocene (pae)
- 1_ts_j_9-13_mrg_Eoc_Oligo-Mid_Eoc_carb (pae)
- 1_ts_j_9-13_mrg_Eoc_Oligo-Mid_Eoc_carb_new (pae)
- 1_ts_j_10_Middle_Eocene (pae)
- 1_ts_k_11_Middle_Eocene_carbonates? (pae)
- 1_ts_k_11_Middle_Eocene_carbonates?_overthrust (pae)
- 1_ts_l_12_Early_Eocene_carbonates? (pae)
- 1_ts_l_12_Early_Eocene_carbonates?_overthrust (pae)
- 1_ts_m_13_Paleocene_Base_Eoc (pae)
- 1_ts_m_13_Paleocene_Base_Eoc_overthrust (pae)
- 1_ts_n_14_Cretaceous (pae)
- 1_ts_n_14_Cretaceous_overthrust (pae)
- 1_ts_o_15_Intra-Cretaceous_Muerto? (pae)
- 1_ts_p_16_Paleozoic_meta (pae)
- 1_ts_p_16_Paleozoic_meta_overthrust (pae)
- 1_ts_q_17_Precambrian_Crystalline_Bsmt (pae)

Perú petro

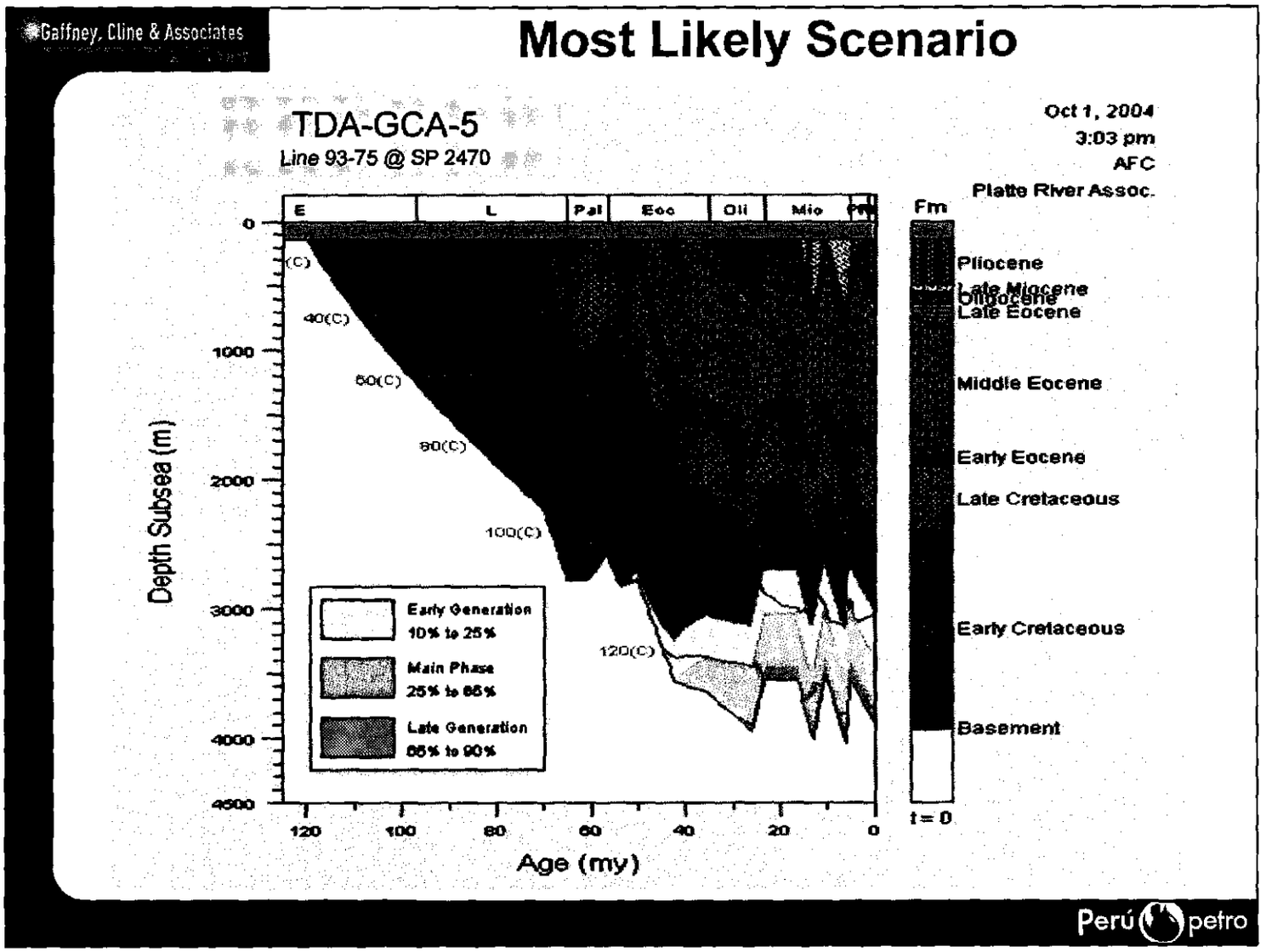
Use this legend to interpret the age of the interpreted horizons in the seismic lines that follow in this presentation. Overall, dark blue marks Paleozoic metamorphic basement, dark green is top Cretaceous, and red is top Paleocene. The Eocene is broken into several intervals as shown. The Oligocene (orange) has been largely eroded throughout the area. The Miocene is complicated by several episodes of channel cut and fill, which is represented by several horizons in the regional interpretation. Finally, the section is capped off by Pliocene and Quaternary sediments.



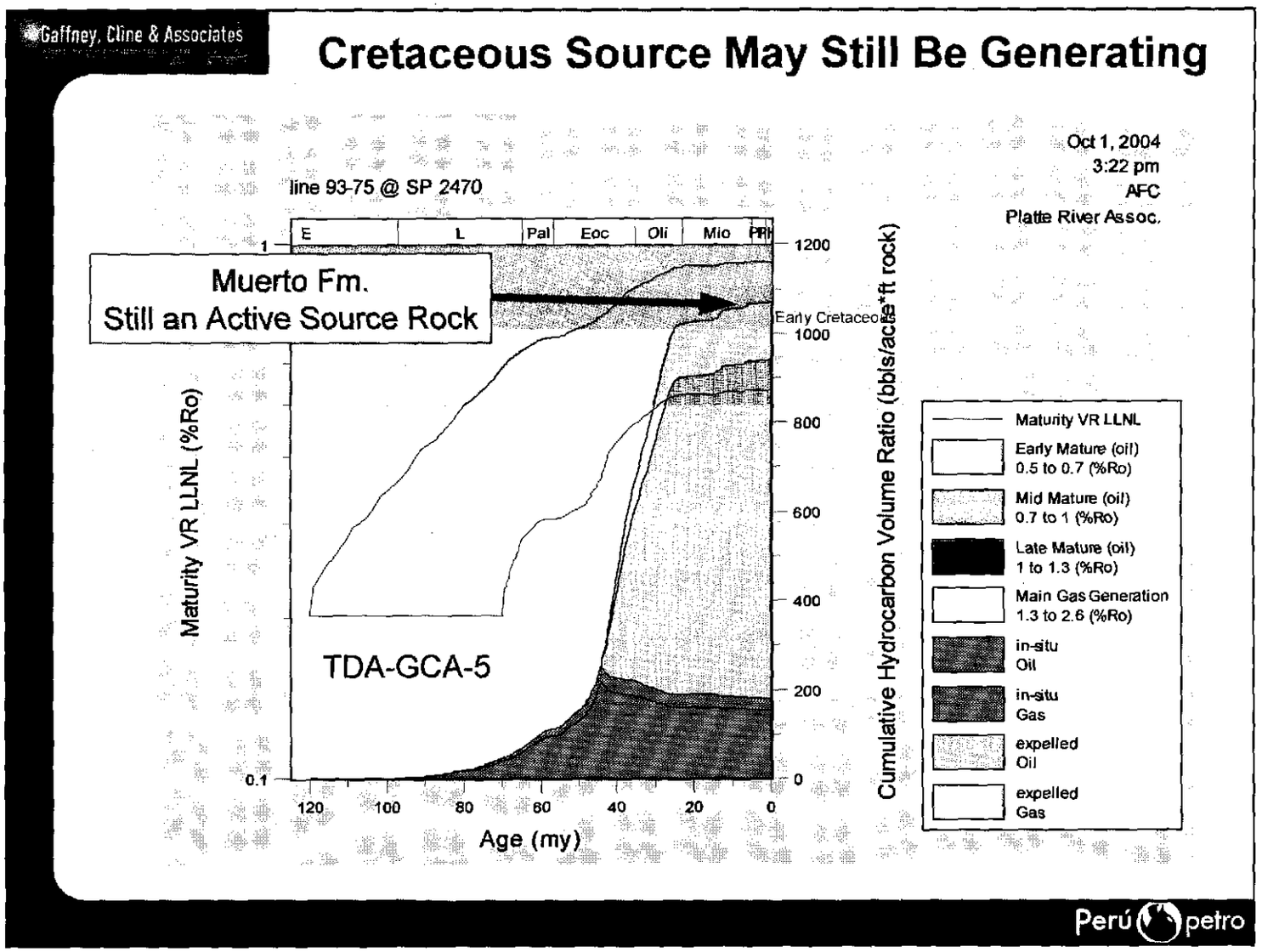
Here is the seismic section that illustrates the location along line 93-75 where the maturation model was done in the Pisco basin. Notice that this possible Cretaceous kitchen lies directly below a potential Eocene carbonate build-up that might serve as a very large reservoir and stratigraphic/structural trap.



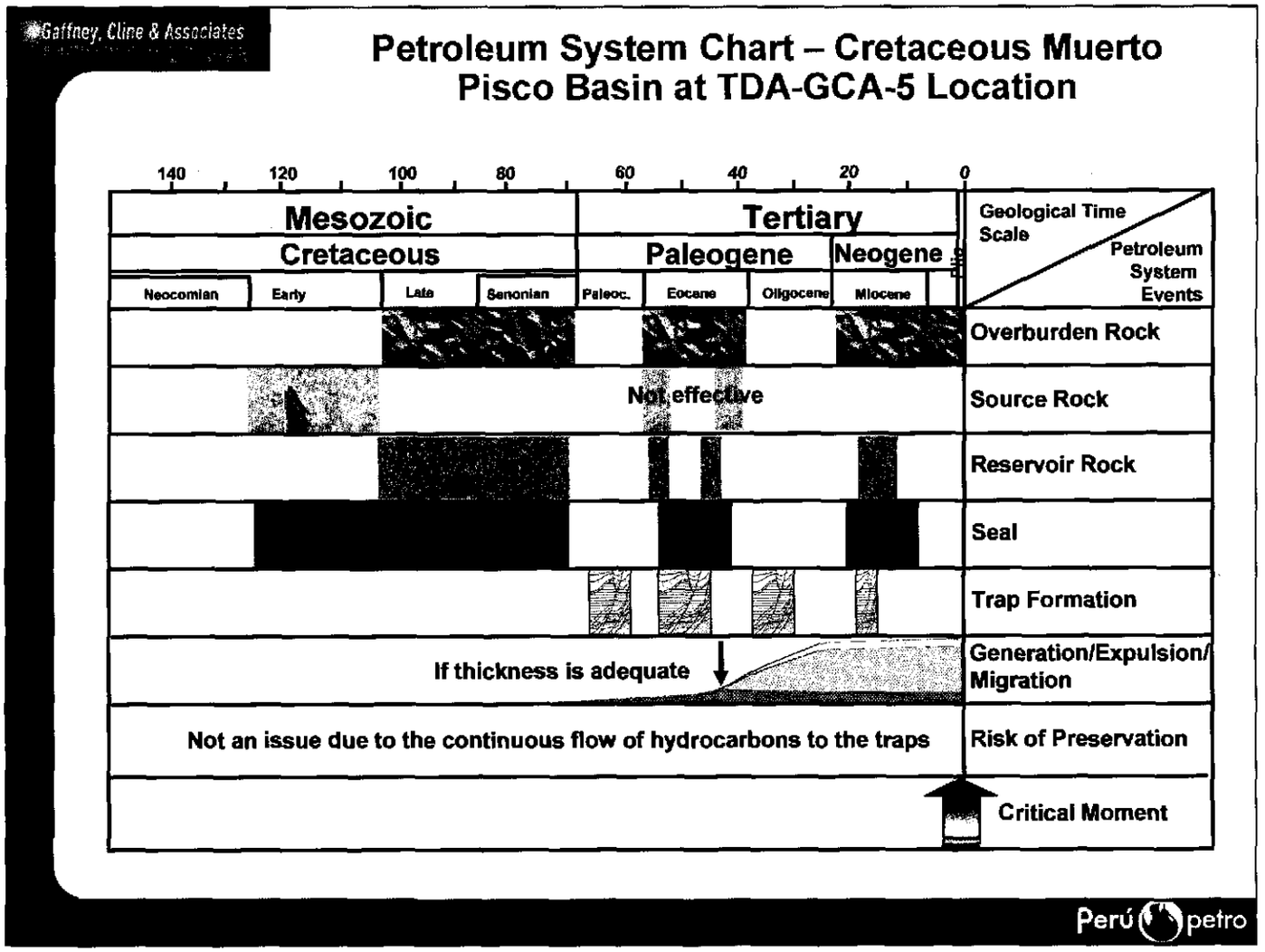
A top Cretaceous horizon was extended from the Salaverry basin to the Pisco basin through just two long strike lines (93-68 and 93-69). Therefore, the actual presence of Cretaceous source rock is uncertain. With this important uncertainty in mind, the depth converted line 93-75 shows slightly less than 1,500 meters of Cretaceous at location TDA-GCA-5. The two maturation profiles above show how the maturation picture changes if this thickness were increased or decreased by 500 meters. However, even at 1,000 meters thick, the Cretaceous source enters the oil window in Eocene time. If it were 2,000 meters thick, it would have entered the oil window in Late Cretaceous time.



In this "most likely" scenario, a potential source rock in the Early Cretaceous (Muerto formation equivalent) may be in the generative stage, but any potential Eocene source rock probably did not attain thermal maturation for oil generation. However, this location is surrounded by several thicker and deeper depocenters which might have cooked Eocene source rocks at those locations more thoroughly than here.



As this profile shows, the early Cretaceous Muerto formation may still be generating and expelling hydrocarbons today.



Little is known about the stratigraphy of the Pisco basin. Strong deformation segments the basin and inversion probably destroyed some early traps. Inferred Eocene source rocks are likely immature. Inferred Cretaceous source rocks may have matured prior to the formation of traps in the Oligocene and Miocene. The blue arrow on the generation event line represents the beginning of hydrocarbon expulsion and migration to the available traps. Traps formed at Oligocene and Miocene times have a higher risk of not receiving hydrocarbons, due to a timing issue between the beginning of the expulsion of the hydrocarbons around 40 million years ago and the creation of the traps after the beginning of the expulsion. Nevertheless, these later traps may have been sufficiently charged by expulsion that may have continued to the present.

Gaffney, Cline & Associates

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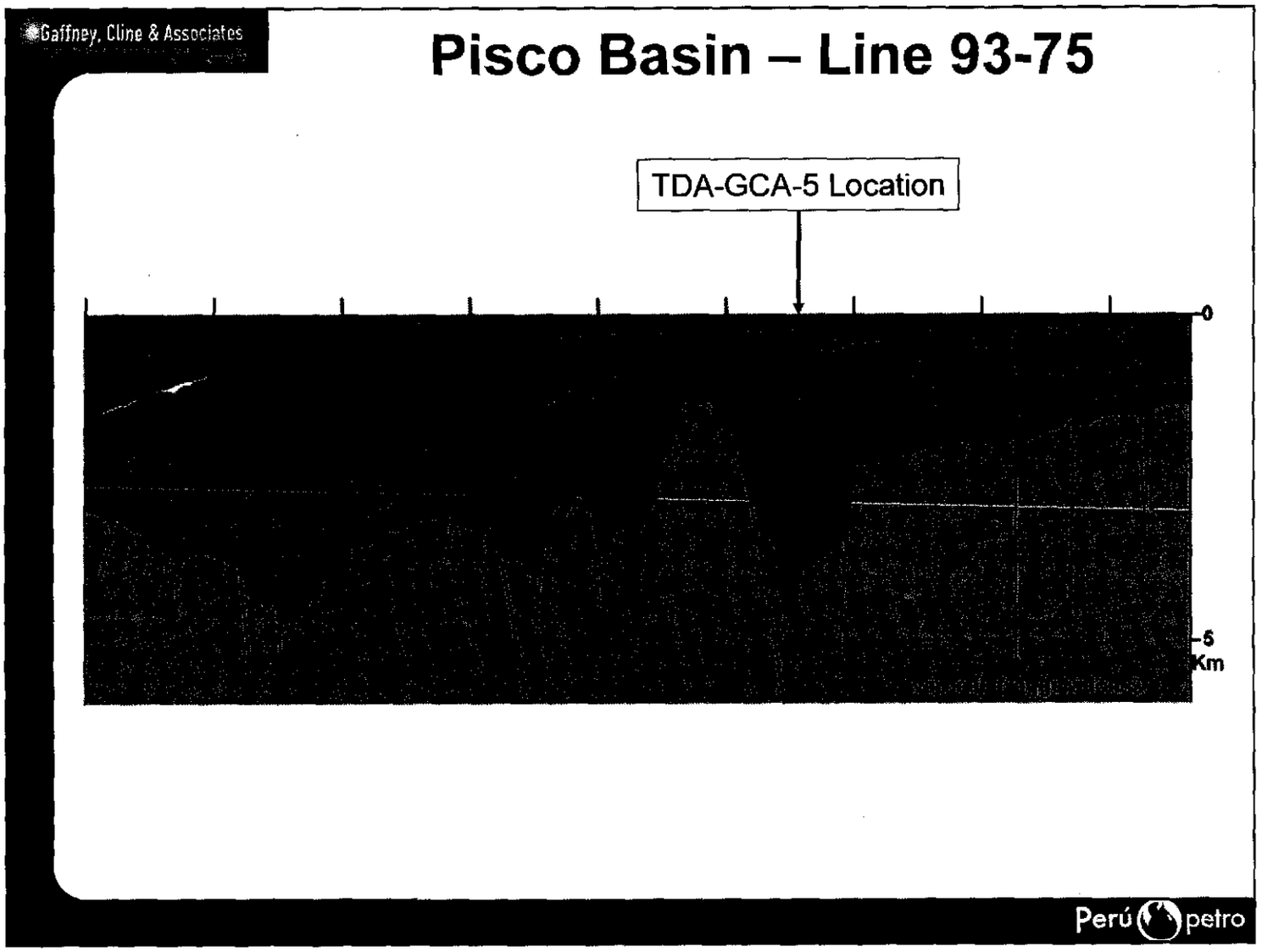
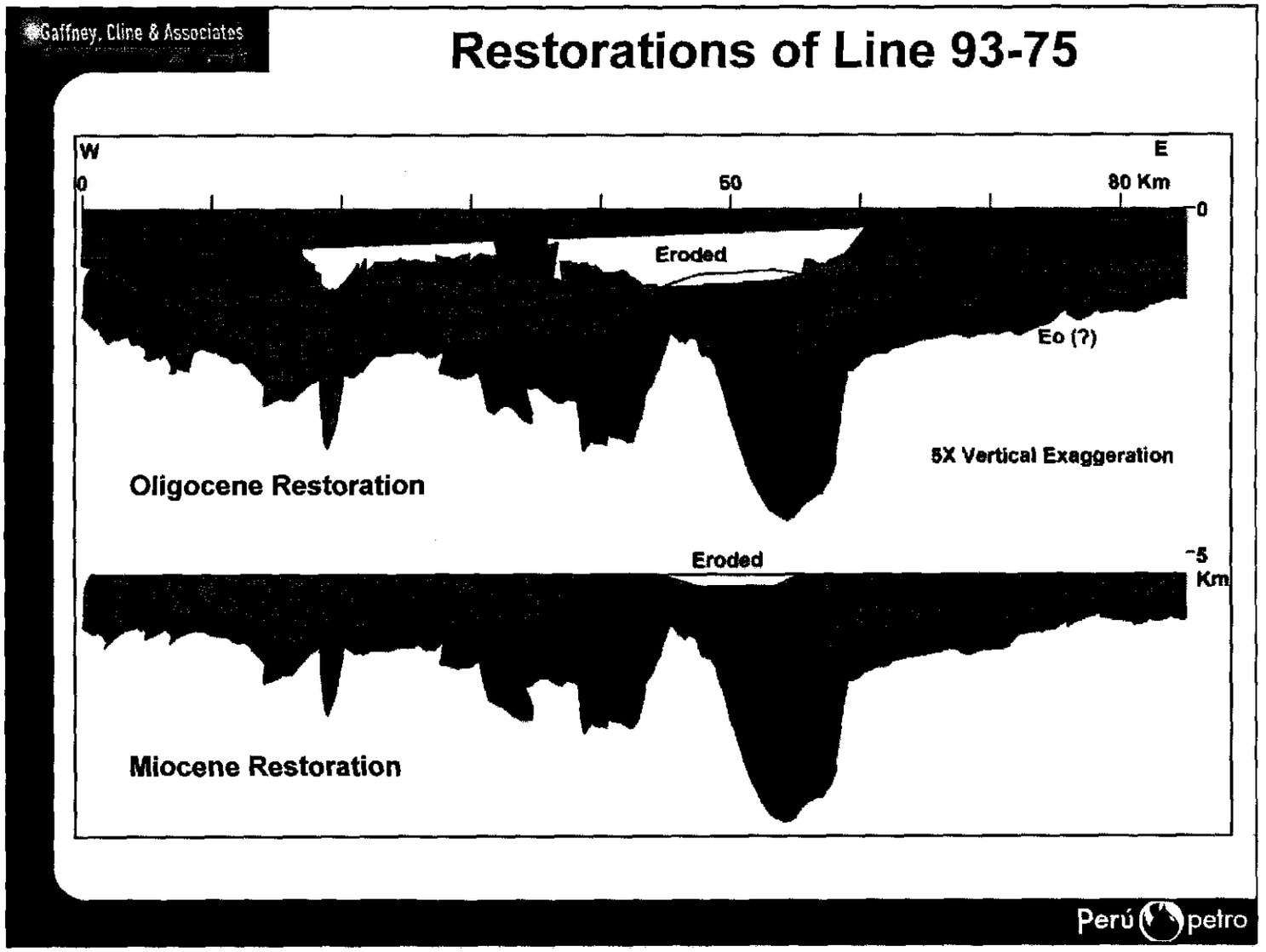
Perú petro

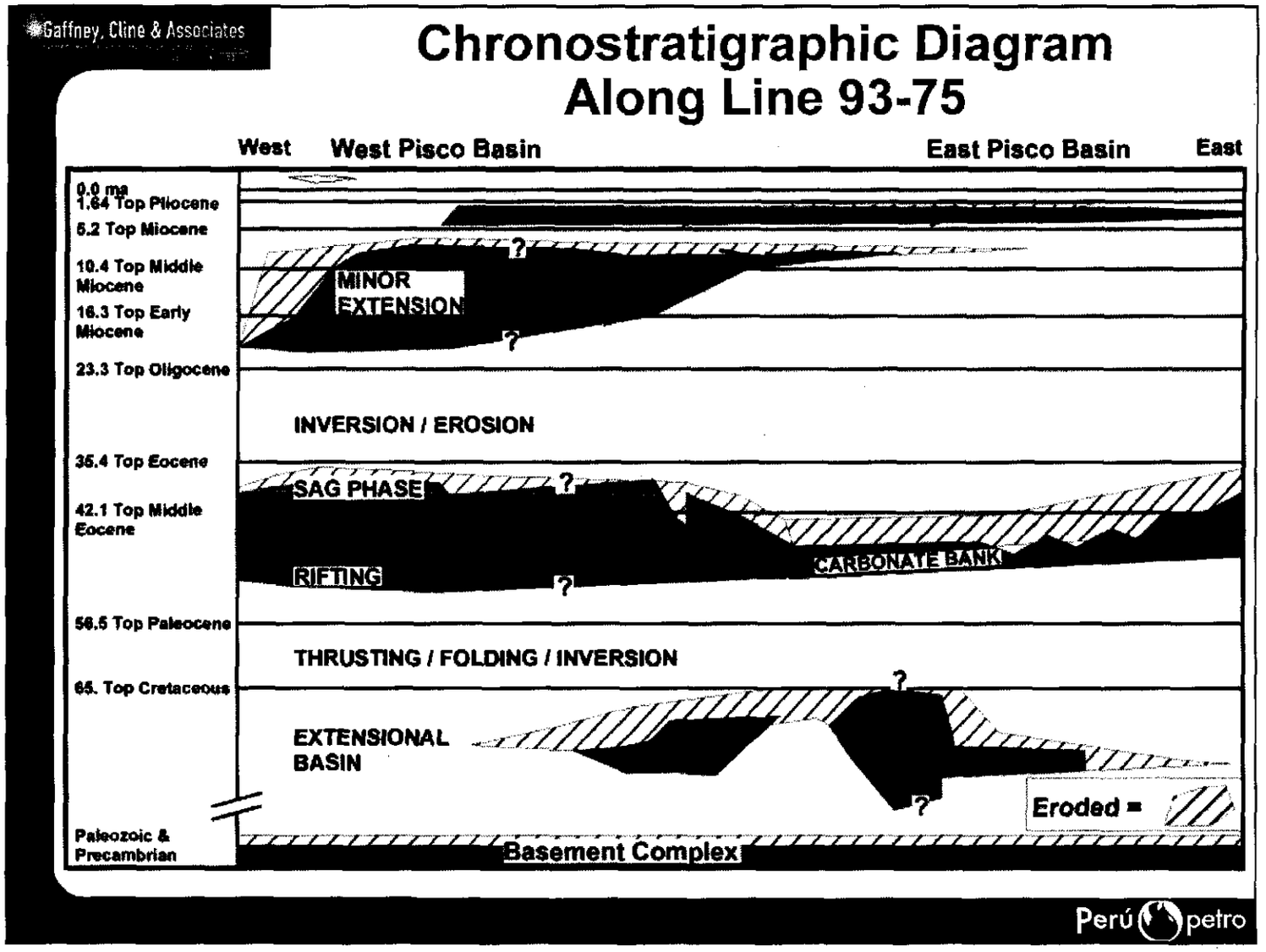
This study suggests the strong possibility of carbonate build-ups in the Eocene and Cretaceous that previously have been interpreted as volcanic intrusions and extrusions. Drilling is the only conclusive way to confirm which interpretation is correct.



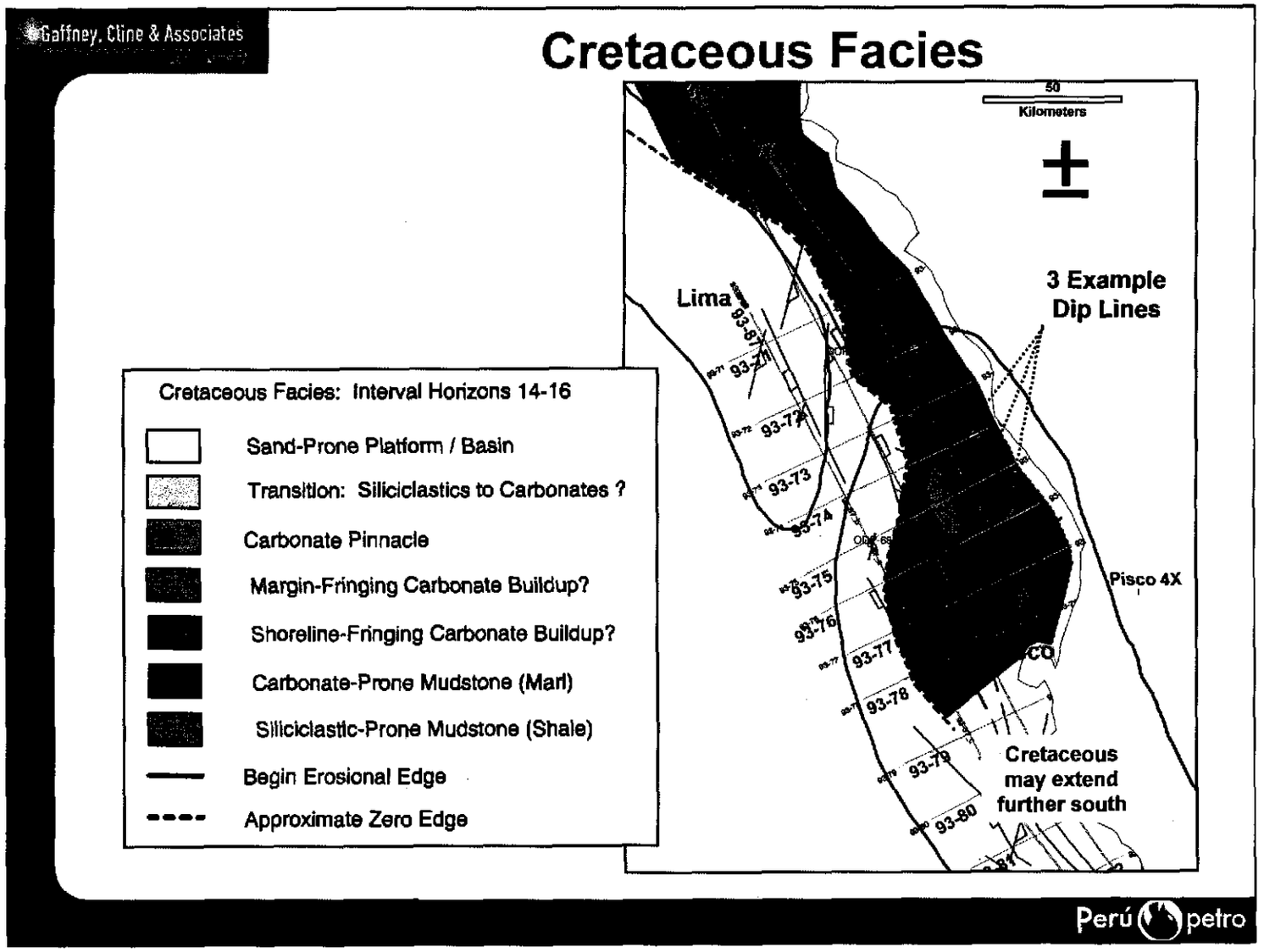
As an essential early step in building the new framework was preparing several balanced and restored sections at key locations. Line 93-75 was selected for this purpose in the Pisco basin. Note the location of the maturation model.



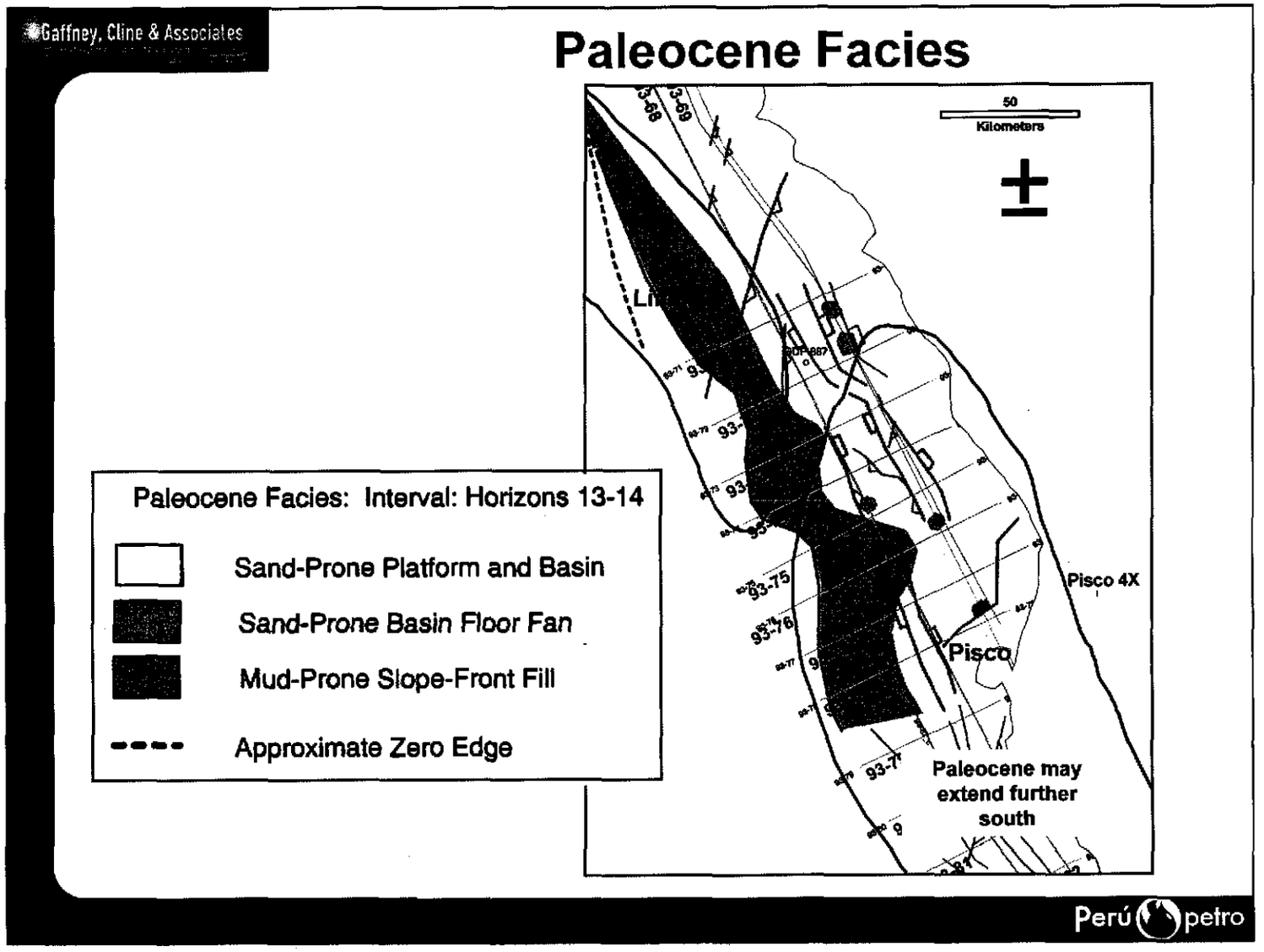
Here are the Oligocene and Miocene restorations of line 93-75. Notice the significant thickness eroded during the Oligocene over the Cretaceous kitchen. This estimate of eroded section helped calibrate the maturation model.



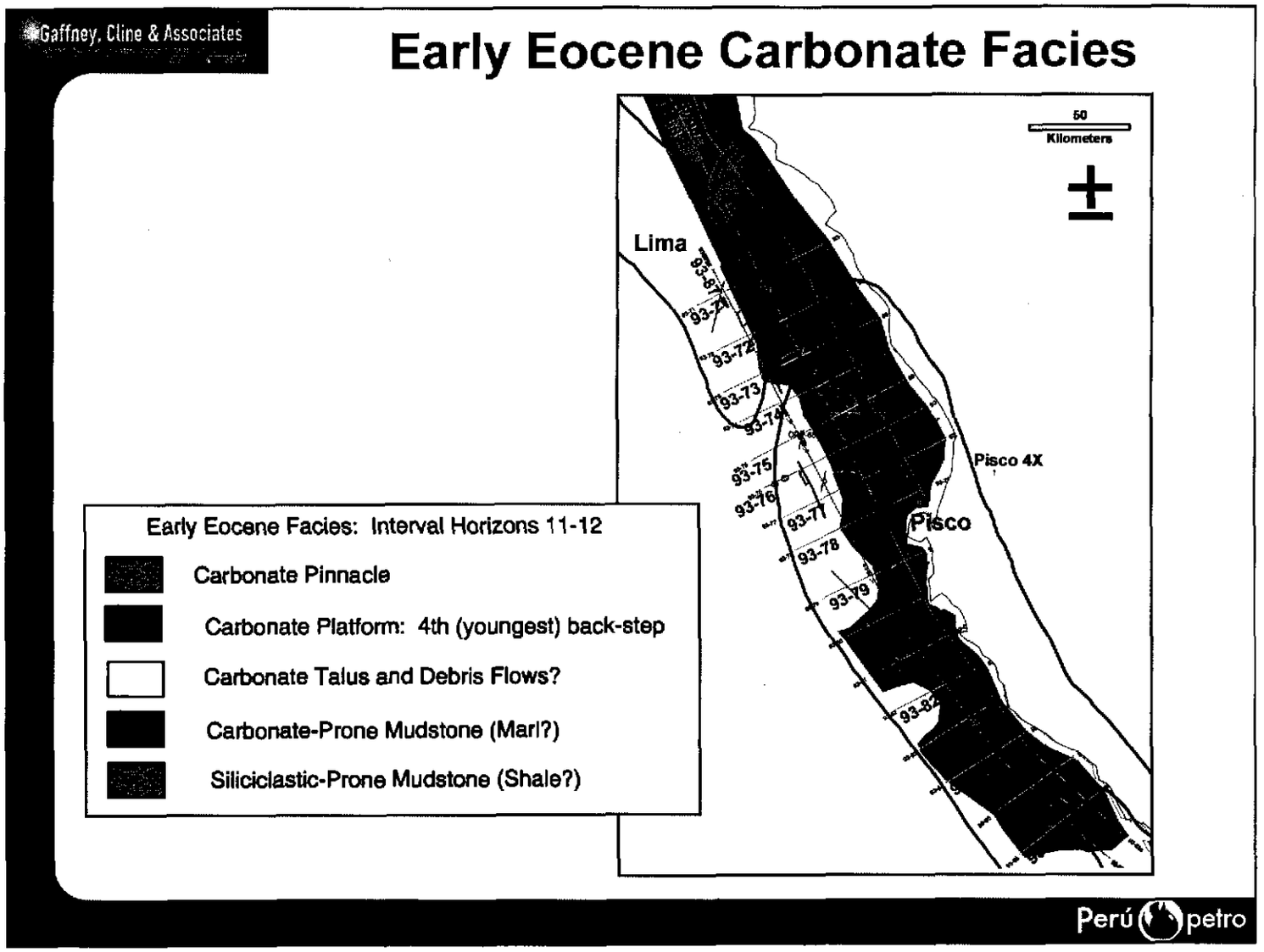
This is a chronostratigraphic diagram along seismic line 93-75. Eroded parts of the section are shown by hatching; non-deposition is indicated by white space. Most of the studied basins had histories similar to this one – three episodes of deposition during the Cretaceous, Eocene and Miocene, separated by two episodes of tectonic upheaval and erosion in the Paleocene and Oligocene. The main potential reservoir intervals lie mainly in the Eocene, with secondary possibilities in the Cretaceous, Paleocene and Miocene.



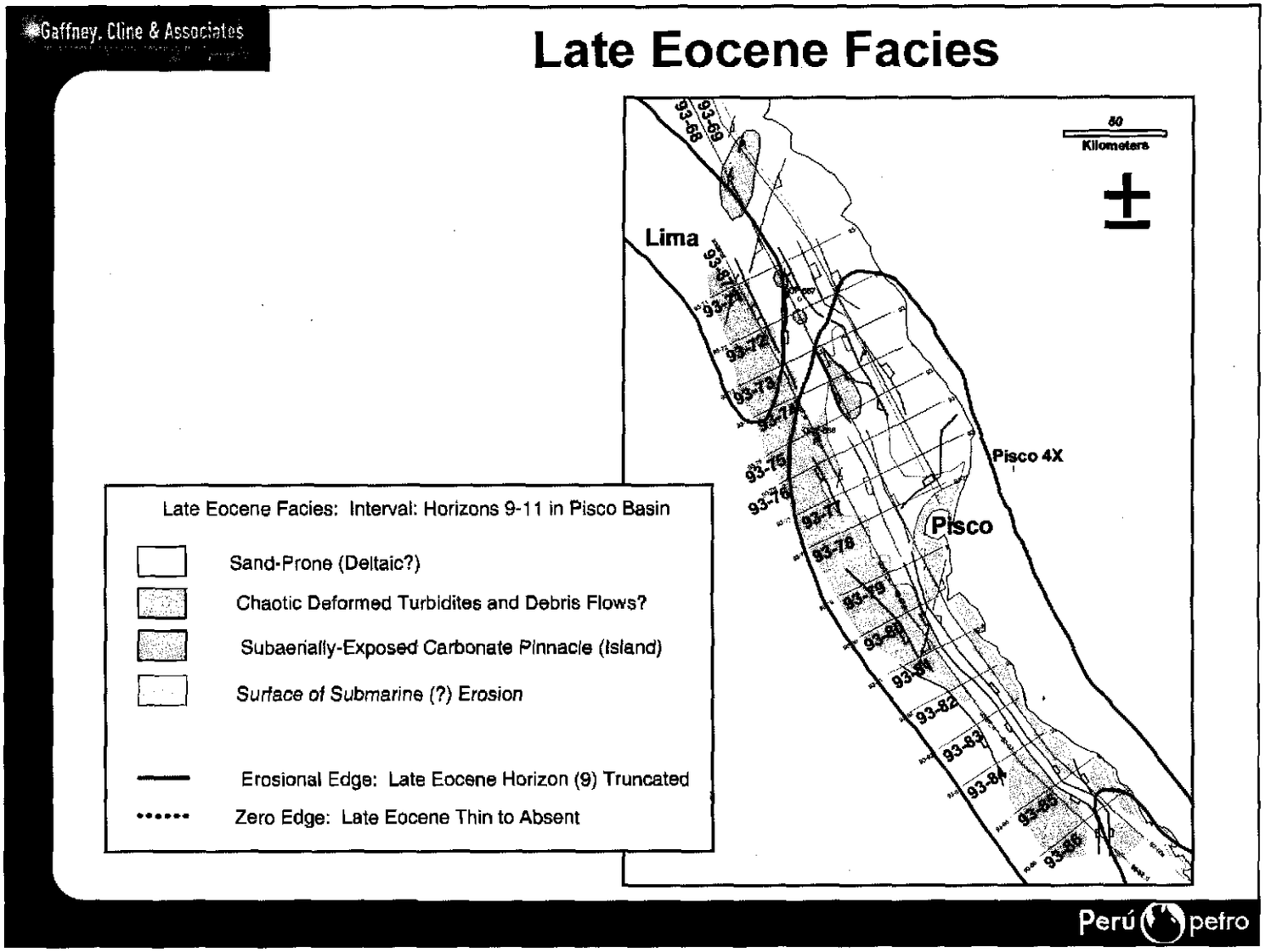
This map shows the extent of a Cretaceous carbonate-prone facies, which may extend further south but could not be reliably interpreted. The three dip lines indicated on the map appear in this presentation after the rest of the facies maps. These dip lines are annotated to show the vertical stacking of the mapped facies.



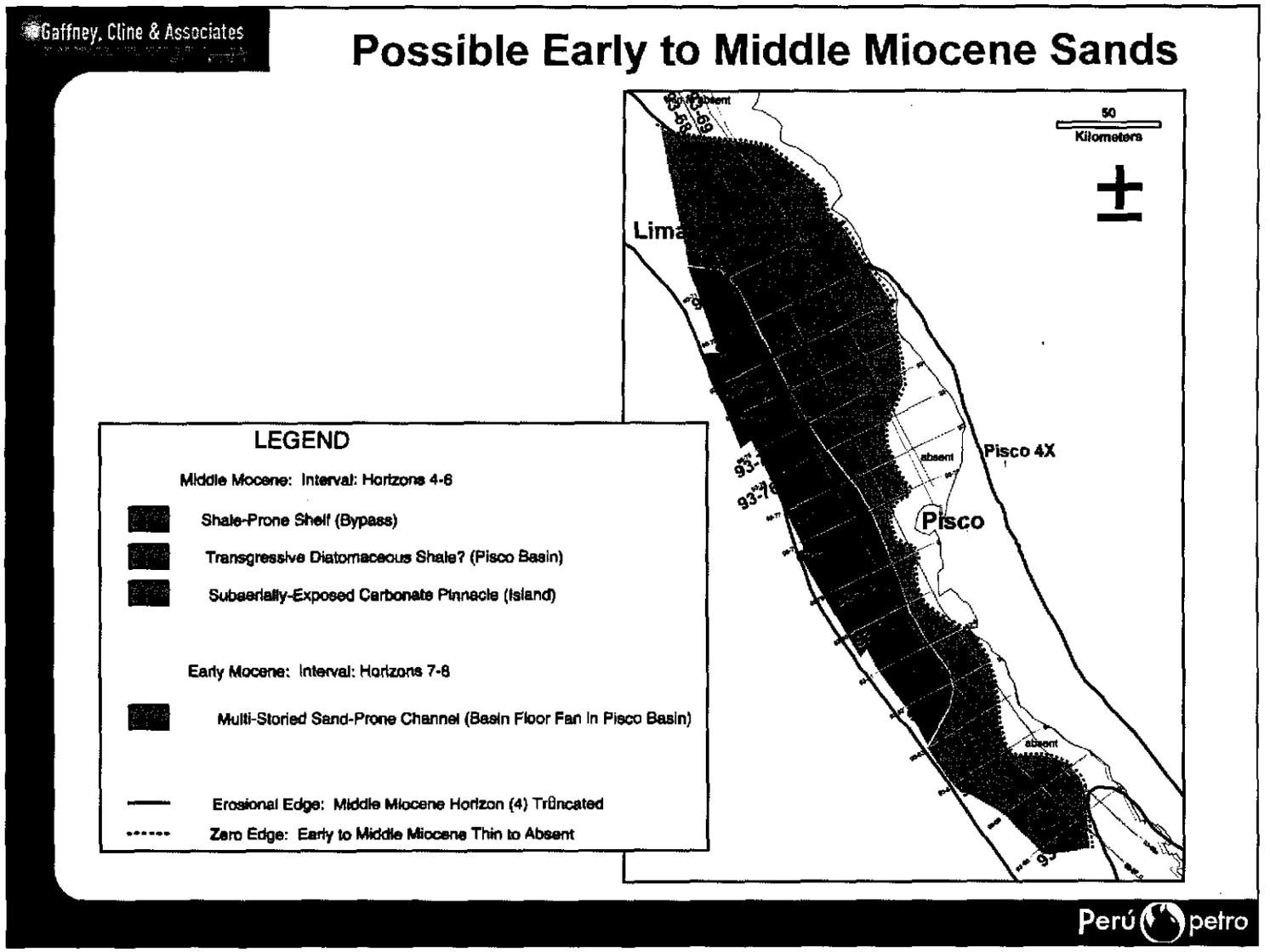
Although the Paleocene was generally a period of tectonic inversion and erosion, it appears to be at least partially preserved in the Pisco basin and has a near-shore possibly sandy reservoir component. As with the Cretaceous, the Paleocene facies may extend further south, but could not be reliably interpreted.



The most interesting new reservoir potential to emerge from this study is the possibility of Eocene carbonate build-ups. This is an alternative interpretation of the seismic morphology that has previously been interpreted as volcanic intrusives and extrusives. While volcanics are still a possibility, the detailed seismic character of these intervals is more consistent with organic build-ups. This issue will not be conclusively resolved until key locations are drilled. See the Exploration Plan section of this presentation for more detail.



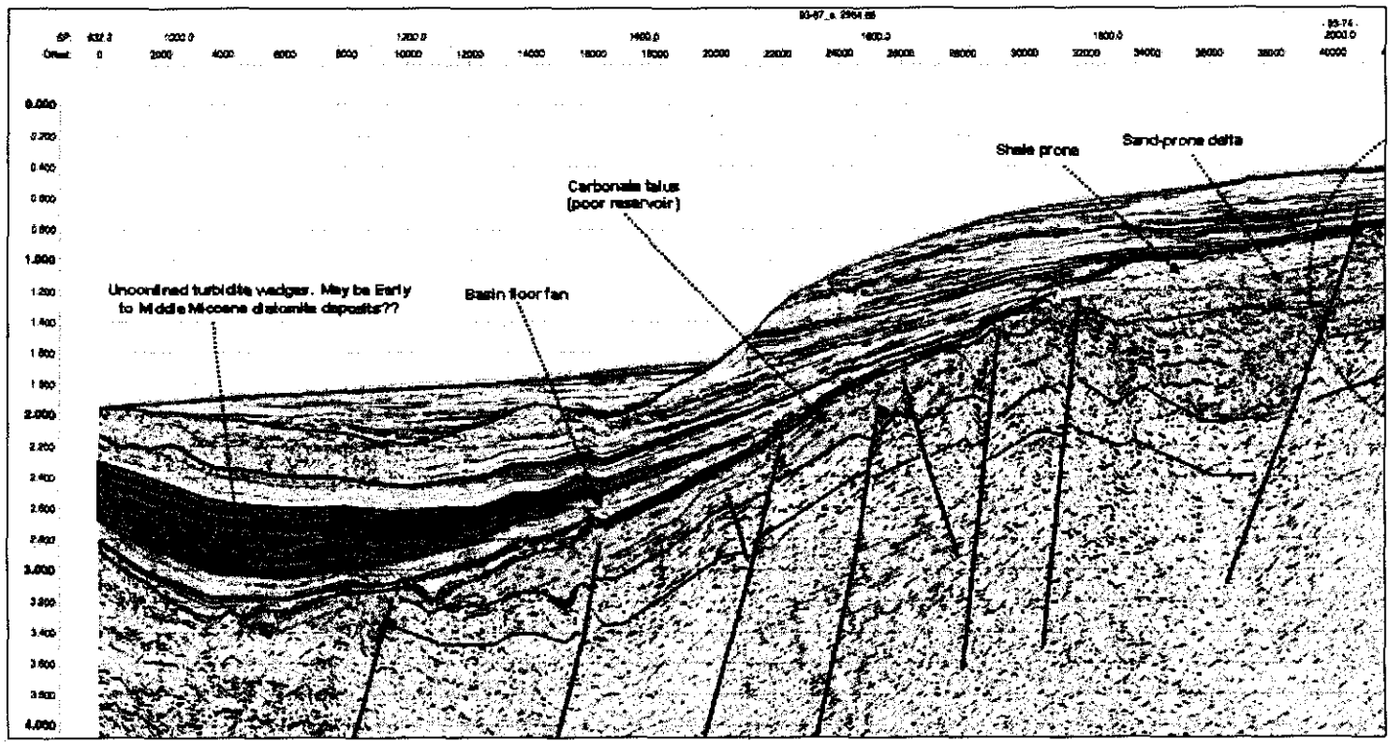
The example dip lines following these maps also show a Late Eocene section with distinct sand-prone (deltaic?) seismic character. The lateral extent of these possible deltaic sands is shown in this map.



This map shows the distribution of two possible sand-prone basin floor fans in the Early to Middle Miocene. This possible reservoir facies is a secondary target, compared to the Eocene carbonates.

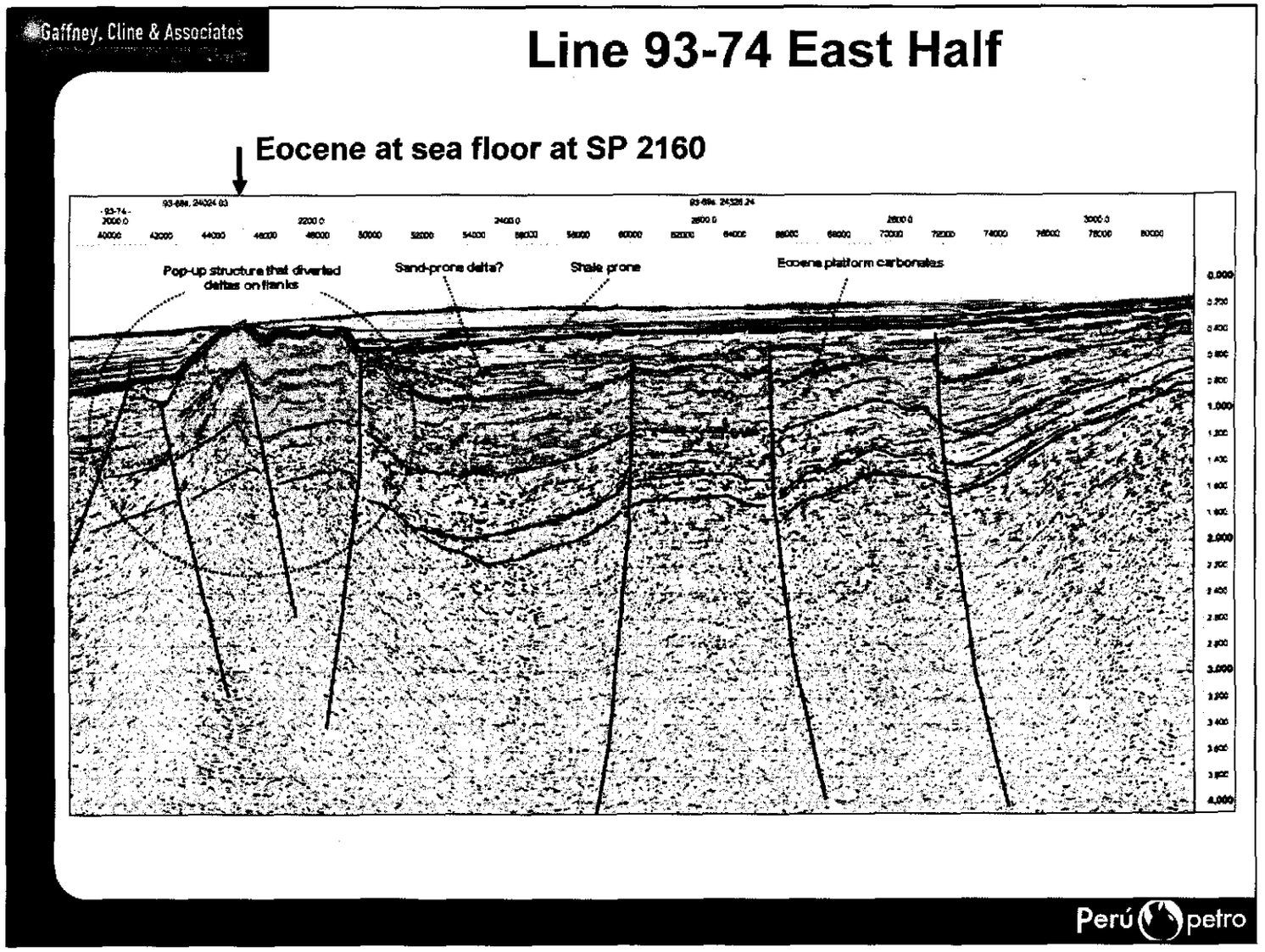
Gaffney, Cline & Associates

Line 93-74 – West Half



Perú petro

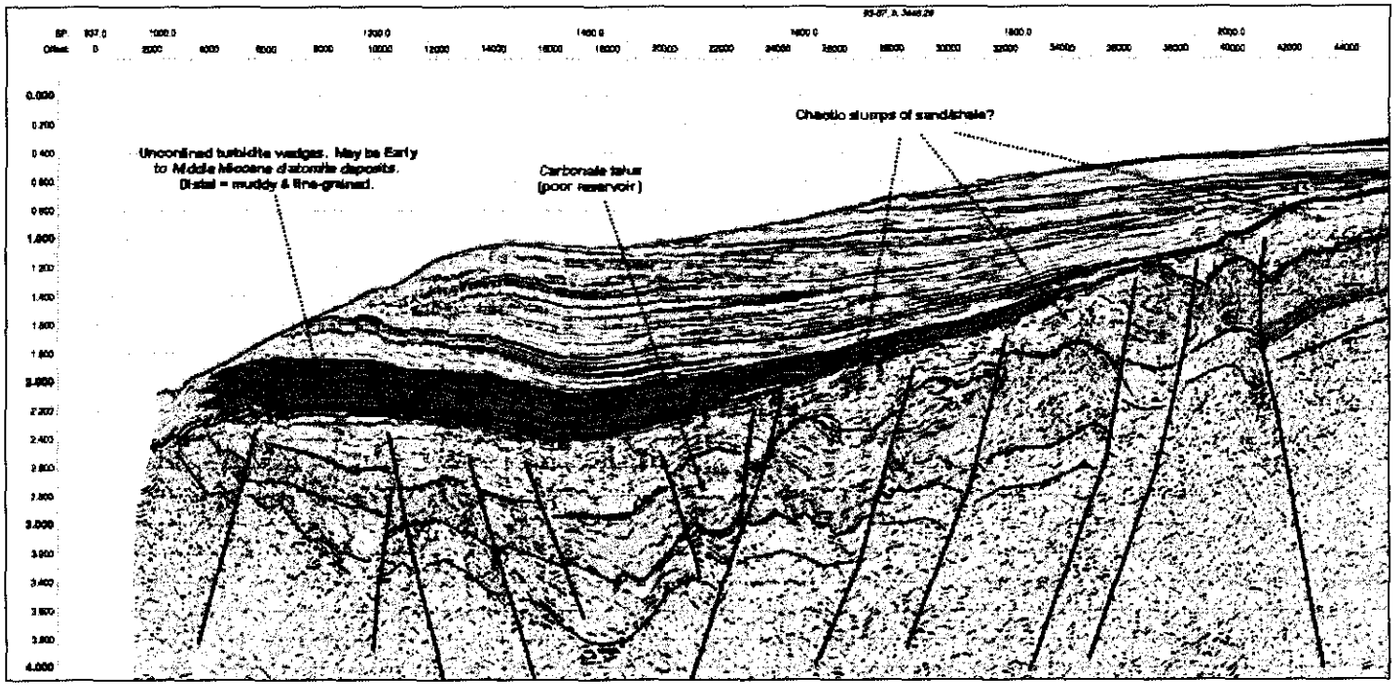
This is the western half of the northern-most of the three representative dip sections marked on the Cretaceous facies map. The various facies previously shown on the maps are marked appropriately on these sections, along with other interesting structural and stratigraphic features.



This is the eastern half of the previous section. Notice the large pop-up feature centered over shotpoint 2160. The crest of this structure apparently pierces the sea floor, and would be a convenient place to drill a slim hole to establish the presence of Eocene carbonates in this basin. Pinchouts of the sand-prone facies in the Upper Eocene around this high could be potential stratigraphic traps.

Gaffney, Cline & Associates

Representative Line 93-75 – West Half

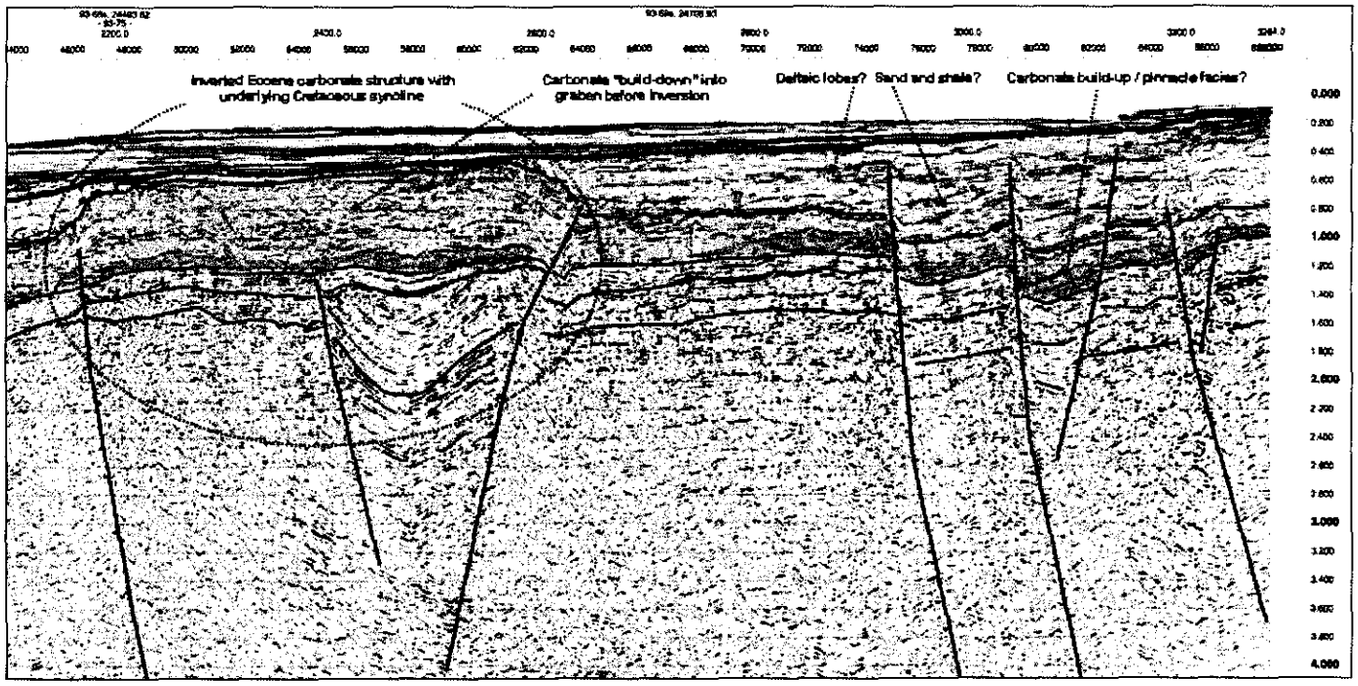


Perú petro

Line 93-75 is the next line south of 93-74 and helps establish the lateral continuity of the interpreted facies. The possible diatomites in the Miocene might be analogous reservoirs to the Monterey formation in California.

Gaffney, Cline & Associates

Representative Line 93-75 – East Half

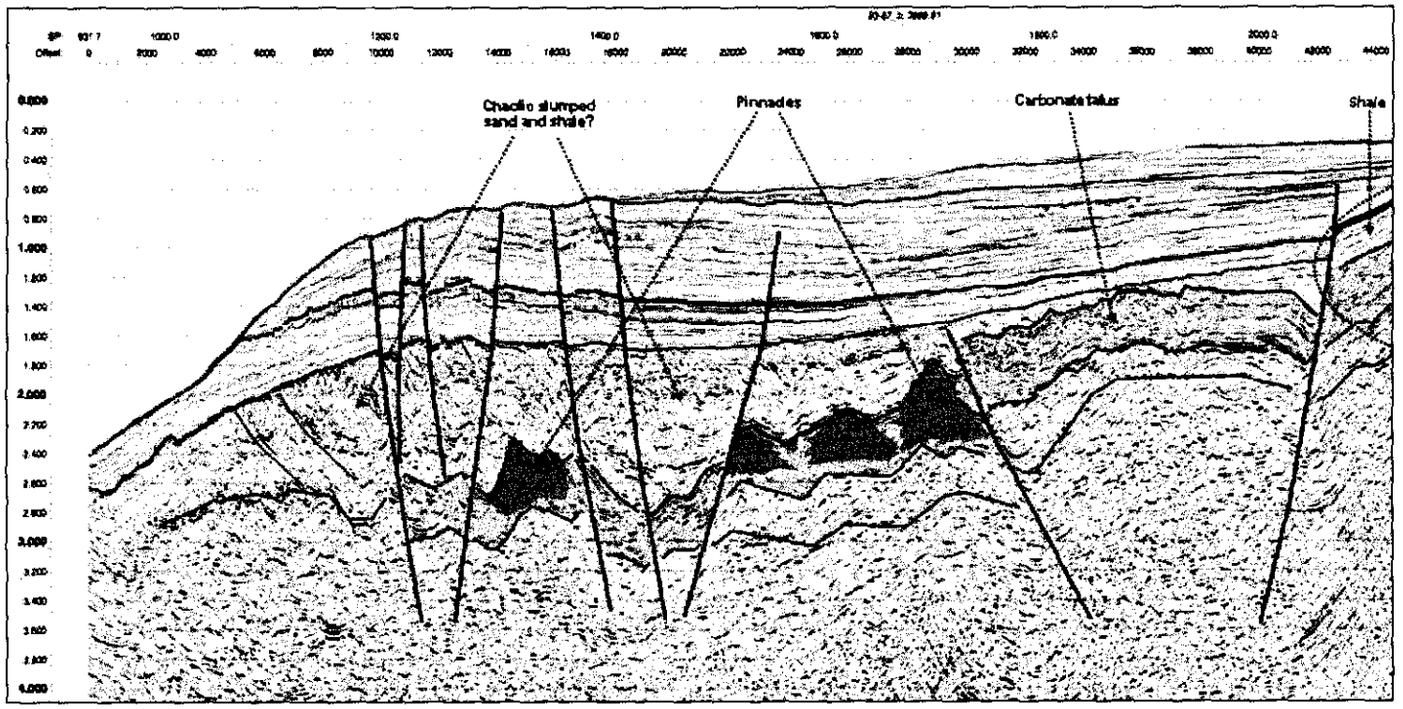


Perú petro

The pop-up feature in Line 93-74 is also clearly apparent on this line, as are the sand-prone (deltaic?) packages in yellow.

Gaffney, Cline & Associates

Representative Line 93-76 – West Half

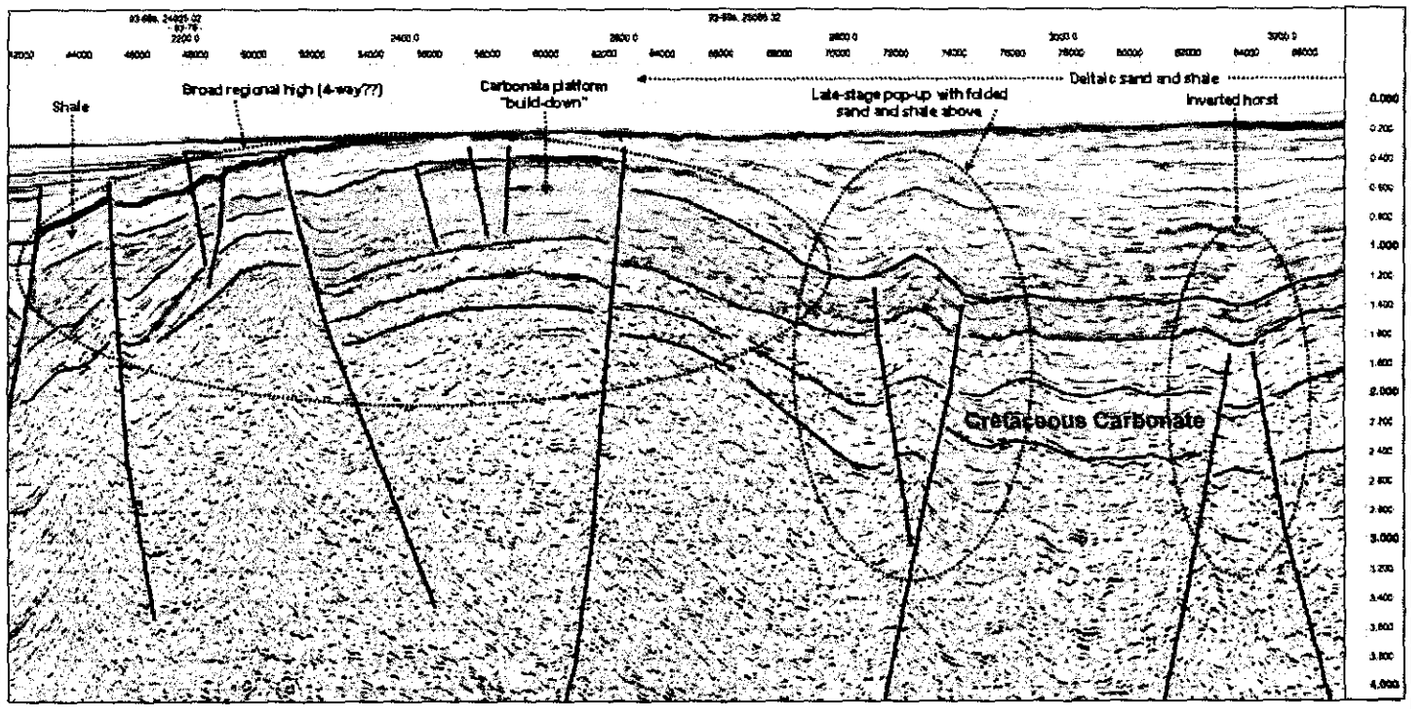


Perú petro

This is the western half of the last of these representative lines. The culminations of interpreted pinnacle-reef build-ups are especially clear on this line, with no apparent "roots" that might be expected if these were volcanic intrusions.

Gaffney, Cline & Associates

Representative Line 93-76 – East Half



Perú petro

The pop-up feature in lines 93-74 and 93-75 to the north is much broader here. Several smaller structural features are also marked here. Also note the basinward thinning of the Cretaceous that is suggestive of the "shoreline fringing carbonate build-up" on the Cretaceous facies map.

Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Source
- Reservoirs
- Leads
- Exploration Plan
- Economics

Perú petro

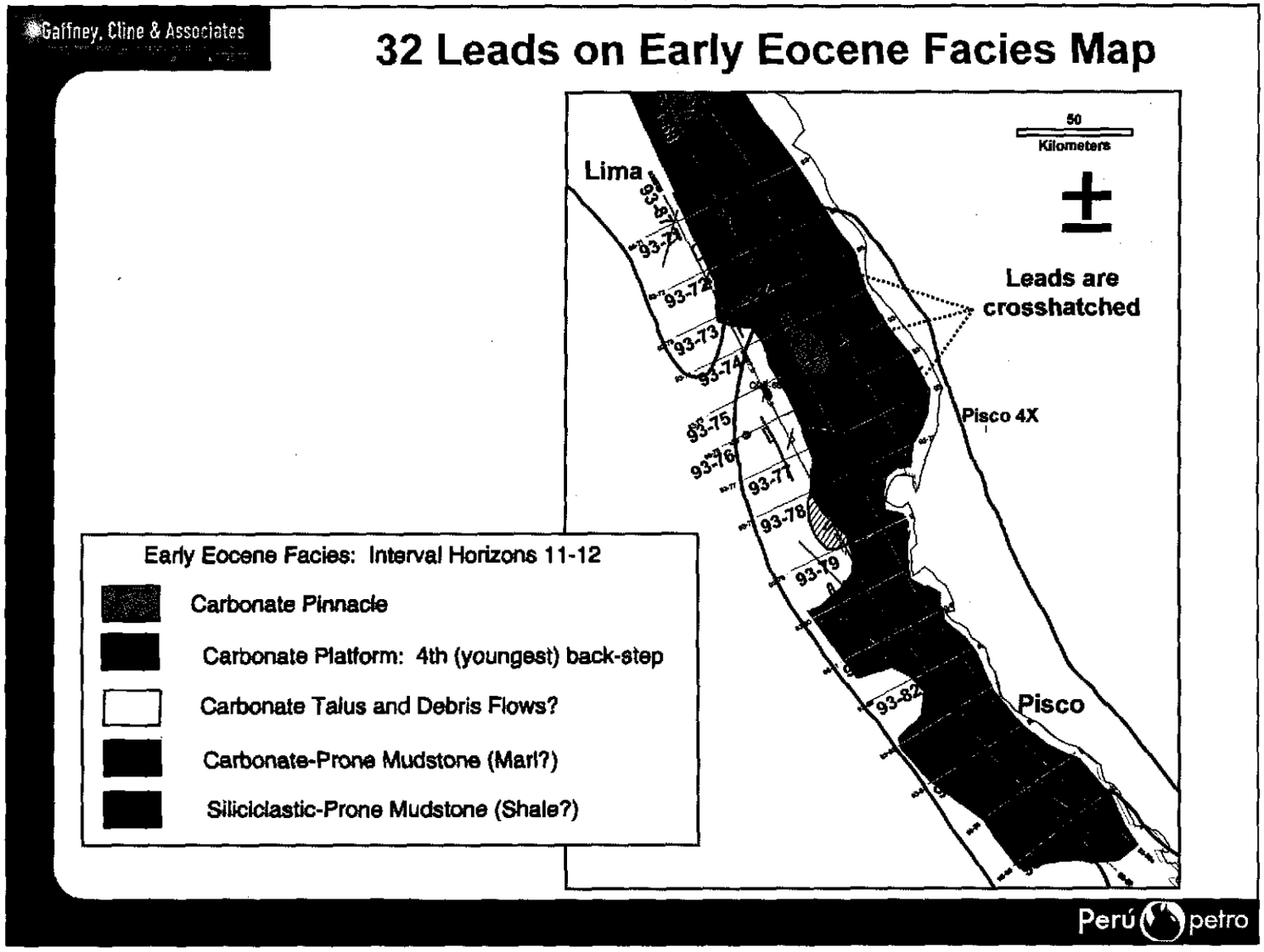
Gaffney, Cline & Associates

Pisco Leads

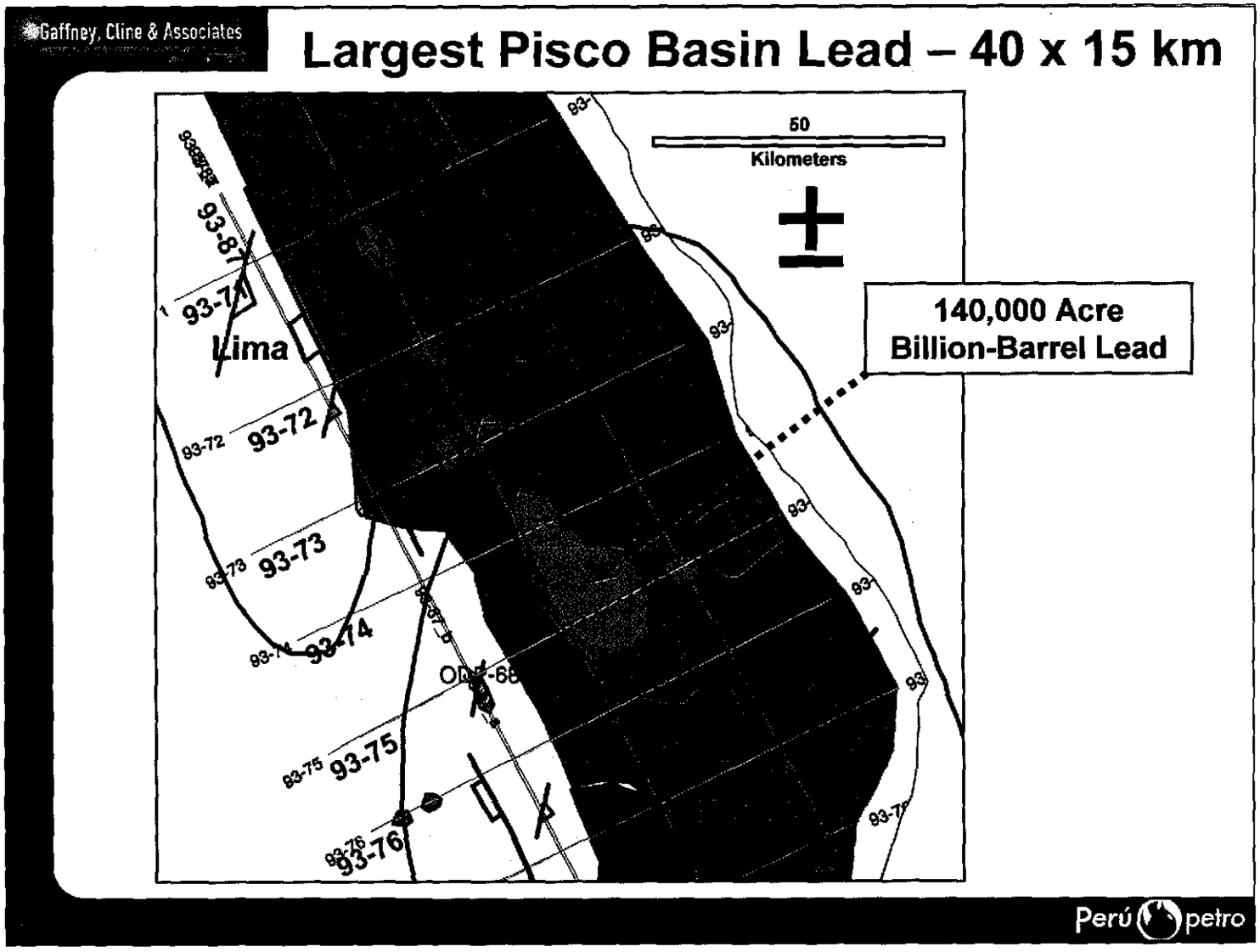
- 32 leads
- Carbonate buildups, pop-ups, tilted fault blocks
- Total over 3,000 km^2
- Largest (40 x 15 km) extends across three dip lines

Perú petro

A wide variety of structural and combined structural-stratigraphic leads were mapped in this study. While most of them were one-line anomalies, the largest one (as seen in the previous three seismic lines) covered at least three dip lines.



Here the 32 leads are shown on the Early Eocene facies map. The main fault fabric is also shown on this map, and provides the sideboards for two long and narrow fault-trap trends at the southern end of the basin.



The broad inverted carbonate build-up as seen in detail on lines 93-74, 93-75 and 93-76 is large enough to contain on the order of a billion barrels of oil in place.

Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Source
- Reservoirs
- Leads
- Economics
- Exploration Plan

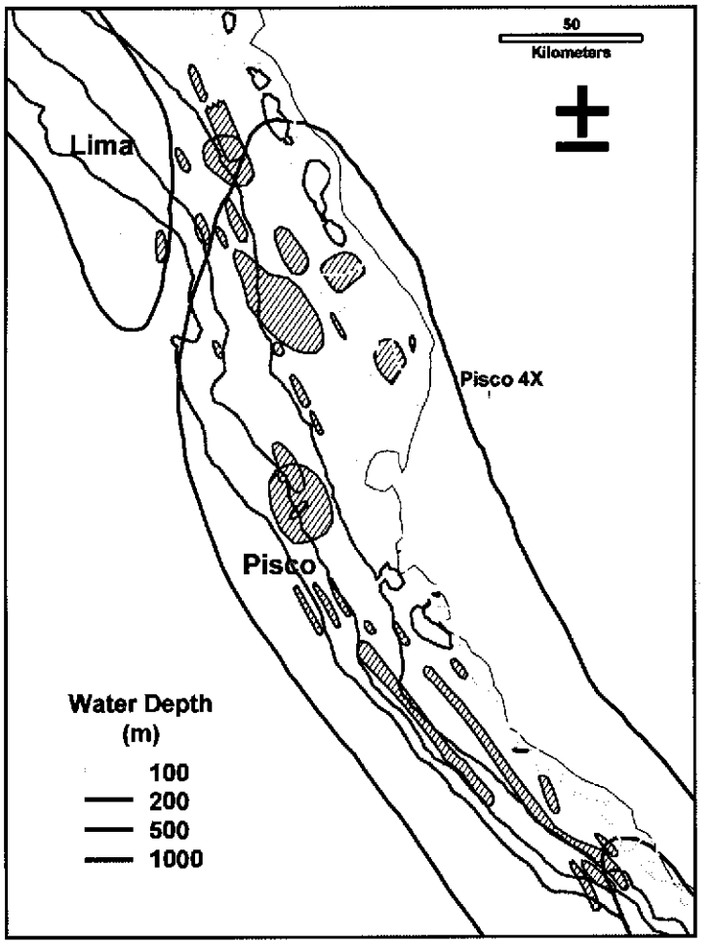
Perú petro

The best part of the Pisco offshore exploration fairway has arguably already been secured by Petro-Tech Peruana. They signed an exploration and production agreement for Block Z-33 in September, 2004.

Gaffney, Cline & Associates

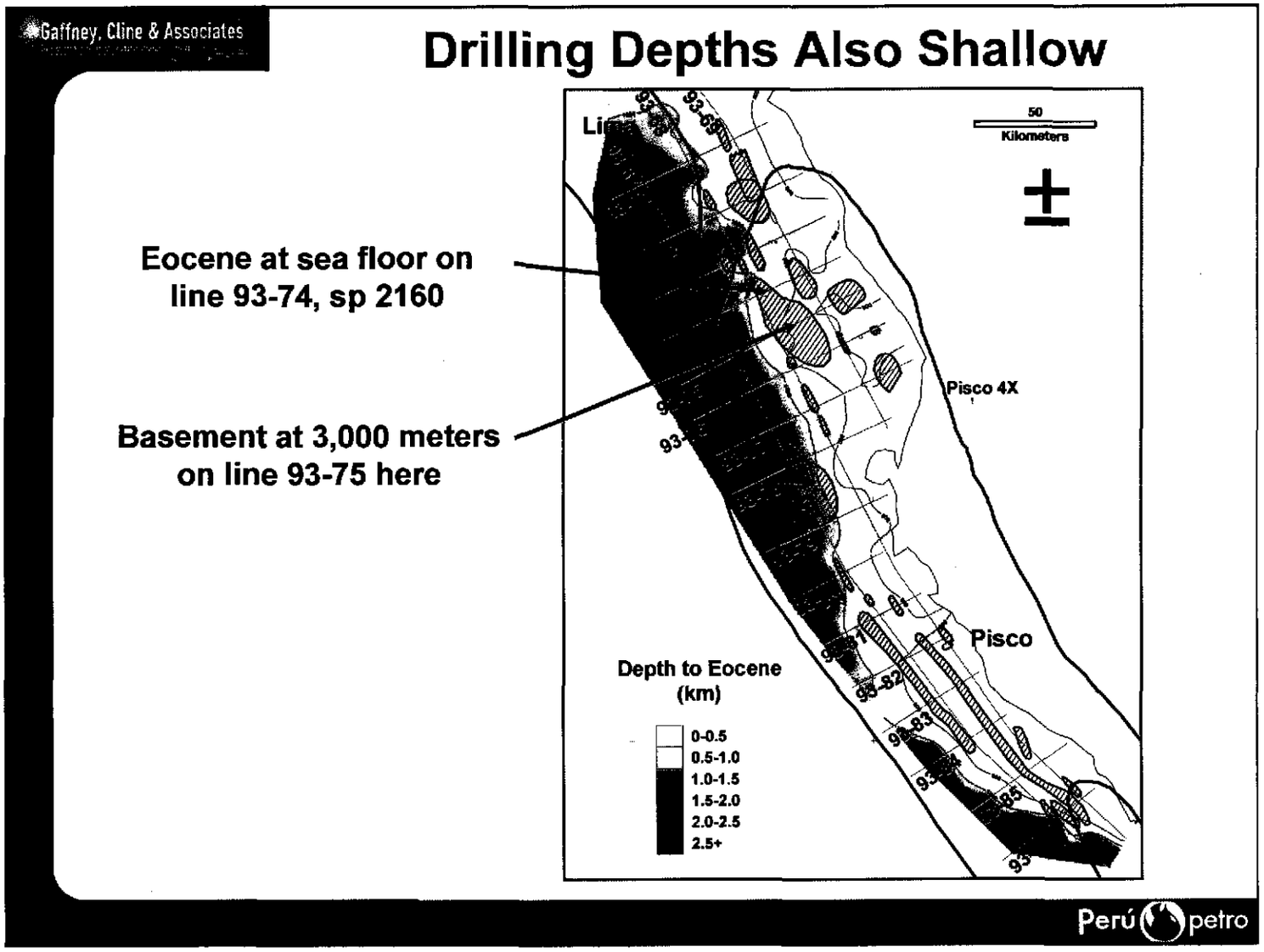
Water Shallow in East Half of Basin

The 200 m isobath runs down the center of the basin



Perú petro

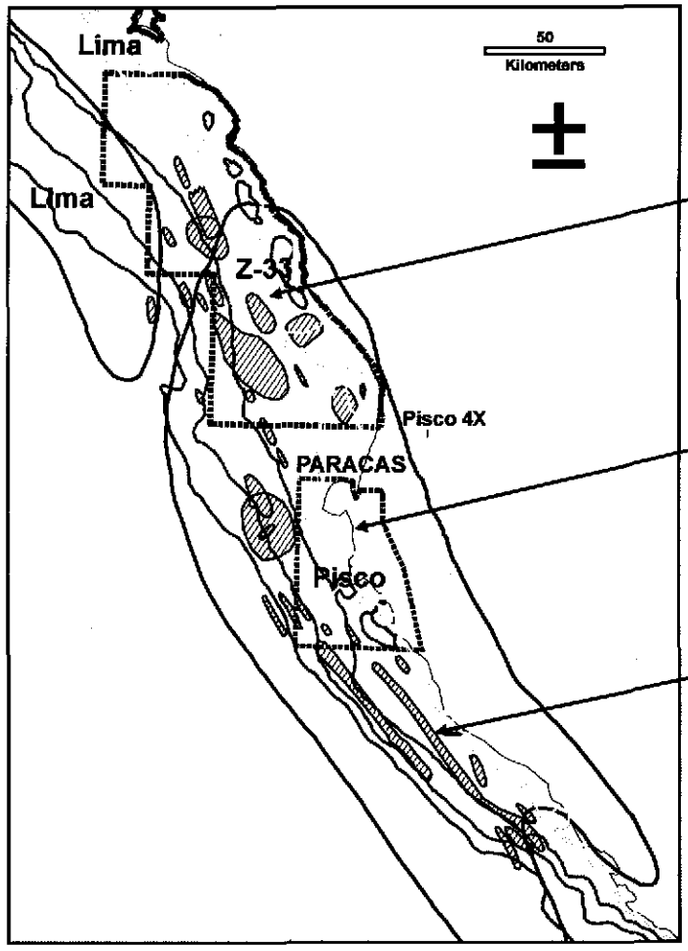
Water depths for the near-shore half of the Pisco basin, especially over the largest lead, are 200 meters or less. Numerous other leads are situated in shallow water.



The slide showing the eastern half of line 93-74 showed how this structure may have pierced the sea floor. The entire sedimentary column under this lead at the 93-75 location could be tested by a 3,000-meter well.

Gaffney, Cline & Associates

Petro-Tech Peruana Takes Block Z-33



Petro-Tech Peruana Block Z-33

National Reserve of Paracas

Additional Exploration Fairway

Perú petro

This map shows the location of block Z-33, and how it covers the largest leads that are in shallow water. It also shows the location of the National Reserve of Paracas, which is an environmentally sensitive reserved area both onshore and offshore south of block Z-33. South of the National Reserve, additional shallow-water exploration fairway still exists, with substantial leads identified between the coast and the 200-meter isobath. This should be sufficient to justify promoting another exploration block at the southern end of this basin.

Gaffney, Cline & Associates

Z-33 Work Commitment

- Reprocess and interpret 1,500 km 2D seismic (300 UTEs)
- Shoot 150 km^2 of 3D seismic (150 UTEs)
- One well a year for four years (302 UTEs per year)
- Total 1,658 UTEs = $8.3 million (1 UTE = US$5,000)
- Further investments based on results

Perú petro

Petro-Tech is committed to a work plan that includes 2D seismic reprocessing and interpretation, a new 3D seismic acquisition program and four exploration wells.

Gaffney, Cline & Associates

Outline

- Conclusions
- Data
- Hydrocarbon Source
- Reservoirs
- Leads
- Economics
- Exploration Plan

Perú petro

Gaffney, Cline & Associates

Largest Pisco Lead – 40 x 15 km

Volumetric Parameters

- Area: 570 km^2 = 140,000 acres
- Net Pay: 30 feet
- Porosity: 8%
- Oil Saturation: 60%
- Formation Volume Factor: 1.1 RB/STB

1.4 Billion Barrels in Place

Perú petro

These are example choices of volumetric parameters for a possible carbonate reservoir in this lead. This simple calculation shows the billion-barrel potential for this basin.

Gaffney, Cline & Associates

Three Scenarios Show an Overall Favorable Economic Picture

(US$ million unless otherwise noted)	Low	Mid	High
Oil (millions of barrels)	100	200	350
Producing Wells	40	70	120
Gross Project Revenue	3,000	6,000	10,500
Royalty	221	588	1,360
CAPEX	285	470	770
OPEX	215	342	547
Net Cashflow Before Tax	2,279	4,600	7,823
Tax	668	1,362	2,303
Net Cashflow After Tax	1,611	3,238	5,520
NPV (Discount 10%)	358	720	1,184
IRR (%)	38	41	43

Perú petro

There is no doubt that the new chronostratigraphic framework produced in this study has documented a substantial amount of exploration potential in the Pisco basin. However, there is considerable doubt about how much of that potential will be realized, and when. Therefore, the economic analysis was based on a simple three-scenario approach – a low case, a mid case and a high case. The range between the low case and the high case was chosen to roughly match the hypothetical prospect in the previous slide. The exploration and development costs were based on information in the public domain and advice from PERUPETRO. In general, because oil prices are high and costs are low in this shallow-water, close-to-shore environment, even the low case delivers a sizable rate of return.

Gaffney, Cline & Associates

Conclusions Revisited

- Strong possibility of several Cretaceous source kitchens in the northern part of the basin
- Possible Eocene/Cretaceous carbonate reservoirs/traps – also deep-water sands in Cretaceous, Eocene and Miocene
- Wide variety of large-potential traps with attractive economics
- Shallow water and shallow drilling over half of the offshore part of the basin
- Petro-Tech Peruana secured block Z-33 and has committed to an initial $8 million exploration program
- Additional attractive exploration fairway remains, south of the National Reserve of Paracas

Perú petro

GCA's evaluation of the Pisco basin potential includes identification of the strong possibility of a viable Cretaceous source, several new possibilities for good-quality reservoirs, and a wide variety of new leads with large potential and attractive economics, owing to shallow water and shallow drilling depths. In September 2004, Petro-Tech secured the Z-33 block, which covers the heart of the Pisco exploration fairway. They plan an initial $8 million exploration campaign, with seismic acquisition commencing very soon. Petro-Tech's parent company owns a seismic boat that is in Peruvian waters, which will greatly facilitate Petro-Tech's progress in exploring this and other offshore blocks in the Talara, Sechura and Salaverry basins. Additional shallow-water fairway remains, with substantial leads identified south of the National Reserve of Paracas that may attract other operators into this basin.

Gaffney, Cline & Associates

April 2005

Hydrocarbon Prospectivity of the Pisco Basin

Perú petro

APPENDIX A

CONTRACT TERMS OF REFERENCE

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Annex 1

Terms of Reference

SEQUENCE STRATIGRAPHY ANALYSIS OF THE PERUVIAN OFFSHORE CONTINENTAL SHELF-SLOPE

The Peruvian offshore sedimentary basins are largely unexplored and remain as "frontier" areas for hydrocarbon exploration. PERUPETRO is currently engaged in promotional efforts to offer promising hydrocarbon exploration acreage in these offshore areas. In order to improve their ability to recognize and develop plays, leads, and prospects for promotional offerings, PERUPETRO considers it necessary to evaluate these areas applying concepts of sequence stratigraphy.

Sequence stratigraphy is a science dealing with the correlation of rock successions with contemporaneous depositional histories in laterally adjacent environments. These stratal units represent the depositional products of changes in relative sea level and rates of sedimentation and are bounded by common surfaces of erosion or non-deposition. Interruptions in sedimentation (i.e. discontinuities) usually coincide with periods of erosion, which create breaks or voids in the rock record (i.e. unconformities). In sequence stratigraphy, unconformities define the ends of depositional sequences and the beginnings of new sequences. Identification of these time significant surfaces is fundamental to a sequence stratigraphy interpretation as they can be employed as a tool for unraveling basin-fill history by providing a time framework for correlation, mapping and prediction of basin stratigraphy.

The application of sequence stratigraphy methodology provides a systematic approach to the interpretation of a sedimentary succession. Through the integration of data sets including sea-level cycle charts, surface data from rock outcrops and subsurface data from seismic recordings and well logs, sequence stratigraphy applications can be successfully used to predict the distribution of hydrocarbon reservoirs, sources and seals in hydrocarbon-bearing basins.

The majority of the Terms of Reference is intended to be performed in the U.S.

1. TECHNICAL ANALYSIS

(A) Project Objective

The sequence stratigraphy project will attempt to establish a time-stratigraphic framework for the country's offshore sedimentary basins that can be employed to predict the distribution of depositional sand units such as basin floor fans, channel fills and turbidites. Analogous deposits have been established as prolific hydrocarbon bearing and producing reservoirs in various basins of the world.

(B) Project Study Area

The proposed sequence stratigraphy study will be focused on eight sedimentary basins located in the Peruvian offshore province. Oriented in a northwest-southeast trend along the offshore continental margin shelf and slope, the basins cover an area of more than 40 million acres. Basin locations and configurations are shown in *TABLE 1 - PERU BASINS SUMMARY* provides a listing of the basins with general descriptions of their dimensions and associated data sets. Additionally, a map of the basins is included as *MAP – PERUVIAN OFFSHORE BASINS.*

TABLE 1 – PERU BASINS SUMMARY

OFFSHORE BASIN	AREAL EXTENT OF BASIN (million acres)	SEDIMENTARY THICKNESS OF BASIN (ft.)	AVAILABLE DATA IN BASIN STUDY AREA		
			2D-SEISMIC (mi)	# WELLS	OTHER DATA
Tumbes	2.4	16,400	4,360	18	Geological & Geochemical
Talara	5.0	26,000	500	183	Geological & Geochemical
Sechura	4.9	11,500	1,467	0	Geological & Geochemical
Trujillo	2.2	13,125	5,000	4	Geological & Geochemical
Salavarry	7.4	8,200	1,000	0	Geological & Geochemical
Lima	5.6	6,500	4,300	0	Geological & Geochemical
Pisco	6.7	9,800	4,300	1	Geological & Geochemical
Mollendo	5.1	6,500	600	0	Geological, Geochemical & Aeromagnetic
TOTALS	39.3		21,527	206	

(C) PROJECT DATA BASE

PERUPETRO will authorize access to its data bank and allow the release of information needed to support project implementation. A brief description of the PERUPETRO data is provided below.

(1) Seismic Information: Nearly 21,500-miles (34,600-km) of 2D seismic in digital SEG-Y format and in paper copy; surveys of varying vintages, recorded from 1970 to 2000.

(2) Well Information: 206 exploratory wells in LAS digital format and in paper copy.

(3) Reports: Various technical reports of upstream contractors with offshore operations, theses for academic degrees, and all the works of geologic, geophysical or geochemical evaluations made or requested by PERUPETRO S.A.

(4) Geochemical, gravimetric, magnetometric, biostratigraphic information and other documents or files relevant to the areas under study.

(D) PROJECT WORK SCOPE

Determination of project tasks and a detailed work scope for the project will be dependent on the relevance and quality of the above-mentioned data. However, the sequence stratigraphy interpretation should be aligned with the following general approach:

(1) Assessment and Management of Data Base

Data assessment and management will be an important aspect of the sequence stratigraphy project since it will involve the integration of diverse data sets including seismic data, well data and other information. The review, preparation and organization of this information will be required to optimize project efficiency and facilitate its timely completion. Data management tasks may include (but are not limited to) any of the following:

a) Reviewing and assessing the available information and data needed for study project and coordinating release of data with PERUPETRO Data Bank.

b) Selecting appropriate log curves for correlation and lithology data.

c) Editing log curves as needed (for data quality control, synthetic seismograms, etc.).

d) Generating synthetic seismograms for key well/seismic ties-ins, as needed.

e) Organizing relevant support data (geochemical, biostratigraphic, hydrocarbon seeps, drill shows and tests, etc.).

f) Reviewing and organizing key seismic and well data sets for interpretation.

(2) Development of Chronostratigraphic Framework

The establishment of a chronostratigraphic or time-stratigraphic framework will provide an interpretive model to understand the depositional histories of sedimentary fills of the Peruvian offshore basins. The model(s) should be developed through an integrated approach, utilizing all applicable information from the project database including seismic, well, outcrop and other information. Although these data can be employed independently of each other to produce reasonably accurate models, the integrity of the interpretation can be optimized with their combined use. The following methodology should be used as a guideline to establish the chronostratigraphic framework(s) for the project:

a) Data Grid - Key well data should include synthetic seismograms and biostratigraphic data. Key seismic lines should be oriented along strike and dip and located in close proximity to wells to allow accurate tie-ins.

b) Well Data – Well logs should be analyzed for porosity, fluid content, grain size and lithology information using combinations of spontaneous potential (SP), gamma ray (GR), resistivity, neutron-density and sonic. Log curve trends should be analyzed to interpret depositional environments (cleaning-up, dirtying-up, etc.) and sequence stacking patterns and sequence boundaries. Biostratigraphic data should be analyzed in conjunction with the well logs to provide age dating of sequences and information on paleo-environments.

c) Well / Seismic Integration - Synthetic Seismograms will be required to provide accurate ties of well and seismic data. As precision is essential to tie reflections with stratal surfaces, acoustic and density log curves may need editing to eliminate spurious data created by cable stretch, cycle skips, etc.

d) Seismic Data - The seismic data should be interpreted using sequence stratigraphy techniques with a focus on the following:

   i. Identification of reflector terminations at discontinuity surfaces.

   ii. Analysis of convergent reflector surfaces to establish sequence boundaries.

   iii. Delineation of sequence geometries and associated system tracts.

   iv. Mapping and construction of chronostratigraphic charts (Wheeler Diagrams) showing sequences, key surfaces and systems tracts.

(3) Analysis Of Basin Tectonics

Analysis of basin tectonics should be a part of the sequence stratigraphy study. This will involve the characterization of tectonic events (e.g. uplift, subsidence, folding, faulting, etc.), recognizing their depositional "signatures" (e.g. slides, slumps, transgressive-regressive wedges, etc.) and understanding the effects of tectonic relationships with eustatic cycles and sedimentation on basin development.

(4) Development of Plays, Leads and Prospects

The integrated study grid will provide a model to identify system tracts within the sequences. Evaluations of system tracts can be employed to interpret depositional environments and develop plays and leads. Plays and leads should be evaluated using seismic facies analysis techniques to quantify risks and generate prospects. The risk assessments may include (but should not be limited to) the following: reservoir volumetrics (continuity, quality, thickness), seals (continuity, thickness), source rocks (continuity, thickness), isopachs (thickness), burial history and heat flow for maturation studies.

2. ECONOMIC ANALYSIS

The prospects generated by the technical study should be analyzed to determine their viability as commercial ventures. The following factors should be considered for the analysis:

(A) Volumetric determination of prospect/reservoir size.

(B) Exploration, development and production costs

(C) Deliverability or production schedule

(D) Technical and economic risk

(E) Market pricing forecast

3. FINANCIAL ANALYSIS

Financial evaluation of the prospect begins with the typical industry method, discounted cash flow. Based on the technical evaluation of the prospect, estimated reserves are determined and production rates are forecasted. Market prices for the products (adjusted for delivery cost) establish revenues. Adjustments are then made to reflect the corresponding revenues for each ownership category as reflected in the lease agreements. Costs are calculated and discount rates are applied to develop the discounted cash flow of the prospect. From these projections and calculations, the net present value (NPV) and the internal rate of return (IRR) are formulated and adjusted based on risk criteria. Typical risk criteria would include:

(A) Country

(B) Economic

(C) Political

(D) Currency

(E) Technical Development Factors

(F) Location and Access

4. ENVIRONMENTAL ANALYSIS

Determine concerns or potential negative impact on environmental, social and cultural integrity resulting from project exploration activities and operations. Propose mitigation measures. Accordingly, determine consequential risks to Project success (e.g. construction delays, financing uncertainties, etc).

5. REGULATORY REVIEW

Identify any regulatory control issues that negatively impact project development schedules and project economics.

6. PROPOSED EQUIPMENT AND SERVICES

A list of materials, equipment and services should be included as supporting documents to exploration / development costs employed in the economic analyses of the prospects.

7. IMPLEMENTATION PLAN

Provide an implementation plan for each economically viable prospect to recommend the critical steps required to implement exploration program.

8. DELIVERABLES

(A) Final Report

A project-oriented team of specialists will carry out the sequence stratigraphy evaluation. The technical assistance (TA) work scope will include the technical and economic analyses described above. Completion of the work scope is estimated to take ten (10) months. A Final Report must be prepared and submitted at the end of the TA. The contents of the report are summarized below.

(1) Individual executive summary reports for each basin (pending data quality).

(2) Maps showing sequences, key surfaces, systems tracts, plays, leads and prospects.

(3) Chronostratigraphic charts showing sequences, key surfaces and system tracts.

(4) Economic analyses of commercially viable prospects.

(5) Recommendation of plans to implement exploration programs for commercially viable prospects.

The Final Report shall be prepared in accordance with Clause I of Annex 2, and shall include prospective U.S. sources of supply.

(B) Technical Briefing

At the conclusion of the sequence stratigraphy evaluation and Final Report, the contractor will coordinate and conduct a Technical Briefing to present the results of the TA to representatives from the USTDA and interested U.S. firms. The Technical Briefing forum (i.e. location and date) will be established in coordination with PERUPETRO, S.A. and USTDA officials. One prospective forum for the Technical Briefing is the Houston Geological Society's (HGS) monthly International Explorationists Dinner Meeting. In the reception hour prior to the dinner, the HGS provides a forum where technical information is displayed and discussed in an informal setting.

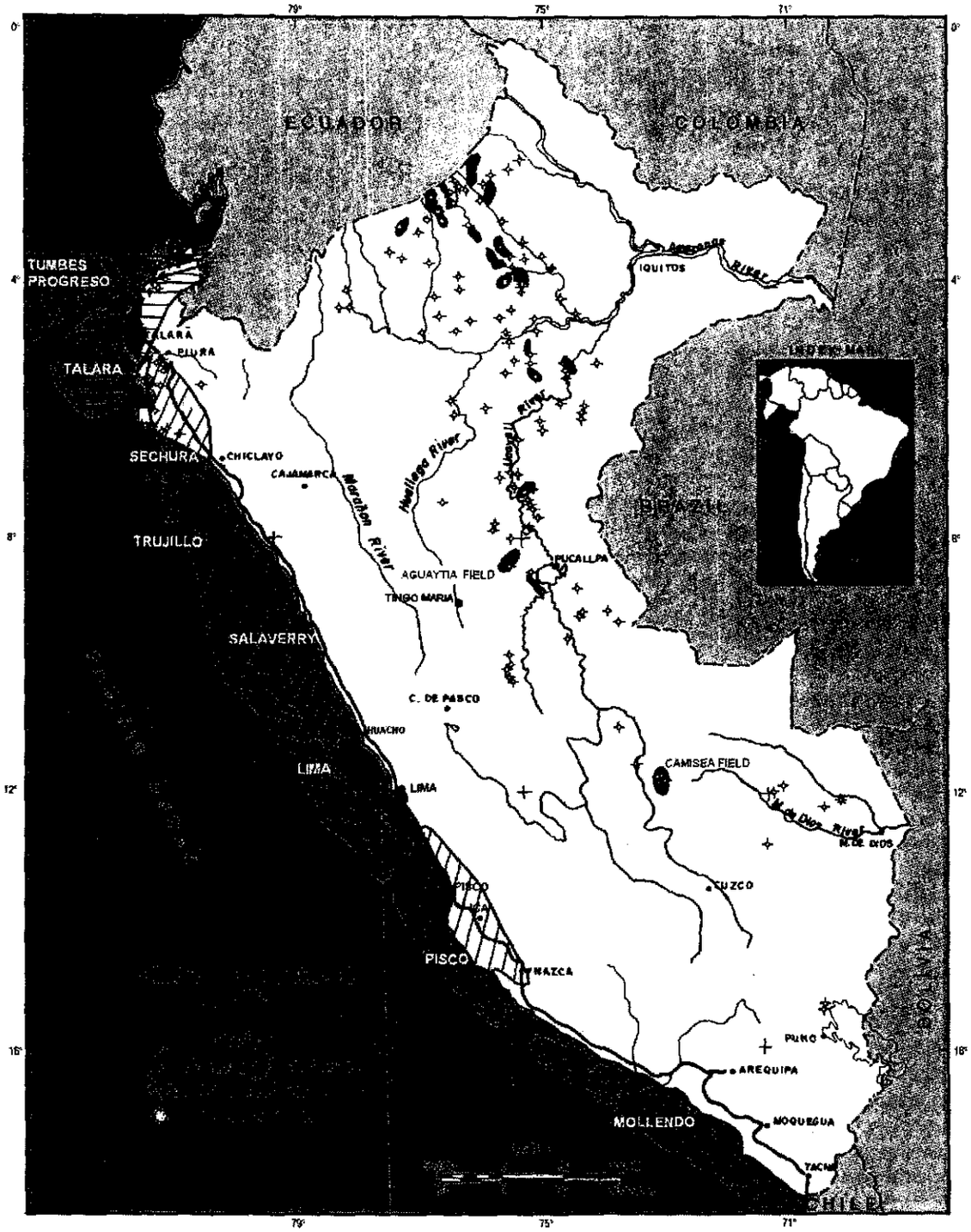
9. ILLUSTRATIVE BUDGET FOR TECHNICAL STUDY

The sample budget presented in the following table is based on estimates of personnel labor costs and expenses (travel and lodging), hardware equipment with support software, and time requirements needed to complete the TA. It is illustrative only, and is provided to give the Contractor a sense of anticipated effort and expenses. The Grant amount is fixed.

SEQUENCE STRATIGRAPHY ANALYSIS OF THE PERUVIAN OFFSHORE CONTINENTAL SHELF-SLOPE (TO BE DEVELOPED IN THE U.S.)

TECHNICAL STUDY BUDGET SEQUENCE STRATIGRAPHY ANALYSIS OF THE PERUVIAN OFFSHORE CONTINENTAL SHELF-SLOPE			
DIRECT LABOR SPECIALIST OR TASK	**MAN-MONTHS**	**COST PER MONTH**	**TOTAL COST**
Project Leader / Sr. Geologist	10	$16,000	$160,000
Sr. Geophysicist	10	$16,000	$160,000
Geochemist	2	$12,000	$24,000
Biostratigrapher	2	$12,000	$24,000
LABOR TOTALS			**$368,000**
EXPENSES	**NUMBER**	**COST PER TRIP**	**TOTAL COST**
Travel	4 trips	$1,200	$4,800
Lodging (Lima Hotel)	4 weeks	$1400 / week	$5,600
EXPENSES TOTALS			**$10,400**
OTHER COSTS	**LABOR**	**EXPENSES**	**TOTAL COST**
Post-Study Technical Briefing	$6,400	$3,000	**$9,400**
HARDWARE/SOFTWARE RENT / LEASE EQUIPMENT	**MONTHS**	**COST PER MONTH**	**TOTAL COST**
HARDWARE/SOFTWARE TOTALS	12	$6,475	**$77,700**
TECHNICAL STUDY GRAND TOTALS			**$465,500**

Map - Peruvian Offshore Basins



APPENDIX B

CONTENTS OF THE DIGITAL DATABASE

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CONTENTS OF THE DIGITAL DATABASE

The Digital Database for this study has been packaged onto a set of 11 DVDs that together hold slightly over 34 GB of data. The contents of DVDs 4,5,7,8,9,10 and 11 have been compressed using WinZip 9.0. **To successfully restore these Zip files (especially DVD-8), WinZip 9.0 or later must be used.** Once restored, the contents of the 11 DVDs are detailed below.

DVD-1: REPORT_ARCVIEW_MAPS_AND_WELL_DATA

- 1 - Final Report
- 2 - ArcView Interactive Map
- 3 - Maps
- 4 - Chronostratigraphic Charts
- 5 - Wells
- 6 - Composite Log Project
- 7 - Composite Log Exports
- 8 - Full Log Data Exports
- 9 - Tectonic Models
- 10 - Maturation Models
- 11 - Economics
- 12 - PARSEP
- 13 - INGEPET
- 14 - AAPG
- 15 - Calgary Promotion

This DVD contains 15 folders, as listed above. The Final Report folder contains all of the digital files that are necessary to reproduce all of the study results that have been delivered in paper form, including the Final Report, Figures, Basin Presentations, Appendices and Enclosures.

- Basemaps
- Map Data
- Peru Interactive Map.mxd

The contents of the ArcView Interactive Map folder are listed above. **ArcView 9.0 (SP2) or later** will be necessary to open the Peru Interactive Map. All of the geographic data layers in the Map Data folder, including the georeferenced maps from this study, are all linked to the Peru Interactive Map with relative path names.

Basin Outlines	HC Modeling
Bathymetry	Leads
Blocks	Magnetics
Coastline	Maps
Environmental	Seeps
Fairways	Seismic Navigation
Fields	Surface Geology
Gravity	Wells

The contents of the Map Data folder are shown above. They are all linked to the Peru Interactive Map, and were used to produce most of the map-based displays in the Final Report. The Map Data folder **must reside in the same folder** as the Peru Interactive Map in order to maintain these links.

Considerable effort was invested in producing the basemaps in Enclosures 1-5 with ArcView. The ArcView project files in the **Basemaps** folder correspond to these Enclosures, and can be linked back to the Map Data by moving them out of the Basemaps folder and into the same folder where the Map Data folder resides – again, to maintain the relative path name links to the data.

Returning to the root directory of DVD-1, the **Maps** folder contains all of the time and depth maps that were produced in this study. Most of the maps are available as 300 dpi GIF files. Some have been imported into individual PowerPoint presentations. Selected grids have also been exported as tab delimited files, and are included in this folder.

The **Chronostratigraphic Charts** folder contains a PowerPoint presentation that is a convenient accumulation of all of the charts that were generated in this study, plus a few useful charts from other sources.

The **Wells** folder contains all of the well-based displays that were produced in this study, including the detailed completion logs for the Trujillo basin wells, the Pisco 4-X well, and the 10 ODP wells. The Composite Log Project folder contains the Seismic Micro-Technology (SMT) Kingdom Suite project that was used to produce the composite log displays. **Version 7.5 or later of The Kingdom Suite** software will be required to access this project. **The Composite Log Exports** folder contains ASCII file exports of the contents of this SMT project. The last of the well-related folders on DVD-1, the **Full Log Data Exports** folder, contains ASCII exports of all of the well-related data from the two main SMT projects – one for the Trujillo, Salaverry, Sechura and Pisco basins, and the other for the Tumbes and Talara basins. These two SMT projects are also incorporated into the Digital Database in DVDs 4 and 5.

The **Tectonic Models** folder contains the final project files that were used to generate the balanced and restored cross sections in this study. The software employed for this modeling is called LithoTect. Further detail about this software is available at www.geologicsystems.com.

The **Maturation Models** folder contains the final project files that were used to model hydrocarbon maturation and expulsion. BasinMod software from Platte River Associates was employed for this task. More information about this software is available at www.platte.com.

The **Economics** folder contains further detail supporting the illustrative economics that were performed on twelve "type discoveries" in this study. GeoX software from GeoKnowledge was used to model success volumes and cashflow. These results were exported from GeoX

into MS Excel. The GeoX project and the Excel files, plus other supporting information, are included in this folder. Further detail about GeoX can be found at www.geoknowledge.com.

The **PARSEP** folder contains reports on the Trujillo and Salaverry basins, which are vital precursors to this study, and are recommended reading for those who are seriously interested in exploring these basins.

The **INGEPET** folder contains a copy of a paper that summarizes the results of this study that will be presented by Dr. Peter Emmet in Lima in November 2005 at the INGEPET conference. The **AAPG** folder contains a digital copy of the poster that Dr. Robert Hickman will present at the AAPG Annual Convention in Calgary in June 2005, which also summarizes the results of this study. Lastly, the **Calgary Promotion** folder contains a copy of the presentation that Dr. Hickman will give at the promotional event scheduled by PERUPETRO in Calgary on June 21, 2005.

DVD-2: SEISMIC_SECTIONS _DEPTH

As the title suggests, this DVD contains 259 300-dpi JPEG files of the depth-converted and interpreted seismic sections that were produced in this study. These displays are readily viewable with Microsoft Office Picture Manager in the Office 2003 suite, or comparable picture-viewing software. These files average about 15 MB each. It is therefore advisable to view these files on a computer with adequate RAM (typically 512 MB or greater).

DVD-3: SEISMIC_SECTIONS _TIME

The contents of this DVD are similar to DVD-2, but are the time-domain displays of the framework interpretation prior to depth conversion. The same recommendations apply for viewing these 15 MB 300-dpi JPG files.

DVD-4: SMT PROJECT_TRUJILLO-SALAVERRY-PISCO

This DVD contains a Zip file that holds a compressed version of the SMT project that covers the Trujillo, Salaverry, Sechura and Pisco basins. As mentioned previously, WinZip 9.0 and SMT The Kingdom Suite 7.5 or later are required to extract and use this project. A seismic workstation-grade PC computer is also required, with at least 1 GB of RAM, and a 40 GB or larger hard drive.

DVD-5: SMT_PROJECT_TALARA-TUMBES

This DVD is similar to the previous one, except that the SMT project on this disk covers the Tumbes and Talara basins. The same software and hardware requirements apply.

DVD-6: HORIZONS_FAULTS_AND_DEPTH_CONVERSION

This DVD contains two general types of data. First, there are ASCII exports of the horizons and faults, both in time and depth, from the two SMT projects on DVDs 4 and 5. The second data type includes all of the final project files that were used to execute the depth conversion with a software package called VelPro that is available at www.in-depthsolutions.com.

DVD-7: SEG-Y_SEISMIC_TIME_TRUJILLO-SALAVERRY-PISCO

This DVD contains SEG-Y exports of all of the time-domain seismic lines in the SMT project that covers the Trujillo, Salaverry, Sechura and Pisco basins and has been zipped and copied to DVD-4. The seismic navigation has been embedded in the headers of these SEG-Y files to ease loading into other workstation software. Note that the map coordinate system used for the entire study was WGS-84, UTM 17S.

DVD-8: SEG-Y_SEISMIC_TALARA-TUMBES

This DVD contains the zipped SEG-Y exports of all of the seismic lines (both time and depth) in the SMT project that covers the Tumbes and Talara basins and is on DVD-5. The same details apply for this data as for DVD-7.

DVD-9: SEG-Y_SEISMIC_DEPTH_TRUJILLO-SALAVERRY-PISCO 1993

The contents of this DVD are similar to those of DVD-7, but these are exports of the depth-domain SEG-Y data in the SMT project on DVD-4. However, not all of these lines would fit on one DVD, so the contents of this DVD are limited to the SEG-Y exports of the Ribiana 1993 seismic survey, with the exception of those Ribiana 1993 lines that are on DVD-11.

DVD-10: SEG-Y_SEISMIC_DEPTH_TRUJILLO-SALAVERRY-PISCO 1996

The contents of this DVD are similar to those of DVD-9, except that these are exports of depth lines from the 1996-vintage infill lines in the Trujillo basin that are part of the SMT project on DVD-4.

DVD-11: SEG Y SEISMIC DEPTH TRUJILLO SALAVERRY PISCO 1993 LONG

This last DVD contains the depth-domain exports of the following lines:

93-30_z.sgy
93-36_z.sgy
93-37_z.sgy
93-38_z.sgy
93-39_z.sgy
93-40_z.sgy
93-41_z.sgy
93-42_z.sgy
93-43_z.sgy
93-44_z.sgy
93-45_z.sgy
93-66_z.sgy
93-67_z.sgy
93-68n_z.sgy
93-68s_z.sgy
93-69n_z.sgy
93-69s_z.sgy
93-70_z.sgy

This is a collection of especially long lines that would not fit on DVD-9.

APPENDIX C

GEOLOGICAL BACKGROUND

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1. PERU CONTINENTAL MARGIN

INTRODUCTION

In the course of the Nazca Plate Project of the mid- to late 1970's, Thornberg and Kulm (1981) identified approximately 10 fore-arc basins along the upper slope and shelfal to onshore areas of the Peruvian continental margin. From north to south these are the Tumbes-Progresso, Talara, Sechura, Trujillo and Yaquina, Salaverry, Lima, West and East Pisco, Mollendo and Moquegua basins respectively (see Figures C-1 and C-2). The offshore portion of the Talara basin represents about 85% of its total basinal acreage and its shallow nearshore and coastal inland encompasses most of the basin's production, which dates back to the late 19th century. The deeper offshore Talara basin has not yet yielded a major discovery. Although a number of promising shows have been documented, there is no production from this part of the basin. The Talara basin is one of the very few basins with giant fields (>500MBO) in a convergent tectonic setting worldwide. The La Brea (Parinas) field is estimated to have an ultimate recovery of 1 billion barrels of oil (Bbo) and 15 trillion cubic feet (Tcf) of gas.

The adjacent Sechura basin to the south-southeast of the Talara also lies mostly onshore and although some wells have been drilled, it is greatly underexplored. Similarly, the Moquegua basin in the far south of Peru lies entirely onshore. Of this latter basin little is documented or known in the project data base and it is not further studied for this report. The small Yaquina basin lies west and downslope from the Trujillo basin and may be considered a deeper-slope satellite of the Trujillo. Because of the Yaquina basin's greater water depths, its hydrocarbon potential also has not been further analyzed for this study, although its structural style and position has been analyzed within the framework of understanding the spatial and temporal structural and tectonic history of the Trujillo basin (Thornberg and Kulm, 1981; Suess and von Huene, R., et. al., 1988). Similarly, analysis of the upper slope Lima basin in terms of hydrocarbon prospectivity also has been excluded from this study, although some of the seismic coverage across the continental shelf does extend into the Lima basin and has been used to better understand the regional framework (Miller, et. al., 1986).

Strictly speaking, it should be noted that the Peru offshore basins are not true fore-arc basins as they are not associated with an accompanying volcanic arc system, like for example farther north in Central America (e.g. Costa Rica, Nicaragua), or the complex volcanic terranes of the Sunda arc in Indonesia with numerous giant fields. A more appropriate term is shelf and slope basin in a convergent continental margin setting, with complex strike slip faulting and episodic cycles of uplift and subsidence related to oblique subduction of the Nazca Plate under South America.

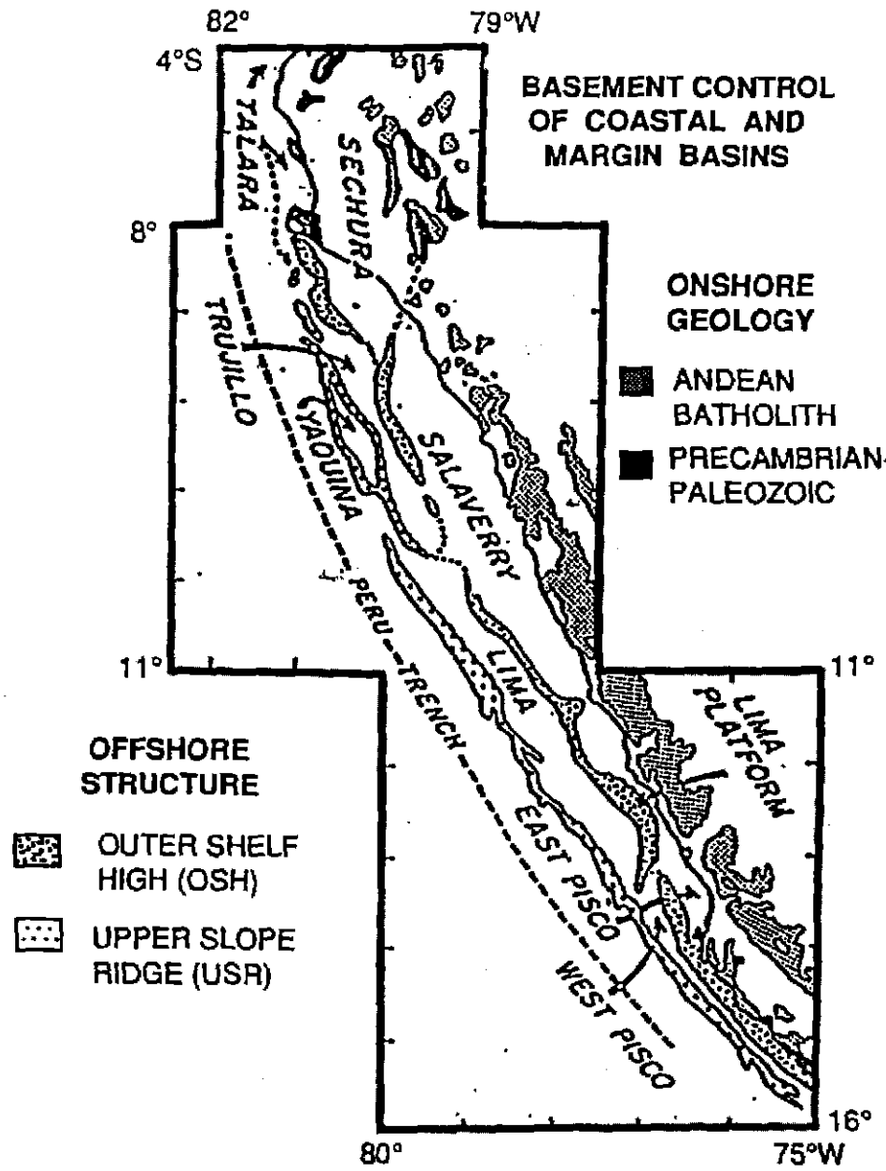

Figure 1.5 MAJOR CONTINENTAL SHELF AND UPPER SLOPE BASINS, AND THE ONSHORE - OFFSHORE STRUCTURES THAT CONTROL THEIR DISTRIBUTION

Thornburg and Kulm (1981)

Figure C-1: Shelf and Upper Slope Basins of Peru

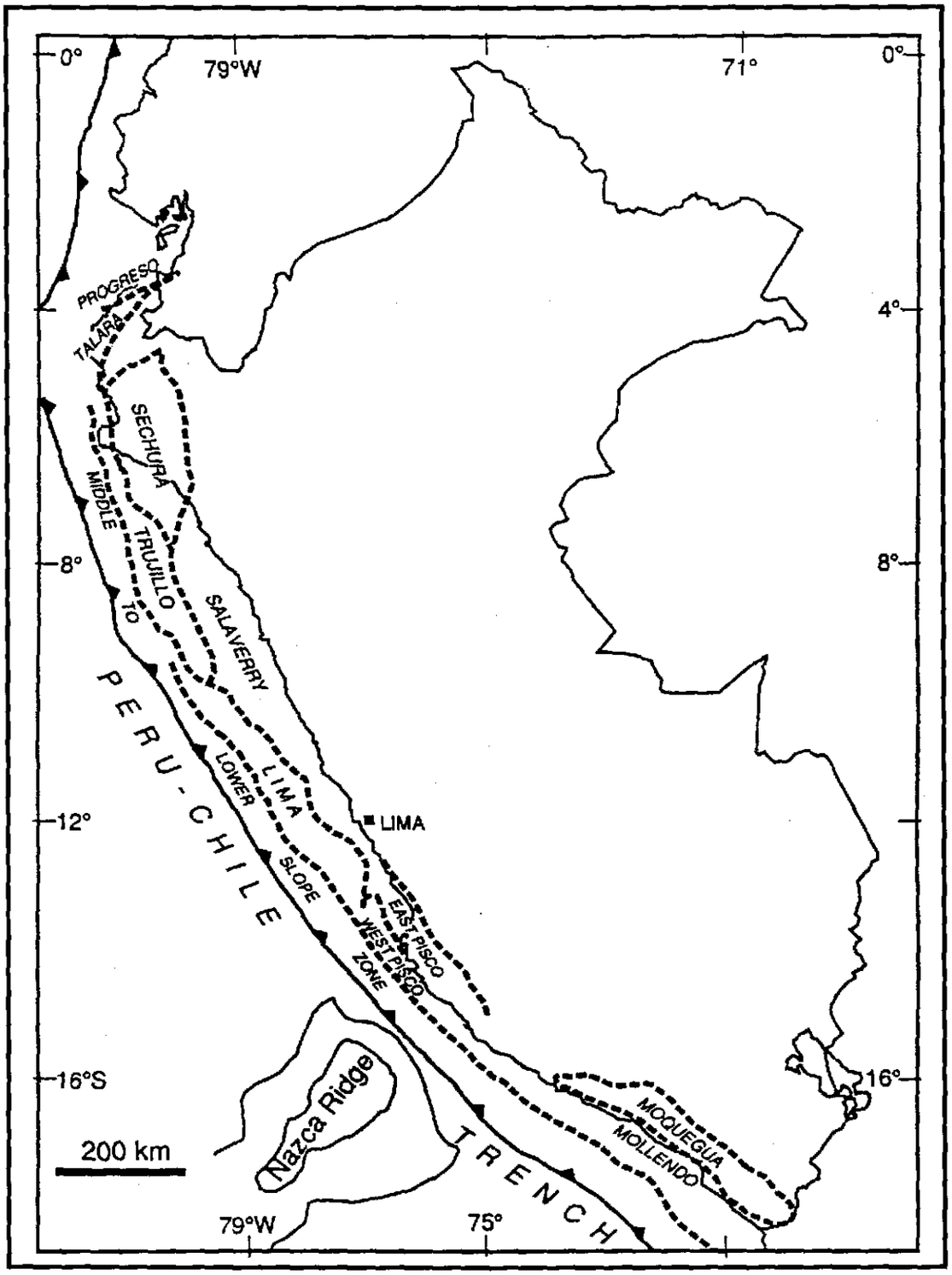

Figure C-2: Alternative Basin Map Showing Location of Moquegua Basin

Compared to the Talara and Tumbes-Progreso basins farther north, well coverage along the offshore continental margin of central and southern Peru is sparse to nil. The well coverage that exists is of an uneven distribution (see basemaps in Enclosures 1-5 for locations). Aside from the ten Ocean Drilling Program (ODP) sites drilled in the course of ODP Leg 112 in 1986 and for wholly different objectives, international oil companies have drilled only four other wells in the southern offshore basins. The ODP wells sample two transects across the margin, the northern corridor near 9°S off the central Peruvian coast with three wells (Sites 684, 683 and 685 from shallow to deepest respectively), and the southern corridor at @ 11°S with five wells (Sites 681, 680, 679, 682 and 688 from inner shelf to upper slope). Two further ODP wells are drilled in the east and west Pisco basins respectively, Sites 687 and 686. Of the four exploration wells drilled by oil companies, two of these, the Delphin-1 and the Ballena-1, were drilled in 1970 by Occidental on seismically poorly defined locations in and on the eastern flank of the southern Trujillo basin. The other two exploration wells, the Lobos-1X and Morsa-Norte-1X, were drilled by Repsol in 1995 in the northern and central part of the Trujillo basin respectively, their locations based on more extensive 2-D seismic coverage shot in 1993. No wells have been drilled within the Salaverry, Yaquina, Lima, the offshore part of the Pisco, and the Mollendo basins.

Data from several onshore wells are available. The most important of these is the Pisco-4-X-1 well, drilled in 1953 by IPC. It lies to the east of the regional right-lateral strike-slip Cerritos Fault, penetrating an upper Tertiary section that unconformably overlies Cretaceous rocks. The well did not have any shows or an indication of potential reservoir rocks. The Inca-5-1-1 well lies in the southern onshore Sechura basin about 60 km to the east-southeast of the Bayovar Peninsula. It was drilled in 1956 and encountered Upper Eocene sandstones unconformably overlying igneous basement. Reportedly some oil shows were encountered in the Inca well, but no such details have been found. Several other wells farther north in the onshore Sechura basin all show Tertiary sediments on top of basement, some with shows. All other onshore source and reservoir rock work has been done in field work and on outcrop samples.

2. PROJECT DATA BASE

An extensive data base was obtained from PERUPETRO, which included both raw data and numerous proprietary and published reports. Understandably, by far the major part of these data and information cover the northern basins of Tumbes-Progreso, Talara and Sechura, and the inland Lancones basin east of the Tumbes and Talara basins. The latter is the region of long-time established production and consequently a considerable exploration effort has been done toward finding new resources in this proven petroleum system. Much less information exists for the southern basins (Trujillo, Salaverry, Lima, Pisco, and Mollendo). Exploration activities have been uneven and intermittent, and only span the past 40 years.

Raw Data from PERUPETRO

The raw data available for the project consisted of:

Seismic Data – in the form of post stack processing through migration, in SEG-Y format on tape and selected hard-copies. Some low-fold multi-channel seismic was probably shot for the Ocean Drilling Project site surveys and would be available if requested. However, these data probably are not of the quality of the existing exploration seismic. Thus far, no 3-D seismic survey data has been gathered in any of the southern basins. The absence of any 2-D onshore data along and inland from the Peruvian coast does not make it possible to tie the sparse onshore wells to the offshore geological framework established in this report.

Of the 2-D data (see basemaps in Enclosures 1-5 for locations), the 1993 Ribiana seismic is the only regional survey that extends from the far northern Tumbes basin south over the shelf and upper slope of most of the Peru margin. These data are of fair to good quality, with an approximate overall grid spacing of 15 x 15 kilometers (kms) in the north that becomes wider south of the Salaverry basin and into the Pisco basin. This survey formed the backbone of the new interpretation framework. All of the lines were used, except for 93-65, for which no usable trace data could be loaded.

Repsol completed two additional infill 2-D seismic surveys over the Trujillo basin in 1996 and 1998. Most of the 1996 survey lines were used to supplement the Ribiana 1993 regional grid. However, only one of the 1998 lines (lo98-10b) was used, to help tie the Lobos-1X well to the interpretation grid. The 2-D data shot by CGG and Delta in 1973 and 1982 was also provided, but was not required for the interpretation grid for this study.

The 2-D seismic data contains RMS stacking velocity information across the section headers for each line and a pre-selected data and line shotpoint grid of this seismic data has been used for the construction of depth structure maps and geologic cross sections. However, the very complex spatial and temporal structural and stratigraphic framework of the shelf and upper slope constructed in this and in many previous studies, as well as the few well data locations, suggest that lateral and vertical velocity changes throughout the accumulated sediment packages are highly likely. Furthermore, due to project time constraints, a rather coarse seismic shotpoint velocity grid had to be selected in the feasibility study of attempting regional depth conversion of the time maps. Therefore, the resulting depth maps and cross sections can only be considered as preliminary. Much additional work must be done ahead of the drill bit.

Navigational data was also included on the seismic tapes. Considerable effort was expended in reconciling the navigation with the SEG-Y traces. The long strike lines in the Ribiana 1993 survey were particularly troublesome.

Well Data – As mentioned above, exploration well data is sparse, with only four offshore exploration wells, all of which are in the Trujillo basin or on its flanks (see Enclosure 3 for locations). The log data for these wells was made available on tapes in LAS format.

A certain amount of interpretation of the log data from the four exploration wells can be found in the reports and documents in the data base. The reports done by Repsol, Yukos, Petro-Tech Peruana and Hunt Peru in the course of their exploration activities, as well as in the two PARSEP reports that are included in the data base, have proven to be quite useful and informative documents.

The data sets for the two onshore wells previously mentioned, the Pisco-4-X-1 and Inca-5-1-1, were rather incomplete. Most of the information from these wells has been gleaned from cryptic comments in company reports and field studies.

In spite of the large volume of well data provided, no comprehensive composite logs could be found, which would clearly summarize and enable correlation of key well logs, interpreted tops, seismic ties, lithology and hydrocarbon show descriptions, cored and tested intervals and geochemical analyses. To fill this gap, a significant effort was expended in this study in the construction of composite logs for the four Trujillo wells, Pisco-4-X-1 and the 10 ODP wells. Further detail about the well data used in this study can be found in Appendix D – Well Details.

Information in Reports, Published Articles and Public Domain

None of the OPD Leg 112 information was included in the PERUPETRO data base, but this is available in the public domain. For the ODP wells the published report proceedings were acquired. Although these reports contain very little raw data, the comprehensive summaries and interpretations of the collected data, including detailed core descriptions and interpretation, detailed micro-paleontogical data and biostratigraphic summaries, and some geochemical data and results are very useful and informative. The focus of the ODP geochemistry is more on evidence of diagenesis in the sediment column, rather than on hydrocarbon geochemistry and typing. Therefore, little information is available on source rocks and such.

In the course of the data gathering effort, many CDs were made available to GCA from which to build the project data base. All of these CD's were subjected to review with respect to their contents and to obtain insights into the nature, size and completeness of the data base.

In the course of this review, the problems of working with this data base were recognized, which have been briefly summarized in the section entitled, "Data Base Observations" below.

Of the many reports and documents in the data base, the two PARSEP reports on the Salaverry and Trujillo basins proved to be particularly useful for their scope and contained information.

It was noted, however, that the results of the PARSEP reports have not been integrated into the PERUPETRO database spreadsheets and maps as to the information and contribution they bring to the offshore knowledge of Peru. In part this may be due to:

- The PARSEP studies, although very good and geologically informative, need to be transformed from their academic style to basin/block summaries that focus on prospectivity assessments.

- Conversely, the PARSEP studies do not appear to include all or part of the "potential reserves" estimations arrived at by PERUPETRO.
- In the PARSEP Trujillo basin study, for example, only a select few of Perupetro's listed prospects appear to be included.

Data Base Observations

As received from Perupetro, the following observations regarding the database and the ease of its use have been made:

- As a whole, the data were provided as a vast collection of files, with little accompanying information to help organize this collection and judge the relative importance of each file.
- In particular, many of the digital file names contained only the Data Bank identification number. The descriptive information in the Data Bank spreadsheets under these identification numbers was insufficient to understand the actual contents of the files, which made it necessary to open them individually. This was a very time-consuming process.
- For some reports and document files, key figures and appendices are referenced in the text, but could not be readily found in the data base.

In summary, a very large amount of information is available for studies like this, but is not organized to easily facilitate the work. It is therefore very important to ensure that the digital results and physical reports contained herein are effectively integrated back into the Data Bank, so that future workers can continue building on this foundation. This is especially true for the seismic navigation and trace data, in which there are several man-months of painstaking quality control invested.

3. BASIN STRATIGRAPHY

The literature is rich in papers that deal with the geological history and evolution of the tectono-stratigraphic framework of the Peru-Chile trench in general and the Peru continental margin more specifically (Kulm et. al., 1981; Schweller et. al., 1981; Couch & Whitsett, 1981; Jaillard, 1994; Jaillard et.al, 1995; Vega-Guzman, 2003). These publications and studies mostly go into various levels of detail regarding regional margin structure and stratigraphy and only rarely deal with the offshore basins in any other detail, due to the general lack of public domain information on the exploration wells and seismic data. Therefore, for the purpose of this report only much-abbreviated summaries have been completed on the most important basins of the central and southern Peru margin.

Trujillo and Salaverry Basins

These basins are the northernmost of the central Peru margin and they are here discussed together. Based on the interpretation of seismic and regional geological data they appear to be closely related genetically with respect to their structural and stratigraphic evolution, notwithstanding some significant differences between them.

The PARSEP reports on the Salaverry and Trujillo basins do not detail the pre-Cenozoic history of these basins, mainly because of the long-standing perception that economic basement in these basins is Paleozoic to Mesozoic age, and is represented by a major unconformity at the base of the Cenozoic section that extends across the entire span of the two basins. This perception arose partly because of the poor quality of pre-1990 seismic, which severely limited any sub-unconformity imaging. However, the geochemical signature of the offshore oil seeps in the northern part of the Trujillo basin (see Figure 7[1] or Enclosure 3 for seep locations) indicate these are probably sourced from Mesozoic (lower Cretaceous?) source rocks (Muerto Formation?) and are similar to oils in wells from the onshore Talara and Portachuelo fields father north. These data are suggestive of the existence of a generative petroleum system below the historically defined economic basement event. The other reason for this lack of understanding of the early history lies in the limited well control. Representative rocks for the offshore pre-Cenozoic history can best be found and studied in onshore outcrops. The results then have to be extrapolated and projected for a considerable distance westward.

A further dilemma is presented in the apparent differences in basement between the north and south sectors of the Trujillo-Salaverry basins, as summarized in the PARSEP reports, and that a significant structural, roughly NE-SW trending, suture may be the cause of this difference. North of the suture, the basement rocks consist of highly metamorphosed igneous intrusives of varied lithologies, which have no equivalents with the rocks of Andean affinities to the east and south. The basement rocks south of the suture are slightly metamorphosed volcaniclastic assemblages and intrusive batholiths. These different basement characteristics have been taken as key evidence for the accretion of an allochthonous terrain onto the continental margin of northern Peru in late Cretaceous to early Tertiary time, which has left its mark on the evolution of the Tumbes-Talara-northern Sechura basins. The distribution of different basement types has been reinterpreted for this study, and is shown in Enclosures 6 and 14.

Salaverry Basin Specifics

In outcrops onshore of the eastern flank of the Salaverry basin, the oldest rocks are schists, slates and phyllites of the Proterozoic Olmos complex. These are unconformably

[1] The figures and enclosures referenced in this Appendix C are those contained in the main body of the Final Report. Figures that are embedded in the text of this appendix are numbered with a "C" prefix, e.g. Figure C-1.

overlain by a series of quartzites and sandstones with thin argillites of the Lower Paleozoic Naupe Formation. Directly overlying the Paleozoic rocks are the carbonates and calcarenites of the Upper Triassic La Leche Formation. The Mesozoic rocks span the interval from the Upper Triassic to the Upper Cretaceous and can reach up to 6,000 m in thickness of sandstones, argillites and shales interbedded with volcanics, andesites and rhyolites. The upper Jurassic Chicama Formation, composed of mainly black shales with interbedded sandstones, siltstones and dark limestones, is one of the main intervals of sedimentary rock that may have both source and reservoir potential. Outcrop data suggests that in the offshore these are both overmature and too tight respectively. However, the maturation modeling done in this study suggests the opposite – that the Cretaceous is not overmature. See Appendix I for more for more detail. The late Cretaceous Casma Formation tops the Mesozoic succession with a thick series of pyroclastics and interbedded andesites, rhyolites and submarine basaltic rocks.

Interpretation of the seismic data suggests that this entire pre-Cenozoic section extends well into the offshore and can be traced to underlie the width of the shelf and upper slope as far out as the Yaquina basin in water depths of more than 500 meters.

Overlying the Mesozoic rocks is a thick Cenozoic section that comprises Miocene to Plio-Quaternary sediments in the Salaverry basin and Paleocene to Plio-Quaternary sediments in the Trujillo basin.

For the Salaverry basin, fine-grained sandstones interbedded with silty limestones and mudstones lie at the base of the Neogene (Lower Miocene) sediment package, which higher up in the section turn into predominantly dolomitized limestones with interbedded sandstones, siltstones and mudstones. This is evidence for an upward deepening sequence. These sediments also have a relatively high Total Organic Carbon (TOC) content. The middle Miocene is represented by micritic dolomitized limestones with interbedded silty limestone and generally fine grained sandstones. These sediments contain abundant and generally well preserved microfossils. The overlying Upper Miocene to Pliocene sediments are comprised of mostly siltstones to sometimes coarse sandstones interbedded with brown limestones. These facies are thought to represent open shelf to shallow near-coastal environments. Sediment bypass across the inner to middle and outer shelf is evident from the seaward thickening wedge of clastic and hemipelagic sediments of Plio-Quaternary age that tops the Neogene sediment column and which becomes dominantly fine grained pelagics at the outer shelf and upper slope. Once across the shelf edge and onto the upper and middle slope, this wedge thins rapidly.

Trujillo Basin Specifics

Unlike in the onshore of north central Peru and in the Salaverry basin with their volcaniclastics and andesites of the late Cretaceous Casma Formation, in the Trujillo basin the late Cretaceous Campanian-Maastrichtian sequences are interbedded claystones, sandstones and conglomerates with interbedded silty claystones. These lithologies are supported by the results of the four wells drilled in the basin (see Appendix D for details). For the Campanian, these represent a general and subtle fining upward sequence, while for the Maastrichtian it is more a coarsening and thickening upward sequence. Overall, the Campanian through Maastrichtian sequence is thought to represent deposition from outer shelf to upper slope environments and sediment transport by shelf and slope currents, as well as mass wasting of sediments, i.e. by sediment gravity flows.

With the onset of the Tertiary, the sediment succession of claystones, sandstones and conglomerates strongly suggests continued transportation and deposition through various sediment gravity flow processes wherein deposition by trans-shelf and downslope turbidity currents becomes the dominant process. By early Eocene times, hemipelagic sediments

become more prevalent, with interbedded coarse-grained sediments, indicative of hemipelagic sedimentation at the shelf edge and/or upper slope with intercalated coarse sediment deposition from turbidity currents. Sedimentation of dominantly fine grained hemipelagic and pelagic material continued through the middle and upper Eocene across the outer shelf and the upper slope. The organic content in these predominantly biogenic sediments is surprisingly low, which suggests that the water masses impinging on the slope and shelf were quite well oxygenated. A thin Oligocene section may be present in the basin, based on very limited micropaleontologic data from the Lobos 1-X and the Delfin 1-X wells.

Interpretation of the Ballena-1-X, Delfin-1-X and Morsa-1-X wells, and the ODP wells, documents a pronounced erosional unconformity at the base of the Lower Miocene, which coincides with the world-wide reported Late Oligocene eustatic drop in sea level. This unconformity can be clearly tracked on seismic across the Peru margin. The Middle Miocene sedimentary interval is generally represented by fine-grained sandstones interbedded with silty limestones and mudstones and calcareous mudstones. Iron nodules occur in the lower part of the section. Calcareous sandy mudstones with high pyrite contents are encountered in the Morsa Norte 1-X well. These observations indicate that anoxic conditions probably existed at the sea floor at this time. The entire Lower Miocene interval is suggestive of an upward deepening sequence, which further supports the interpretation of anoxic bottom-water conditions.

Middle Miocene sediments are encountered in three of the Trujillo basin wells – the Ballena 1-X, the Delfin-1-X and in the Morsa Norte 1-X. Micritic dolomitized limestones are interbedded with fine to medium grained sandstones and silty limestones. Calcareous microfossils are abundant and provide good biostratigraphic age control.

The Upper Miocene to Pliocene sediments generally comprise a spectrum of siltstones to fine and coarse sandstones with interbedded micritic limestones, and which are indicative of a high energy environment of cross shelf and slope sediment transport. The low fossil content and poor preservation corroborates rapid transportation of the sediments. The Pliocene-to-Recent sediments occur as a westward prograding wedge onto the outer shelf and upper slope, where this package thins rapidly and pinches out.

Lima Basin

The Lima basin lies south of the Trujillo basin along and parallel to the outer shelf and upper slope of the south central Peru margin. The continental shelf here narrows considerably. The Lima basin lies in water depths between 500 to 2,000 meters. The basin is poorly studied and, except for the two ODP wells (Site 679 on its eastern flank in the north and close to the southern end of the Salaverry basin, and Site 687 in the far south and near the East Pisco basin) is undrilled. Seismic data coverage is sparse.

Like for the Salaverry basin, the deeper subsurface stratigraphic interval is surmised based on the extrapolation of onshore field work. It is thought that the base of the basin's stratigraphic section is comprised of thick (over 2,000 m) intercalated volcaniclastic and sedimentary rocks of the upper(?) Jurassic to lower Cretaceous Punta Piedra Group. Overlying these is a thick section of lower Cretaceous siliciclastics of the Morro Solar Group, which encompasses the Salto del Frayle, Herradura and Marcavelica formations. These in turn are overlain by over 1,000 meters of the Valenginian-Hauterivian and Aptian-Albian limestones with interbedded claystones and marls of the Pamplona and Atocongo formations. The Mesozoic interval is capped by well over 1,000 meters of Albian-Cenomanian volcaniclastics and siliciclastics of the Casma Group.

A major angular unconformity separates the Cretaceous from the upper Tertiary sediments. The ODP well 679 recovered middle Miocene sediments where it bottomed at 360 meters depth below the sea floor. Well site 687 bottomed in Pliocene sediments at 200 meters depth. Based on site surveys carried out prior to the drilling of the ODP Leg 112 sites, as well as from the 1993 Ribiana 2-D seismic, an estimated 1,200 meters of Miocene and younger sediments have accumulated in the Lima basin. Small normal faults occur on the flanks of the basin.

East and West Pisco basins

The East and West Pisco basins lie across the narrow continental shelf and upper slope of the south central Peru margin more than 100 km south of Lima and extend for about 300 km southward and parallel along the continental margin. The East Pisco basin straddles the coastline, with its western half overlying the continental shelf and its eastern part extending southward for several hundreds of kilometers onshore. The West Pisco basin lies mostly south and seaward of the East Pisco basin in water depths of up to 1,000 meters.

The East Pisco basin has been the subject of field work starting in the early 1950's and its single exploration well, the Pisco-4X-1 was drilled onshore in 1953 by IPC. The results of this well were not encouraging and exploration interest waned in the ensuing decades. In the late 1990's a resurgence in exploration interest in the basins led to several Technical Evaluation Agreements (TEAs) between PERUPETRO and oil and gas companies, i.e. with Petro-Tech Peruana for two offshore blocks in the northern part of the East Pisco basin, a TEA with Hunt Peru Exploration in an onshore block of the southern part of the East Pisco basin, and yet another TEA with YUKOS for four offshore blocks from the southernmost Lima basin into the northern West Pisco basin. No exploration wells have been drilled in the offshore basins. ODP site 687 is just northwest of the northern end of the East Pisco basin and more in the southernmost Lima basin. ODP site 686 is located on the upper continental slope in the northern part of the West Pisco basin. Neither site reached significant depths, with the oldest recovered sediments of Pliocene age.

The Pliocene-Quaternary sediments in the ODP sites are mostly laminated and heavily bioturbated diatomaceous muds with some thin and fine-grained sand intervals in the Pliocene section that are typical for deposition in a shelf edge to upper slope setting in a high productivity upwelling zone.

Similar to the other offshore basins, the pre-Cenozoic stratigraphic column of the Pisco basins is derived from onshore outcrop and field studies. The base of the column is represented by the Proterozoic Basal de la Costa Complex that consists of metamorphic suite of gneisses, schists and amphibolites, which are unconformably overlain by recrystalized limestones and dolomitized marbles of the Cambrian Marcona Formation. An angular unconformity cuts across the Marcota Formation, which is overlain by several hundred meters of the continental deposits of the Carboniferous Ambo Formation. The Ambo sedimentary rocks contain carbon-rich high TOC interbeds with abundant and well preserved fossil plant remains. The Ambo is seen as a likely source rock for the region. The Ambo formation is overlain by limestones interbedded with claystones and fine-grained sandstones of the Permian Copacabana Formation. A major angular disconformity separates the Paleozoic from the overlying Mesozoic rocks. A thick (± 2,000 meter) sequence of volcanics and pyroclastics intercalated with limestones, sandstones and quartzites of the Jurassic Chocolate and Guaneros formations form the basal part of the Mesozoic column. The Jurassic volcanics are overlain by the lower Cretaceous Yura Group, which is composed of quartzitic sandstones interbedded with siltstones and mudstones. Another pulse of andesites and pyroclastics with interbedded sandstones, limestones and volcanic breccias represents the Copara Formation of

Aptian to Albian age. These in turn are overlain by dark limestones, marls and calcareous siltstones of the Albian Portachuelo Formation. The latter is considered as having source rock potential next to the rocks of the Ambo Formation. Another major angular unconformity separates the Cretaceous from a thick section of overlying Cenozoic sedimentary rocks. Shallow to deep marine clastic and biogenic sediments of the Eocene Paracas Formation, the Oligocene Caballas Formation and the Miocene Pisco Formation encompass the bulk of the Tertiary interval. Well developed thick sandstones of Cenozoic age are thought to be rare in the Pisco basins, which significantly impacts the occurrence of potential reservoir rocks.

Mollendo and Moquegua Basins

The onshore Moquegua and offshore Mollendo basins lie in the far south of Peru. No wells have been drilled anywhere near these basins, and seismic coverage is sparse.

The Mollendo basin lies entirely along the outer continental shelf and upper slope of the Peru margin. The lithostratigraphic column of the Mollendo basin is thought to be rather similar to the one for the Pisco basins, in particular for the Proterozoic, Paleozoic and Jurassic to lower Cretaceous (i.e. Albian).

The perception is that any hydrocarbon potential in the Molledo basin is to be found in water depths of 200 meters or more, where thin turbiditic sandstones of Tertiary age may present the best chance for reservoir properties.

4. BIOSTRATIGRAPHY

The comments below are based on biostratigraphic information available in the project database that primarily focuses on work performed on four exploration wells and ten wells in the ODP Leg 112 report, sparse information on the single onshore Pisco-4X-1 well, and summaries of paleontologic work on outcrop samples contained in several field trips reports along the coastal areas of central and southern Peru. No actual samples from either the onshore or the offshore were available for examination and analysis for this study.

The details regarding the biostratigraphic reporting in the PERUPETRO database are limited, and that most of the available biostratigraphic information has already been extracted from well summaries, various geologic-stratigraphic and sedimentologic reports, and other notes. .No raw data listings or reporting on raw data was found in the database. Thus, this review is based on the information contained in the evaluation and summary reports, as well as a few PowerPoint presentations.

Neither is there any clear mention on how samples have been chosen, treated and otherwise been prepared for examination and analyses. Similarly, it is also not known if the biostratigraphic reporting has been based on first occurrences only or if on both first and last occurrence, or if total faunal and floral assemblages from the samples have been studied. Commonly, just the reporting on the first occurrence of a species does not yield any useful or reliable information on paleo-environment and/or depositional setting. Similarly, the reported observation of a first – or last – occurrence of a species can be based on just seeing one specimen or on a number of specimens.

Comments on the preservation state of a microfossil can be useful to derive some information on the physical forces or chemical nature of the marine/non-marine depositional environment. This is of particular relevance to any biostratigraphy using planktonic and benthic foramanifera, and to some extent in the use of calcareous nannoplankton. For both planktonic foraminifera and calcareous nannoplankton, the effects of calcite dissolution in the oceanic water column and the depth of the calcite-compensation-depth (CCP) can have a significant effect on pre-burial preservation of the calcareous skeletons. Post deposition and burial diagenesis can significantly alter a microfossil's appearance. For example, the complete absence of these microfossils in sediments underlying highly productive offshore or mid-ocean water masses and the known locations in which these organisms commonly thrive, could suggest that these were either not a part of the shallow surface waters' biomass, or alternatively, that the CCP was at such shallow depths that all calcareous matter was completely dissolved from the settling microfossil death assemblages. In conclusion, the more pristine the preservation state of the microfossils or megafossils, the more reliable its proper identification will be.

From personal experience on several Deep Sea Drilling Cruises and its continuation as the ODP, the DSDP and ODP, reporting commonly is solid and follows the above outlined routines as standard procedures to ensure proper biostratigraphic analyses and reporting.

For the review of the biostratigraphic reporting on the four exploration wells in the Trujillo basin the master's thesis of Azalgara (1993) proved to be of great value for the review of the Ballena and Delfin wells. For the Morsa-Norte and Lobos wells, no such detailed information was available and only the summaries in the Repsol and PARSEP report on the Trujillo basin have been found. The well and biostratigraphic summaries in the PARSEP report on the Salaverry basin are identical to those in the Trujillo basin report.

The manner of reporting the biostratigraphy for the Morsa Norte and Lobos wells in the PARSEP reports, combined with the summaries for the Ballena and Delfin wells from Azalgara's

work, present a useful reference framework to the biostratigraphic analysis for the offshore basins.

Over the past 35 years, planktonic microfossils have provided an improved chronostratigraphy for many sedimentary basins in the world, stimulated in particular by the extensive work done on hundreds of worldwide drilled sites in the course of the Deep Sea Drilling and Ocean Drilling Programs along continental margins and in the open ocean basins. As a result, areas with sparse well coverage now is joined with much more confidence into a regional chronostratigraphic framework making sequence stratigraphy such an important tool in the unraveling of an area's complex tectonic evolution and its geologic, stratigraphic and sedimentological history.

Onshore Field Studies: Only cursory information on biostratigraphic dating methodologies and the fossil record is found in reports on the paleontologic analysis of outcrop studies, using both macrofossils (e.g. ammonites and cephalopods) and microfossils (e.g. benthic and planktonic foraminifera, radiolarians and diatoms, palynology). Both the dating techniques and paleo-environmental inferences appear to be sound, valid and fit into a reasonable stratigraphic and sedimentary framework that ties fossil occurrences into the established and accepted dating records. In some instances, similarities and affinities to floral and faunal assemblages elsewhere along the margin were noted, specifically for Cenozoic microfossil assemblages between the California borderland and onshore Peru in Monterey-like facies assemblages from Eocene through Miocene times. That such similarities ended in the Miocene may be related to the onset of the unique Peru continental margin upwelling zone as has been documented in the Nazca Plate study program and the ODP leg 112 project.

Offshore Studies: The most comprehensive and best well data and information are those from the Leg 112 ODP well sites with, for this report, well documented reporting on the preservation, as well as the presence and absence of the traditional key microfossil groups such as planktonic and benthic foraminifera, radiolarians, diatoms and silicoflagellates, and the calcareous nannofossils for the Cenozoic. The principal objectives of the ODP Leg 112 cruise in the study of these microfossils groups were: a) to reconstruct the paleo-oceanographic conditions of the Peru upper-slope basins in terms of the response of biological and sedimentary systems to fluctuations in intensity and the source of upwelling waters, gain insight into the changing paleo-oceanographic environments and history of the shelf and upper slope deposits in relation to the variations of biological and sedimentary, and b) to quantify biogenic and clastic fluxes for evaluating interactions among sea level, climate and oceanic circulation.

These objectives far exceed the biostratigraphic dating that is normally required and used and in the exploration for hydrocarbons. Nonetheless, the biostratigraphic datums yielded in the course of the ODP program proved to be very useful and applicable to the construction of the chronostratigraphic of the Peru margin. Notwithstanding that the ODP sites sampled mostly the upper Miocene to Quaternary sedimentary record, the quality and details of the ODP data provided a useful and solid biostratigraphic framework for the calibration of the biostratigraphic dating and paleo-environmental interpretation of the cored and sampled intervals on the four exploration wells in the Trujillo basin.

Based on the information in the Repsol reports on the Trujillo basin, the PARSEP Trujillo basin study, and the updated results for the Ballena and Delfin wells by Azalgara (1993), there is no reason to question the reported results without having had an independent look and analysis of the samples (raw samples or washed residues) from these wells. Thus, the datums and events reported in the Repsol and PARSEP reports for the four wells were accepted for this study and report.

5. SOURCE ROCKS

Because of the paucity of well data, detailed and reliable source rock data is scarce for the study area in question. More is known for the onshore northern basins of Talara and Tumbes-Progreso as result of the many wells for the region and the long history of production that reaches back over 100 years. A smaller number of wells have been drilled in the offshore-nearshore to middle-shelf waters.

For the East and West Pisco basins, for the Lima basin, as well as for the Mollendo and Moquegua basins in the far southern Peru margin, information on source rock occurrence and nature of source rock potential has to come by extrapolation from onshore outcrops and sparse onshore wells. The ten ODP wells and the four exploration wells father north from the East Pisco to Lima basins shelf to slope transect and transect again from the Salaverry to Trujillo basins, providing further information of variable detail and quality. However, little about the regions' source rock potential can be extracted from the ODP wells as the assessment for hydrocarbon potential of a basin or of an area commonly did not fall within the objectives of this program.

South Sechura Basin

Because the offshore portion of the Sechura basin extends to just north of the Salaverry basin, a brief look at Sechura basin source rock potential was deemed to be useful for possible extrapolation into the Salaverry basin. No well data has been found for this part of the Sechura basin causing any source rock evaluation to be based on the information from outcrop studies and from some onshore wells.

This quick assessment indicated that the Tertiary sediments in the Sechura basin do not have good source potential. Their preserved organic matter generally has a low TOC and the sedimentary section has insufficient burial depth.

There are also fine grained clastics from the Cretaceous Copa Sombrero and Redondo formations with poor to moderate organic carbon contents; these, however, appear to be over mature. Potential source rocks from the Jurassic Sábila and Chicama formations are reported to have good organic carbon contents. However, outcrop samples from these formations also register very high maturity indices, thought to be due to tectonic activity and igneous intrusives.

Therefore, the conclusion based on the onshore data is that source rock potential of the southern Sechura basin is very low to absent and that no hydrocarbon generation and migration into the Salaverry basin can be expected from the Sechura basin.

However, it would be a mistake to dismiss the source rock potential based on the onshore data alone. The seeps in the Trujillo basin provide hard evidence of an active petroleum system in the offshore. It seems reasonable to assume that similar source rocks could have accumulated in the southern Sechura basin, if depocenters of sufficient depth and areal extent could be found.

Fortunately, there appears to be a depocenter of sufficient depth. 1D maturation modeling was carried out at this location for this study, which concluded that there is a strong possibility of a mature Cretaceous source at this location. See the Salaverry-Sechura Basin Presentation and Appendix I for details.

Salaverry Basin

As has been commented upon earlier, the lack of any wells or seeps in the Salaverry basin makes any assessment of hydrocarbon potential and the presence of source rocks in the basin dependent on adjacent onshore outcrop and well bore samples, or conversely, on data from the Trujillo basin immediately adjacent to the west.

In the onshore east of the Salaverry, the Mesozoic rocks underlie the Tertiary sedimentary section very similar or analogous to what can be seen from the offshore seismic. Precambrian to Cretaceous metamorphic and sedimentary rocks and lateral equivalents of the Casma group, as well as of the Jurassic Chicama Formation, show high total organic contents, while geochemical modeling of the basement indicates that hydrocarbon generation and expulsion has occurred, but probably is now very mature to over mature.

In the May, 2001, PARSEP report, the earlier conclusions reached and presented by Repsol on the source rock potential of the Salaverry were confirmed during the course of the current study. These can be summarized as follows:

- The Lower Miocene and Upper Eocene source rocks are immature across the study area.
- A possible mature source rock, capable of producing significant volumes of hydrocarbons has to be, by analogy, those of the Lower Cretaceous Muerto Formation, the same that has been found to be the principal source rock in the Talara basin.
- In the absence of sourcing from the Muerto Formation, may have been sourced from the west, out of the active petroleum system in the Trujillo basin.

See the Salaverry-Sechura Basin Presentation and Appendix I for details about in-situ sourcing in the Salaverry basin, as well as the potential for migration from the Trujillo basin.

Trujillo Basin

Of particular interest to the hydrocarbon prospectivity of the Trujillo basin are the oil seeps that are known to the north of the Trujillo basin and roughly on trend with the strike of the basin. The larger oil seeps have been known since the earliest colonial days as the Spanish sailing ships ventured south along the Ecuador and Peru coasts. More recently, in the course of the geochemical surveys conducted as part of their Trujillo basin exploration work program, Repsol and subcontractors documented a number of other large seeps farther south on the western flanks of the Trujillo basin and upper slope of the Peru margin.

As a matter of fact, in a 1995 screening study of the northern Peru margin, Nigel Press & Associates (NPA) came to the conclusion that the northern Peru offshore contained among the highest density of oil slicks encountered anywhere in the world, and second only to those found in the Northern Gulf of Mexico.

In the PARSEP Trujillo basin study, an in-depth review and summary was presented of a number of critical geochemical studies on Talara basin oils, core samples and the known oil seeps in the region. These studies and reports, as they have been available in this project's data base, have been independently reviewed and cross checked for this report. It was found that the Repsol and PARSEP summations of this body of work were well done - accurately and objectively reflecting their contents and conclusions. Consequently, rather than repeating what has already been done, reference is made to the comprehensive summary in the PARSEP report.

Nevertheless, based on the results of the Repsol Trujillo basin final report and the summary in the PARSEP study, the following observations can be made:

- Signatures of the north Trujillo basin oil seeps indicate a predominantly Upper Cretaceous source rock for some of the seeps. Some of the oil seeps signatures are analogous to those of some of the Talara and Portachuelo fields in Talara basin. The Portachuelo oils have an API° 18-45, while Tertiary oils range between 8.5 to 59 API°.

- Gas chromatography results indicate a good relationship between the Lobos de Afuera oil seep in the northern part of the Trujillo basin and the La Breita seep in the southern Talara basin.

- The geochemical fingerprinting of the oil seeps as well as from crude oils in several of the Talara basin wells indicate that the southern Talara basin oils are sourced from a mixed organic facies of terrigenous and abundant algal facies, of apparent upper Cretaceous age, and less likely from an early Cenozoic basin facies.

- Oil geochemistry from an oil seep in the southern part of the Trujillo basin appears to be sourced from a mixed organic facies with substantial amounts of fine grained terrigenous organic matter deposited under anoxic conditions. This suggests a different source rock provenance compared to that for oil seeps in the north.

- No age determination can be made for this source rock, which could be of a local nature in a small isolated slope basin.

- The oils from the northern oil seeps are moderately mature.

The four exploration wells drilled into or on the flanks of the Trujillo basin were expected to provide the best evidence for source rock presence and quality in the Trujillo basin, supported by the results of the ODP transect just to the south of the Trujillo basin. As is briefly discussed below in the Pisco and Lima basin sections, the ODP wells only yielded marginally useful information on source and reservoir rocks because of their relatively shallow penetration and information recovery from the Tertiary sedimentary section.

Ballena-1X: This well, drilled on the southern part of the Salaverry high and not truly in the Trujillo basin, was drilled through a Pleistocene to Lower Miocene section into slightly metamorphosed basement at 963 meters below sea level (mbsl). The well bottomed at 975 mbsl. Undated coarse clastic sediments of possible Eocene age lie at the base of the well and on top of basement. No shows or any other evidence for hydrocarbons were found in the well.

Delfin-1X: The Delfin well was drilled to the west of the Ballena well on the eastern flank of the Trujillo basin and also bottomed in metamorphic basement at 2664 mbsl. The well penetrated a Pleistocene through Middle Eocene sedimentary section. Although no oil shows were found in the well, a number of gas zones were encountered in thin tight fractured dolomites of lower Miocene to Middle Eocene age.

Morsa Norte-1X: The well was drilled in the central Trujillo basin on a fault-controlled paleo-basement high where it encountered metamorphic and volcanic basement. Like the previous two wells, it penetrated a Quaternary-Pleistocene through Middle Eocene sedimentary section. A number of good oil shows were encountered throughout this well, the first ones at 280 meters in fine grained Upper Miocene sediments and down to 1180 meters in Middle Eocene in interbedded coarse clastics with claystones. The shallow oil shows were highly biodegraded heavy oil of type II/III kerogen. Oil typing indicated these to be from either early

Tertiary to possibly Cretaceous source rock. The presence of these oil shows convincingly demonstrates the existence of an active petroleum system in this part of the Trujillo basin.

Lobos-1X: The Lobos well was drilled in the northern Trujillo basin to test a large four-way dip anticlinal structure that proved the result of structural inversion in the Paleogene. The well bottomed at 2,215 mbsl in coarse to fine grained clastics with a high detrital clay matrix of lower Campanian age. A number of oil shows were encountered, beginning at 1,270 mbsl, in generally fine grained sandstones of Lower Eocene to Upper Cretaceous age, giving further evidence for the presence of a petroleum system in the northern Trujillo basin. The quality of the oil shows was disappointing, seen against the presence of high quality oil seeps farther north.

In summary:

- Based on oil seep analyses in the northern Trujillo and adjacent areas, the most plausible mature source rock is likely to be the Lower Cretaceous Muerto Formation. These rocks are known to be widely distributed and prolific source rocks driving the generation, expulsion and migration of hydrocarbons in the Talara Basin.
- The Muerto Formation has not been drilled (yet) in the northern Trujillo Basin or immediate contiguous area to the north and in the Salaverry basin.
- Should the Muerto Formation not be present in any of the deep troughs/sub-basins of the Trujillo, then the oils found in the seeps and in the Morsa Norte-1X well have to be attributed to generation from Upper Eocene source rocks in the deep troughs. If the Muerto Formation is indeed absent in and around the Trujillo basin, then the volume of the accumulated Eocene source rock may be limited to the available accommodation space and, which in turn, could negatively affect the quantity of hydrocarbons feeding the potential reservoirs.
- The differences in geothermal gradient between north and south of Trujillo may be due to differences between the north and south structure of the basin.

Pisco Basin

For the East and West Pisco basins, the most comprehensive information on potential source rocks and hydrocarbon geochemistry is to be found in the technical evaluation work done by Petro-Tech, Yukos and Hunt Peruana. These companies held several offshore and onshore exploration licenses (Blocks Z21 and Z22 in the offshore East Pisco Basin, and the TEA VII onshore) throughout the late 1990's and into the first years of the current decade. Yukos exercised its option on these basins by completing an evaluation study on the region's hydrocarbon potential and summarized their findings in a brief report, upon which they decided not to further pursue exploration rights.

East Pisco Basin

Aside from the reported results based on field outcrops, the single well in the onshore East Pisco basin, the Pisco-4-X-1, encountered an incomplete sequence of Cretaceous, Miocene and Pleistocene sediments. Well tests did not show any evidence for hydrocarbons and there was no indication for potential source rocks.

Initial observations from field work suggested source rock potential for the biogenic mudstones of the Miocene Pisco and upper Eocene and Oligocene Yumaque formations. Both, however, yielded low TOC values (generally well below 0.5 weight %). Furthermore, burial

history plots demonstrated rather conclusively that the entire Cenozoic section is thermally immature.

The dark grey, laminated bituminous limestones of the lower Cretaceous Pariatambo Formation also appeared attractive as a source rock. However, these too proved to generally have a too low total TOC that showed these rocks had no source rock potential. Should there yet prove to be organic rich intervals in the Pariatambo, the burial history results do show that those sediments are currently in the oil window.

Robertson Research reports the occurrence of oil seeps (stains and odor) from the lowermost Los Choros and upper Caballas formations (middle Eocene) in the onshore TEA VII block of Hunt Peru Exploration, but except for a map location reference, no support details have been found in the database.

The dark coals and carbonaceous shales of the upper Paleozoic Ambo Group are now considered as the most likely potential source rock for both the onshore as well as the offshore sectors of the East Pisco basin. The Ambo Group's sedimentary rocks are thought to have been deposited in environments ranging from the fluvio-lacustrine to the paralic-nearshore marine. The fissile black shales, interbedded with thin fine-grained sandstones, show abundant plant remains and woody materials when split in outcrop and hand samples, with closer examination showing evidence of algal remnants. The richness of organic matter is underscored by the measured high TOC of these samples that vary from 0.65% to over 51%. Pyrolysis of the collected field samples indicates that these have the potential to generate rich condensate to gaseous hydrocarbons.

Burial history plots show the Ambo to be at mid-to-late generation stage, and that presently it is in the late-mature-to-gas window.

West Pisco Basin

Only one of the ODP wells, Site 686, is truly in the West Pisco basin. Although the well penetrated over 300 meters of section, these hemipelagic and biogenic sediments proved to be entirely of Pleistocene to Quaternary age and, thus, are not of further interest in source rock considerations.

The other ODP sites of interest containing information on potential source rock analogs to the West Pisco basin sediment section are those of the Lima basin shelf to slope transect, i.e. sites 681, 680, 679, 682 and 688. In these sites, sediments Upper Miocene to Pliocene age show high concentrations of organic matter, reaching as much as between 8-9% or even higher in some cases. For a number of samples, the Pliocene to Miocene hydrocarbon generating potential can be as much as 40 kilograms per ton (kg/ton) of sediment. On the other hand, marked differences in organic content between sites and the age of sediments were also noted. This can be a function of the humus content and the age of the sediments (site 679, Upper and Middle Miocene; site 688, Lower Miocene to Eocene), as well as the site location (Site 687 in the northern west Pisco basin records very low concentrations of organic matter). Of further interest is that the bulk of the Neogene organic matter is mostly of the type II kerogen, which is typical for biogenic materials in open ocean high productivity zones.

On the flanks of the Lima basin, the Tertiary organics are still immature to at least 1,600 meters below the sea floor. Burial history plots indicate that these sediments are still immature. The ODP site surveys indicate that in the deep troughs of the Lima basin sediment thickness varies between 1,800 to 3,500 meters, and it appears very likely that local oil windows exist at one or more of those locations and that some early hydrocarbon generation and expulsion may be taking place at greater depths. Some evidence for direct hydrocarbon indicators in lower

Miocene sediments near the base of ODP site 679 has been inferred from the well and seismic data.

From the available seismic data (Ribiana survey) it appears that the basin conditions with respect to the occurrence of potential source rocks (and reservoir rocks) in the Lima basin can be extrapolated southward into the West Pisco basin and even as far south as the Mollendo basin.

It must be noted that although the ODP wells recovered sediments from middle Eocene to Pleistocene-Quaternary in age, these wells actually probed at most only 800 meters of the generally thick Tertiary sediment cover (site 688) and more commonly less than half of that. Therefore, they do not yield a truly representative sampling of the Cenozoic sediment cover of the southern offshore basins. Nonetheless, burial histories for selected locations in this and others of the southern basins do suggest that the potential rich source rocks have not entered the oil window and that the generation of measurable volumes of hydrocarbons has not yet been initiated. On a final note about the ODP data, there are indications of gas hydrates in the shallow, flank portion of the Lima basin sediment column.

One of the major contributions of the current study was to interpret the possible presence of Cretaceous sediments along the thickest axes of the southern Sechura, Salaverry and Pisco basins. If Cretaceous is indeed present in the Pisco basin, maturation modeling indicates a strong possibility that it is mature, and would have been an effective source to charge potential traps in the western Pisco basin. See the Pisco Basin Presentation and Appendix I for details.

Mollendo (and Moquegua) Basins

Little to no information on the geology and stratigraphy of this pair of basins has been found in the data base. From available literature on the results of field work and outcrop studies, some generative potential may exist in lower to middle Jurassic source rocks such as from the middle to upper Jurassic Plato, San Francisco and Socosani formations, all of which contain bituminous shales. Like in the onshore East Pisco basin, these rocks may be somewhat overmature as indicated from the results of geochemical studies on outcrop samples.

6. RESERVOIR ROCKS

Similar to source rocks, little hard data is known about the nature and quality of reservoir rock potential for the offshore southern basins. For most of the region, the nature and distribution of reservoir rocks must be mostly derived by extrapolation from onshore field (outcrop) and rare well studies. The four exploration wells in and on the flanks of the Trujillo basin are the only true reference points for the presence or absence of reservoir rocks. Extrapolation of any encountered potential reservoir rocks and their characteristics away from the four wells for any distance, and in particular into the other basins some hundreds of kilometers away, demands caution and objectivity as to its reliance and verification. Furthermore, although the regional 1993 Ribiana 2-D seismic data is of reasonably good quality, the purpose for the acquisition of this data set was towards gaining a better understanding and insight into the regional structural framework and relationships, as well as the expectation that the data would help to unravel first and second order events in a sequence stratigraphic framework against the evolution of interaction between the Andean margin of the South American and Pacific/Nazca plates. However, the quality and spacing of this seismic data set is not suitable to gain sufficient detailed insight into the nature, distribution and geometries of reservoir rocks.

Of the many objectives for the drilling of the ODP wells, none cater directly to the exploration for hydrocarbons, while only a few of these objectives have a bearing on this study, such as a) to reconstruct the history of the uplift and subsidence of the fore-arc region, b) the margin response to the subduction of the Nazca Plate under South America, c) understanding the mechanism of tectonic accretion and the resulting erosion of the Peru margin, and d) investigating the age of the metamorphic basement underlying the margin. Of these more specific objectives, the timing and patterns of erosion would be of particular relevance to this study, as would any insight into margin sedimentation and the deposition of intervals with potential reservoir rocks.

The Nazca Plate project (late 1970's – early 1980's) and the ODP Leg 11h 2 report were among the first integrated studies to document the interplay between the vertical movements of the Andean margin and the sedimentary and oceanographic history of the associated upwelling zone in this forearc setting.

None of the ten ODP sites reached basement, and only three bottomed in sediments of middle Eocene age (682, 683, and 688). A major regional middle Eocene to middle Miocene hiatus in deposition was identified from the ODP sites, although localized deposition during the early Oligocene and early Miocene was recorded at several sites (682, 683 and 688). The widespread nature of this hiatus is also recognized from the interpretation of the seismic data and in the onshore outcrops. Similarly, a disconformity seems to be associated with the Pliocene-Pleistocene boundary at all sites, which shows a change from deeper marine to shallow water environments typical for middle to outer shelf settings.

The middle Miocene to Quaternary sedimentary record recovered from the ODP sites reflects a continuous history of upwelling along the margin. This upwelling record shows that migrations and oscillations of the upwelling zone from the inner shelf to the outer shelf and over the upper slope occurred through time, partly in response to changing water depths of the shelf and slope due to subsidence, and partly due to changes in the magnitude of oceanographic circulation patterns, particularly beginning in the Pleistocene. Coastal upwelling conditions that approximate those of the Quaternary are reflected in slump blocks with upper Miocene sediments recovered from the western limits of the present Lima basin and about 100 kilometers (km) west of today's upwelling centers. Data from ODP sites 680, 681, 682, 679 and 688 also suggest that the structural high separating the southwestern Salaverry basin from the

Lima basin must have been sub-aerially exposed during the Miocene and for most of the Pliocene, which effectively barred cross shelf sand to upper slope transport across a broad area. During this time, the southern Salaverry basin probably was confined and only communicated with the open ocean in its northern half. Open ocean circulation and coastal upwelling throughout the Salaverry basin was restored in early Quaternary time when the subaerial ridge and the entire shelf area subsided, in concert with a rise in sea level.

Of note is a large-scale regional thickening of the Quaternary sediment interval along the upper slope from about 14 meters in the north to more than 300 meters in the south along a north south strike margin transect that has been interpreted as being tectonically controlled. While the West Pisco basin subsided and provided plenty of accommodation space, the highly condensed section in the north is a result of vertical oscillations along the shelf edge associated with the structural high separating the Salaverry from the Trujillo basin.

The cores recovered in the ten ODP sites all are marked by their overall sparse and low volume of sand deposition. Furthermore, when sands are encountered in the recovered cores, they are nearly always associated with various quantities of silts, muds, and biogenic siliceous and calcareous oozes. Their deposition generally can be attributed mostly to turbidity currents or occasional slumping and slide transport. Site 688 on the slope below the Lima basin and at a current water depth of more than 3,800 mbsl has the richest sand content in sediments of middle Eocene and lower Miocene to Pliocene age. Middle Eocene sands were also recovered at the base of Site 682 at less than 3,800 mbsl, also on the slope. Pliocene to Quaternary sands of variable thickness were encountered at various intervals in nearly all sites, but none of these appear to be attractive as potential reservoirs. Conglomeratic sediments of upper Miocene age were found at site 679 and are thought to be associated with the emergence of the Salaverry high separating the Salaverry from the Lima basin, and an interval with conglomerates of roughly the same age were encountered in Site 685 downslope of the Trujillo-Yaquina basin, currently at over 5,000 mbsl, probably as a result of slope failure and resulting sediment gravity flows.

In summary, the sedimentary record from the ODP sites does not yield much positive or encouraging information for the presence of reservoir sands for the Salaverry basin and from the southern end of the Trujillo basin southward into Lima and the West Pisco basins area, and possibly also into the Mollendo basin with its narrow shelf and steep gradient slope.

East Pisco Basin: It is questionable if the results of the ODP wells should be extrapolated eastward into the onshore and offshore East Pisco as this basin is more proximal to clastic sediment input from erosion of the uplifted hinterland. As mentioned earlier, the only well drilled in the onshore portion of the basin is the 1953 drilled Pisco-4X-1. Below a thin Pleistocene coarse clastic veneer of the Canete Formation, the well penetrated nearly 700 meters of coarse to fine grained clastics from the lower to upper Miocene Pisco Formation. The sandstones of the Pisco Formation are fine grained and interbedded with diatomites and bentonites, tuffaceous siltstones and argillaceous sandstones with nodular phosphorites; the Pisco sandstones are generally tight. Below the Pisco Formation, the well drilled through about 100 meters of sandstones of the uppermost Oligocene to lower Miocene Chilcatay Formation. These show a high content of volcanic rock fragments and which upon burial and low grade diagenesis will negatively affect porosity and permeability. The Chilcatay Formation, in turn, uncomformably overlies a predominantly sandstone section of the upper Jurassic to lower Cretaceous Hualhani Formation, equivalent to the upper Jurassic to lower Cretaceous Yura Group and Copara Formation farther north inland and along the Salaverry onshore. The Hualhani sandstones are tight and have a high volcaniclastic component and have been subjected to low grade metamorphism. They can, therefore, be readily excluded from further consideration as a potential reservoir rock.

Field and laboratory work from outcrop studies identify two additional potential reservoir intervals of middle and upper Eocene age of the Caballas and Los Choros formations respectively, which are not encountered in the Pisco-4X-1 well. The conglomerates and coarse clastics of the Caballos Formation were deposited as mostly alluvial fan to coarse fluvial siliciclastics wedges with interbedded siltstones in an erosional continental environment. The overlying Los Choros sandstones on the other hand were deposited in a transgressive coastal to shallow marine environment with episodic sediment fluxes. The Los Choros represents a fining upward sequence as fault driven subsidence gradually increased water depths.

Petrographic and petrophysical analyses in laboratory work on outcrop samples showed mixed results and indicated poor to good reservoir properties in rocks from the Caballas, Los Choros and Chilcatay formations. In particular, samples from several beach sites on the Paracas Peninsula yielded between 1%-34% porosity and permeabilities ranging from 0.5 to over 530 millidarcies in rocks from the Los Choros formation. These could prove to have fair to good reservoir properties for the East Pisco basin. On the other hand, high quartzitic contents of many of the sandstones, as well high volcanic shards and fragments and tuffaceous material will detrimentally affect reservoir properties, as was seen in many of the Cabballas and Los Choros lithologies. This laboratory work also showed that a potential secondary reservoir rock can be found in highly fractured Cretaceous limestones, but little further details were available.

Trujillo Basin: The four exploration wells in and on the flanks of Trujillo basin suggest a slightly different and somewhat more encouraging record for the deposition of reservoir sands in the Trujillo basin. Of the four wells, the first well, the Ballena-1X was drilled on the Salaverry High that separates the Salaverry from the Trujillo basin. Three of the four wells drilled a Neogene to Paleogene marine sedimentary section uncomformably overlying Paleozoic metamorphic basement, while the fourth well bottomed in upper Cretaceous marine sediments.

The Ballena-1X well was drilled in 120 meter of water depth and bottomed in Paleozoic basement at 975 mbsl. Over the years, the well's data has been repeatedly examined and analyzed, most recently and completely by Azalgara (1993). No record of any subsequent re-interpretation work has been found in the data base. Repsol also seems to have worked with and largely accepted the Azalagara interpretation and which has also been followed here.

Organic rich calcareous mudstones of middle Eocene to Quaternary age are the dominant lithofacies in the well. At the base of the well lies a 108 meter section composed of mostly coarse grained clastics. These lack any preserved microfossils and thus their age and depositional environment cannot be determined. However, based on the well ties with the seismic data, a lower to middle Eocene age is inferred, while from the coarse grained nature of the sediments deposition in a fairly shallow, high energy shelfal environment seems plausible. The seismic data, unfortunately, also does not have the quality to shed much light on this.

After a re-examination of the Ballena data, Repsol concluded that these Eocene clastics do not have any reservoir potential and that is accepted in this report..

The Delfin-1X well was drilled in 180 meter of water depth and bottomed in Paleozoic basement at 2,687 mbsl, unconformably overlain by middle Eocene coarse clastics. Like the Ballena well data, the logs, well reports and samples were also re-examined and re-interpreted by Azalgara (1993) in his Master's Thesis work. Repsol appears to have accepted and worked with his observations and results.

The Delfin well is of particular interest because, with the exception of the ODP well 682, it is the only well that has recovered sediments of unquestionable Oligocene age. Furthermore, although these two wells are about 275 kms apart, and notwithstanding they lie at different current water depths (180 m vs. 3,788 m) and in different basins (Trujillo basin vs. deep slope

bathyal), both document the presence of coarse clastics in late middle Eocene to early Oligocene times. It was also noted that somewhat lower on the slope from site 682, at the ODP site 688, middle Eocene sands also were recovered. Although the information is sparse, it may suggest that the middle Eocene may be a period of more widespread deposition of coarse clastics across the outer shelf and onto the slope of the Peru margin.

As in the Ballena well, the Eocene through Quaternary section consists mostly of biogenic pelagic and fine grained hemipelagic sediments without noticeable coarser grained components. However, several sandstone intervals were encountered in the Eocene-Oligocene section of the Delfin. One of these, a good 110 meters above the basement and about 35-40 meters thick, has porosities greater than 20% at several levels. These fine to coarse grained sands have very angular grains, are unconsolidated and friable, with interbedded siltstones and shales.

As pointed out in the Repsol and PARSEP Trujillo basin reports, given the right timing of trap formation with trap integrity, these and similar sandstones would make for very good reservoir rock.

In 1999, Repsol drilled the Morsa-Norte-1X well over 80 kms northwest of the Delfin and Ballena wells, approximately in the axis of the Trujillo basin. The Morsa Norte structure is a fault controlled basement paleo-high and on seismic showed several high amplitude events that were taken to be possible hydrocarbon indicators. Like the previous two wells, the Morsa-Norte-1X bottomed in Paleozoic low grade metamorphic rocks and volcanics unconformably overlain by middle Eocene deep marine sedimentary rocks.

The drilling results identified the amplitude anomalies to be associated with two upper Eocene conglomeratic volcanoclastic intervals at 970-1,000 mbsl. These lithologies showed poor reservoir characteristics due to the high content of volcanic fragments combined with a detrital clay matrix. These conglomerates have subsequently been interpreted as products of heterogonous sediment gravity flows through submarine canyons and onto the slope or basin floor. The middle and upper Eocene section also contains a number of thin sandstones, again with immature compositions similar to that found in the conglomerates. The recovered sediment samples from this Eocene section all show this petrographic immaturity, which suggest local sourcing from eroding paleo-highs and short distance sediment transport mechanisms into narrow and deep basins.

In Repsol's interpretation of the seismic data, as well as from the interpretation results of this study, it was noted that the middle Eocene section thins across the Morsa-Norte high, probably due to depositional thinning across this paleo-high, and then a thickening of the Eocene sediment wedges east and west away from the high. Depending on the nature of the sediment transport mechanisms of the Eocene clastics across the high, it can be postulated that better sorted clastic wedges have accumulated at the base of the high and basin valley floor. If these were as sediment gravity flows, the clastics could be present at turbidites that could have improved reservoir properties for the accumulation of hydrocarbons depending on timing of trap formation.

No other intervals with coarse clastics interbeds were encountered in the well. Above the Eocene unconformity the sedimentary section consists mostly of fine-grained silty claystones with a relatively high silt and sand content, due most likely to persistently ongoing bottom sediment transport processes and bioturbation at the water-sediment interface.

The Lobos-1X well is the farthest north well drilled in the Trujillo basin by Repsol, also in 1999, and about 110 kms northwest of the Morsa Norte in the then perceived axis of the basin in water depths of 164 m and was to TD in what was thought to be a lower Eocene sediment

column. The well was to test a large anticlinal structure with four-way dip closure. A number of high amplitude events within the "mounded" seismic structure were interpreted as a series of Lower Eocene interbedded sandstones and hemipelagic fine-grained siltstones and mudstones.

Instead, the well penetrated more than 600 meters of lower Eocene and over 200 meters of Paleocene section below the middle Eocene interval, and bottomed in upper Cretaceous sediments of Maastrichtian to Campanian age at 2,469 mbsf. The drilling results thus showed that the pre-drilling interpretation was incorrect. First, the middle Eocene occurred much higher in the well compared to the well prognosis, while the amplitude anomalies showed to be interbedded detrital silt and clay rich sandstones and conglomerates of Campanian and Maastrichtian age deposited as debris flows through incised valleys or canyons crossing a steep and short slope. The Paleocene and Cretaceous sediments had not been expected and showed the existence of a much older sediment package above the basement than previously postulated. The significant lithological disconformity at the Lower Eocene to Paleocene boundary has subsequently been interpreted as due to a major, probably localized, structural inversion event in this part of the basin at the end of the Paleocene.

Similar to the other exploration wells in the Trujillo basin, the Lobos-1X records a long history of deposition and erosion on the Peru margin, in this well from the upper Cretaceous through the Pliocene-Quaternary, punctuated by a number of hiatuses and/or unconformities. Like in the other wells on the margin, with the exception of the Delfin-1X, the absence of Oligocene sediments either represents a period of non-deposition or large scale sediment removal. Most of the lower Campanian through lower Miocene record documents mainly fine- to coarse-grained clastic sediments with repeated intervals of conglomerates and sandstones. These latter lithologies are characterized by an overall immature composition of subrounded to angular fragments of quartz, feldspars and igneous rocks. The presence of the feldspars and rock fragments suggests arid climatic conditions in the provenance area, while the angularity and poor sorting of the grains indicate short transport distances by debris or grain flows. The pervasive high clay matrix contents of these sediments corroborate these types of chaotic sediment gravity flows. These factors combine to make these coarse clastics unsuited as reservoir rocks.

However, it needs to be pointed out that periodic deepening of the Lobos, and of similar on trend structures, could have resulted in marine reworking and cross seafloor transport to where shelf and slope turbidity currents may have given rise to "turbidites" with some reservoir rock potential. The sparse paleontological data for the Lower Campanian through Lower Eocene interval suggests episodically alternating outer neritic to upper bathyal conditions, a good environment wherein outer shelf to upper slope sedimentation processes may have triggered sediment gravity flows and that the downslope transport process led to some improvement of sediment sorting.

In summary, having reviewed all the available data and interpretations from onshore outcrops and the wells in the offshore basins, it appears that absence of evidence for widespread deposition of quality reservoir sediments may be the most serious and limiting risk factor to the exploration of hydrocarbons in the offshore Peru margin basins.

7. BASIN ANALOGS AND COMPETING EXPLORATION OPPORTUNITIES

In the recent summary review on the discoveries of giant oil and gas fields throughout the 1990's (Mann, et. al, 2003), it was pointed out that such large fields in convergent margin settings are very rare and that the number of such occurrences improves only slightly in similar terranes when other factors, such as transpressive structuring (oblique strike-slip), subsidence and extensional tectonics are invoked.

In the following comments, first a number of geological environments and opportunities are highlighted in the larger contiguous area of Peru in South and Central America. Only by some stretch of geological extrapolation can any of these be considered analog competitive fiscal and contractual environments. However, it should be considered that in the current business climate, companies and investors look at the offered opportunity first and only secondly at matters of geological risk. Secondly, some of the analogs herein summarized are chosen to demonstrate that variants of convergent margins can indeed be regions with lucrative exploration potential and that some of the pessimism about convergent or strike-slip margins can be mitigated by other factors, such as contract terms and geographic location with respect to transportation systems and market conditions.

Opportunities in Central and South America

Costa Rica: Although thus far Costa Rica has no commercial hydrocarbon resources and currently does not have an active exploration program due to strong lobbying from environmental sources with support from the government, the results of previous exploration efforts have documented at least one active petroleum system along its east coast across the Caribbean coastal plain and shelfal waters. There does not appear to be the probability of a second petroleum system along the Pacific margin in the west, although good source rocks are known from outcrop and in at least one deep exploration well. Nearly all exploration activity has focused on the Caribbean side of the country but only a few wells have been drilled. No discoveries have been made. However, it also needs to be pointed out that nearly all wells drilled thus far are based on surface geology and that only a rather sparse 2-D seismic survey has been shot on land. Data from one 3-D survey is known to have been acquired, and its mapping interpretation yielded some interesting leads and prospects, such as Limon Norte and Limon Sur. However, due to the growing environmental movement of the past years, none of these structures have been tested thus far.

The black shales of the mid-Cretaceous Loma Chumico Formation are a known and good quality source rock (Erlich, et. al., 1996). It is spatially and temporally equivalent to the prolific hydrocarbon sourcing black shales and mudstones of the La Luna/Querecal and Villeta formations from Venezuela (Lake Maracaibo to Maturín basins) and in the Colombian Llanos and Magdalena basins.

Because of the current embargo on hydrocarbon exploration in the country, and notwithstanding that block awards made in the past are recognized by the government as contractually and legally binding, Costa Rica cannot be considered a real competitor at this time. However, the existence of a petroleum system with known good source and reservoir rocks, both onshore and shallow water exploration, combined with lenient contract terms and conditions would make Costa Rica a serious competitor for small to mid-size independents, should the objections of the environmental lobby be lifted. It should also be noted that the Costa Rica opportunities are on the Caribbean side of the country and therefore do not share the risks associated with convergent and strike-slip margins.

Nicaragua: In 2002, Nicaragua announced its first formal petroleum bidding round with block areas along its offshore Caribbean and onshore/offshore Pacific margins. Of these, the

offshore Caribbean is judged to have the most promising opportunities, which yet should be considered to have high geological risks. Furthermore, the exploration rights to the perceived targets in the far offshore Nicaragua Caribbean shelf have been disputed by Colombia and that adds the element of political risk.

Exploration drilling activities in Nicaragua have been intermittent and date back to the first half of the 20th century, but thus far, no discoveries have been made. However, a number of the wells drilled by international oil companies had oil and gas shows, which suggest that one or more active petroleum systems exist. No detailed information was available for this report, but promising light oil and gas shows and tests in supposedly shallow marine to outer shelf and slope turbidites have been reported for the Caribbean far offshore. Besides the wells drilled, a number of 2-D seismic surveys have been completed, the most recent one of over 3,000 kilometers in 1999-2000 across the Caribbean margin.

Although the Caribbean shelf and slope area is in a mostly transtensional structural regime and does not share many of the characteristics of the Peru offshore basins, it is still considered to be a potential competitor for exploration dollars. The Nicaragua contract terms are reportedly very favorable and the offshore blocks are in shallow water. Political risk is low and should commercial oil and/or gas discoveries be made, market conditions are favorable with onshore transportation into pipelines for sale across Central America and to Mexican markets.

Suriname has had a long history of hydrocarbon exploration and production in the mostly coastal onshore and in very shallow nearshore waters. The onshore Tambaredjo Field, Suriname's only producing oil field, has been on production since its discovery in 1968 and additional onshore exploration acreage recently opened up in the Calcutta and Wayambo areas to the south and southeast of Tambaredjo respectively, resulting in renewed exploration and appraisal drilling activity. Offshore, there has been continued low level seismic surveying in nearshore to shallow marine acreage for Staatsolie, the national oil company, to be made available in evaluating a number of offshore blocks prior to negotiating exploration contracts. Exploration drilling on the nearshore continental shelf began in the early 1980's and resulted in the drilling of a dozen wells with some oil shows in Lower Tertiary sandstones.

Deepwater exploration was first endeavored in the early 1960's. Thus far, more than 20 wells have been drilled and over 33,000 km of 2-D seismic data has been acquired. The drilling encountered a number of high porosity carbonate sediments of Miocene to Oligocene age with oil and gas shows in at least one well. High porosity sandstones of Tertiary to Upper Cretaceous age, probably turbidites, with minor oil shows were found in several other wells.

Suriname's biggest and certainly high-risk prize may be a very large submarine fan system across the deep marine waters beyond the shelf break at the base of the continental slope and into the abyssal plain. Potential reservoirs may be mostly comprised of a variety of clastic sediments deposited by cross-shelf channel and slope turbidite systems. Data and information for this target is sparse, but the structure is known to the industry at large and several wells have been drilled in past decades without reaching good Tertiary reservoirs and the potentially more attractive possible Cretaceous targets. The earlier wells did encounter shows and traces of hydrocarbons at intervals in Tertiary and Cretaceous sediments, which suggest that a petroleum system is active in the region.

Although the Suriname government has been actively promoting exploration activity for some time, this deep fan system has not been the focus of recent exploration activity due primarily to, a) absence of a good exploration seismic grid (only 2-D seismic data has been shot), b) more attractive and highly competitive deep water targets in known petroleum

provinces elsewhere, e.g. offshore Brazil, Angola, Gulf of Mexico, c) poor world economic climate of the past several years, d) uncertainty of oil vs. gas charged reservoirs, and e) uncertainty regarding the presence of good source rocks.

Notwithstanding these concerns, this deep-sea fan system in a passive margin setting along northern South America, may well be among the few remaining areas of South America with the potential of a giant field discovery.

Magdalena Valley, Colombia: Oblique subduction of the Nazca-Pacific plates along the length of the South American plate margin resulted in a two-component tectonic/kinematic vector regime, one being margin-perpendicular convergence with a resultant narrow yet thick foreland basin that extends the length of northern South America, and the other being a margin-parallel strike-slip component with strong regional and dominantly right lateral strike-slip fault systems. Along this trend, three major foreland basins developed with deposition of rich and thick source rocks that contain the spectrum of giant to small prolific producing oil and gas fields, e.g. in the eastern Venezuelan Maturín basin, the Maracaibo basin of western Venezuela and the Llanos basin in eastern Colombia. In any one basin, traps can range from early Tertiary normally faulted to inverted fault traps on the flexed South American plate, or in the footwall and hanging wall of deeply buried thrusts and folds in the center of the foreland basins, to more recently formed structural and stratigraphic traps that formed in the later-deposited sediments along and in the shallower section above the deformed belt that may have captured remigrated hydrocarbons from deeper breached reservoirs.

Westward of the foreland basins, in what may be considered as a paleo-forearc setting, a number of narrow deep basins were generated in response to oblique transpressive subduction along the Peru trench and subject to subsequent complex deformation. Rich and thick accumulations of source rocks, as well as input of large volumes of sediments from the east, provided quality source-reservoir rock associations and upon burial the generation of a good petroleum system with the expulsion and migration of hydrocarbons into complexly faulted traps. This is the setting that gave rise to the oil and gas fields in the Magdalena Valley basins.

In terms of hydrocarbon exploration and exploitation, the Magdalena Valley basins can not yet be considered fully mature. Potential for additional significant discoveries remains and with continuous improvement in exploration and production technologies, it is highly likely that current estimates of ultimate recoverable reserves will continue to be revised upward.

As a result of President Uribe's government's tough stance in response to the continuous challenges from leftist guerillas and right-wing paramilitarists, security in the country has significantly improved over the past year. This in turn has brought about a resurgence of optimism from potential investors, notwithstanding the country's precarious financial balance sheet. Should the improvements in security continue, combined with an easing of contract terms, Colombia is likely to become one of Peru's most challenging competitors for exploration dollars, considering the proven track record of the Magdalena Valley

Falcón Basin – Northwestern Venezuela: The Falcón Basin is a geological province of moderate potential in a transpressive regime with oblique right-lateral strike-slip subduction of the Caribbean Plate under the South American Plate. The Falcón basin is a good example of a competitive analog because it is not only in South America but also because of the size of the discovered and producing fields it is likely to come up for bidding again once Venezuela turns around, and will probably require only moderate exploration dollars. The worst element in the equation will be the harsh Venezuela contract terms.

Analogs in North America

California Borderland: The southern California Borderland region began and subsequently evolved in a fore-arc basin setting resulting from the interaction of oblique subduction of the Pacific plate beneath the westward moving North American plate. This complex history began in late Jurassic time and continued through the late Cretaceous into the early Tertiary. With the onset of increased strike-slip movement in the early Miocene, coupled with ongoing terrane accretion, and mid-Miocene rifting (extension) and block rotation, the Neogene basins of southern California began to form in this active transform margin setting.

The California Borderland encompasses a large number of giant oil and gas fields and for a major part of the 20th century was one of the most prolific producing areas in the world. Some of its basins are among the richest in the world in terms of hydrocarbons per volume of sedimentary fill. Since late Miocene times, the region has undergone a number of repetitive phases of deformation and each phase brought renewed generation of structural traps in concert with the expulsion and migration of hydrocarbons. The Los Angeles and Ventura basins have become classic examples of efficient and hugely prolific petroleum systems.

The borderland basins were sites of thick rich source rock depositions, e.g. the Miocene Monterey diatomaceous shales with oil-prone kerogen from high surface productivity water masses. The flux of large volumes of clastic sediments from the nearby continental landmass to the east resulted in the deposition of thick turbidite sandstones that formed excellent quality reservoirs sealed by efficient top shales and complex fault closures. More recently, stratigraphic traps have become the target of new exploitation efforts in the Ventura and other borderland basins and fields.

Although leasing of new blocks is not being considered as likely in the foreseeable future, both exploration and development activities will continue. It is postulated that large volumes of undiscovered resources remain in Monterey strata in a number of the smaller basins.

Analog Opportunities Elsewhere

Tanaraki Basin, New Zealand: The Tanaraki basin is a Cretaceous – Tertiary sedimentary basin located offshore along the western margin of North Island, New Zealand. It is the only hydrocarbon producing basin in New Zealand, with production from Eocene and Oligocene sandstone reservoirs, some from submarine fan turbidites. Although the Tanaraki basin originated and has an early history as an extensional basin during early rifting between Australia and New Zealand, subsequent subsidence, followed by intense compressional deformation associated with strike-slip movement along the Alpine fault the length of New Zealand during the Miocene, gave rise to a variety of faulted anticlines, high-angle overthrust structures and tilted fault blocks that have been significant exploration targets since the late 1950's, which lead to the discovery of several giant gas-condensate and oil fields (Palmer, J. and Bulte, G., 1999). Because of its largely Neogene transpressional history, the generated structural traps, and its offshore shelf depths, it is considered to at least share some characteristics with the offshore Peru basins.

The McKee oilfield, discovered in 1980 in what previously was seen as a gas-condensate province, represented a new structural trap style from high-angle overthrust structures, which also confirmed the late generation and expulsion of hydrocarbons and contributed to an enhanced perception of prospectivity for the basin. The most significant problems to prolific production from the basin are concerns over reservoir quality and a generally low thermal gradient that may have contributed to restricting kitchen areas.

A major difference between the Tanaraki basin and the Peru offshore basins is the large volume of clastic sediments that have been shed into the basin that guarantee the widespread occurrence and distribution of sand-prone horizons with reservoir potential. Source rock quality and quantity in the Tanaraki petroleum system are considered to be generally fair and may not be of the same caliber as what may potentially be found in the offshore Peru province.

In summary, it can be argued that the Tanaraki basin is a worthy competitor for financial resources for exploration.

Sunda Arc, Indonesia: The Sunda Arc region comprises a vast area that includes Sumatra, the Malay Peninsula and Gulf of Thailand, the northwest Java Sea and Sunda Shelf, southern Kalimantan, and parts of southern Vietnam. Its origin dates back to the accretion of a number of Gondwana-derived continental fragments onto Laurasia from the late Paleozoic and Mesozoic. At the end of the Cretaceous and into the early Tertiary, the Sunda block had become a stable entity attached to and south of Laurasia and was surrounded by subduction zones. Throughout the Tertiary, the Sunda regions have had a tectonically and structurally highly complex geological evolution, in concert with a highly varied and dynamic stratigraphic and sedimentologic development (Hall, 1997; Lee and Lawver, 1995). This resulted in the generation of several different petroleum provinces and the occurrence of many giant to super-giant oil fields.

For comparative geological and structural analogs, only that part of the Sunda Block region is considered as an analog to the Peru margin offshore basins that lies along its south-southwestern margin and which includes the significant oil and gas fields trend of north, central and south Sumatra and into the northwest Java basins, which are north to northeast of the Sunda volcanic arc. Along this trend, that is also characterized by generally high heat flow associated with the volcanic arc, a variety of petroleum systems are encountered in back-arc related rifts with rich lacustrine to marine source rocks that are overlain by Miocene deltaic marine clastic reservoirs and carbonate rocks (Cole and Crittenden, 1997). Repeated deformational phases throughout the Neogene, including structural inversion of rift zones, have resulted into the formation of structural traps prior to the main maturation, expulsion and migration events.

Although it may considered to be a rather far-fetched comparison between the Sunda and the Peru offshore opportunities because of the many large to giant oil fields in the south Sunda region, this part of the Sunda arc-and-trench system is used as a relevant analog because there are tectonic and structural similarities between the Sunda Block-Indian plate interaction and that of the Nazca plate with the Peruvian margin.

Andaman Trench/Archipelago, Myanmar: The East Andaman basin can be considered as a broadly S-shaped pull-apart basin formed about 15 millions years ago. It can be seen as the northward extension of the south Sunda trench-arc system. This basin, in turn, is comprised of a series of extensional en-echelon, left-lateral strike-slip, deep subbasins. A number of giant oil and gas fields have been discovered along its northern margin, e.g. Yadana (EUR @ 5 Tcf) and Yetagun (EUR @ 50 MMBO and 3.2 Tcf).

Major oil companies have been positioning themselves for some time for long-term exploration strategies, but actual exploration operations have been most successfully carried out by large independents, e.g. Cairn Energy, in association with the majors. More recently, the majors themselves have been taking a more direct interest in the region's exploration activities.

The East Andaman basin is considered to be a qualified analog because, to a degree, the overall structural configuration, processes and its Neogene geologic evolution resembles the overall structure and recent development of the Trujillo basin offshore Peru (Harding, 1983).

8. COMMENTS ON GEOLOGICAL RISK OF CONVERGENT AND OBLIQUE SUBDUCTION TO STRIKE-SLIP MARGIN BASINS

Many attempts have been made to relate the world-wide occurrence and frequency of giant oil and gas fields to some form of sedimentary basin classification. These classifications generally have been based on the temporal and spatial relationships between basin forming processes of structure and tectonics on the one hand, and on stratigraphy and sedimentation on the other. From the interaction of these processes, the most common determining factors to giant hydrocarbon accumulations are 1) generation of structural and stratigraphic traps, 2) formation and deposition of source rocks, and 3) formation and deposition of reservoir rocks. The interplay between these factors can occur in and across a wide range of totally different tectonic settings.

Recently, Mann and others (2003) have completed an exhaustive review of previous basin classifications and tabulated the key characteristics of 877 giant oil and gas fields worldwide that are located in a variety of sedimentary basins and tectonic regimes according to a newly developed scheme. The result is a classification using six simplified classes of tectonic settings for hydrocarbon bearing basins, i.e. 1) continental passive margins fronting major ocean basins – 304 giant fields, 2) continental rifts and overlying sag or "steer's head" basins – 271 giants, 3) collisional margins produced by terminal collision between two continents – 173 giants, 4) collisional margins produced by continental collision related to terrane accretion, arc collision, and/or shallow subduction – 71 giants, 5) strike-slip margins – 50 giants, and 6) subduction margins not affected by major arc or continental collisions – 8 giants. Mann et. al. (2003) then further attempted, for giant fields with multiphase histories, to discriminate the single tectonic event/geologic setting that is considered to have the most profound affect on a field's history of hydrocarbon formation, migration, and trapping. They also argue that the most important criterion for basin classification is the basin style dominating at the most typical stratigraphic and structural level of giant accumulations.

The tabulation of Mann and his co-workers indicates that extensional settings active during early and late stages of oceanic opening are among the most important factors for giant accumulations. These rift and passive margin categories combined account for more than 66% of all of the 877 giants. Their results demonstrate a significant difference from previously published tabulations of giant accumulations, wherein collisional settings form the dominant tectonic scenario for the occurrence of oil and gas giants.

Based on the results of their analysis, they then present the following possibilities to explain the dominance of extensional rift and passive margin settings over all other tectonic settings:

A) localization of high quality source rocks in lacustrine and restricted marine settings during the early rift stage;

B) effectiveness of the sag or passive margin section above rifts to either act as reservoirs for hydrocarbons generated in the rift section and/or to seal hydrocarbons generated in underlying rift section; and

C) tectonic stability following early rifting that allows hydrocarbons sources and reservoirs to remain undisturbed by subsequent tectonic events acting on distant plate boundaries.

From this work it is clear that the Peru offshore basins do not fall into any of the top categories of this classification. The one Peru offshore basin with a giant field, the Talara basin, differs from all the others because of a history of apparent crustal accretion of foreign terrane

when a small crustal block first collided, became trapped and then was subducted under the South American plate.

Although the focus of the work of Mann et. al. (2003) was to explain the occurrence of giant oil and gas fields within a tectonic framework, it seems reasonable that when smaller fields are drawn into the analysis these too will fall within and into the broad terms of this classification.

Below are brief comments about the three remaining types of tectonic classification settings into which the offshore Peru basins might be placed, based on their origin, evolution and history.

Subduction (Convergent) Margins

In and along convergent margins, the structure, stratigraphy and thermal histories of fore-arc, intra-arc and arc basins is controlled by the subduction process. The two most notable examples of giants on subduction margins include the fields along the length of the island of Sumatra in the Sunda Arc of the Indonesian Archipelago, and the sector of the western-most margin of South America from southern Ecuador into Northern Peru.

Subduction-related margins are the least productive tectonic environment for giant fields because of the predominance of generally low porosity, clay-rich sediments that are common in arc environments. However, subduction margins in tropical areas, such as those in South East Asia, can contain carbonate and reef-carbonate traps developed on local structural highs above more arc-influenced strata. Subduction margins can also contain rich source rocks related to upwelling in adjacent subduction related trenches (Suess, 1987; Erlich et. al., 1996) or can contain continentally derived reservoir rocks eroded from adjacent continental areas, such as the Sunda continent for the Sumatra fields, or the west coast of North America for fields in the California Borderland basins.

However, combinations of favorable sources, reservoirs, and structures are rare in subduction zones, and according to Mann et. al. (2003) a rather insignificant number of giants (8 out of 877, or .91%) fall into the subduction class.

Along the Peru margin, the Lima and Mollende basins may be the best examples of this category. The Salaverry may also fall into this category although it is positioned farther inward on the shelf and appears to be the youngest offshore Peru basin.

Strike Slip Margins

Strike slip basins are relatively few and small in aerial extent compared to more common and aerially extensive rift, passive margin and collisional basin types. In general, strike-slip margins form during advanced stages of continental or arc collision as occurred in the Anatolian Mountains or in the Caucasus (Reilinger et. al. 1997; Mann 1997), the southern margin of the Caribbean in Venezuela, or during a ridge subduction event along a subduction boundary as occurred along the California margin (Atwater, 1970).

Despite their generally small area extent relative to foreland and rift basins, strike slip basins can contain extremely thick sedimentary sequences, including excellent source rocks such as lacustrine and restricted marine rocks deposited during early basin development. The inherent complexity of strike-slip boundaries with lateral offsets and structural overprinting probably makes it difficult to maintain and preserve traps large enough to qualify as a giant fields. Reactivation of structure might lead to breaching of fault or top seals and, therefore, oil and gas seeps are quite common in this setting. Structural styles along strike-slip faults are

complex (Harding 1985) and can lead to confusion with other, unrelated structural styles, including inverted normal faults (Harding 1990). The establishment of both profile and map criteria is essential for correct interpretations of strike slip faults.

California is a remarkable example of the formation of giant fields in a strike-slip fault zone with an ideal combination of pre-strike slip structures (May 1993) widespread Monterey Formation marine source rocks, and over-printing by largely transpressional strike-slip tectonics (Peters, 1994). Other transpressional strike-slip zones with similar structures, but less rich and extensive source rocks, are relatively poor in hydrocarbons (e.g. New Zealand, northern Caribbean, Turkey). Of the 877 giants reported by Mann et. al. (2003) only 50 basins (5.70%) are assigned to this class.

The Trujillo, Yaquina and Pisco basins may be categorized as predominantly strike-slip, although an oblique subduction component seems to have played an important role.

Continental Collisions Related to Terrane Accretion, Arc Collision, and/or Shallow Subduction

This collisional class was created for foreland settings in non-terminal settings such as the Rocky Mountains and the Andes. This style of foreland basins in non-terminal collisional settings is identical to those formed in collision-collision margins, although the former tend to have much longer depositional histories instead of being formed by a single, short-lived pulse of continent-continent collision.

Foreland basins in this category can sometimes be much narrower and will contain thinner stratigraphic fill compared to those in continent-continent collisional settings because island arcs usually lack the size, sufficient exposed landmass to supply thick erosional clastic fill into the basins, crustal thickness, and the deformation effect of two converging continents. For example, many of the circum-Caribbean forelands are narrow as a result of the oblique collision of the Caribbean arc and other exotic terranes with the North and South American continents (Lugo and Mann, 1995, Pindell and others, 1998). Important structural traps in foreland basins are formed by normal faults related to flexure and downbending of continental crust beneath the foreland basins (Hardin and Tuminas, 1989; Bradley & Kidd, 1991). Of the 877 giants reported on by Mann et. al. (2003), only 71 (8.10%) are in this class.

Both the Talara and the Tumbes-Progreso basins may belong to this category.

Based on the above, it seems plausible to conclude that, with the exception of the Talara Basin, the other offshore Peru basins carry an overall high exploration risk compared to basins in other settings.

9. CONCLUSIONS

Based on the review and analyses of the currently available data and information, the assessment of exploration potential and hydrocarbon prospectivity for the southern offshore basins along the continental margin of Peru, leads to the following preliminary conclusions:

General:

- The exploration risk for all of the basins on the central and southern Peru continental margin is considered as high to very high.
- By far, the most attractive basin as an exploration target is the Trujillo basin.
- The single most critical risk element shared by all basins is a concern about the occurrence and distribution of quality reservoir rock.
- The second most critical risk element is regarding the style, nature and size of the trap required to make a commercial discovery.
- Potential good-quality source rocks are thought to be present in all of the basins.
    - However, Tertiary source rocks seem to be generally immature except possibly in the far north of the Trujillo basin.
    - Mesozoic or older source rocks, when present in the basins, are likely to be overmature.
- Seal risk is not seen as a major limiting factor to the accumulation of hydrocarbons, notwithstanding the presence of oil seeps in the northern Trujillo basin.
- Opportunities in Colombia and Venezuela with known prolific petroleum systems that are near to existing infrastructure and markets offer competition for exploration investment capital.
- Attractive and competitive opportunities also exist in other basins worldwide that have a proven exploration and production history.

Below are a number of conclusions that are basin-specific. The basins are listed in terms of their potential exploration appeal, but this listing does not imply or express a ranking of the opportunities.

Salaverry Basin:

- Two basement types underlie the Salaverry basin, separated by a northwest trending 10-20 kms wide suture zone.
    - To the south of the suture, and for the larger part of the basin, it is underlain by metamorphosed volcaniclastic rocks and intrusive batholiths, typically representative of Mesozoic Andean rock suites.
    - To the north of the suture, and extending into the Talara basin province, moderate to highly metamorphosed igneous intrusives represent the basement rocks.
- No potential Tertiary source rocks have been identified in the basin.

- The basin originated as the eastern shelf to the Trujillo basin in mid- to late Miocene time and only later (Pliocene) subsidence and structural isolation from the Trujillo basin gave the basin its current shape and form.
- Hydrocarbons from Tertiary sources only possible if having migrated from the west (i.e. Trujillo basin).
- But timing critical against uplift of basin separating high between Trujillo and Salaverry in Pliocene times.

- Potential or possible active petroleum system may exist in the Mesozoic section, i.e. below the regional Eocene/Cretaceous unconformity.
  - Evidence for Cretaceous or older sourced hydrocarbons from onshore sampling sites and in southern Sechura basin.
  - Pre-Cretaceous fold and fault structures may present possible potential traps in what has thus far been called the economic basement interval.
  - Risk that reservoirs are tight – low porosity and permeability
  - Source rock may be overmature

Trujillo Basin:

- Like in the Salaverry basin, two basement types underlie the Trujillo basin, separated by a northwest trending 10-20 kms wide suture zone.
  - To the south of the suture, and for the larger part of the basin, it is underlain by metamorphosed volcaniclastic rocks and intrusive batholiths, typically representative of Mesozoic Andean rock suites.
  - To the north of the suture, and extending into the Talara basin province, moderate to highly metamorphosed igneous intrusives represent the basement rocks.
- The basement type and configuration may have a "significant" bearing on hydrocarbon potential of the basin.
- A proven petroleum system is associated with the Trujillo basin, as evidenced by a number of active seeps and hydrocarbon shows in several (two) of the wells drilled into the basin.
  - The best source rocks are lower to middle Miocene and upper Eocene shales, with kerogen types II to II/III. Gas prone source rocks are of lower Eocene age containing type III kerogen.
  - Oil chemistry from oil seeps in the north of the basin appears to have an analogous fingerprint to the oils sourced from the lower Cretaceous Muerto shale in the Talara basin.
  - Basin modeling suggests that the most likely source for the Trujillo basin hydrocarbons is Cretaceous in age.

- Good reservoir rocks have not thus far been identified in the basin, based on the available well data, with the exception of the Delfin well. However, the seismic sequence interpretation suggests that good reservoir rocks could very well be present in upper Cretaceous to upper Miocene sequences as turbidite channel and fan complexes
    - Size and thickness of these complexes need to be carefully determined and mapped in detail before drilling the next well.
    - Validation of size (footprint, volume) and structural (faulting) geometry is essential for making an early assessment of economic risk of such prospects in these deep water environments.
    - The presence of good and extensive reservoir rocks remains the most critical geological risk factor.
- Stratigraphic traps, or combination stratigraphic/structural traps, are seen as potential lucrative plays in this basin, considering its recent geological history within this rather unique structural setting.
    - Timing/migration and trap formation are seen as a second set of critical risk factors.

East Pisco Basin:

- Potential Tertiary source rocks in the offshore sector of the East Pisco basin have not yet entered into the oil window and are immature, based on information from the ODP sites.
- In the onshore East Pisco basin the upper Paleozoic Ambo Formation and the lower Cretaceous Portachuelo Formation are recognized as potential source rocks in outcrop.
    - The Ambo Formation does not seem to be consistently present and therefore any sourcing is likely to be localized and of limited volume.
    - The Ambo Formation is presently in the mid- to late generation stage based on burial history, temperature and maturity plots.
    - Reported, but unconfirmed, onshore oil seeps may indicate an active petroleum system.
    - The Ambo Formation is presently in the mid- to late generation stage, based on temperature and maturity plots.
- Reservoir rocks will vary from very good to poor quality, as available data indicates.
    - Sandstones from the Tertiary Los Choros Formation can be very good to fair to poor quality reservoir rocks.
    - Abundance of volcanic rock fragments affects reservoir quality.
    - Quartzitic sandstones tend to have poor primary porosity and secondary porosity is poorly developed.
    - Potential Mesozoic reservoir rocks generally have only fair to poor reservoir character.

- Reservoir rock intervals contain large quantities of volcanic rock fragments.
- Reservoir rock intervals have been subjected to low-grade metamorphism.

- Basin prospectivity is downgraded due to source rock and reservoir rock concerns.

West Pisco Basin

- The presence of quality reservoir rocks cannot be documented from the existing and available data base.
- Denudation of the onshore and transport of fine to coarse grained sands into the offshore can be postulated, but is not documented.
- Rates and volumes are difficult to assess due to the apparent persistence of low rainfall across the region during recent (Neogene) times.
- As a corollary to the above, there is insufficient data on across shelf sediment transport routes and systems into the basins
- Tertiary intervals with potential reservoir rocks would be Eocene and Neogene terrigenous clastics brought into the basin by means of sediment gravity flow processes, i.e. slope channels and fans and turbidites
- Potential Tertiary source rocks have not yet entered into the oil window and are immature, based on information from the ODP sites.
    - Thick accumulations of high TOC biogenic sediments throughout the Tertiary have the potential for providing good source rocks.
    - Rocks from the upper Paleozoic Ambo Formation and of the lower Cretaceous Portachuelo Formation show good source rock potential from outcrop data
    - Their burial depth below the West Pisco basin may now be too deep and
- Although the presence of stratigraphic traps cannot be ruled out, particularly for the Miocene and Pliocene intervals, faulted anticlines are likely to present the more attractive and best structural traps.
- Basin prospectivity is downgraded due to source rock and reservoir rock concerns.

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APPENDIX D

WELL DETAILS

Gaffney, Cline & Associates

April 2005

Appendix D – Well Details

Perú petro

Basin Comparison Criteria

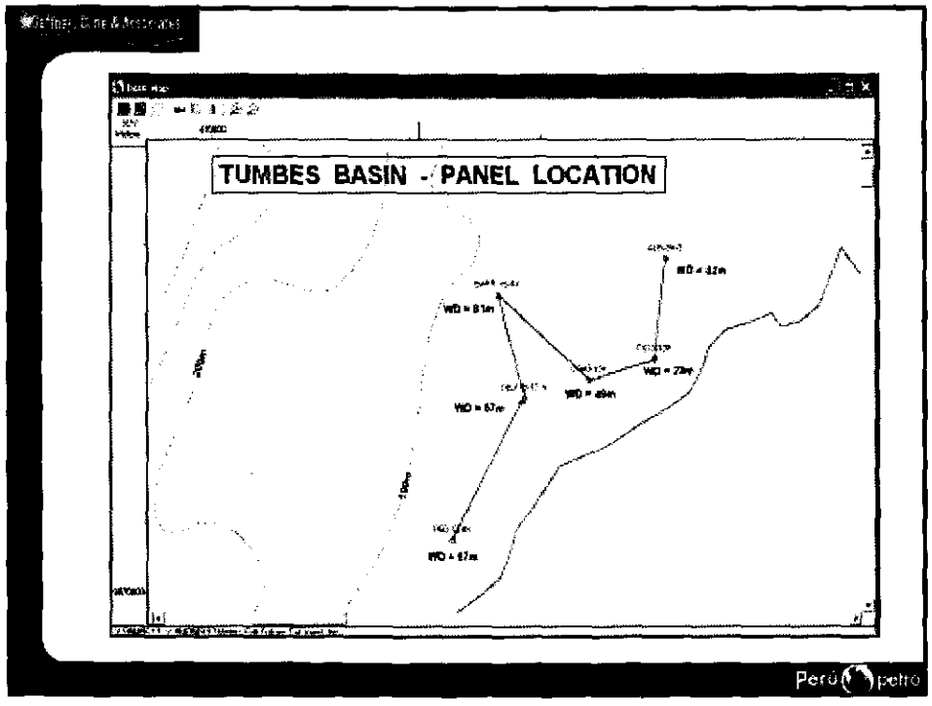
- All the basins are on continental crust, except for outer Tumbes, which is on transitional crust (pull-apart basin)
- Tumbes-Progreso developed on flank of regional megashear (pull-apart basin)
- Talara is situated on basement-rooted arch. Good regional focus for migration
- Salaverry is an older basin, characterized by broad subsidence – saucer shaped. Might tie to Jurassic/Cretaceous onshore
- Trujillo is a product of periodic extension and compression – looks like a rift basin. Similar features, but smaller amplitude, in Salaverry
- Very little of Cretaceous basin fabric preserved in Trujillo. Better preserved in Salaverry

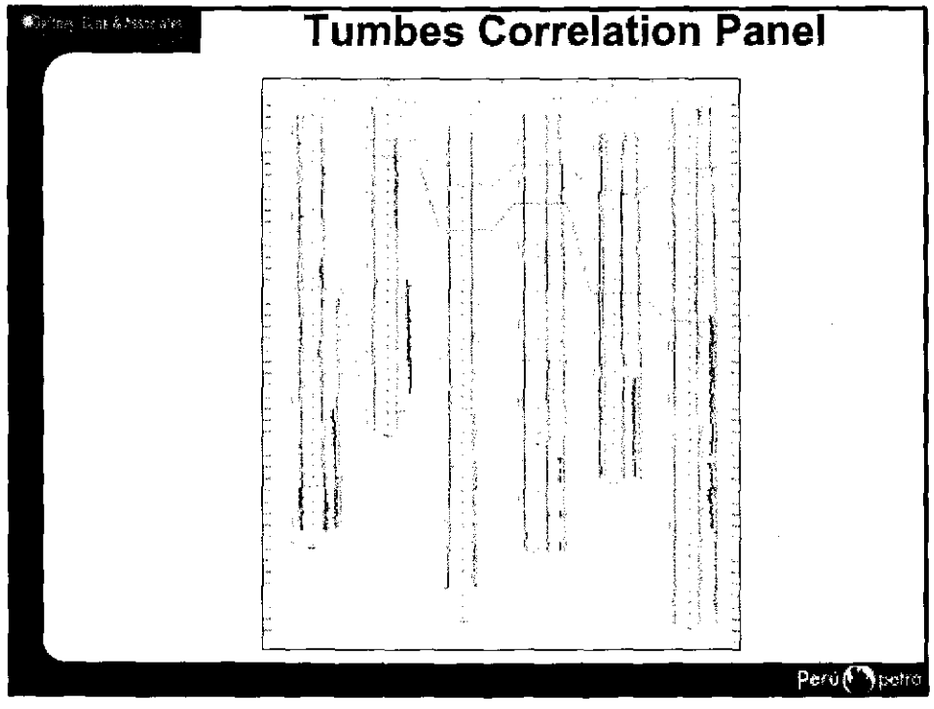
Perú petro

Tumbes Basin

Tumbes Basin Drilling History

- Only 19 wells drilled in offshore portion of basin to date
- Tenneco drilled 9 wells from 1971 to 1974
- Every well was a surprise. Every fault block potentially different.
- Belco farmed-in to block in 1975 and drilled 10 wells from 1977 to 1984
- 6 of 19 wells have produced hydrocarbons in commercial quantities
- All wells drilled in less than 100m water depth
- BPZ current operator of Block Z-1


TUMBES BASIN - PANEL LOCATION
Perú petro


Tumbes Correlation Panel
Perú petro

Piedra Redonda C-18X

- Drilled by Belco
- Only offshore well in Tumbes Basin to reach Eocene
- Minor shows in L. Miocene Zorritos Fm.
- Oligocene Mancora Fm.
  - Perf: 3303-3398m (11m net)
  - IP: 6.8 MMCFGD
- Temp. Abandoned 12/78
- BPZ plans gas/power project from Corvina and Piedra Redonda fields

Perú petro

Delfin B-17-X

- Drilled by Tenneco
- P&A 1/77 – poor shows - no tests
- Top Zorritos – 86m low to Delfin 39-X-1
- Oil and gas shows over 217m gross sand
  - Ran 8 DSTs – 7 possible productive zones not tested
- Zorritos Fm – tested 311bo + 240 mcfg
- Deemed non-commercial
- P&A 5/73

Perú petro

Barracuda 15-4X

- Drilled by Tenneco
- Tested large, young, faulted structure
- Shows in 32 zones totaling 260 m
- 10 DSTs
  - 8 in Zorritos, 2 in Cardalitos
  - All zones too tight to produce
  - Minor oil recovered (35-37° API)
- P&A 8/73

Perú petro

Corvina 40-10X

- Drilled by Tenneco
- 2nd well drilled on Corvina structure (large, tilted fault block)
- No shows in Zorritos
- Minor oil and gas shows in Heath
- P&A 3/75
- 1st well Corvina 41-X-1 (7/73) was P&A with gas shows in Zorritos

Perú petro

Corvina CX13-18X

- 3rd well drilled on Corvina structure by Belco
- Weak gas shows in Zorritos
- P&A 9/83
- Prior well CX-12-23X was P&A 2/83 with weak gas shows in Zorritos
- Prior well CX-11-16X tested 4.6 mmcfg from Zorritos
  - Well was completed – cumulative production 135.7 mmcfg (time period – not available)
- BPZ planning Corvina/Piedra Redonda gas/power project

Albacora 8-X-2

- 2nd well drilled by Tenneco on Albacora structure (1st was shallow blow-out)
- 5 productive zones in Zorritos
  - Zones tested cumulative rate of 5246 bopd + 19 mmcfg
- T&A 8/72
- Tenneco drilled 3 additional wells on structure – all P&A with fair to good shows
- Belco drilled 3 wells on structure in 1977
  - All productive from Zorritos – IP rates 120-1100 bopd
  - Wells produced 99mbo + 107mmcfg over approximately 1.5 years

Albacora Structure

- No seismic coverage available over structure
- Tenneco – 5 wells (1971-74) – operational problems + indications of complex structure
  - 8-X-1: blow-out at 229m
  - 8-X-2: discovery – 5000 bpd test (?)
  - 8-X-3: directional to SE flank – minor shows
  - 8-X-4: directional to SW flank – fair shows – no tests
  - 8-X-5: directional to NE flank – good shows – stuck swc tool – abd. w/ no tests
- Belco – 3 wells (1977) – tested (W, NW and SW flanks) - all productive
- Complex – needs 3D (Post-Stack Depth Migration)

Perú petro

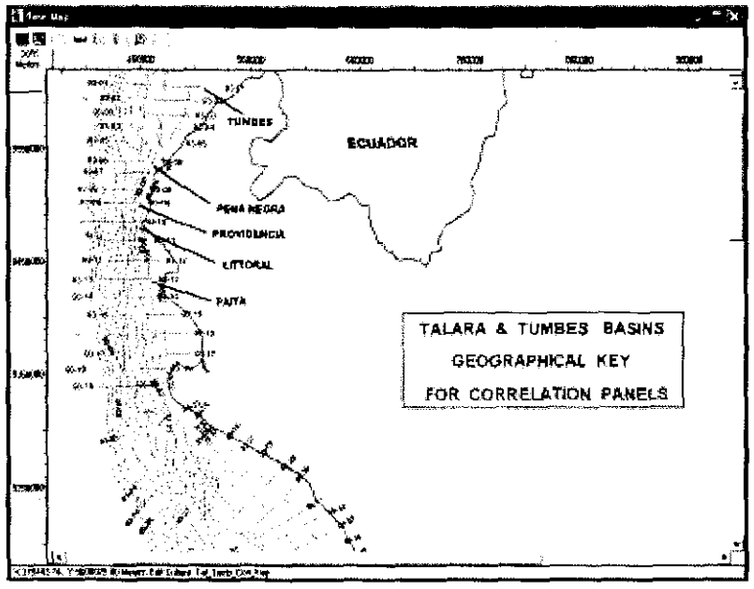
Talara Basin

Perú petro

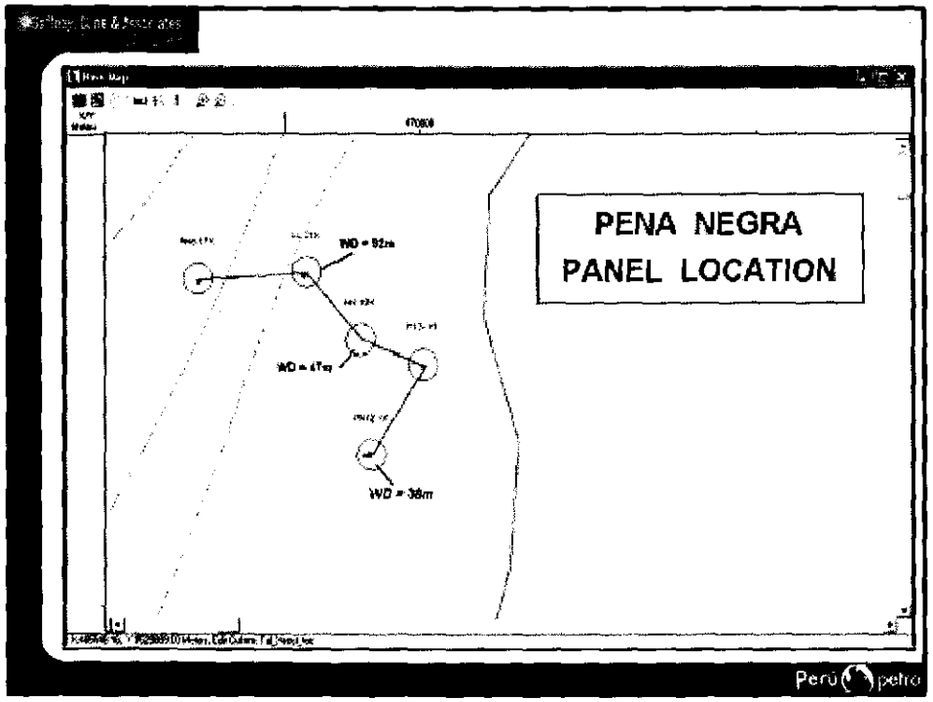
Correlation Panels

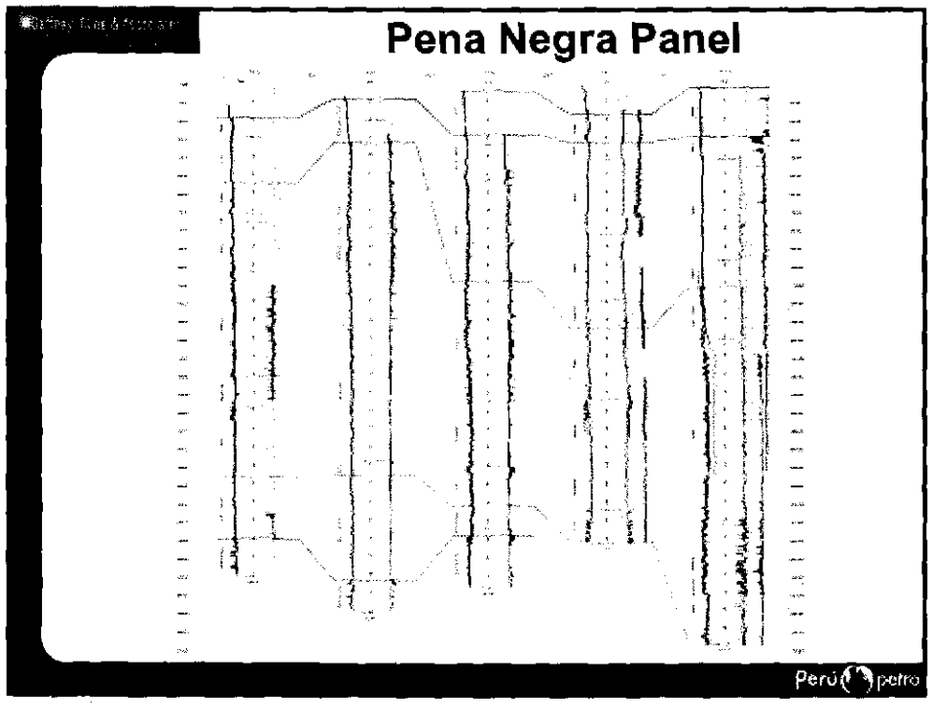
- Offshore Talara Basin wells culled for deepest penetrations and most complete log suites (32 selected out of approximately 125 wells)
- Only utilized Talara wells with TD in Paleocene or older sediments
- All formation tops and ages from Perupetro or original operator
- Local formation names included for historical continuity
- Designed to provide "snapshot" of stratigraphy in area

Perú petro



Perú petro

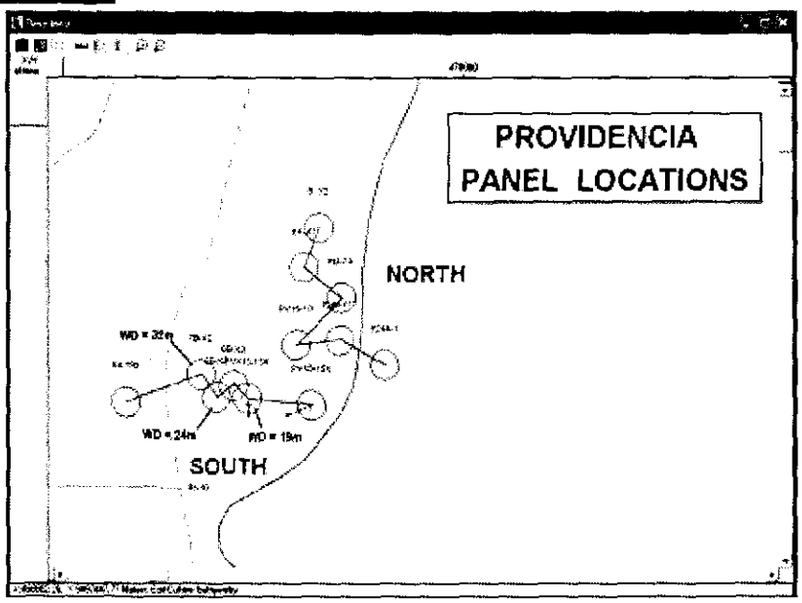

PENA NEGRA
PANEL LOCATION
WD = 92m
WD = 38m
Perú petro


Pena Negra Panel
Perú petro

Pena Negra Panel Highlights

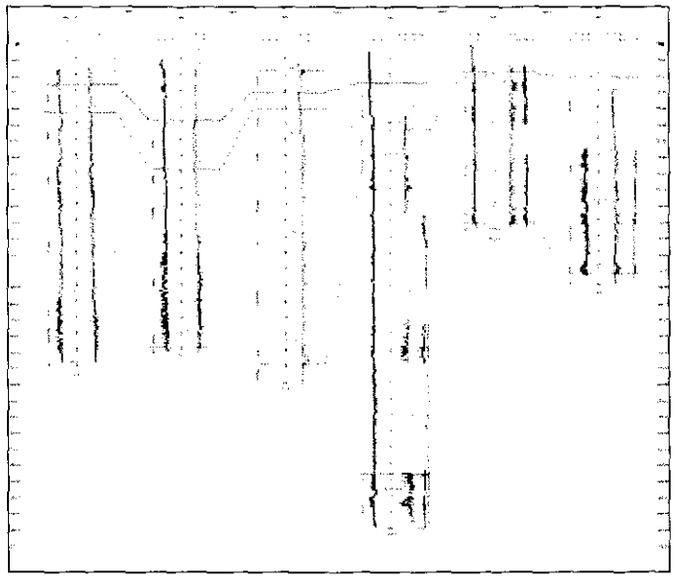
- **LL-21X**
  - Completed 6/76 Perfs 658-1005m
  - Mogollon – IP 1286 BOPD
- **HH-10X**
  - Comp 8/75
  - Tested oil from Mogollon & Cretaceous
- **PN8-17X, H13-X1, PN12-1X**
  - Operator Final Well Reports not available

Perú petro



Perú petro

Providencia North Panel



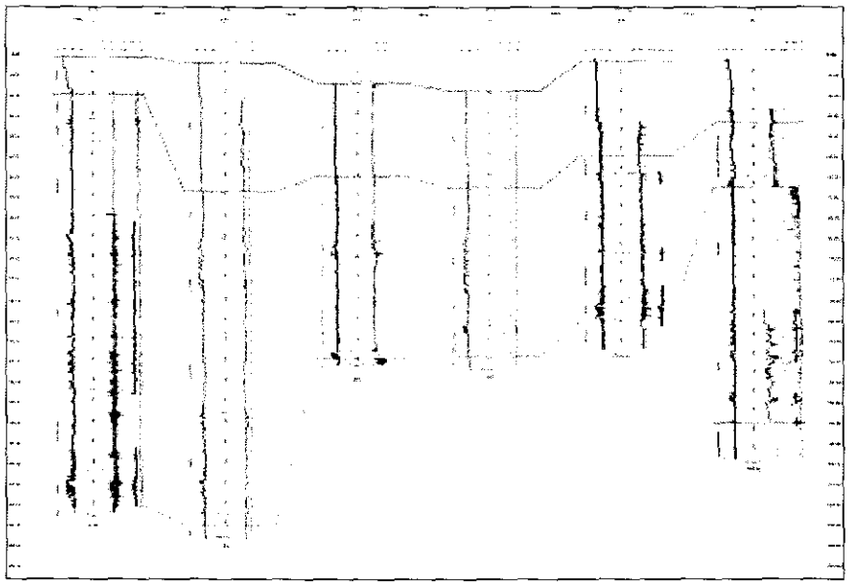
Perú petro

Providencia North Highlights

- **PQ-7A**
  - All local L. Eocene formations present
  - Possible complete L. Eocene section
- **PV15-10**
  - Very thick, possibly complete Paleocene section present
- **All 6 wells**
  - Operator Final Well Reports not available

Perú petro

Providencia South Panel



Perú petro

Providencia South Highlights

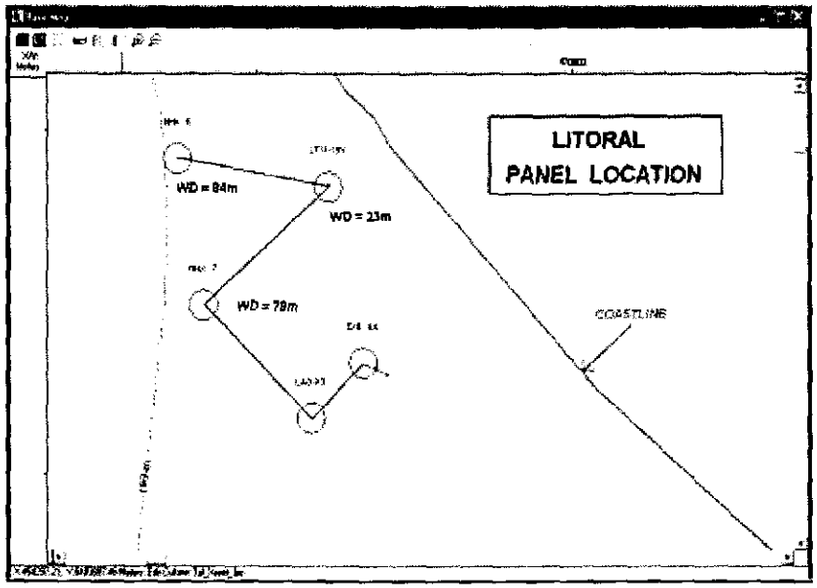
- **A4-19X**
  - Operator Final Well Report not available
- **7B-X2**
  - Target: Basal Salina – absent
  - No tests – P&A 6/69
- **6B-X2**
  - Salina gas discovery
  - DST: 1469-1531m – IP 2.1mmcf

Perú petro

Providencia South Highlights (cont.)

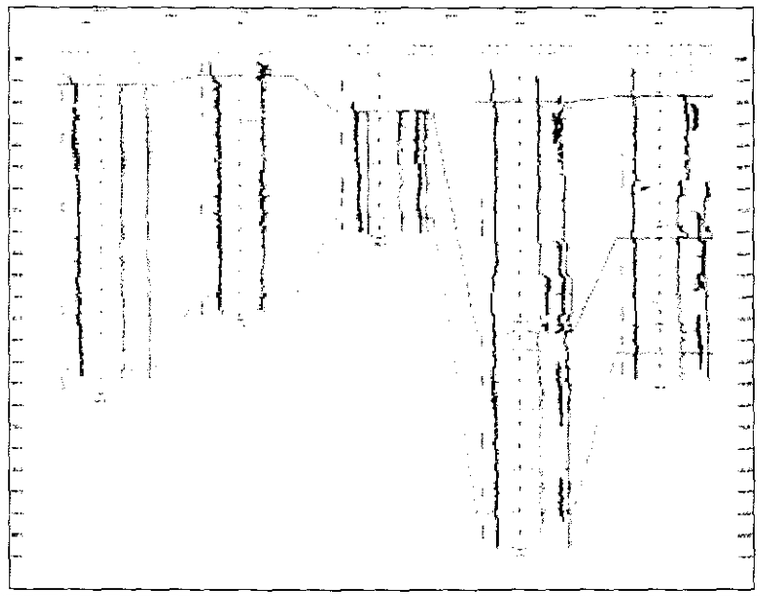
- **6B-X3**
  - Drilled downdip from 6B-X2 discovery
  - Basal Salina absent
- **PVX13-13X**
  - Salina Perfs: 1313-1391m
  - IP 585 bopd
- **PVX8-15X**
  - P&A 2/89 – No Tests

Perú petro



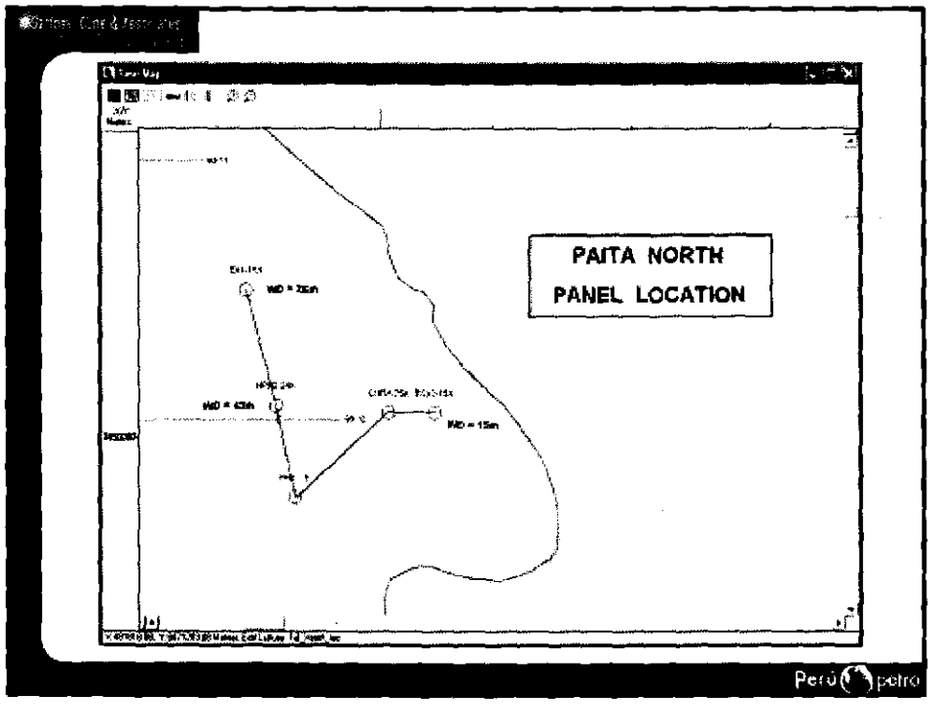
Perú petro

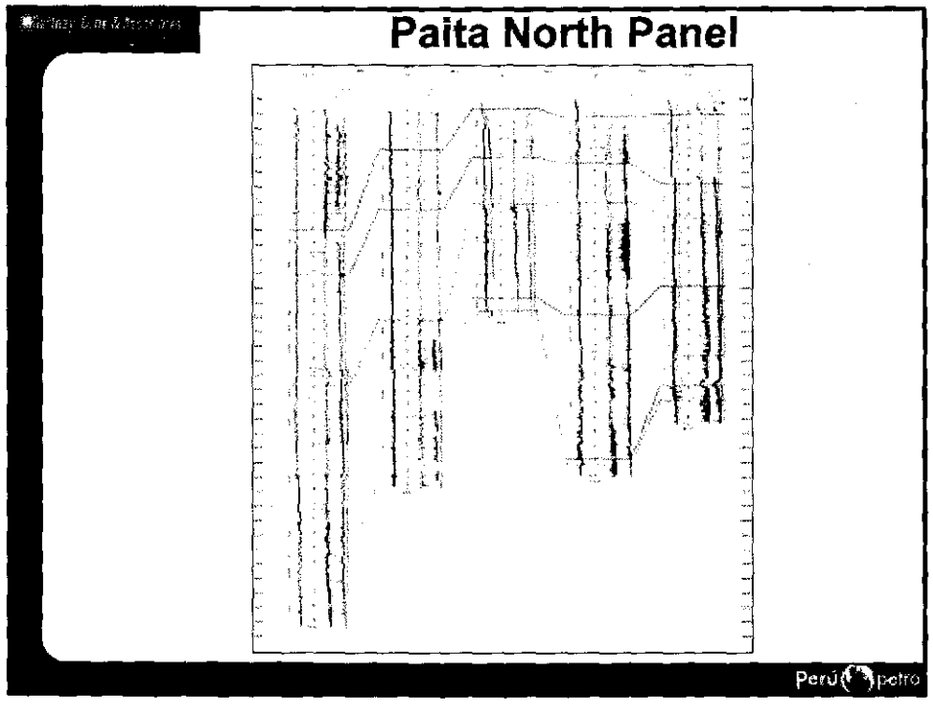
Litoral Panel



Litoral Panel Highlights

- NHX-6
  - P&A 12/84 – No Tests
- NHX-7
  - P&A 10/84 – No Tests
- LT14-15X, LAG-X3, EX6-8X
  - Operator Final Well Reports not available


PAITA NORTH
PANEL LOCATION
Perú petro


Paita North Panel
Perú petro

Paita North Highlights

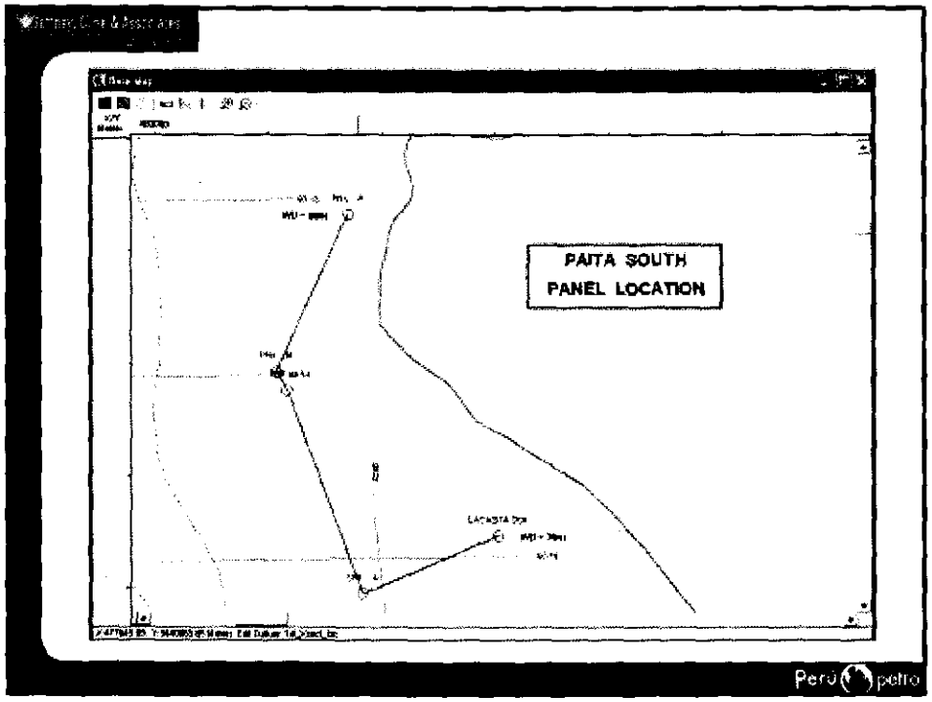
- EX4-15X
  - P&A 7/81 – No Tests – Good gas show in Mesa
- NPXB-24X
  - Parinas DST: 1891-1951m
  - IP: 2.8-7.0 mmcfd - T&A 6/95
- PHX-E
  - Operator Final Well Report – not available

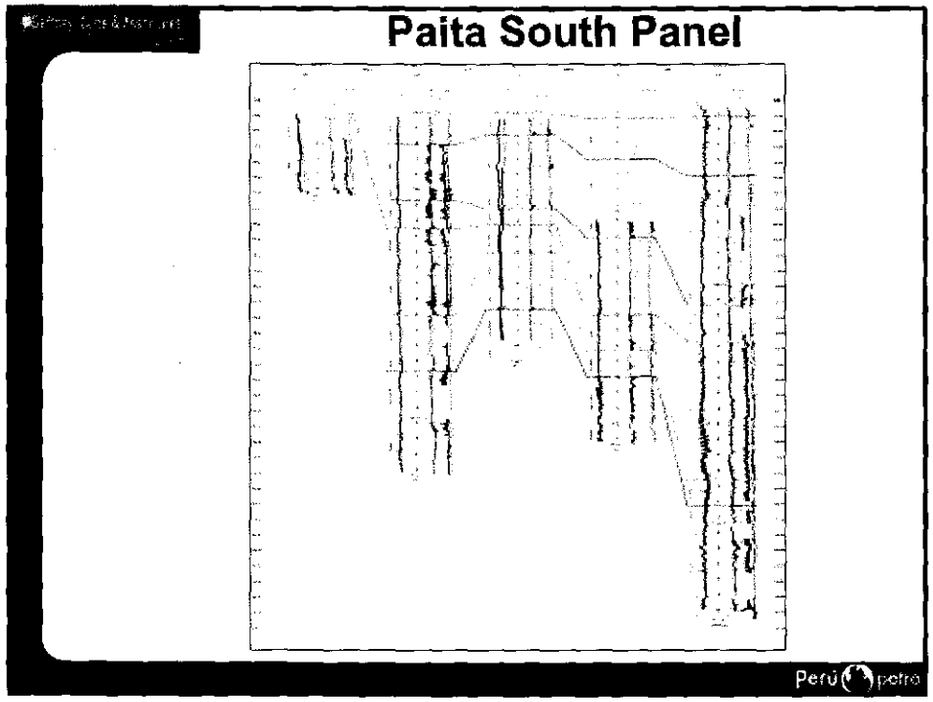
Perú petro

Paita North Highlights (cont.)

- CHIRA-75X
  - Poor HC shows – Salina & Redondo
  - Fair HC show – Mesa
  - P&A 7/75
- RCX3-15X
  - Oil shows – Salina, Redondo, Muerto and Paleozoic
  - Tests: Paleozoic – tight, Muerto – tight w/ trace oil, Redondo – wet
  - P&A 10/81

Perú petro


PAITA SOUTH
PANEL LOCATION
Perú petro


Paita South Panel
Perú petro

Paita South Highlights

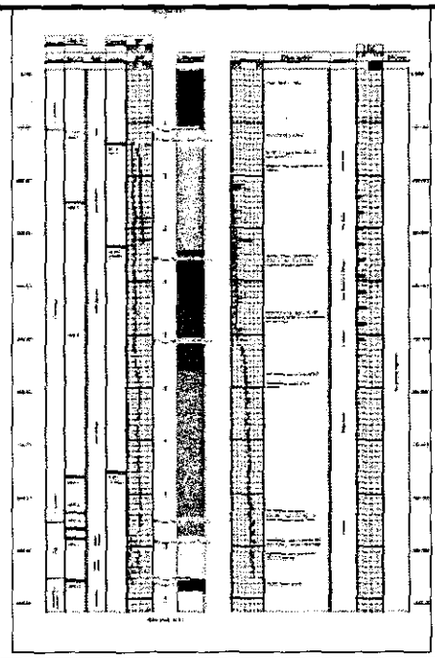
- Only Talara transect with penetration of Oligocene section
- PHX-A
  - P&A 9/84 – No Shows
- PHX-N, PHX-O, SBX-A
  - Operator Final Well Reports not available
- LA CASITA-55X
  - DSTs: Monte Grande (Late Cretaceous) – minor gas, Chira (Late Eocene) – minor gas, Salina (Early Eocene) – salt water
  - P&A 2/75

Trujillo Basin

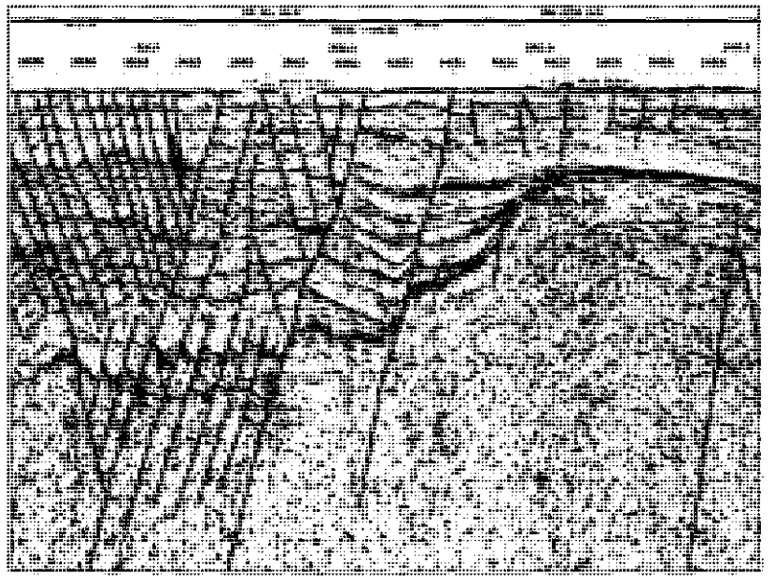
Trujillo Exploration Wells

- Total of 4 wells
- 2 wells drilled by Occidental in 1971
  - Ballena-8-X-1 - no shows
  - Delfin-20-X-1 - gas shows
- 2 wells drilled by Repsol in 1999
  - Morsa Norte-Z29M-37-1X – oil shows
  - Lobos-Z29M-9-1X – heavy oil shows only

Ballena 8-X-1 Composite Log



93-45 Tie to Ballena and Delfin



Perú petro

Ballena 8-X-1

- First offshore exploration well drilled south of Talara basin
- Located on Salaverry High (separates Trujillo and Salaverry Basins)
- Drilled July 1971 by Occidental (water depth: 106m)
- Located near seismic line 96-105 and 93-45
- Drilled to 975m - TD in metamorphic basement

Drill Results

- 721m of Miocene upper bathyal to middle neritic deposits
  - Interbedded siltstone, mudstone, muddy limestone and sandstone
  - Clastic fraction generally poor reservoirs
  - Good source potential – TOC up to 4.1%
- 108m of Eocene poorly sorted sandstone and conglomerate
  - High metamorphic-fragment content
  - Generally poor reservoir potential
- 12m of Basement consisting of quartz, biotite schist

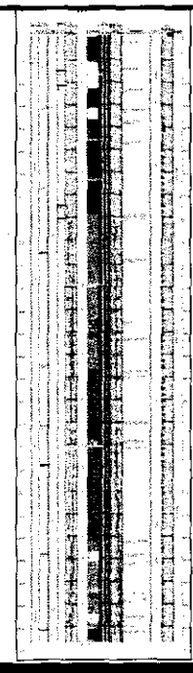
Perú petro

Ballena Conclusions

- Drilled on a prominent, but very young structure (late Miocene uplift)
- No hydrocarbon shows in well
  - Located considerable distance from nearest Cretaceous subcrop
- Miocene section – very argillaceous
  - High TOC shales in Miocene – good source potential, but thermally immature
- Coarse grained (but immature) clastics in Eocene (close to base – might be colluvium)
  - Well location too proximal for turbidite potential

Perú petro

Delfin 20-X-1 Composite Log



Perú petro

Delfin 20-X-1

- First exploration well drilled in Trujillo Basin proper
- Drilled immediately following Ballena by Occidental in 1971 (water depth: 110m)
- Located __km downdip from Ballena on western flank of Salaverry High
- Like Ballena, located near seismic line L96-105 and 93-45
- Drilled to 2668m - TD in metamorphic basement

Drill Results

- 929m of Miocene upper bathyal to outer neritic deposits
  - Predominantly calcareous MUDST and muddy LS with occasional thin, interbedded SLTST and SS
  - Clastic fraction – generally poor reservoirs – no shows
  - Good source potential – TOC up to 3.5%
- 1513m of Eocene inner neritic to upper bathyal deposits
  - General upward-deepening sequence
  - Two levels of C1 gas shows in Upper Eocene siltstones
  - Good quality reservoir sands encountered in lower Middle Eocene and Lower Eocene – no shows
- 56m of Basement consisting of foliated, mica schist

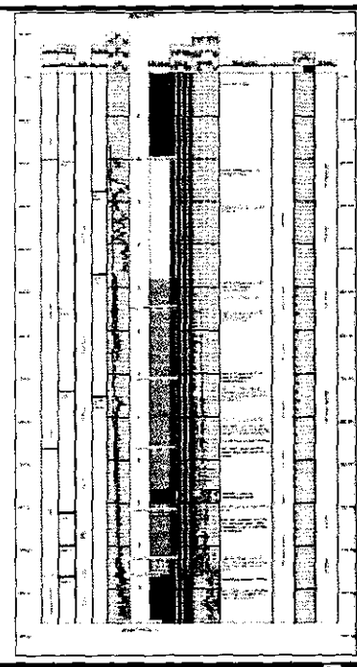
Perú petro

Delfin Conclusions

- New seismic clearly illustrates that well not located within structural closure
- Minor gas shows (methane only) in Eocene siltstones
  - possible biogenic source
- Miocene section – very argillaceous
  - High TOC shales in Miocene – good source potential, but thermally immature
- Good quality reservoirs in shelfal and turbidite deposits of Middle and Lower Eocene
  - 2 stacked sand packages totaling 30m net sand each
  - Good porosity – in the range of 17-24%
- Well located considerable distance from Cretaceous subcrop

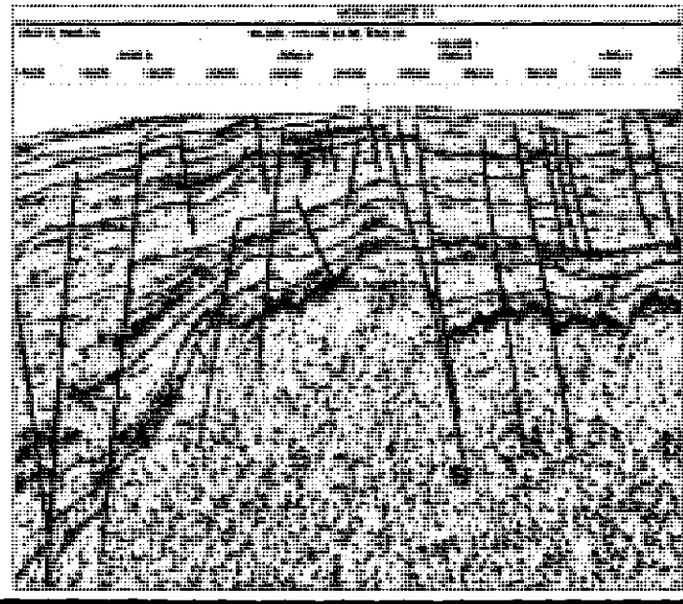
Perú petro

Morsa Norte Z29M-37-1X Composite Log



Perú petro

96-069 Tie to Morsa Norte



Perú petro

Morsa Norte Z29M-37-1X

- First exploration well drilled by Repsol in Trujillo Basin
- Drilled during April-May 1999
- Located on intrabasinal high 90km NNW of Delfin
- Target: Eocene turbidite SS
- Located half way between dip lines 93-40 and 93-39 on strike line Z29-96-069 but directly tied by 96-98
- Drilled to 1281m - TD in metamorphic basement

Drill Results

- 672m of Miocene lower bathyal to outer neritic deposits
  - Predominantly silty CLYST with thin, micritic LS
  - Live oil observed during 20" casing run (to 470m). No cuttings samples collected at this level.
- 295m of Eocene outer neritic to lower bathyal deposits
  - General upward-deepening sequence
  - Immature SS and CONGL interbedded with silty CLYST
  - Oil shows recorded in SS and CONGL
- 111m of basement (schist)

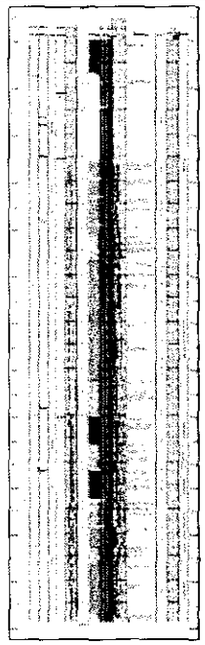
Perú petro

Morsa Norte Conclusions

- Probably a valid structural test
- Miocene section – very argillaceous
- Shallow "ROV" oil – biodegraded – probable Cretaceous source (previously thought to be Miocene)
- No Eocene turbidites encountered
- Immature Eocene sandstones and conglomerates are probable debris flows
- All Eocene clastic intervals stained with oil – Cretaceous source ?
- Active petroleum system, but poor reservoirs

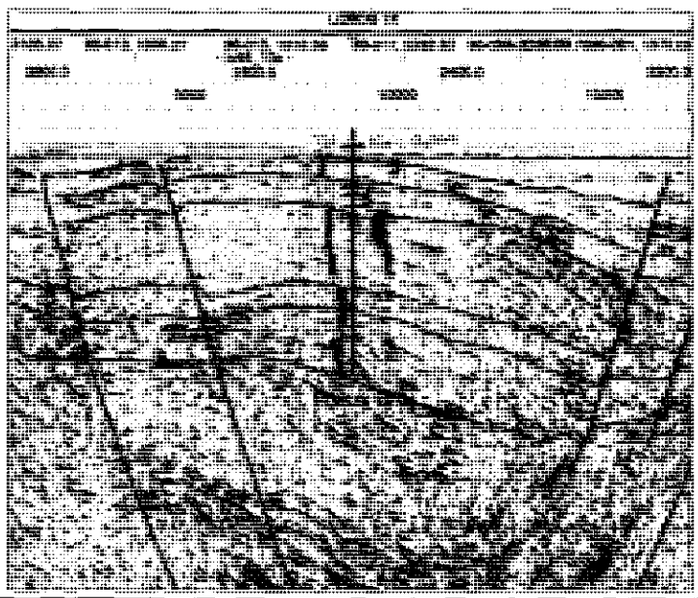
Perú petro

Lobos Z29M-9-1X Composite Log



Perú petro

Io98-10b Tie to Lobos



Perú petro

Lobos Z29M-9-1X

- 2nd Repsol well in Trujillo Basin – drilled immediately following Morsa Norte-1X during May-June 1999
- Well located 30-40km south of active oil seeps attributed to L. Cretaceous Muerto Fm. source rock
- Target: Eocene turbidite SS, located on large 4-way dip closure (originally interpreted as differentially compacted basin floor fan)
- Well penetrated Cretaceous syncline
- Amplitude anomalies in "mounded" structure interpreted as reservoirs
- Drilled to 2469m - TD in Campanian debris flow

Perú petro

Lobos Z29M-9-1X

Drill Results

- 441m of Miocene (probable) bathyal claystone
- 1009m of Eocene outer neritic to upper bathyal deposits
  - Predominantly silty CLYST with occasional SS and CONGL
  - Rare heavy oil shows recorded in coarse clastics
- 230m of Paleocene lower bathyal SS and CONGL
  - Rare heavy oil shows
- 635m of Cretaceous outer neritic to upper bathyal deposits
  - Interbedded silty CLYST, SS and CONGL
  - Rare heavy oil shows recorded in coarse clastics

Perú petro

Lobos Conclusions

- Structure due to inversion – not mounding
- First penetration of Paleocene and Cretaceous in basin – significant enhancement to exploration outlook
- Cretaceous not anticipated in wellbore - structural position highly unfavorable for Cretaceous test
- Eocene clastics – predominantly immature SS and CONGL (debris flows)
- Occasional well sorted, low clay matrix SS in L. Eocene and Campanian (turbidites)
- Shows consisted of asphaltic, residual oils only
- Source rocks present in area - generation and migration have occurred
- Better reservoirs expected in more distal locations

Perú petro

Pisco Basin

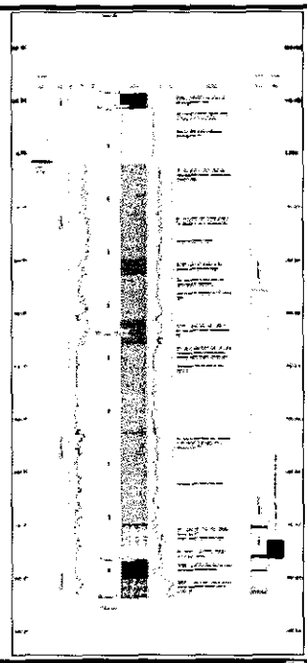
Perú petro

Onshore PISCO BASIN

- Bounded on east by Coastal Batholith
- Most of basin bounded on west by Coastal Cordillera (open to NW ?)
- Filled with approximately 2000m of Eocene to Quaternary sediments
- Basin stratigraphy divided into 3 major fining-upwards, transgressive packages, each bounded by a major unconformity
- Fine grained clastics, at the top of each package, include biosiliceous deposits with high organic carbon content
  - Only the lowermost, Eocene package has potential to be thermally mature
- Basal conglomerates and sandstones of each sequence may provide good reservoir targets

Perú petro

PISCO – 4X
New Composite Log



Perú petro

PISCO – 4X

- First (and only to date) exploration well drilled in Pisco Basin
- Drilled by International Petroleum Company
- Status: P&A October 1955
- Drilled on seismic prospect, supported by grav-mag – no surface expression of structure
- Pre-drill target: Eocene (Chira or Verdun-type reservoirs) and possible Oligocene and Miocene sandstones

Drill Results

- 425m of Pliocene diatomaceous and tuffaceous shales
- 359m of Miocene diatomaceous and tuffaceous shales
  - poor source potential
- 67m of Miocene shallow marine sands
  - fair to good reservoir quality
  - FT revealed good permeability, but recovered fresh water only
- 65m of Cretaceous(?) conglomerates and hydrothermally-altered quartzites and shales

Perú petro

PISCO-4X Conclusions

- No indication of hydrocarbons in the well
- Eocene – Oligocene not recognized in well, but Eocene to early Oligocene outcrops are present in basin
- Good quality Miocene reservoirs were flow tested in well (good perm, but water-bearing)
- Source potential is problematic at well location - better indications in outcrop
- Cretaceous identified in well
  - based on lithology change – not paleontology
  - not corroborated by surface geology
  - potential Cretaceous thickness (if any) unknown in basin
- Onshore portion of Pisco basin considered non-prospective. Thick mature sediments not likely.

Perú petro

The Ocean Drilling Project Leg 112

Ocean Drilling Project - Leg 112

- 10 wells drilled / cored on Peru continental slope in 1986 as part of ODP Leg 112
- Provide good stratigraphic control for shallow sedimentary section at several locations in basin
- Heat flow measurements – valuable data for maturation models
- Also evidence of gas hydrates. Recovered hydrates from one hole, and saw evidence in seismic.
- Seismic-reflection data (ODP Line 5) was used to tie (with minor offset) industry seismic line 93-45 to extend interpretation out to the Peru Trench

Location of ODP Wells

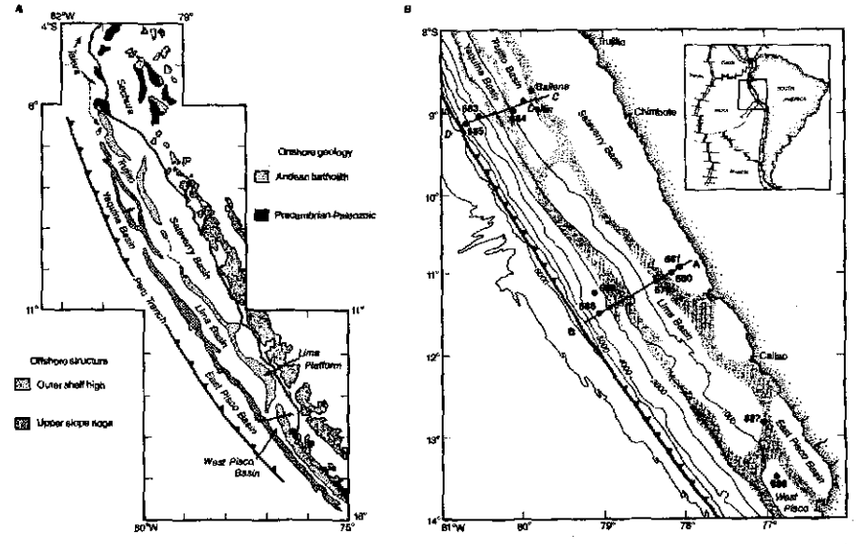


Figure 1. A) Major forearc basins along the Peru Continental Margin, onshore and offshore structures that control the distribution of these sedimentary basins; B) Locations of transects in the northern (C–D) and southern (A–B) areas of investigation, bathymetry, and location of sites drilled during leg 112; modified from Thornburg and Kulm (1981). Bathymetry in meters.

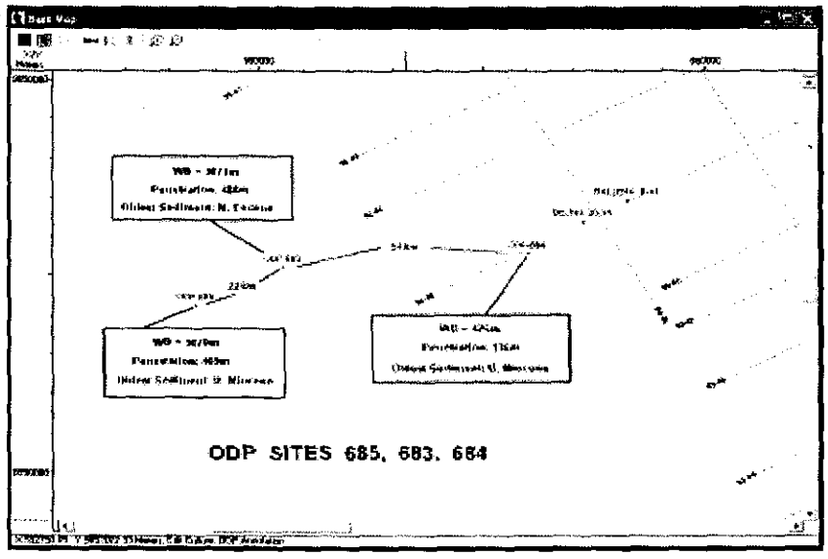
Perú petro

Sites 683, 684 and 685

- Cored Oct-Dec 1986 during the Offshore Drilling Program Leg 112
- Sites comprise a dip-oriented transect that ties industry wells Ballena and Delfin from the Trujillo-Salaverry High down-dip to the lower slope
- Cored lower to upper bathyal (and abyssal) sediments
- Sediments consist of diatomaceous mud with occasional thin layers of silt, sand and ash
- Mio-Pliocene sediments at sites 683 and 684 are rich in organic matter (TOC 6-10%)

Perú petro

ODP Sites 683, 684, 685



Sites 683, 684 and 685

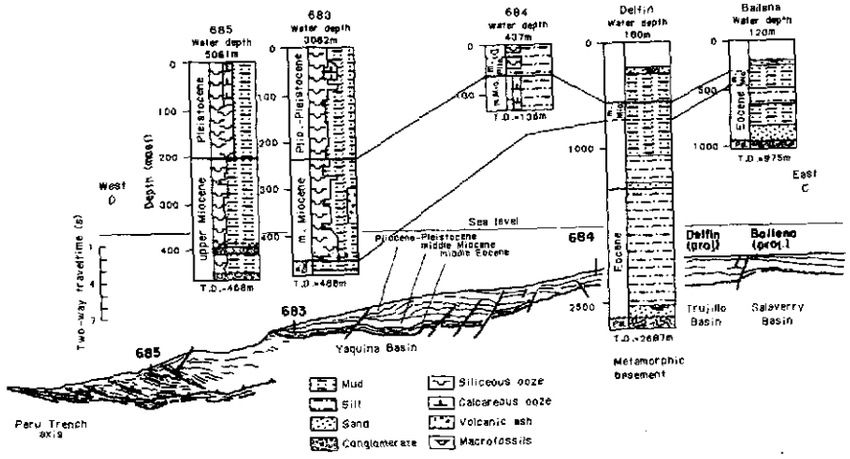
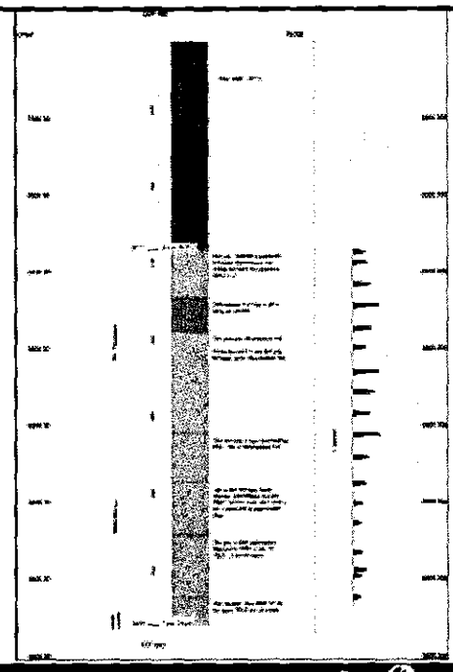


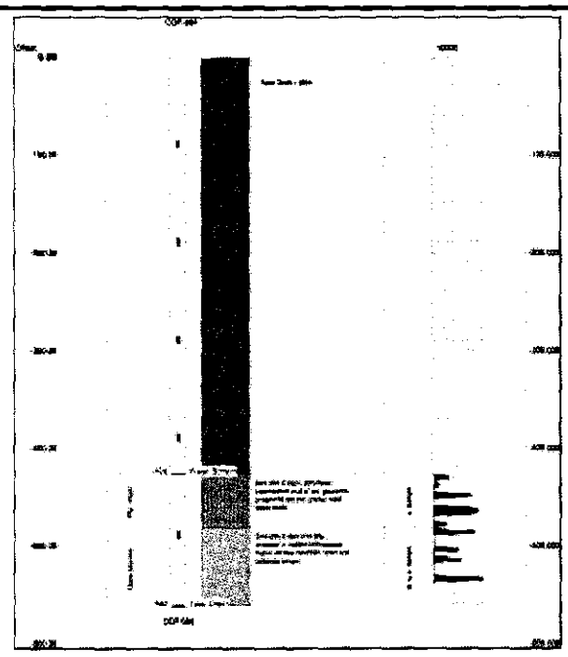
Figure 3. Simplified structural transect, based on seismic survey (Thornburg, 1985) and results of Leg 112 across the Peruvian margin at 11°30'S.

ODP 683 Composite Log



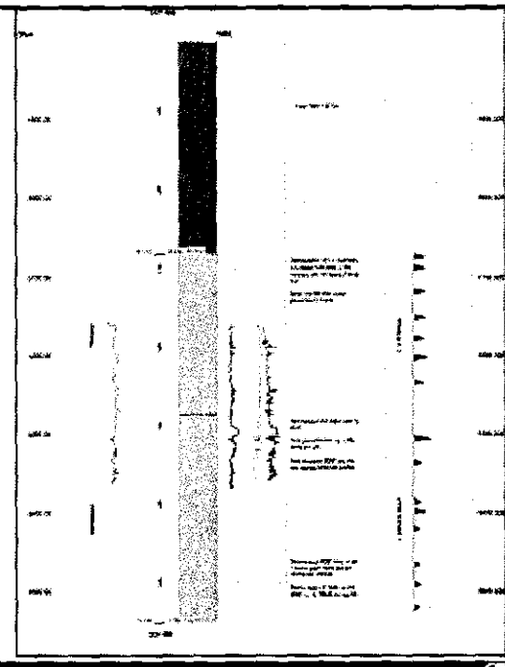
Perú petro

ODP 684 Composite Log



Perú petro

ODP 685 Composite Log

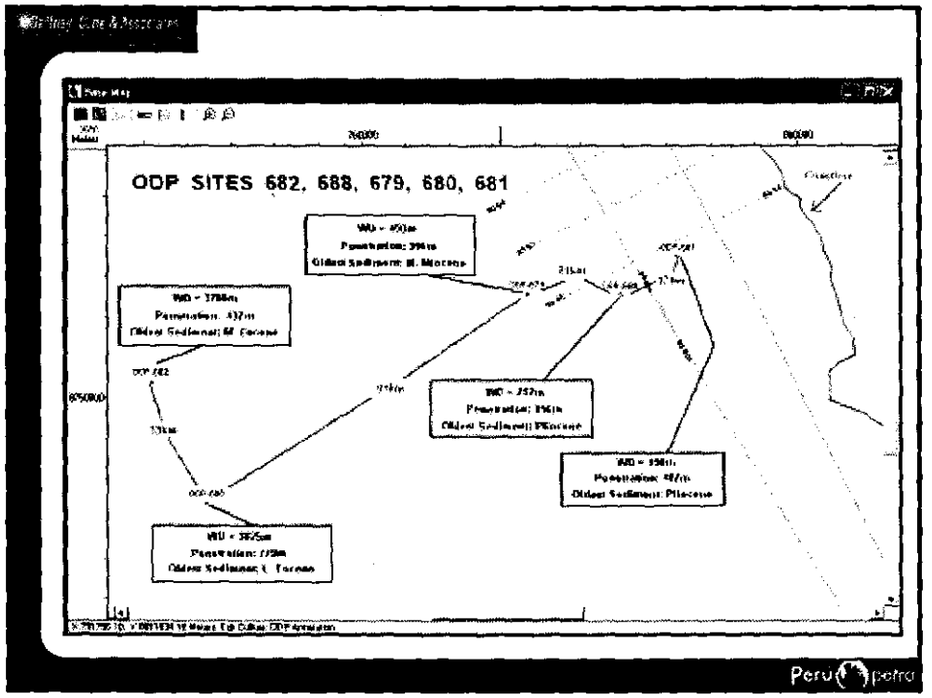


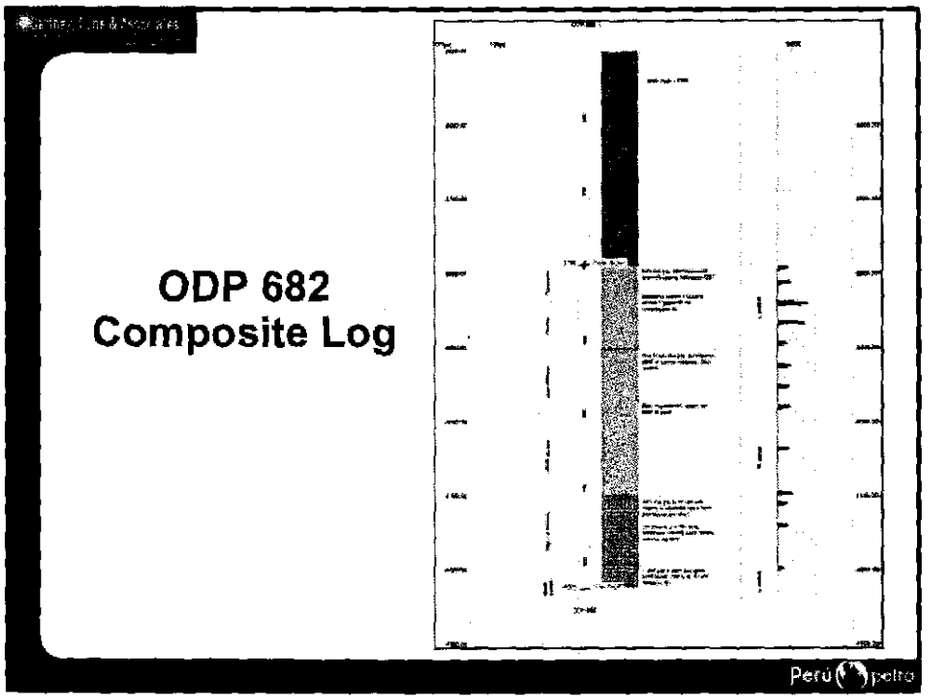
Perú petro

Sites 679, 680, 681, 682 and 688

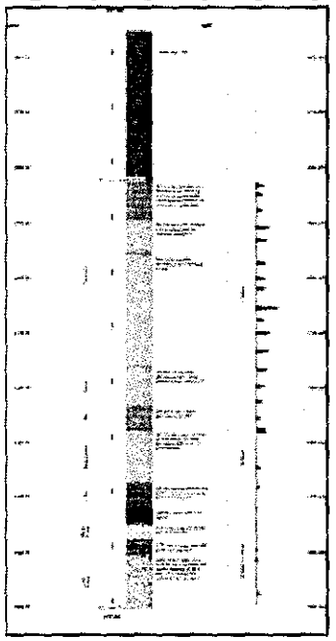
- Sites cored Oct-Dec 1986 during the Offshore Drilling Program Leg 112
- Sites comprise a dip-oriented transect located between the Trujillo and Pisco Basins
- Site 688 penetrated oldest (L. Eocene) and coarsest (c-gr to pebbly) sediments of all Leg 112 sites
- Sites 682 and 688 document a gradual upward deepening since L. Eocene from middle neritic to lower bathyal environments
- Sites 679, 680, 681 document shallower environments that range from middle neritic to upper bathyal
- Plio-Pleistocene sediments at all 5 sites contain intervals that are very rich in organic matter (TOC 7-10%)
- Diatomaceous muds are still the dominant lithology, although coarser clastics are more prevalent than at other transects

Perú petro


ODP SITES 682, 688, 679, 680, 681

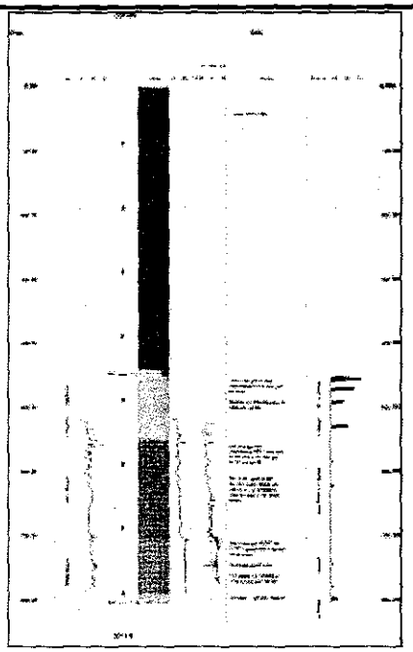

ODP 682
Composite Log

ODP 688
Composite Log



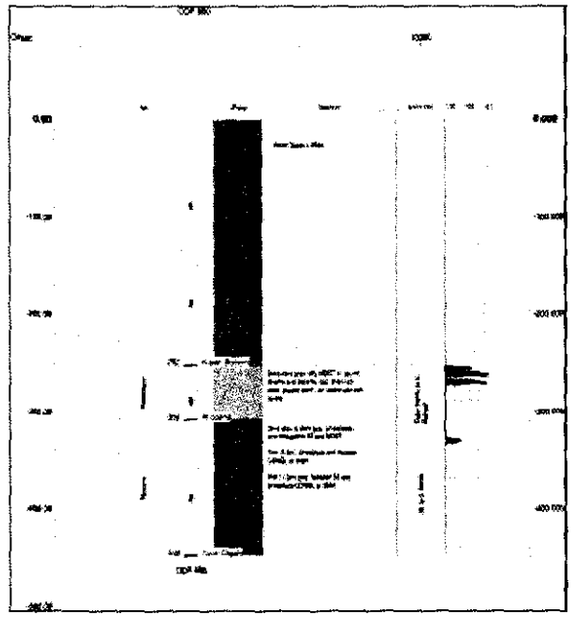
Perú petro

ODP 679
Composite Log



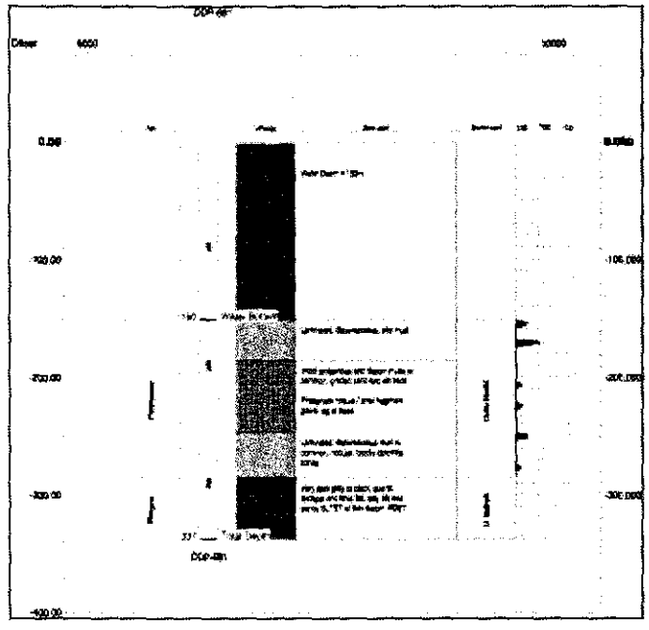
Perú petro

ODP 680 Composite Log

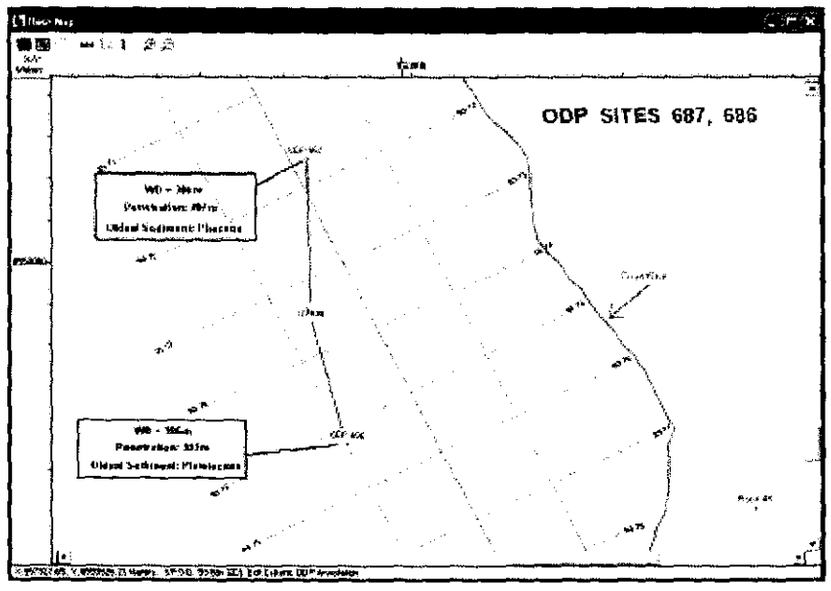


Perú petro

ODP 681 Composite Log



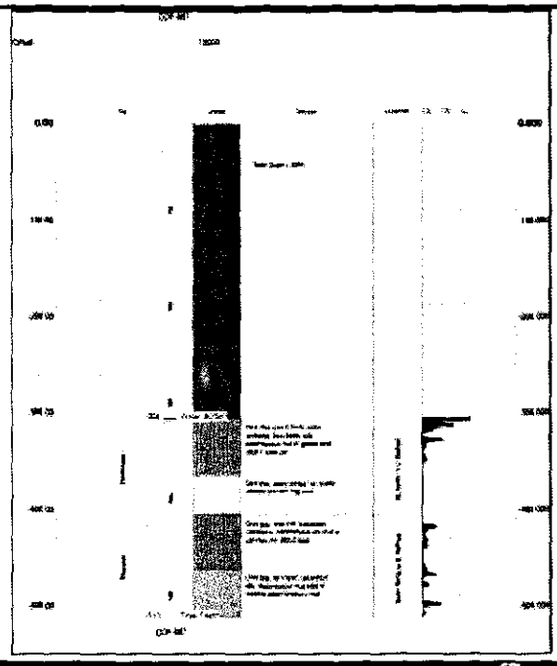
Perú petro



Sites 686 and 687

- Sites cored Oct-Dec 1986 during the Offshore Drilling Program Leg 112
- Southernmost sites of Leg 112 - located in the offshore Pisco Basin
- Cored young sediments – Pliocene and Pleistocene only
- Sites document relatively shallow environments that range from middle neritic to upper bathyal
- With exception of the upper 10m at both sites, organic content is only moderately high (TOC up to 4%) compared to other Leg 112 sites
- Diatomaceous muds are the dominant lithology, with the exception of a 40m thick Pleistocene sand interval at Site 687

ODP 687 Composite Log



Perú petro

ODP 686 Composite Log

Perú petro

APPENDIX E

BASIN TECTONICS

Gaffney, Cline & Associates

April 2005

Basin Tectonics

Perú petro

Gaffney, Cline & Associates

Nazca-South America Plate Interaction Controlled The Evolution Of Peru Continental Margin

- Rapid subduction causes forearc compression and increases sediment supply from onshore arc
- Slow subduction favors extension and low terrigenous sediment input
- Subduction of oceanic ridges causes outer forearc compression followed by subsidence of inner forearc
- Because of tectonic erosion, the accretionary wedge in the Peru forearc is small and most of the forearc is underlain by continental crystalline rocks

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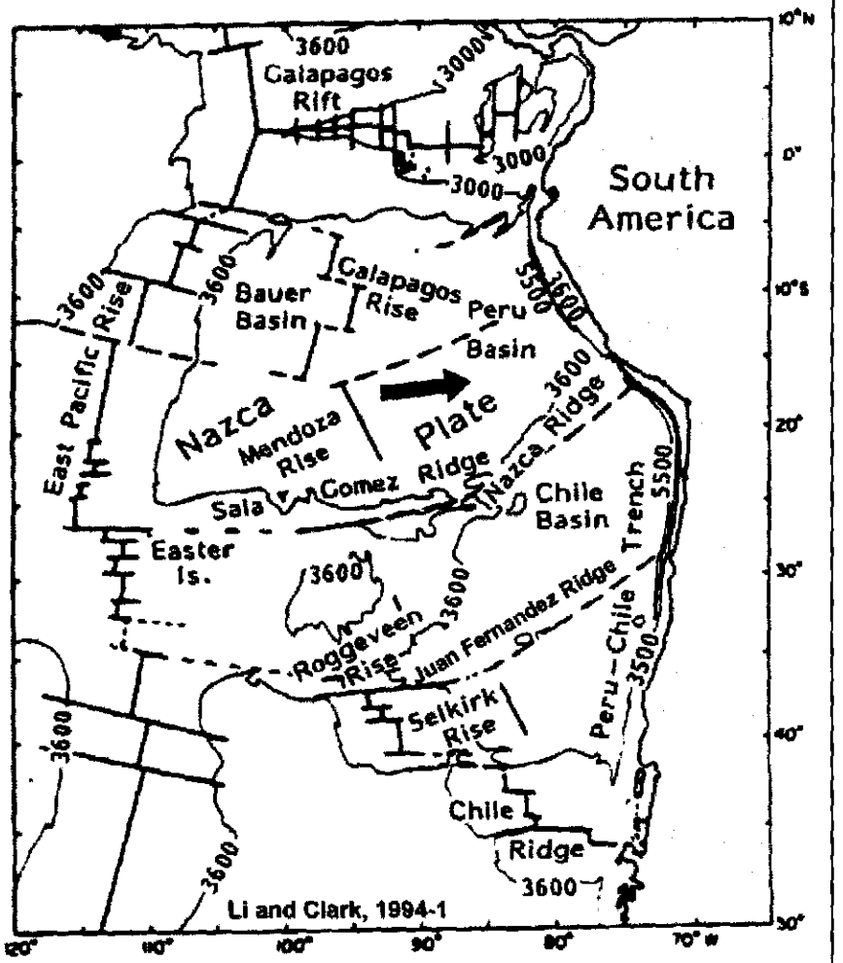
Gaffney, Cline & Associates

Map Showing Motion Of Nazca Plate Relative To South America

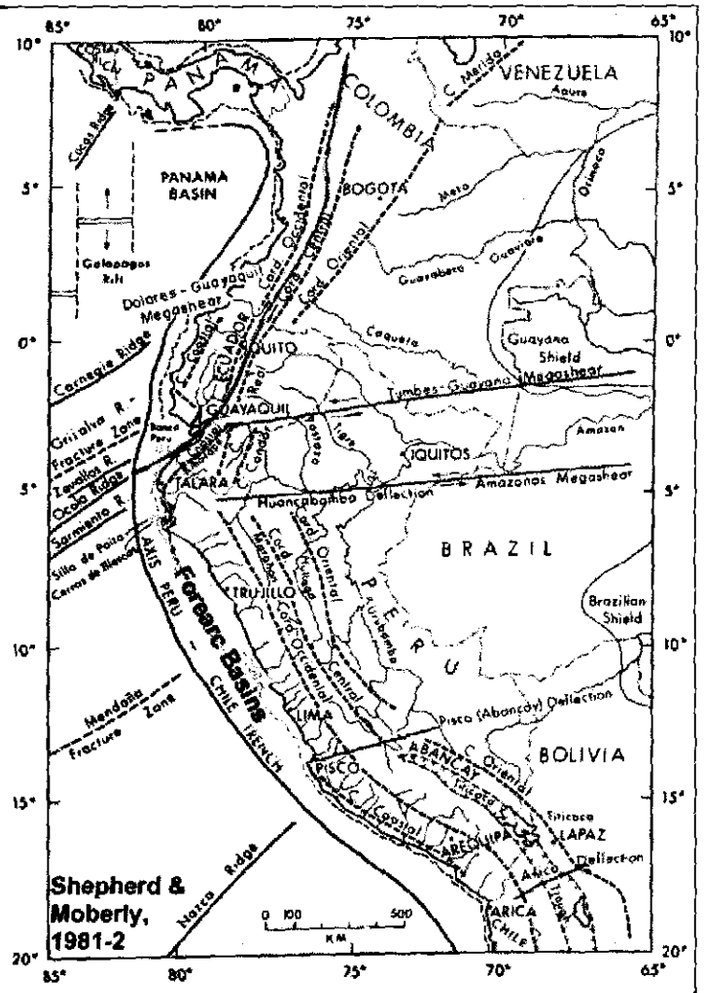


Perú petro

Map shows current motion of Nazca plate relative to South America. The rate and direction of convergence has influenced tectonics and sedimentation history of the Peruvian forearc since at least the Cretaceous.

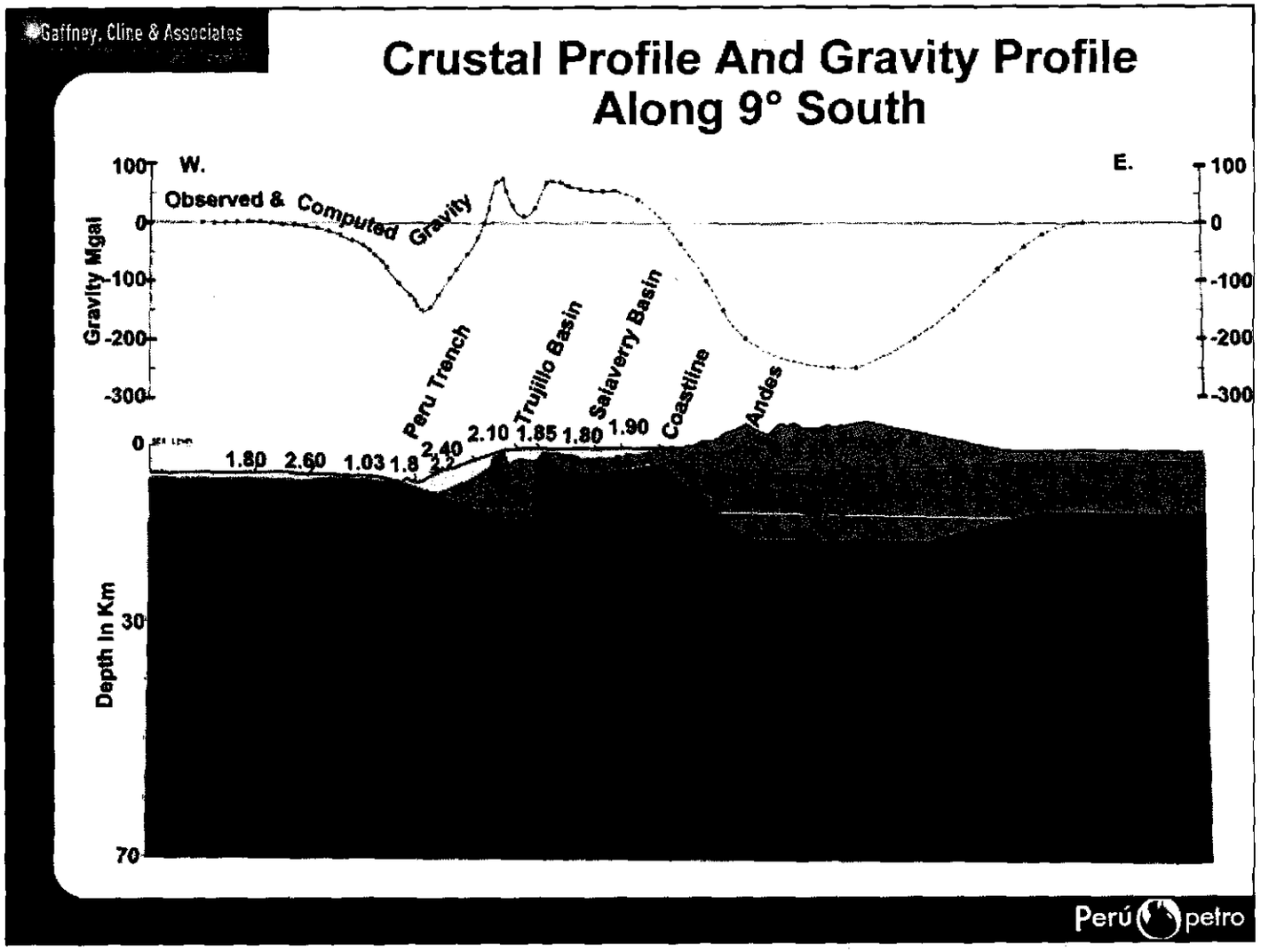
Gaffney, Cline & Associates

Position Of Major Tectonic Trends Relative To The Peru Forearc Basins

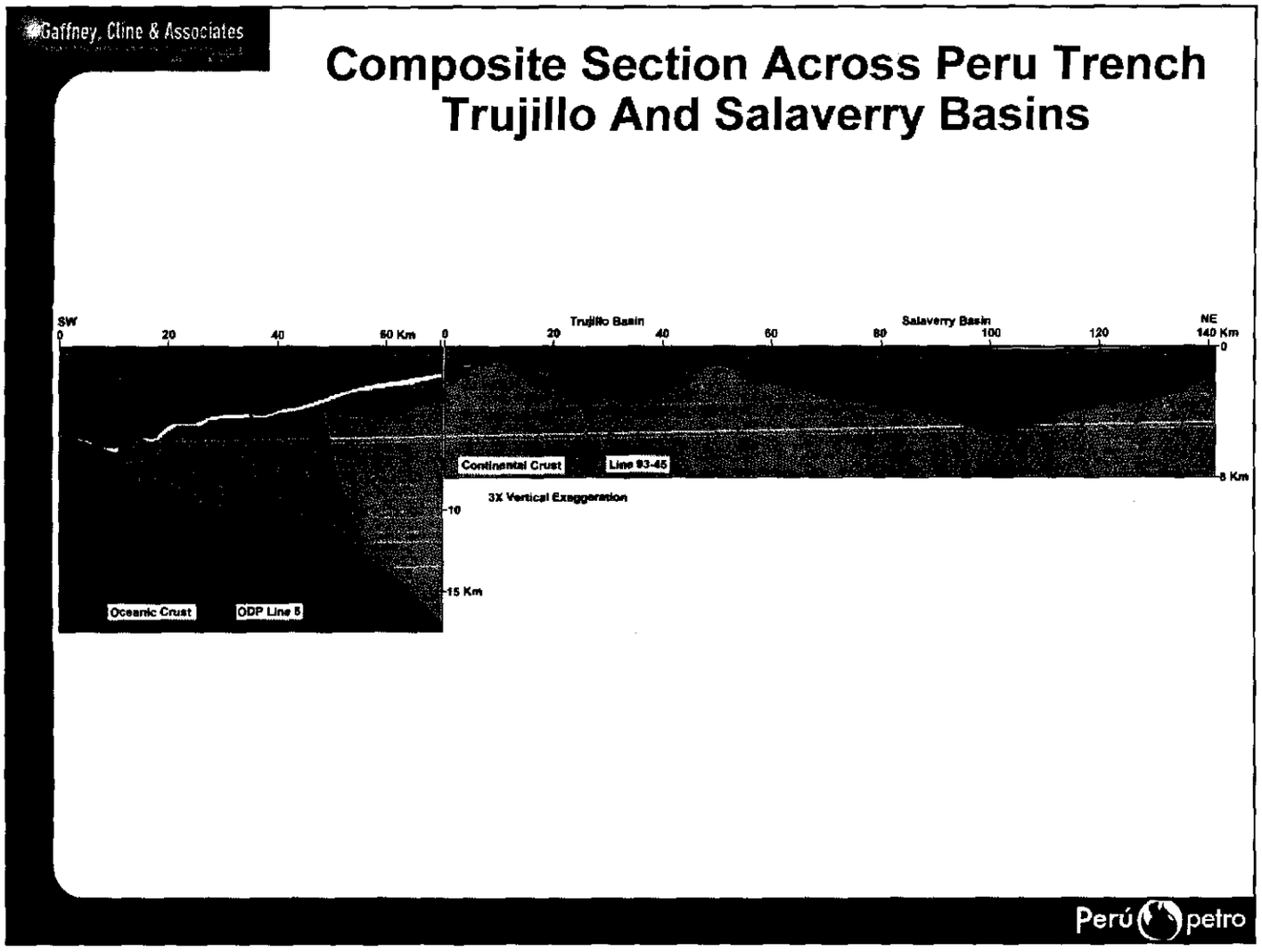


Perú petro

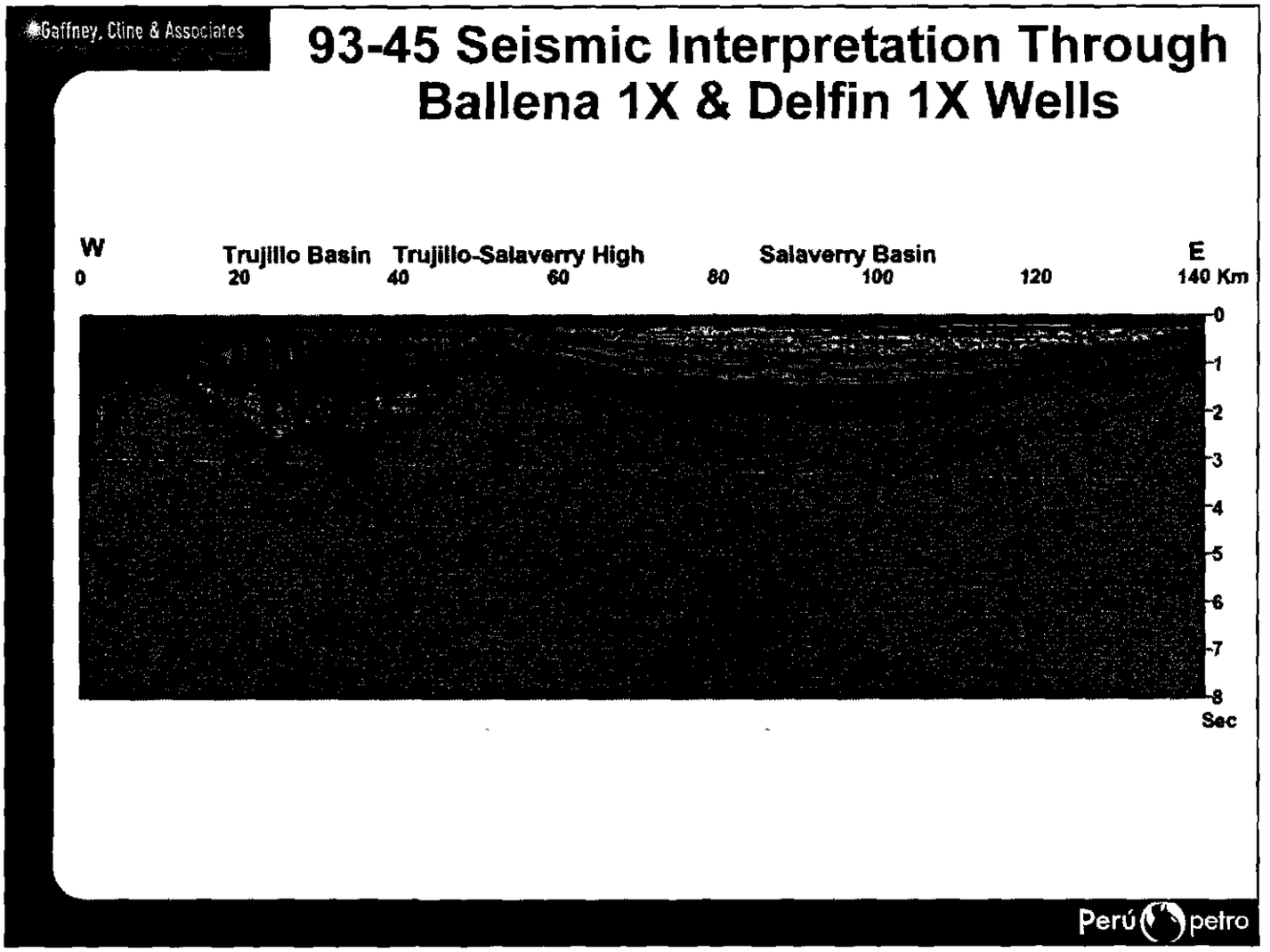
Map shows some major geomorphic features of northwestern South America and the trends of ridges and fracture zones on the Nazca plate. Head-on subduction of oceanic ridges that trend orthogonally to the continental margin results in segmentation of the forearc basins. This can be seen in the Talara and Tumbes basins today. Subduction of oceanic ridges that are oblique or perpendicular to the margin produces compressional deformation in the outer part of the forearc and tectonic erosion at the base of the continental plate. Due to the thinning of the continental plate by tectonic erosion, the inner forearc subsides following subduction of a ridge. This presumeably occurred beneath the Peruvian forearc basins when the now subducted, north-trending segment of the Nazca ridge was subducted in the Miocene.



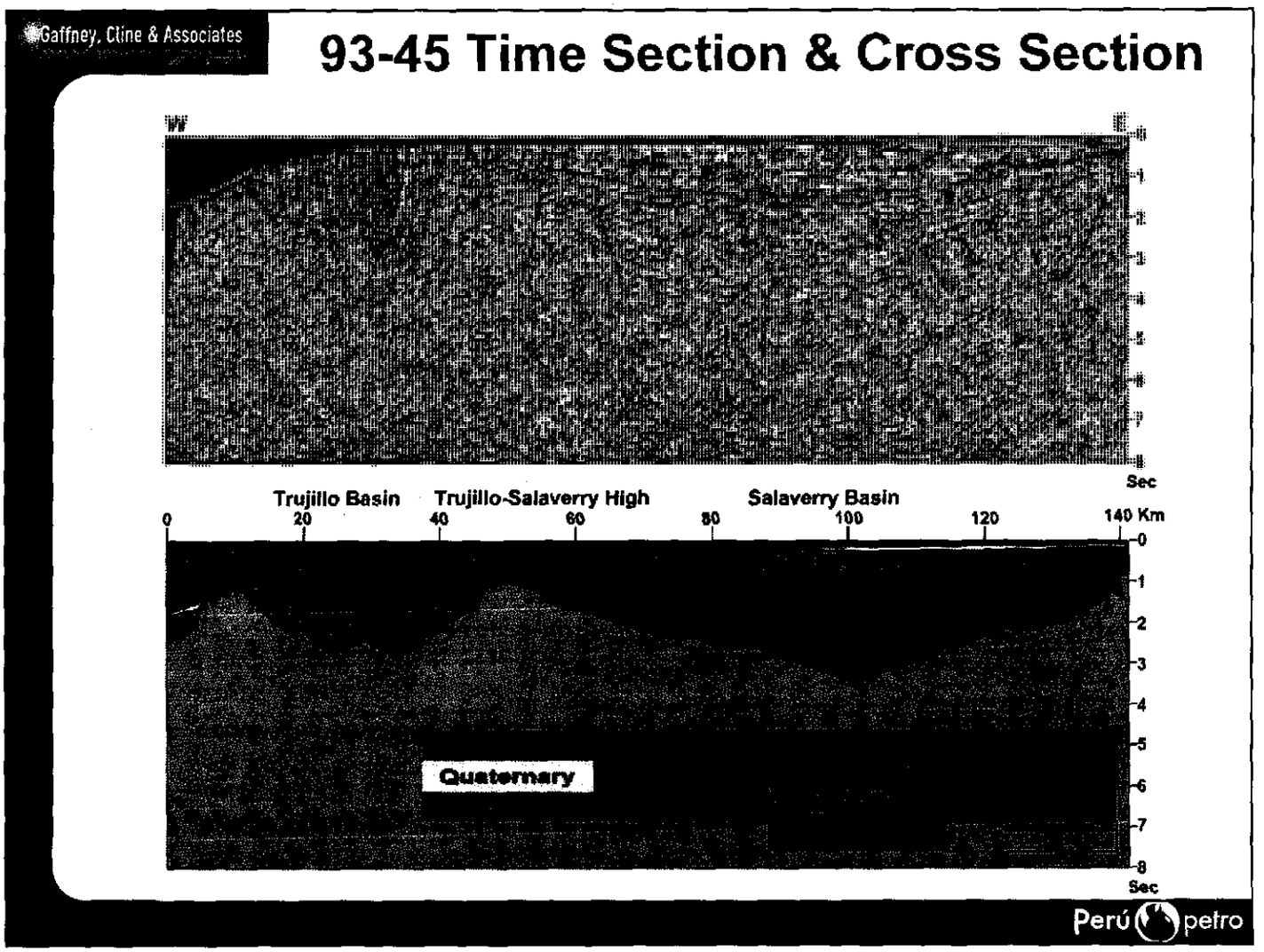
This crustal profile model is based on matching the observed gravity profile along 9° S latitude. Note extent of 2.6 to 3.0 density **continental** crust beneath Salaverry and Trujillo basins. Oceanic crust and mantle have density > 3.0. The thin strip of 2.65 to 3.0 density material beneath and west of the trench is oceanic basalt and associated sediments.



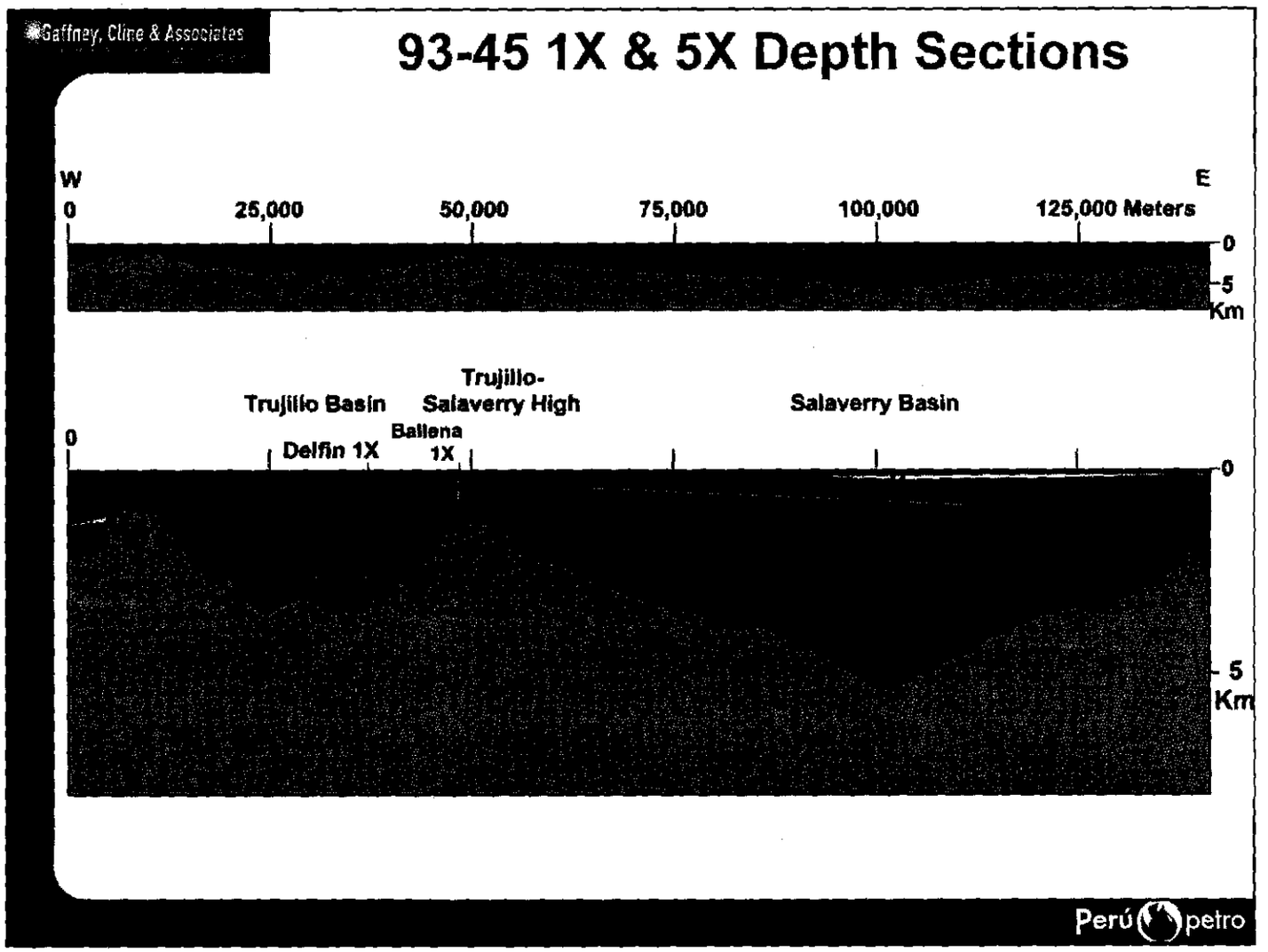
3:1 depth section based on ODP line 5 and seismic line 93-45. The Trujillo and Salaverry basins overlie continental crystalline crust. The accretionary wedge is small and confined to the area beneath the outer continental slope. There is good agreement between the regional gravity profile and this composite section based on seismic data.



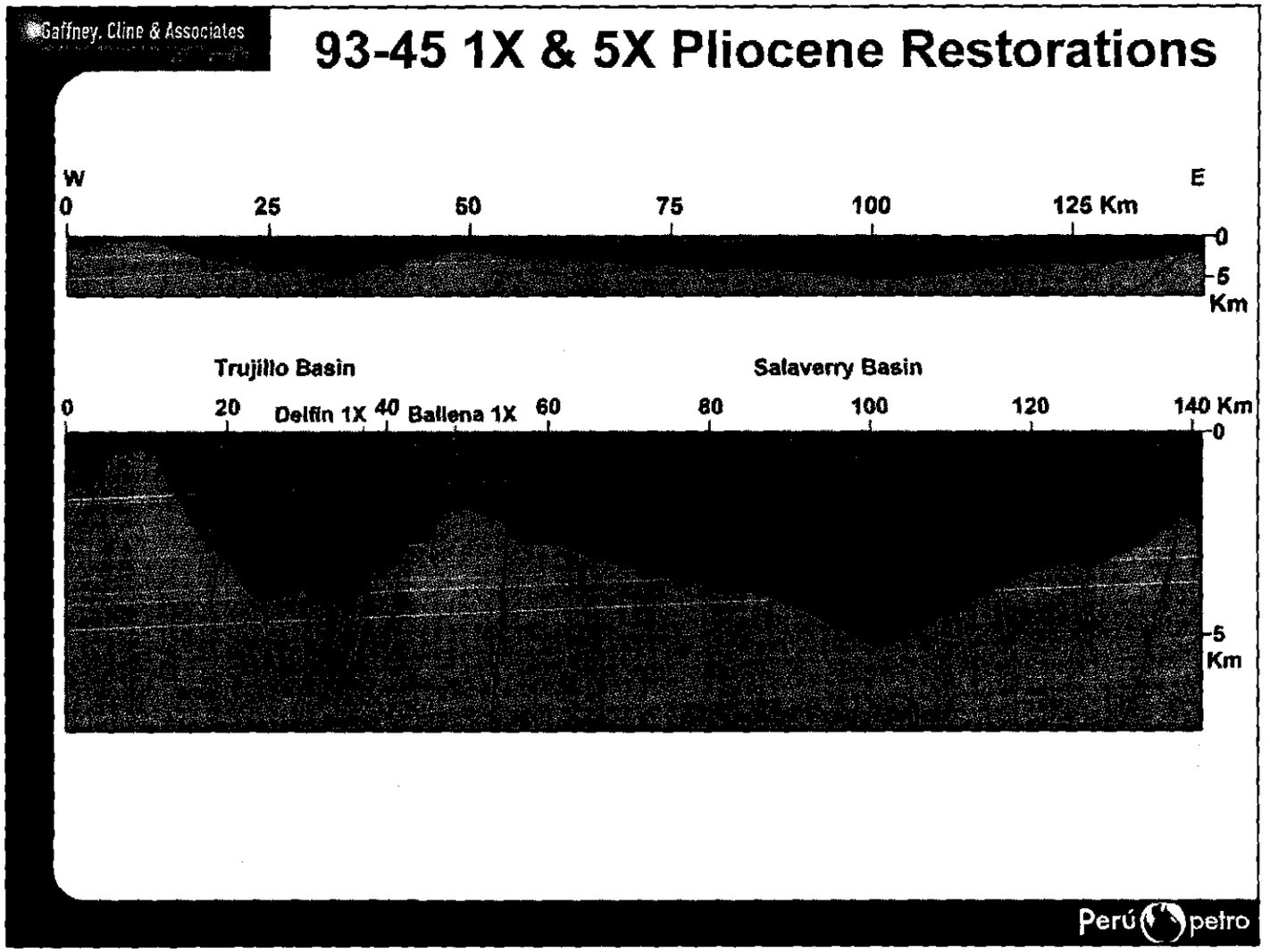
SEG-Y file, horizons & faults are imported into cross section program & edited for structural and geometric consistency.



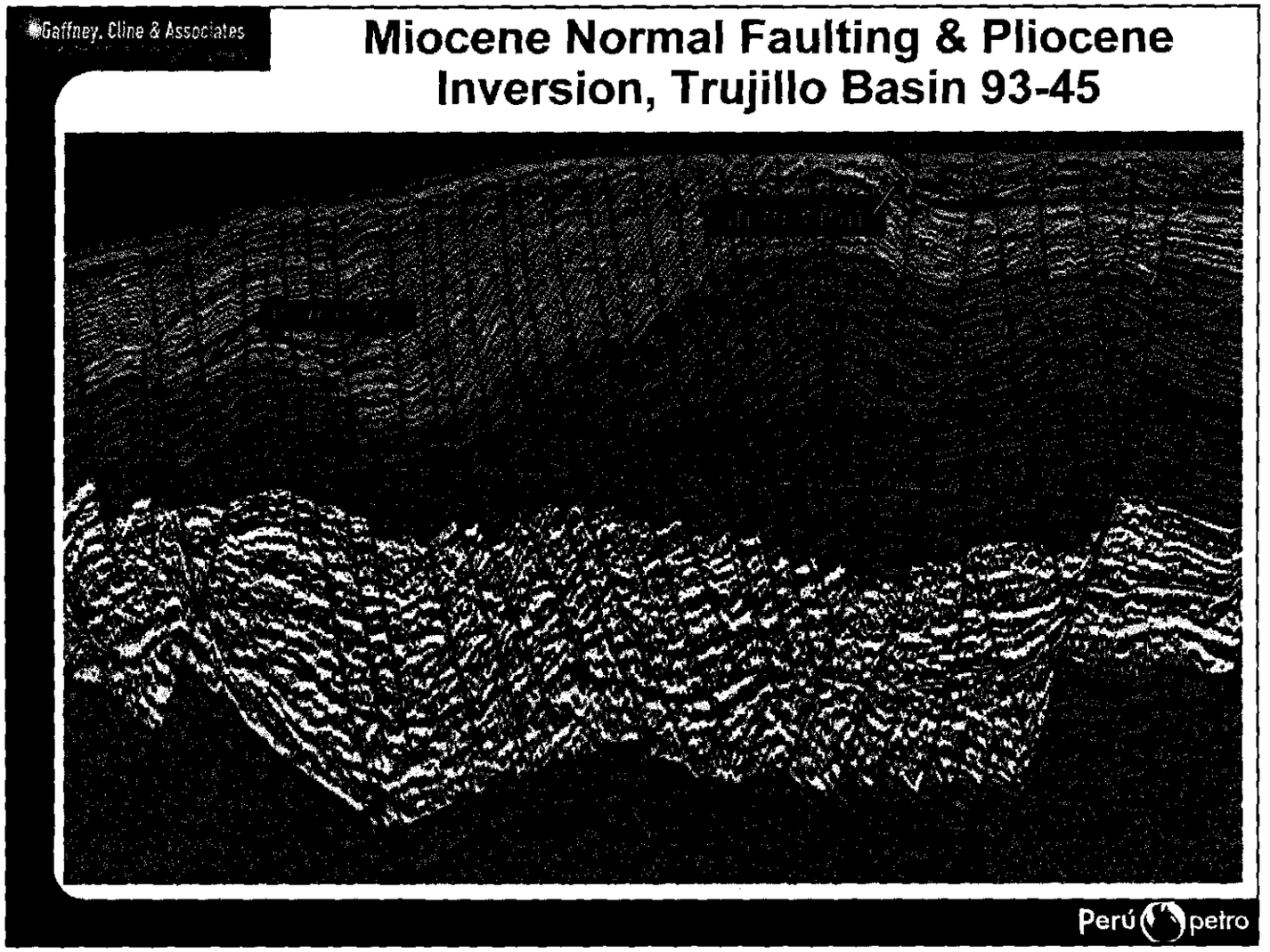
Comparison of seismic interpretation and geoseismic time section.



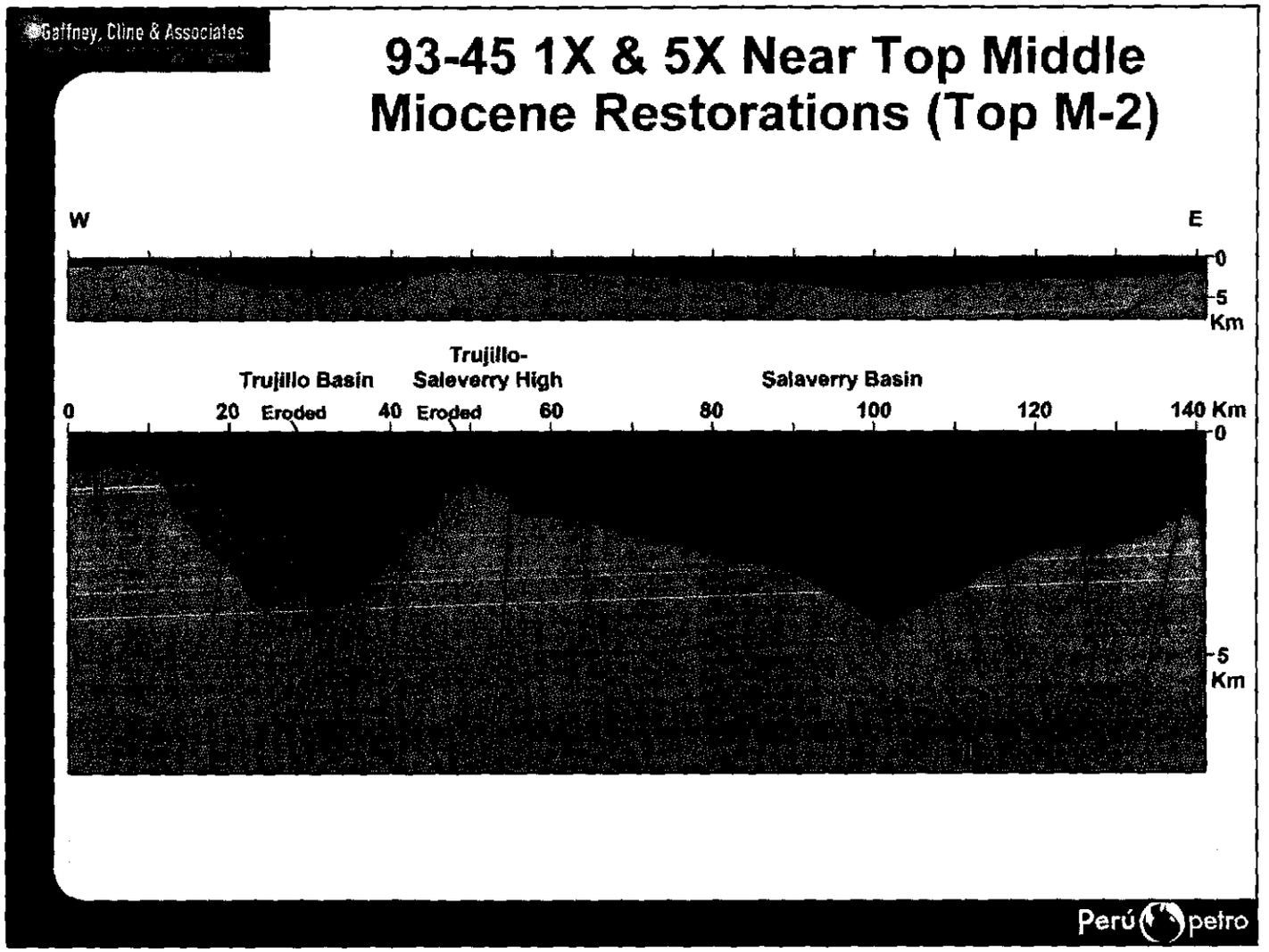
A depth section is generated from the time interpretation using interval velocities determined from stacking velocities and well data. Deep crustal faults have been important in the development of both the Salaverry and Trujillo basins. At various times these faults have acted as normal faults producing regional extension and as reverse faults producing inversion. The Trujillo basin developed as a rift basin during the Eocene. In contrast, regional subsidence is more important in development of the Salaverry basin. Intense, small-scale normal faulting developed in the Trujillo basin during the Middle and Late Miocene. These faults die out downward in the sedimentary section. Late Miocene to Pliocene inversion of the Trujillo basin and the Trujillo-Salaverry high to place mainly by reactivation of basement-involved faults.



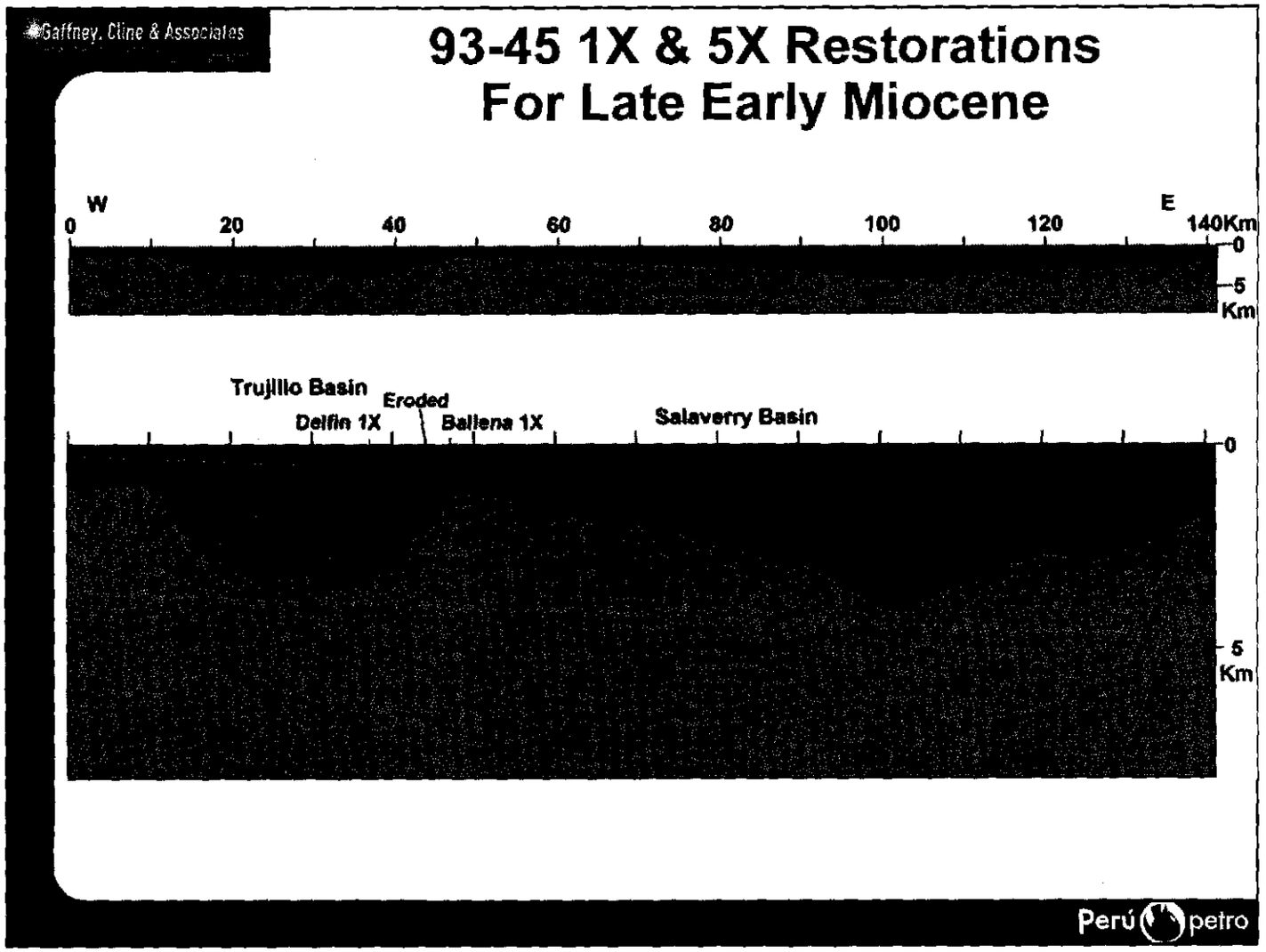
A Pliocene restoration was made by assuming that 1) Pliocene strata extended across the Trujillo basin prior to inversion and 2) that water depth gradually increased to the west. This is the time of maximum sediment thickness in the Trujillo basin. Note reduced structural closure at Ballena 1-X location at this time.



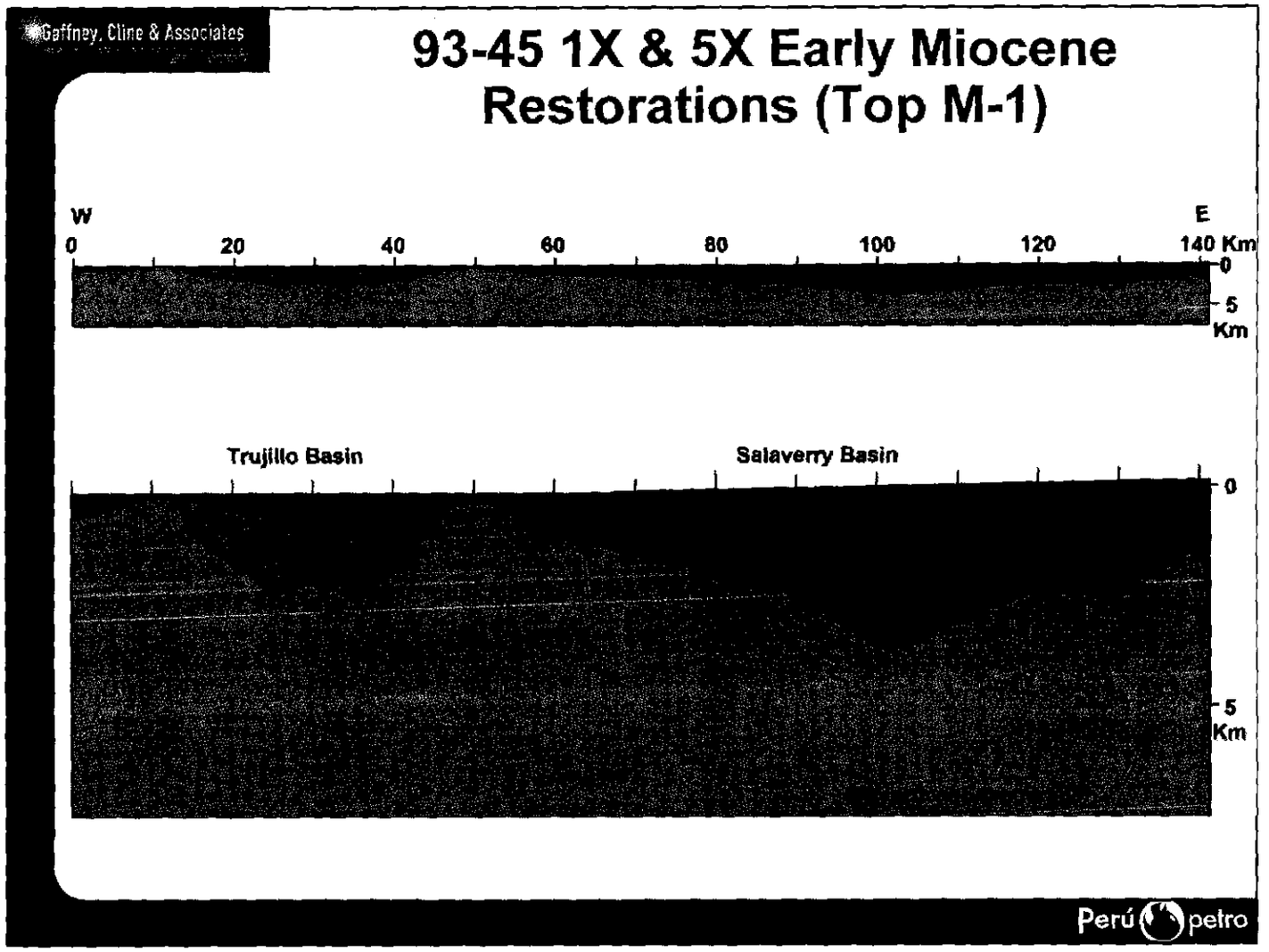
This detail shows the closely spaced normal faults cutting the Trujillo basin. These faults sole out the in rift sequence or terminate against basement-involved faults. Inversion occurred mainly along reactivated basement-involved faults.



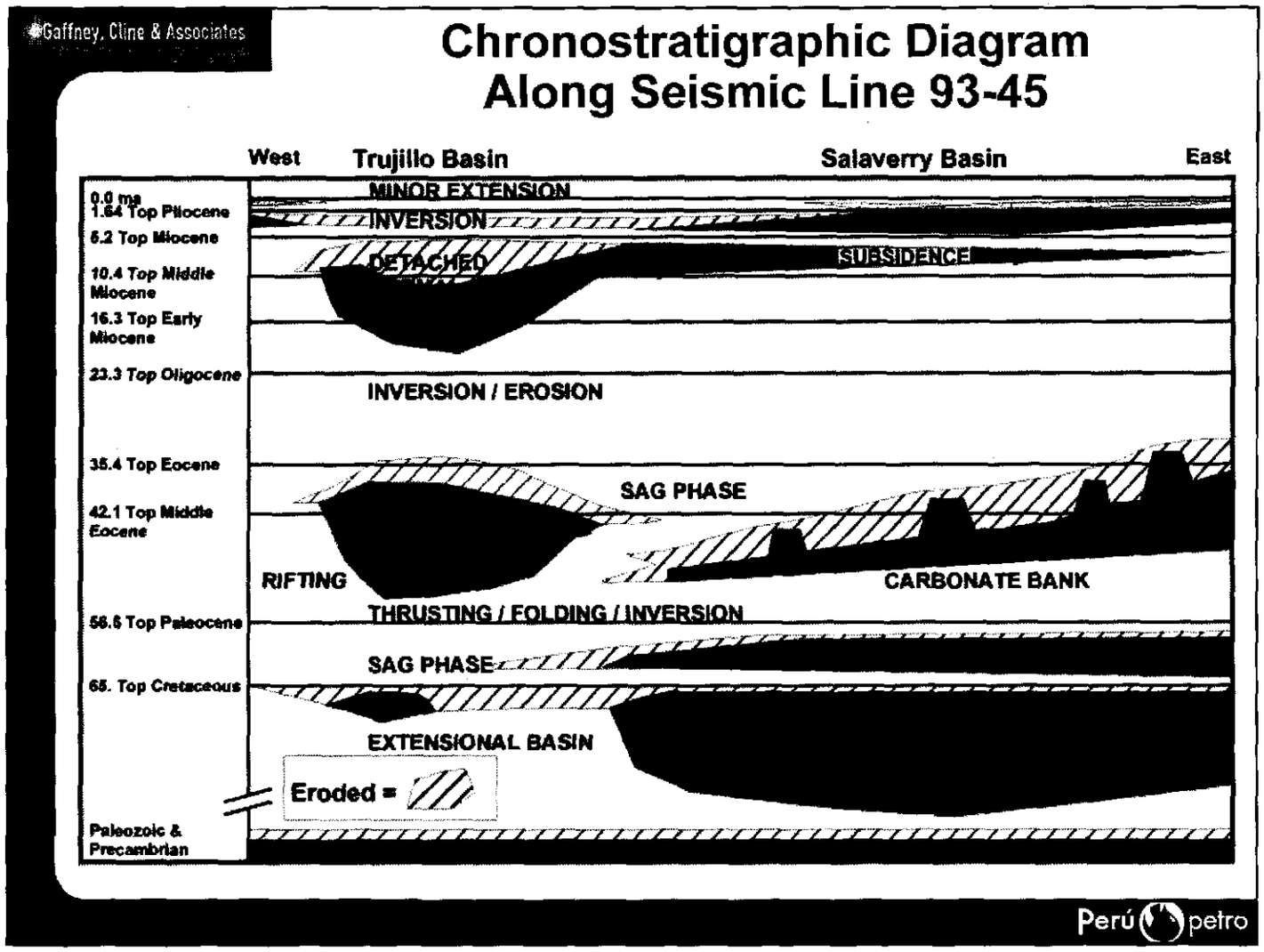
This is the restoration for the Top Middle Miocene. The restoration assumes that water depths increased to the west and were of bathyal depth in the Trujillo basin. Middle Miocene section eroded above the Trujillo-Salaverry high and the center of the Trujillo basin has been restored. Note turquoise M-2 unit filling canyons cut in the brown infra-Miocene unit above the Trujillo-Salaverry high uplifted during Early Middle Miocene. Basin geometry permitted migration of hydrocarbons from Trujillo basin into Salaverry basin at this time.



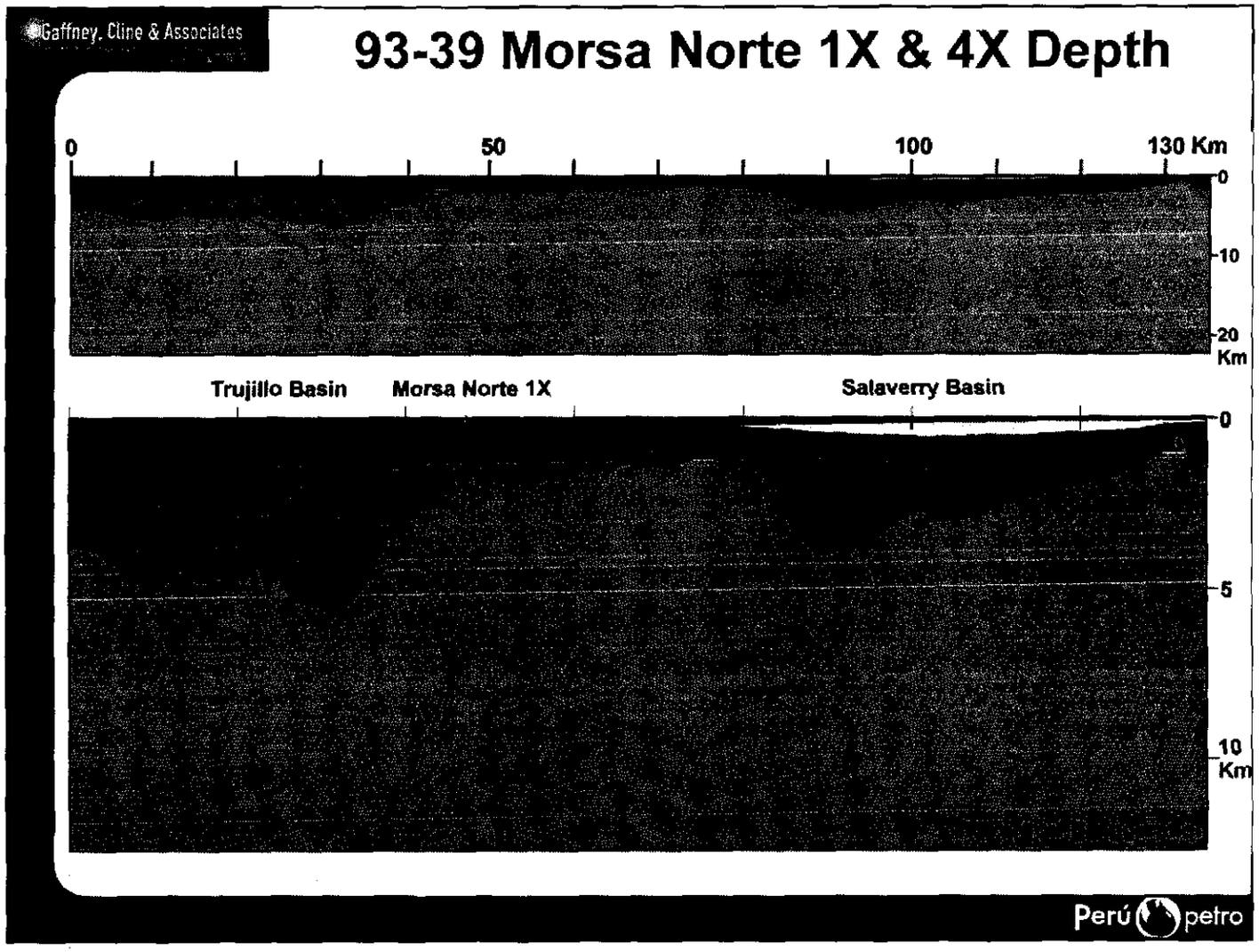
This restoration is for the top of the brown, Late Early Miocene unit. Thickness changes in the infra-Miocene (brown) unit are interpreted to represent shelf to slope transition. To prevent the western part of the Trujillo basin from being strongly elevated, water depth is assumed to be great in the western part of the basin. At this time the Trujillo-Salaverry high had not yet formed. Note unfavorable structural position of Delfin well and lack of closure at Ballena location at this time.



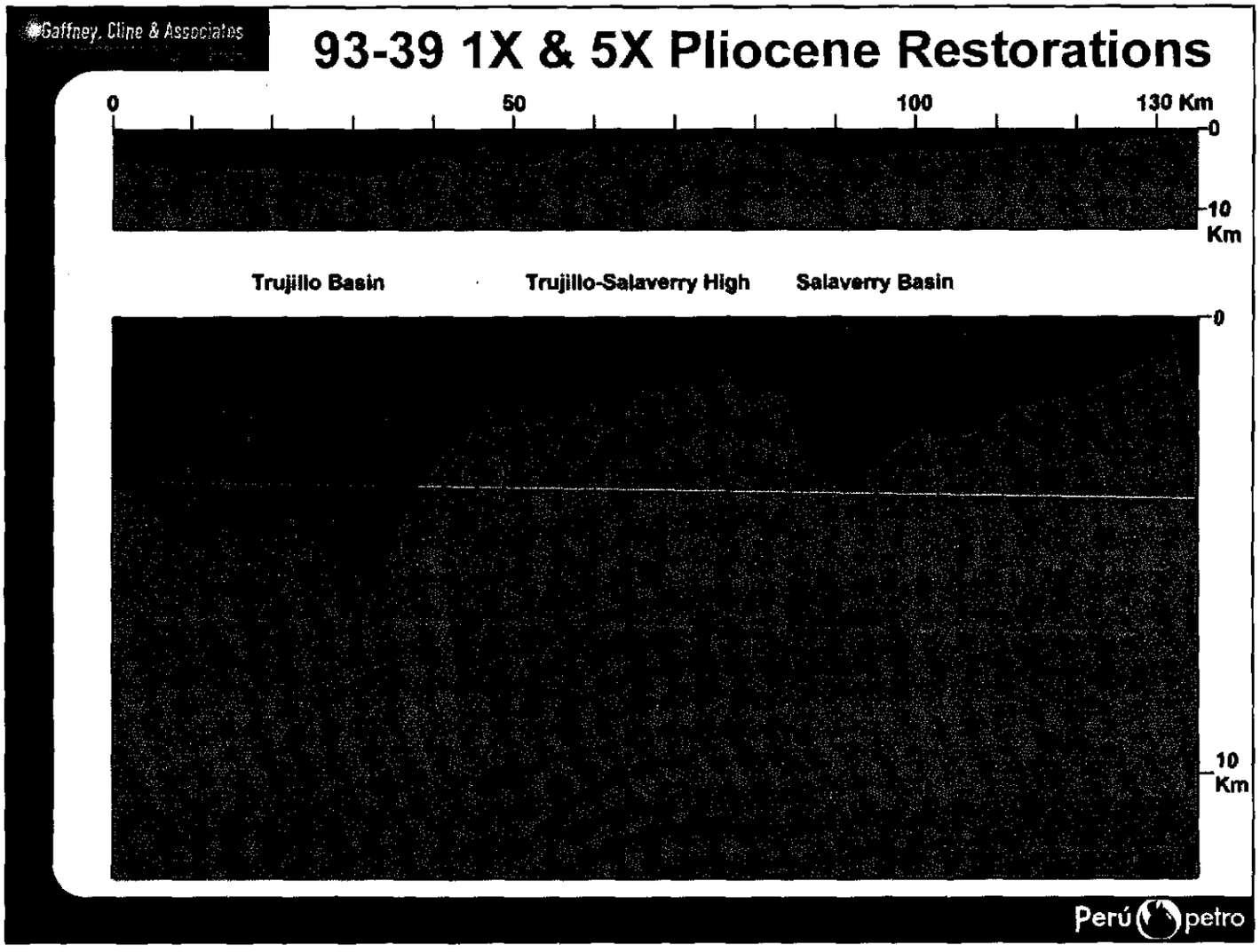
This restoration is for the top of the Early Miocene. At this time the Salaverry basin was sub-aerially exposed. During the Miocene the ocean transgressed across the Salaverry area, producing a sand-prone basal unit.. Subsidence and Early Miocene deposition was focused in the eastern part of the Trujillo basin.



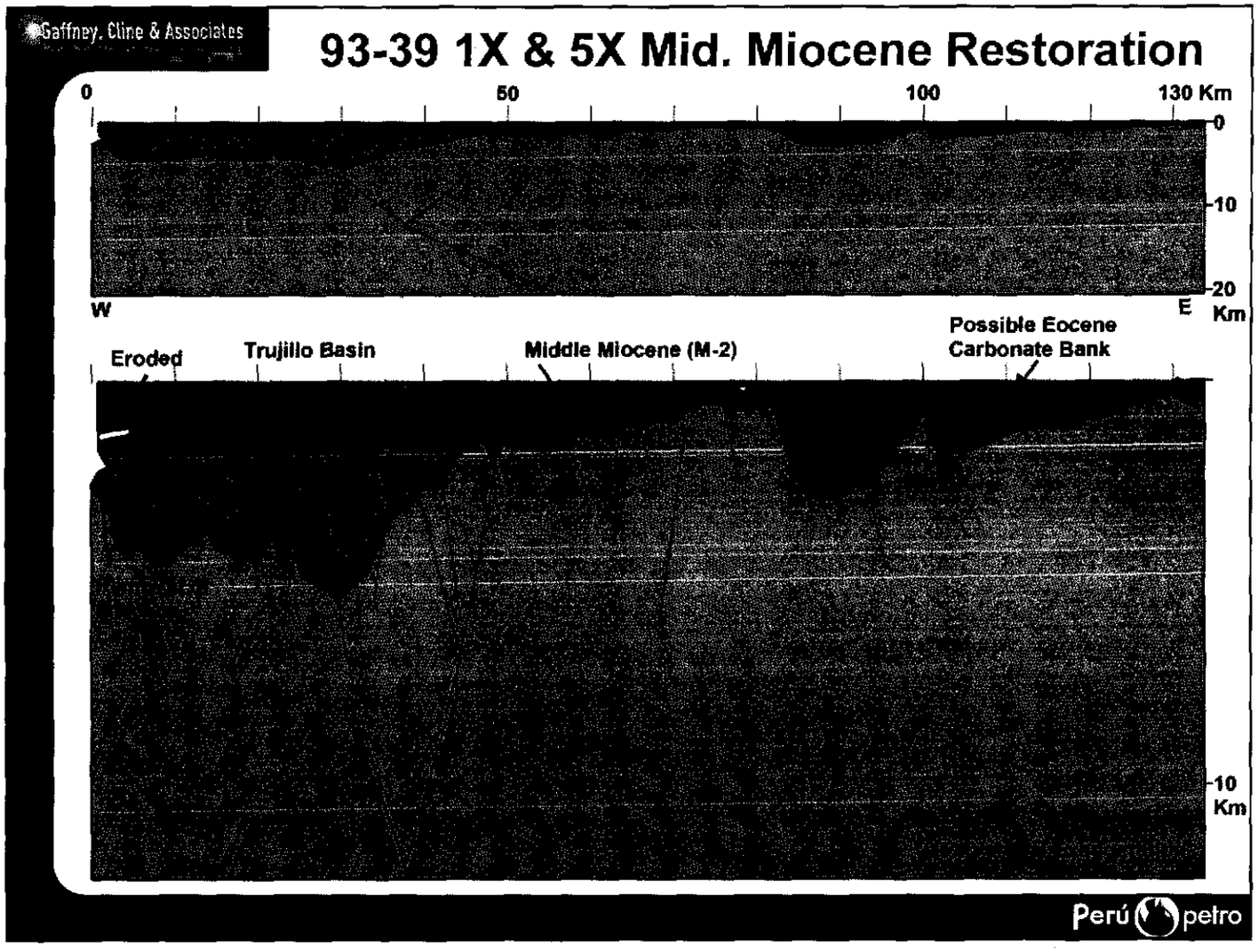
This is a chronostratigraphic diagram along seismic line 93-45. The color of the stratigraphic packages corresponds to the general colors on the cross sections and restored sections. Eroded parts of the section are shown by hatching; non-deposition is indicated by white space.



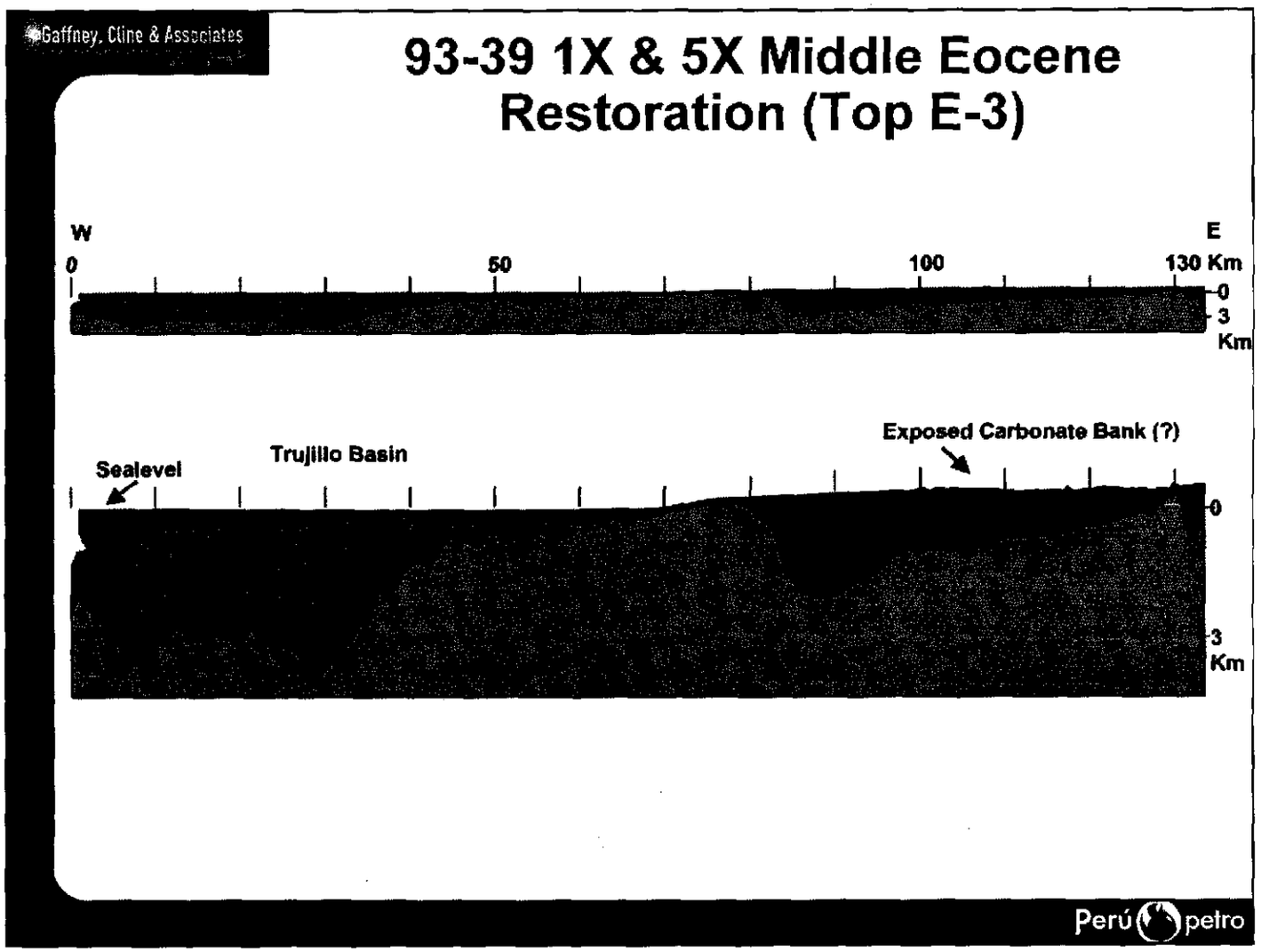
This is a depth section along seismic line 93-39. Note that the Trujillo basin is controlled by reactivated deep crustal faults. Miocene units (blue) are currently arched over Trujillo-Salaverry high as a result of Pliocene reactivation of basement faults. Late Miocene-Pliocene normal faults of the Trujillo basin die out or are detached in rift fill. Folded remnants of Paleocene and Cretaceous strata are interpreted to be present beneath Salaverry basin. The "popup" structure in the Salaverry basin is interpreted to be a detachment fold formed as a result of slip along a detachment near the base of the Paleocene.



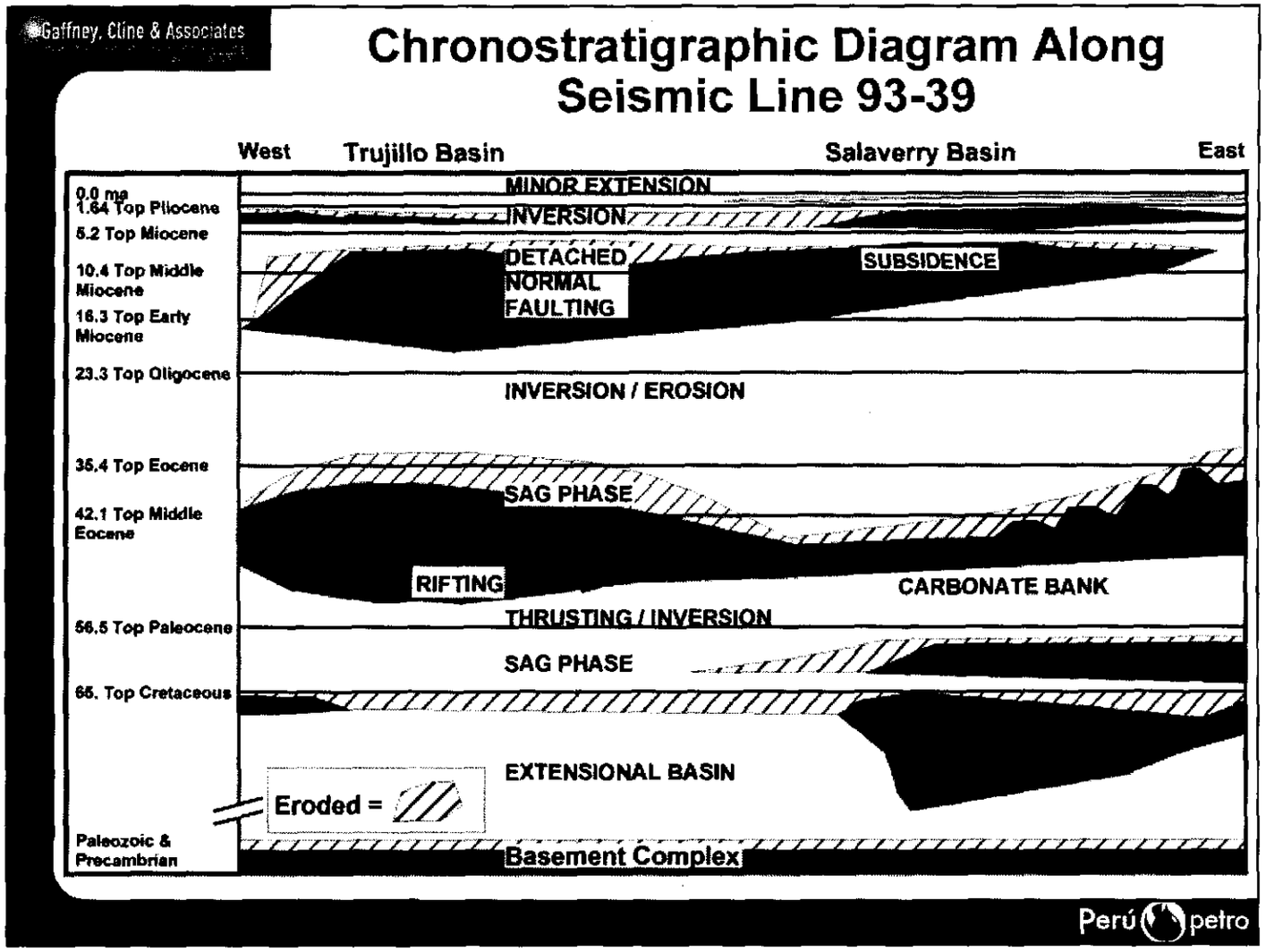
A Pliocene restoration was made along line 93-39 assuming that 1) the Pliocene originally extended across the Trujillo basin and 2) that water depth increased to the west. The restoration removes much of the arching of the Miocene units. The Trujillo basin reached maximum burial at this time.



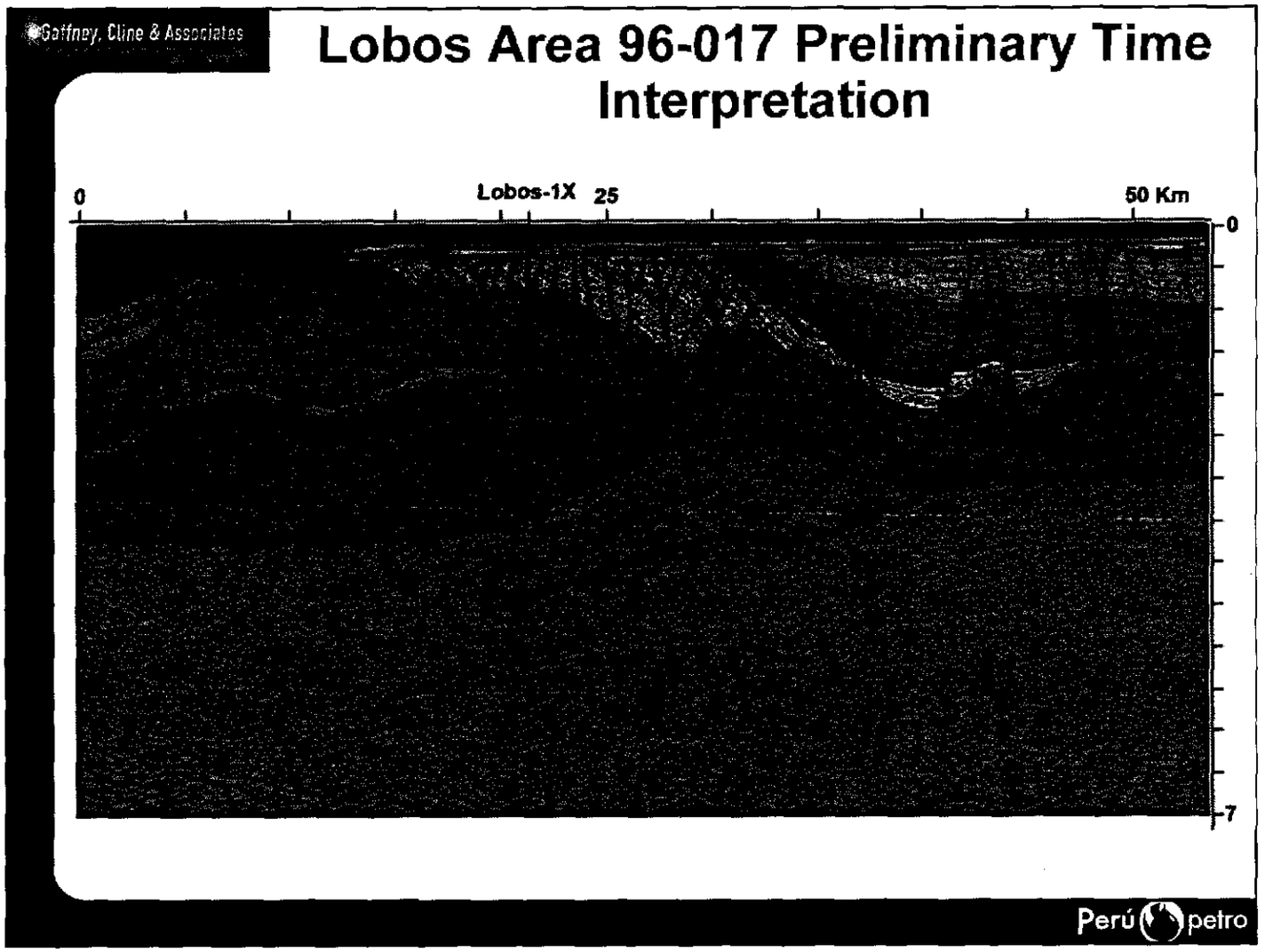
This restoration is for the top of the Middle Miocene. Middle Miocene sediments downlap and onlap onto a thin section of Middle and Early Eocene sediments. Removal of the Trujillo-Salaverry high in this restoration allows any hydrocarbons generated in the Trujillo basin at this time to migrate toward the future Salaverry basin.



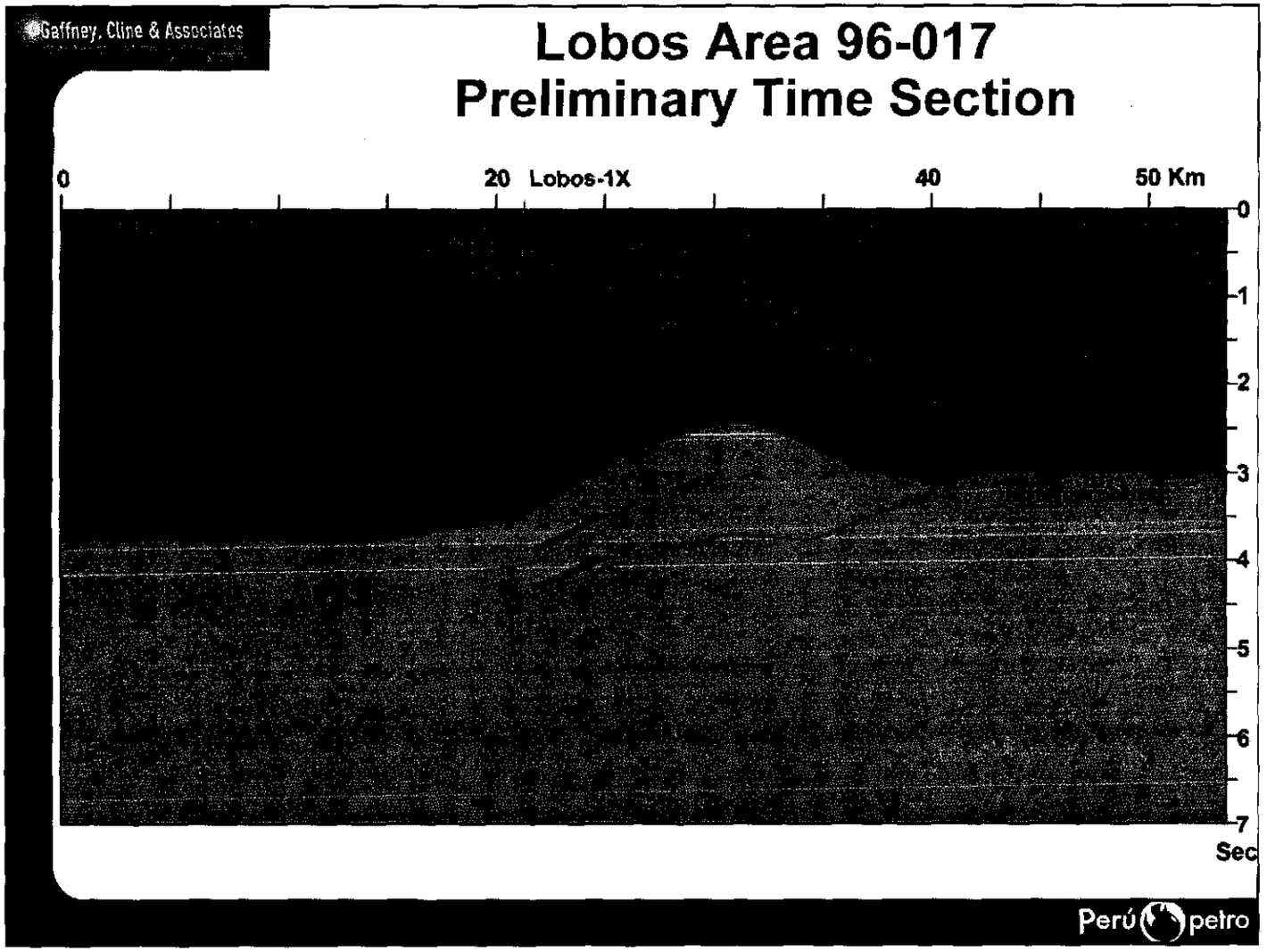
This restoration is for the top of the Middle Eocene (E-3 unit) following filling of Trujillo basin with deepwater sediments. Older Eocene carbonate (?) sediments east of Trujillo basin were sub-aerially exposed at this time.



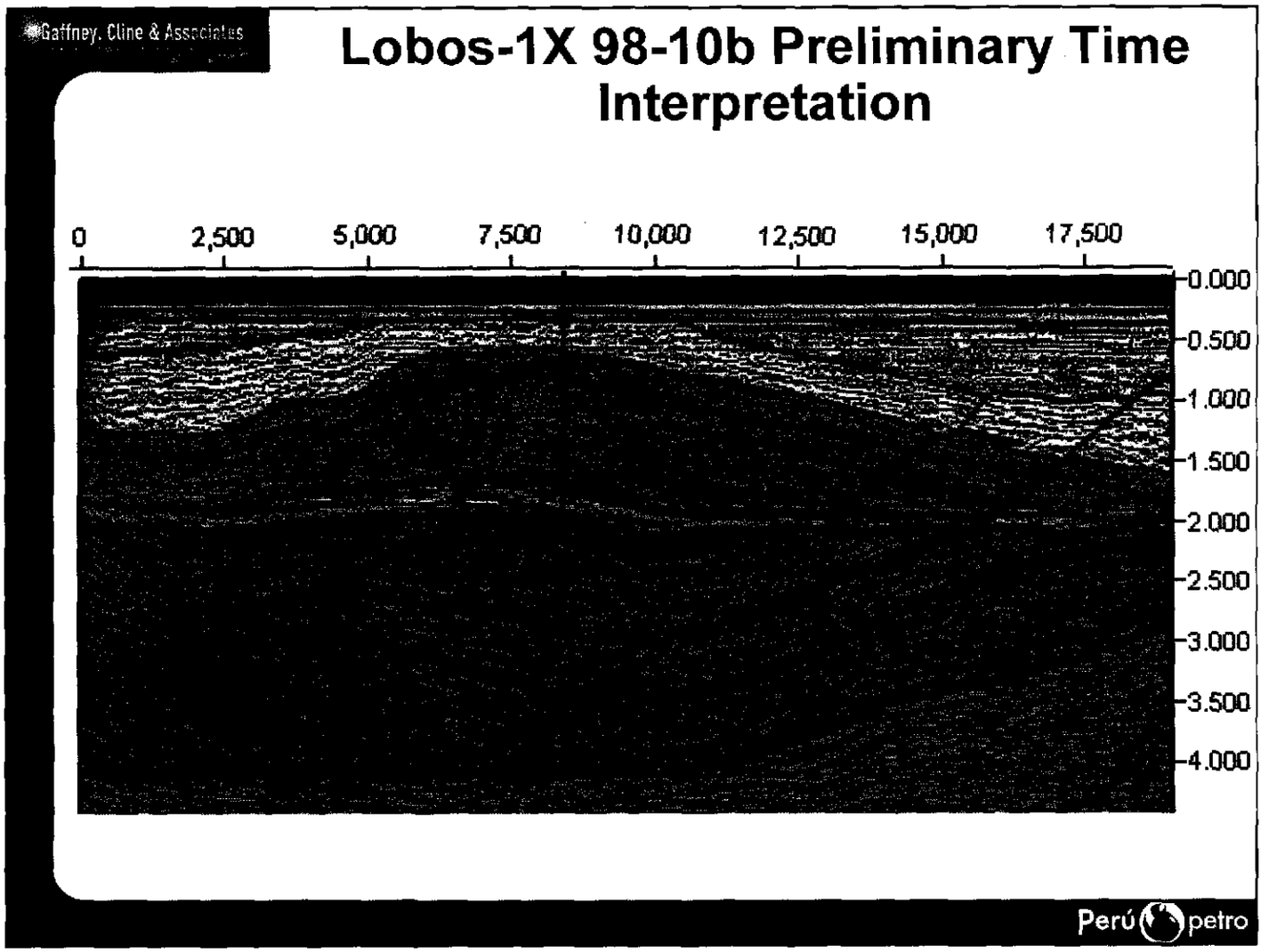
This is a chronostratigraphic diagram along seismic line 93-39. The color of the stratigraphic packages corresponds to the general colors on the cross sections and restored sections. Eroded parts of the section are shown by hatching; non-deposition is indicated by white space.



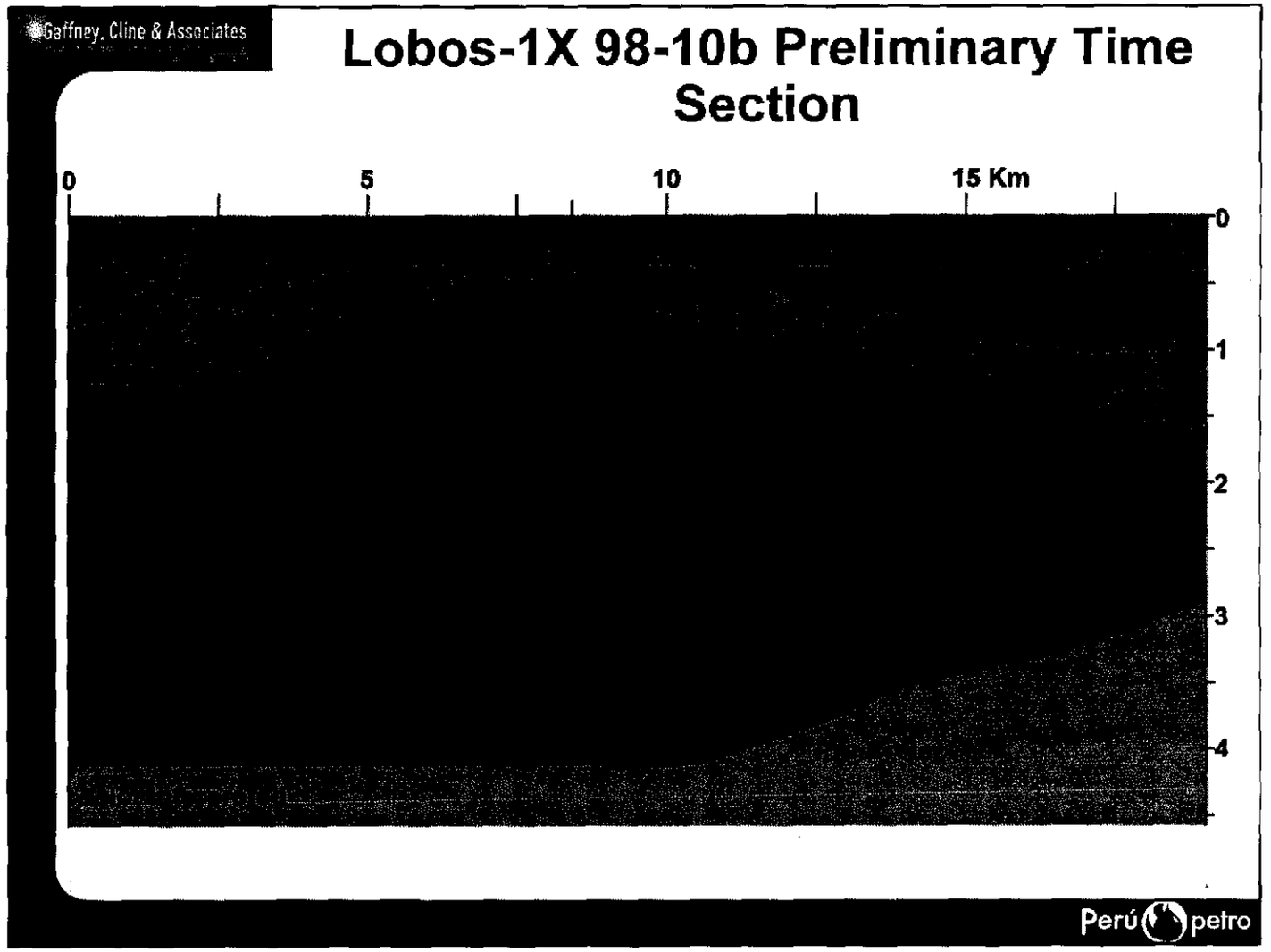
Interpretation shows folded and thrusted Cretaceous older strata, detached and deformed Paleogene strata and Miocene basin formed by seaward displacement of Paleogene strata.



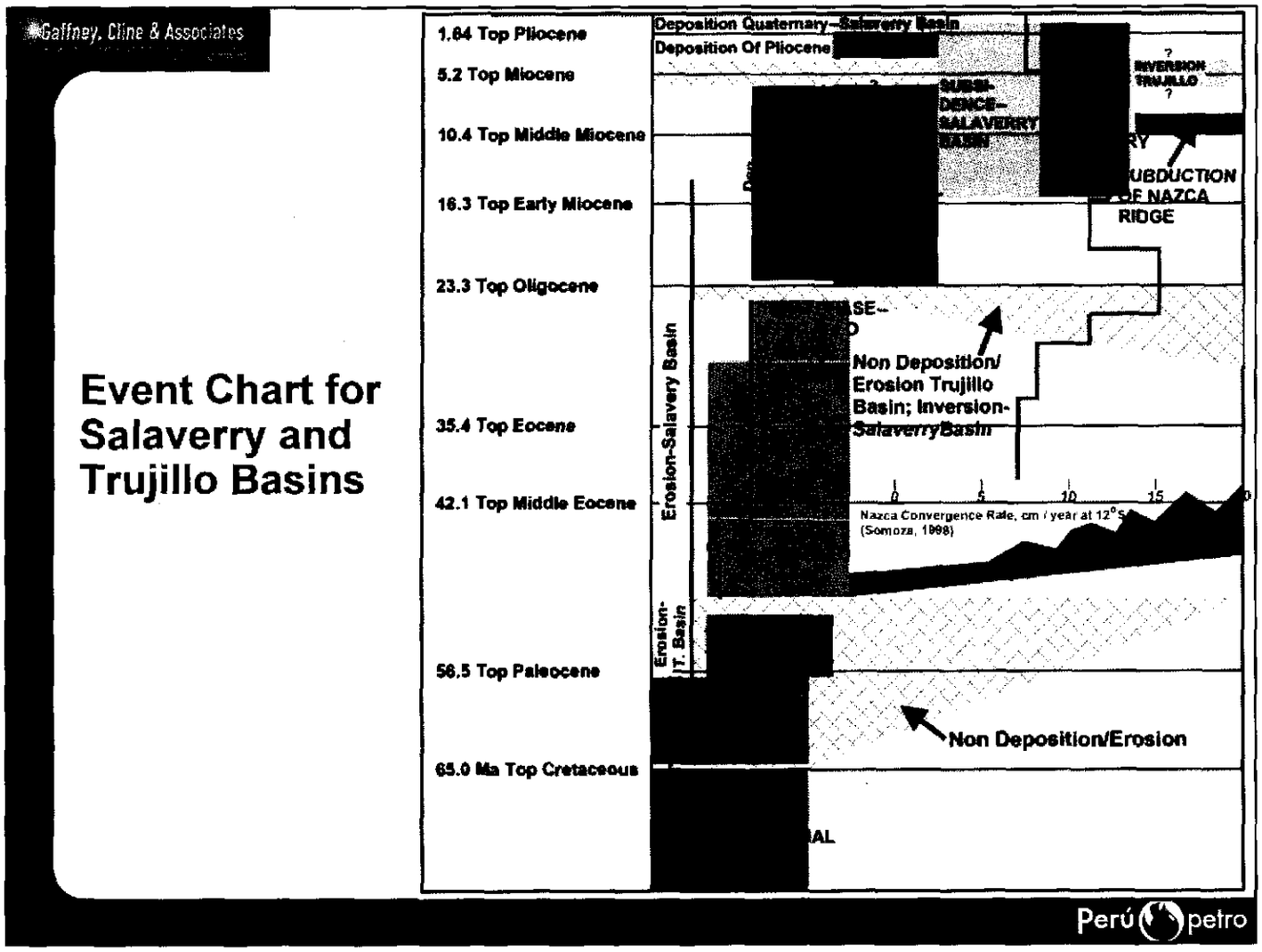
Late Miocene strata encountered by Lobos-1X well are interpreted to be Pliocene strata containing reworked Miocene microfossils based on the lack of deformation.



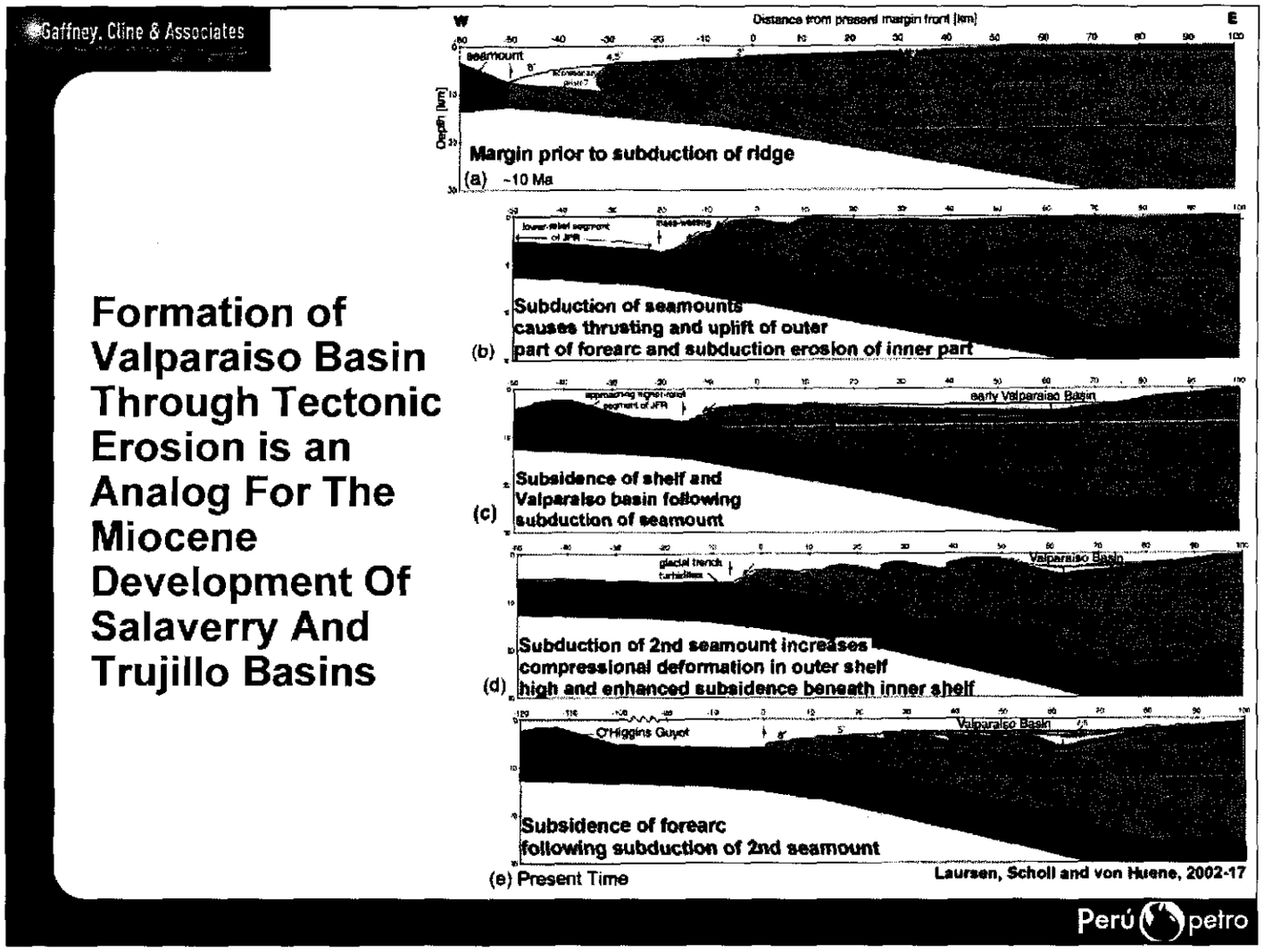
These are the preliminary horizons and faults that formed the basis of the interpretation that is illustrated in the next slide.



Cretaceous structures are nearly at right angles to trend of Tertiary structures.



This event chart summarizes major tectonic and depositional events for the Trujillo-Salaverry basin area. Non-deposition or erosion is indicated by cross hatching. Note Oligocene inversion coincides with rapid convergence of the Nazca plate and Early to Middle Miocene and Pliocene periods of normal faulting coincide with slowing or low convergence rates. Subsidence in the Salaverry basin and Late Miocene inversion in the Trujillo basin is probably related to subduction of the Nazca ridge which occurred in this region about 9 to 10 million years ago.



The Valparaiso basin of the central Chile margin formed since the Middle Miocene as a result of subduction of the Juan Fernández Ridge. Subduction of the ridge produced compressional deformation in the outer forearc and subsidence in the inner forearc due to tectonic removal of continental crust. This style of deformation is analogous to the Miocene development of the Salaverry and Trujillo basins which was probably caused by subduction of the Nazca ridge.

Gaffney, Cline & Associates

Trujillo/Salaverry Well Summary

Ballena 1-X

- No shows
- Poor reservoir section (Too proximal)
- No closure prior to Pliocene

Delfin 1-X

- One reservoir quality sand in Eocene
- Gas shows in Miocene
- Not clear that trap is present

Morsa Norte 1-X

- Good oil shows in Miocene and Eocene
- No reservoir section (Too proximal)
- Prominent young structure

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Well Summary Conclusions

Lobos 1-X

- Abundant fair to poor sands
- Oil shows in Eocene, Paleocene, Cretaceous
- No closure present (?)

Conclusions

- 3 of 4 wells poorly located
- Better sands likely in center of Eocene basins
- Multiple petroleum systems present
- Paleocene & Cretaceous potential objectives
- Late development of Trujillo-Salaverry high permits early migration into Salaverry basin

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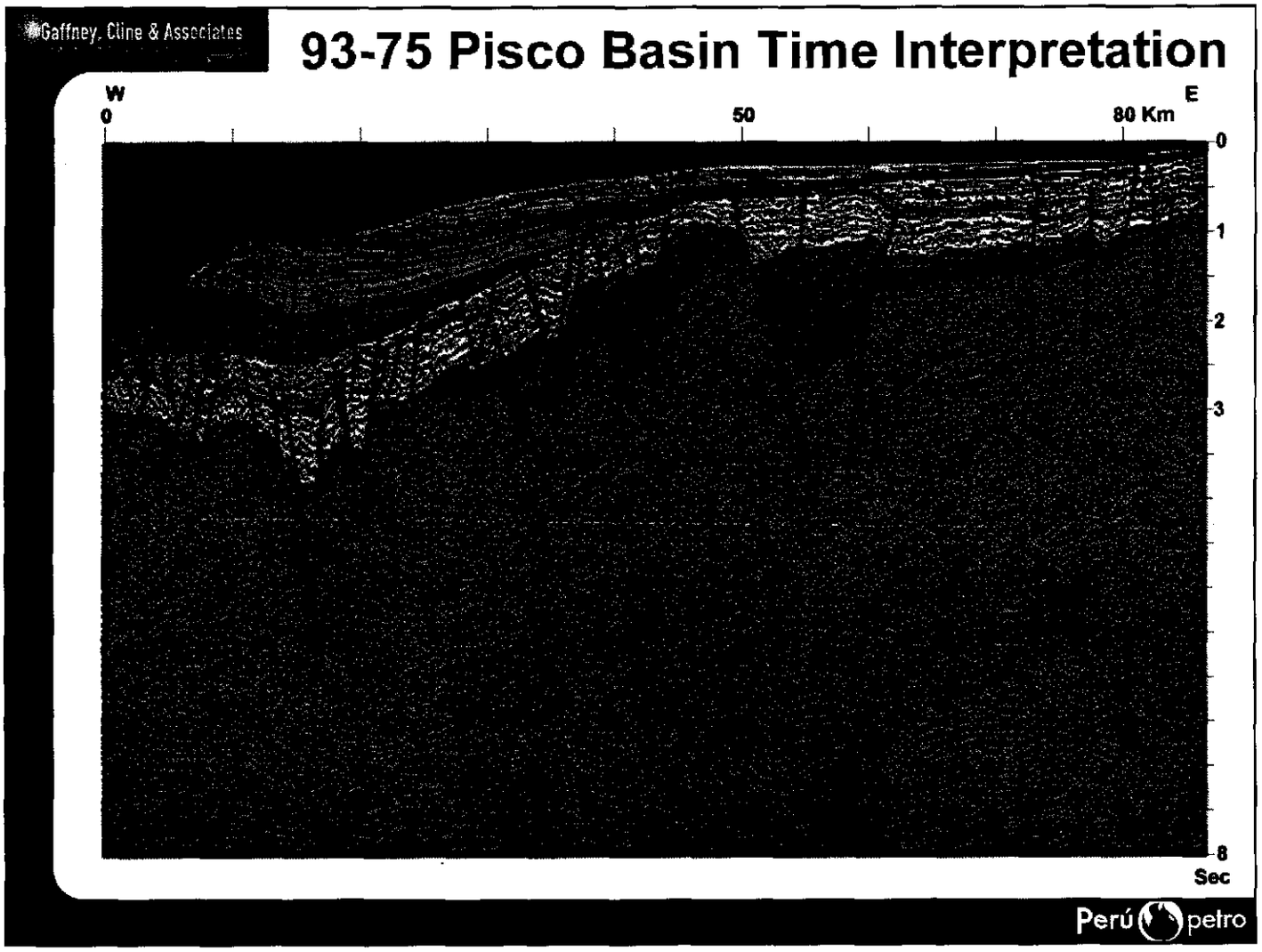
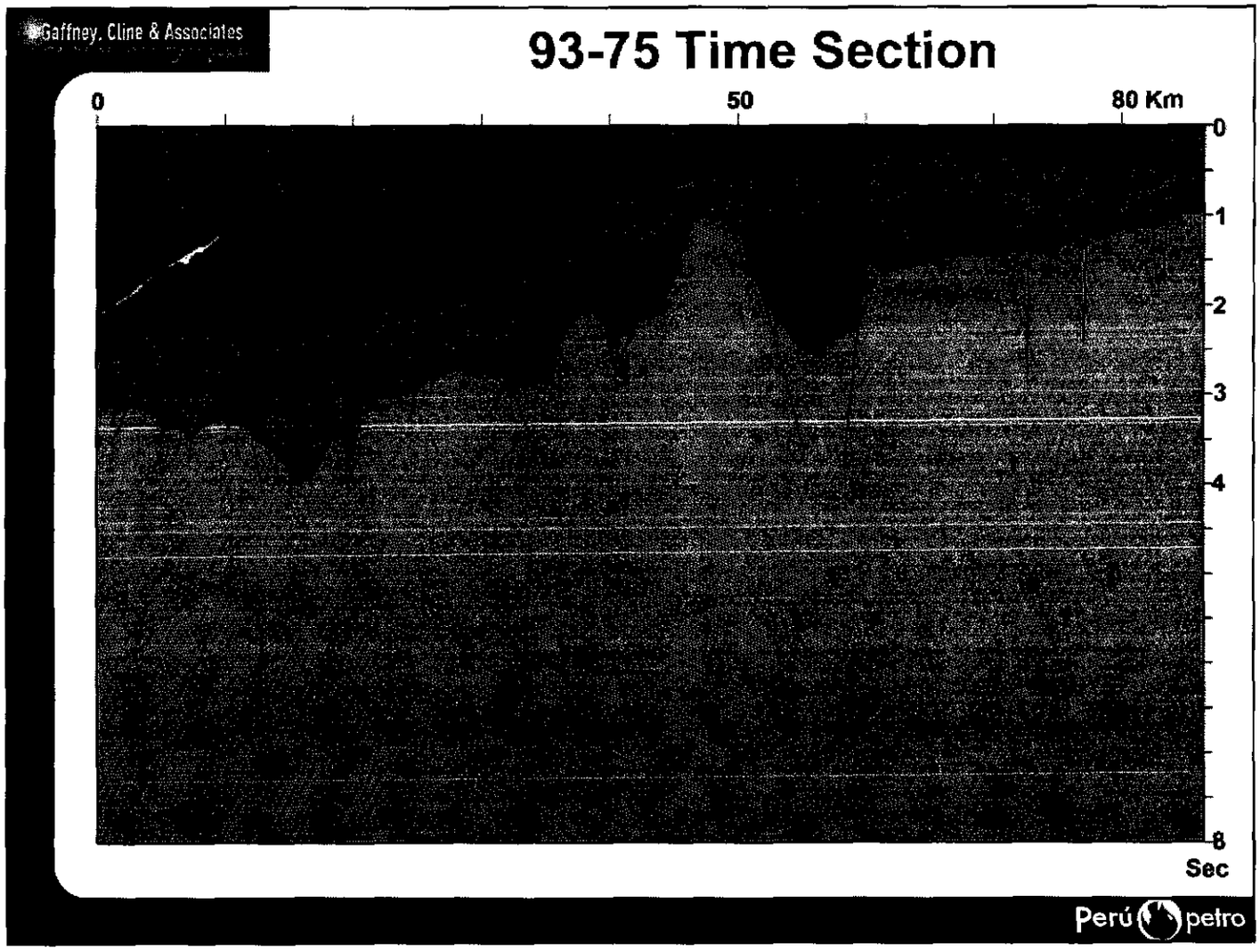
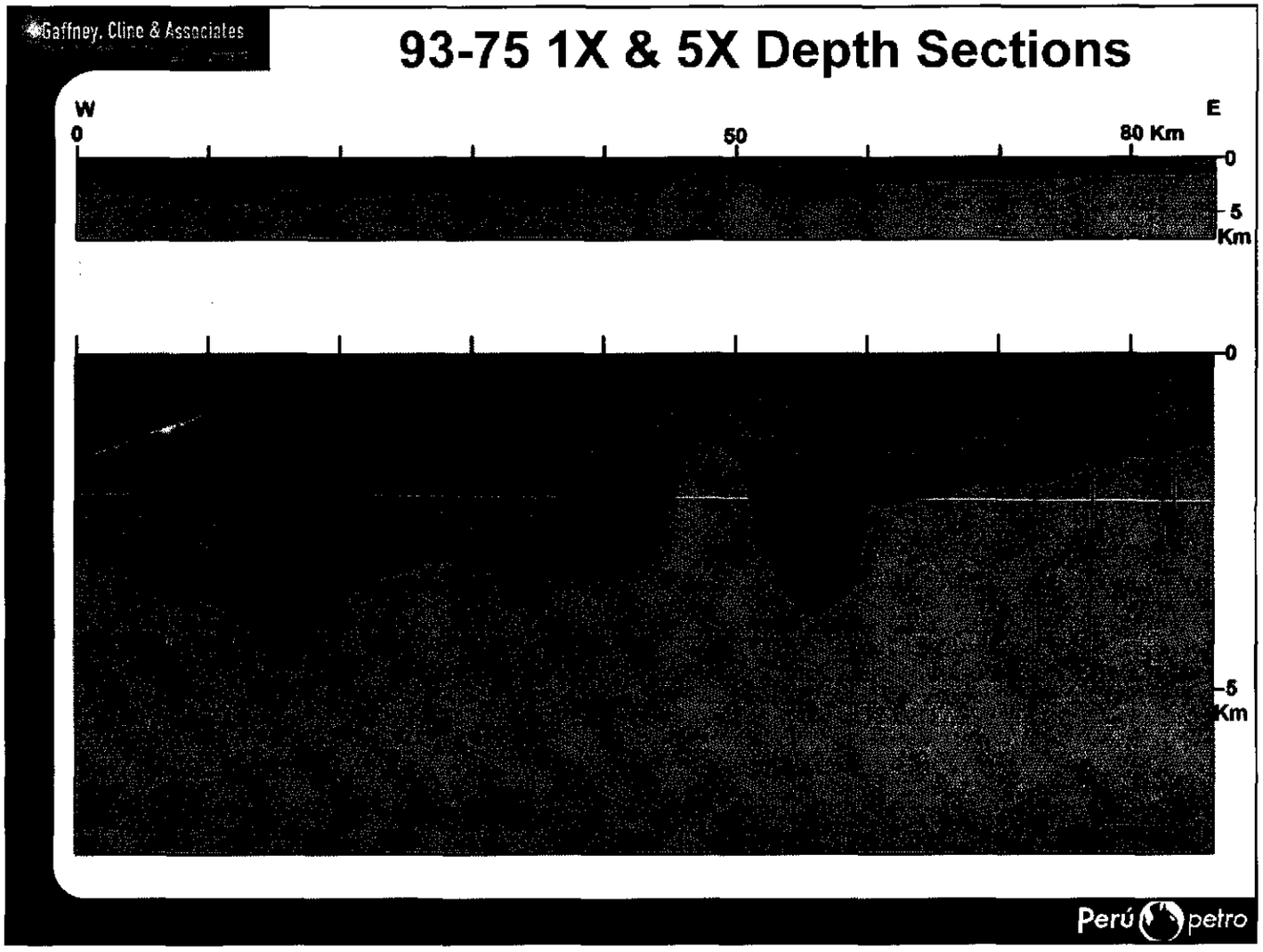


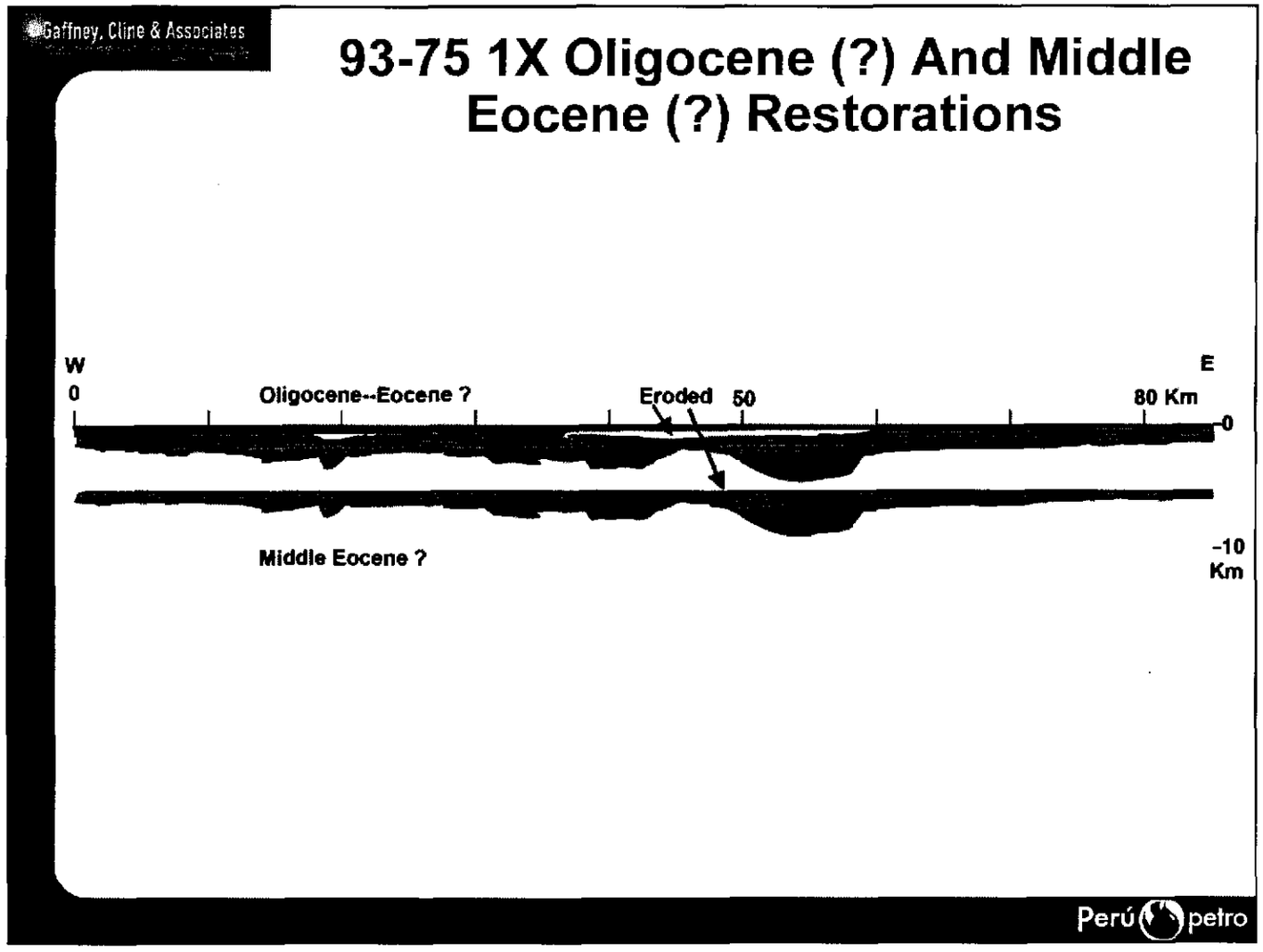
Time interpretation of seismic line 93-75 in the Pisco basin. Note the Oligocene or Late Eocene inversion of former graben containing preserved syncline of Cretaceous strata(?). The coastal wedge probably corresponds to Miocene sequences exposed in Trujillo and Salaverry basins.



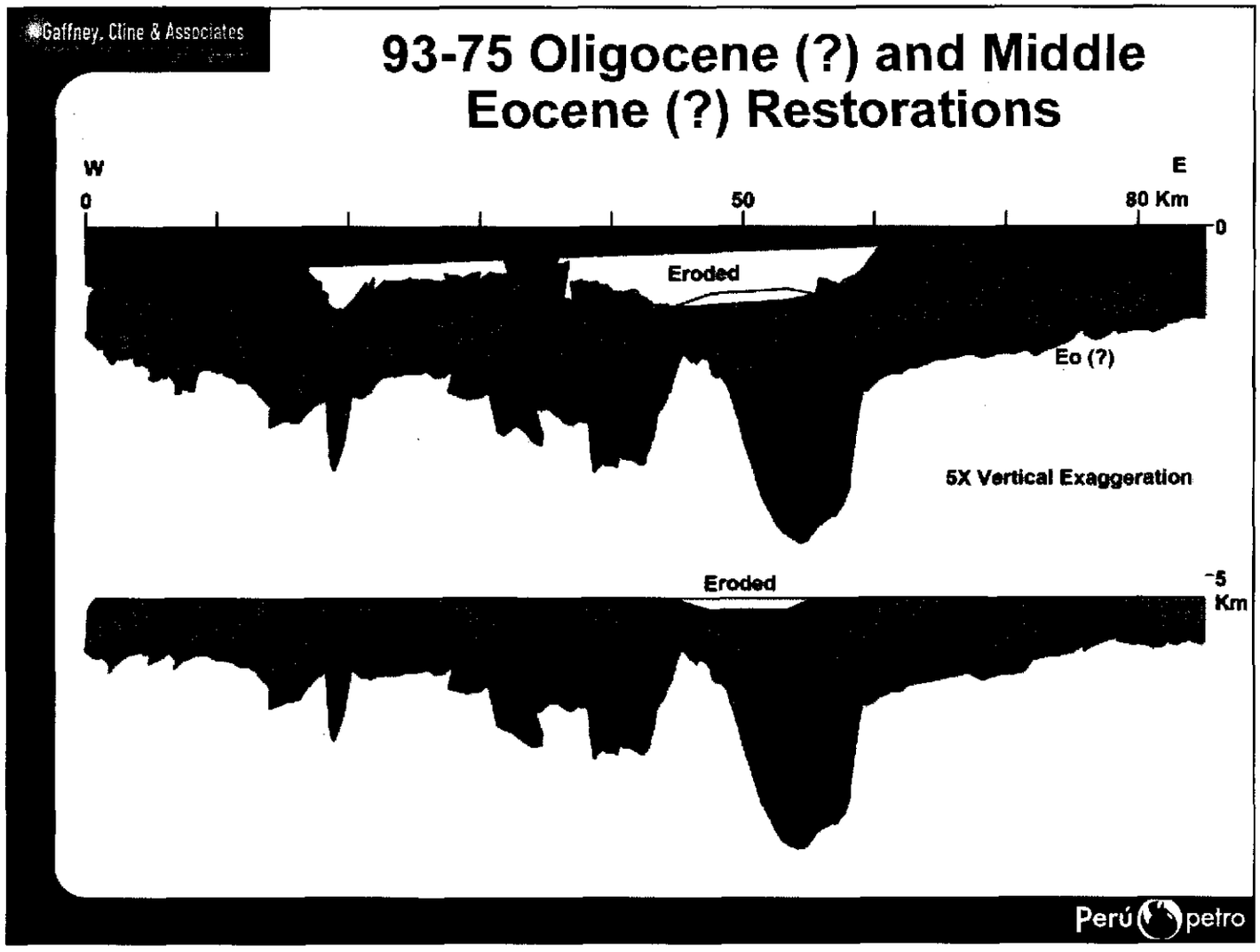
Time section along line 93-75 in the Pisco basin. Note the strong evidence of Oligocene or Late Eocene inversion.



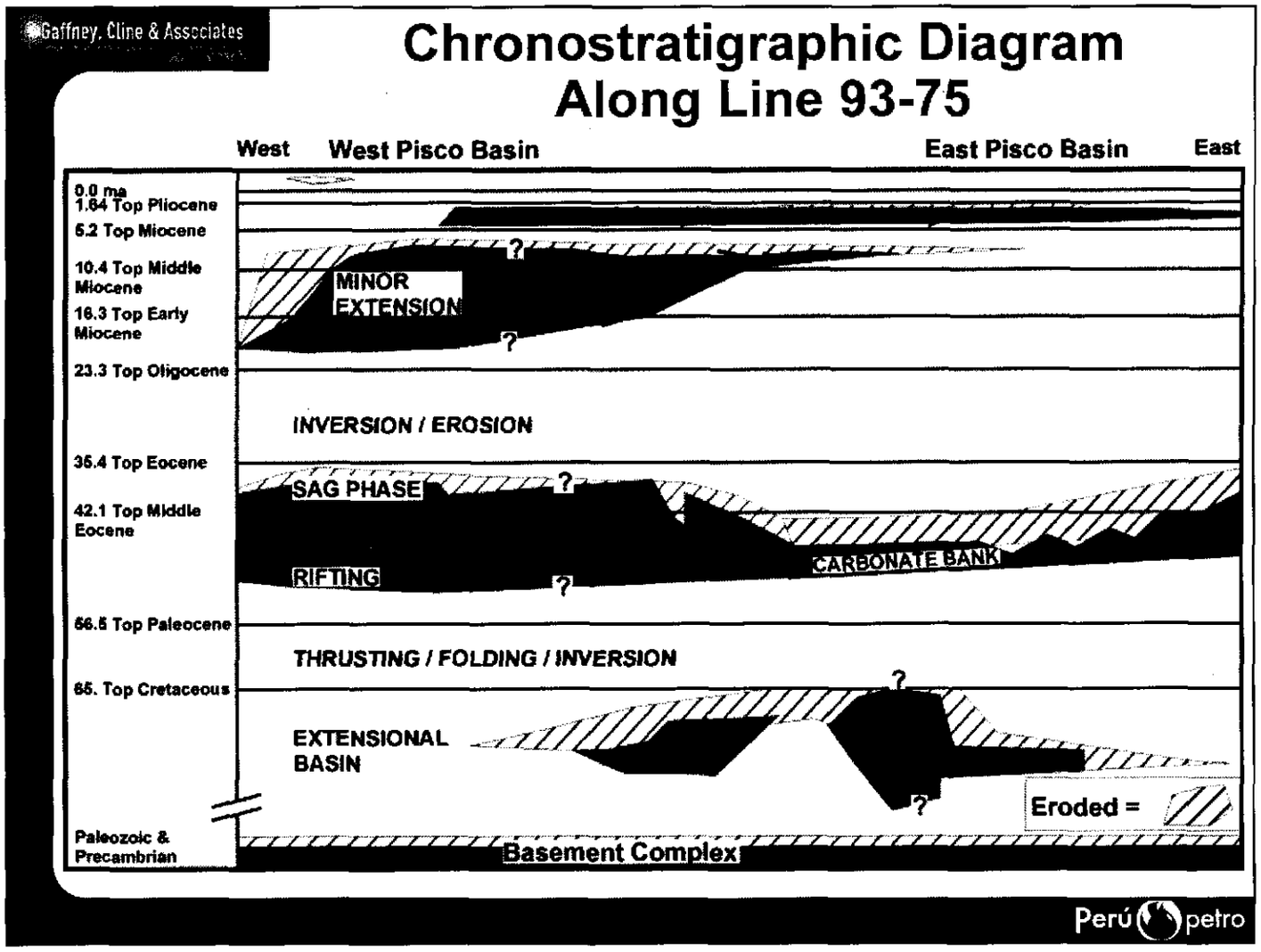
1X and 5X depth sections along line93-75. Note Oligocene or Eocene inversion followed by Miocene (?) subsidence of outer part of the basin. Pliocene sediments prograded across older Tertiary sediments. Tertiary sediments in the outer part of the basin currently are at maximum burial depth.



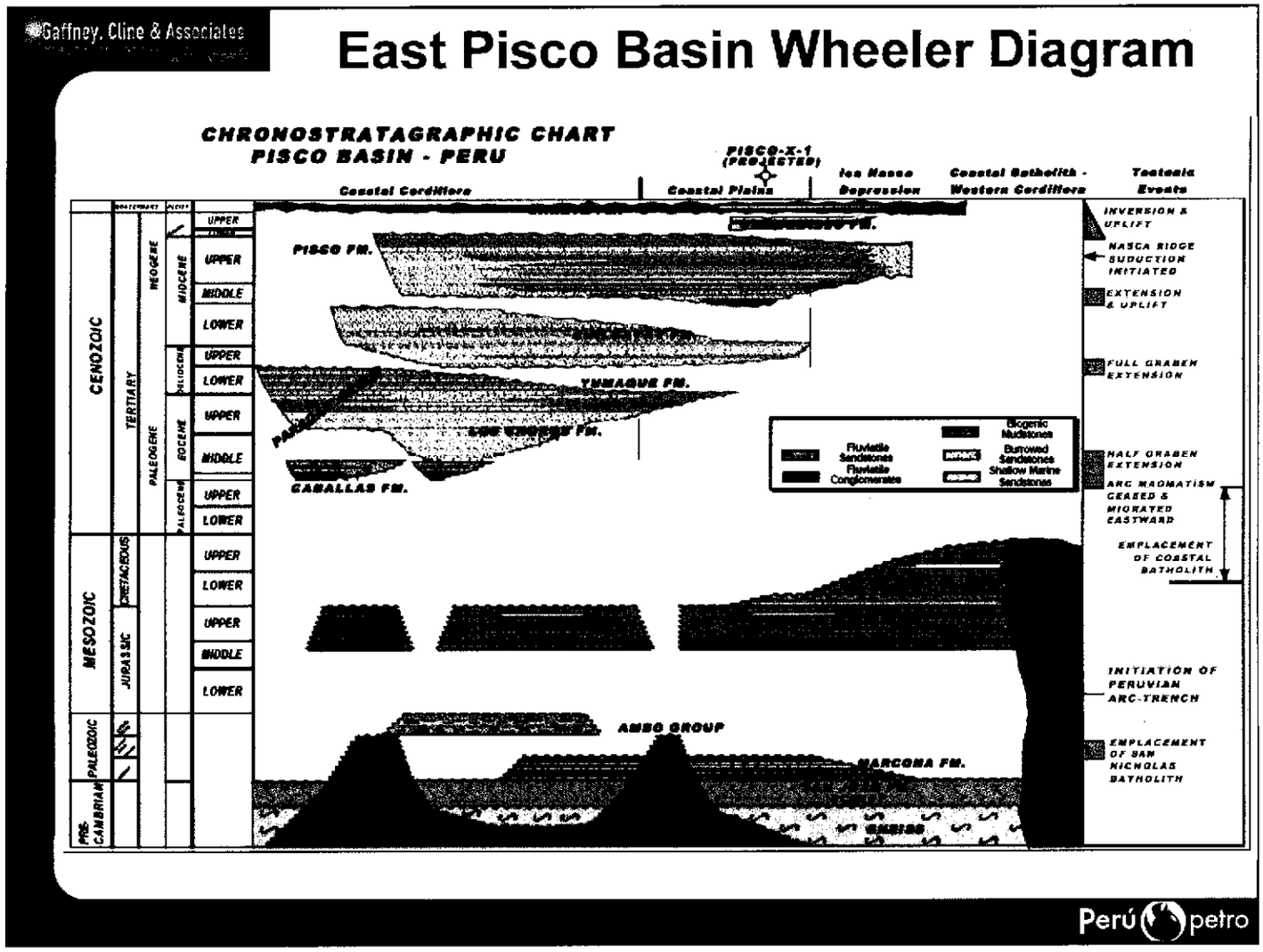
1X and 5X restorations of line 93-75 for top Oligocene (?) and top Middle Eocene (?) time. These restorations remove the effects of Miocene (?) subsidence and Oligocene (?) inversion.



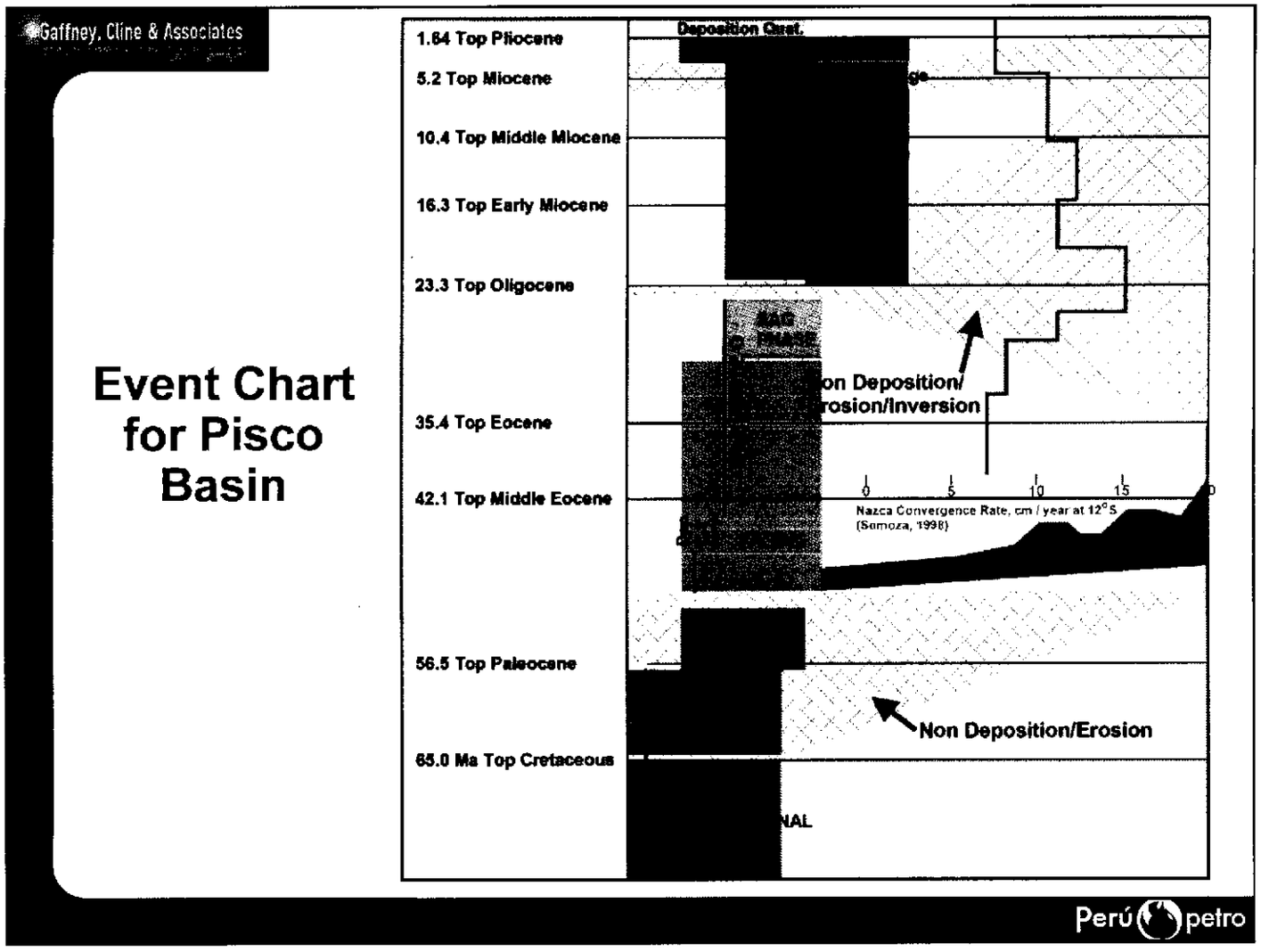
5X restorations of line 93-75 for the top Oligocene (?) and top Middle Eocene (?). Note the large amount of Oligocene (?) section that has been eroded. The actual slope of sea floor in the Oligocene restoration is 0.4 degrees. The Middle Eocene restoration shows the approximate basinal geometry following Eocene rifting.



This is a chronostratigraphic diagram along seismic line 93-75. The color of the stratigraphic packages corresponds to the general colors on the cross sections and restored sections. Eroded parts of the section are shown by hatching; non-deposition is indicated by white space.



Wheeler diagram for East Pisco basin from Peru Petro.



This event chart summarizes major tectonic and depositional events for the Pisco basin area. Non-deposition or erosion is indicated by cross hatching. Note Oligocene inversion coincides with rapid convergence of the Nazca plate and Early to Middle Miocene and Pliocene periods of normal faulting coincide with slowing or low convergence rates. Non-deposition at the end of the Miocene coincides with subduction of the Nazca ridge about 5 million years ago.

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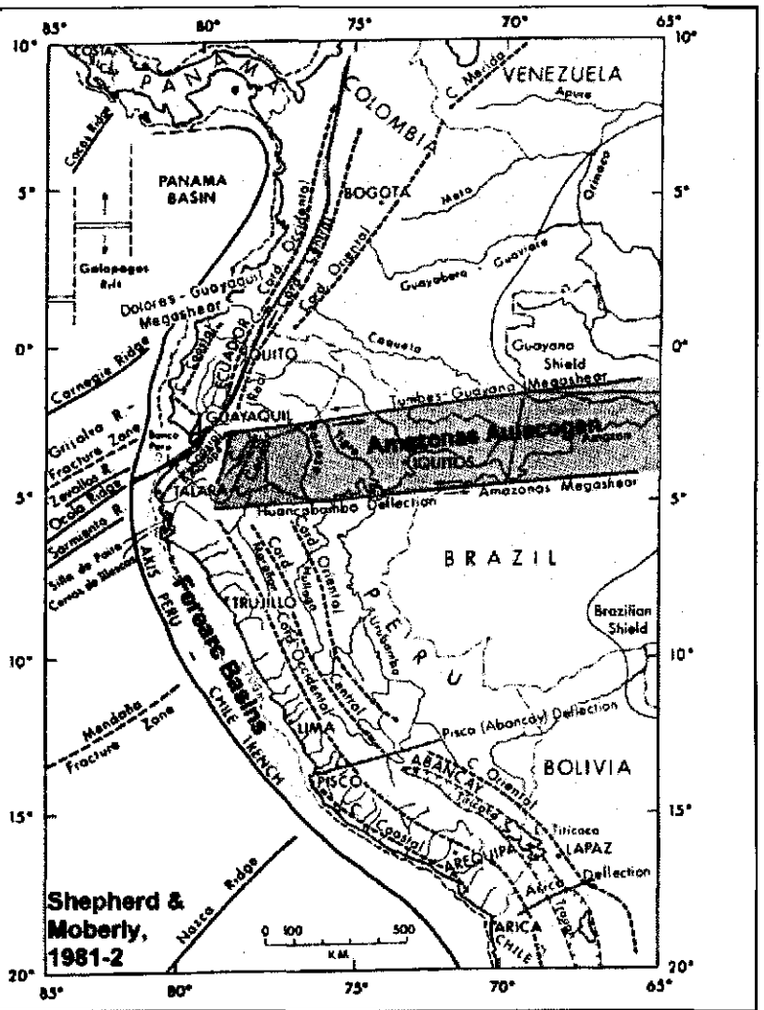
Tectonic Setting of Northern Peruvian Forearc Basins



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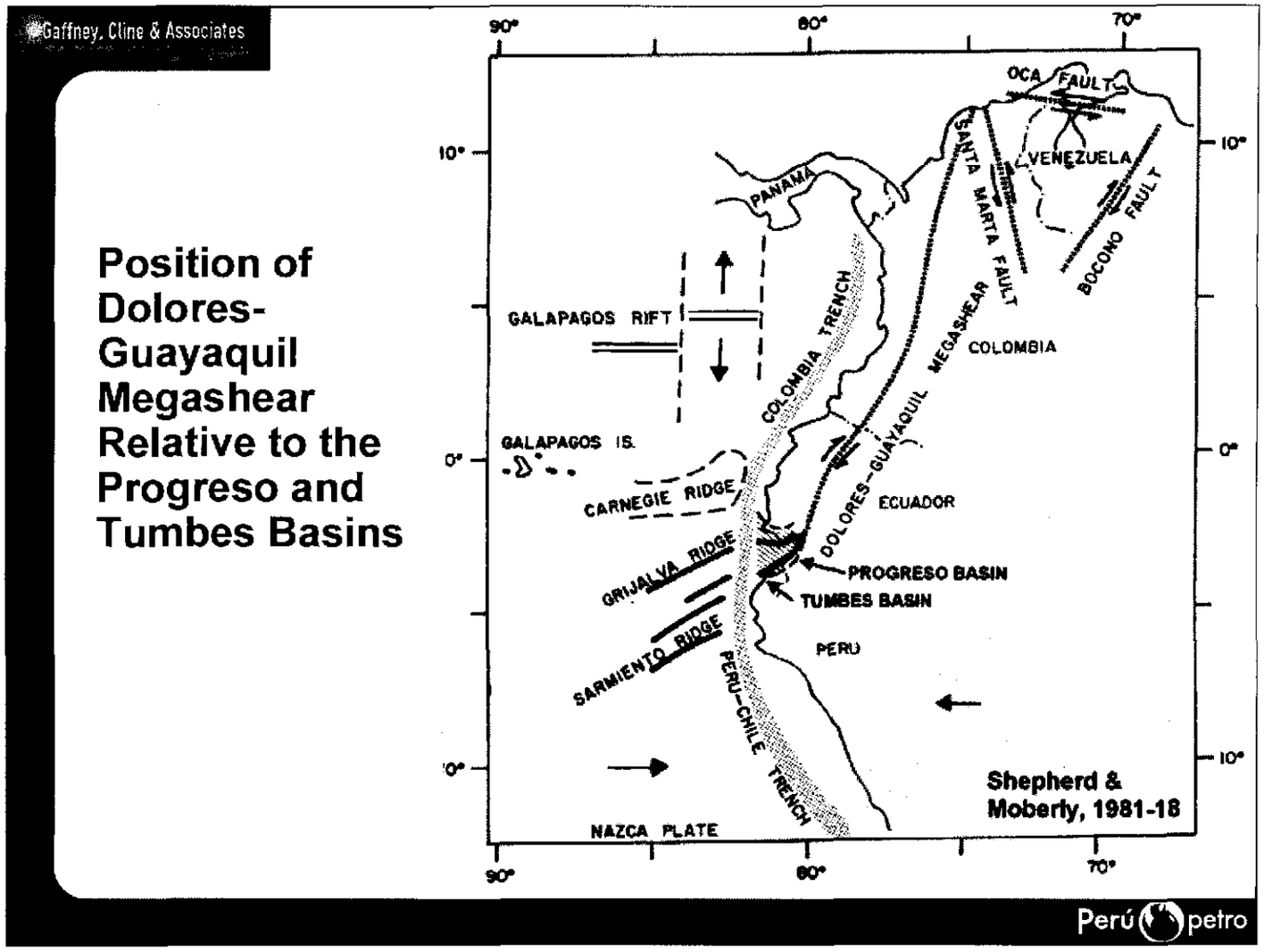
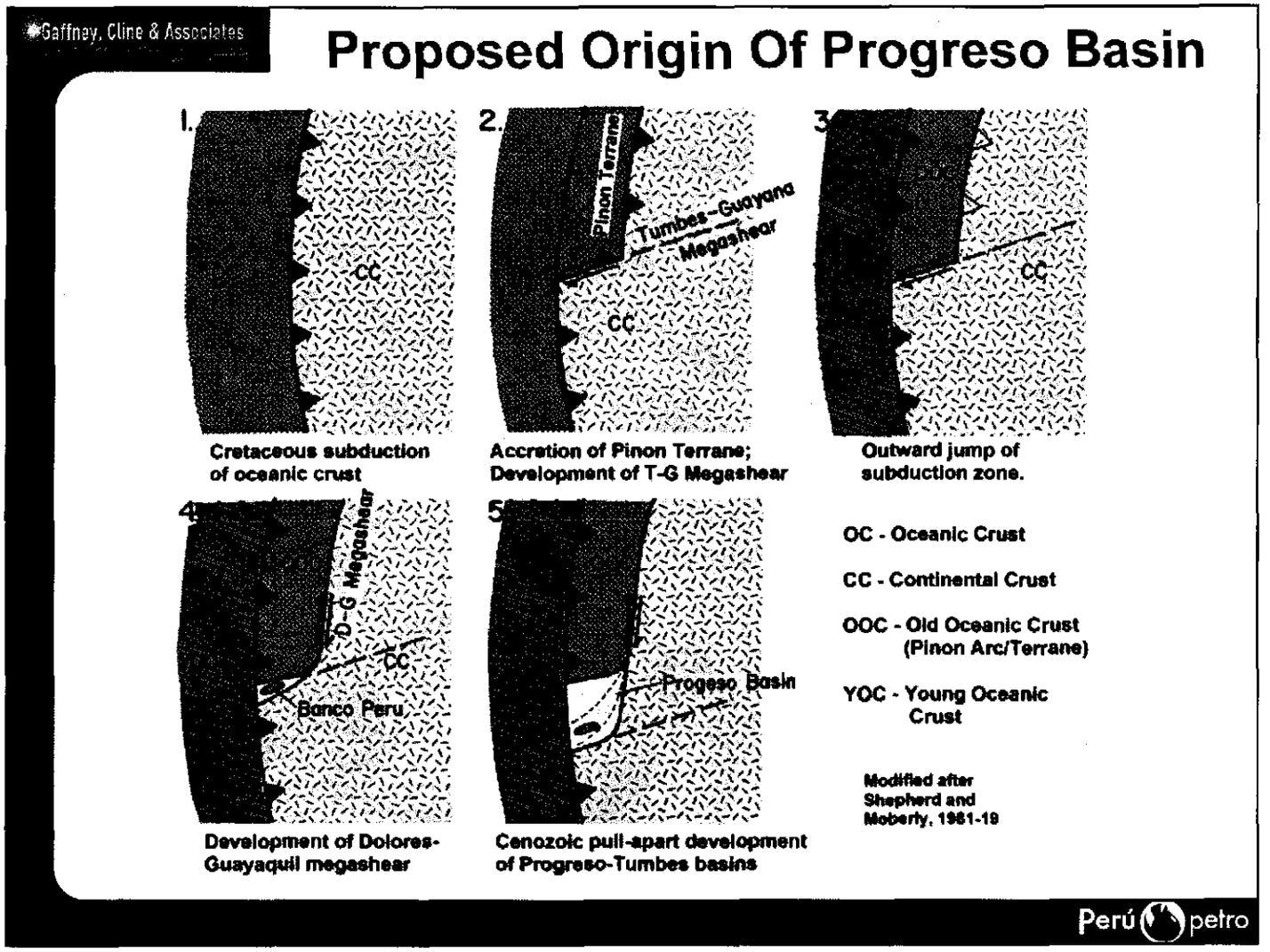
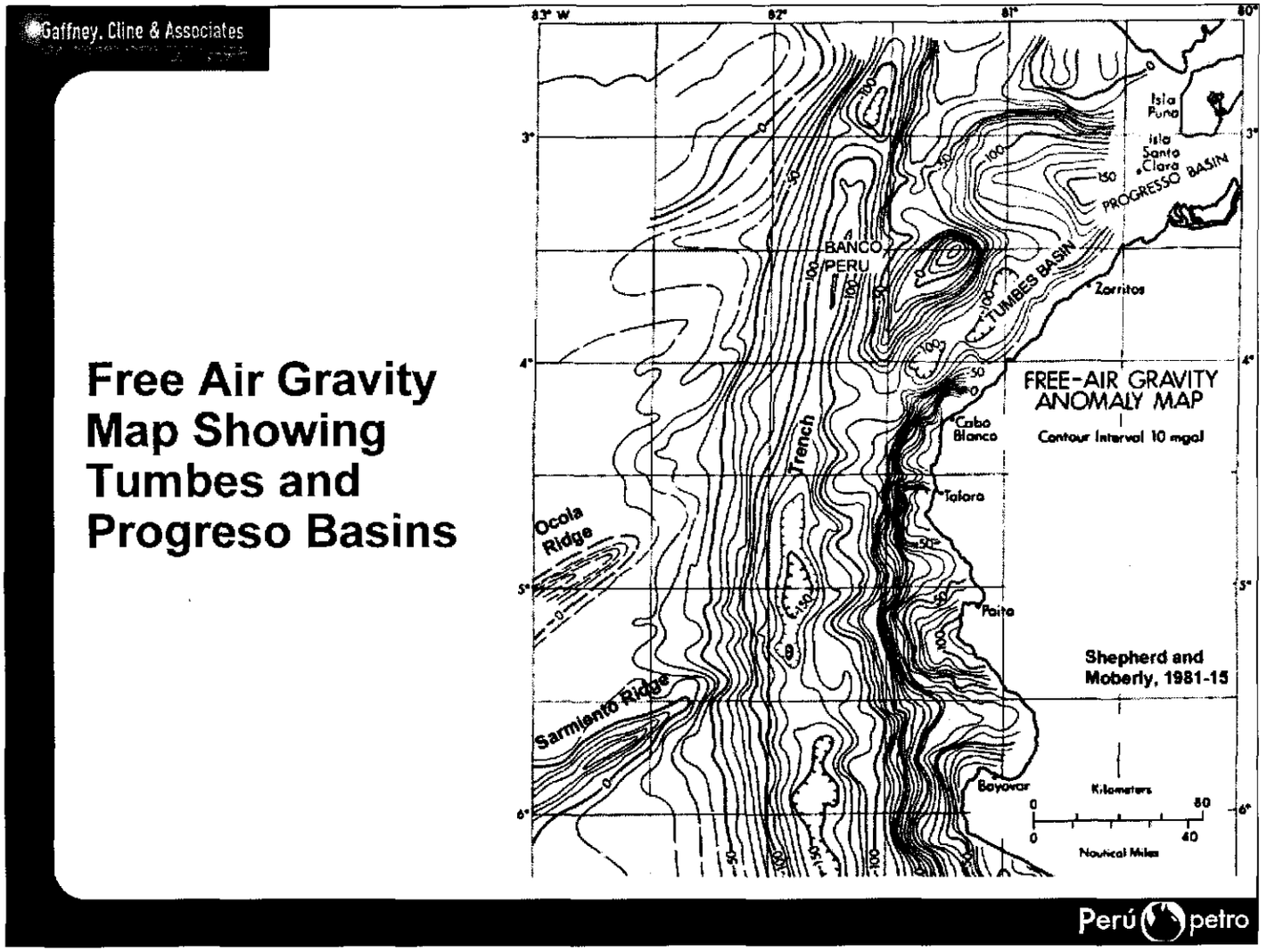
In addition to the effects of plate convergence that largely control the development of the southern Peruvian forearc basins, other tectonic elements play a role in the Progreso, Tumbes and Talara basins. One of these elements is the Amazonas aulocogen. While this is mainly a Paleozoic rift basin, this structural trend may have facilitated transport of clastic sediments from interior South America to these basins during the early Tertiary.



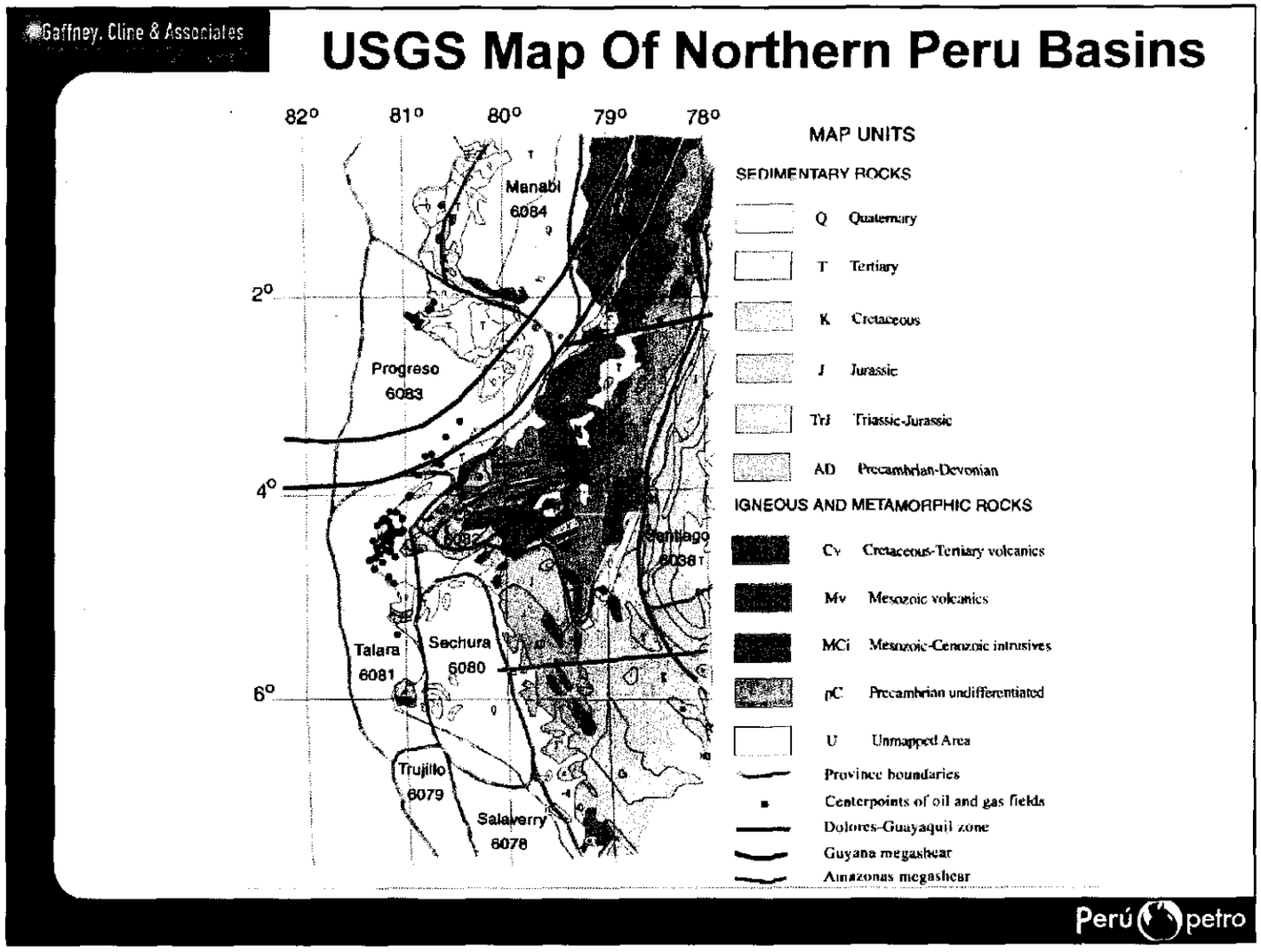
In addition the Dolores-Guayaquil megashear has plated a role in the development of these basins. The megashear is interpreted to mark the eastern boundary of a piece of oceanic crust and overlying arc that was accreted to South America in Cretaceous time.



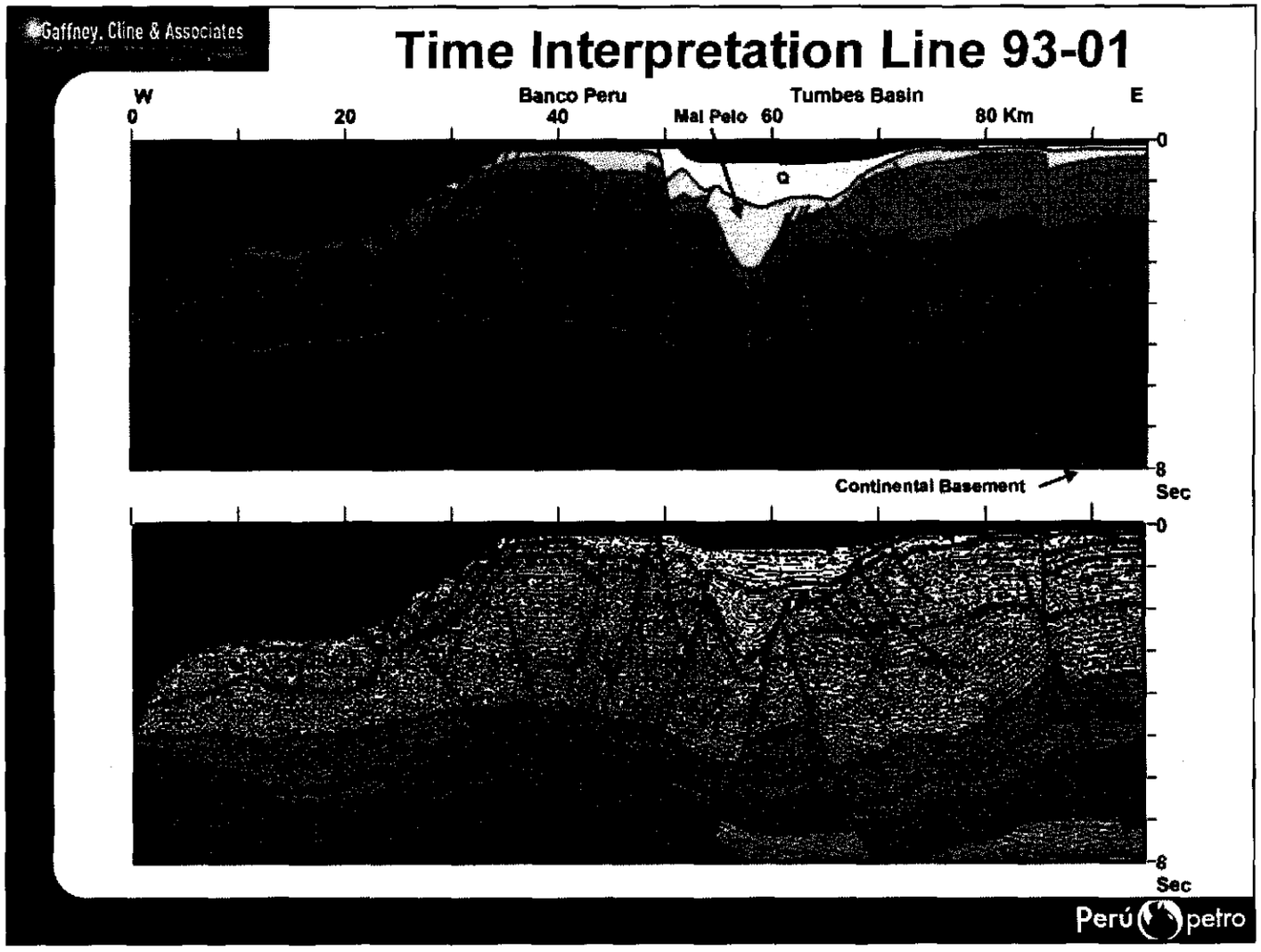
The development of the Tertiary Progreso basin is interpreted to be related to the accretion of an arc developed on oceanic crust to South America and the subsequent lateral displacement of the micro-plate. Eastward subduction occurred during the Mesozoic. During the Cretaceous an arc underlain by oceanic crust collided with the margin. This resulted in an outboard jump of the subduction zone. During the Tertiary, right lateral slip on boundary of accreted Pinon terrane formed a pull-apart and led to development of the Progreso basin.



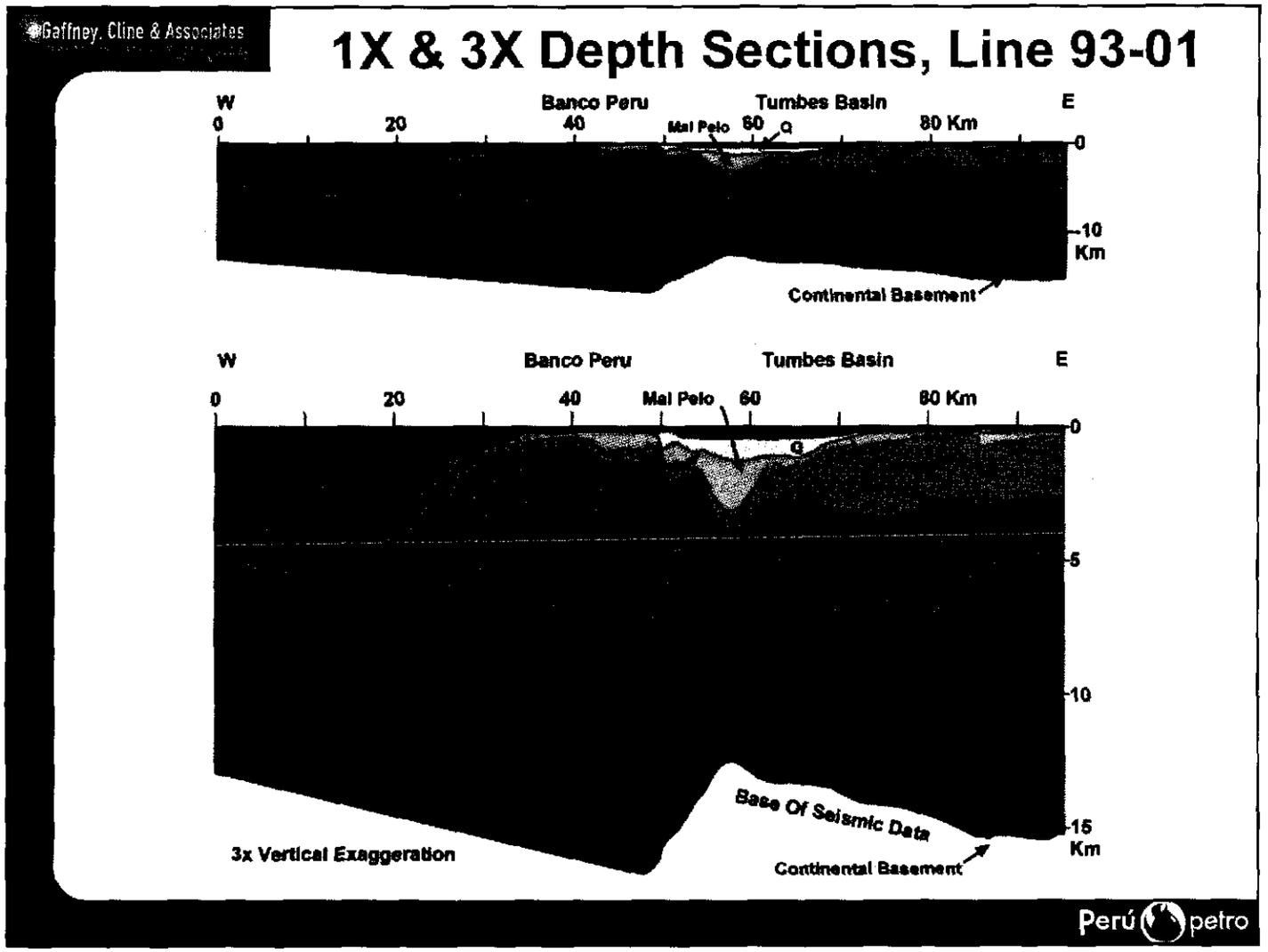
A map of free air gravity shows many of the important features of the northern Peru offshore region. The Tumbes and southern Progreso basins are well defined by a gravity low (yellow). The Tumbes basin is bounded on the west by Banco Peru. Based on strong gravity and magnetic anomalies, Banco Peru is interpreted to be underlain by mafic igneous rocks, perhaps a piece of trapped oceanic crust. The present trench is marked by the prominent gravity low. Prominent points along the coastline are underlain by shallow continental basement. The gravity shows that these highs extend into the offshore.



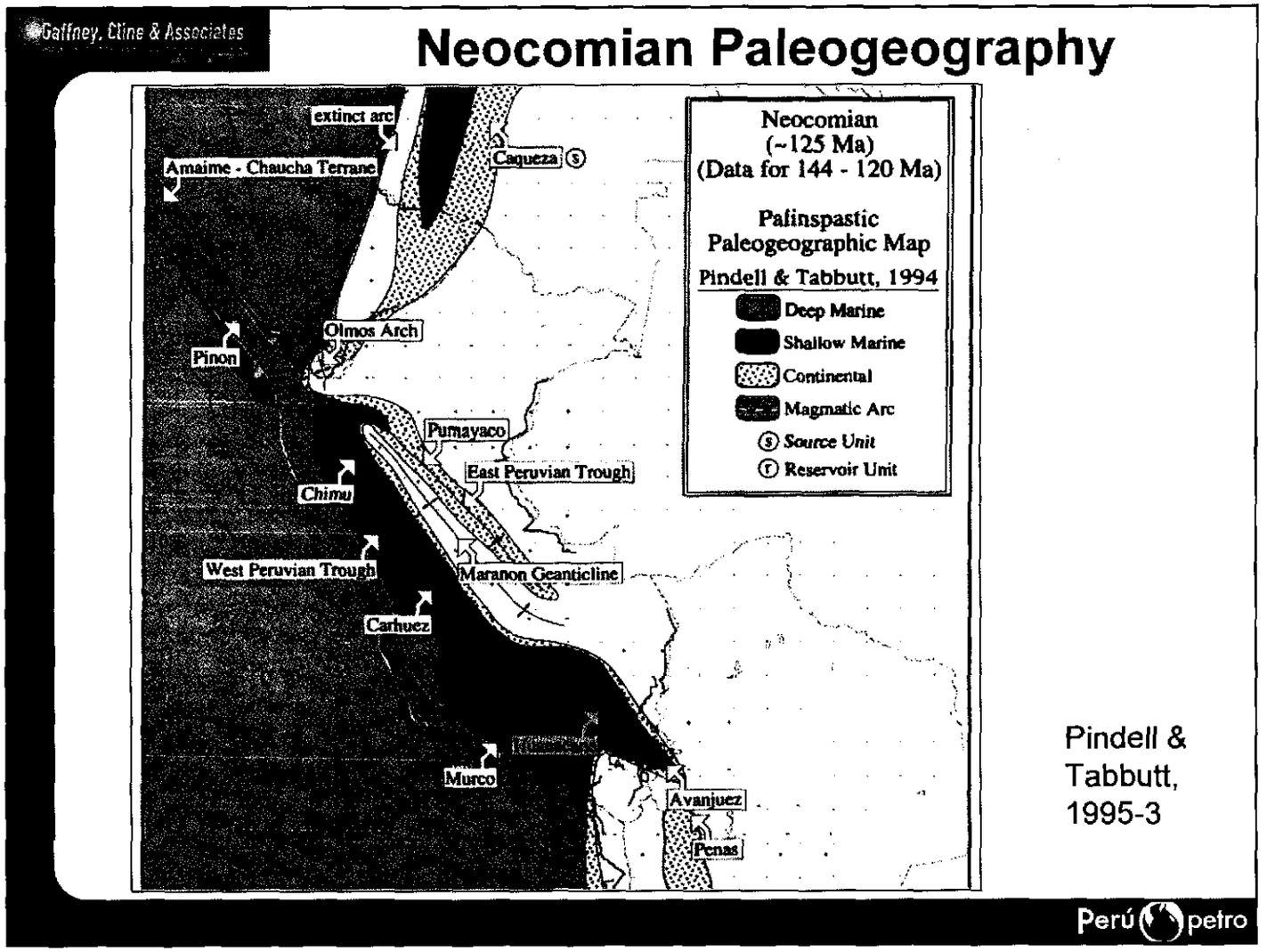
USGS map of northern Peru basins from Peru Petro



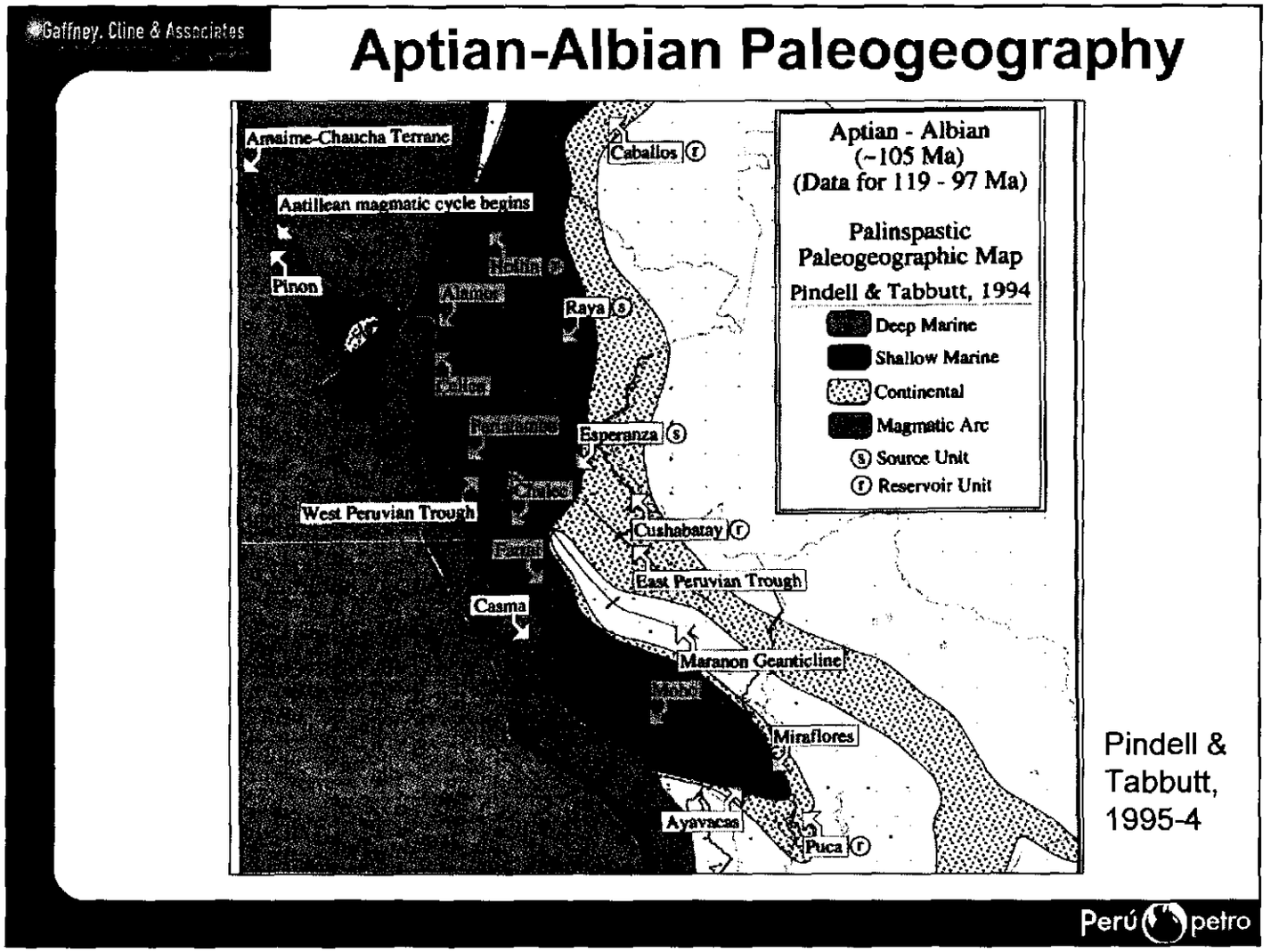
This is a time interpretation extending from near the Peru trench across the Tumbes basin. The Tumbes basin is interpreted to be a pull-apart basin that developed during the Tertiary. Banco Peru is underlain by a dense, magnetic body that is interpreted to be a piece of Mesozoic oceanic crust, perhaps part of the Pinon terrane. Currently oceanic crust and mantle are being subducted beneath the Tumbes basin.



1X and 3X depth sections across the Tumbes basin. Conversion to depth flattens the dip of the subduction zone and makes it more nearly planar.



Generalized distribution of the magmatic arc, and continental, shallow and deep marine sediments during Neocomian time.



Pindell & Tabbutt, 1995-4

Generalized distribution of the magmatic arc, and continental, shallow and deep marine sediments during Aptian-Albian time.

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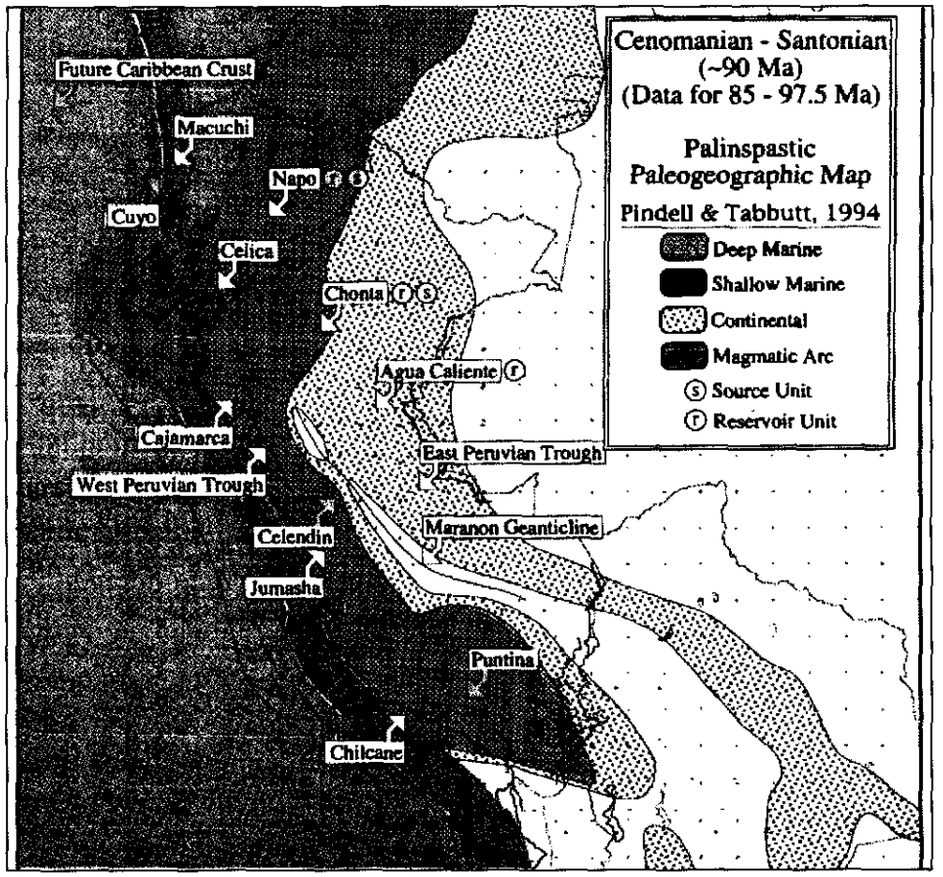
Cenomanian-Santonian Paleogeography



Pindell & Tabbutt, 1995-5

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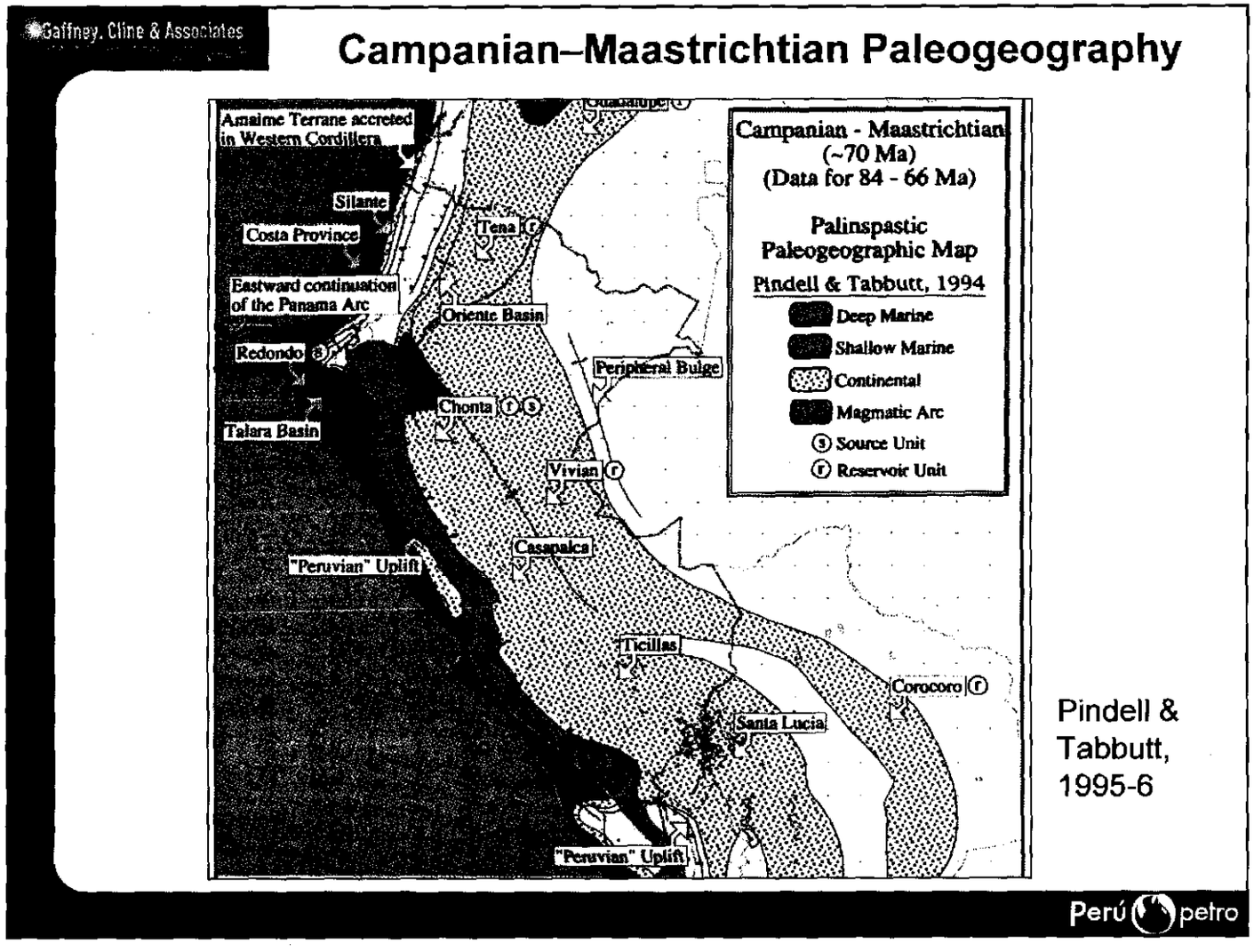
Generalized distribution of the magmatic arc, and continental, shallow and deep marine sediments during Cenomanian-Santonian time.



Generalized distribution of the magmatic arc, and continental, shallow and deep marine sediments during Campanian-Maastricthtian time.

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Exploration Plan

- Trujillo-Salaverry-Pisco Basins
- Test reprocessing of 93 seismic to remove multiples & improve frequency content, if possible
- If successful, reprocess 93 seismic data
- Acquire limited infill seismic over leads
- Use original unfiltered marine magnetic data to distinguish between carbonate buildups or igneous bodies in Salaverry basin
- Identify areas favorable for submarine fan development using maps of Trujillo Eocene thicks and faults that controlled deposition

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Salaverry Basin Plays & Leads

Type of Trap	Age Of Reservoir	Reservoir Lithology	Major Risks
Carbonate bank / reef	**Eocene**	**Carbonate**	**Presence of carbonates; charge**
Popup folds	**Miocene-Paleocene**	**Varied carbonate & clastic**	**Reservoir; charge**
Stratigraphic	**Miocene**	**Transgressive basal sand**	**Reservoir quality; trap**
Stratigraphic	**Paleocene-Cretaceous**	**Submarine fans; channel levee deposits**	**Reservoir**
Truncation beneath Tertiary unconformity	**Paleocene-Cretaceous**	**Deep water sands**	**Closure; presence of sand**

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Trujillo Basin Plays & Leads

Type of Trap	Age Of Reservoir	Reservoir / Lithology	Major Risks
Fault	**Eocene**	**Deep water sands**	**Presence of sands; charge**
Stratigraphic	**Eocene**	**Submarine fans and channel levee deposits**	**Presence of sands; charge**
Channels	**Miocene**	**Deep water sands**	**Charge**
Fracture	**Miocene or Eocene**	**Brecciated dolomites**	**Charge; detection problem**

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Trujillo-Salaverry High Plays & Leads

Type of Trap	Age Of Reservoir	Reservoir / Lithology	Major Risks
Fold	**Miocene or Eocene**	**Channelized (?) deep water sands**	**Reservoir; timing of structure**
Fault	**Miocene or Eocene**	**Channelized (?) deep water sands**	**Reservoir; timing of structure**
Fractured basement against source rock	**Paleozoic or Precambrian**	**Basement**	**Fracturing; detection problem**

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Pisco Basin Plays & Leads

Type of Trap	Age Of Reservoir	Reservoir / Lithology	Major Risks
Fault	**Eocene or Cretaceous**	**Deep water Sands**	**Charge; reservoir**
Stratigraphic	**Eocene or Cretaceous**	**Carbonate bank / reef**	**Presence of carbonates; charge**
Stratigraphic	**Eocene or Cretaceous**	**Deep water sands**	**Reservoir; charge**
Stratigraphic pinchout	**Miocene**	**Deep water sands**	**Reservoir; charge**

Perú petro

APPENDIX F

INTERPRETATION OF BALANCED AND RESTORED SECTIONS

for the

TRUJILLO, SALAVERRY, AND PISCO BASINS, OFFSHORE PERU

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Interpretation of Balanced and Restored Sections for the Trujillo, Salaverry, and Pisco Basins, Offshore Peru

SUMMARY

The continental shelf of Peru has had a complex depositional and deformational history. Cretaceous and Paleocene marine strata were deposited across a peneplaned basement complex composed of Precambrian and Paleozoic (?) rocks. The Cretaceous and Paleocene strata were compressively deformed, uplifted, and widely eroded during the Late Paleocene or Early Eocene. During the Early Middle Eocene a marine transgression occurred across much of the present-day continental shelf and carbonate banks (?) locally developed in the Salaverry and Pisco basins. Rifting occurred during the Middle and Late Eocene. The rift fill consists largely of clay-rich biogenic sediments with some interspersed turbiditic sandstones. The rift geometry was controlled by basement-involved faults, some of which were repeatedly activated during the Cenozoic.

Over most of the area, the Oligocene was a period of non-deposition and local uplift, although sag-phase Oligocene sediments were deposited in some of the rift basins. Miocene strata onlap onto either Eocene or basement rocks. Intense detached extensional faulting occurred during the Miocene. The Trujillo-Salaverry high developed partly concurrently with this faulting and continued to develop during local inversion in the Late Miocene and Pliocene. Middle and Late Miocene development of the high led to extensive submarine canyon formation along and west of the uplift. In the Trujillo and Salaverry basins, sets of minor strike-slip faults of Miocene and Pliocene age trend northeast-southwest and northwest-southeast. These trends may be controlled by old structures in the basement. In the Late Pliocene some rift-related faults underwent slight reactivation.

Construction of Cross Sections In LithoTect

Key seismic lines were selected for construction of cross sections and restored sections based on their geologic significance, ties to key wells and distribution over the study area (Figure F-1). The following procedures were used in constructing cross sections and restored sections. Interpretations made in the SMT seismic interpretation software were reviewed to address any geometric balancing concerns with the initial interpretation. As required, slight modifications were made to the interpretation. The SEG-Y time seismic data and revised interpretation were imported into a LithoTect project.

Figure F-1: Location of Seismic Lines Used in Cross Section Construction in Trujillo and Salaverry Basins

The horizon and seismic trace data were then depth converted using interval velocities. For some sections (93-45; 93-75) interval velocities were determined from a combination of time-depth pairs from wells and RMS velocities from the seismic data and related to the mapped reflectors (Table F-1) and depth converted within the LithoTect program. Following depth conversion, horizons and faults were edited in LithoTect to remove local spikes produced by abrupt lateral velocity changes across significant faults. For other seismic lines (93-39), traces, horizons and faults were depth converted in the VelPro software and the resulting depth data were imported into LithoTect. Stratigraphic nomenclature is modified from Azalgara (1993) which is based on a sequence stratigraphic approach (Figure F-2).

Table F-1: Interval Velocities Used In Depth Conversion

Unit	Line 93-45 Velocity m/s	93-75 Velocity m/s
Sea Water	1480	1480
Quaternary	2325	2200
Pliocene	2337	2300
Miocene-3	2512	2400
Miocene-2	2512	2400
Infra-Miocene	2512	------
Miocene-1	2157	2400
E-O	2749	2649
E-3	3199	3100
Eo	3199	3100
Cretaceous	------	3600
Pre-Tertiary	5100	5000

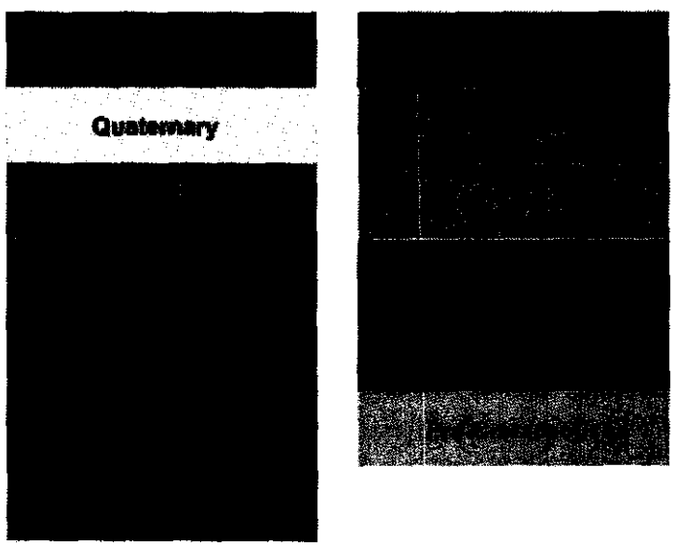

Figure F-2: Stratigraphic Units Used In Cross Sections

Sequential restored sections were made for dip sections which are sub-parallel to the tectonic transport direction and thus are suitable for restoration. The starting bathymetry for the sections was based on paleo-bathymetric data available from wells and any evidence of bathymetric relief from the seismic data. Where necessary, parts of shallow units missing due to erosion were extrapolated from adjacent areas.

In general, each restoration was made by first applying a vertical simple shear algorithm to each fault block capped by the horizon to be restored. Following restoration of the fault blocks containing the key horizon, deeper units were restored using base of the previously restored overlying fault blocks as the template. This process was repeated until all fault blocks were restored. In some cases, where many small displacement faults were present, adjacent fault blocks were grouped into a single larger block and restored.

Vertical simple shear has been demonstrated to be an appropriate algorithm for poorly consolidated sedimentary strata, particularly in extensional settings (Rowan and Kligfield, 1989). This algorithm maintains cross sectional area and the vertical thickness of units. This method distorts the stratigraphic thickness of non-horizontal units, but the distortion is small for low dips. Where strata were steeply dipping or strongly folded in the deformed state section, they were restored using a flexural slip algorithm. This method maintains cross sectional area and bed length, but changes the shape (unfolds and rotates) the restored polygon.

Time sections were exported from LithoTect as CGM files with appropriate aspect ratios. Each depth and restored section was exported as a 1:1 and a 5:1 vertical exaggeration CGM file. These were annotated and also saved as TIF files.

Geologic Interpretation Of The Area Of The Lobos 1-X Well (Profiles 96-017 and 98-10b)

Two seismic lines (96-017 and 98-10b) were interpreted to show structure in the vicinity of the Lobos 1-X well. Line 96-017 is about 53 kilometers long and trends northeast-southwest passing just south of the well location. It extends across the outer continental shelf and upper continental slope. Line 98-10b is about 19 kilometers long and extends in a northwest-southeast direction though the well location. It crosses the outer continental shelf.

The structure in the Lobos area is complex. The Lobos 1X well is reported to have penetrated a thin Upper Miocene section, a faulted Upper and Middle Eocene section, a thin Paleocene section and bottomed in Upper Cretaceous strata (Figures F-3 and F-4). Based on regional seismic correlation and the undeformed nature of the shallow sediments penetrated by the Lobos well, these latter sediments are tentatively interpreted to be Pliocene sediments containing reworked Upper Miocene microfossils. The seismic indicates that considerable sedimentary section is present beneath the Upper Cretaceous strata penetrated by the well. These strata include older Mesozoic strata and possibly Paleozoic rocks.

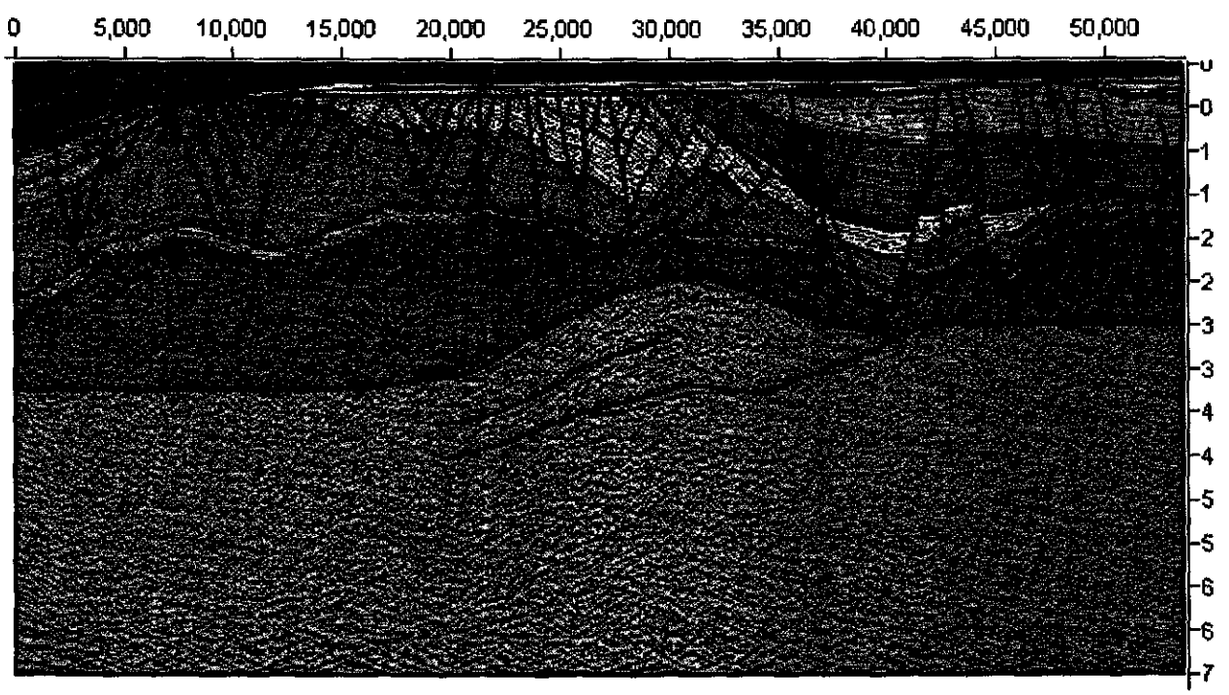

Figure F-3: Interpretation of Seismic Line 96-17

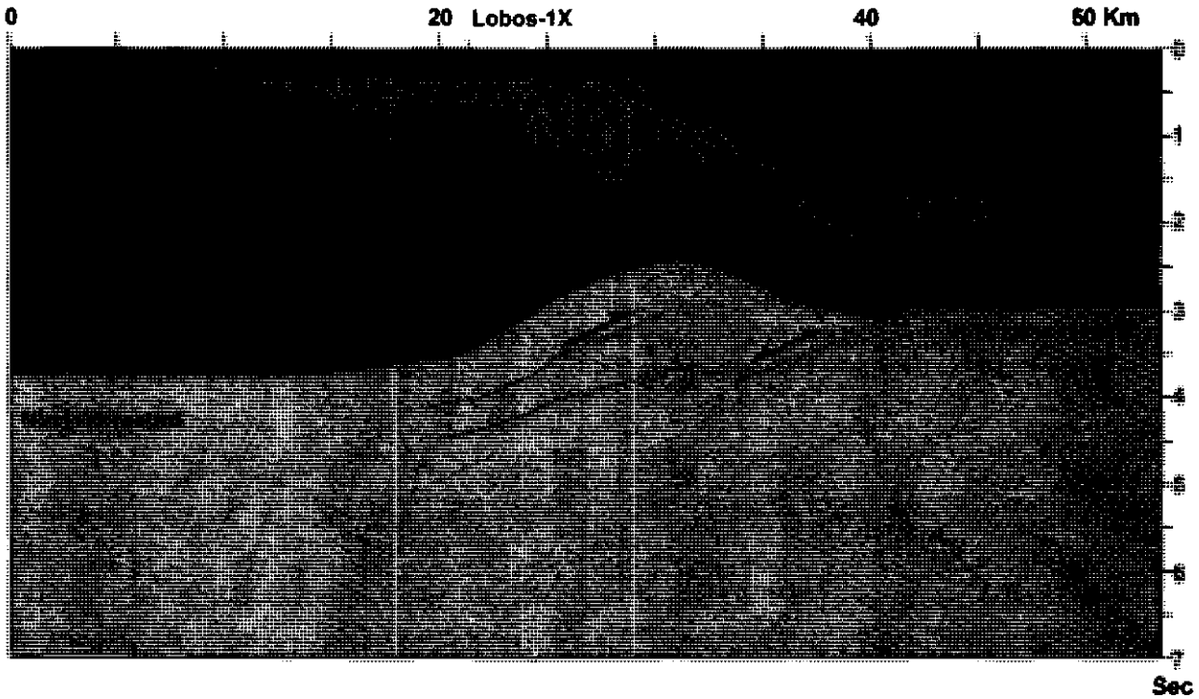

Figure F-4: Time Section Across Lobos Area Based on Seismic Line 96-17.

The area has experienced multiple periods of deformation. The oldest strata were deposited across a peneplained basement surface. In the early Tertiary these strata and the overlying Paleocene, and Cretaceous strata were deformed into a series of northwest-trending folds. The asymmetry of these folds and suggestion of repeated section suggests that they are fault-bend and fault-propagation folds related to regional thrusting (Figures F-3 and F-4).

In the Lobos area, the Cretaceous and Paleocene strata are overlain by a thick sequence of Eocene shales, sandstones and conglomerates that are cut by numerous normal faults most of which terminate downward near the top of the Paleocene. Based on the downward termination of these faults, and the structural discordance between the Eocene section and the underlying Paleocene and older section (Figures F-5 and F-6) a detachment surface is interpreted to be present at the top of the Paleocene section. The cross sectional geometry of the Eocene section suggests that these strata initially were deposited in a shelf margin setting and were subsequently deformed during the Early Miocene by slopeward gravity sliding and probably by normal reactivation of deeper thrust faults (Figure F-5). As this deformation took place, a Miocene basin developed east of the deformed Eocene basin.

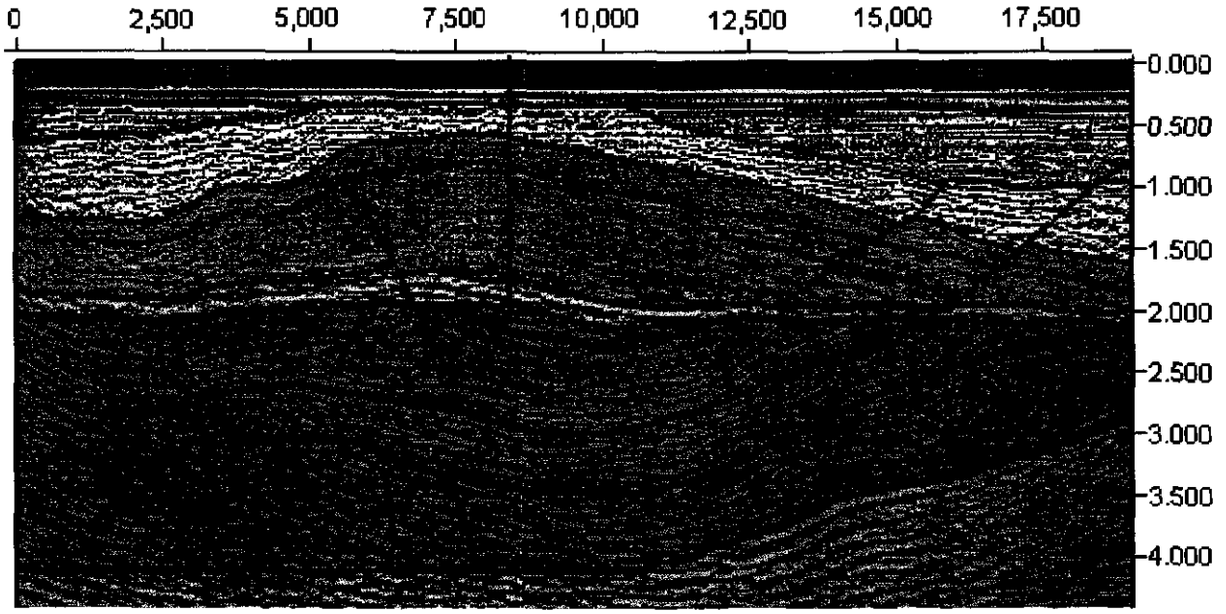

Figure F-5: Interpretation of Seismic Line 98-10b through Lobos Well

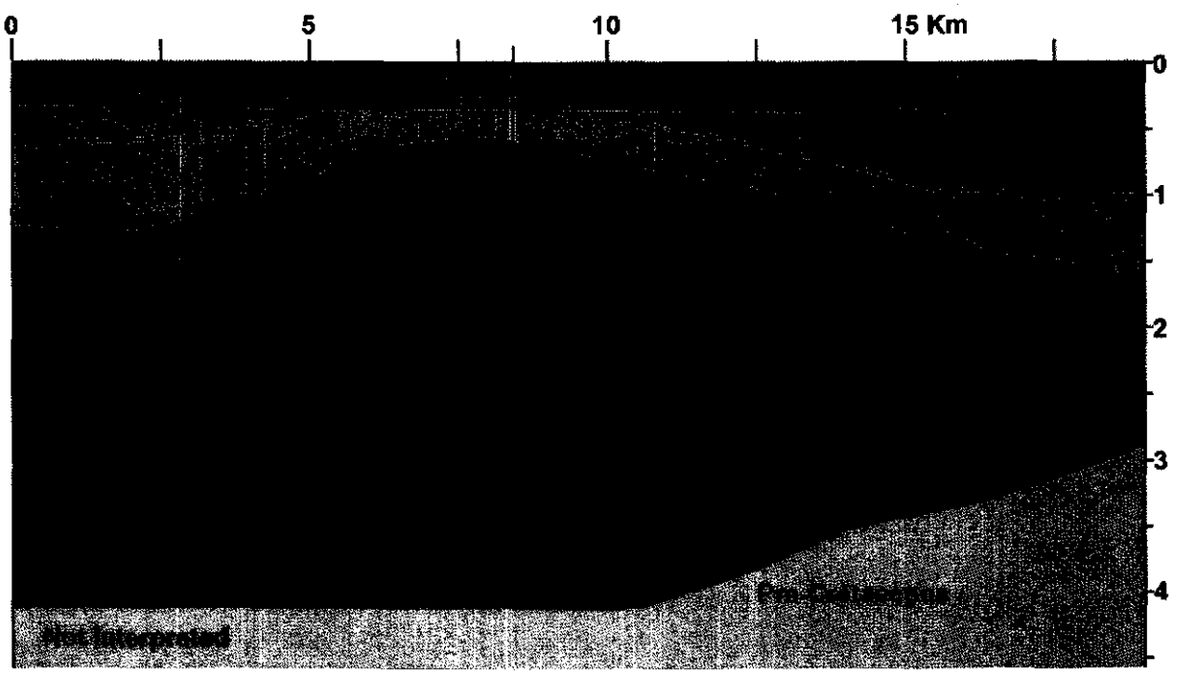

Figure F-6: Time Section Based on Seismic Line 98-10b

Geologic Interpretation of Profile 93-39 (Area of Morsa Norte 1-X Well)

This profile, which is based on seismic line 93-39, is an approximately 135 kilometers long dip section that extends across the present-day continental shelf, the shelf-slope break and about 40 kilometers down the continental slope. The section crosses the Salaverry basin and a sub-basin of the Trujillo basin, and passes very close to the Morsa Norte-1X well (Figure F-1). Based on the nearby well, this Trujillo sub basin is referred to as the Morsa Norte sub-basin.

Salaverry Basin

At the latitude of section 93-39, the Salaverry basin is about 60 kilometers wide. The Neogene section within the basin has an open synclinal form. Middle and Upper Miocene strata downlap or onlap onto the basal Middle Eocene sequence (Eo) (Figure F-7). Inferred Pliocene and Quaternary strata conformably overlie the Late Miocene strata. In the eastern part of the basin the top of the Eo sequence forms a series of positive features 0.5 to 1.5 kilometers in width. From west to east, Middle Miocene, Late Miocene and Pliocene strata progressively onlap onto these features. Based on their geometry and stratigraphic relationships, these features are interpreted to be carbonate bank deposits. Alternatively they could be resistant intrusive or extrusive rocks. The maximum thickness of the Cenozoic section in this part of the Salaverry basin is about 1800 meters. Synclinal reflectors beneath the Eo sequence indicate the presence of an older layered sequence (Figure F-7). This sequence is poorly imaged because of strong multiples. Based on the presence of folded Cretaceous strata in the Lobos 1-X well, this sequence is tentatively thought to be Cretaceous in age.

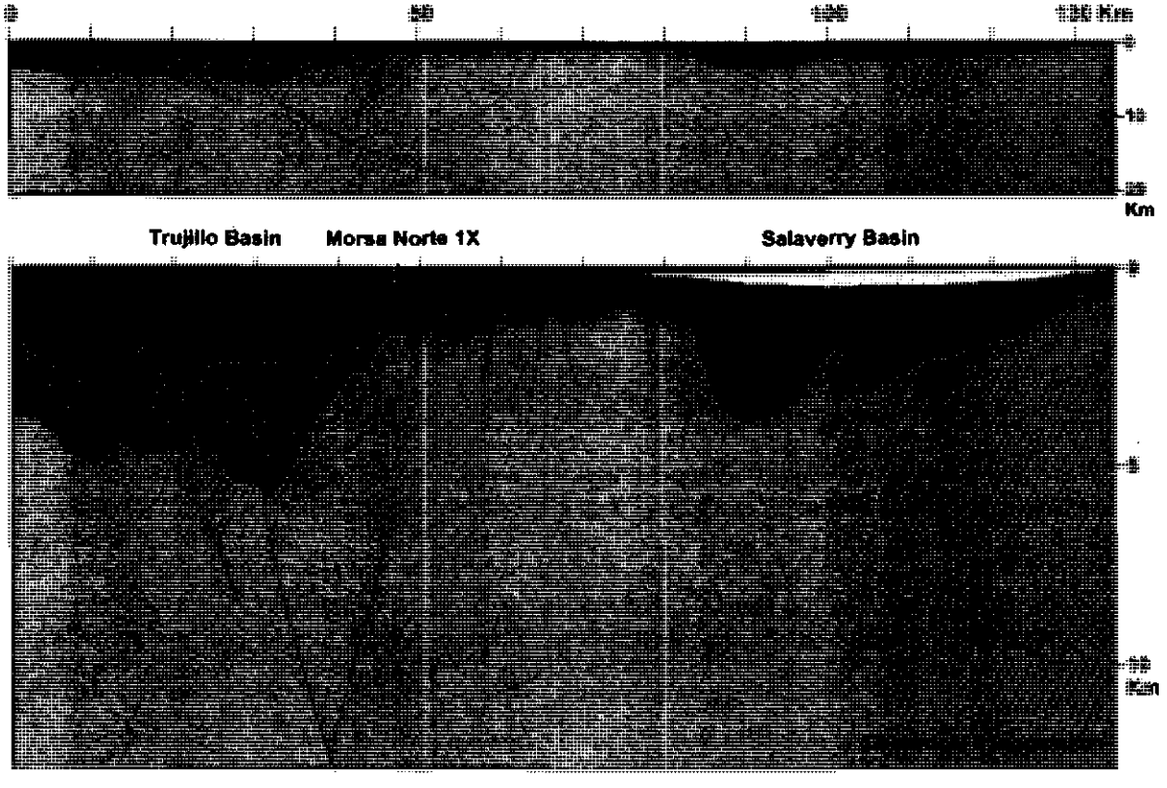

Figure F-7: 1:1 and 5:1 Cross Sections through Morsa Norte 1-X Well Based on Seismic Line 93-39

Salaverry-Trujillo High

The portion of the Salaverry-Trujillo high that separates the Salaverry basin from the Morsa Norte sub-basin consists of a series of horsts and graben involving Precambrian crystalline rocks and the overlying Eo sequence. Middle Eocene to Middle Miocene strata onlap to the east onto these fault blocks. The Morsa Norte-1X well, located about 7 kilometers southeast of this profile, was drilled on the crest of one of the horst blocks.

Trujillo Basin—Morsa Norte Sub-Basin

The Morsa Norte sub-basin is exposed along about 70 kilometers of transect 93-39 (Figure F-7). The basin is roughly symmetrical in cross section; however the profile does not extend entirely across the western margin of the basin which has also been modified by Miocene detached normal faulting. The central, thickest part of the basin is a complex graben formed by basement-involved normal faults. The maximum stratigraphic thickness of the Oligocene (?)-Eocene fill within this graben is about 5000 meters. The Oligocene (?)-Eocene rift fill is overlain by about 1270 meters of Cenozoic, mostly Miocene, sediments.

Growth across basement-involved faults shows that the Morsa Norte basin started to form during deposition of the Eo sequence. The bulk of the Paleogene basin fill consists of strata of sequence Eocene 3. A limited amount of growth across faults during this time shows that accommodation space was produced by subsidence rather than faulting. This dominance of subsidence over faulting probably continued during deposition of the E-O sequence, but Late Miocene faults that cut the sequence make this difficult to determine. Local inversion occurred in the central part of the basin during deposition of the E-O sequence. This occurred above a basement-involved fault. This local deformation continued during deposition of the Miocene 1 sequence in the early Miocene.

During the Miocene, deep water largely biogenic sediments were deposited across the Morsa Norte sub-basin (Wine et al, 2001). During the Late Miocene these sediments and the underlying Oligocene-Late Eocene strata were deformed by extensive small normal faults. Most of these faults die out in the upper part of the Eocene 3 sequence or form antithetic and synthetic fault arrays that join reactivated, basement-involved rift faults. Along the upper continental slope Late Miocene faults appear to detach in the lower (shale-prone?) part of the Middle Eocene (Eocene 3) sequence, facilitating downslope movement.

Restorations Of Section 93-39

Restorations were made for section 93-39 for the top of the Pliocene, the top of the Middle Miocene, and the top of the Middle Eocene time.

Pliocene Restoration

This restoration was constructed by assuming that Pliocene strata originally extended across the Trujillo-Salaverry high and dipped very gently seaward (Figure F-8). The result of this restoration is the nearly complete removal of the high. The absence of this barrier may have allowed hydrocarbons generated in the Trujillo basin to migrate into the Salaverry basin during the Pliocene.

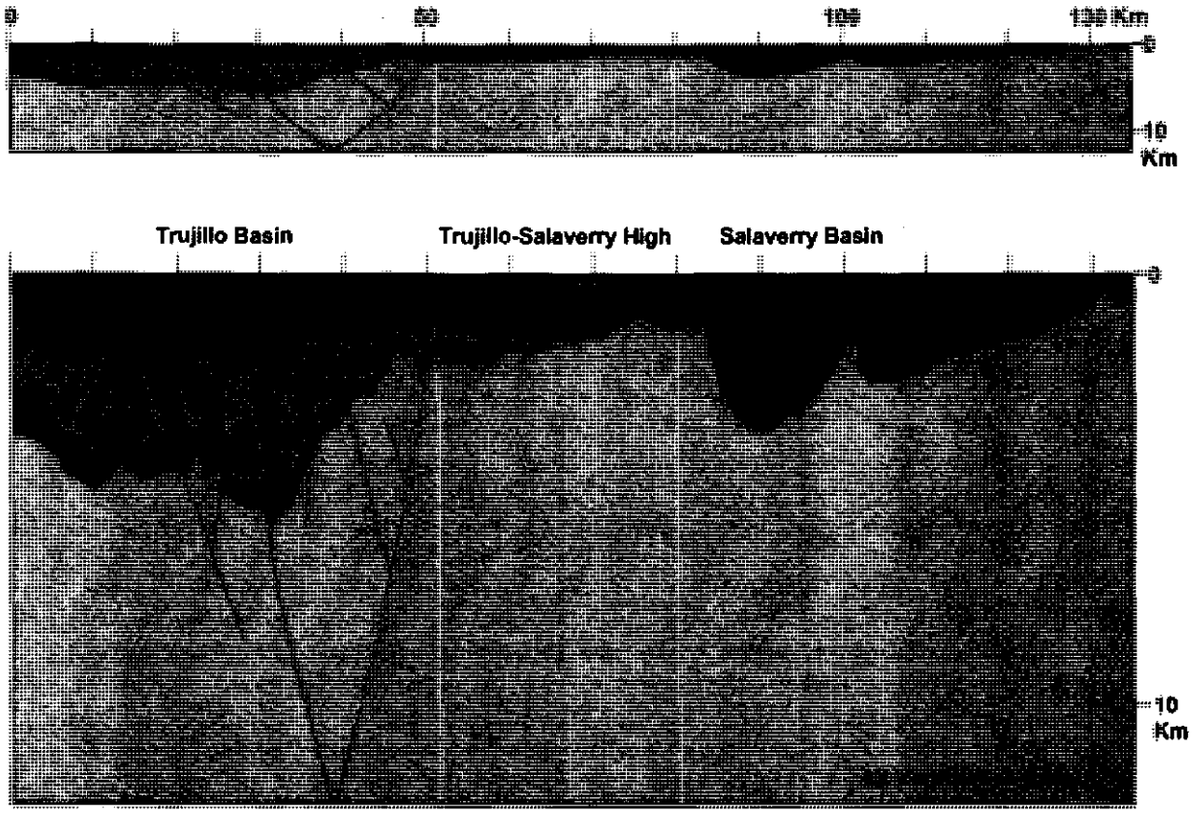

Figure F-8: 1:1 and 5:1 Pliocene Restorations of Section 93-39

Middle Miocene Restoration

By restoring the top of Middle Miocene to a gently seaward-dipping surface, the incipient Trujillo-Salaverry high is completely removed (Figure F-9). At this time, hydrocarbons generated in the Trujillo basin could have migrated toward the Salaverry basin. The restoration also removes Late Miocene extension within the Trujillo basin.

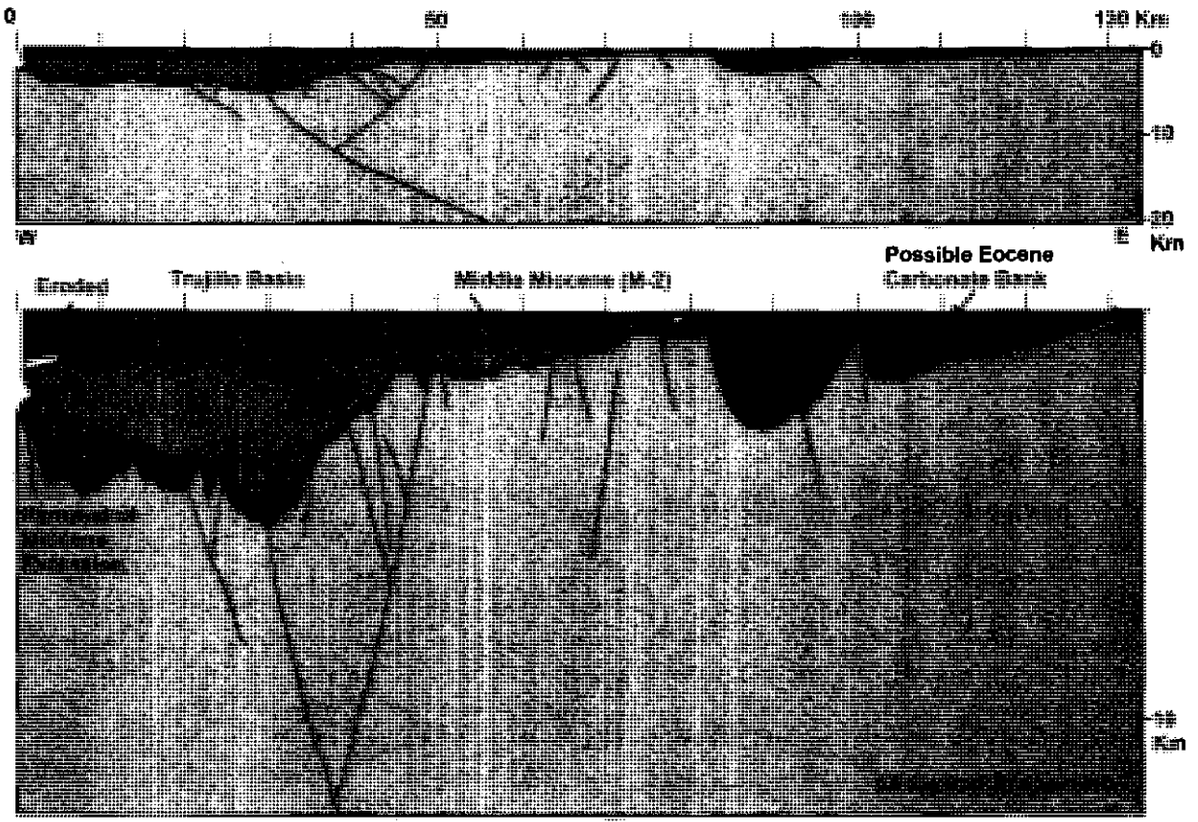

Figure F-9. 1:1 and 5:1 Middle Miocene Restorations of Section 93-39

Middle Eocene Restoration

This restoration shows the general geometry of the Trujillo basin immediately following fill of the basin (Figure F-10). The restoration suggests that possible Early (?) Eocene carbonate banks (?) may have been sub-aerially exposed at this time. Alternatively, if the slope of the seafloor was less, these possible carbonate rocks could have been in a marine setting and continuing to develop in Middle Eocene times.

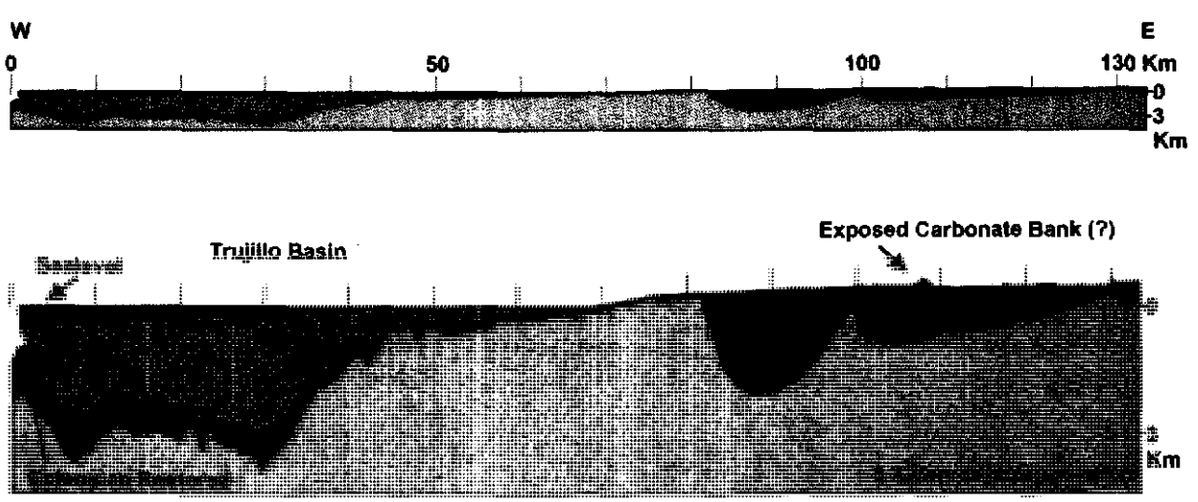

Figure F-10. 1:1 and 5:1 Top Middle Eocene Restorations for Section 93-39

Geologic Interpretation of Profile 93-45 (Ballena 1-X & Delfin 1-X Wells)

This profile, which is based on seismic line 93-45, is an approximately 145 kilometers long dip section that extends across the present-day continental shelf, the shelf-slope break and about 25 kilometers down the slope. The section crosses the Salaverry basin and one of the sub-basins of the Trujillo basin and passes very close to the Ballena-1X and Delfin-1X wells (Figure F-1).

Salaverry Basin

The coastward 90 kilometers of this section crosses the Salaverry basin which is a structurally simple Neogene synclinal basin with thin Quaternary section, and moderate thicknesses of Pliocene, Upper Miocene (M-3) and Middle/Lower Miocene (M-2 and Infra-Miocene) (Figure F-11). The maximum thickness of Neogene sediment within the Salaverry basin along this section line is about 1950 meters.

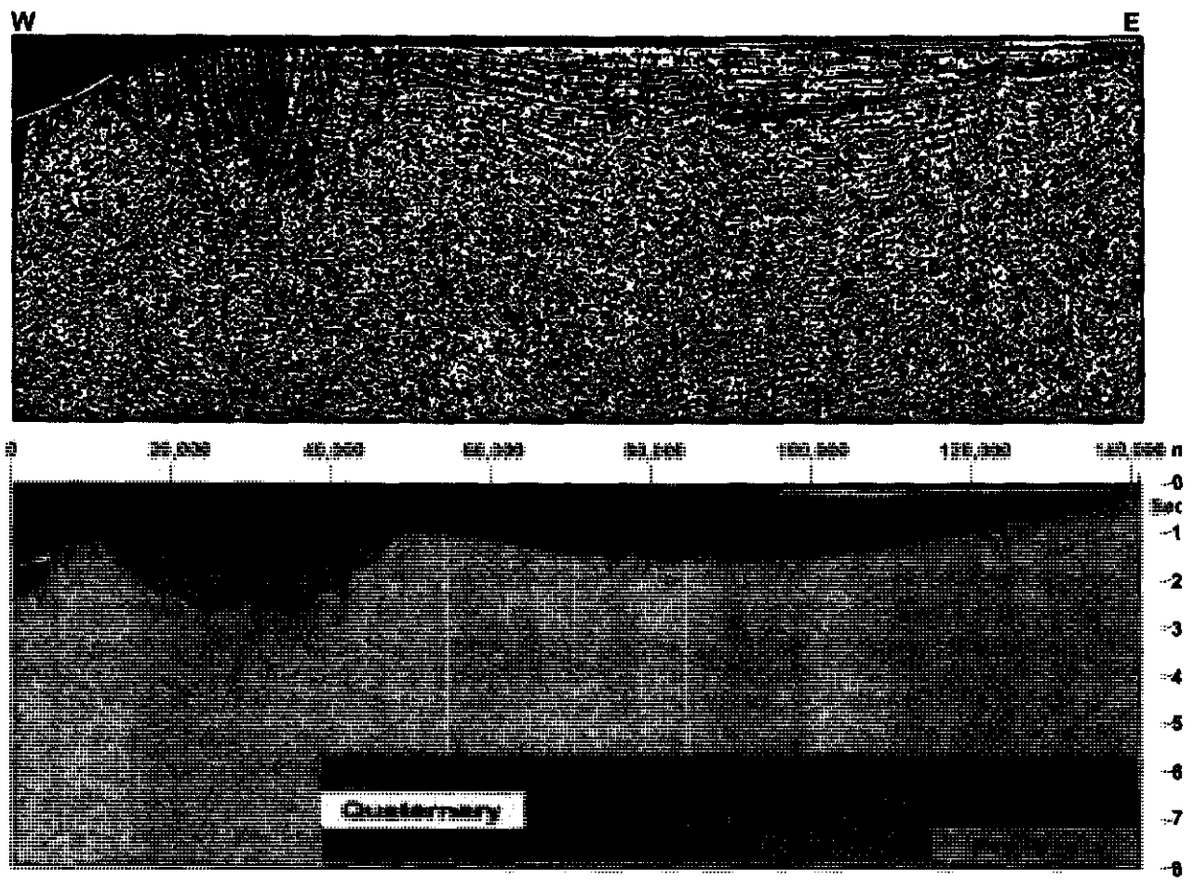

Figure F-11: Seismic Interpretation and Time Section of Seismic Line 93-45

Along the western margin of the Salaverry basin, the Infra-Miocene sequence downlaps onto a prominent unconformity. This unconformity extends across the entire Salaverry basin and separates the Neogene section from the underlying older rocks. This surface is largely peneplained, suggesting that it developed through sub-aerial erosion. Local highs on this surface (Figure F-12) may be Eocene carbonate bank deposits or erosional remnants of Paleogene intrusions or volcanic centers (Azalgara, 1993). Based on the Ballena-1X well, Precambrian crystalline rocks are interpreted to sub crop beneath the unconformity over much

of this part of the Salaverry basin. Locally, down faulted or synclinal remnants of pre-Eocene, probably Cretaceous strata, are present beneath the unconformity (Figure F-11).

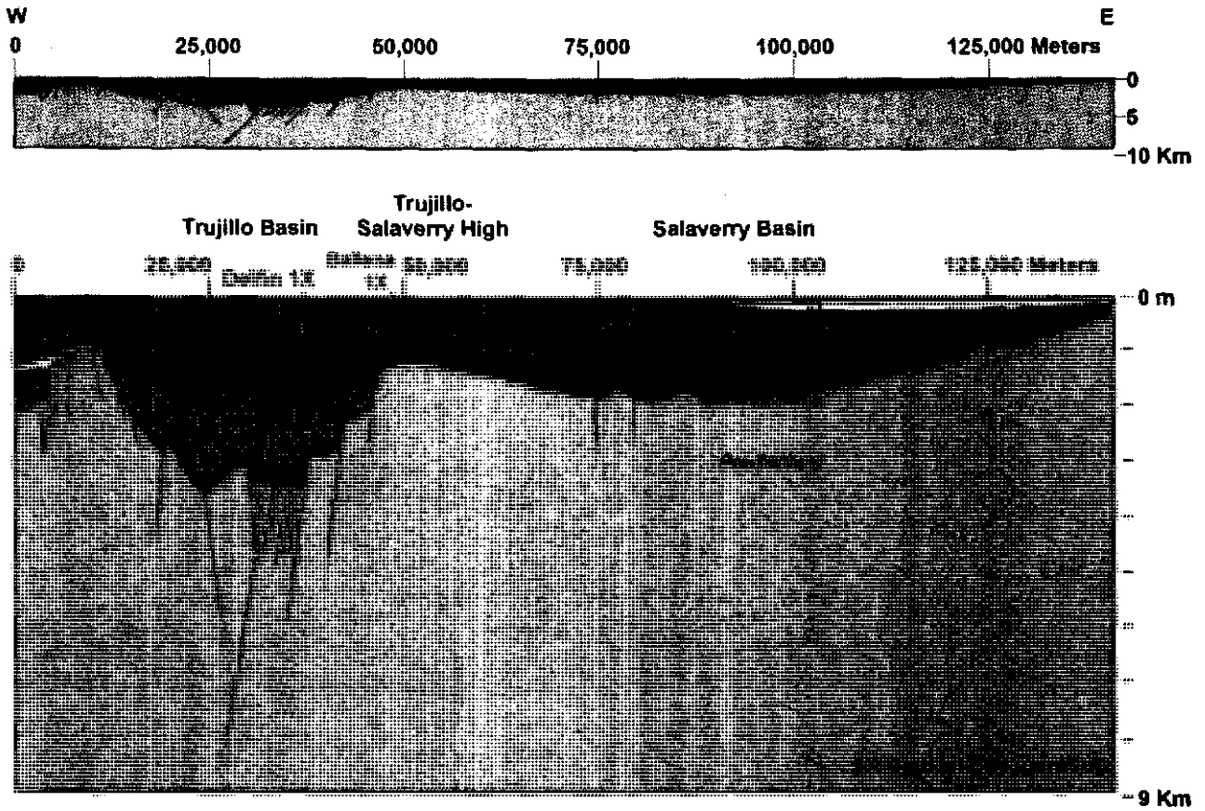

Figure F-12: 1:1 and 5:1 Depth Sections of 93-45

From east to west across the Salaverry basin the Quaternary, Pliocene, and Upper Miocene sequences are progressively beveled at the sea floor. This occurred in response to the Neogene uplift of the Salaverry-Trujillo basement high concurrently with subsidence of the central part of the Salaverry basin.

Salaverry-Trujillo High

The Salaverry-Trujillo high separates the Salaverry basin from the Trujillo basin to the west. The high developed as a result of a combination of major down-to-the-west, basement-involved normal faulting and subsequent eastward tilting of the footwall block. Prior to late Neogene faulting and tilting, the Neogene sequences are interpreted to have formed a generally westward-thickening coastal wedge. On the east flank of the high, the Lower/Middle Miocene, (Infra-Miocene sequence), reflectors that presently strongly downlap onto the top of the Precambrian are interpreted to have formed by onlap prior to tilting of the footwall block that comprises the Salaverry-Trujillo high. The Ballena-1X well was drilled on the crest of the high.

Trujillo Basin—Delfin Sub-Basin

West of the Salaverry-Trujillo high, a prominent 35 km wide, fault-bounded basin is present beneath the present-day outer shelf. This is one of several north-northeast trending, left-stepping en echelon sub-basins that make up the overall Trujillo basin. Along this transect

this single fault-bounded basin, here referred to as the Delfin sub-basin, comprises the entire Trujillo basin. At the latitude of the transect, the basin has a general half graben geometry and is subdivided into five major domino-style blocks by five down-to-the-west normal faults (Figure F-12).

The Delfin sub-basin records a complex tectonic history. It is floored by a Middle Eocene sequence (Eo) of nearly uniform thickness of except sequence in the east-central part of the basin where it is slightly thickened by Middle Eocene normal faulting. The faults active at this time were are largely "west-dipping" basement-involved faults. This sequence is overlain by another Middle Eocene sequence (E-3). The transparent seismic character of this sequence suggests that it is shale-prone. During E-3 time the depocenter was broader than during Eo time. The major west-dipping faults continued to be active during this period, but other parallel faults died out. This probably occurred as due to the lateral linking of the major faults and the resulting "short circuiting" of shorter faults.

During the Late Eocene-Oligocene (E-O sequence) deposition was centered in the west-central part of the Delfin sub-basin and continued to be influenced by the major "west-dipping" basement-involved faults. During Early Miocene time (M-1) the depocenter shifted back to the east and was centered above the initial Middle Eocene area of extension.

Probably as a result of flexural and isostatic rebound produced in response to fault displacement of the bounding western fault system (Jackson and McKenzie, 1983), the eastern flank of the Delfin sub-basin was differentially uplifted during the Miocene and Pliocene producing an eastward dip on the top of the Precambrian. This tilting had a several effects. It produced the closure on Salaverry-Trujillo high and caused the late Early-Middle Miocene onlap surfaces (M-1 and lower part of Infra Miocene sequences) to appear as downlap surfaces (Figures F-11 and F-12).

West of the high, the lower part of the Infra-Miocene sequence progressively thickens and then drastically thins into the central part of the Delfin sub-basin suggesting that the sequence prograded into substantially deeper water west of the high. Details of this sedimentary sequence are obscured later deformation. Following deposition of the Infra-Miocene sequence, continued tilting led to submarine canyon development along the western flank of the Salaverry-Trujillo high and related erosion of parts of the Infra-Miocene sequence.

Uplift of the eastern flank of the graben also caused the Late Early and Middle Miocene depocenter (M-2 sequence) to shift further to the west. A closely spaced array of small displacement, slightly listric, east-dipping normal faults are associated with this depocenter. These faults die out downward in the E_3 sequence or terminate against the west-dipping basement-involved normal faults (Figure F-13). This fault style implies the presence of a cryptic detachment surface or zone within the E_3 unit. These faults may have started to develop as early as the Late Oligocene (E-O sequence), but evidence of this from increasing fault displacement with depth is not clear because of the overall small displacement of the faults. The faults continued to be active during the Late Miocene as indicated by offset of the M-3 sequence and possibly were active into the Pliocene.

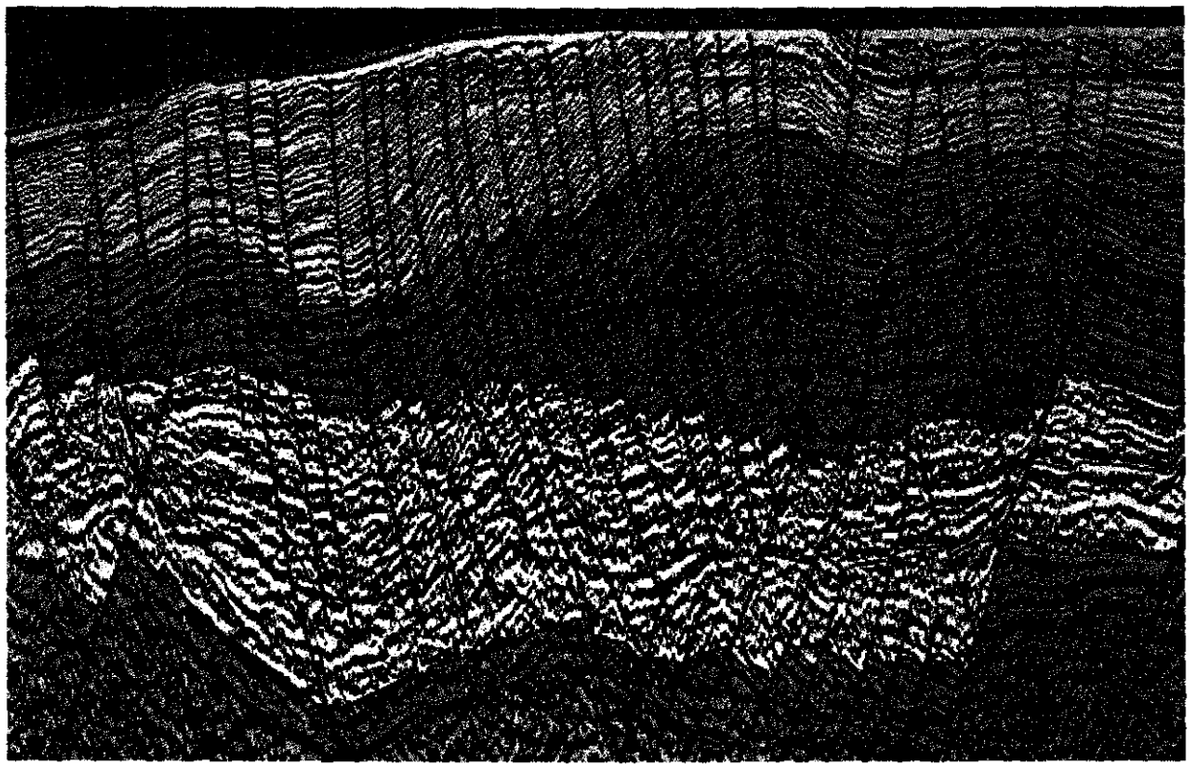

Figure F-13: Detail of Seismic Line 93-45 Showing Numerous Normal Faults Cutting the Miocene and Eocene Section – (Note inversion of some basement-involved faults)

During the Late Miocene, mudstones and diatomaceous sediments were deposited across the Salaverry basin and the Trujillo basin. This pattern continued in the Salaverry basin and possibly in the Trujillo basin during the Pliocene. During the latter part of the Late Miocene or the early Pliocene, the central part of the Delfin sub-basin was partly inverted. This inversion took place through reversal of displacement along some of the basement-involved faults that bound the area of thick Late Early and Middle Miocene strata and through east-west shortening that thickened and broadly folded the Neogene. There is little evidence of inversion of the numerous detached normal faults that cut the M-2 sequence either because these faults were not reactivated or because they postdate the inversion.

In summary the Delfin sub-basin shows 1) Middle Eocene-Oligocene rifting, 2) a late Oligocene-Early Miocene sag phase, 3) Middle Miocene deposition associated with detached normal faulting, 4) Late Miocene or early Pliocene inversion and 5) Late Miocene or Pliocene normal faulting. The relative sequence of inversion and late normal faulting can not be determined due to erosion.

Restorations of Section 93-45

Restorations for section 93-45 were made for the top Pliocene, the Middle Miocene (M-2 horizon), the Early Middle Miocene (Infra-Miocene horizon), and the Early Miocene (M-1 horizon).

Pliocene Restoration

This reconstruction (Figure F-14) shows the basin configuration during early stages of inversion of the Delfin sub-basin prior to erosion over the crest of the inverted area. Inversion is inferred to have occurred during the Pliocene, but may have started in the Late Miocene. To make this restoration, the original thicknesses of the Pliocene and M-3 sequences, and upper part of the M-2 sequence are estimated across the now-eroded central part of the basin. Using these estimates, a maximum of about 4000 meters of Tertiary sediment was present in the Delfin sub-basin along the transect at this time.

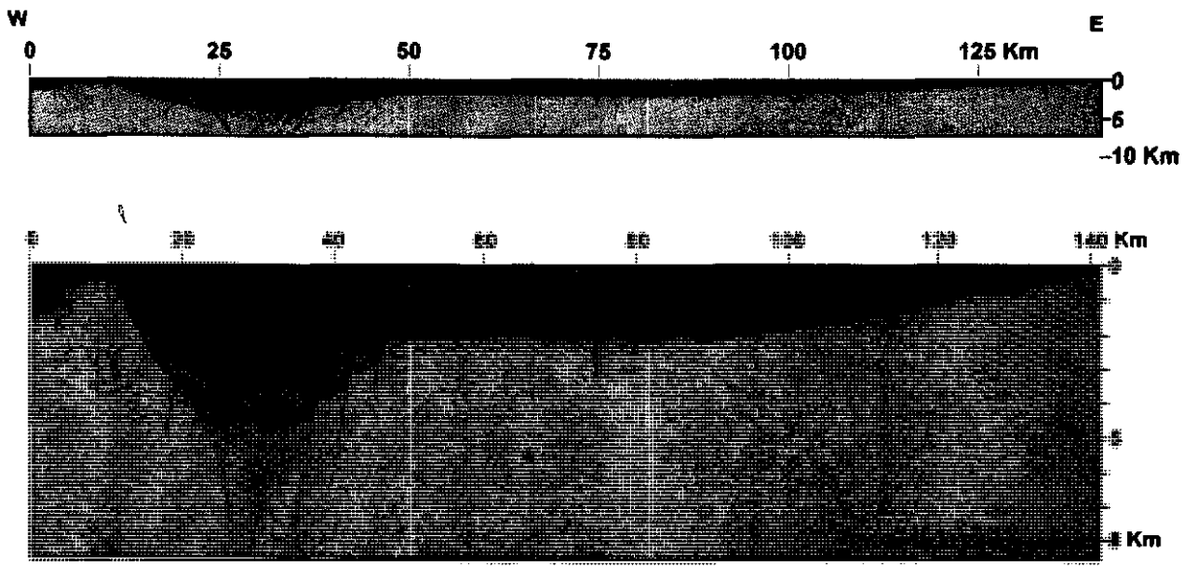

Figure F-14: 1:1 and 5:1 Pliocene Restorations of Section 93-45.

Middle Miocene (M-2) Restoration

The M-2 reconstruction (Figure F-15) illustrates the westward shift of the Middle Miocene depocenter as a result of the uplift of the Trujillo-Salaverry high. Displacement on the detached normal fault array probably provided accommodation space for the M-2 sequence.

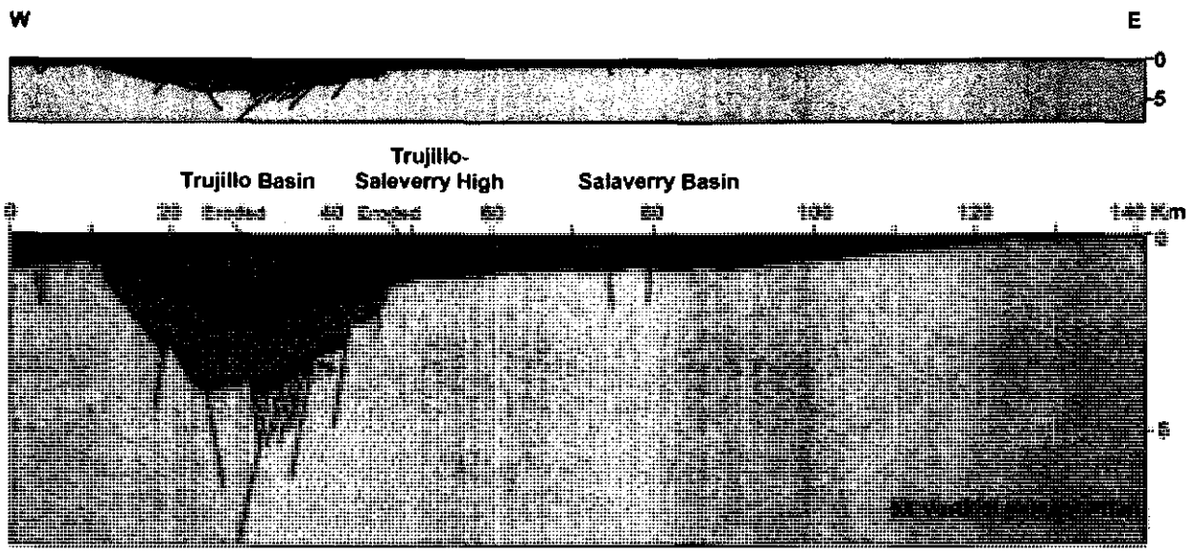

Figure F-15: 1:1 and 5:1 Middle Miocene Restorations of Section 93-45

Infra-Miocene Restoration

Restoration the top of the Infra-Miocene sequence is constructed so that 1) markers within the sequence onlap (rather than downlap) on to the incipient Trujillo-Salaverry high, 2) part of the upper part of the sequence removed by submarine canyon development is restored, and 3) westward thinning of the sequence reflects increasing water depths in the central part of the Delfin sub-basin (Figure F-16). The assumption of greater water depths in the western part of the sub-basin prevents the underlying M-1 sequence from arching upward unrealistically beneath the western part the basin in the reconstruction and supports the paleo-bathymetry from the Delfin-1X well (Azalgara, 1993).

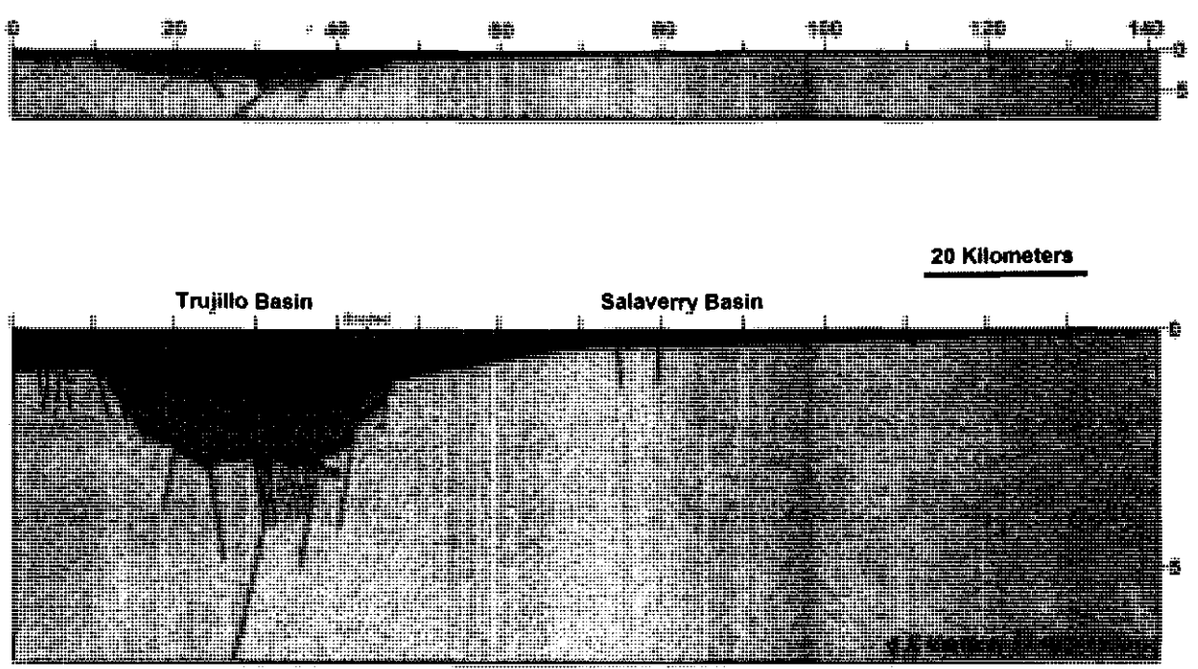

Figure F-16: 1:1 and 5:1 Infra Miocene Restorations of Section 93-45

Early Miocene (M-1) Restoration

This restoration assumes that 1) the region of the present-day Salaverry basin was a peneplain with an elevation slightly above sea level, 2) the bathymetry of the Delfin sub-basin was about 200 meters, and 3) the shelf break lay just west of the basin (Figure F-17). The reconstruction thus shows the geometry of the Delfin sub-basin after its rift and sag phases of evolution.

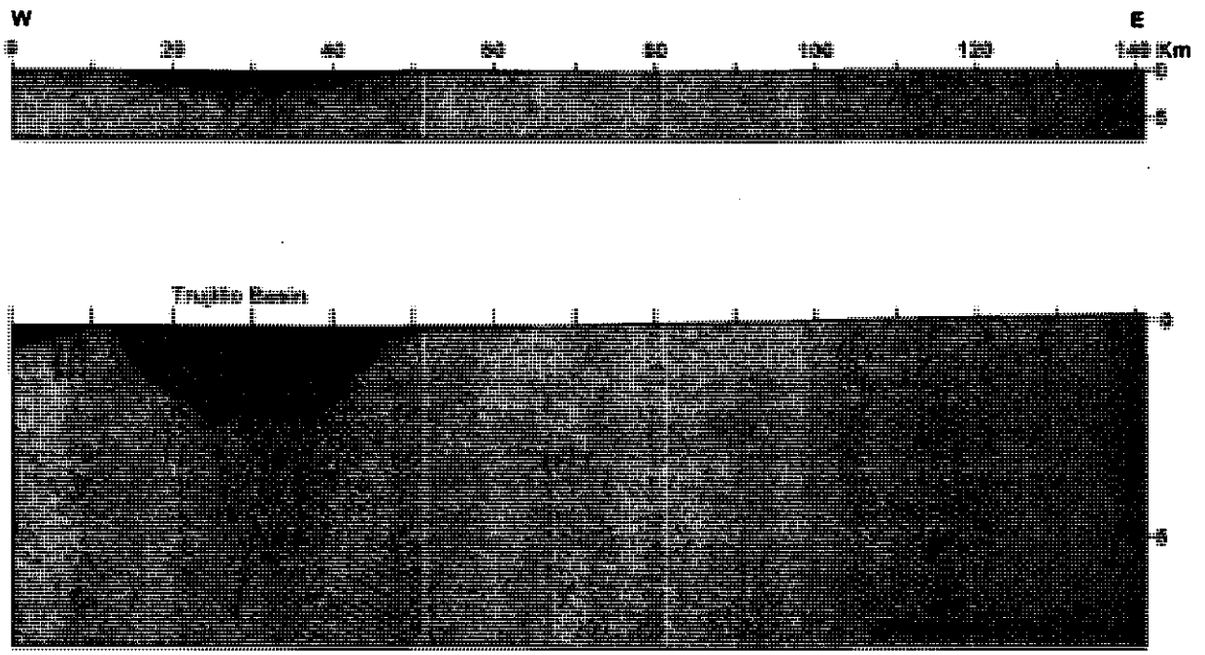

Figure 17: 1:1 and 5:1 Early Miocene Restorations of Section 93-45

Geologic Interpretation of Profile 93-75, Pisco Basin

This profile, which is based on seismic line 93-75, is an approximately 86 kilometers long dip section that crosses the northern part of the composite Pisco basin. The line extends across the present-day continental shelf, the shelf-slope break and about 45 kilometers down the continental slope to a water depth of about 1500 meters (Figures F-18 and F-19). The stratigraphy of this region is less well known than that of the Trujillo and Salaverry basins because of the lack of well data. Correlations with the northern basins are difficult because the limited number of regional seismic strike lines connecting the basins cross numerous faults and unconformities.

Four general stratigraphic packets are present that can be related to the sections in the Salaverry and Trujillo basins: 1) a young, prograding Plio-Pliestocene section, 2) an oceanward thickening wedge mainly beneath the continental slope thought to be of Miocene age, 3) an underlying sequence cut by extensional faults which is correlated with the Eocene rift sequence in the Trujillo basin, and 4) local synclinal remnants of probable Cretaceous age. Locally the Eocene (?) and Cretaceous (?) sequences were inverted during the Late Eocene to Early Miocene by reactivation of basement faults.

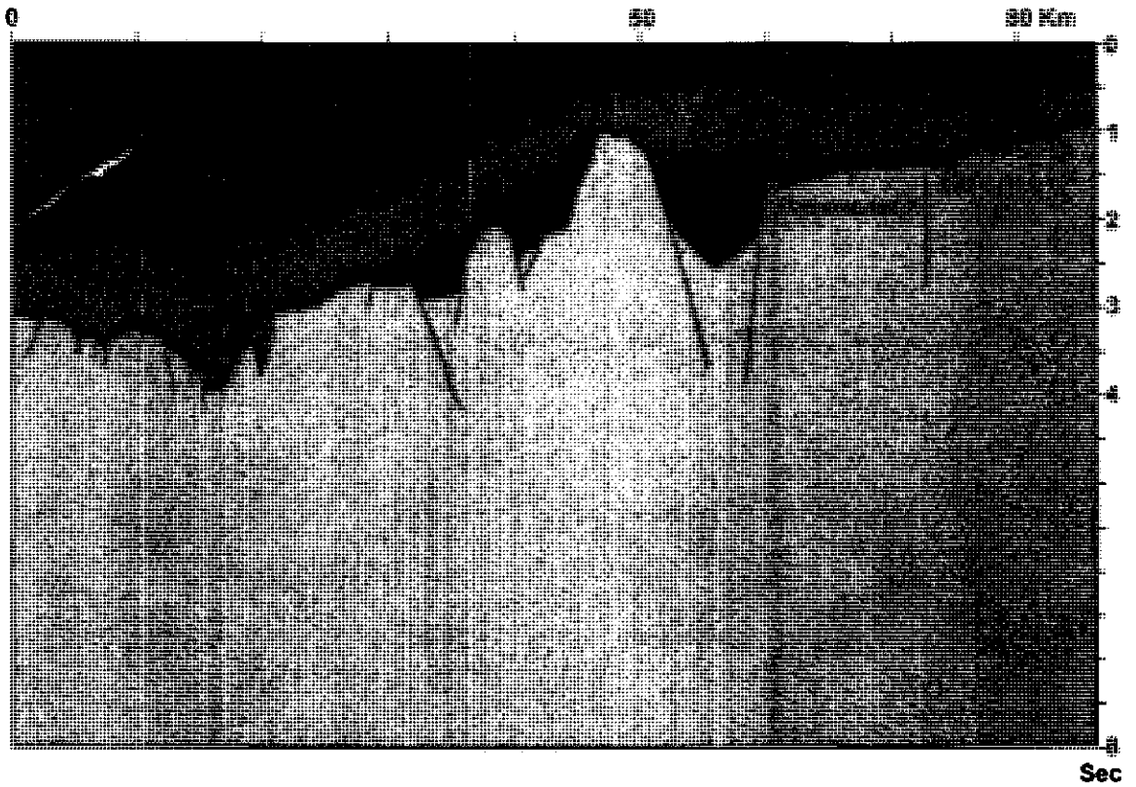

Figure F-18: Time Section Based on Seismic Section 93-75

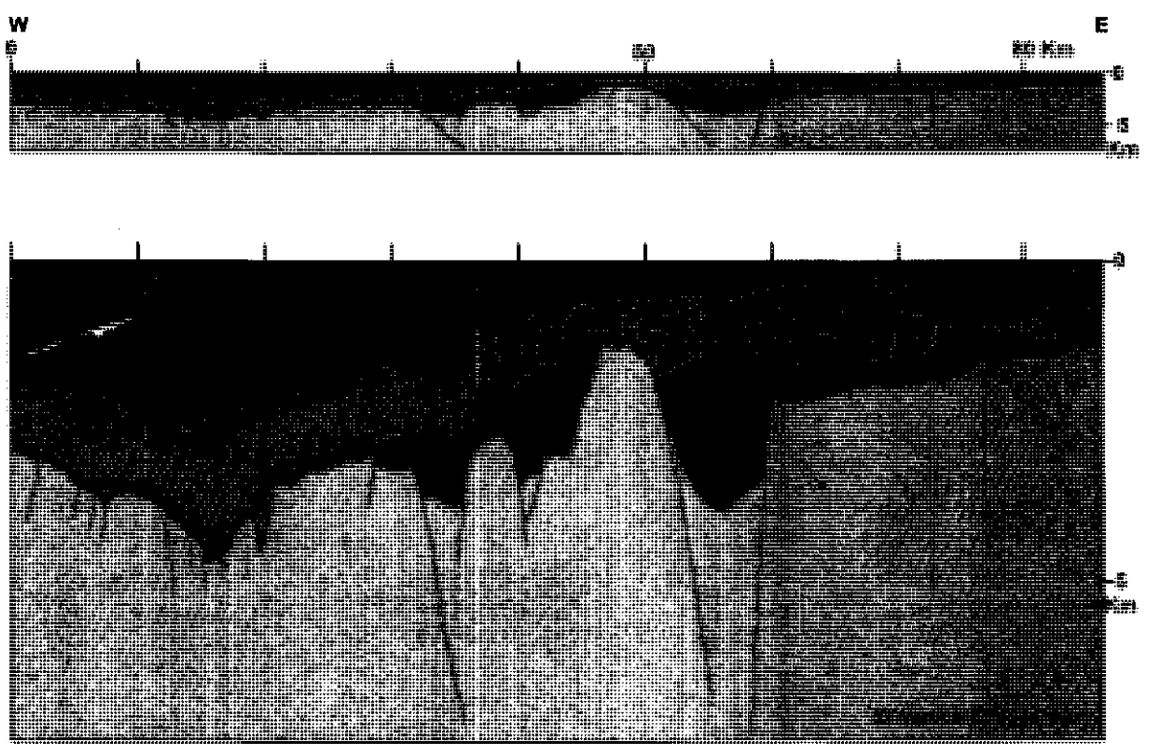

Figure F-19: 1:1 and 5:1 Depth Sections based on Seismic Line 93-45.

Restorations of Section 93-75

Restorations of section 93-75 were made for the Oligocene or Late Eocene (?) and for the top of the Middle Eocene (?).

Oligocene/ Late Eocene Restoration (?)

This restoration shows that the Pisco basin was a broad basin that extended across much of the current continental shelf (Figures F-20 and F-21). The Oligocene /Late Eocene (?) section is cut by fewer extensional faults, suggesting that it is a sag phase sequence. Considerable parts of this latter sequence were eroded as a result of Oligocene or Early Miocene inversion.

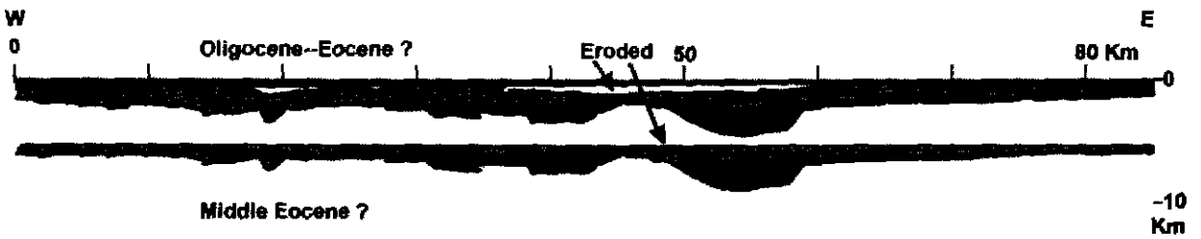

Figure F-20: 1:1 Restorations of Section 93-75 for the Top Oligocene and Top Middle Eocene

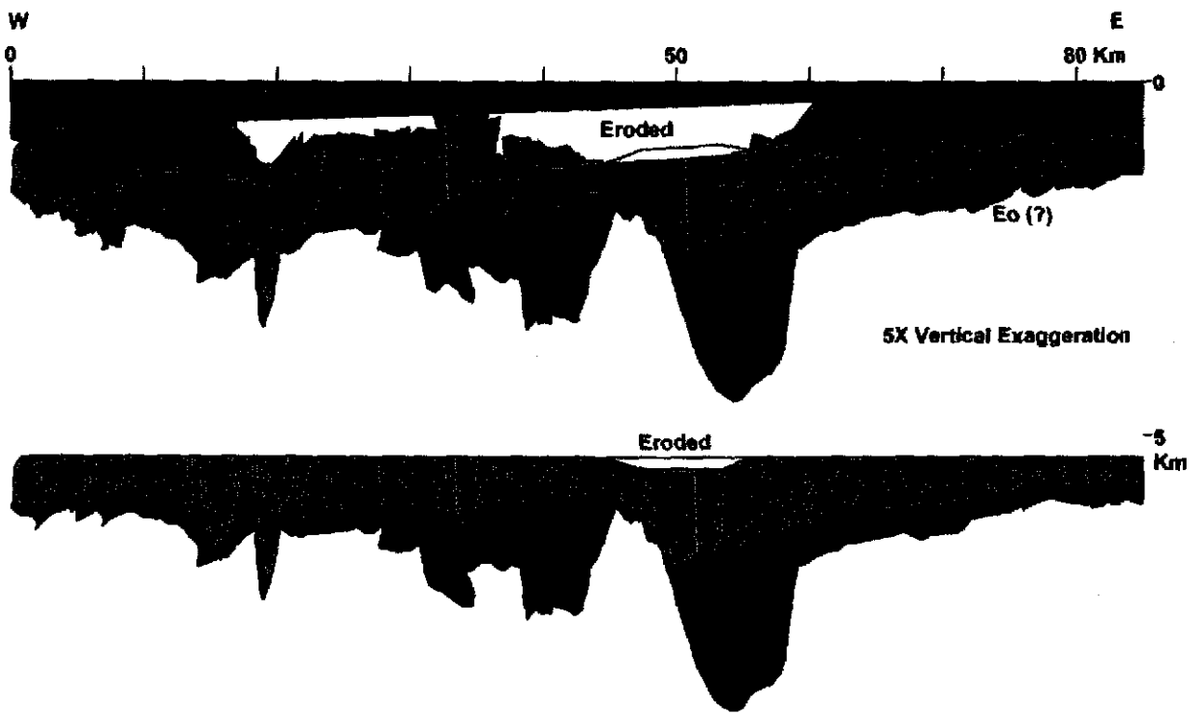

Figure 21: 5:1 Restorations of Section 93-75 for the Top Oligocene and Top Middle Eocene

Middle Eocene (?) Restoration

Normal faults and abrupt thickness changes indicate that the Middle Eocene (?) sequence was deposited during a period of rifting. Because we have no information about paleobathymetry, the section is restored to a horizontal surface. Locally, folded synclinal

remnants are present beneath the Eocene (?) strata. Based on the stratigraphy in the Trujillo basin, these remnants are assumed to be of Cretaceous age. If source rocks are present, these remnants may be local hydrocarbon kitchens.

Mesozoic and Cenozoic Evolution of Basins

While each of the basins of coastal Peru has a unique history, the basins have many characteristics in common (Figure F-22). Cretaceous and Paleocene marine strata were deposited across a peneplaned basement complex composed of Precambrian and Paleozoic (?) rocks. The Cretaceous and Paleocene strata were compressively deformed, uplifted, and widely eroded during the Late Paleocene or Early Eocene. During the Early Middle Eocene a marine transgression occurred across much of the present-day continental shelf and carbonate banks (?) locally developed in the Salaverry and Pisco basins. Rifting occurred during the Middle and Late Eocene. The rift fill consists largely of clay-rich biogenic sediments with some interspersed turbiditic sandstones. The rift geometry was controlled by basement-involved faults, some of which were repeatedly activated during the Cenozoic.

The Oligocene was a period of non-deposition and local uplift, although sag-phase Oligocene sediments were deposited in some of the rift basins. Miocene strata onlap onto either Eocene or basement rocks. Intense detached extensional faulting occurred during the Miocene. The Trujillo-Salaverry high developed partly concurrently with this faulting and continued to develop during local inversion in the Late Miocene and Pliocene. Middle and Late Miocene development of the high led to extensive submarine canyon formation along and west of the uplift. In the Trujillo and Salaverry basins, sets of minor strike-slip faults of Miocene and Pliocene age trend northeast-southwest and northwest-southeast. These trends may be controlled by old structures in the basement. In the Late Pliocene some rift-related faults underwent slight reactivation.

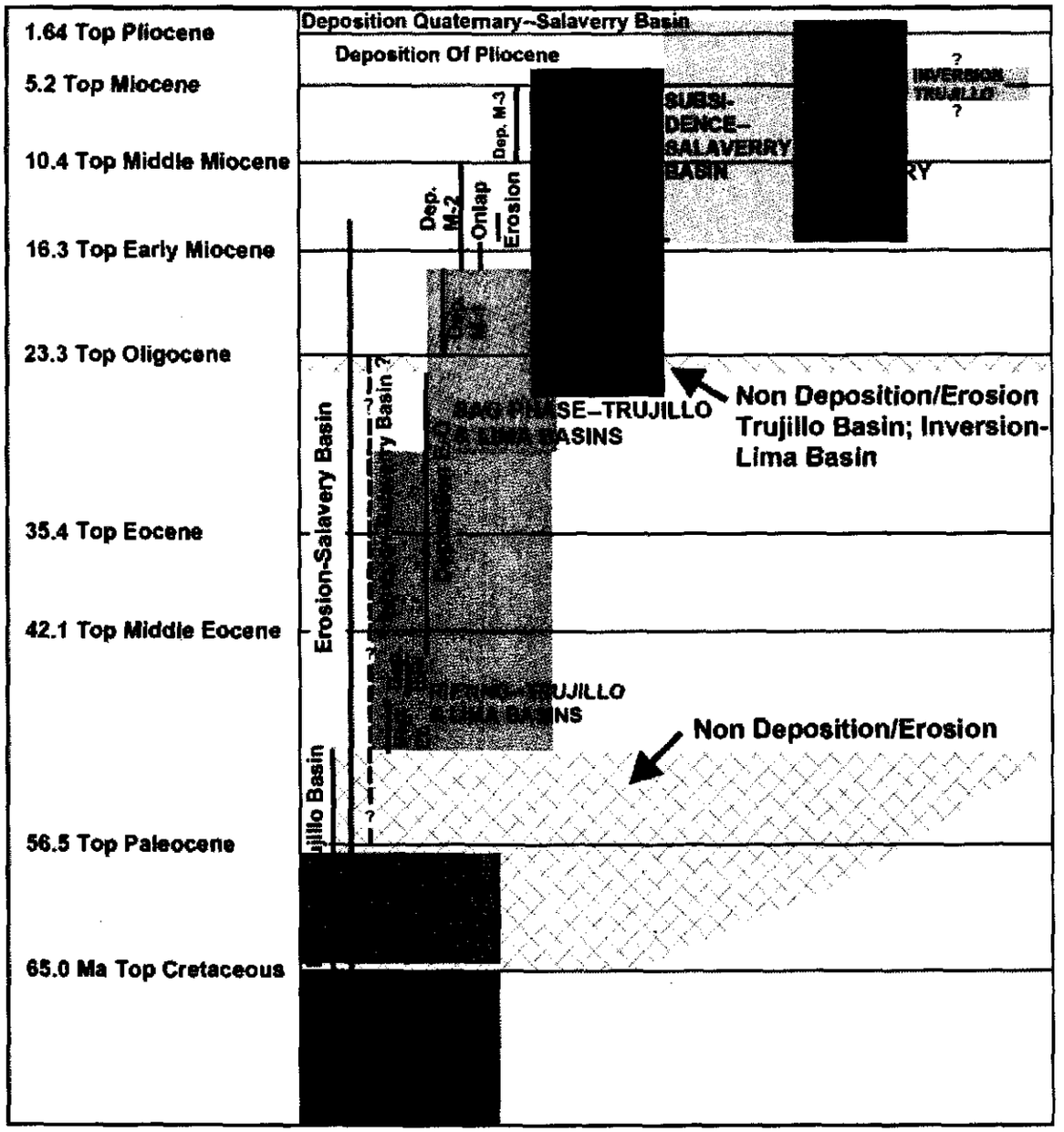

Figure F-22: Major Cretaceous and Cenozoic Events of the Trujillo, Salaverry and Pisco Basins

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Wine, G., J. Arcuri, E. Martinez, C. Monges, Y. Calderón, C. Carlos, 2001, The Trujillo Basin, CD produced by Perú Petro, 131 p.

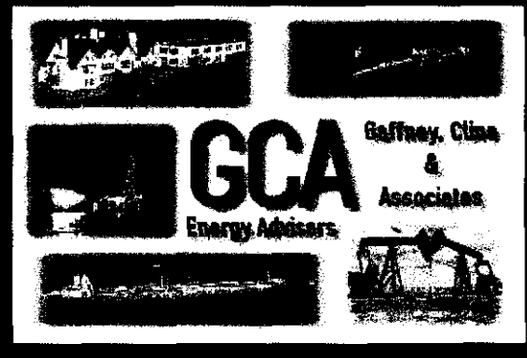
APPENDIX G

DEPTH CONVERSION METHODOLOGY

Gaffney, Cline & Associates

April 2005

Depth Conversion

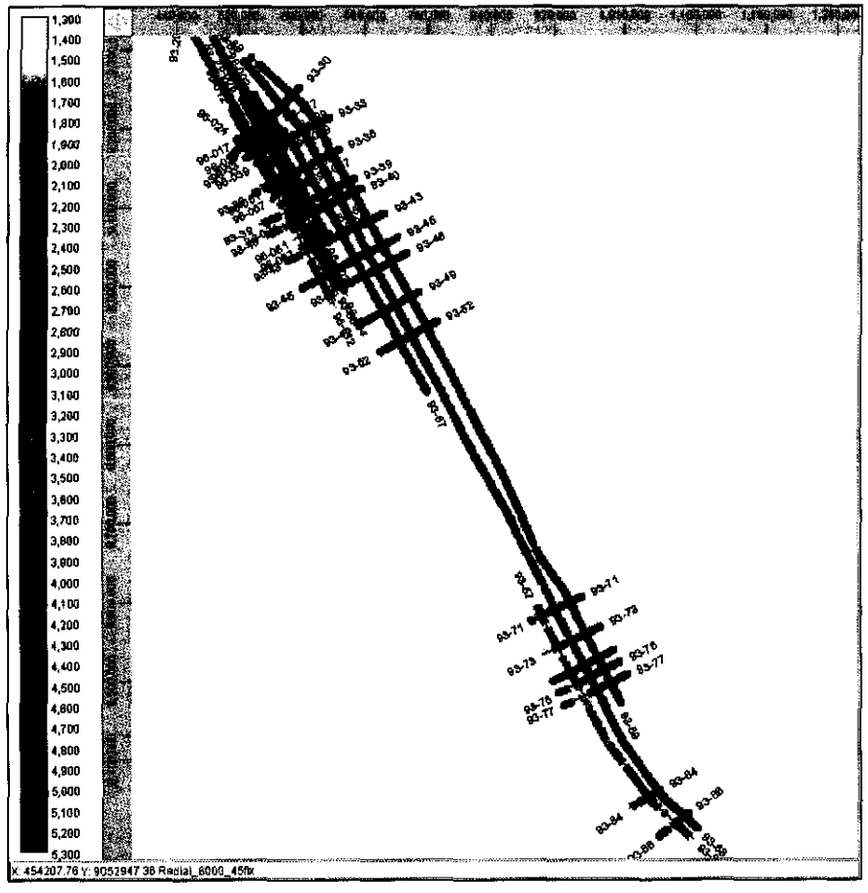


Perú petro

A major contribution of this study was a regional depth conversion of the horizons and trace data to enable viewing of depth-converted seismic sections.

Gaffney, Cline & Associates

Trujillo-Salaverry-Pisco Velocity Model



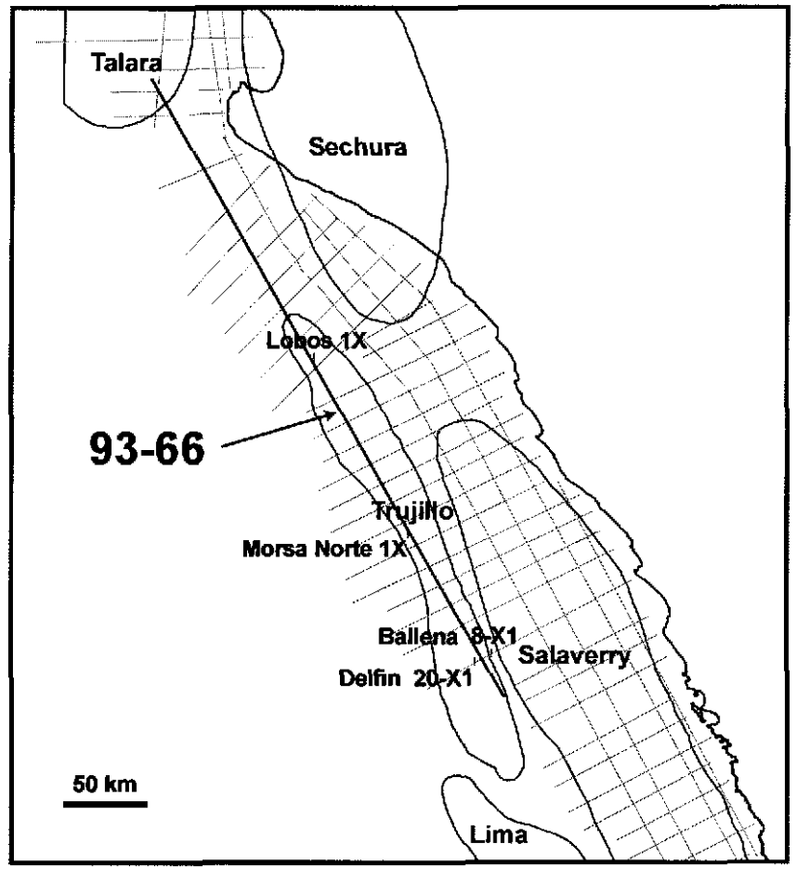
Perú petro

The input stacking velocities were manually quality-controlled and corrected for data entry errors and implausible velocities. A volume was built by slicing the stacking velocities at 100 ms slices hung from the seafloor and gridding the individual interval velocity data points using a radial technique with radius of 6,000m to provide both moderate smoothing and interpolation between input stacking velocity functions. The resulting volume has a clearly defined seafloor and interval velocity "slices" every 100 ms to a total depth of 8 seconds.

Volume details: 100 ms interval velocity slices from waterbottom to 8 seconds; 1,000 m grid cell size; 6,000 m search radius, moderate smoothing, minimal extrapolation away from control

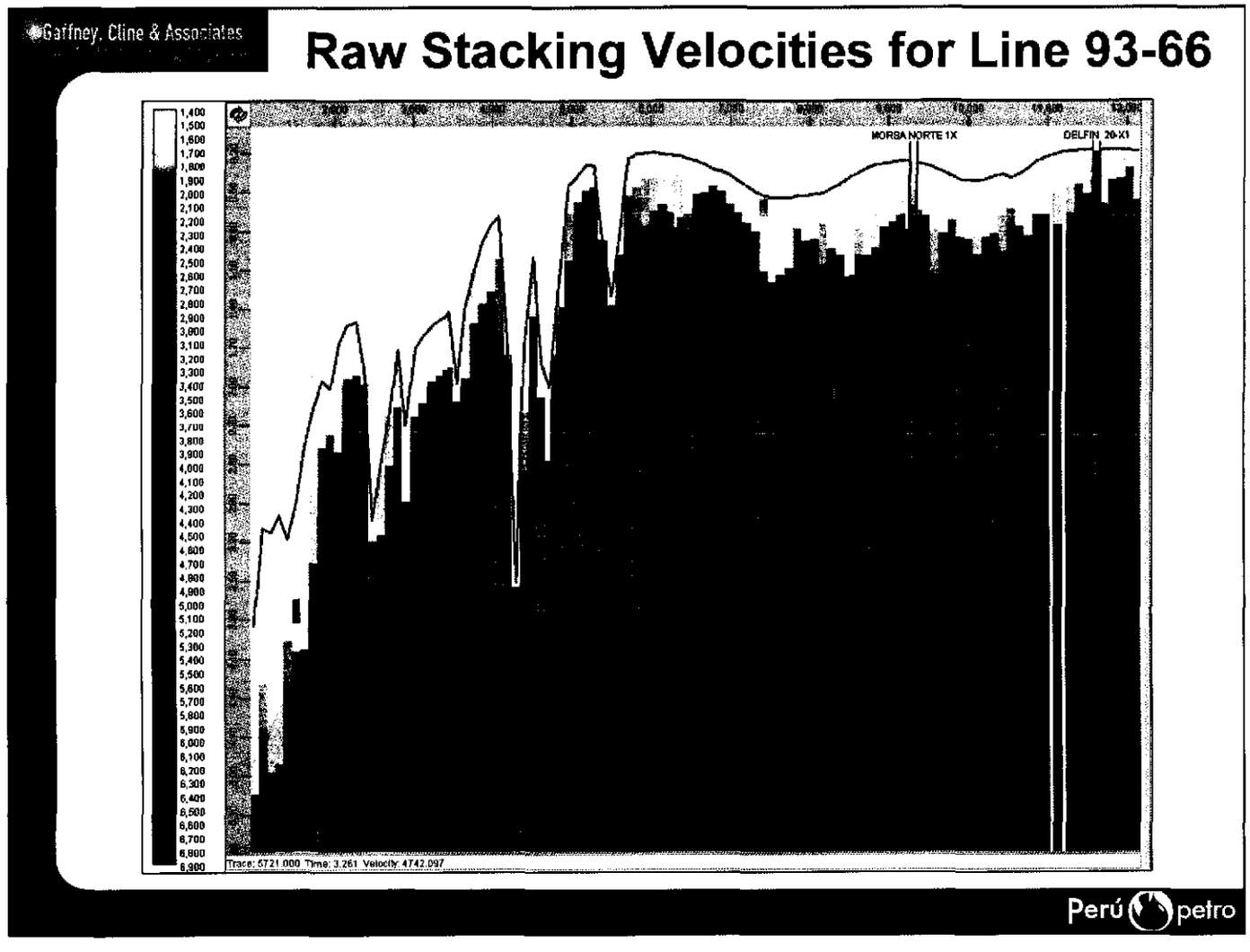
Gaffney, Cline & Associates

Location of Line 93-66 and Morsa Norte Well

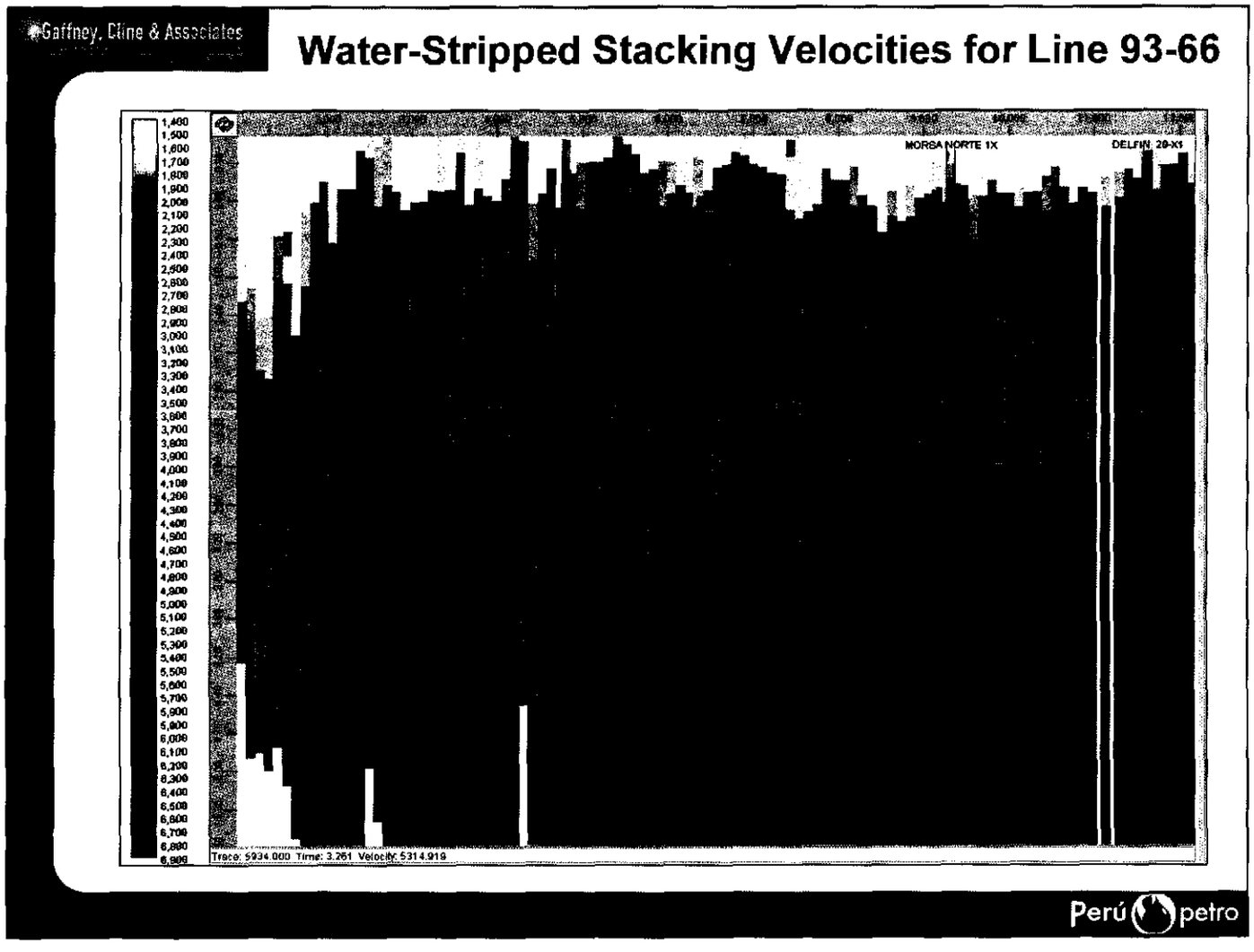


Perú petro

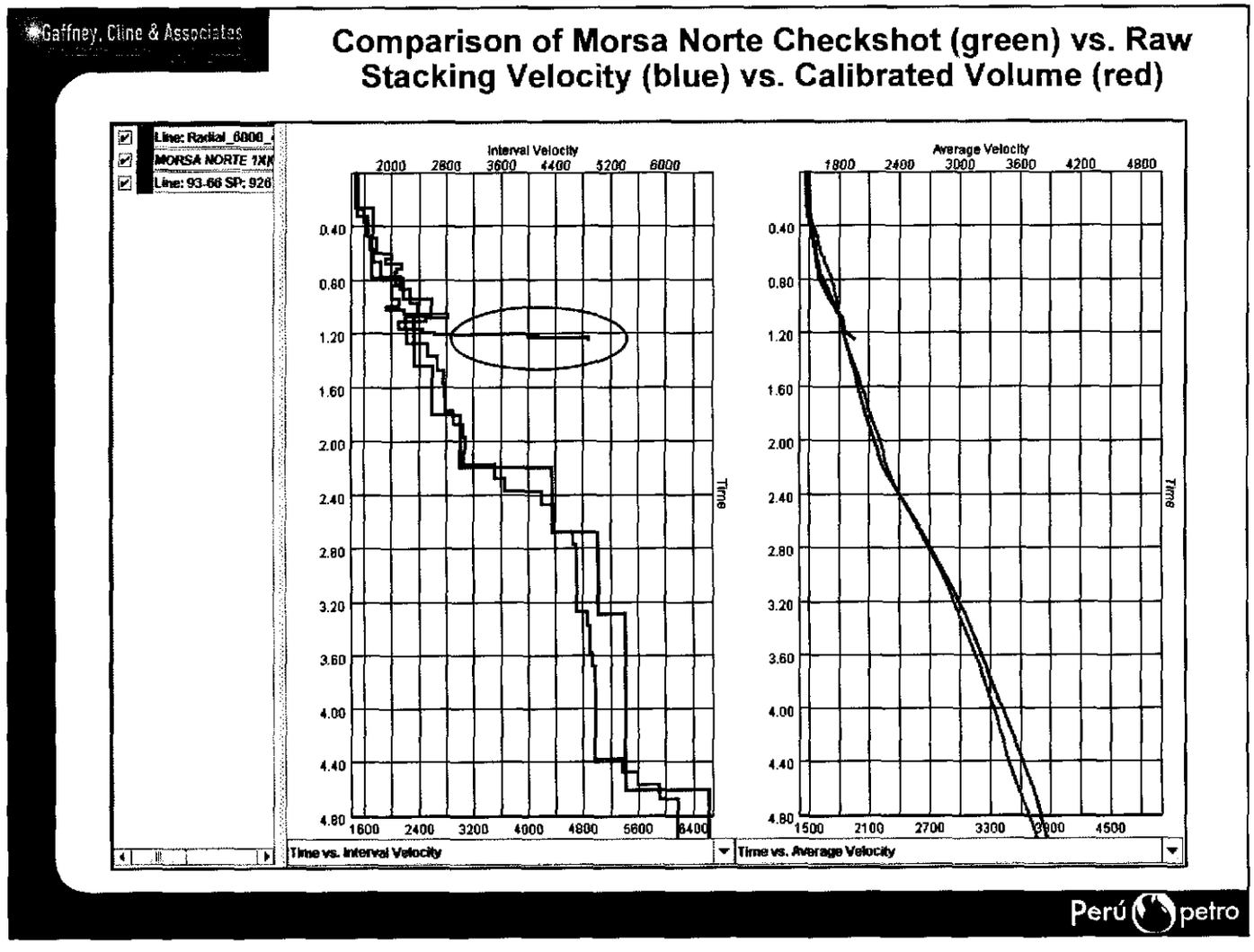
This is the location map for the seismic line and well checkshots that are presented in the next slide.



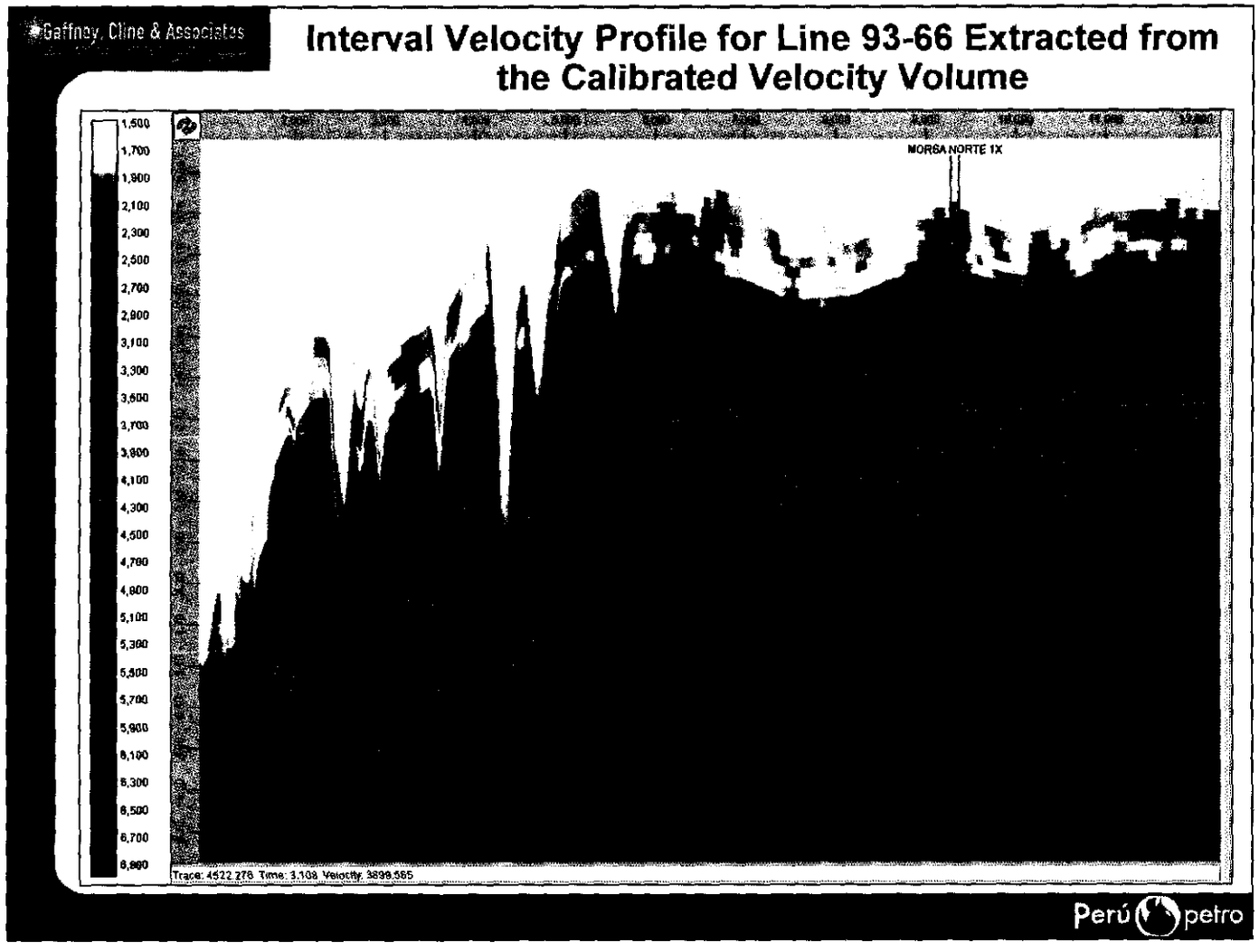
This velocity profile shows the raw stacking velocities for Line 93-66, with the checkshot function for the Morsa Norte and Delfin wells superimposed. Note that the well velocity is slightly slower. The rapidly changing seafloor elevation necessitates the use of water-stripping in building the velocity model to prevent the smearing of water and sediment velocities in the volume gridding process.



Slide showing stacking velocities with the water layer removed. Note that interval velocities have "flattened" and can be more effectively gridded at constant time slices.



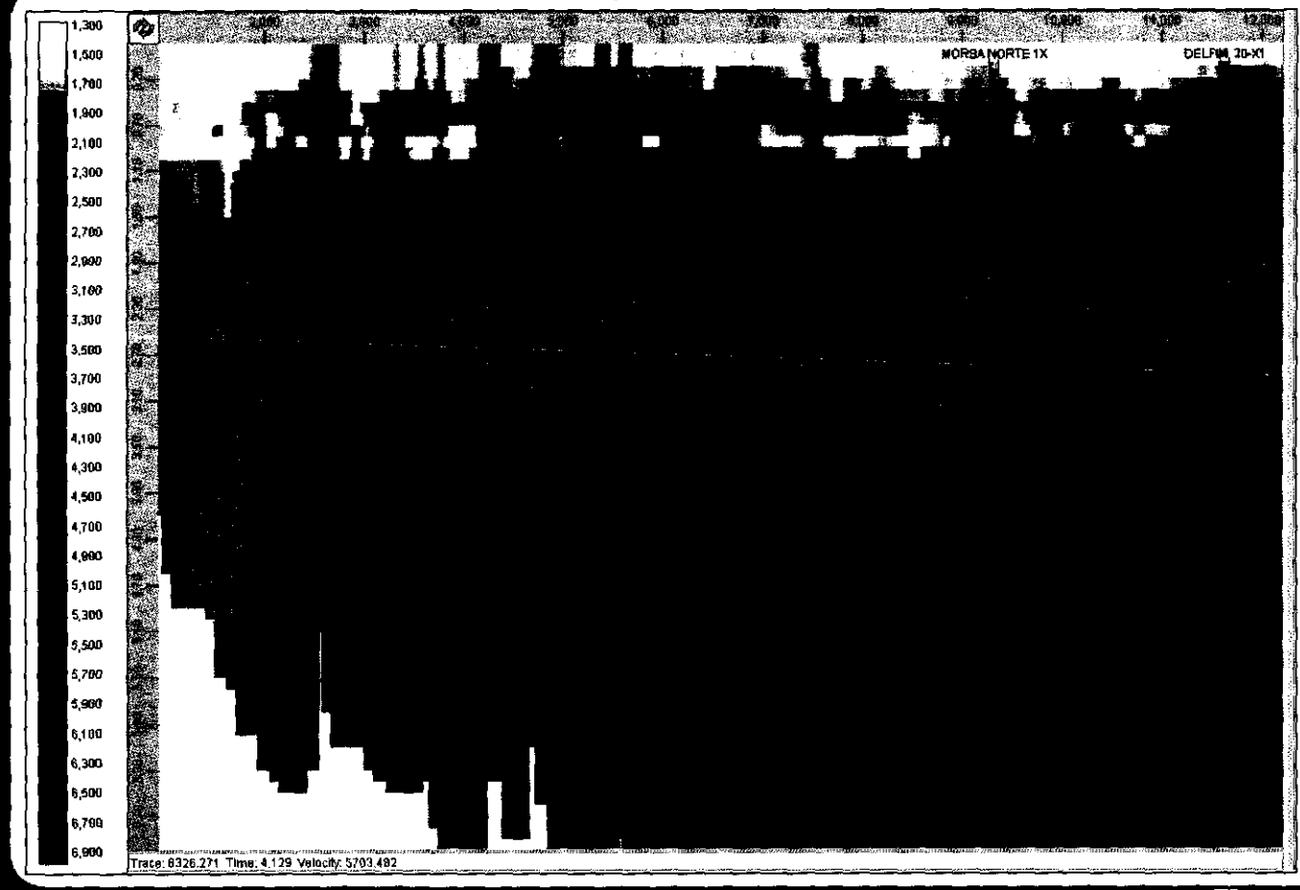
Comparison of the checkshot velocity at the Morsa Norte well (green) vs. the nearest stacking velocity function (blue). The red function represents the final velocity in the calibrated velocity volume. A calibration function starting with 0% correction at sea floor and gradually increasing to a 3% slowdown of the stacking velocity was used, based on a comparison of the available well data with the stacking velocity data. Spikes in the well data (circled in blue) are ignored to prevent contaminating large portions of the velocity volume with local velocity anomalies.



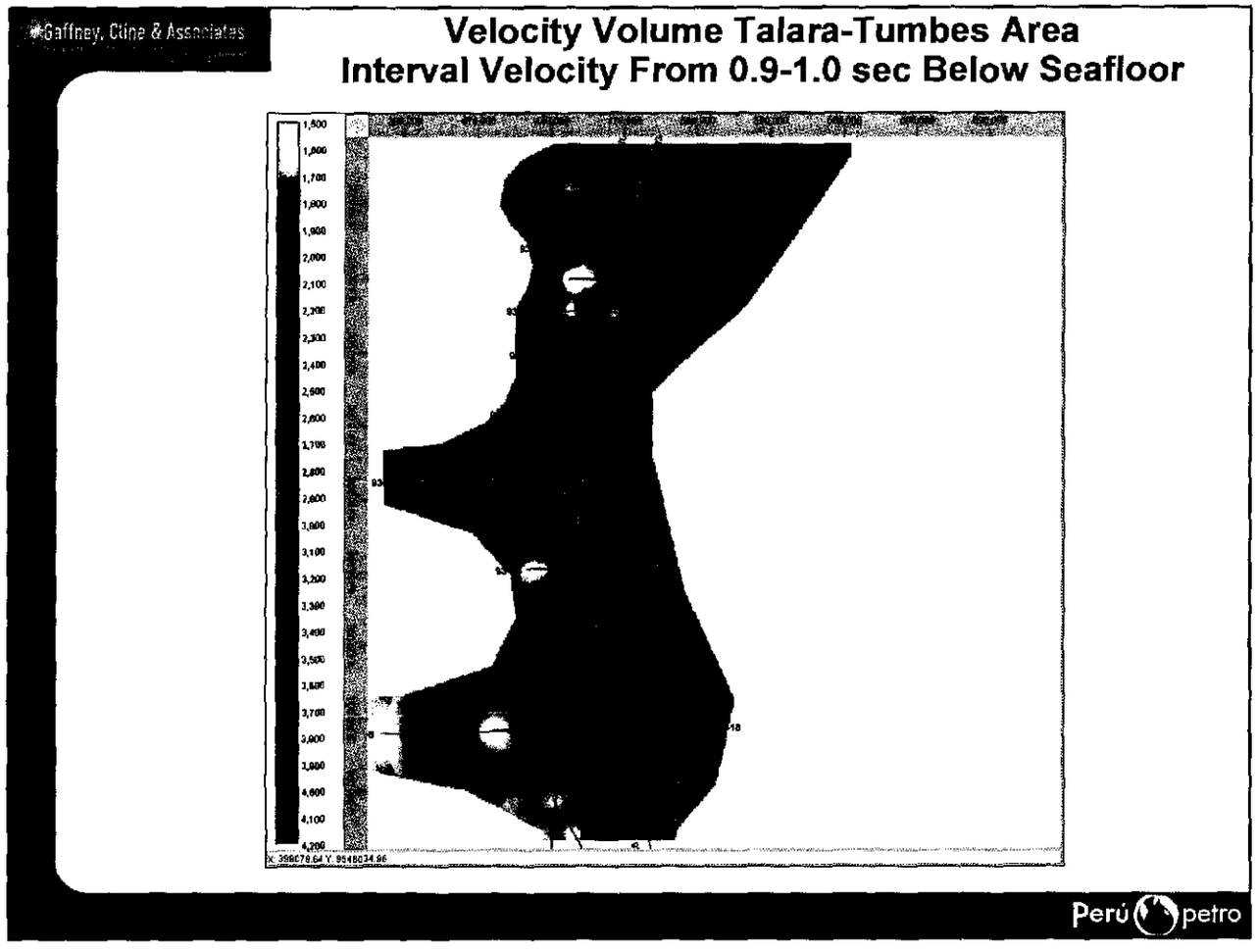
Compare this slide and the following slide with slides 4 and 5 to validate that the stacking velocities for Line 93-66 have been honored in the final model for the Talara-Salaverry-Pisco area.

Gaffney, Cline & Associates

Interval Velocity for Line 93-66 from the Calibrated Velocity Volume, Water-Stripped



Perú petro



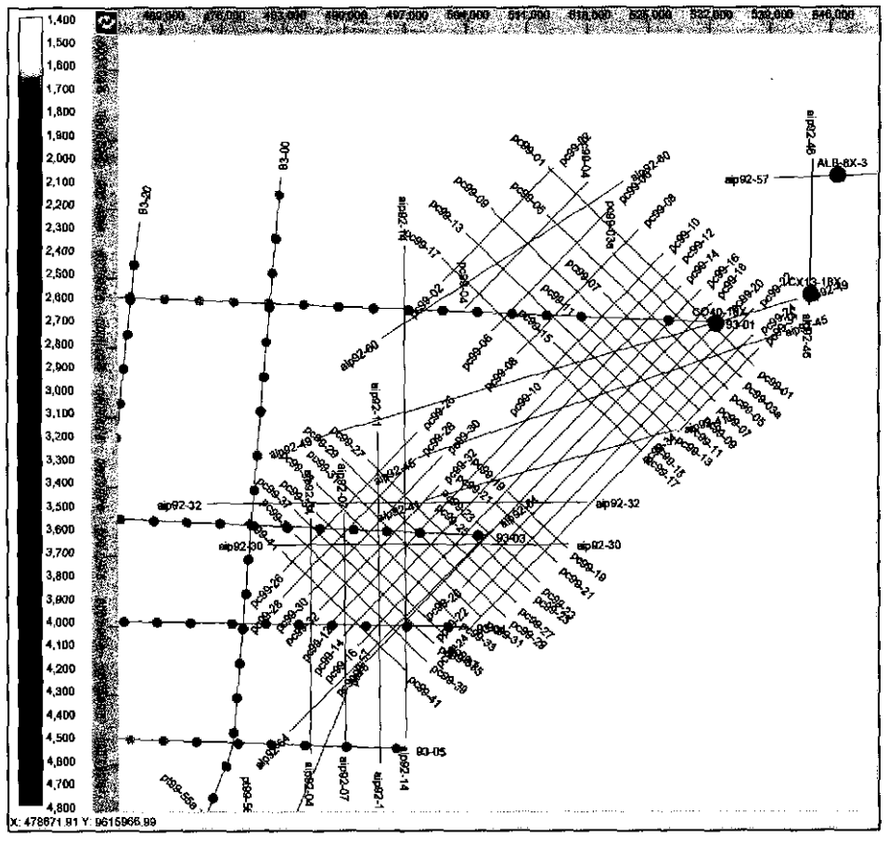
The Talara-Tumbes area presented a different challenge, which was extrapolating the sparse velocity control enough to allow depth conversion of data with no velocity control, while incorporating checkshots from wells. Additionally, the rapidly changing water bottom needed to be properly modeled using data from some seismic lines with no accompanying velocity information. The volume was built by:

1) Creating an average calibration function by comparing the checkshots with the stacking velocities; 2) Calibrating the stacking velocity functions directly with this average function; and 3) Gridding the now calibrated stacking velocity functions *and* checkshots together using kriging to both honor the datapoints and obtain a reasonable extrapolation away from control.

Volume details: Velocity grid cell size: 400m; Water bottom grid cell size: 200m; Slices of interval velocity at constant time slices 100ms apart

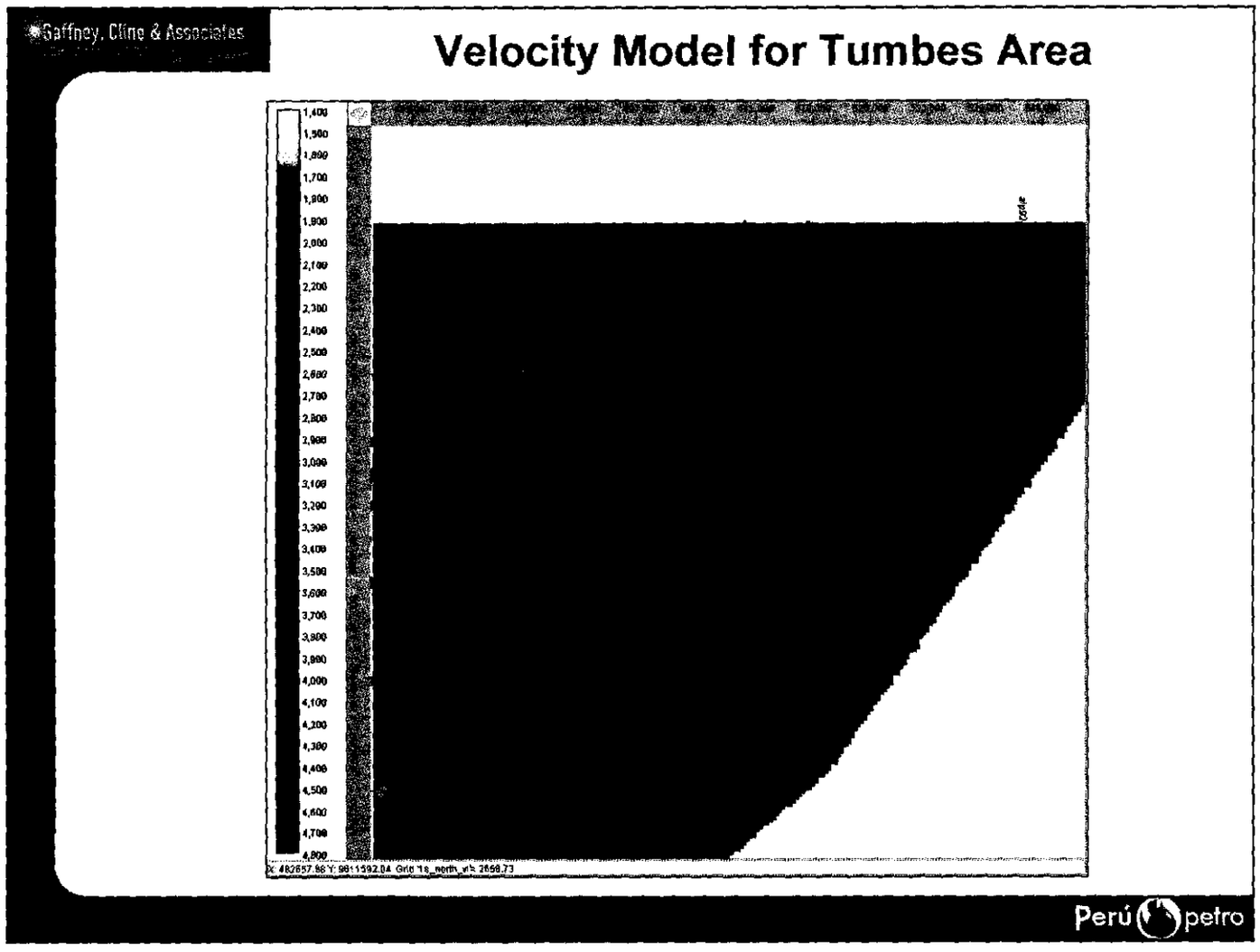
Gaffney, Cline & Associates

Velocity Control Points – Tumbes Basin Stacking Velocities and Checkshots

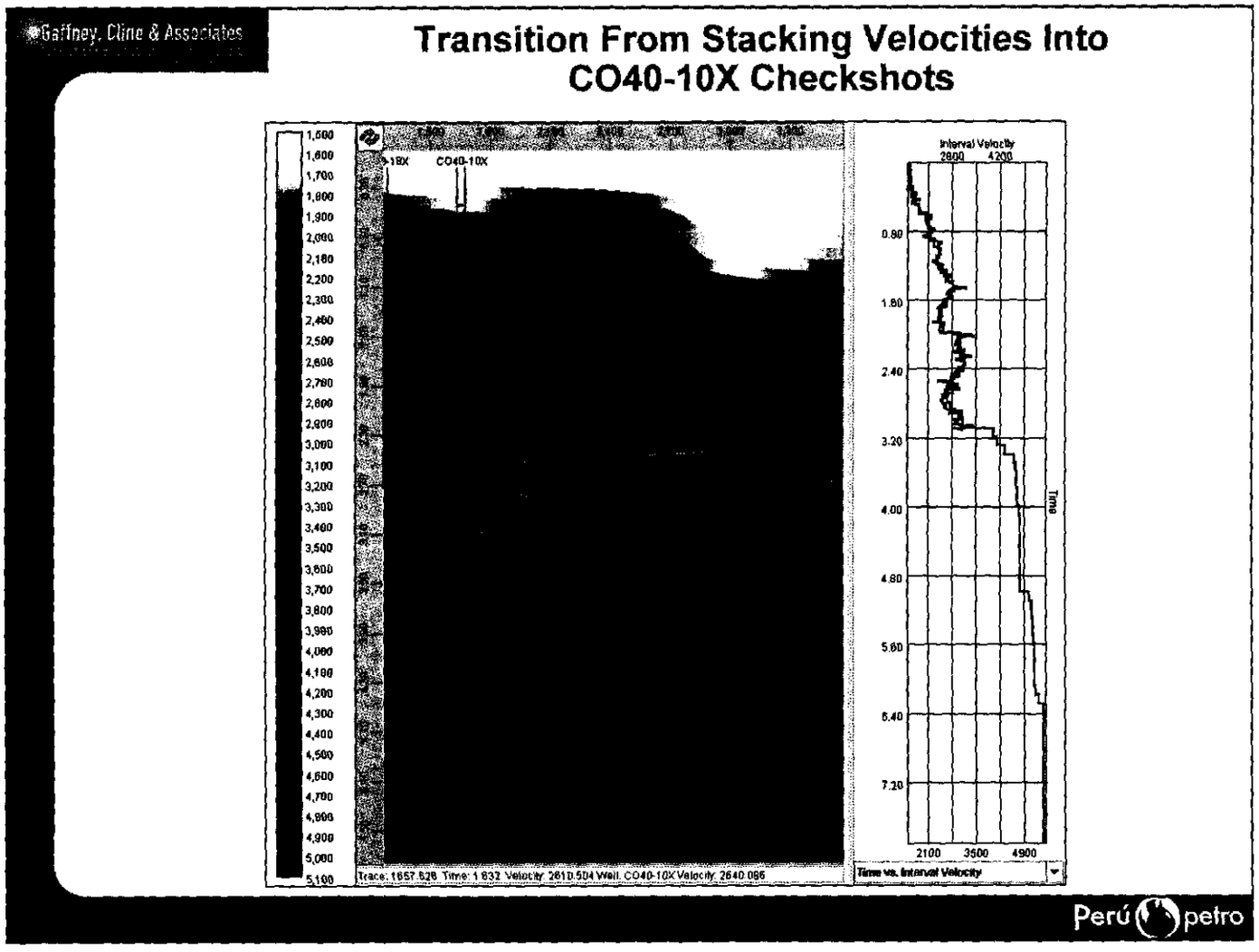


Perú petro

Though velocity control was sparse, water bottom information was available for most lines, allowing acceptable modeling of the water layer.



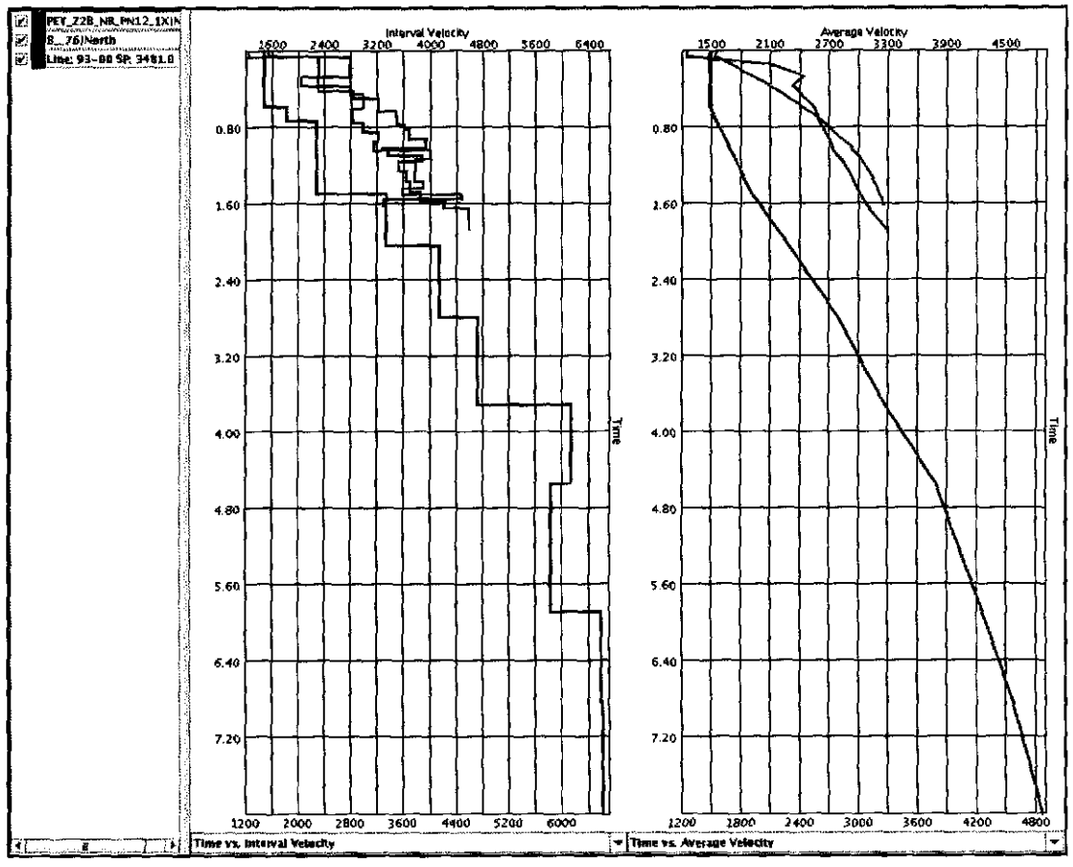
This is a sample interval velocity slice from the completed volume (0.9-1.0 seconds). Extrapolation of the stacking velocities and checkshots, combined with the actual water-bottom interpretation from all surveys provides for a reasonable velocity volume for depth conversion of all lines.



Profile showing the transition from stacking velocity data into checkshot data. Note the additional detail near the checkshot location and the infill of the deeper velocity control from the stacking velocities. The graph shows the checkshot function (green) superimposed on the velocity function at the checkshot location extracted from the final volume.

Gaffney, Cline & Associates

Exclusion of Some Well Data



Perú petro

Several checkshots were difficult to reconcile with the stacking velocity data, and were ignored. In this example, the average velocity in the checkshots is nearly twice that of the nearest stacking velocity function. Possible sources of error include water bottom discrepancies (water depth at the well location does not match seismic time for some reason), wrong well location, one-way vs. two-way time loading issues, or a combination.

The stacking velocities were consistent as a set, and their interval velocities seem geologically reasonable (as opposed to the checkshots shown, which exhibit a velocity of 2,300-2,800 m/s at the seafloor). This indicates that the problem lies with the well data.

APPENDIX H

DEPTH SECTION DESCRIPTIONS

Gaffney, Cline & Associates

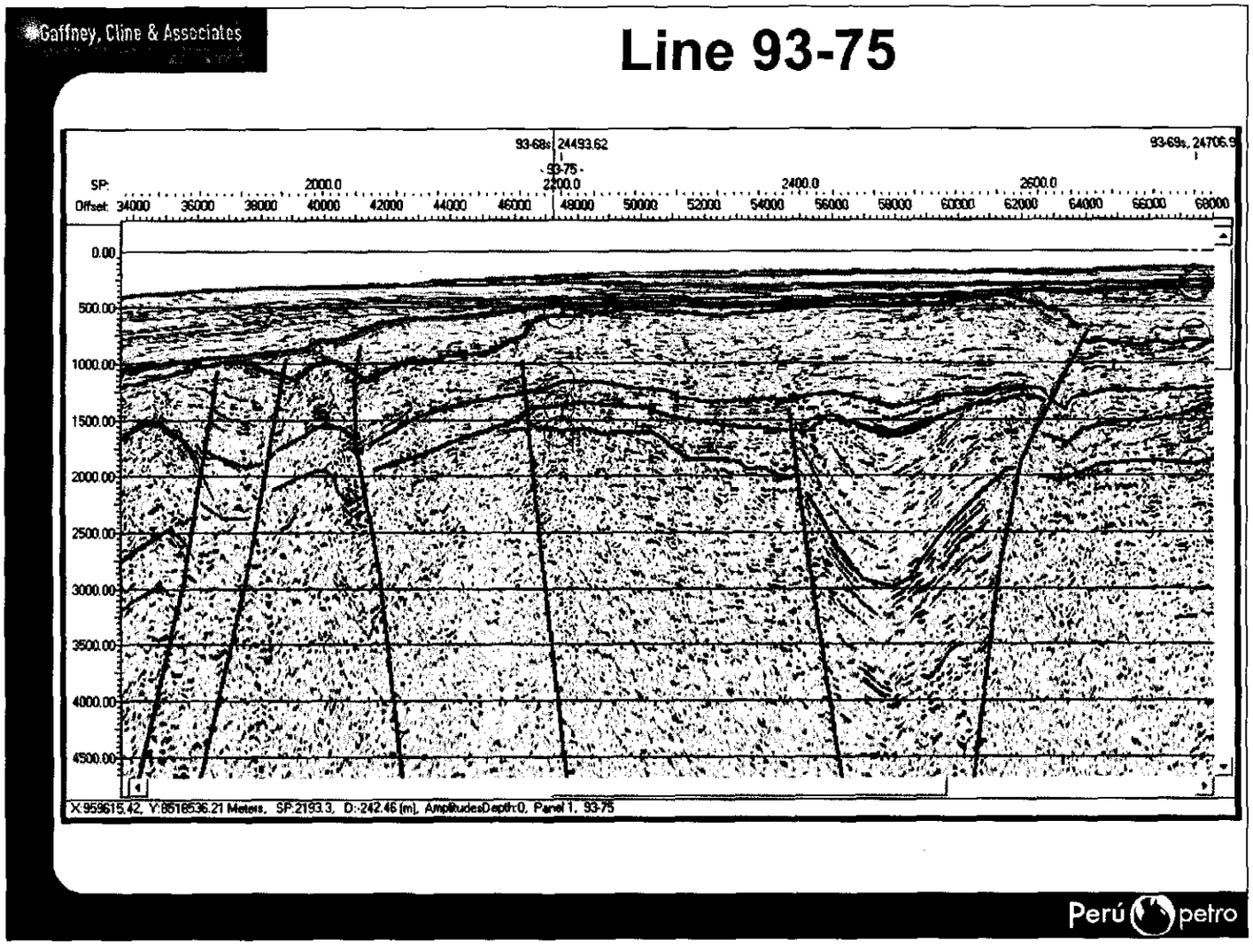
April 2005

Depth Section Descriptions

GCA Gaffney, Cline & Associates Energy Advisors

Perú petro

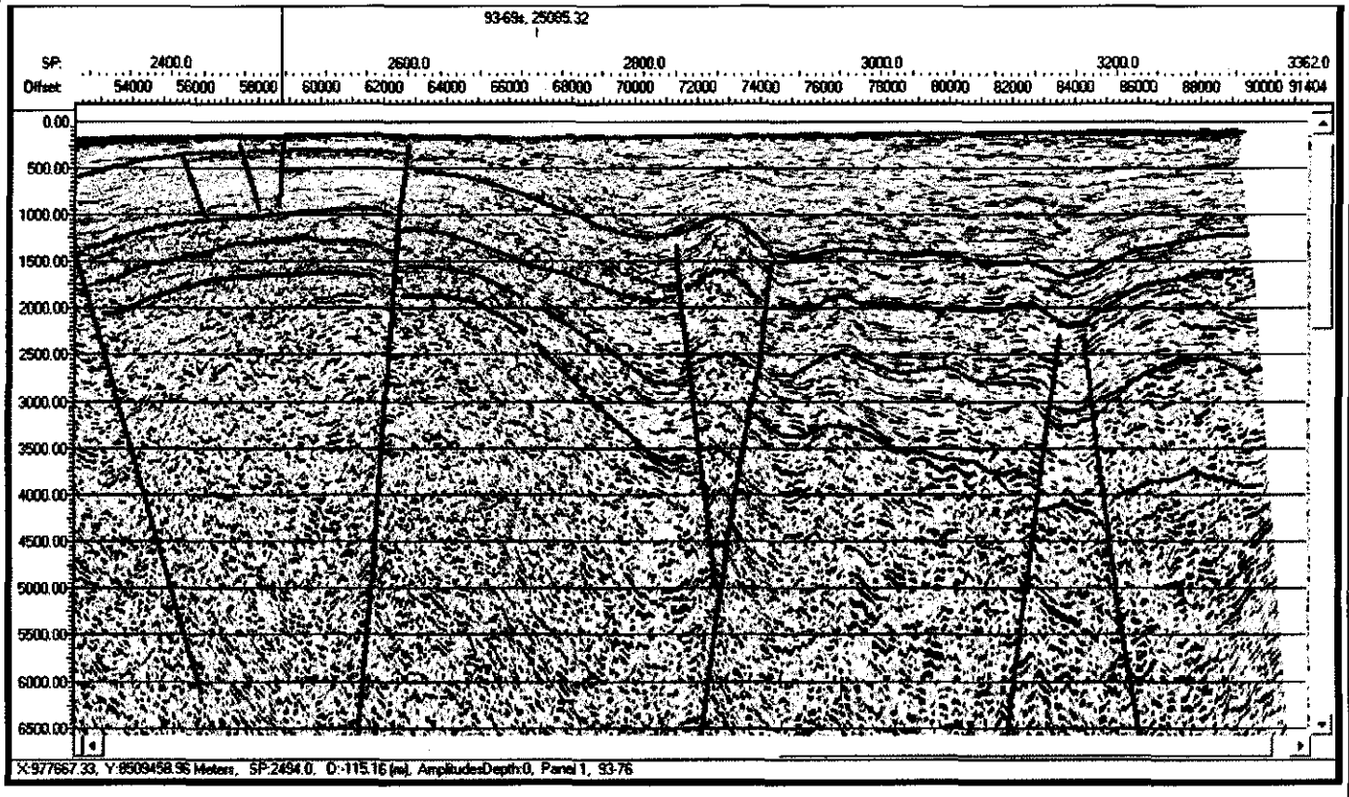
The following slides describe the key structural and stratigraphic features of a selection of depth-converted seismic lines that covers the entire study area. The slides progress roughly from south to north, beginning in the Pisco basin and finishing in the Talara basin.



Key line to illustrate the petroleum system in Pisco Basin. Thick Cretaceous kitchen below Eocene thick (carbonate bank?). Both Cretaceous source potential and Paleocene. The lower part of the Eocene package here is carbonate-prone. The upper part is probably sand-prone (deltaic?). Down-dip there are the transgressive sequences in the Lower Miocene. Likely biosilicious sediments. Similar sediments present onshore. Modeled the thermal maturity of the Cretaceous syncline. Concluded that it is likely mature.

Gaffney, Cline & Associates

Line 93-76 – Eastern End

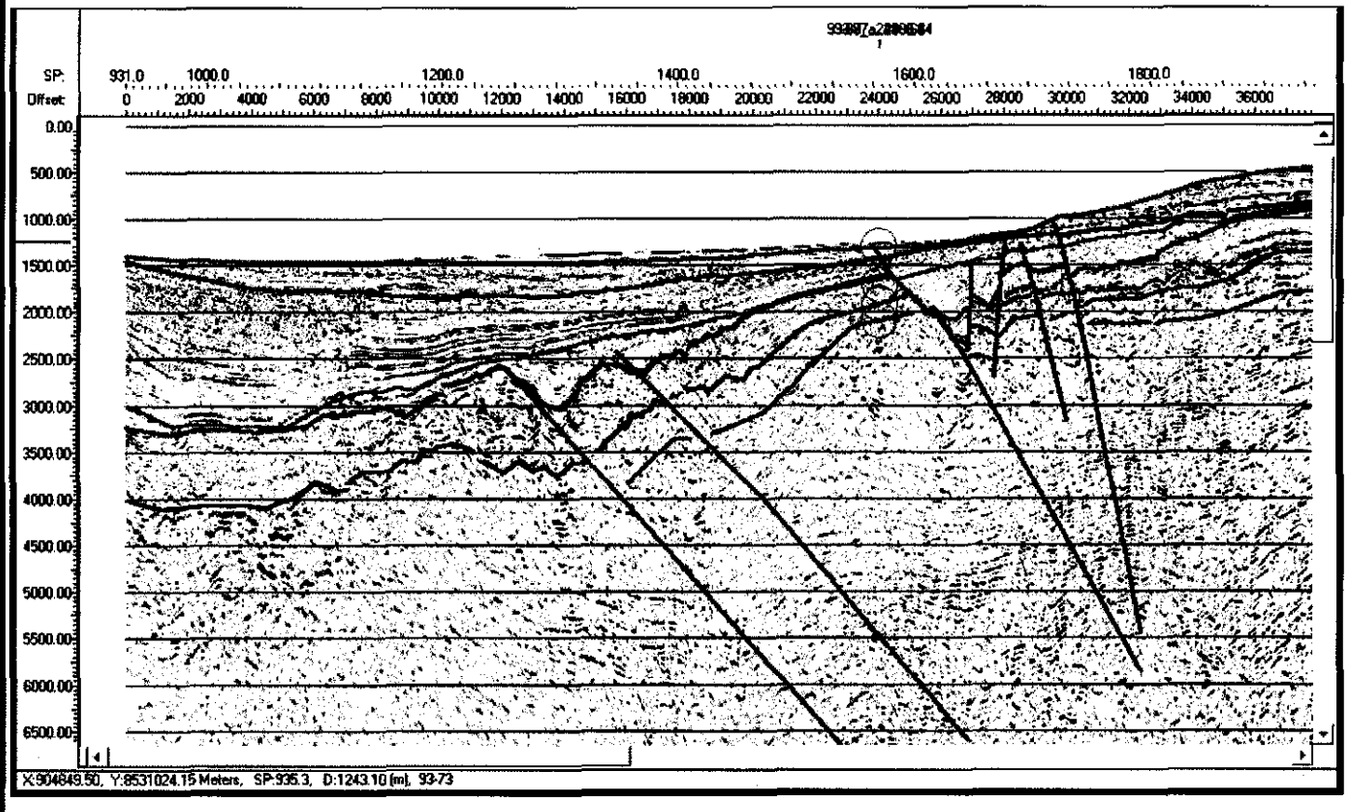


Perú petro

Shows Cretaceous thinning basinward, interpreted as shoreline-fringing carbonate shelf-edge.

Gaffney, Cline & Associates

Line 93-73 – Western End

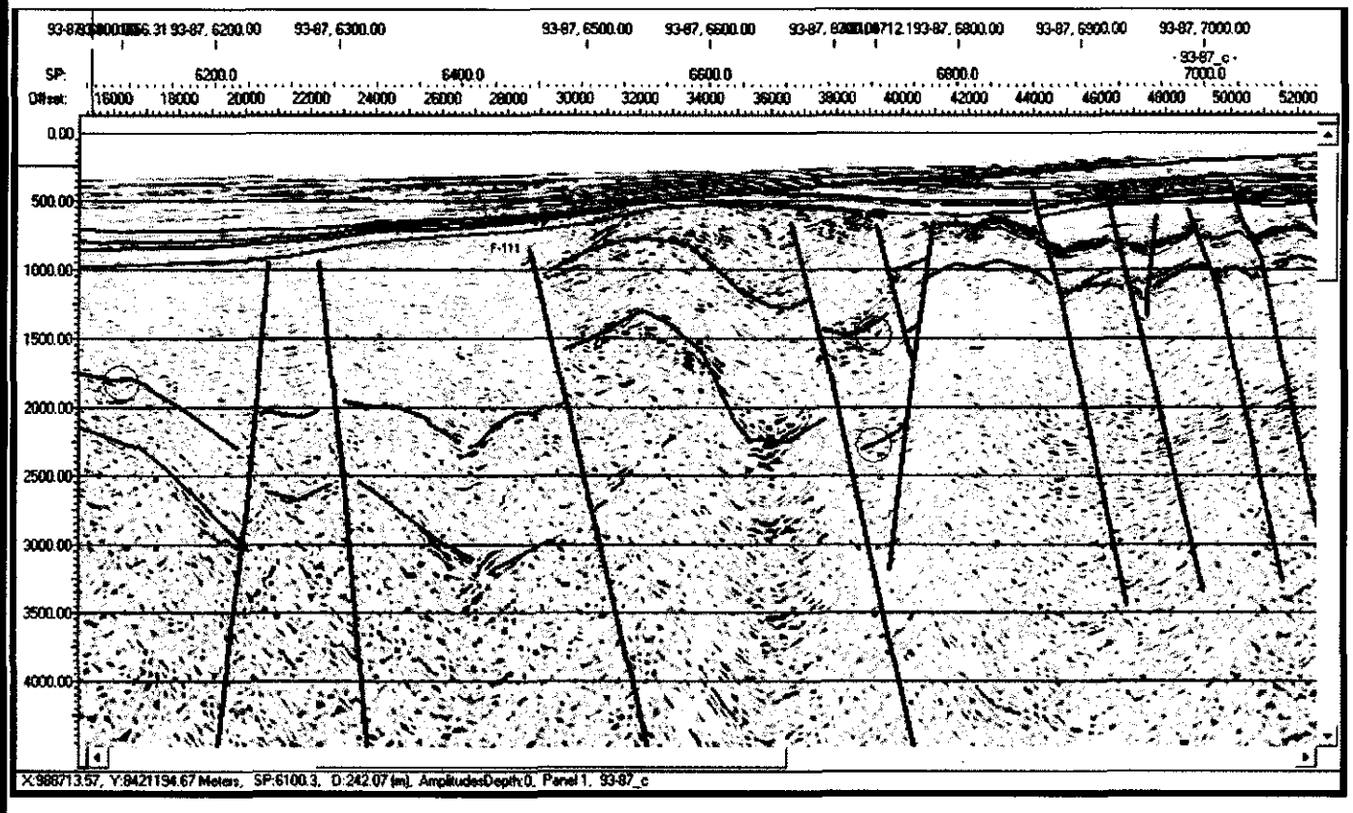


Perú petro

Shows mounded onlapping basin floor fans at base of Miocene (just above the orange horizon -- the laterally continuous reflectors). See annotated time section in Digital Database for more detail.

Gaffney, Cline & Associates

Line 93-87c – Around SP 6500

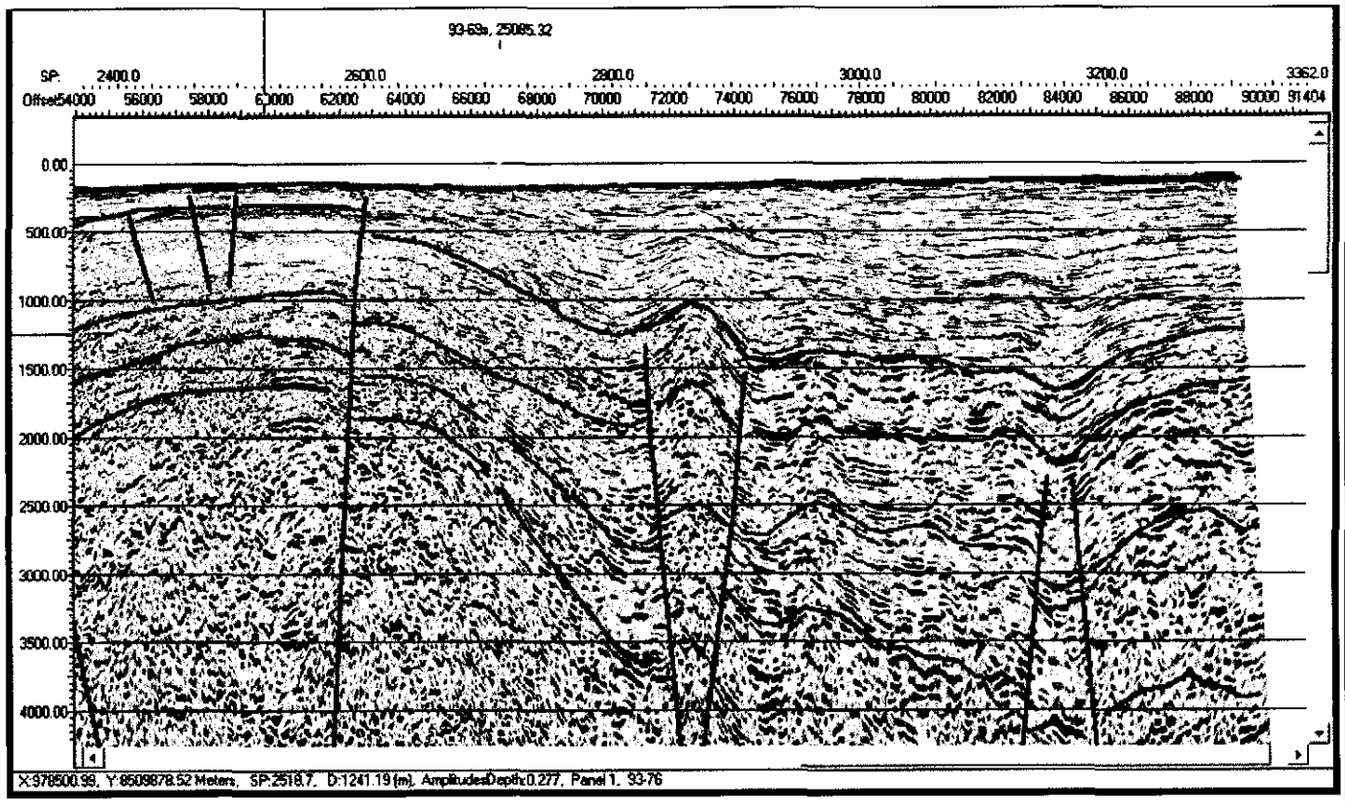


Perú petro

Shows large reactivated Paleocene thrust that created major unconformity in late Miocene.

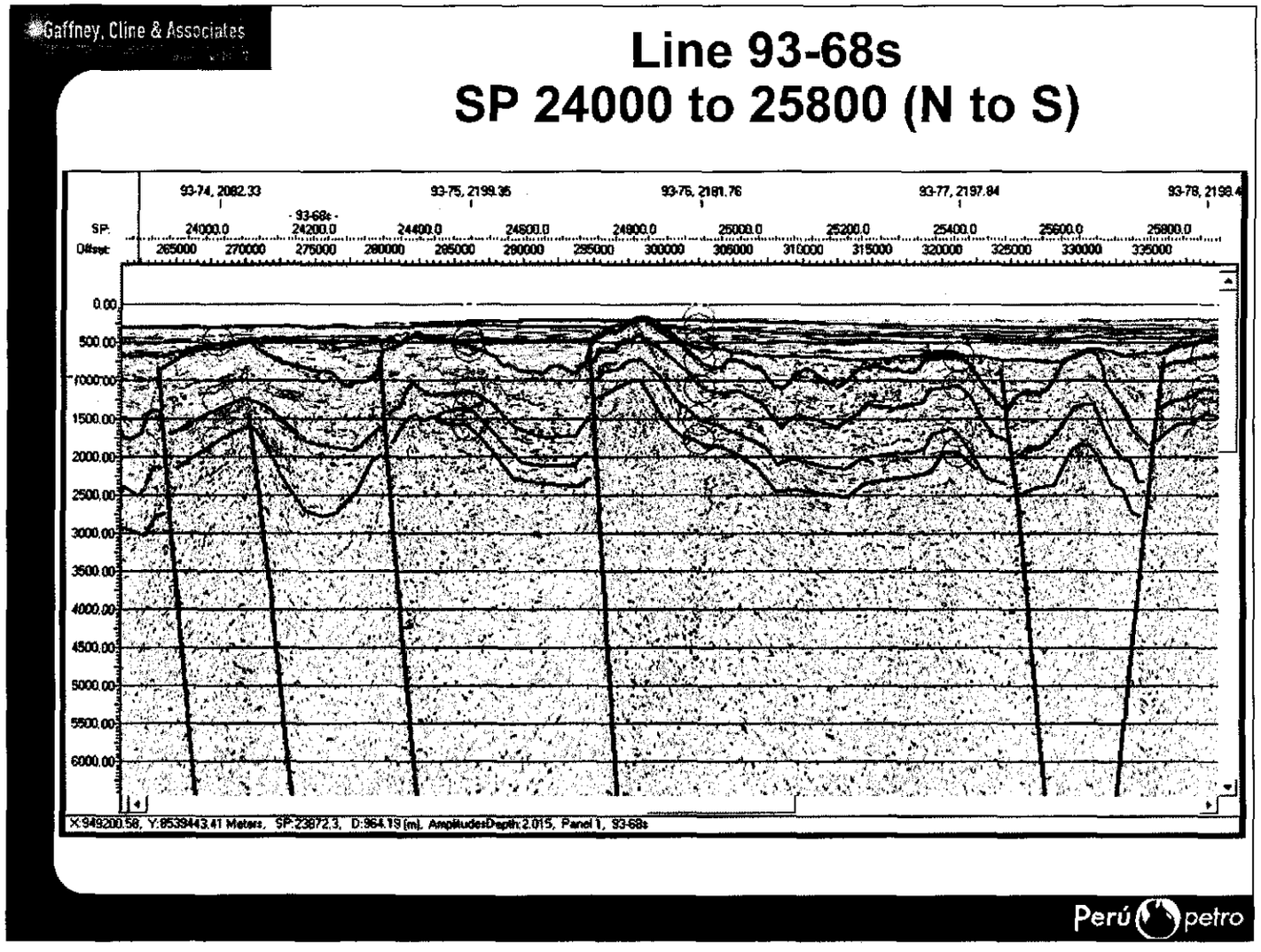
Gaffney, Cline & Associates

Line 93-76 – Eastern End (again)

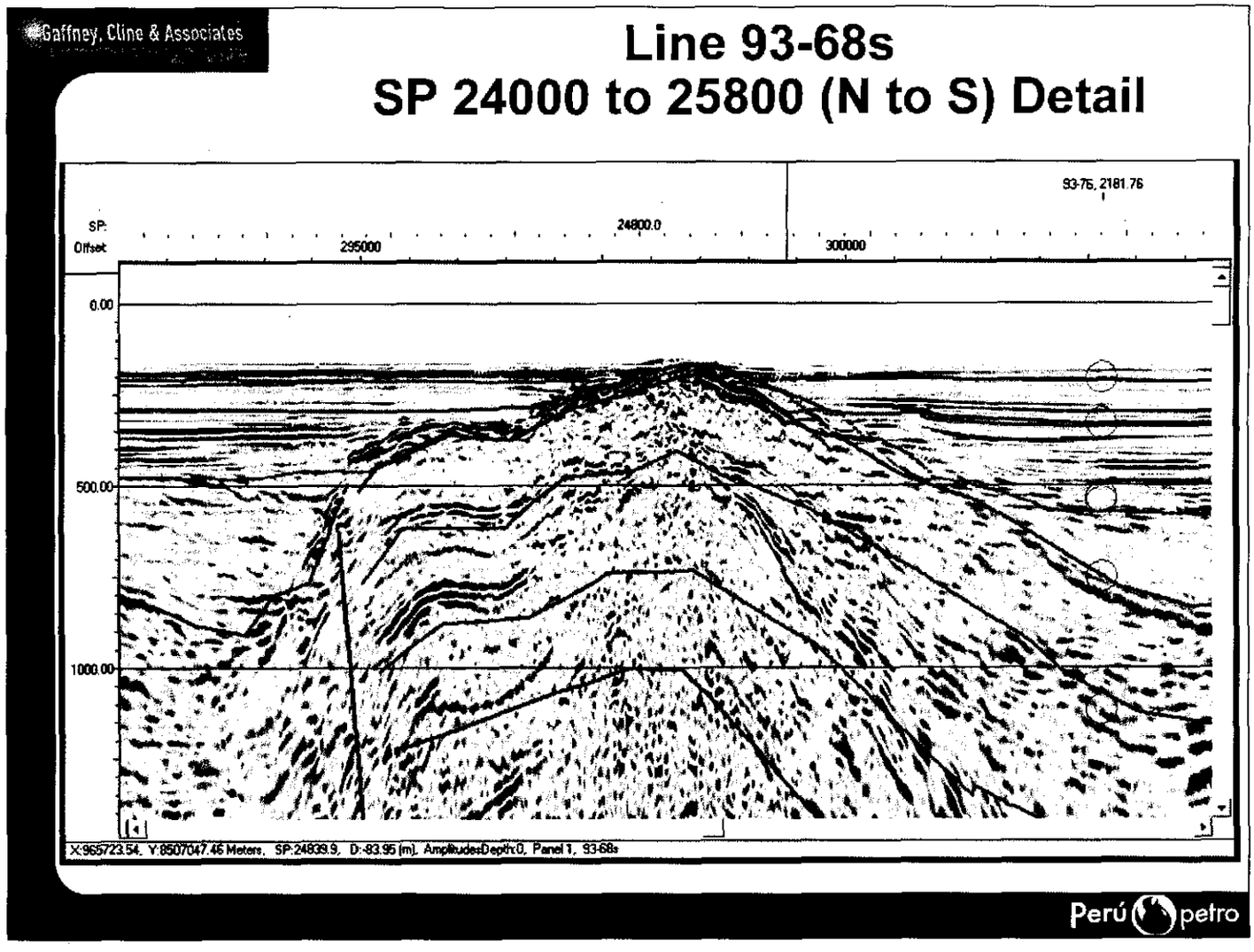


Perú petro

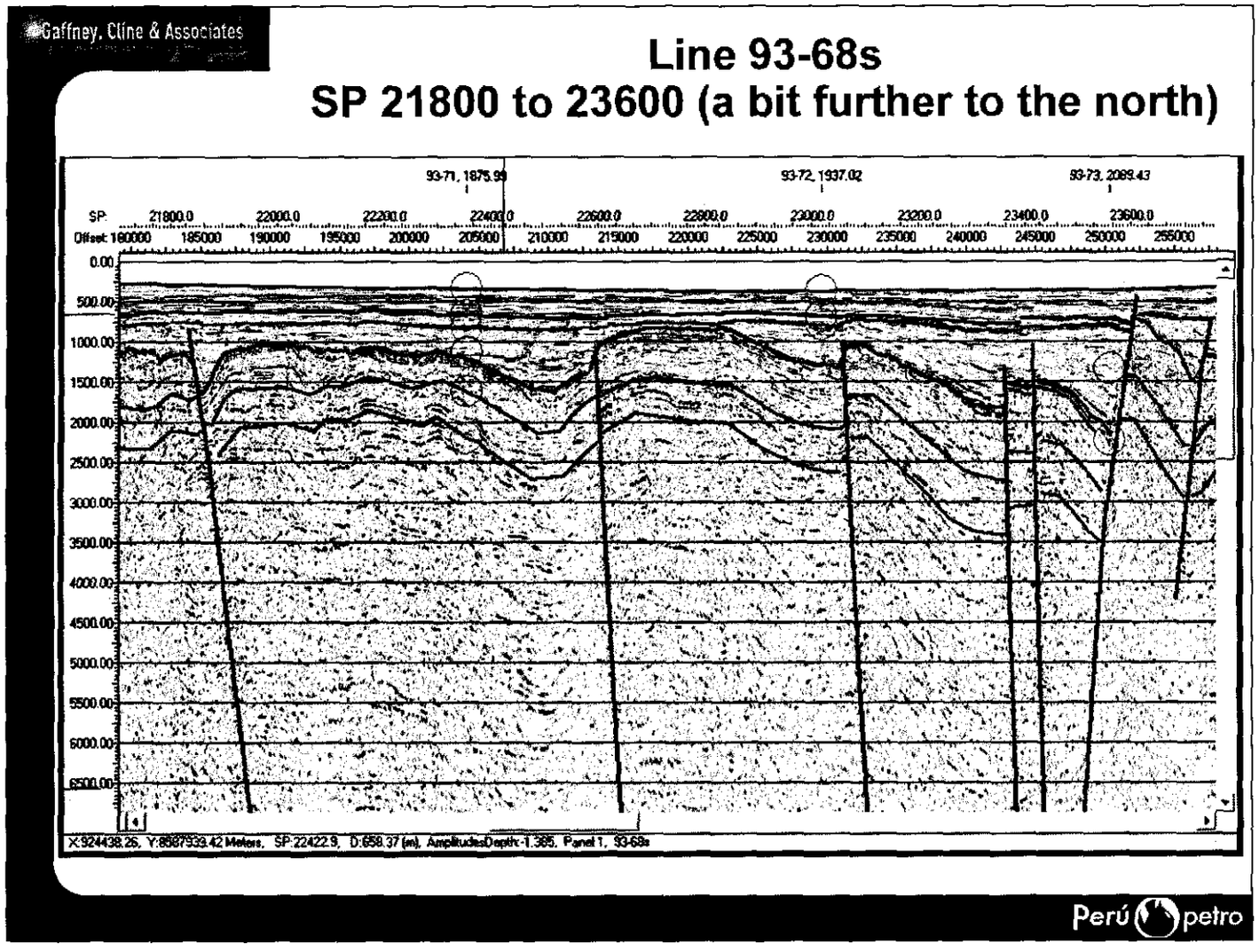
This time to show thick deltaic? Late Eocene sediments, with drape over popup structure.



Shows high-relief structures (folds and thrusts) that involve Cretaceous to Eocene section (carbonate prone) with infill of Eocene turbidites in faulted synclines. Note that one location at sp 24800 could be sampled at sea bottom to test carbonate stratigraphic interpretation (see detail in next slide).



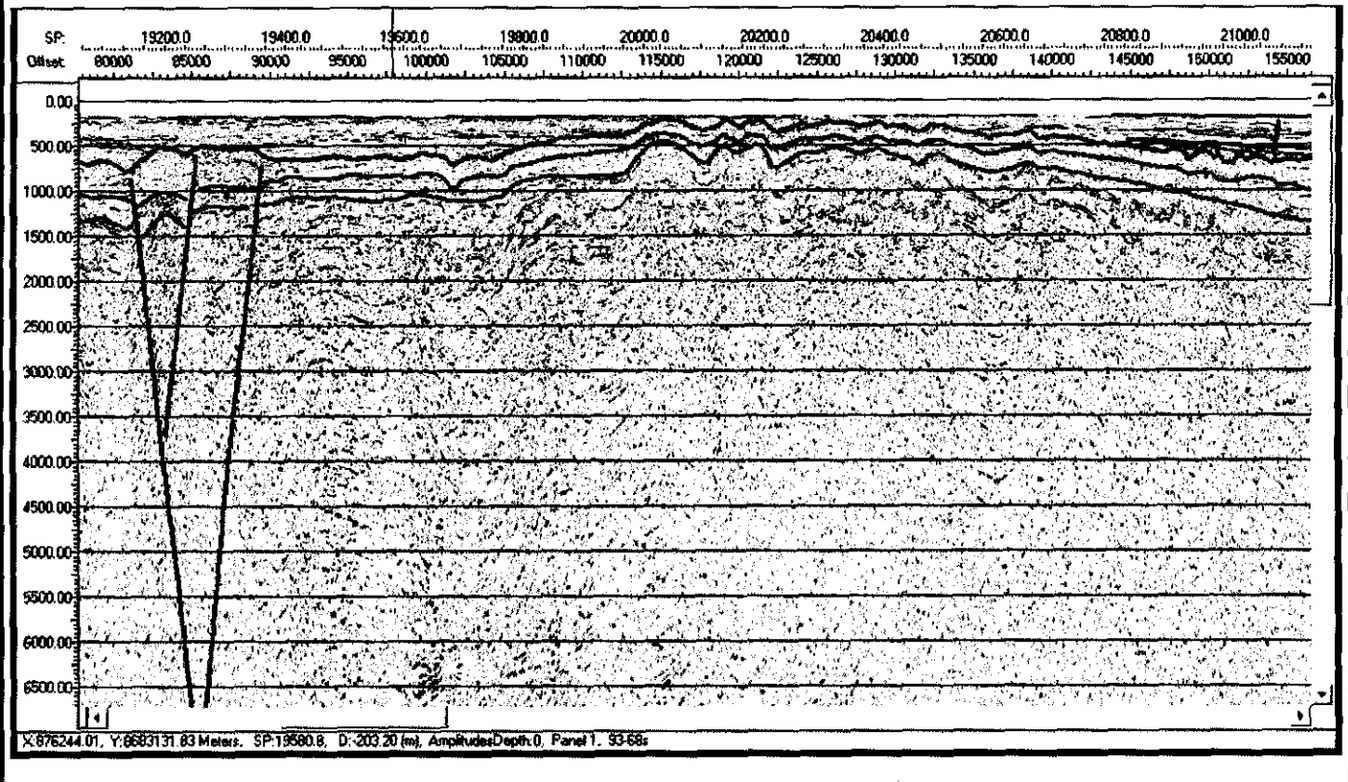
Location where interpretation suggests Eocene carbonates might be present. This could be confirmed with a very shallow hole here.



Large, broad faulted anticlines (there are many) involving Cretaceous-Paleocene-Eocene carbonates.

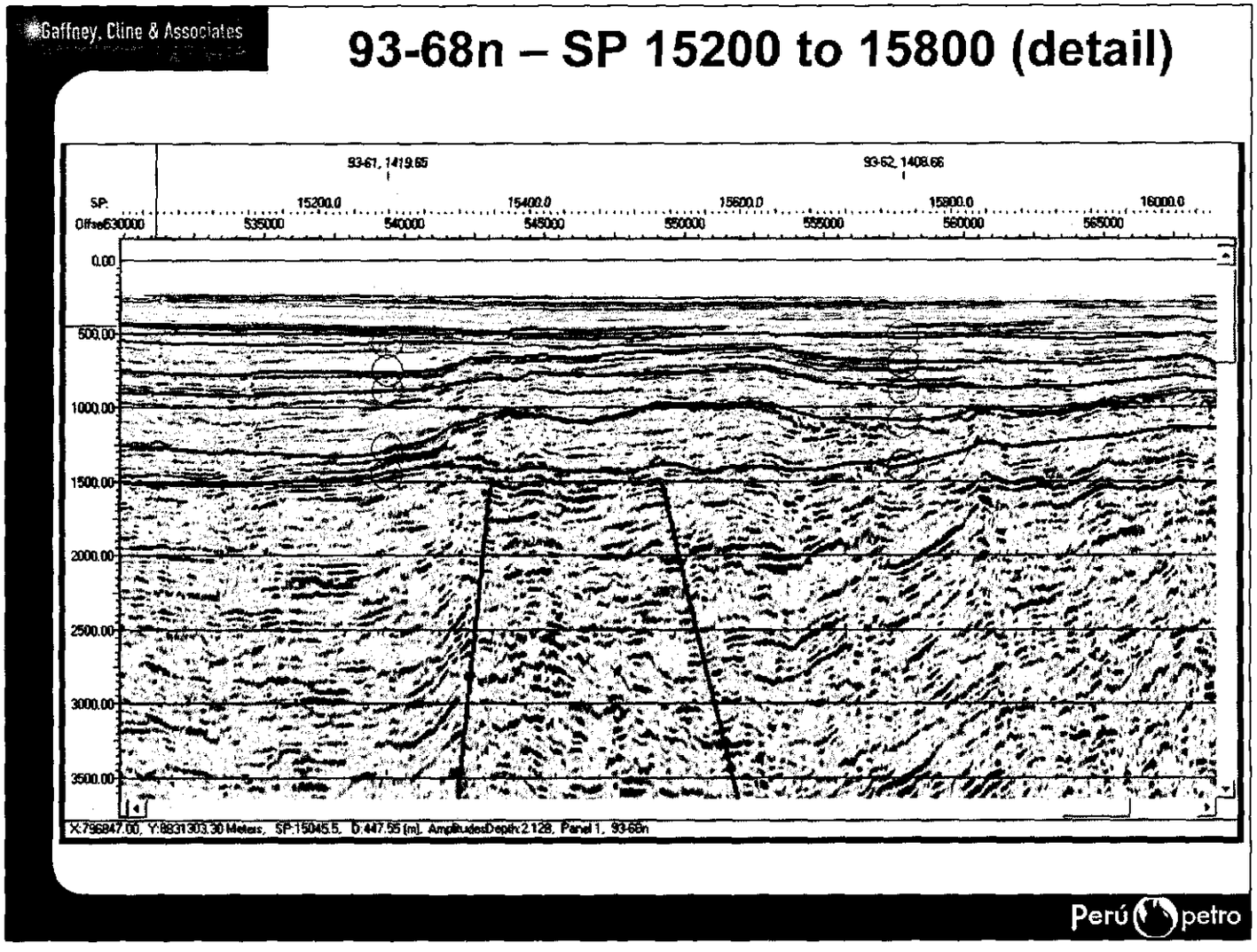
Gaffney, Cline & Associates

Line 93-68s – Still Farther North

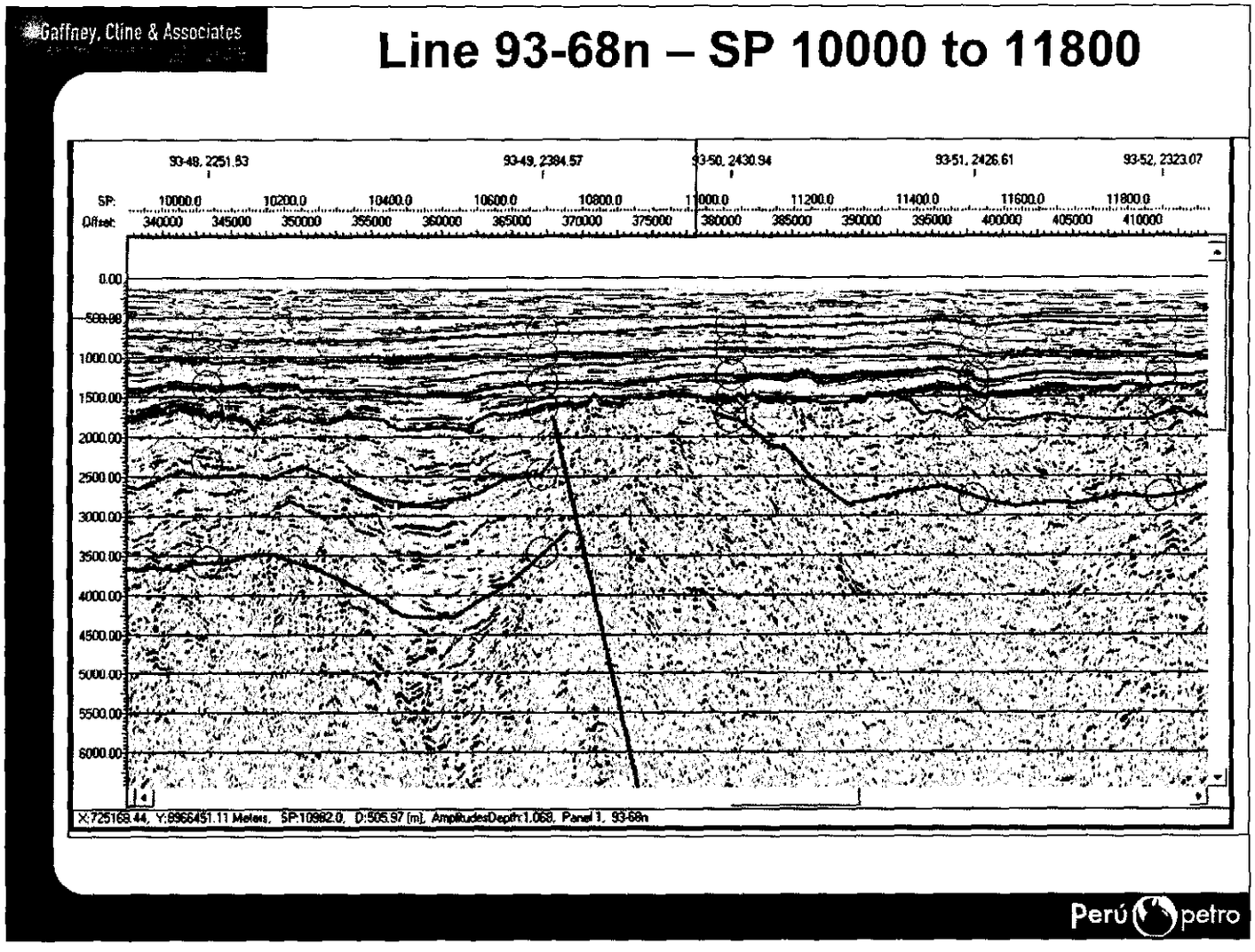


Perú petro

This area lacks dip lines. It is representative of several broad highs capped by Eocene carbonates, not just shallow basement. May be prospective. Should acquire dip lines to investigate.



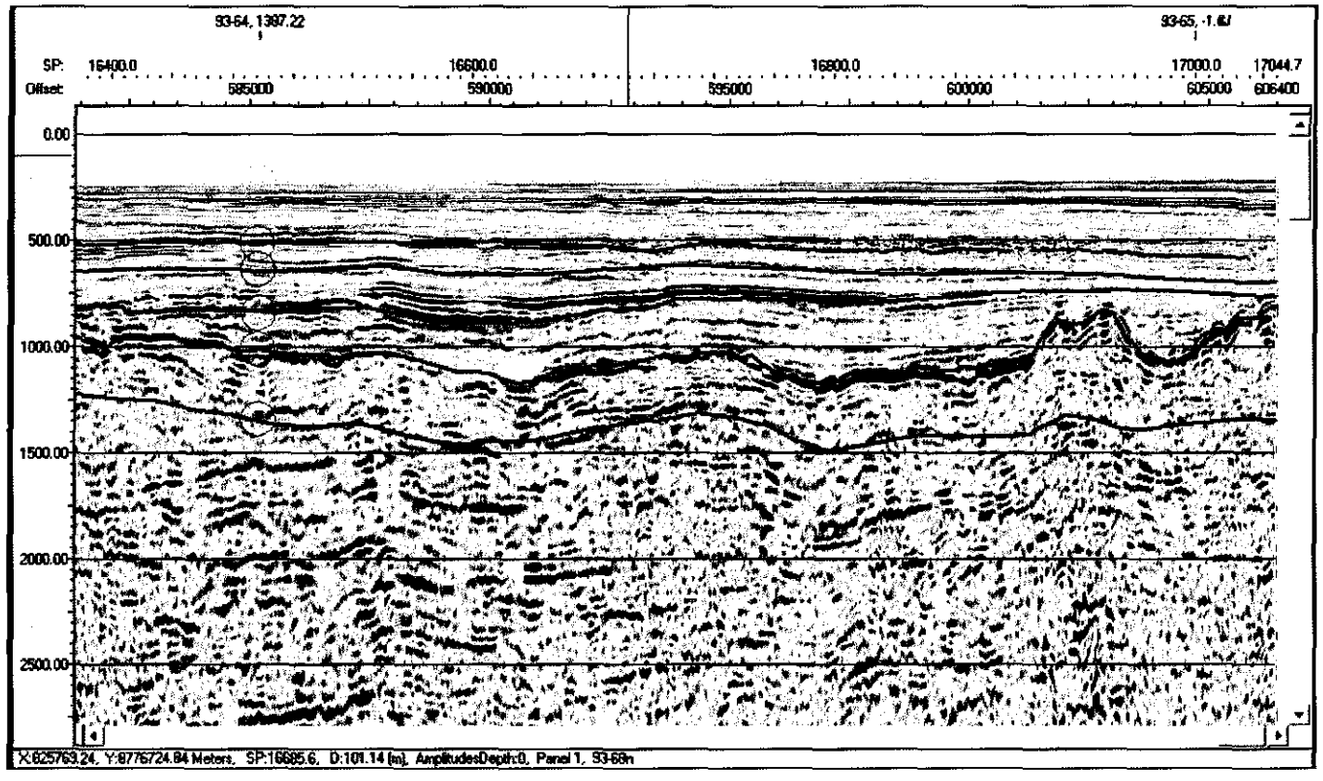
Now in southern Salaverry basin. Cretaceous margin-fringing reef. Left is north. Lagoon between reef and shoreline (see Cretaceous facies map – Enclosure 12).



Folding and thrusting within Cretaceous-Paleocene section (compare to slide 5 in Pisco basin for younger analog). Cretaceous basin at sp 10500 was site of maturation model by Angel Callejon.

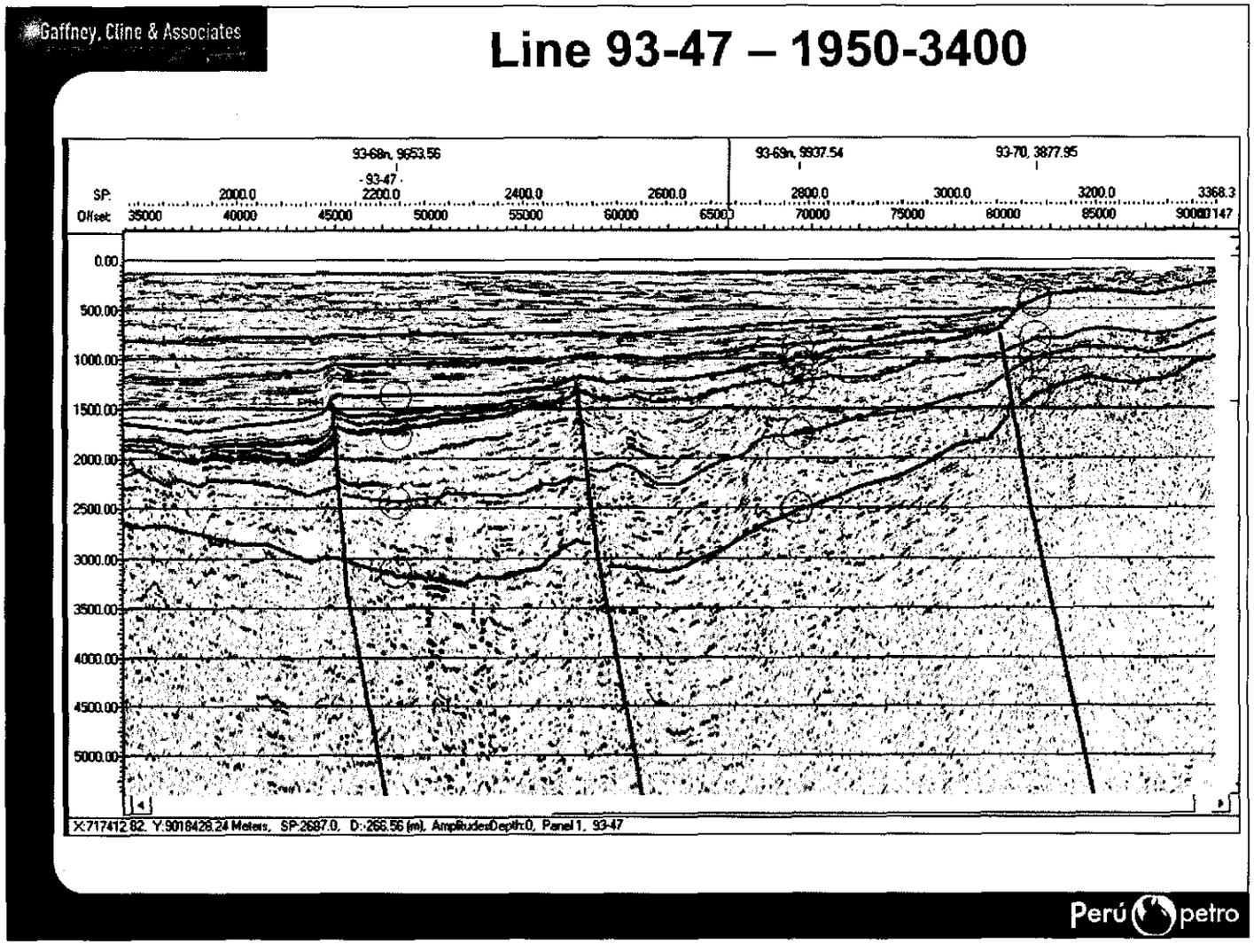
Gaffney, Cline & Associates

Line 93-68n – SP 16400 to 17000

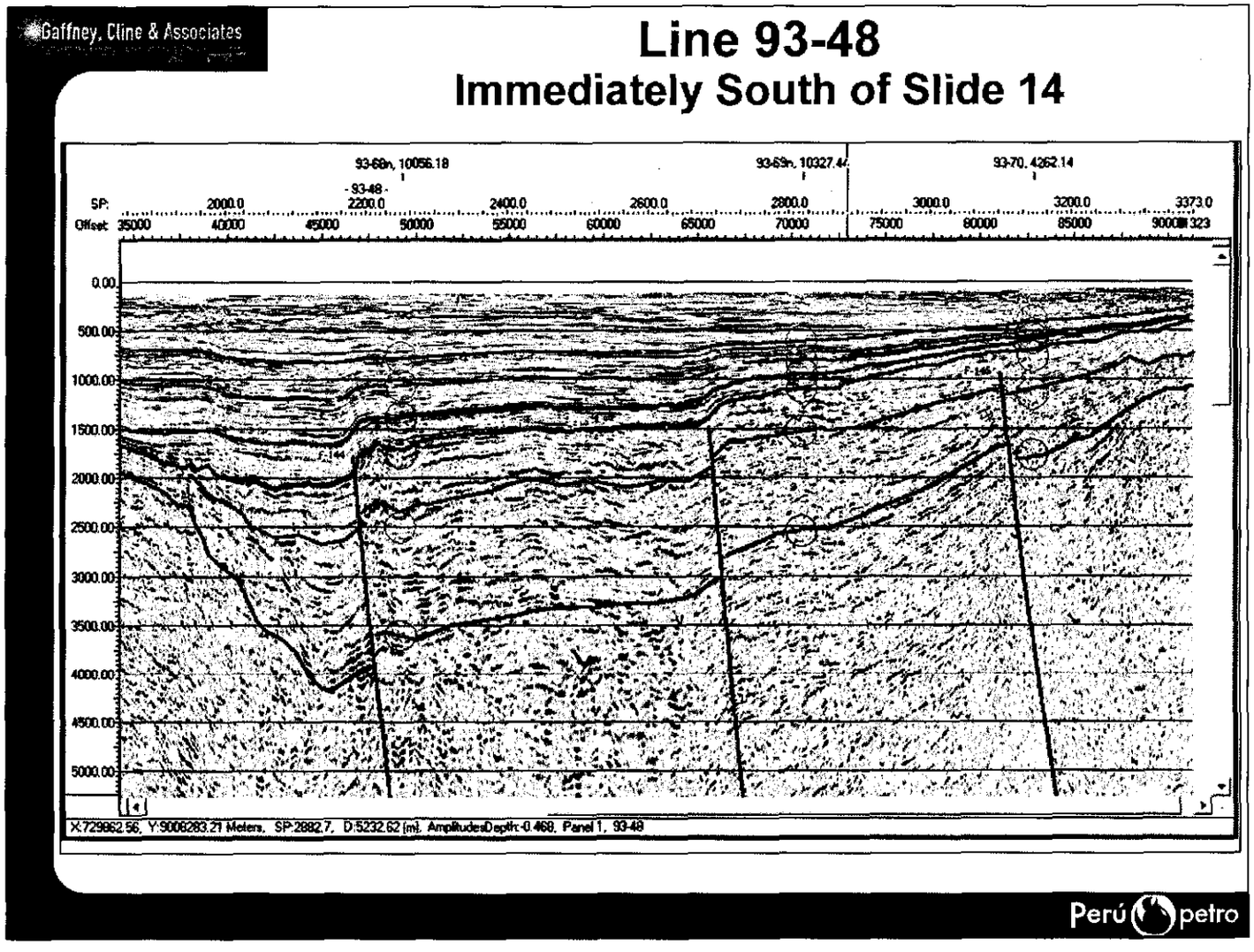


Perú petro

Basal Early Eocene channel at sp 16,600. Sand-prone? Cretaceous pinnacle also at sp 16,950 (compare to slide 11, which shows broader buildup).



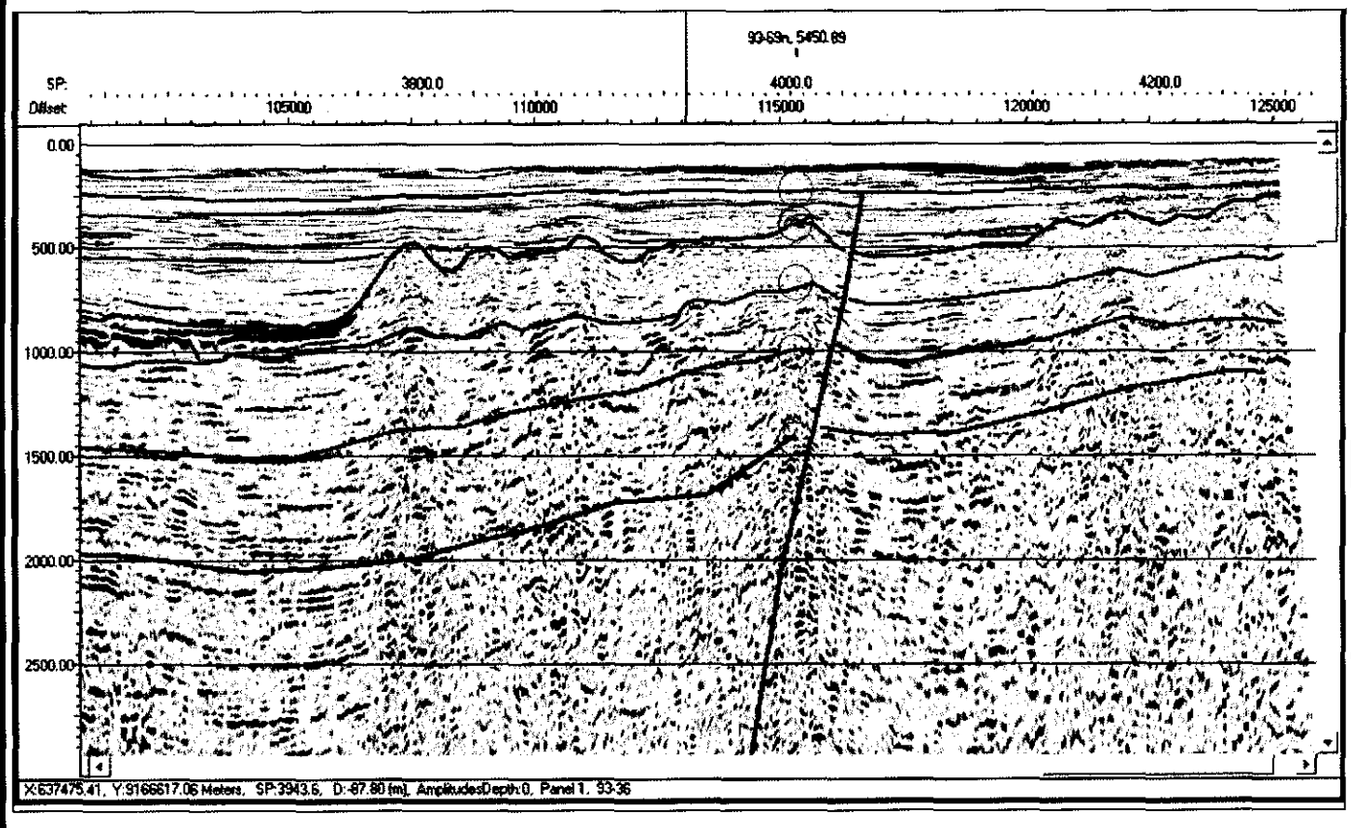
At sp 3200 an uplifted fault structure. Note also fault control of other mini-margins at sp 2100 and sp 2500, and the Paleocene sag basin (refer to facies map in Enclosure 11 for area view of Paleocene sag).



Cretaceous faulted basin (source-prone?). See facies map in Enclosure 11 for details.

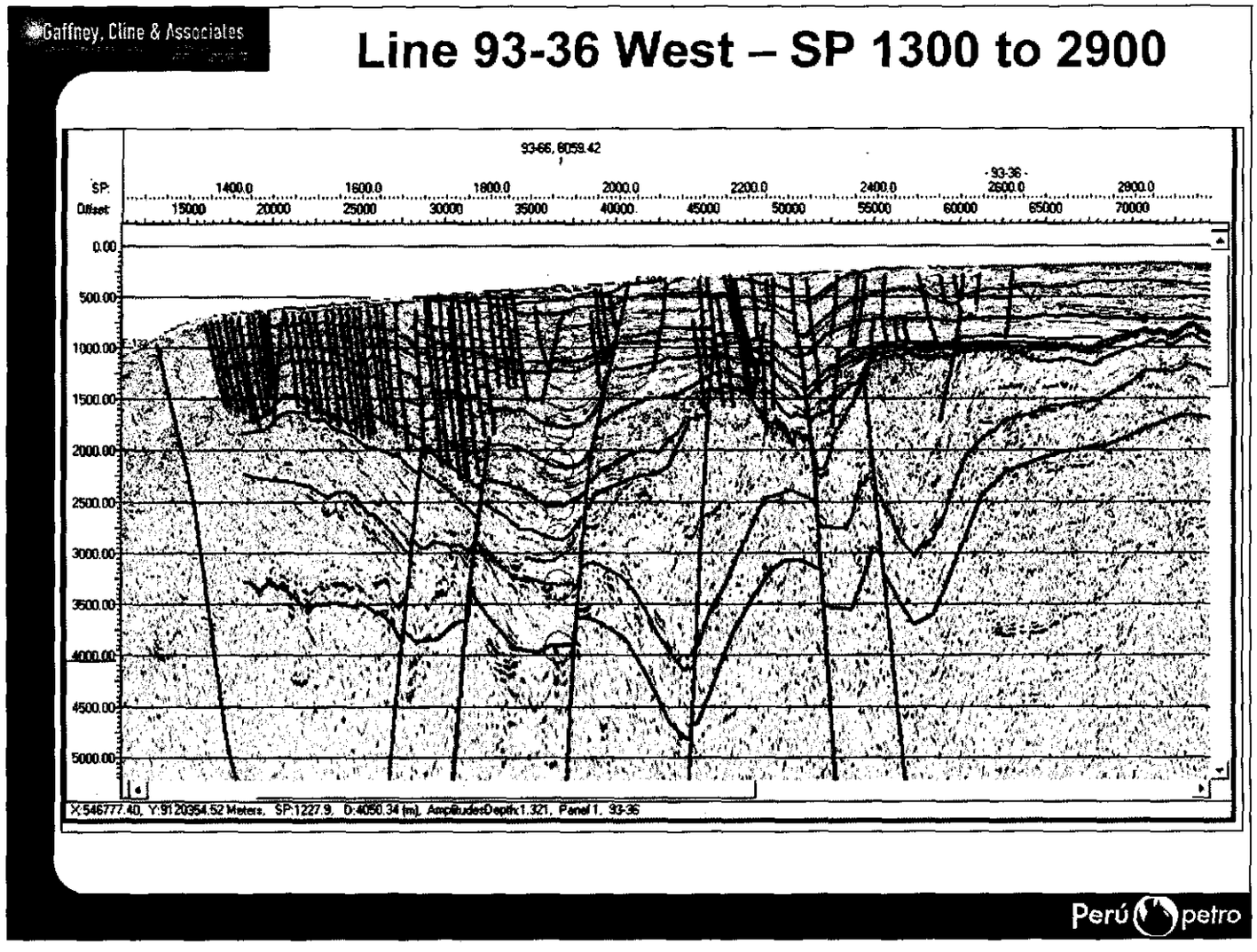
Gaffney, Cline & Associates

Line 93-36 – SP 3700 to 4200

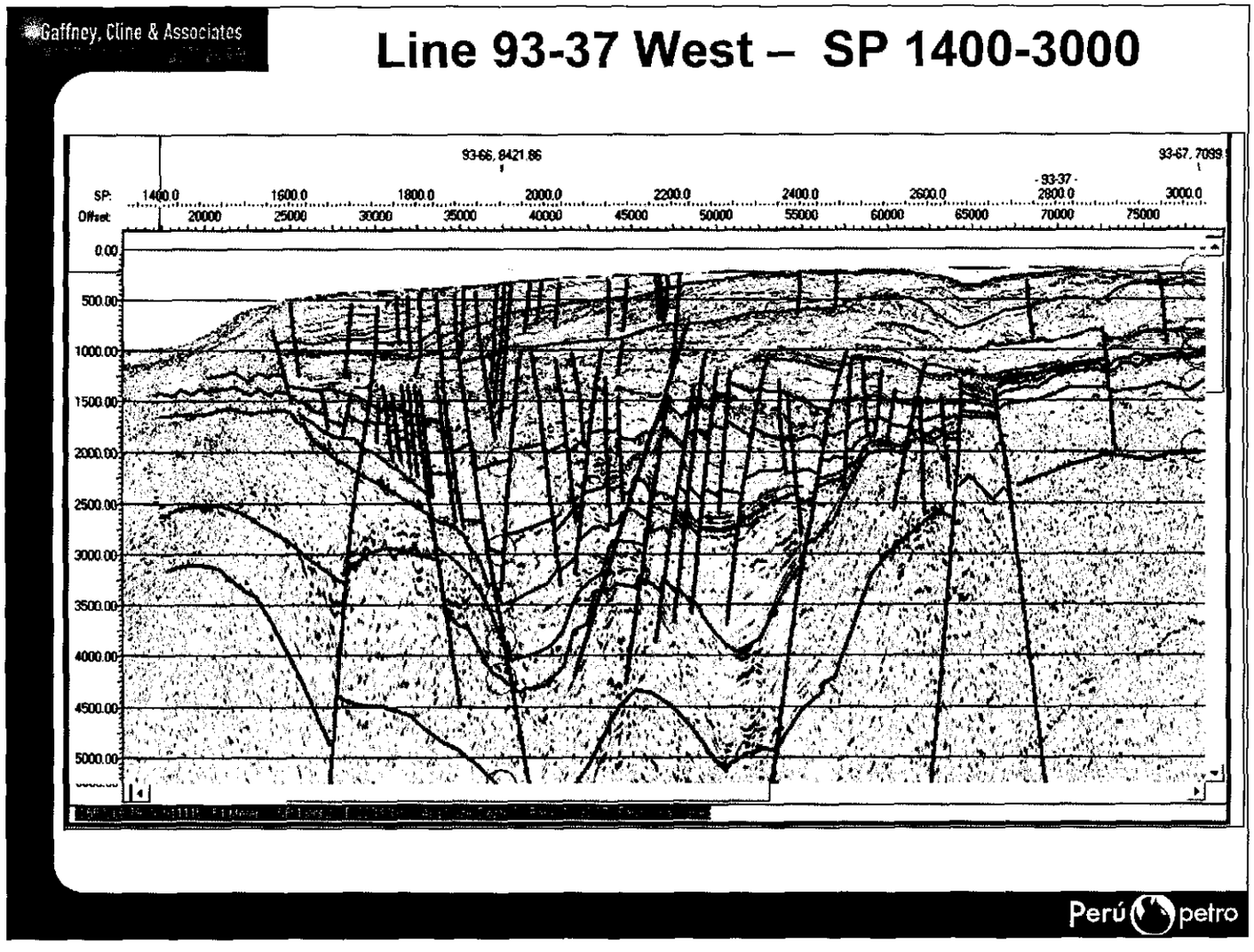


Perú petro

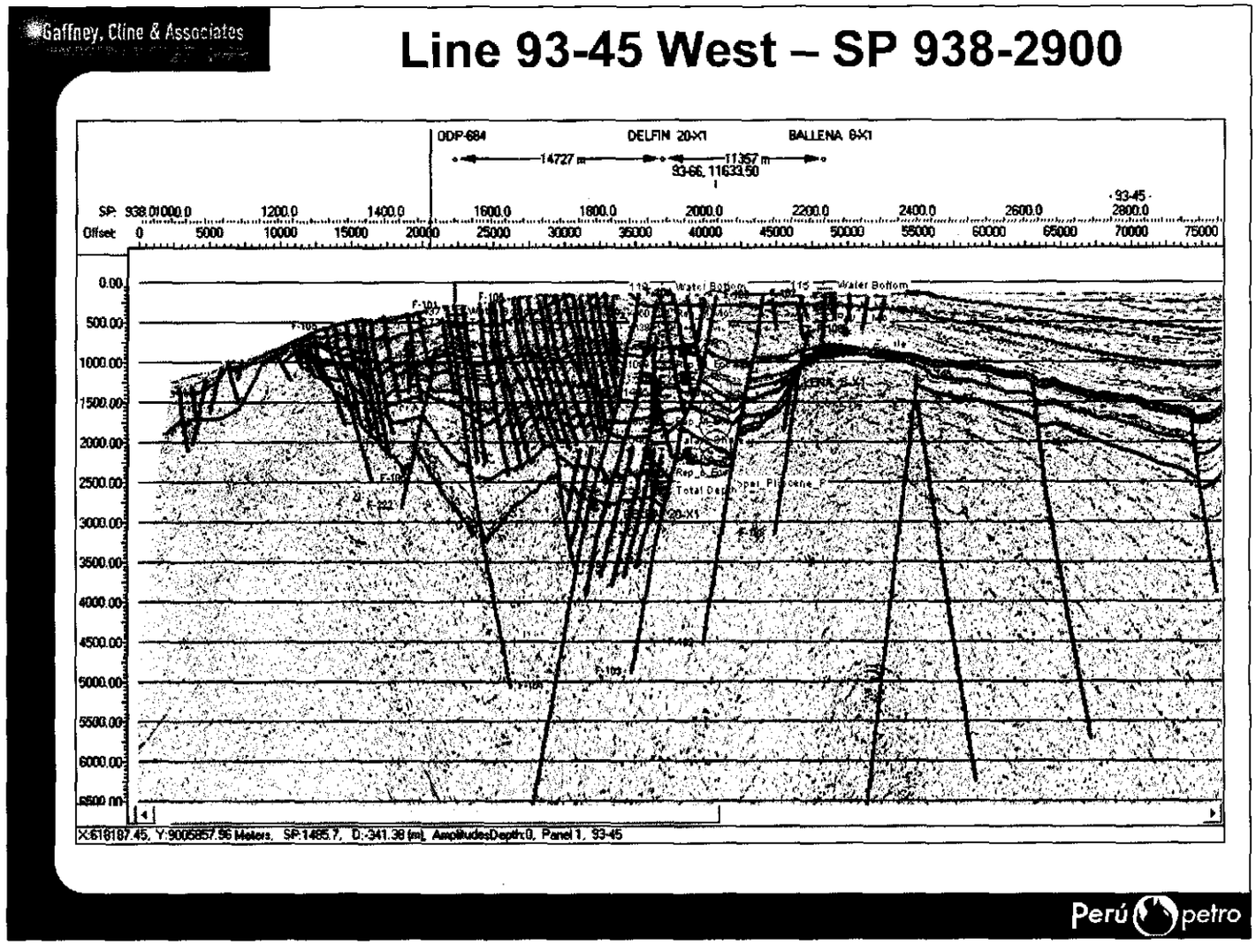
Best illustration of pinnacle development in Early Eocene carbonates (detail). SP 3700 to 4200.



Good illustration of margin-fringing carbonate buildup in Cretaceous section (green to blue horizons) at sp 1400 to 1600. Also thick Paleocene wedges at sp 2000-2200 and 2400-2600 are probably mud-prone slope front fill deposits.



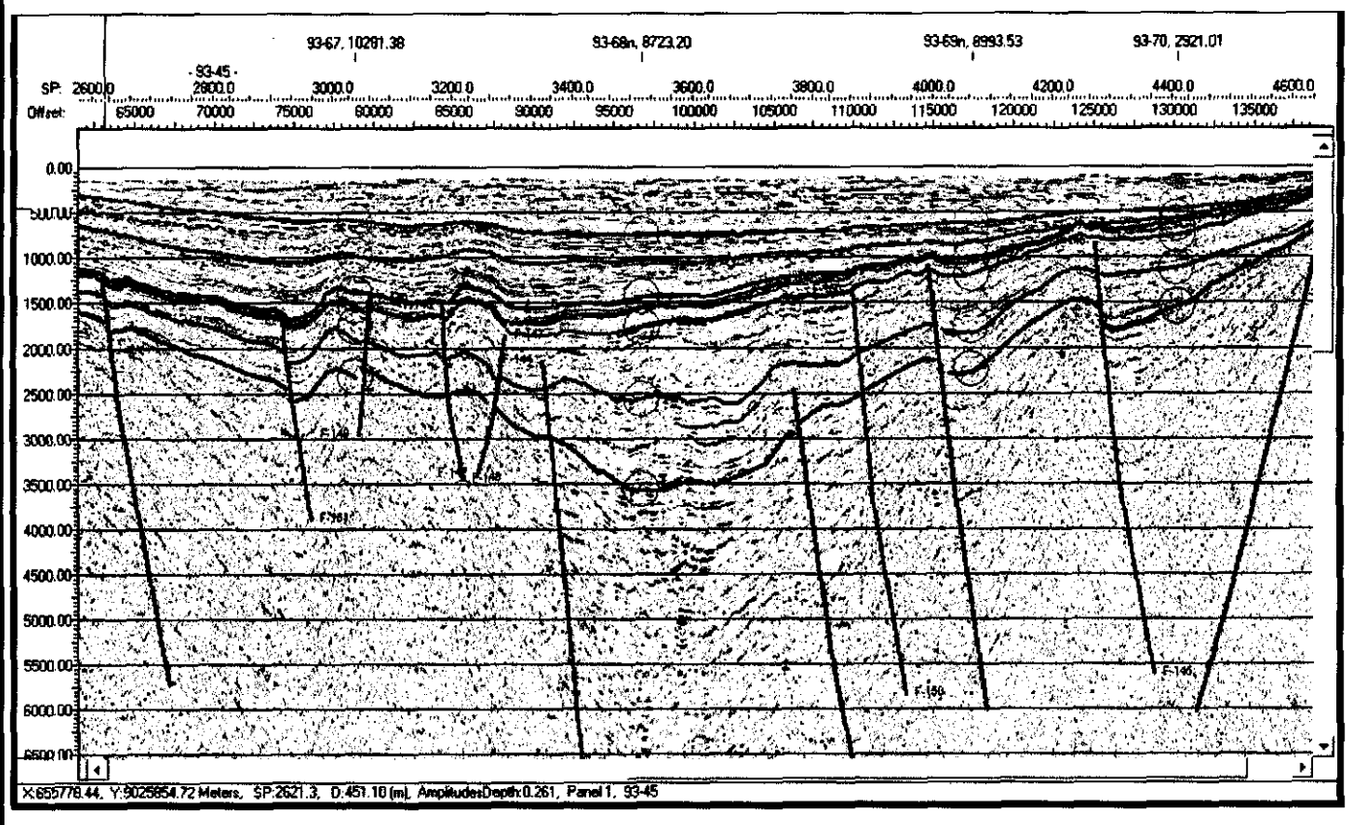
A better illustration of a) Cretaceous margin-fringing carbonate buildup; and b) Paleocene thicks that are probably mud-prone.



Trujillo Basin, Delfin and Ballena well ties (regional scale) showing inverted, faulted Eocene graben and late uplift of Trujillo-Salaverry high.

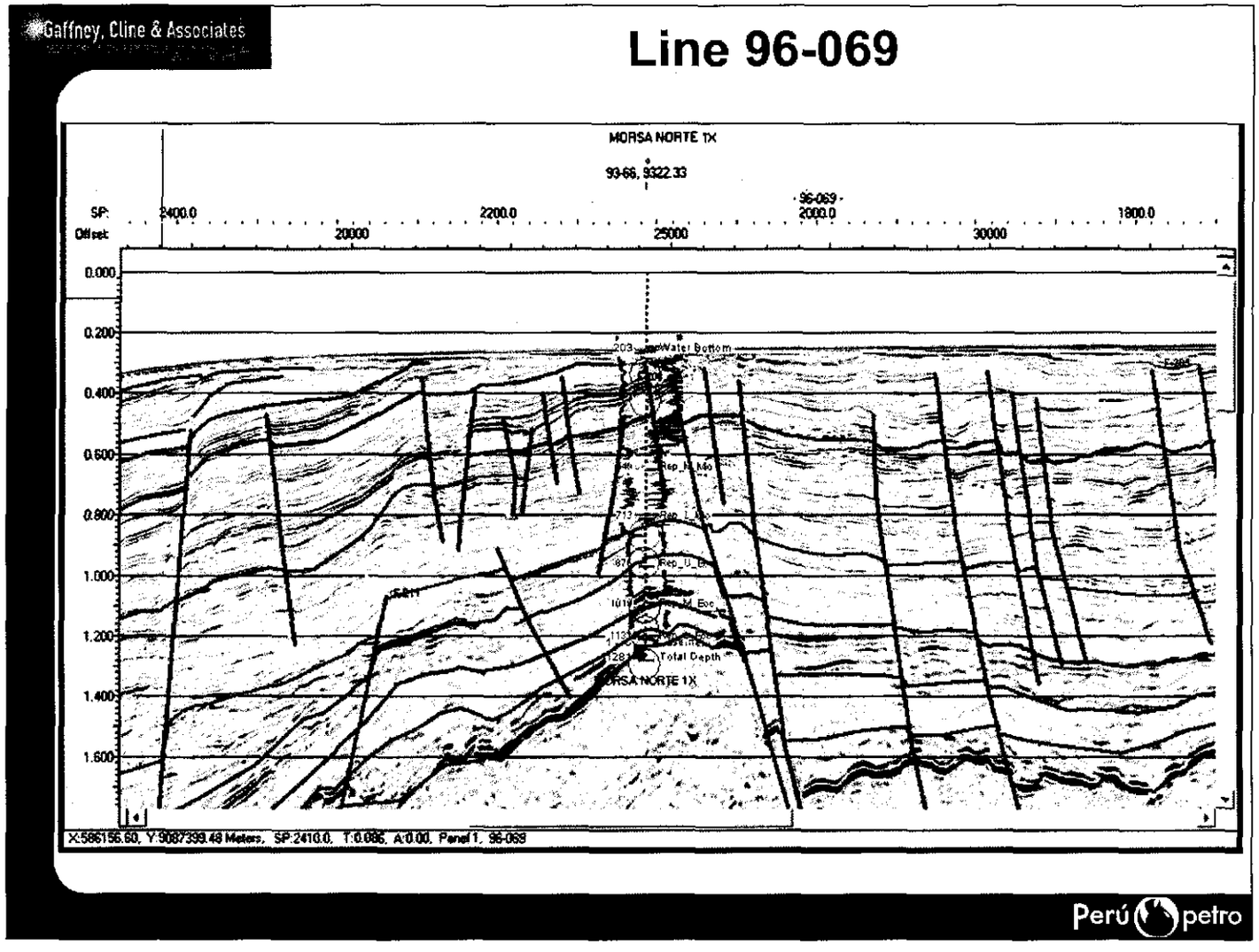
Gaffney, Cline & Associates

Line 93-45 East – SP 2600-4600

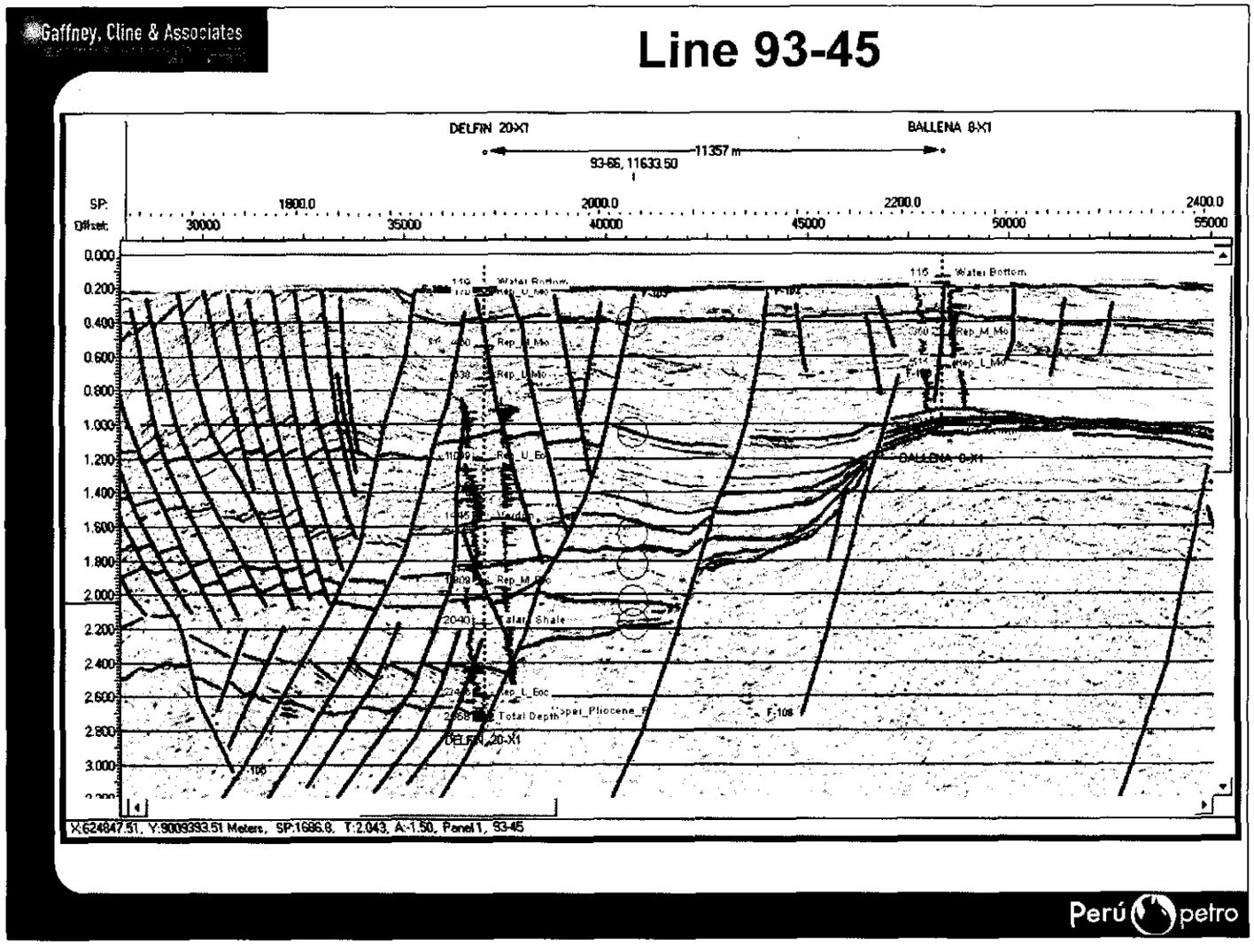


Perú petro

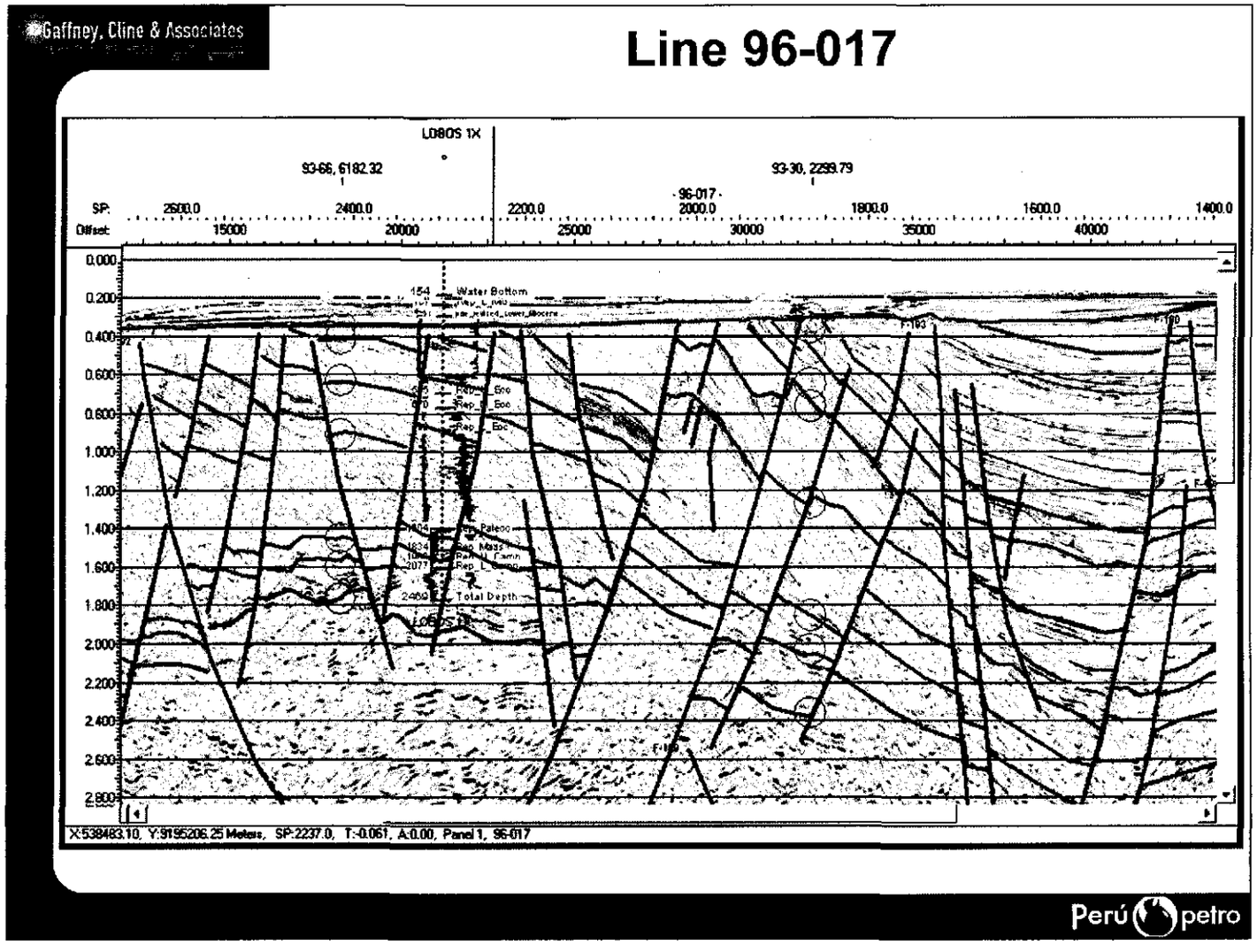
Salaverry basin. Cretaceous/Paleocene sag basin with some reactivated normal faults as thrusts and pop-ups.



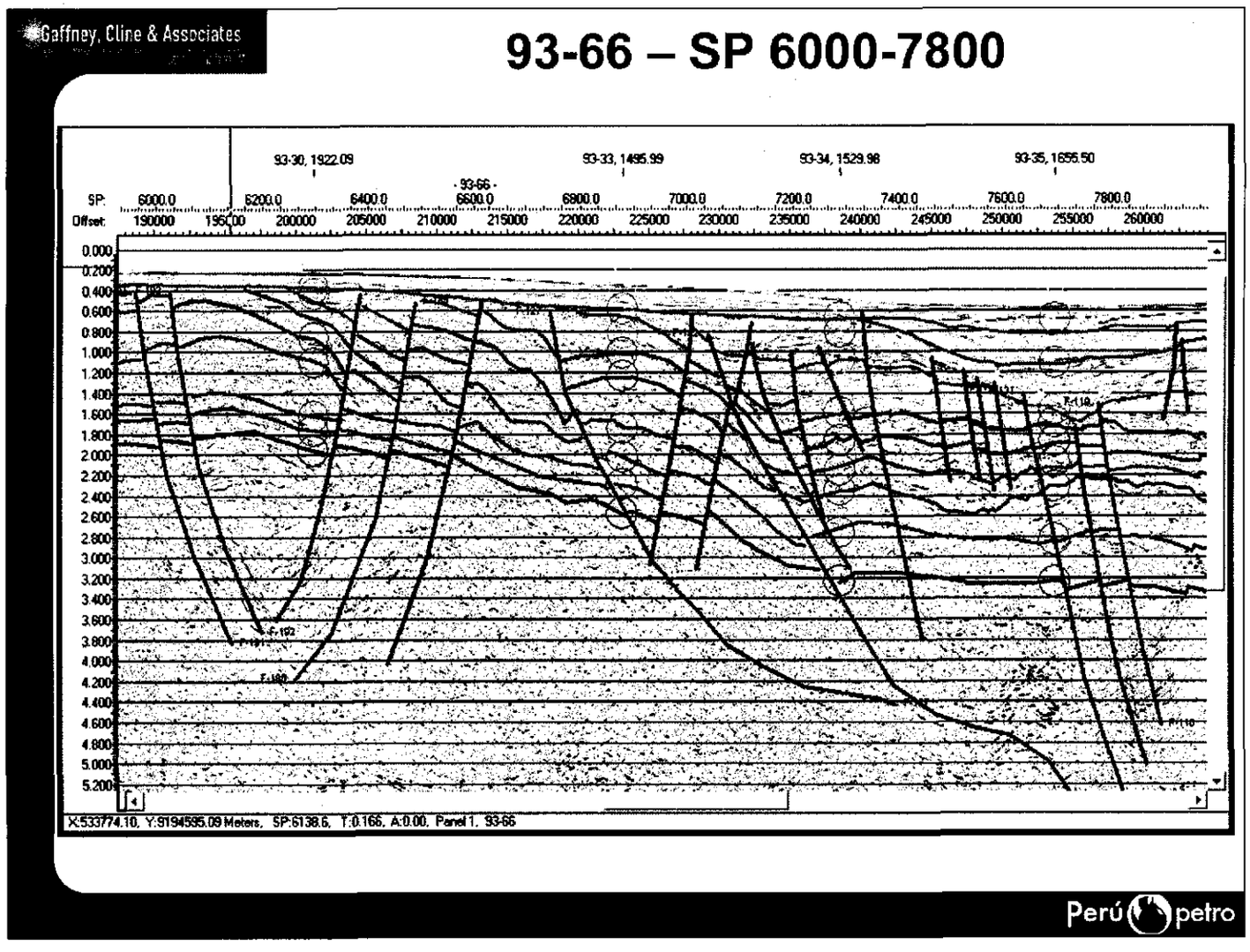
Detail showing Morsa Norte high. Repsol drilled the well on a basement high, targeting Eocene turbidite sands draped over the structural high. They did find a small amount of conglomeratic reservoir, with the rest shale.



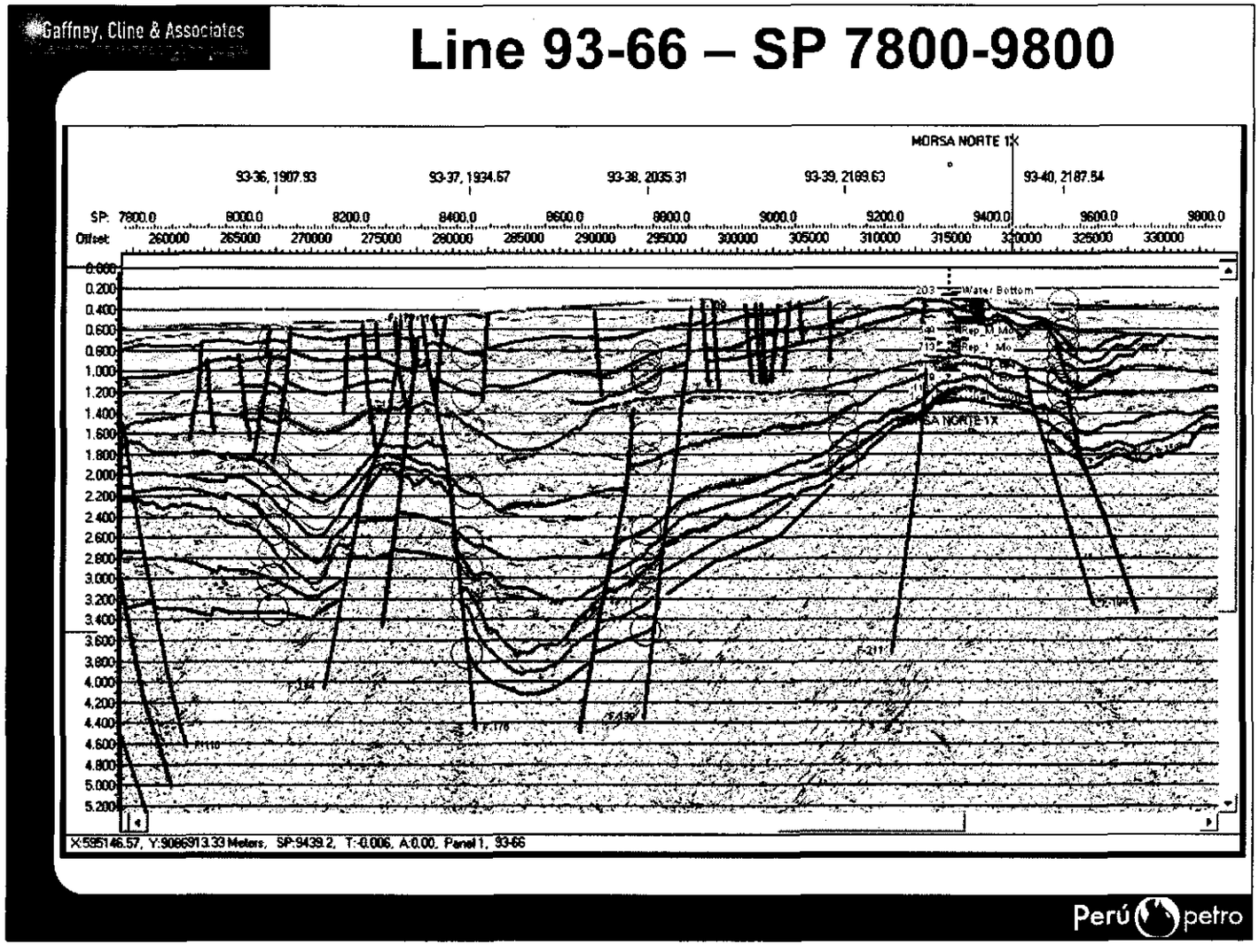
Detail showing Delfin and Ballena ties. Base Eocene conglomerates suggest that Paleocene to Eocene transition was one of widespread uplift and subaerial erosion. Earliest Eocene deposition may have been in localized fault-bounded basins. This interval (horizons 12-13) is quite thick in Lobos well.



Detail showing Lobos well tie.



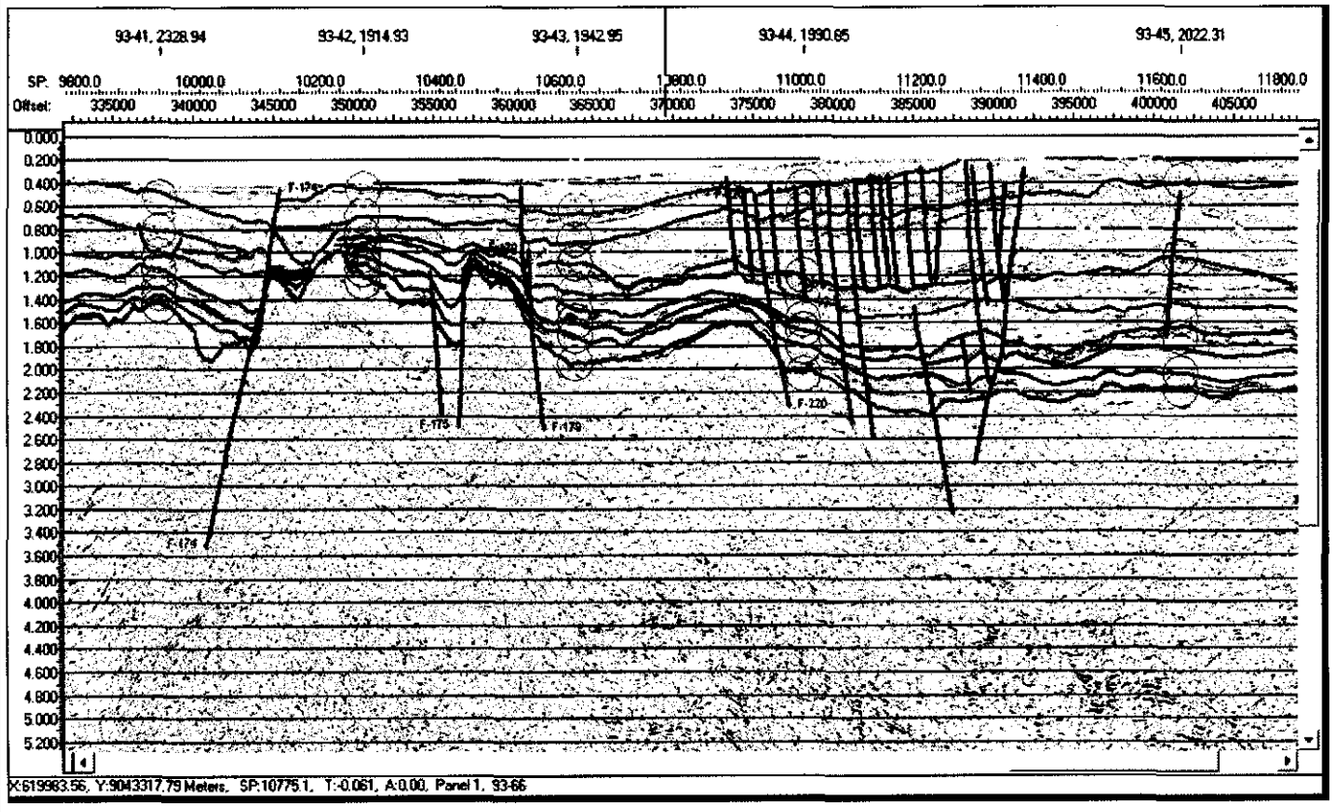
Regional strike line that ties or nearly ties the four wells in the Trujillo basin. Lobos well projects into the line at SP 9350.



Morsa Norte well ties at SP 9350.

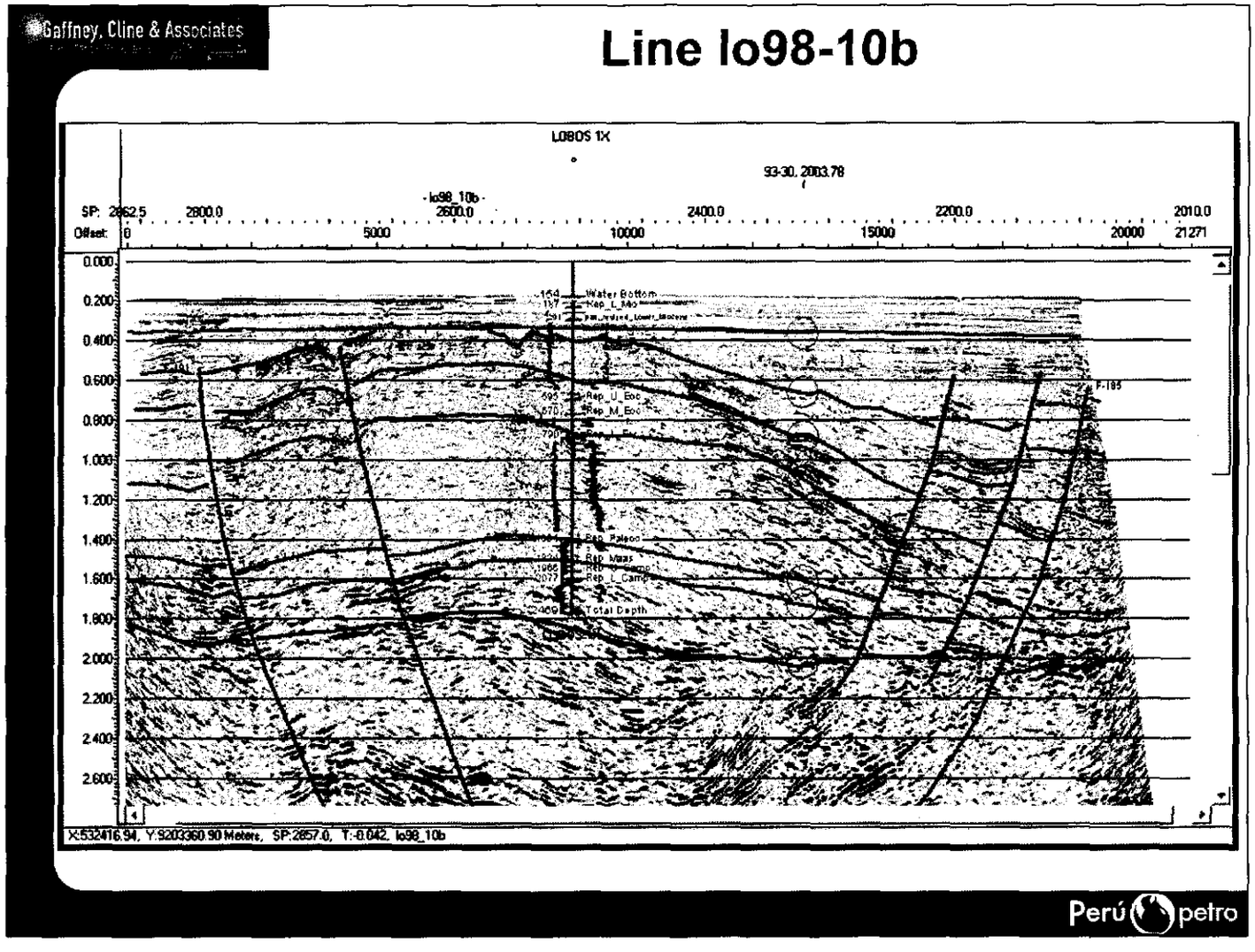
Gaffney, Cline & Associates

Line 93-66 – SP 9800-11,800



Perú petro

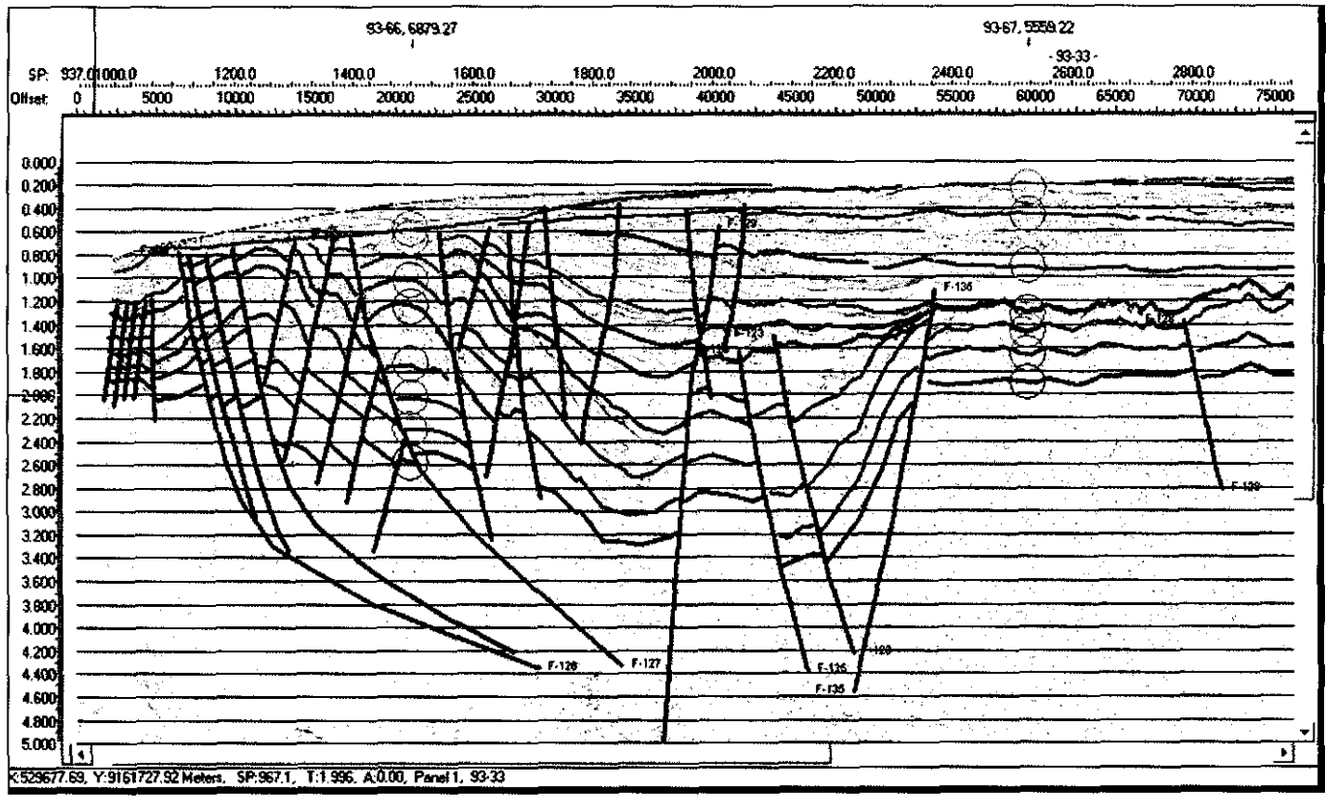
Delfin and Ballena tie at 93-45 at SP 11600 (roughly).



Detail of Lobos well tie. Also shows Paleozoic syncline at depth (angular unconformity at the blue horizon).

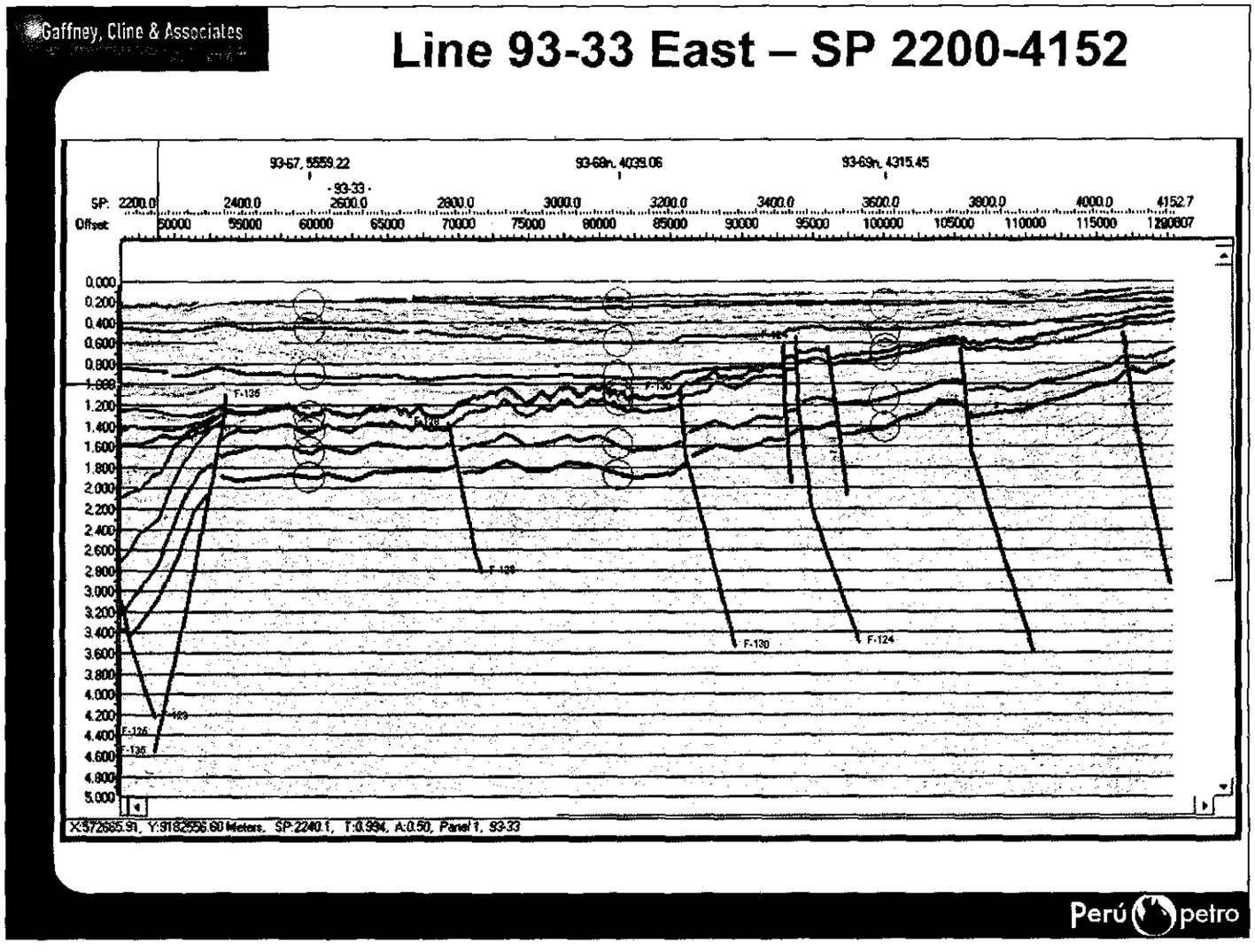
Gaffney, Cline & Associates

Line 93-33 West – SP 937-2900

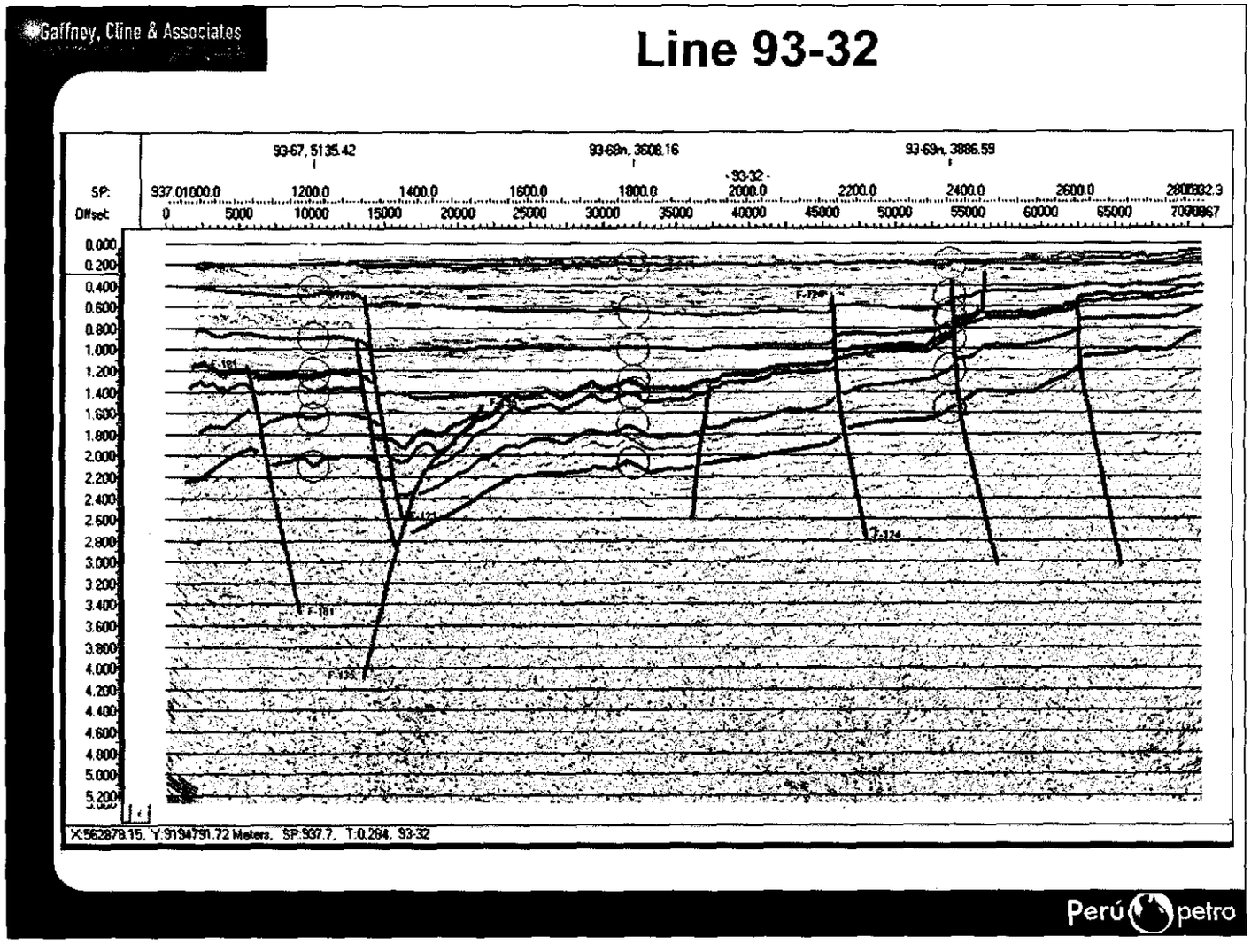


Perú petro

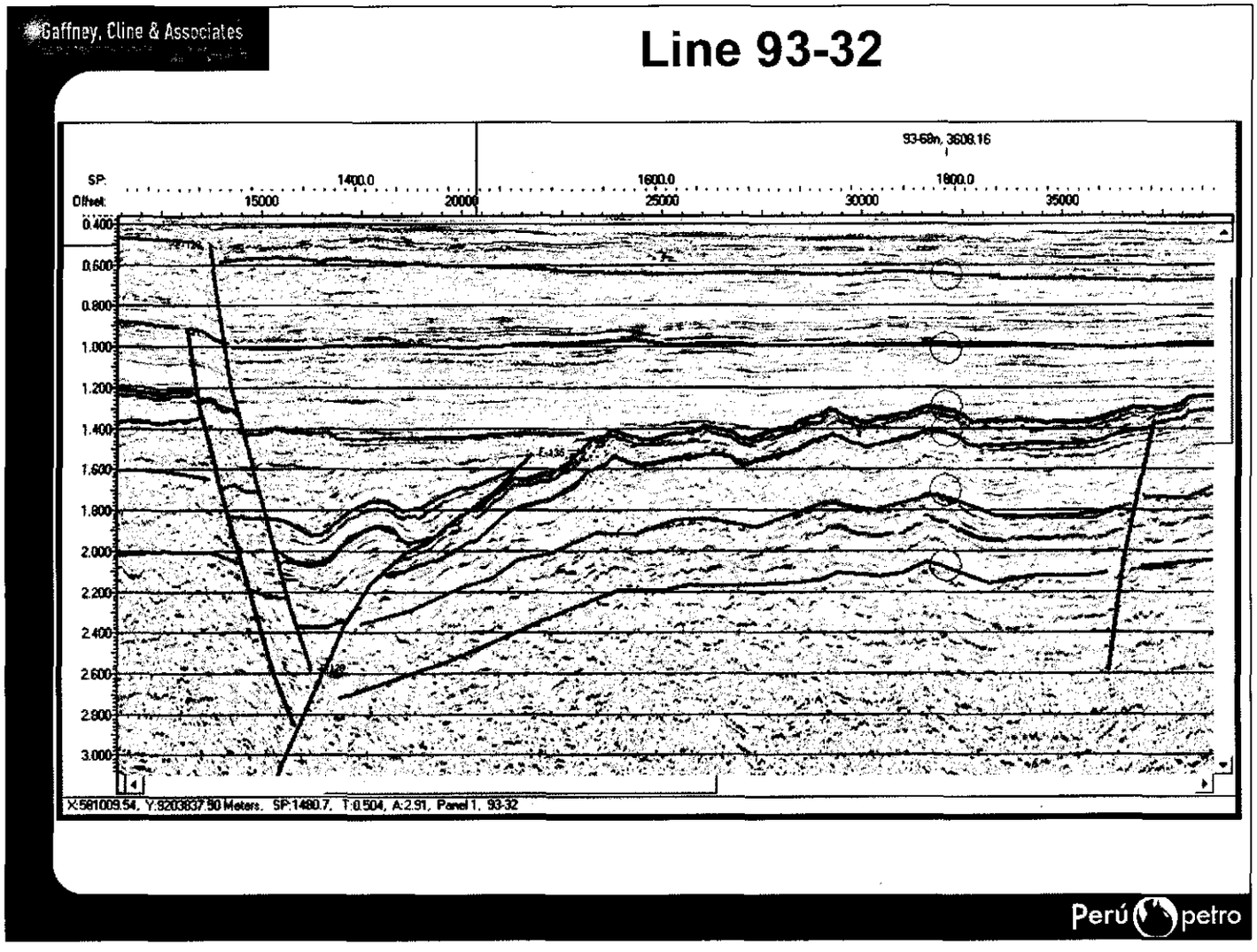
Late Miocene thrust fold-belt just south of Lobos well.



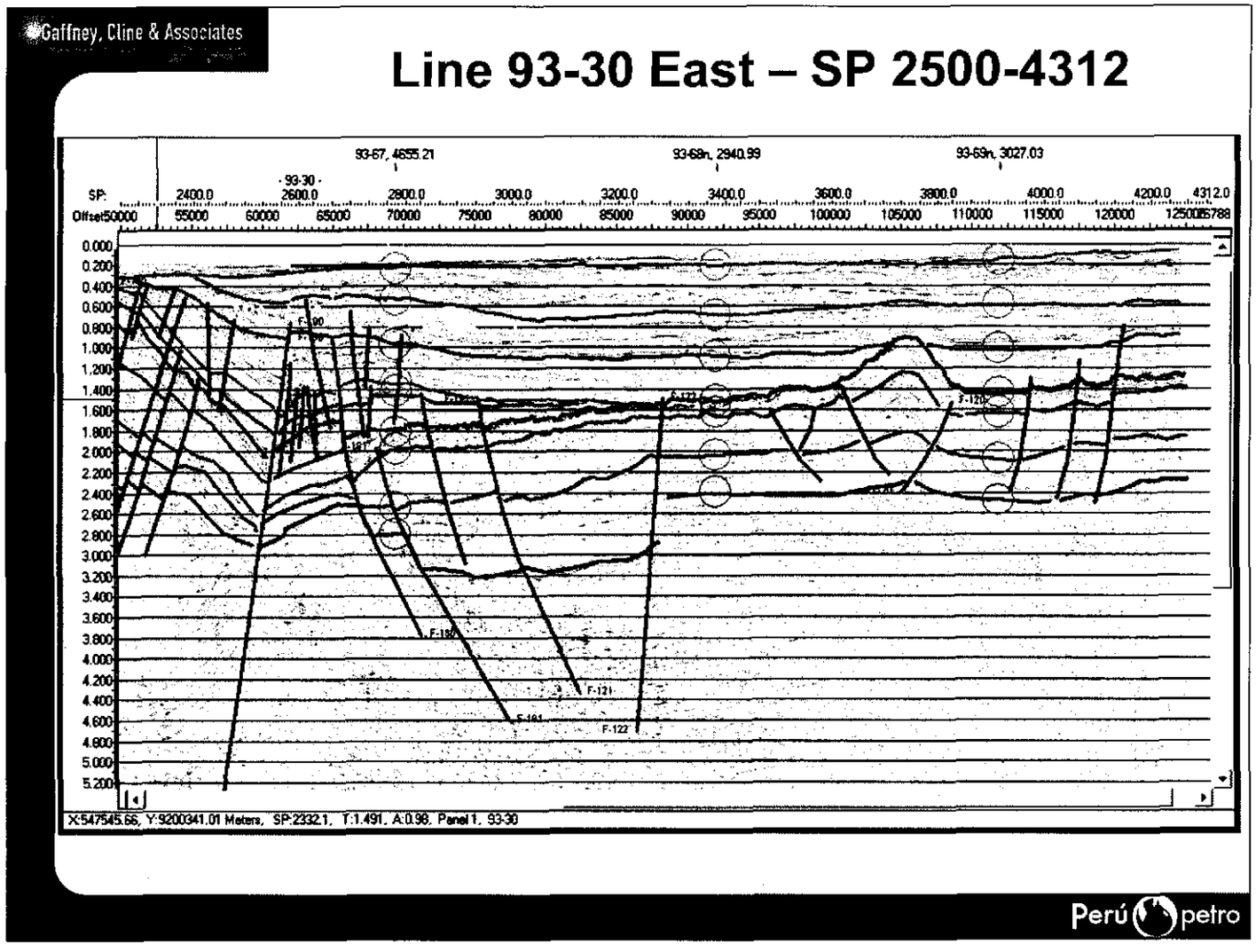
Northern Salaverry Basin, showing onlap of Early to Middle Miocene section onto Early Eocene carbonates. *Contrast this geometry* with that shown on line 93-45 (slides 19 and 20) which is rotated by Middle Miocene thrusting/uplift of the Trujillo/Salaverry high.



Mild inversion of extensional structure within deep Eocene graben.



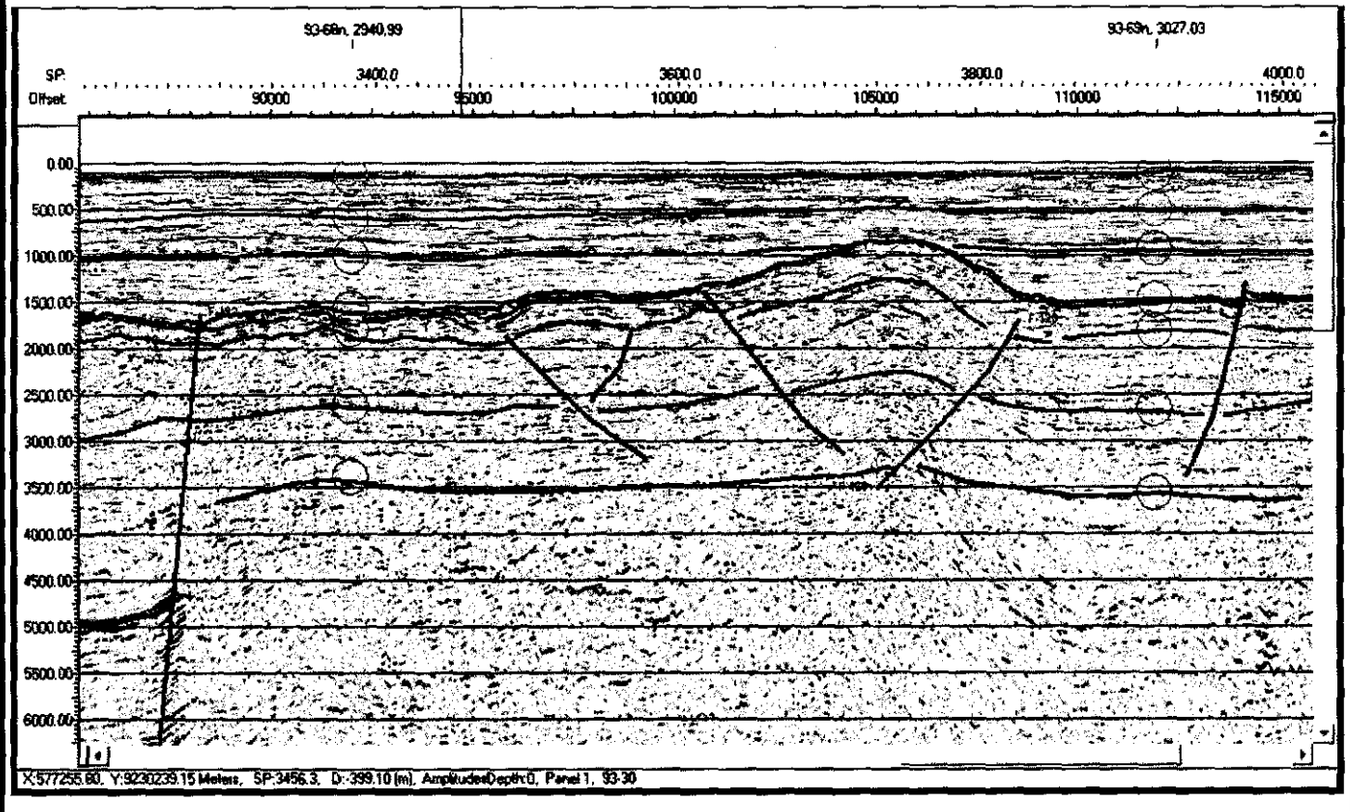
Detail of slide 30.



Shows Cretaceous and Paleocene graben (modeled by Angel Callejon, has source potential) that has been mildly inverted with a pop-up structure at sp 3700. Slide 33 (next) is a zoom (detail) sp 3200-4000 showing popup structure and also showing edge of Cretaceous graben.

Gaffney, Cline & Associates

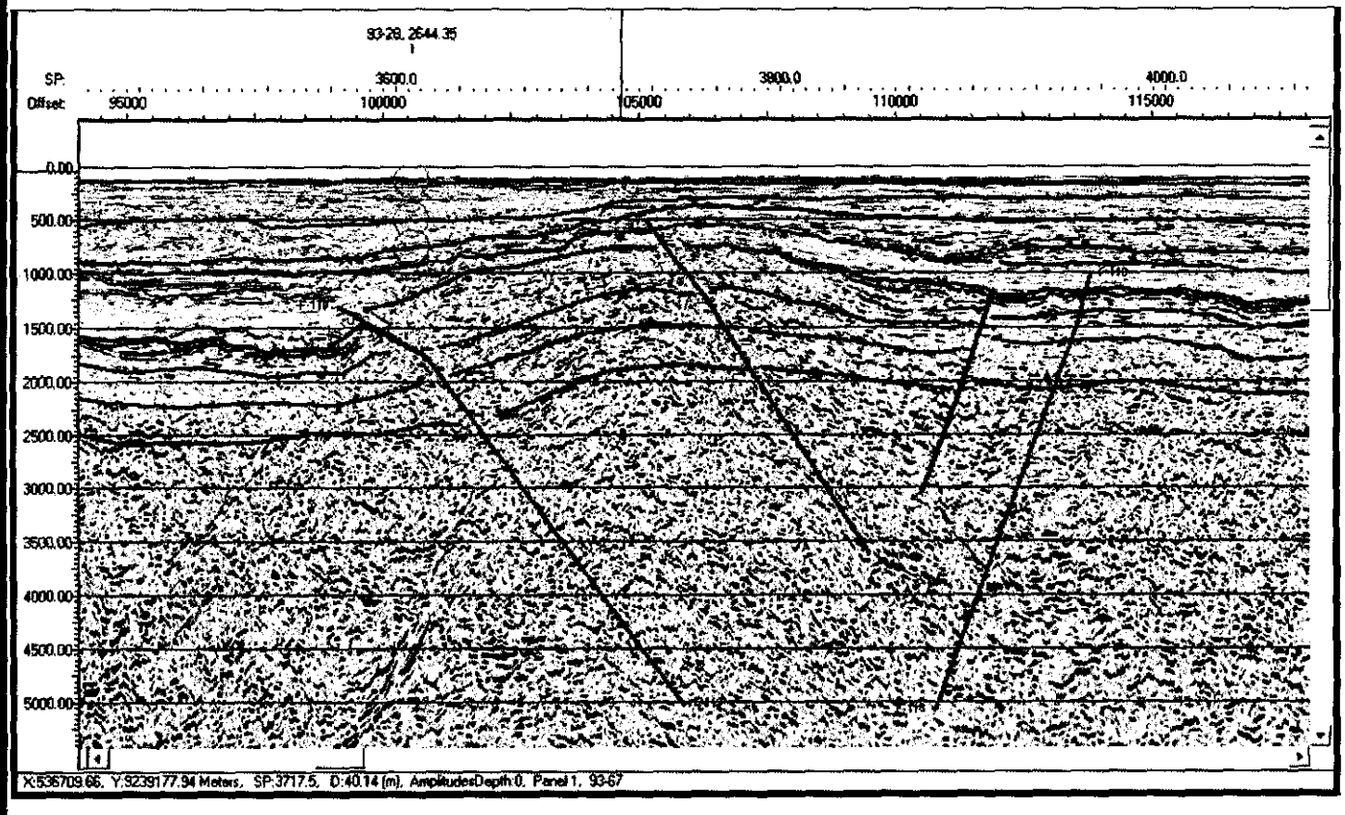
Line 93-30 East – SP 2500-4312 (Detail)



Perú petro

Gaffney, Cline & Associates

Line 93-67 – SP 3500-4100

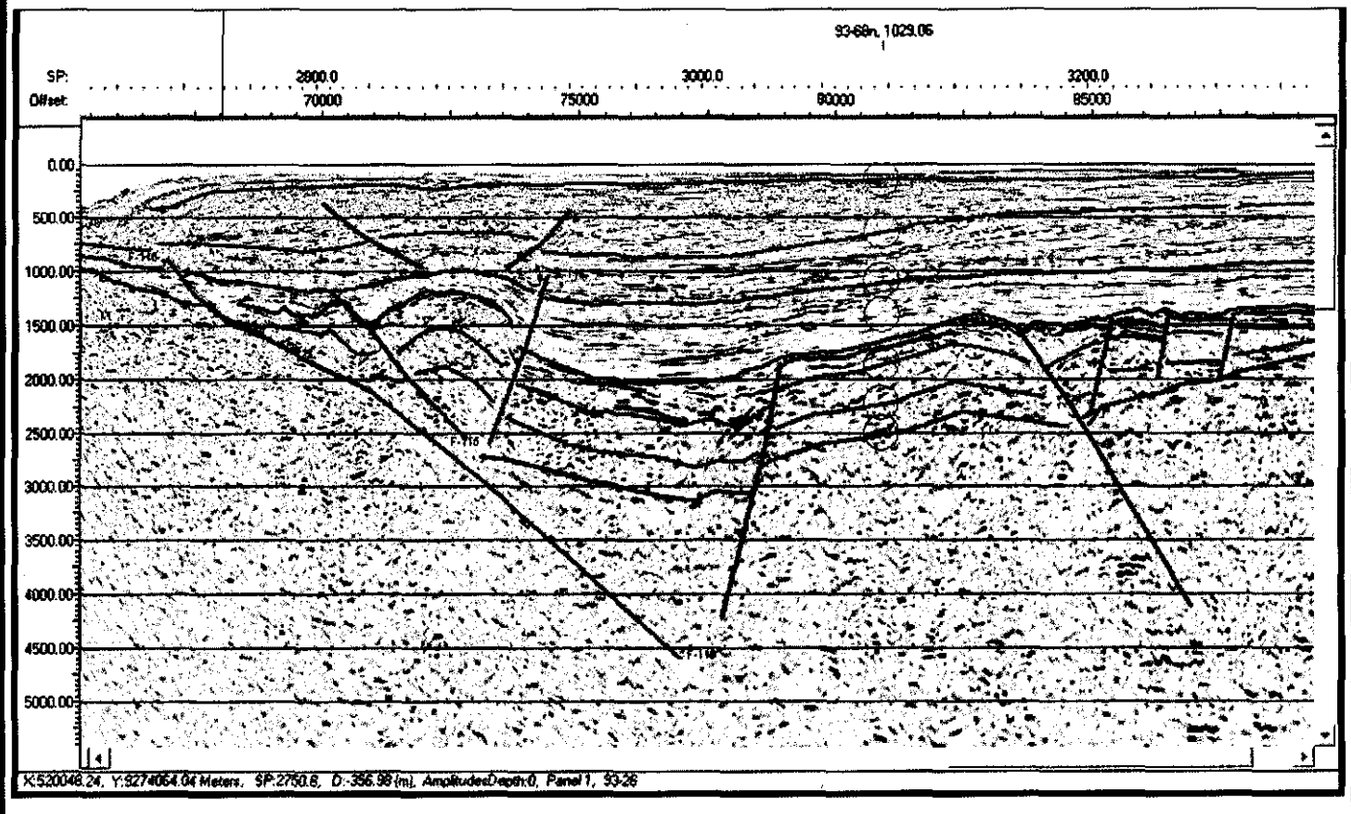


Perú petro

Northern Salaverry basin – might be southern Sechura. Another pop-up structure. Eocene inversion of Cretaceous/Paleocene thick.

Gaffney, Cline & Associates

Line 93-26 – SP 2700-3100

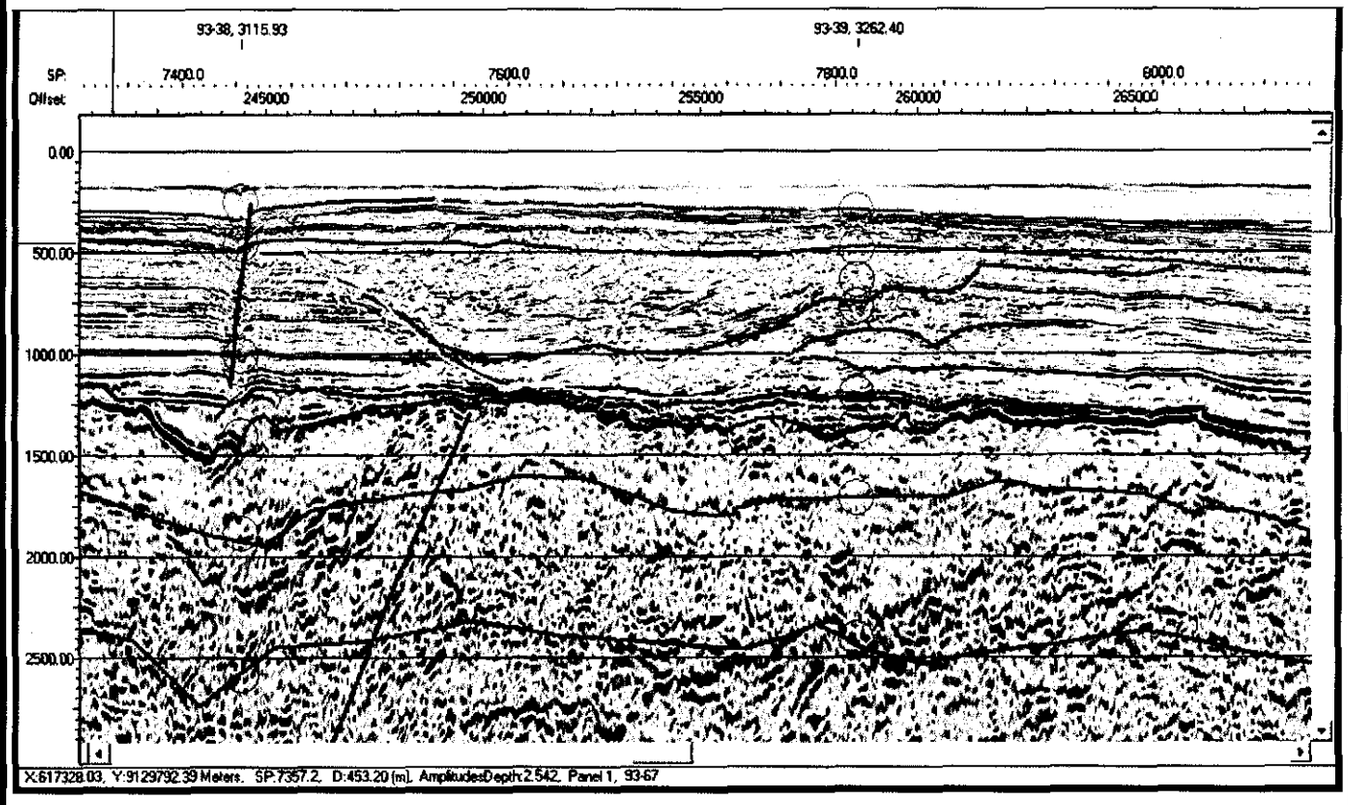


Perú petro

Another pop-up structure, which has been active into Miocene time (Miocene deformed).

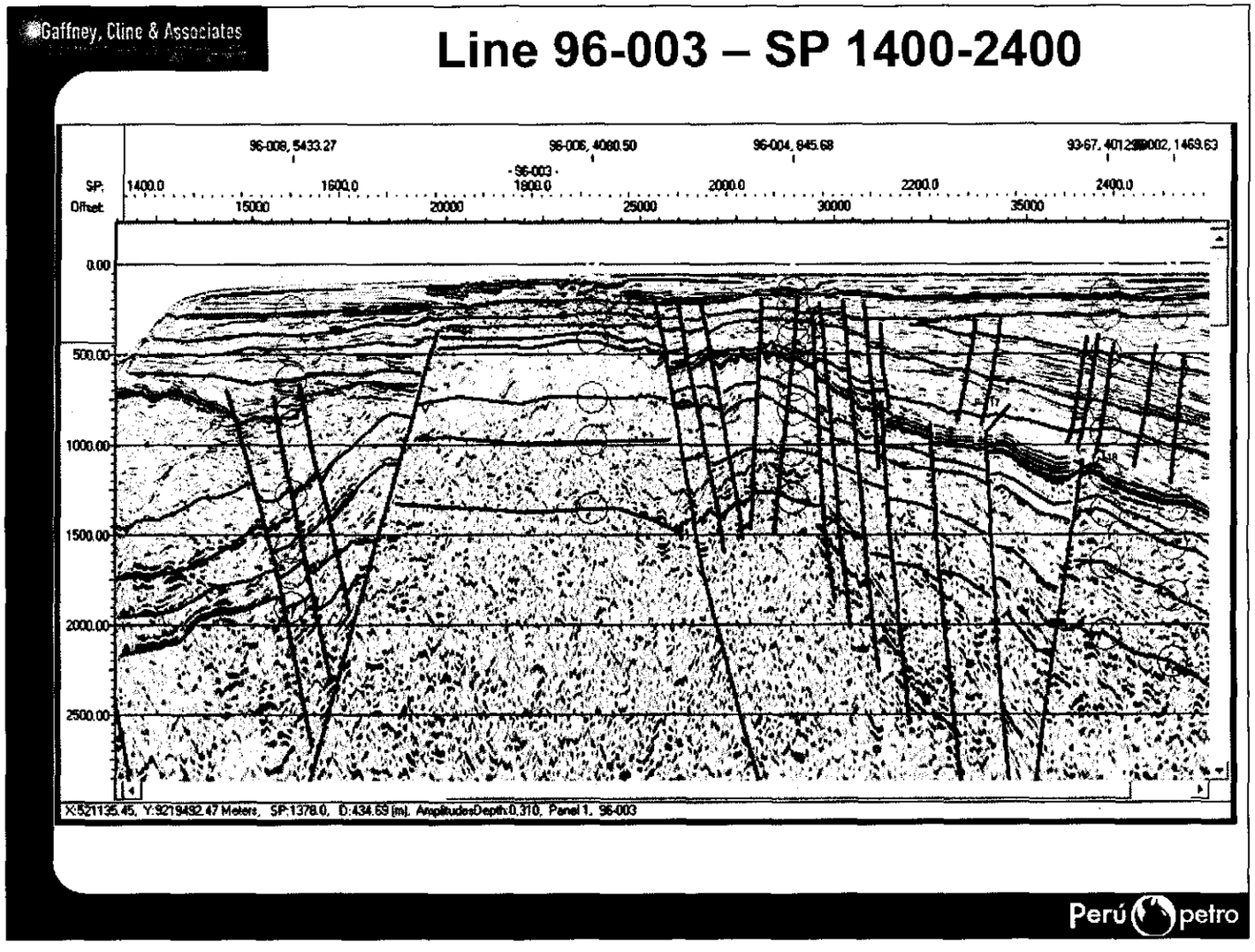
Gaffney, Cline & Associates

Line 93-67 – SP 7400-8000



Perú petro

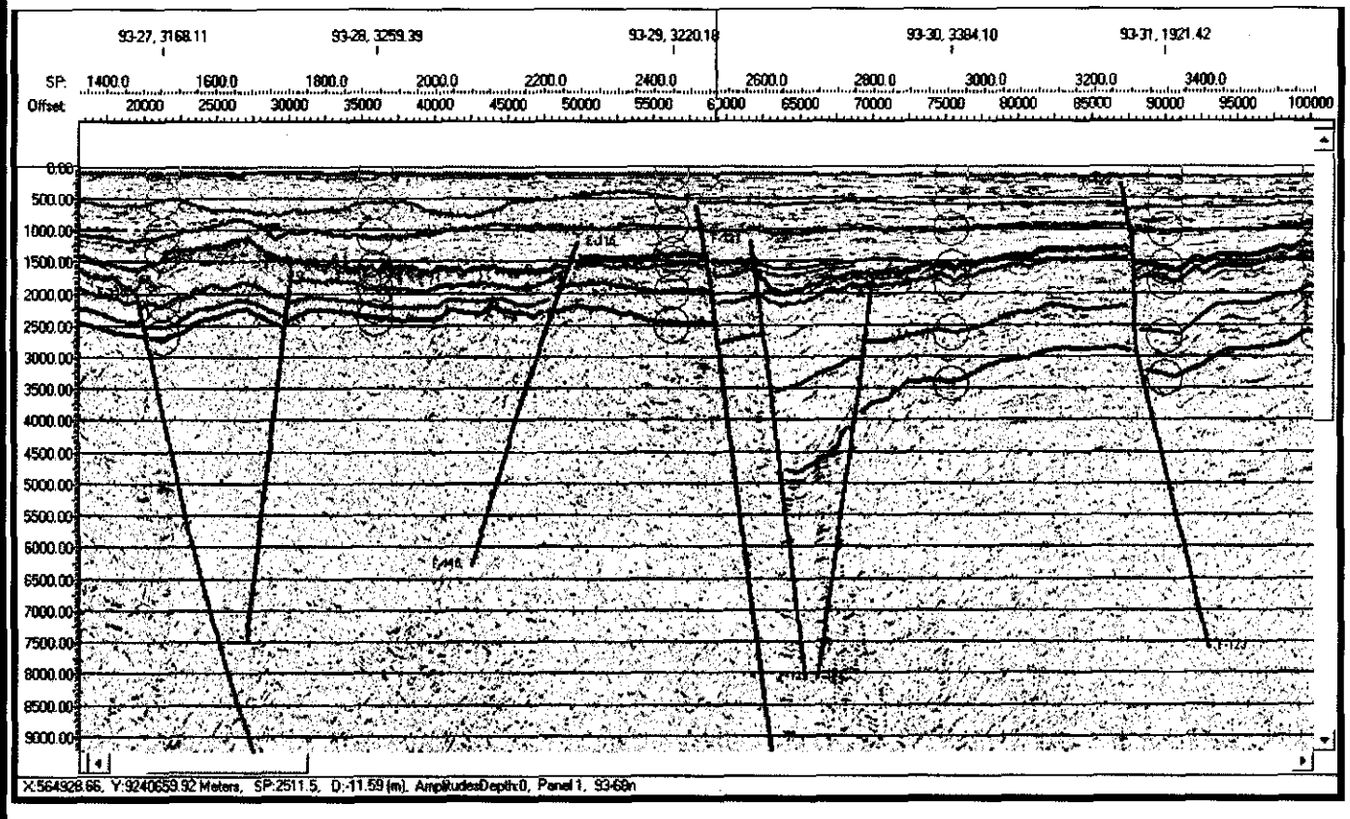
Shows intra-Middle Miocene channel. Refer to Middle Miocene facies map in Enclosure 7. Multi-storied incised submarine canyon.



Northern Trujillo basin. Highlights channels in the Middle Eocene (horizons 11 dark magenta-10 dark cyan). Refer to Enclosure 8, which is a facies map for horizons 9-11. Channels at 1400 to 1600 (axis 1500). The other channel starts at sp 2100 off to the right past 2400. No axis shown on this line. Maybe at 2350.

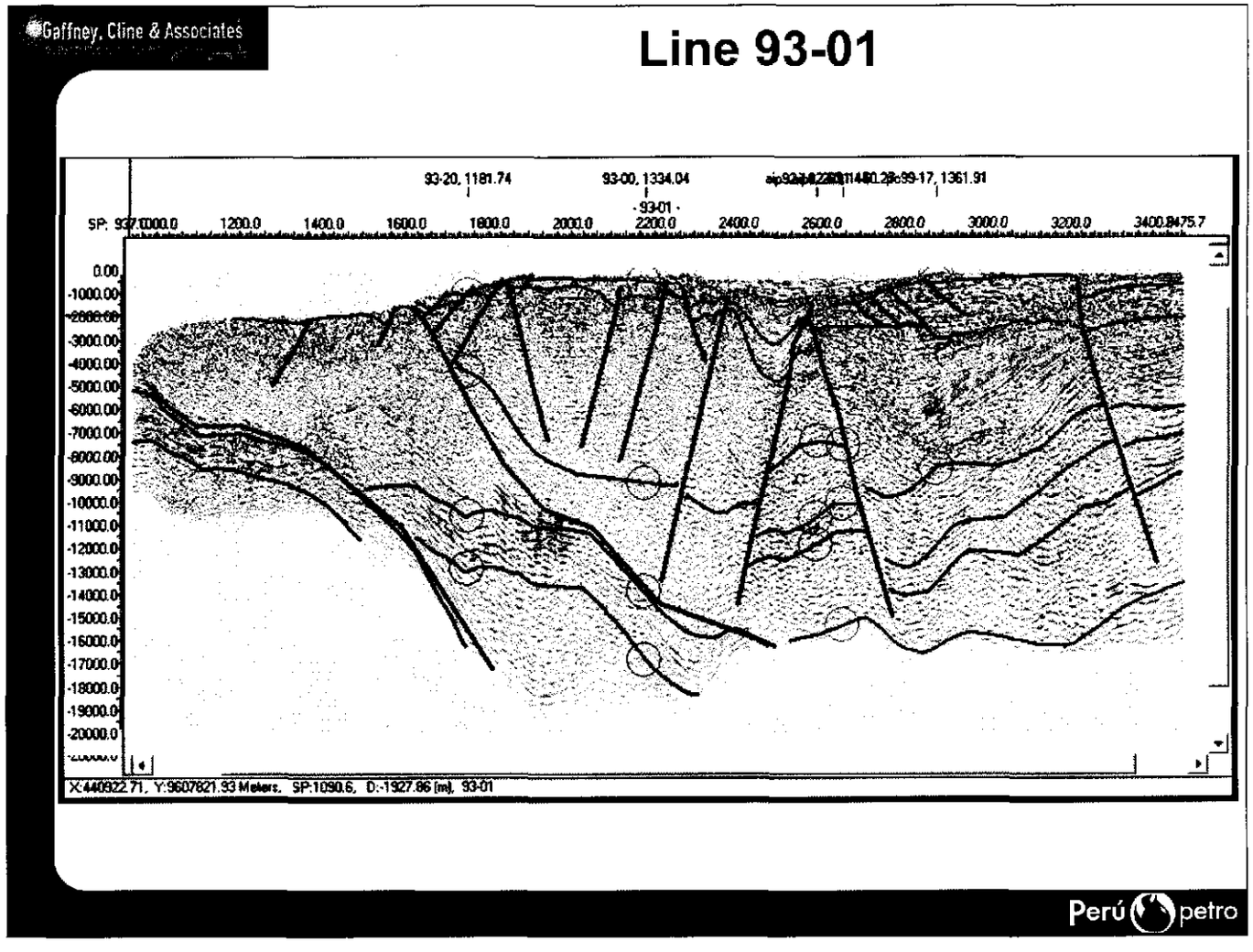
Gaffney, Cline & Associates

Line 93-68n – SP 1400 to 3500

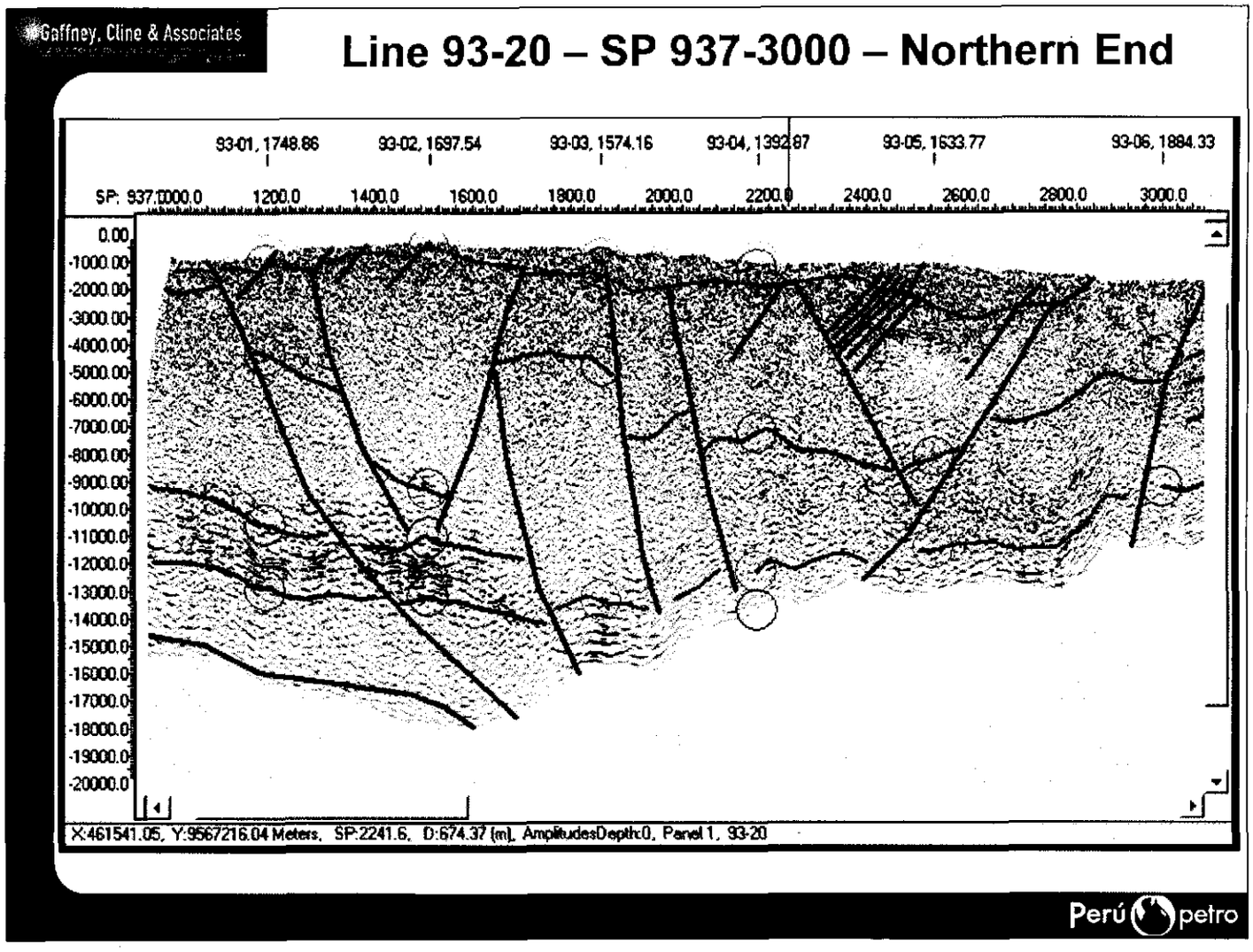


Perú petro

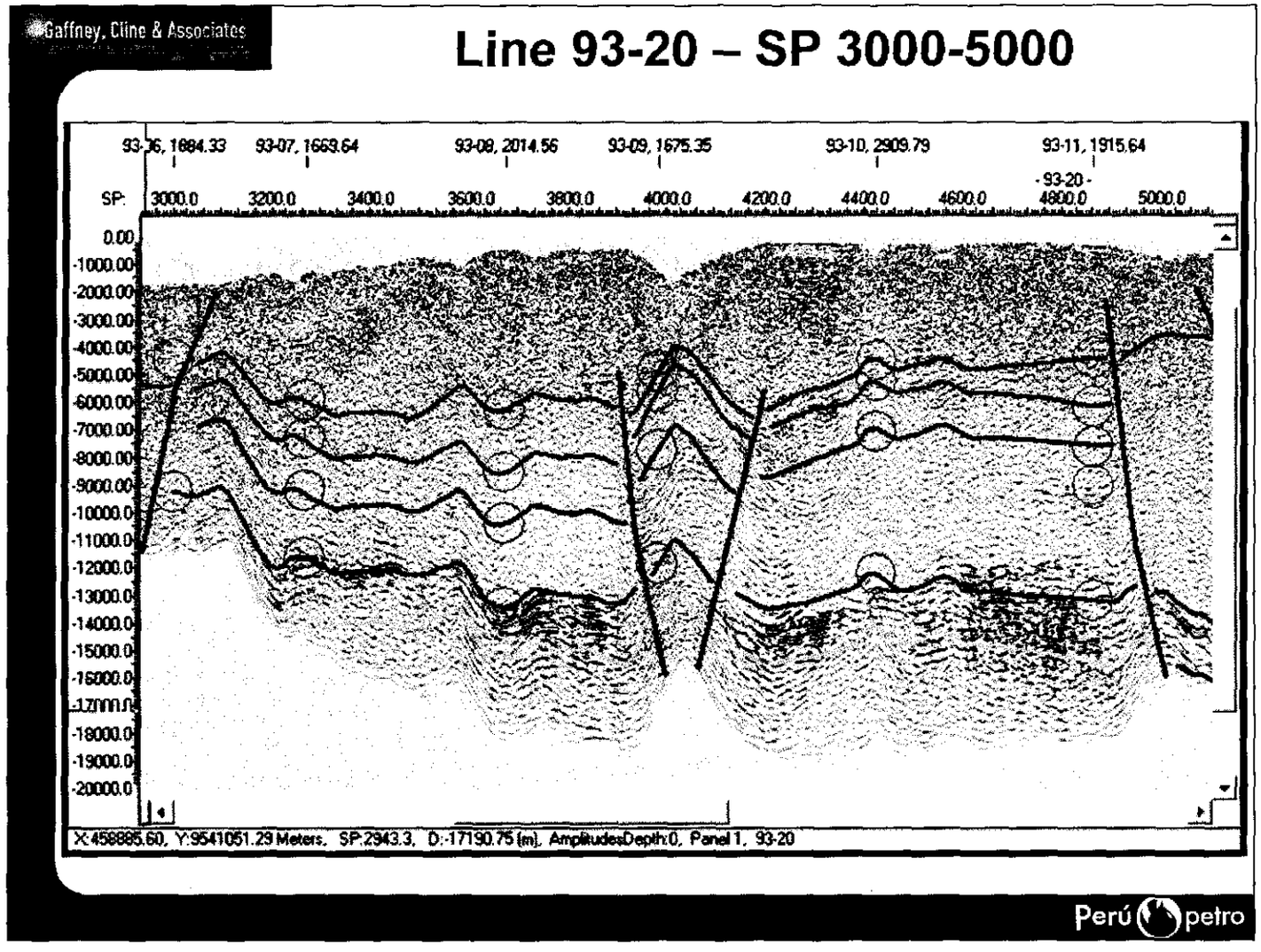
Regional view of horst and graben structures with minor inversion. These are mainly Paleocene to Cretaceous thicks. Carbonate thicks in interval from Paleocene horizon 13 to Eocene horizon 11 indicate reef growth on growing inversion structures.



Crustal scale profile showing imbricate slivers of oceanic crust at toe of slope – subduction zone. There is a big Eocene thick (uplifted, inverted) just landward of the subduction zone. Seabottom is beveled flat above the inversion. This is the Peru Bank. Peru Bank is underlain by oceanic crust. The boundary of the subduction zone/oceanic crust is well expressed in the magnetic data (see Tumbes Basin Presentation). Landward of Peru Bank is a Miocene syncline that could have trapped turbidites being shed from the periphery of the Tumbes basin. Landward of that, there is a thick Cenozoic section, possibly including Cretaceous strata, that is overlying transitional crust. If this crust is due to movement of a megasheer that opened up the Gulf of Guayakil, then the pre-Eocene section does not include Cretaceous, but instead might include a thick shale package – possibly anoxic.



This strike line cuts across salients and reentrants of continental crust.



Likely depth conversion feature (bogus anticline under a submarine canyon).

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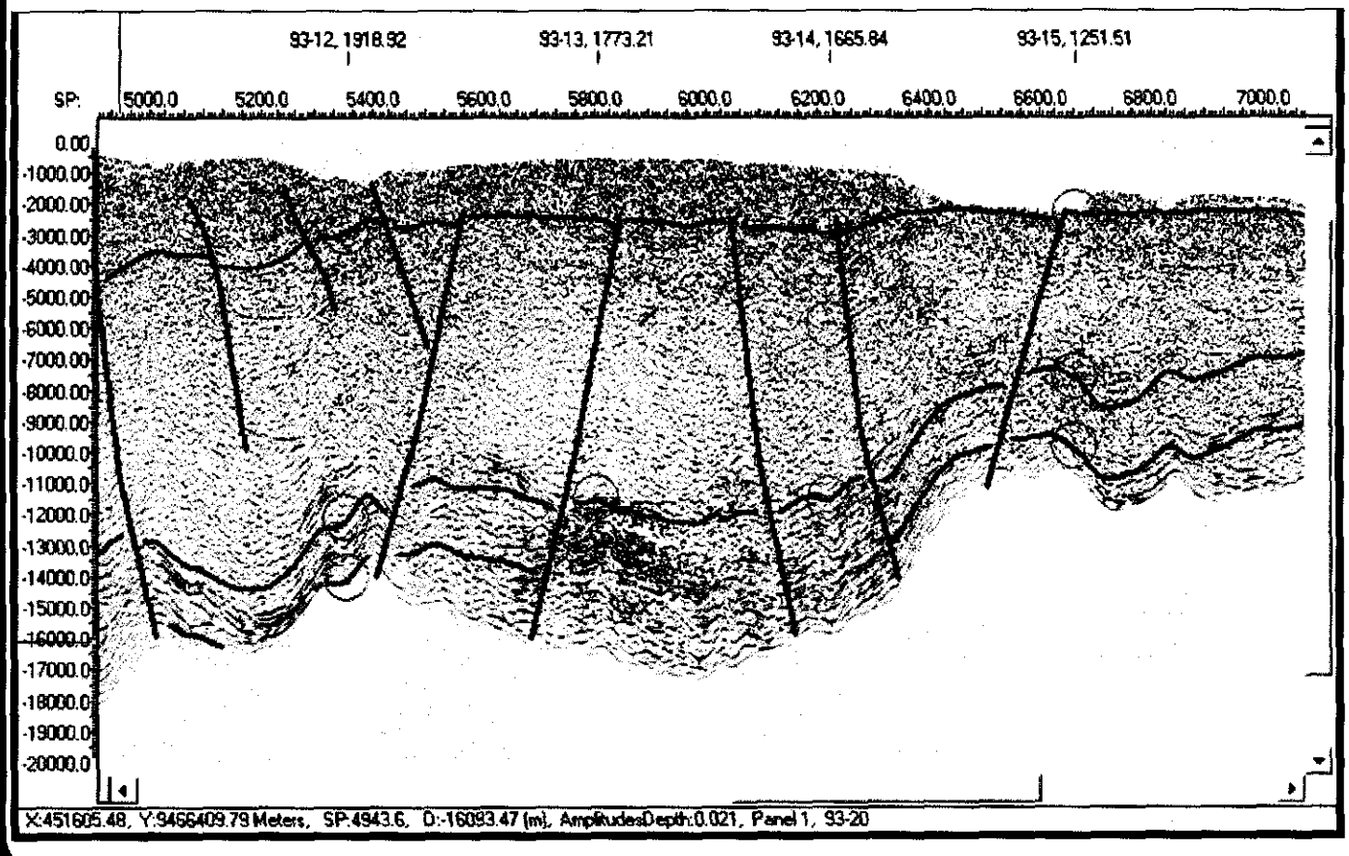
Line 93-20 – SP 5000-7000
(south of slide 41)

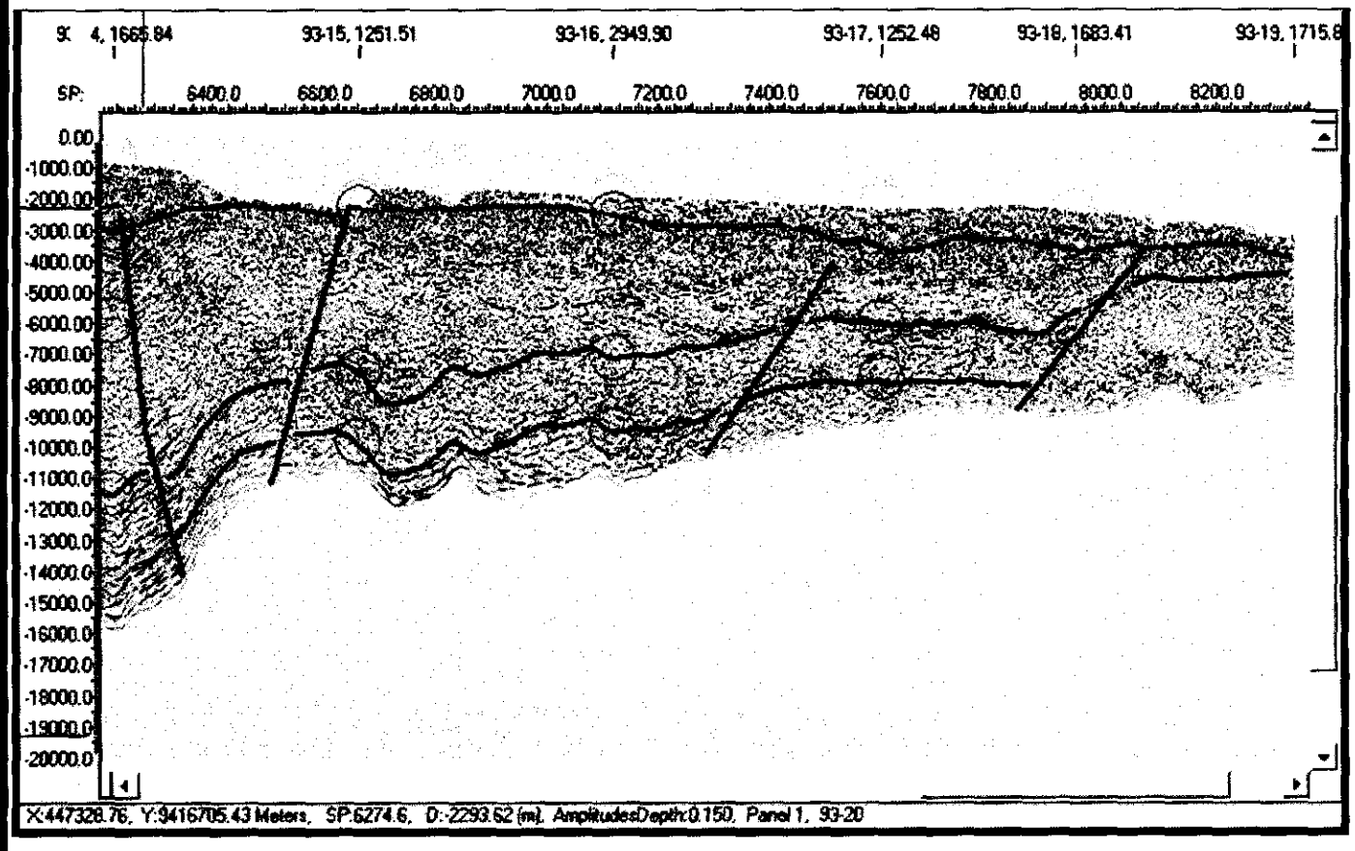


Perú petro

Continuation of previous slide.

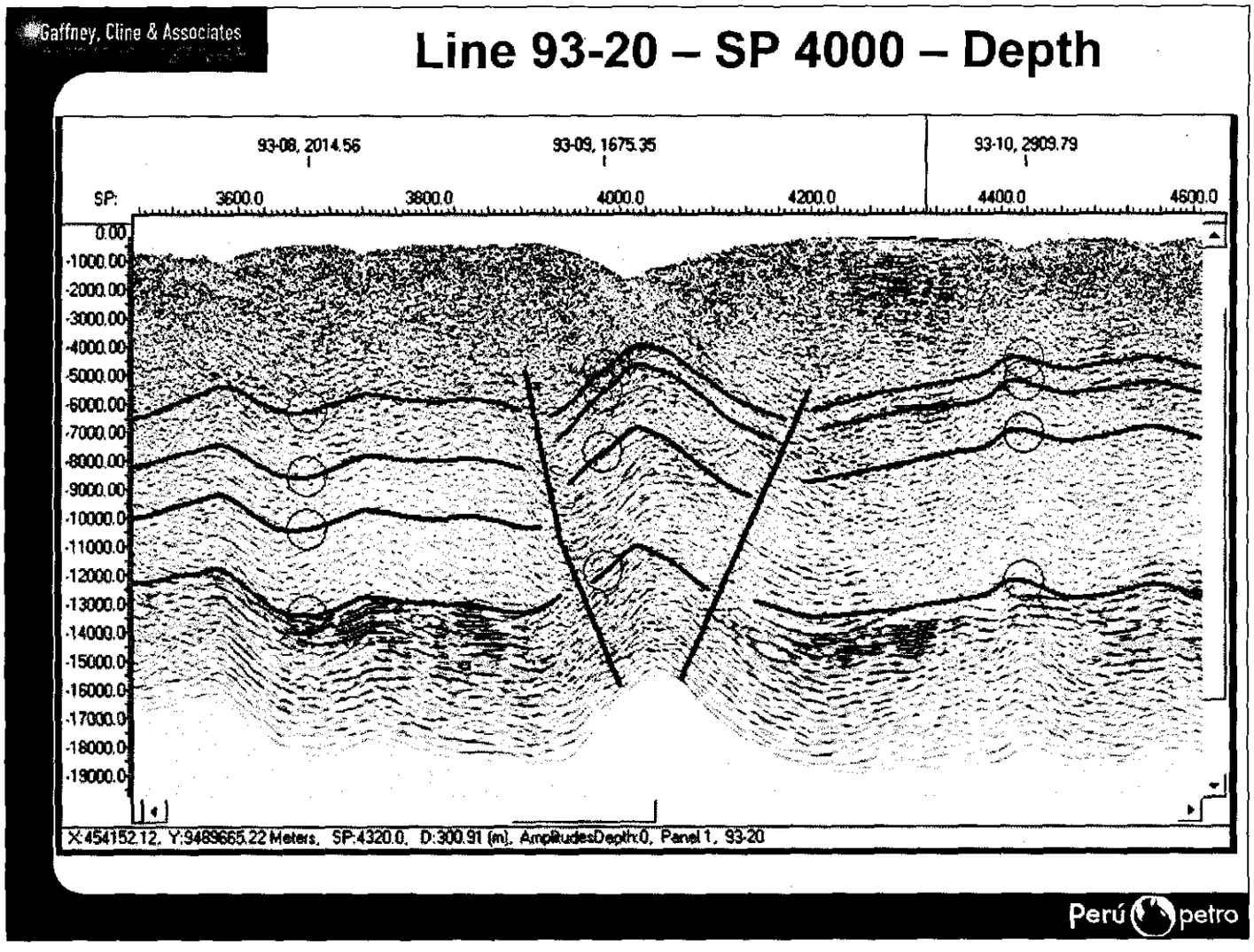
Gaffney, Cline & Associates

Line 93-20 – SP 6300-8300 – (south of 42)

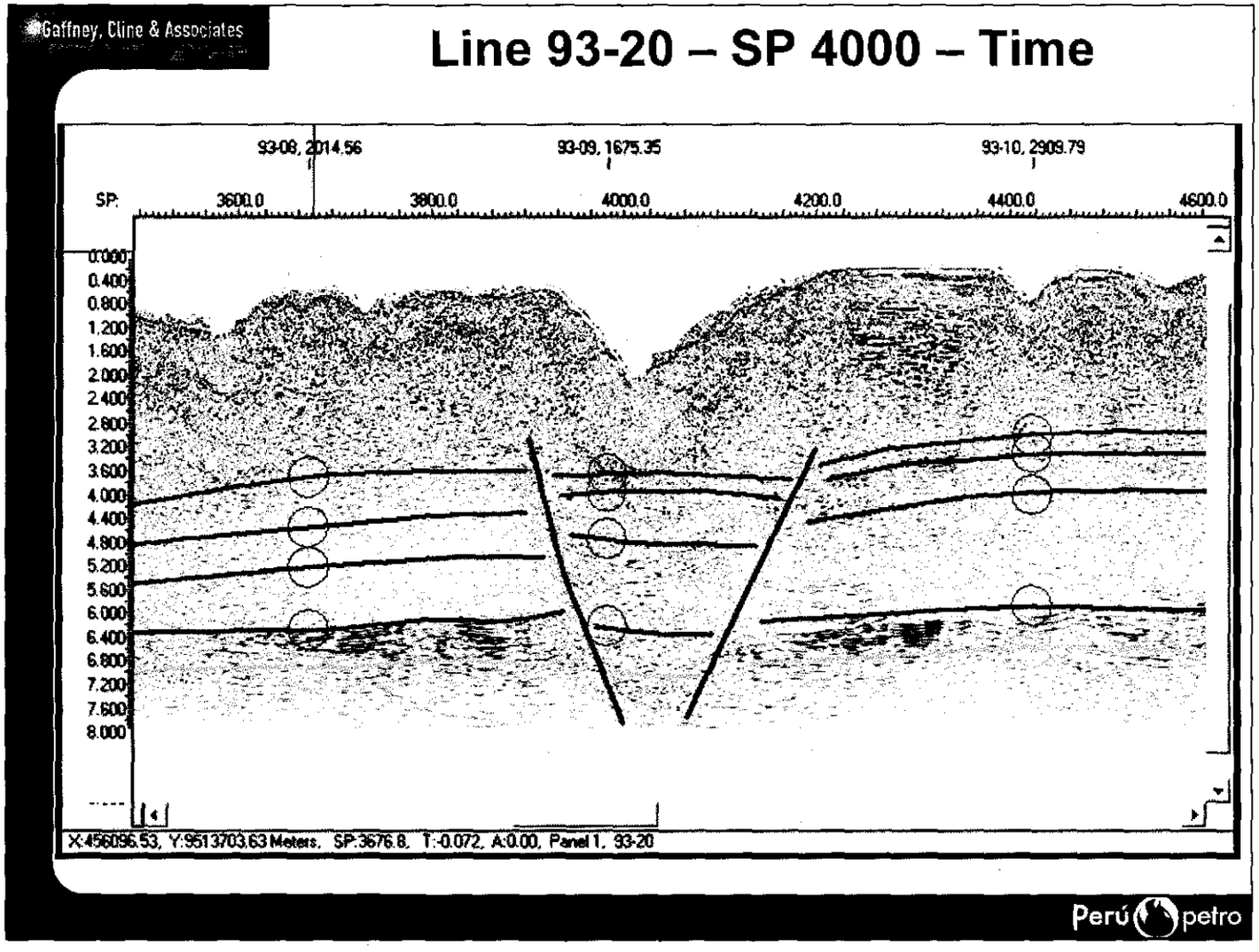


Perú petro

Continuation of previous slide.



Detail of depth conversion below canyon showing possibly bogus structure.



Detail of depth conversion below canyon showing possibly bogus structure. Combine with previous picture in one slide.

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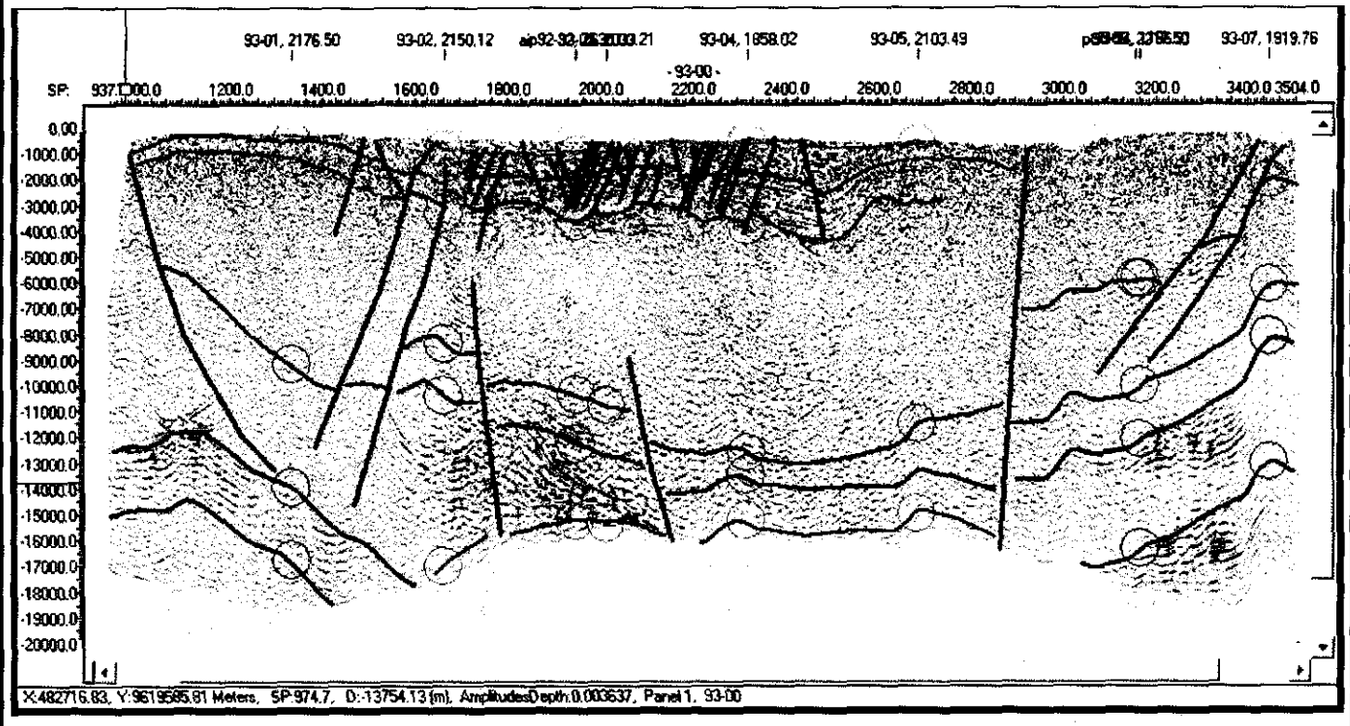
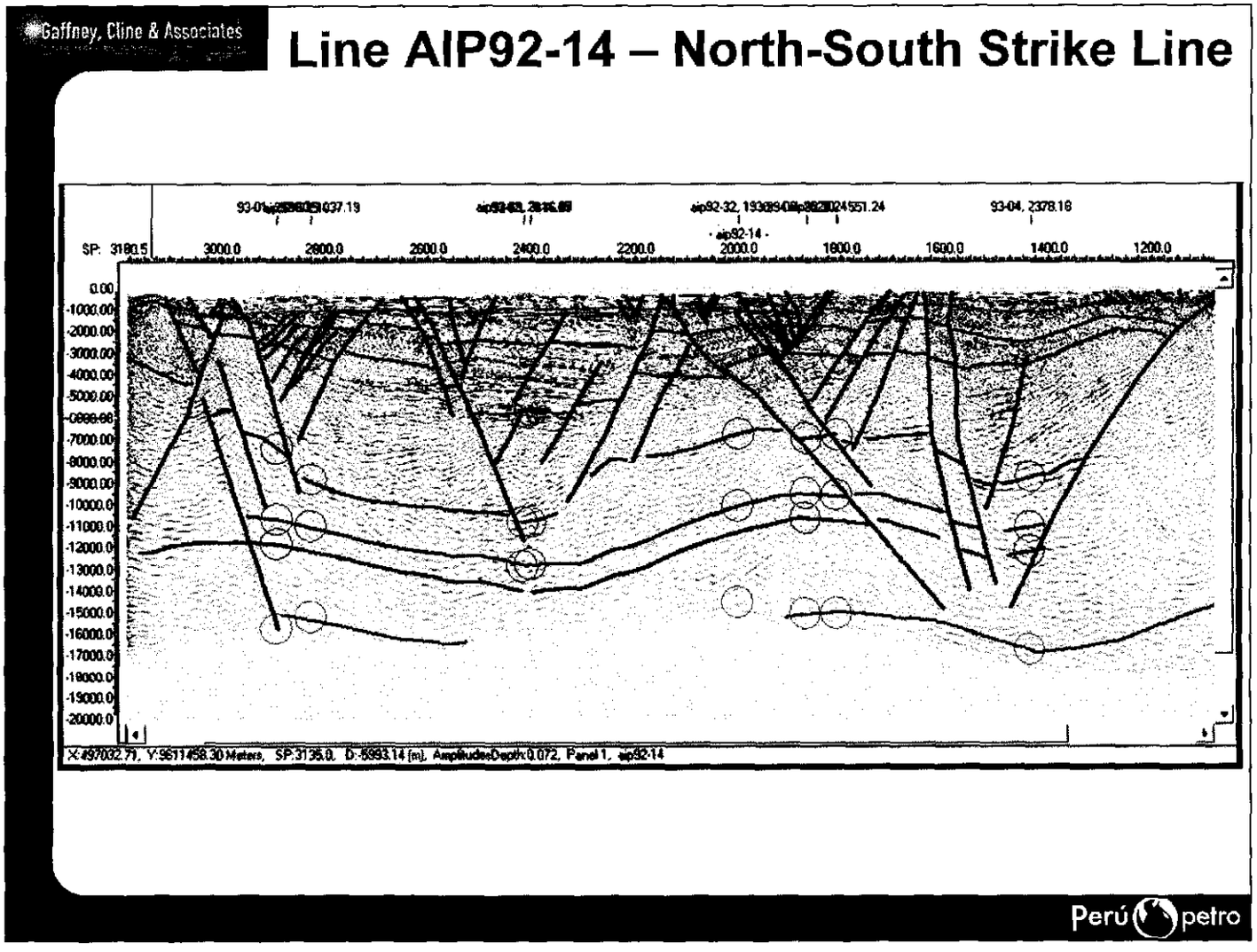
Line 93-00 – Strike Line

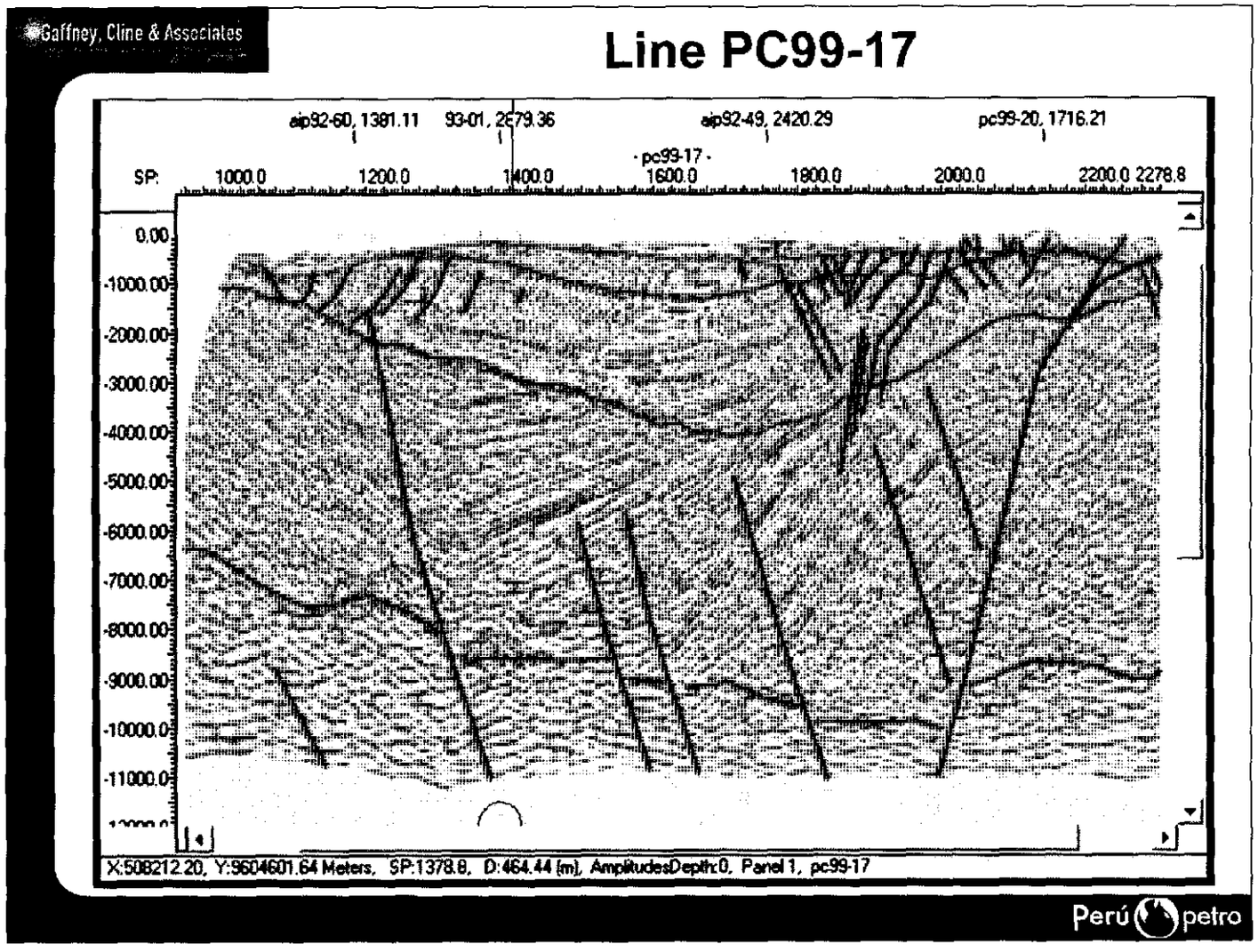


Perú petro

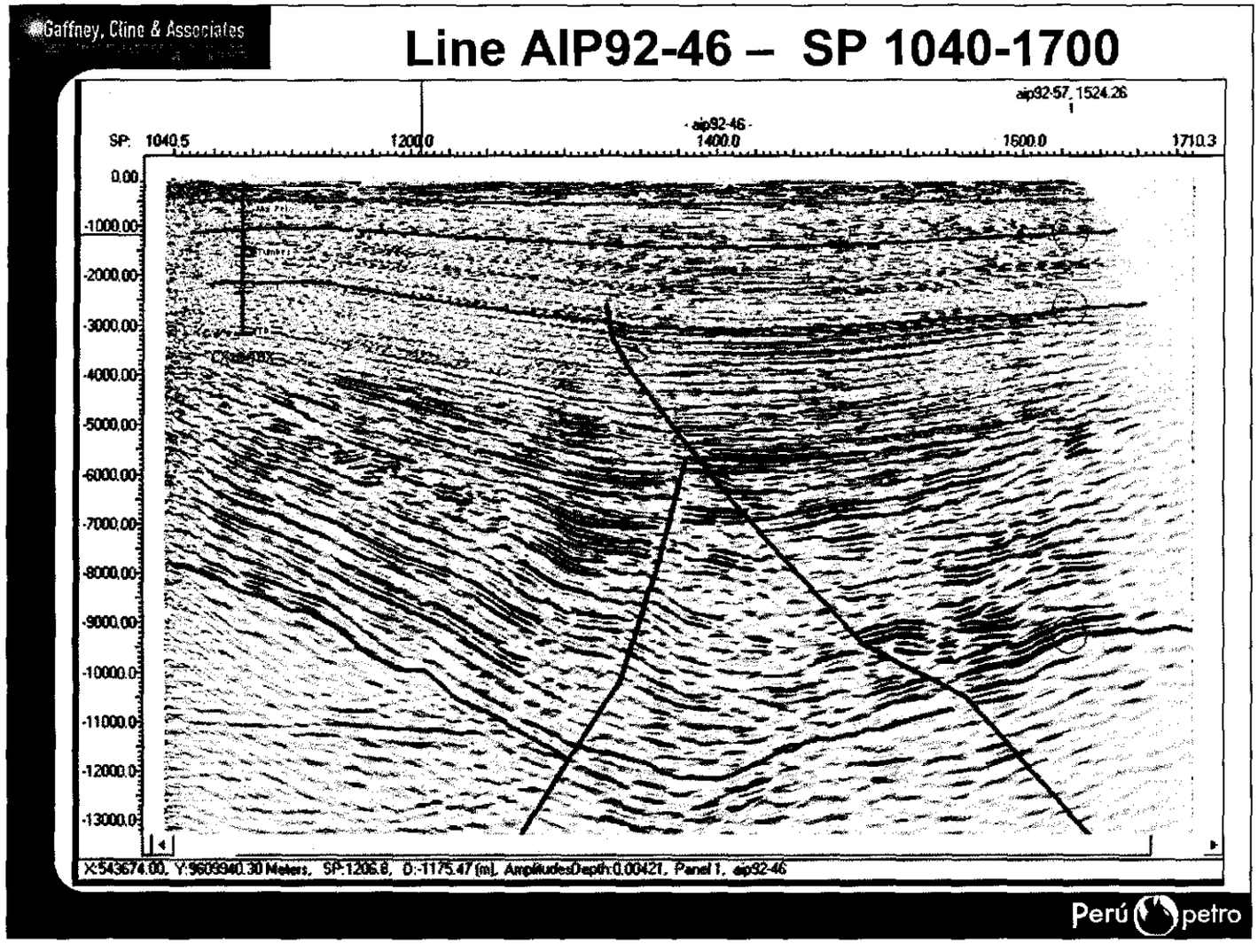
Underlain by oceanic crust in north from sp 937-1600, then transitional crust from sp 1600 to 2900, then continental from 2900-3500. Biggest feature is large thickness of Eocene sediment over the transitional crust



Tumbes basin. Underlain by transitional crust with possible Cretaceous subcrop, with same caveats as at end of 93-01 description. One reason for conjectural Cretaceous subcrop is Angel Callejon's belief that the oils in this area can be tied to a Cretaceous source. The alternative would be thick marine shale of Eocene or Paleocene age, with similar geochemical characteristics as if Cretaceous.



Illustrates fanning of dips onto base Eocene (Top Paleocene, red horizon 13). Could be that instead of a stratigraphic surface, that this is actually a fault, and that the Eocene section is detached, and has slid downdip along an old fault plane. Hickman saw this, and concurs.



Shows well tie, Eocene thick, faulted syncline, structures typical of area.

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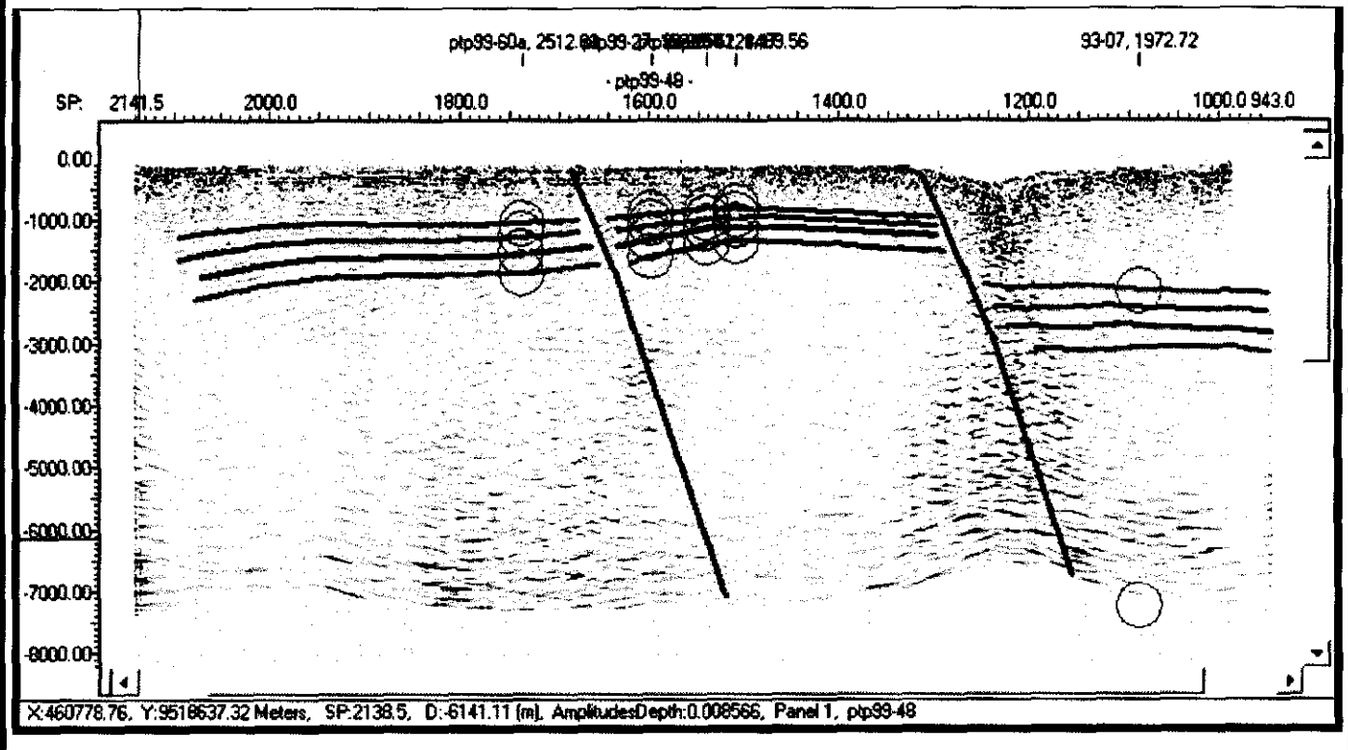
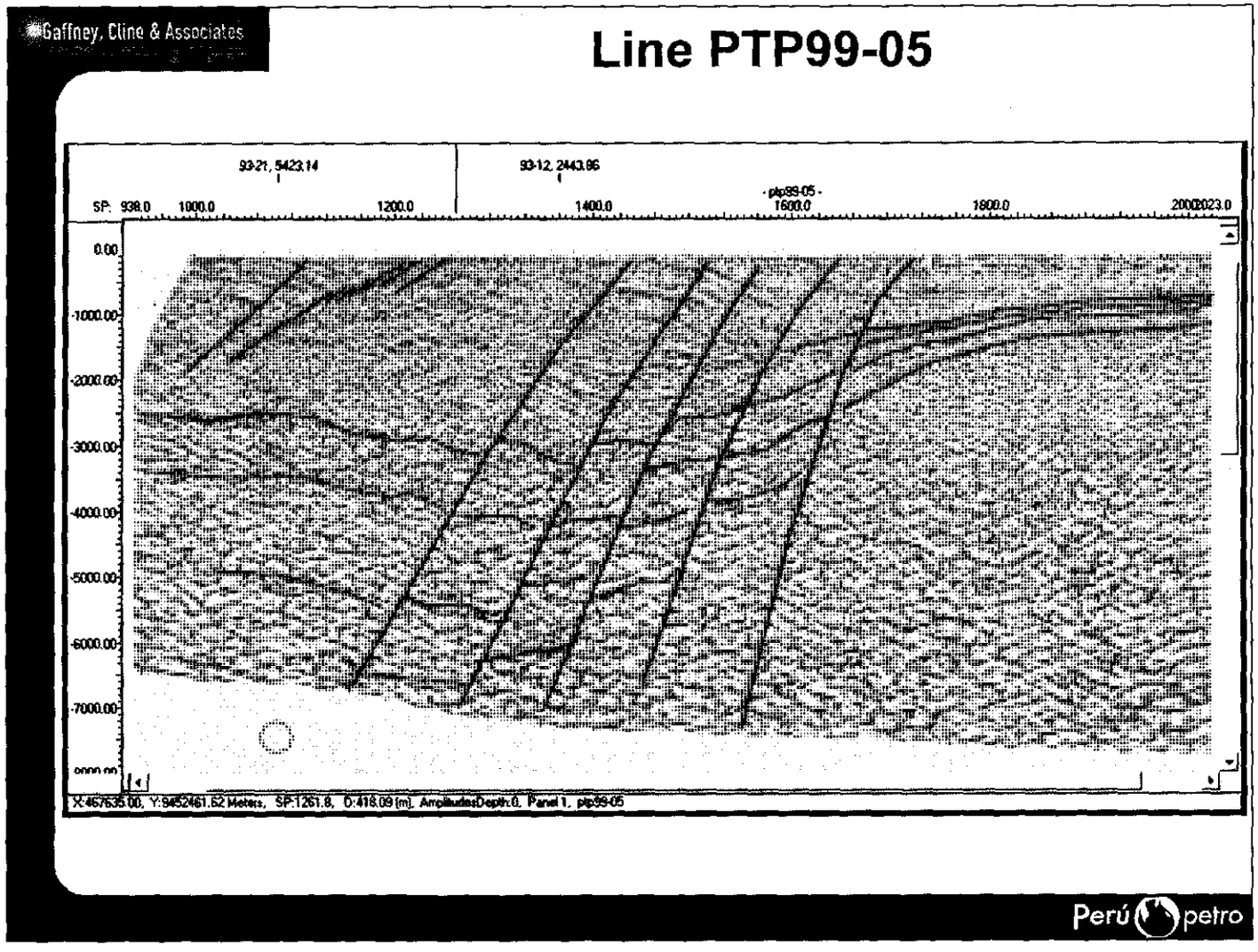
Line PTP99-48

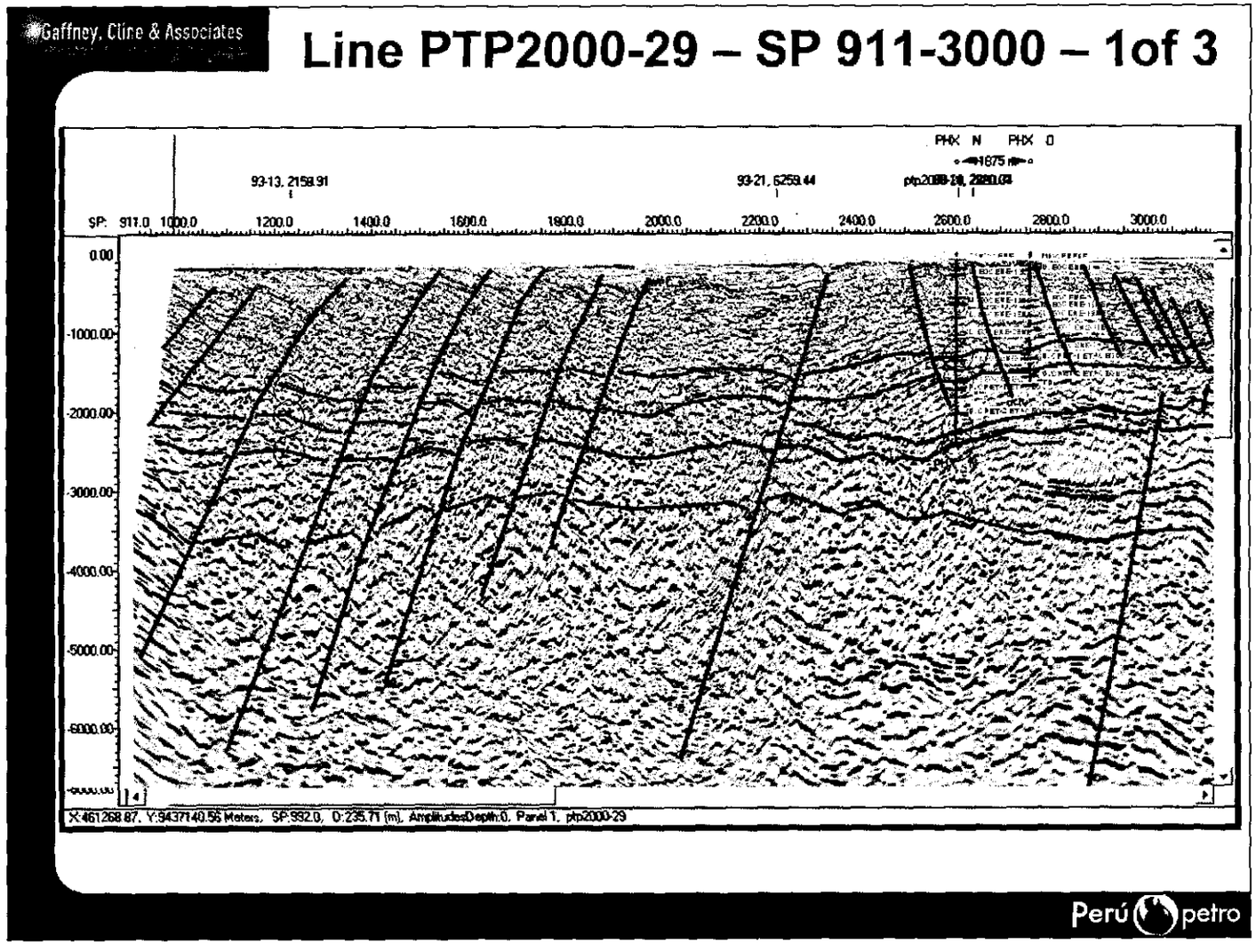


Perú petro

Shows faulted character of the Paleocene and older section.



NW to SE profile. Evidence of extensional tectonics in Talara basin.



Extensional tectonics effecting Cretaceous section in Talara basin. Evidence of inversion. Implication here is that you have thickening in the Paleozoic that is reactivated during deposition of lower part of the Cretaceous, so there is an inversion of Paleozoic extensional basins that is affecting Cretaceous basins. Cretaceous marker is dark green – speculatively assigned to the Muerto formation.

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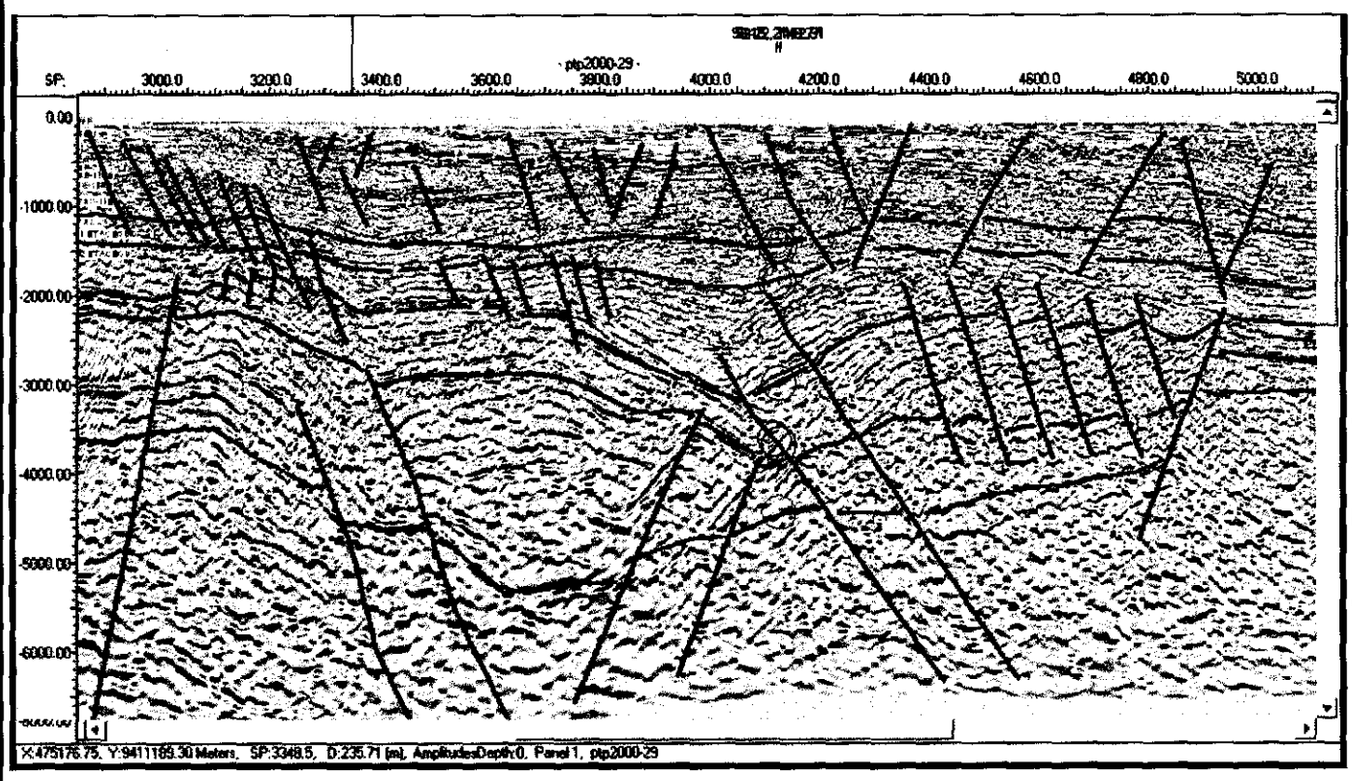
Line PTP2000-29 – SP 3000-5000 – 2of3



Perú petro

See slide 52 above.

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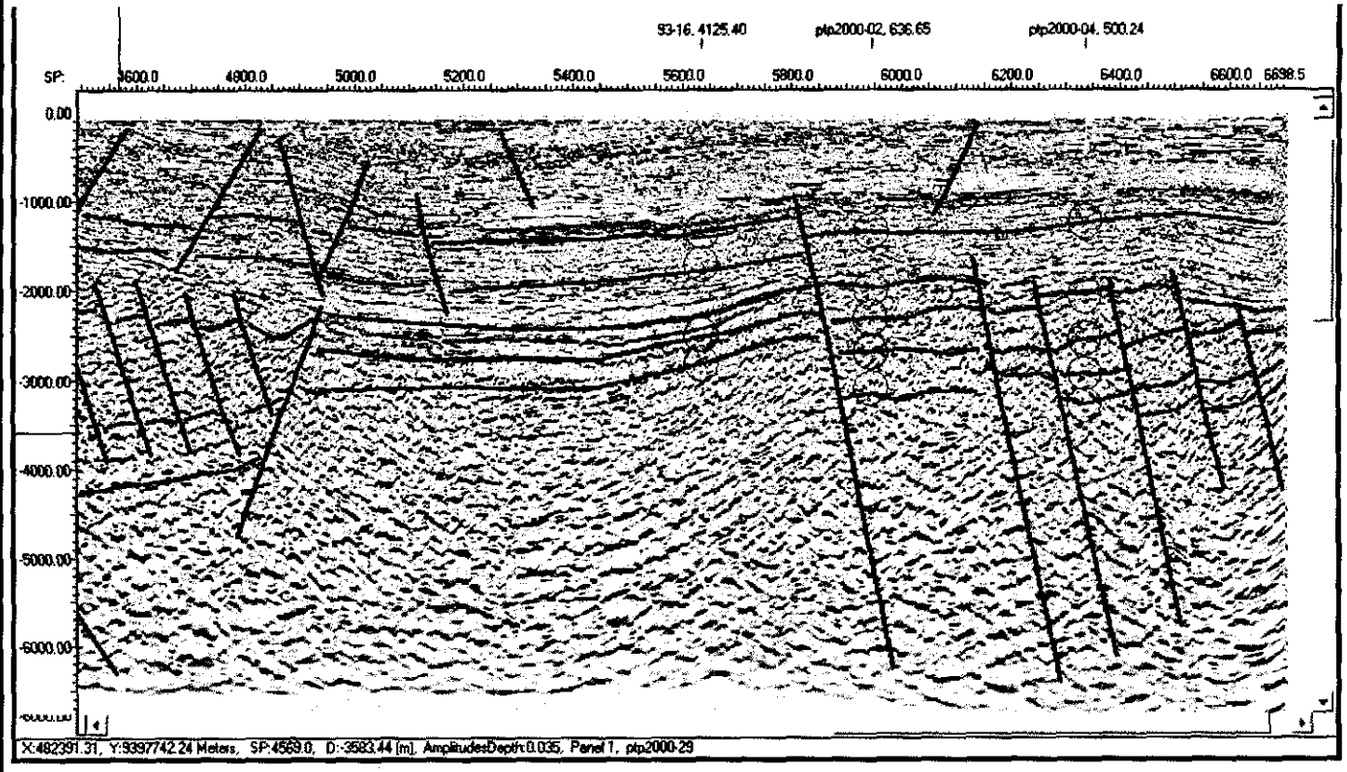
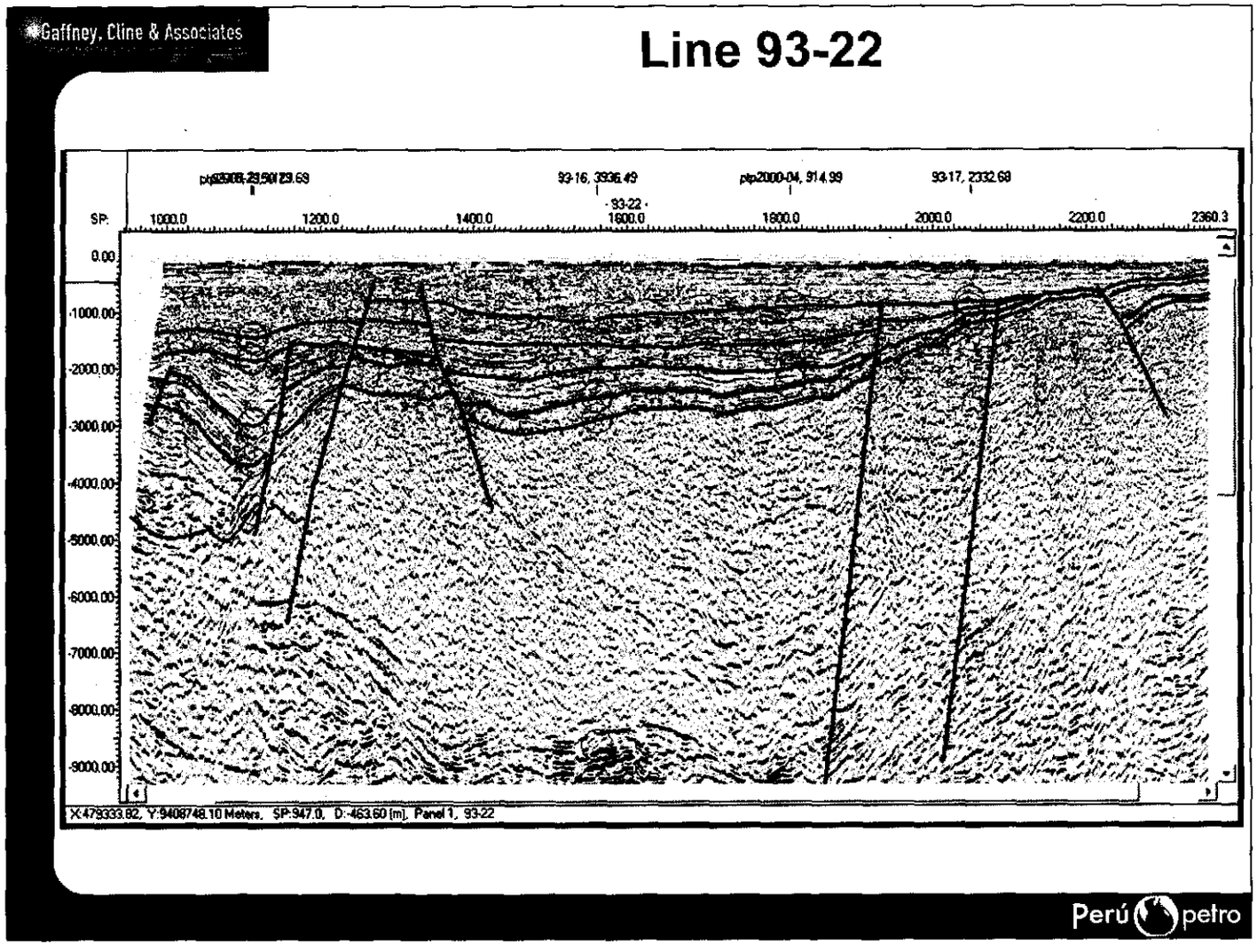
Line PTP2000-29 – SP 4600-6699 – 3of3



Perú petro

See slide 52 above.



Horst and graben structure at north end of line in southern Talara basin, involving Paleozoic and Cretaceous. Everything lapping out against basement high to south.

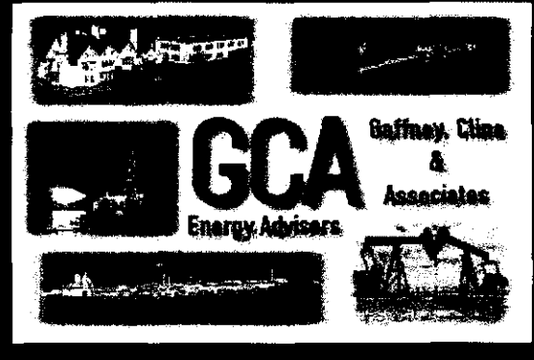
APPENDIX I

MATURATION MODELING

Gaffney, Cline & Associates

April 2005

Source Rock Geochemistry and Modeling of Thermal Evolution for Oil Generation



Perú petro

Gaffney, Cline & Associates

Data Summary: Reports

- Regional Petroleum Geochemistry of Crude Oils from Peru – Geomark, 1996
- Peru Trujillo Basin Block Z29, Source Potential and Geochemical Modeling – Repsol, 1996
- Block Z29M Offshore Peru Source Rock Characteristics, Maturity Modeling and Oil to Source Correlation - Repsol, 2000
- The Remaining Undiscovered Hydrocarbon Potential of the Trujillo Offshore Basin – PARSEP, 2001

Perú petro

Gaffney, Cline & Associates

Data Summary: More Reports

- Petrographic Report for Repsol Exploration Peru, LOBOS Z29M-9-1X Well Offshore Peru - Core Laboratories, 1999
- Petrographic Report for Repsol Exploration Peru, MORSA NORTE Z29M-37-1X Well Offshore Peru - Core Laboratories, 1999

Perú petro

Gaffney, Cline & Associates

Data Summary: Publications

- Echavarria et al (2003) – Subandean thrust and fold belt of northwestern Argentina: Geometry and timing of the Andean evolution AAPG v.87
- Jordan and Alonso (1982) – Cenozoic stratigraphy and basin tectonics of the Andes Mountains, 20°- 28° south latitude, AAPG, v.71
- Zúñiga et al, (2001) – Complex Hydrocarbon Reservoirs and Petroleum Systems of the Offshore Talara Basin, NW Peru, AAPG Annual Meeting

Perú petro

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Data Summary: Well Data

- Drilling and electric log reports for wells:
  - Morsa Norte 1X
  - Lobos 1X
  - Delfin 1X
  - Ballena 1X
  - 10 Wells from Offshore Drilling Project (ODP), Leg 112 -- 1986

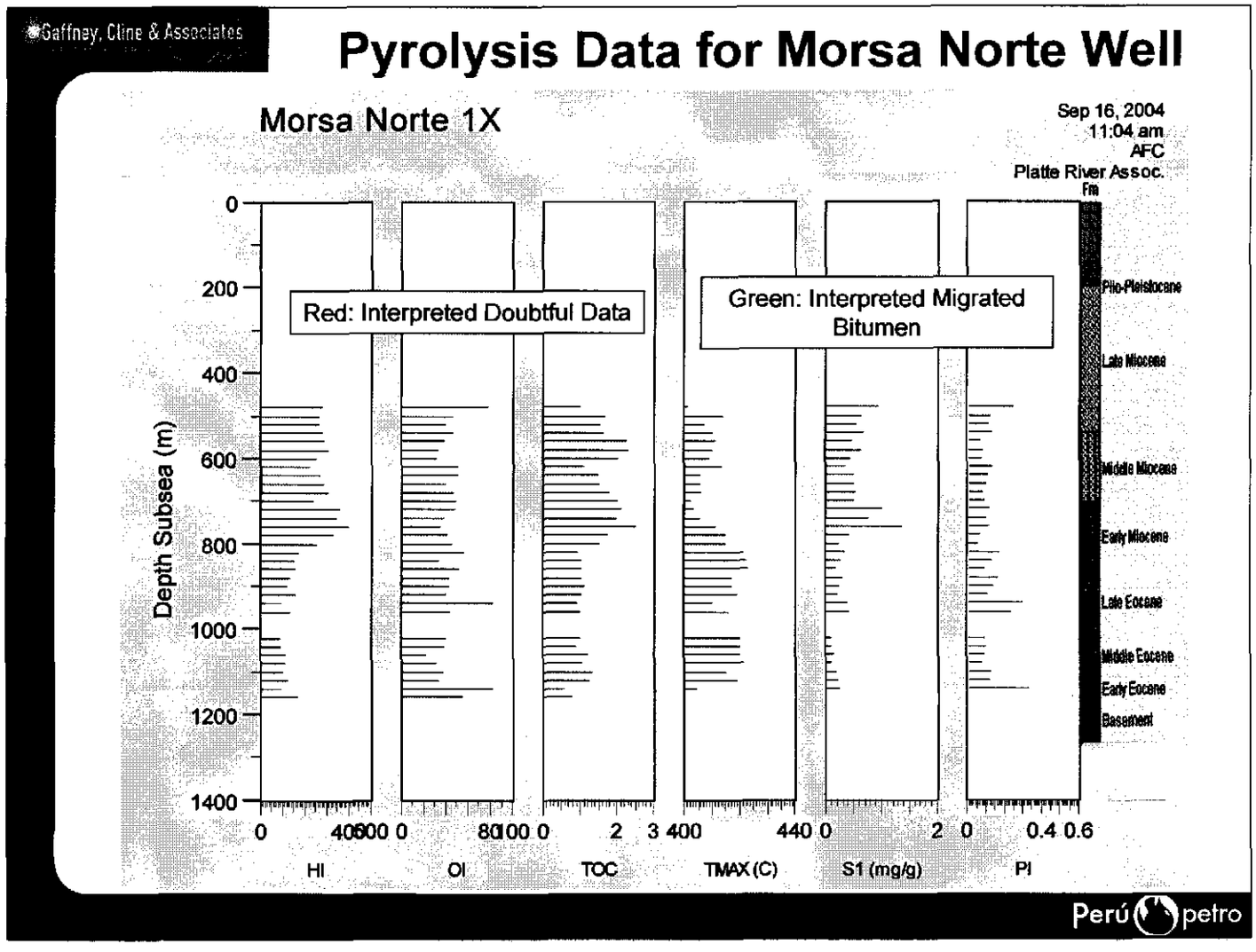
Perú petro

Gaffney, Cline & Associates

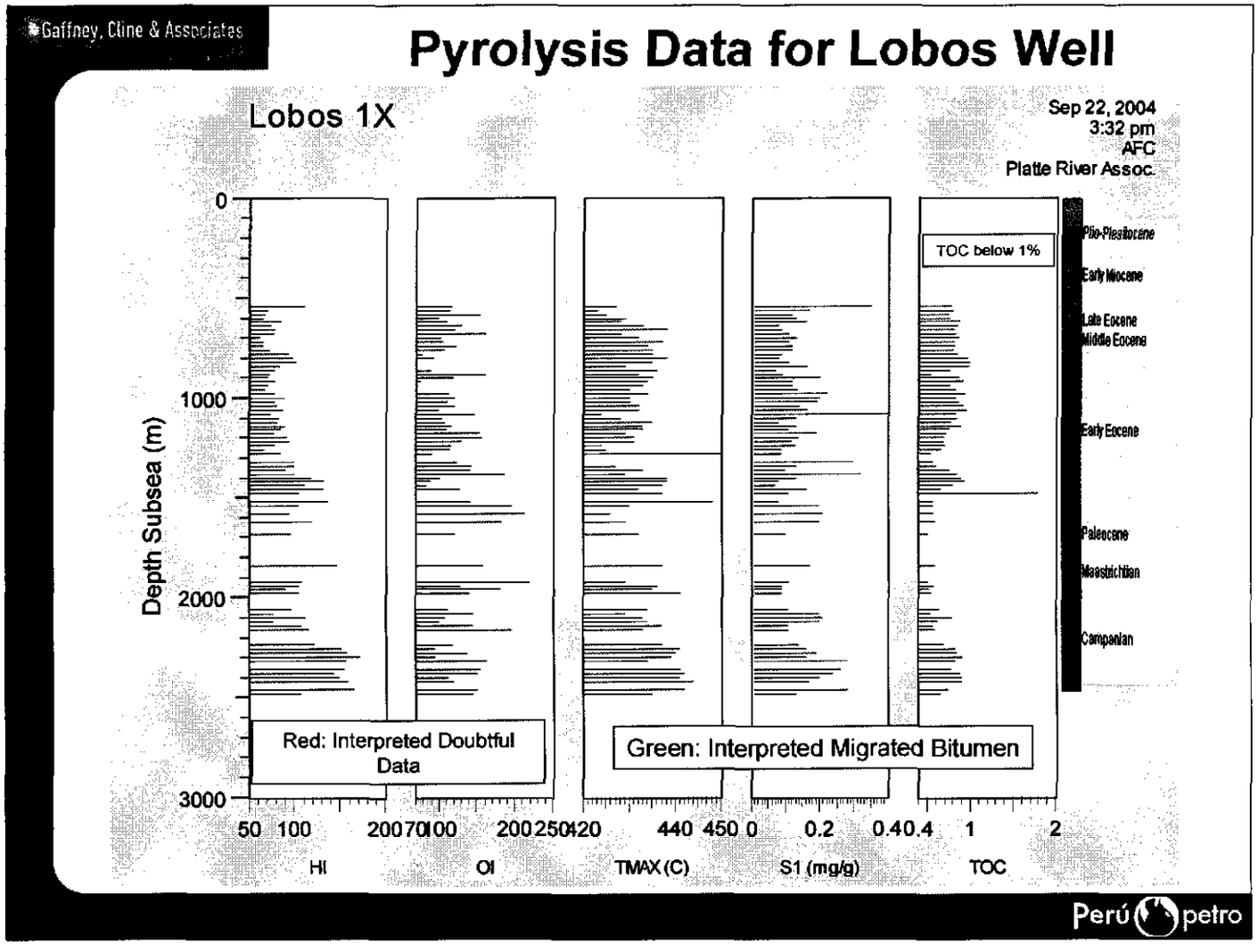
Section 1: Review of the Compiled Geochemical Data

- Pyrolysis Rock Eval
- Wet chemistry in oils and impregnated bitumens
  - Whole oil gas chromatography
  - Biomarkers
    - Terpanes
    - Steranes

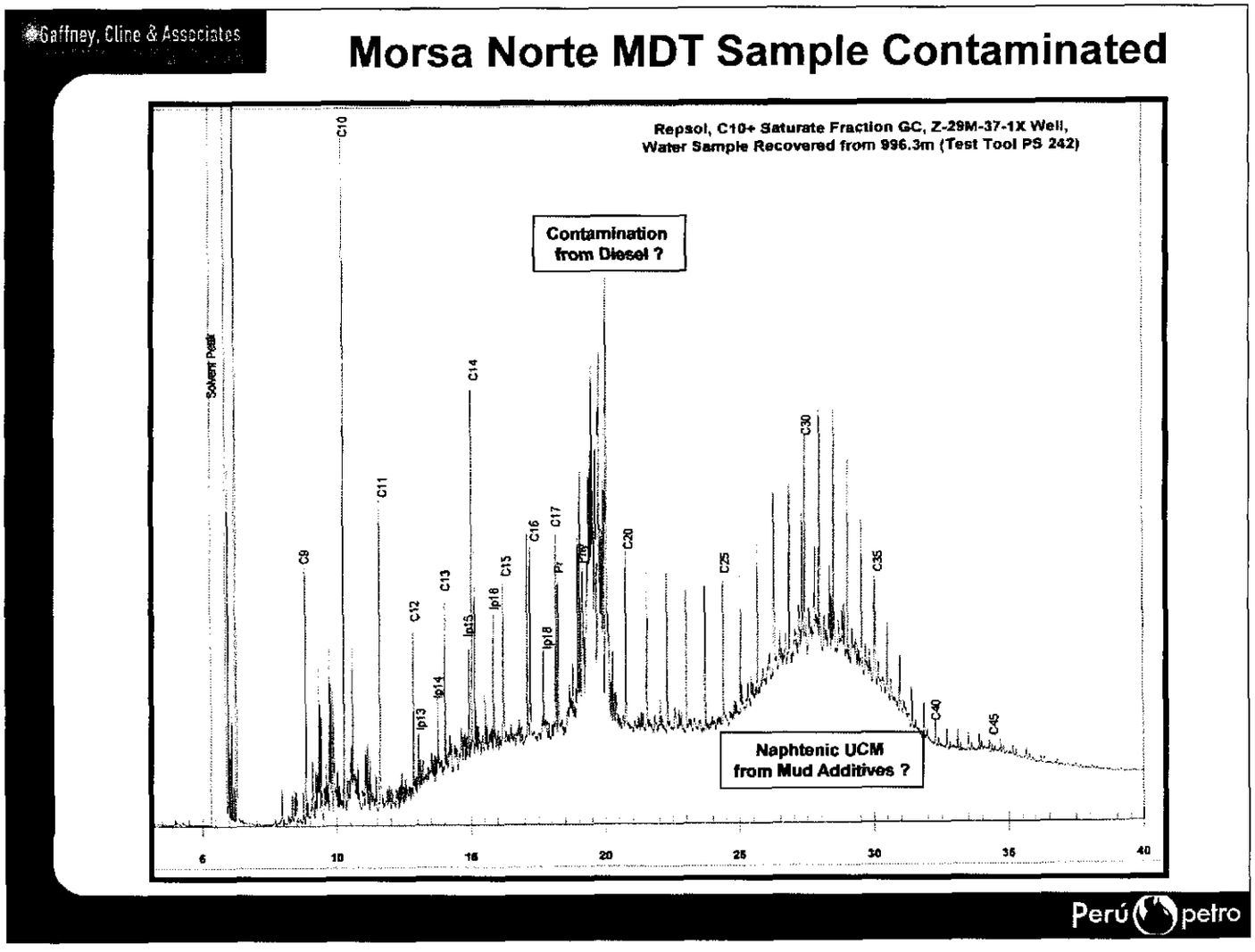
Perú petro



Geochemical data reported for Morsa Norte 1X were filtered using the REESA rules (Nelson and Peters - 1992), and loaded into the BasinMod software. Red bars are data that may be biased by analytical problems intrinsic to the methodology. Green lines correspond to data interpreted as migrated oil by the REESA rules. Migrated bitumens were identified at Early and Middle Miocene intervals.



Geochemical data reported for Lobos 1X was filtered using the REESA rules by (Nelson and Peters - 1992), and loaded into the BasinMod software. Migrated oil appears in Campanian, Paleocene/Early Eocene and Early Miocene intervals.



Sample recovered from Morsa Norte MDT at 996.3m seems to be affected by an external source of some kind of oil-like substance that appears as a cluster of peaks around the 20min signal. Any interpretation derived from this sample may be erroneous.

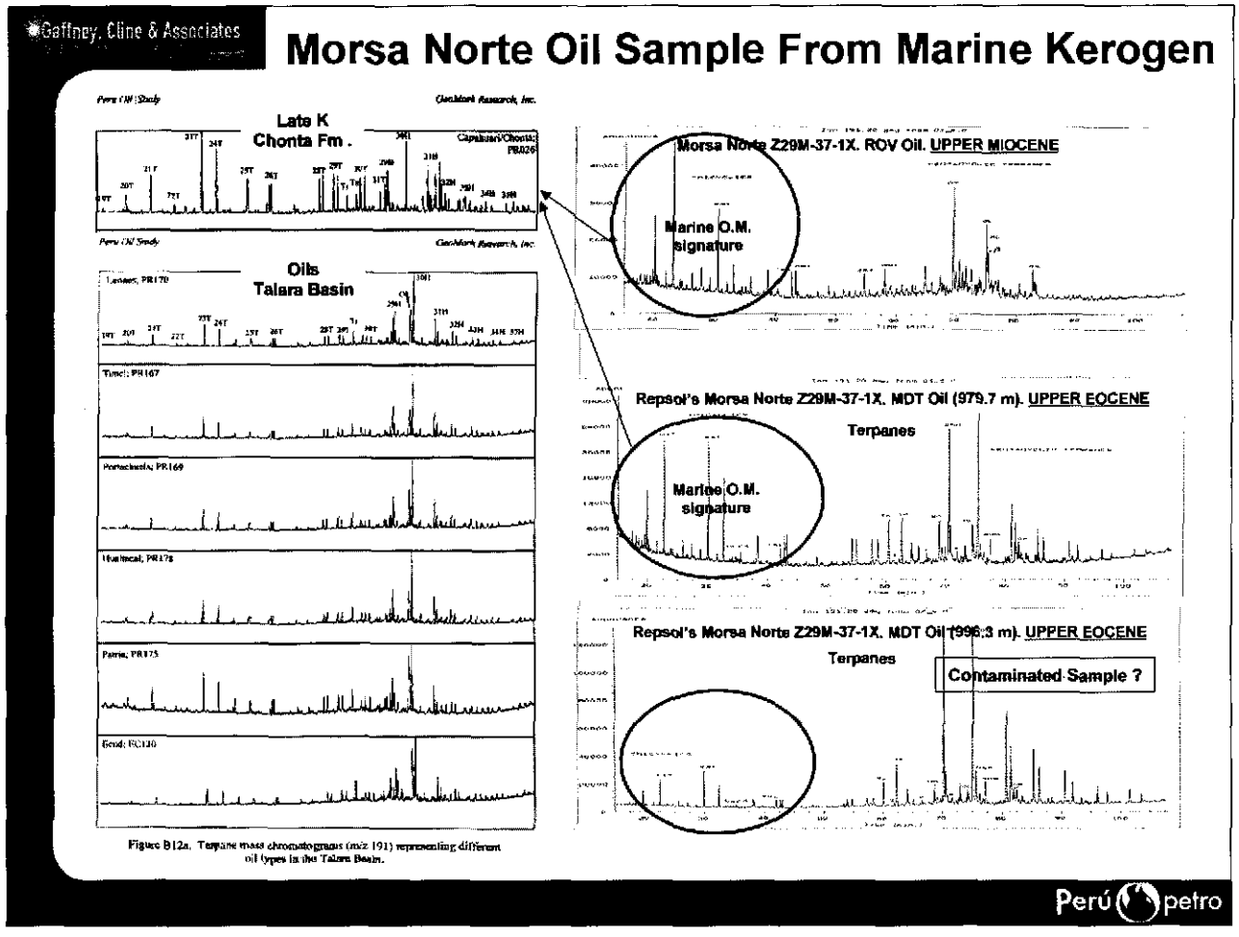
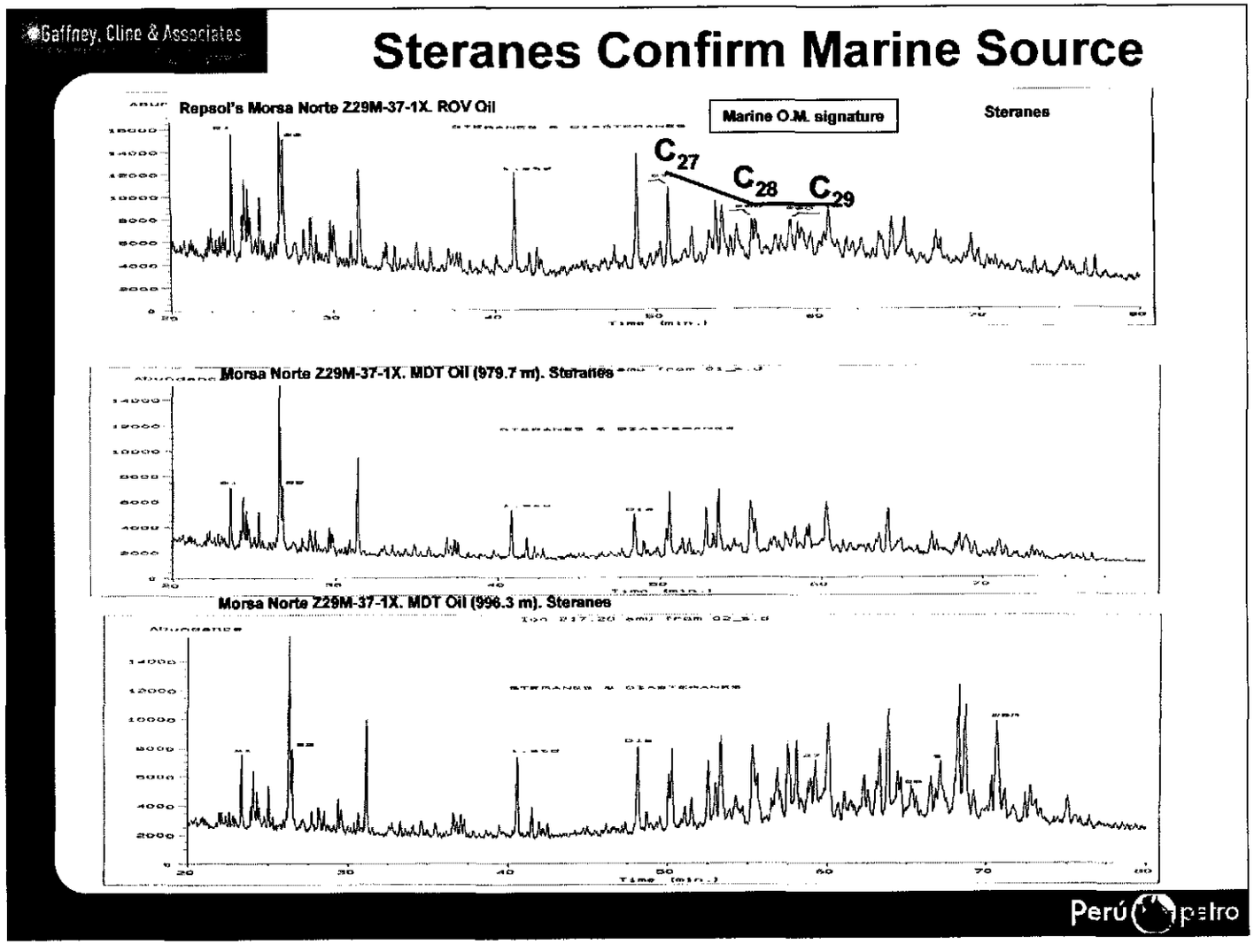


Figure B12a. Terpane mass chromatograms (m/z 191) representing different oil types in the Talara Basin.

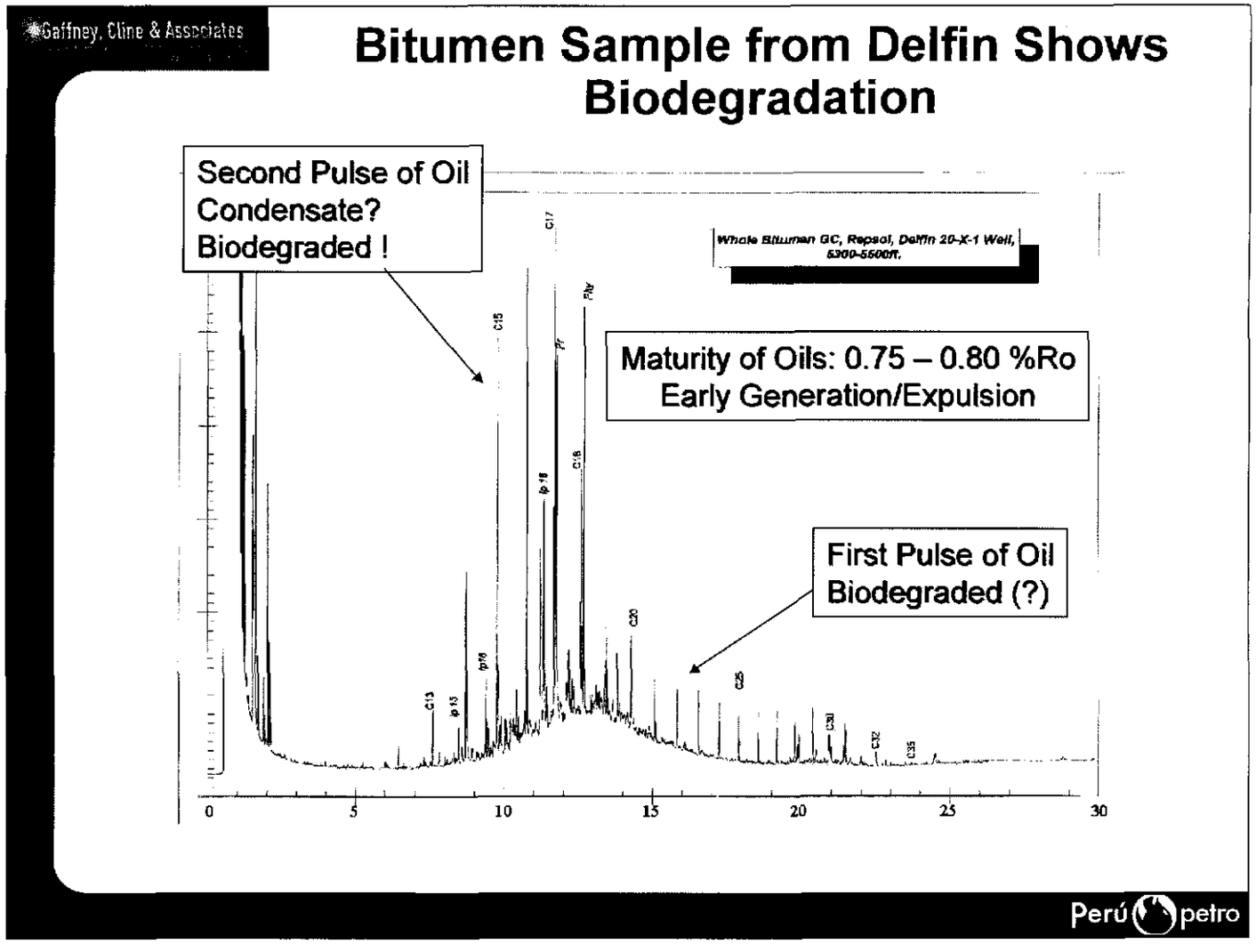
Data from the Terpanes distribution (a biomarker family) from oils recovered during the perforation of Morsa Norte 1X indicates the presence of marine organic matter in the kerogen that originates those oils, based on the high signal from tricyclic Terpanes highlighted by the red circles. For the first two samples this statement is true but not on the sample recovered from MDT at 996.3 meters. This sample seems to be affected by and external, anthropogenic, source of oil mixed with the natural hydrocarbon as can be appreciated in the gas chromatogram of the whole oil in the insert and detailed in the previous figure.

The reported presence of *Oleannane*, a biomarker derived from flowering plants, is an indication of some supply of organic matter from the continent to the final kerogen mixture.

A comparison of the Terpane distribution between the samples recovered from Morsa Norte 1X and sample reported for the Talara Basin by Geomark, as well as a sample from the late Cretaceous Chonta Formation indicates that samples in Talara basin may have a source with facies changes from more marine to more terrigenous organic matter, but Chonta bitumen is definitively sourced from marine kerogen. The natural samples from Morsa Norte 1X correlate better with a marine kerogen similar to the one in Chonta Formation.



Sterane distribution in the same set of samples also indicates an origin from a source rock containing marine kerogen as indicated by the distribution of the C27 to C29 steranes. Usually, a high proportion of C29 sterane is a clear indication of terrigenous organic matter.



The bitumen sample recovered during the drilling of the Delfin 1X well indicates that the reservoir was filled with oil that was biodegraded with a second pulse of light oil/condensate that was also biodegraded in the reservoir. Reservoirs below the isotherm of 80C can be affected by biodegradation if the conditions are adequate in terms of bacteria and nutrient supply from the hydrogeological cycle. This is a clear indication that biodegradation is a risk to consider in the exploration of the area.

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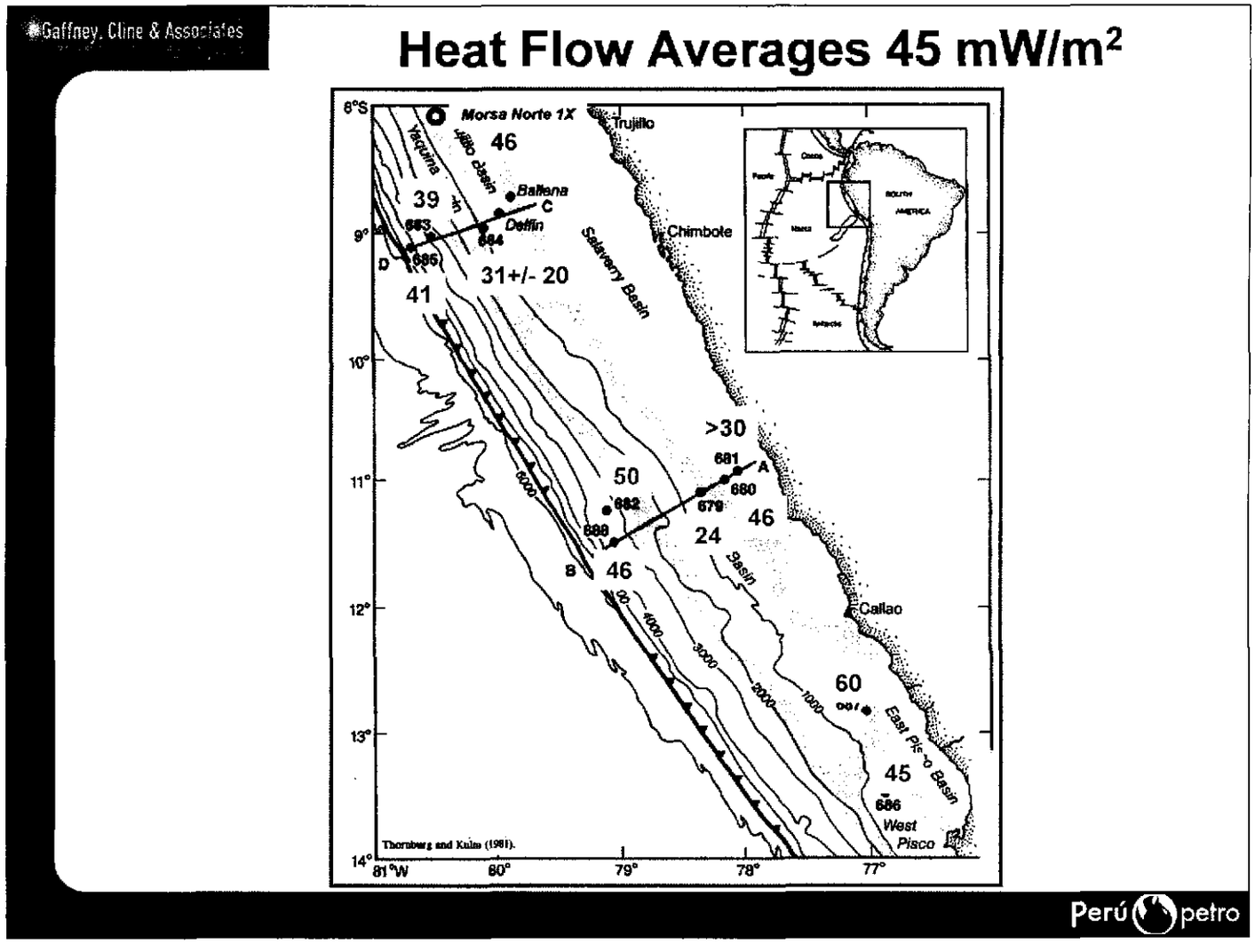
Section 2: Thermal Evolution of the Basins

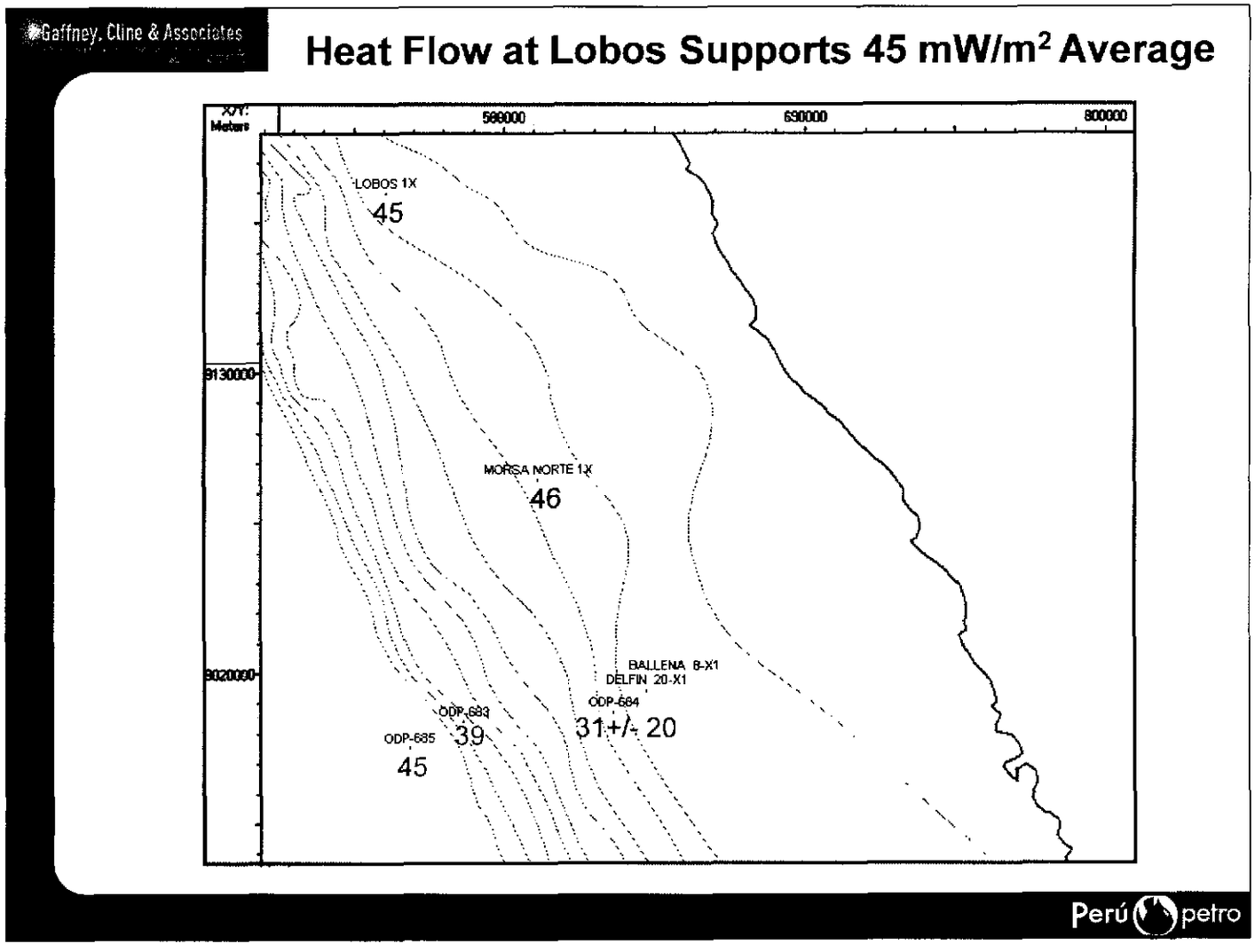
- Review of available data
- Calibration of compaction from selected lithologies for the basins
- Calculation of heat flow from temperature measurements and lithologies
- Calibration of maturation parameters
  - Vitrinite Reflectance (%Ro)
  - Pyrolysis Tmax

Perú petro

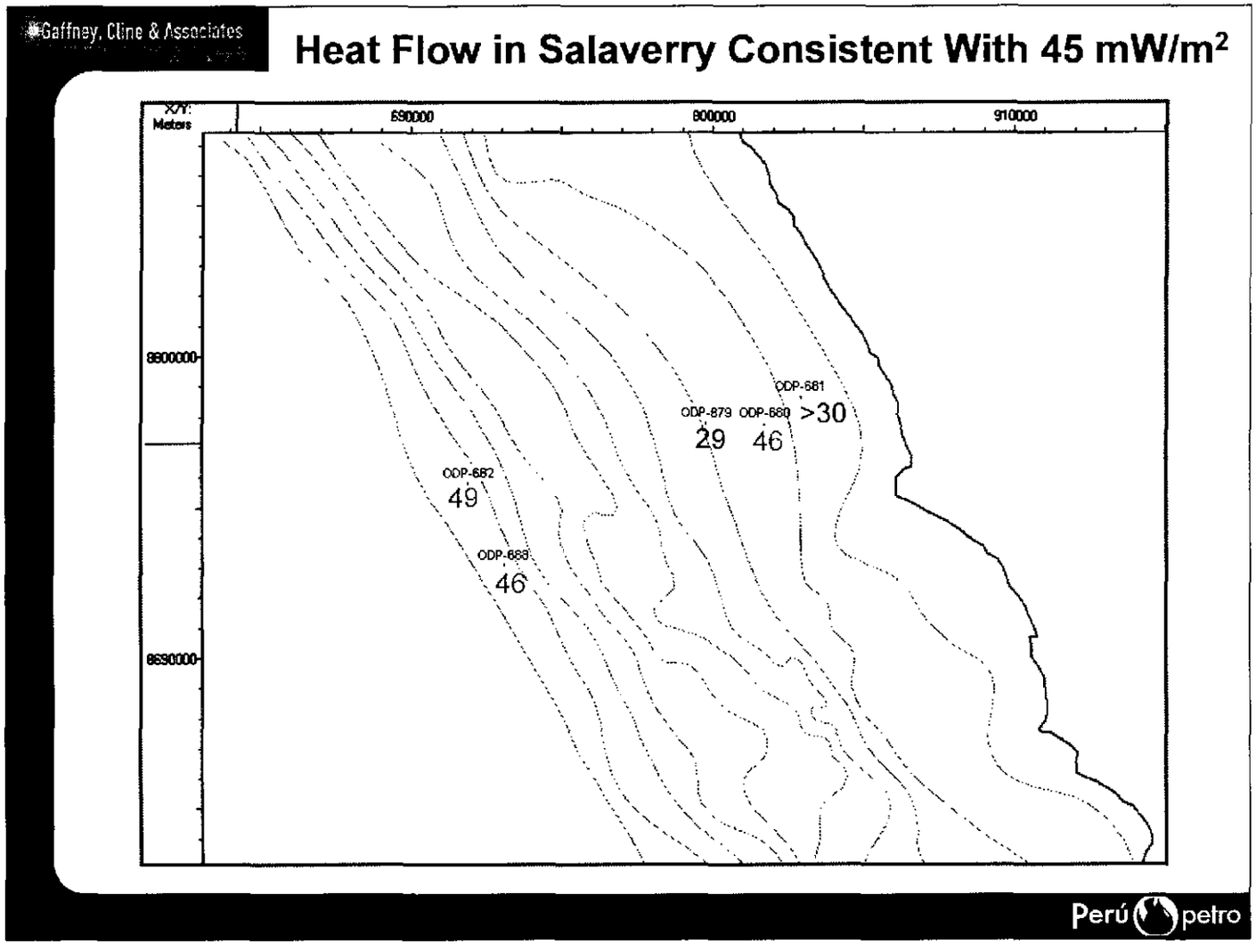


Heat flow from the ODP data shows a consistent value around 45 mW/m2 (values in blue). Data in red represent the reported data, which is uncertain due to technical problems in the acquisition of the raw heat flow data.

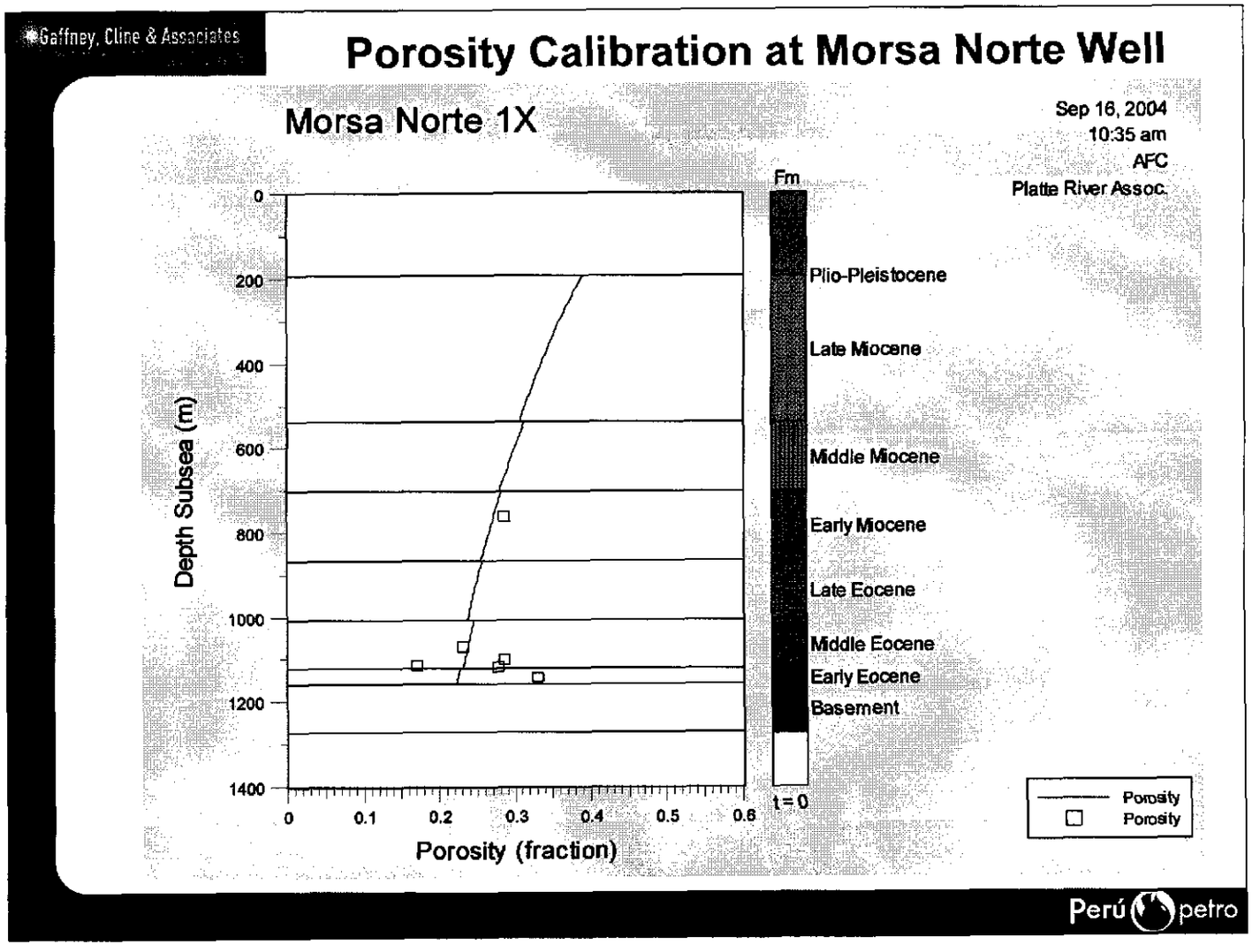
The green values were derived from this study.



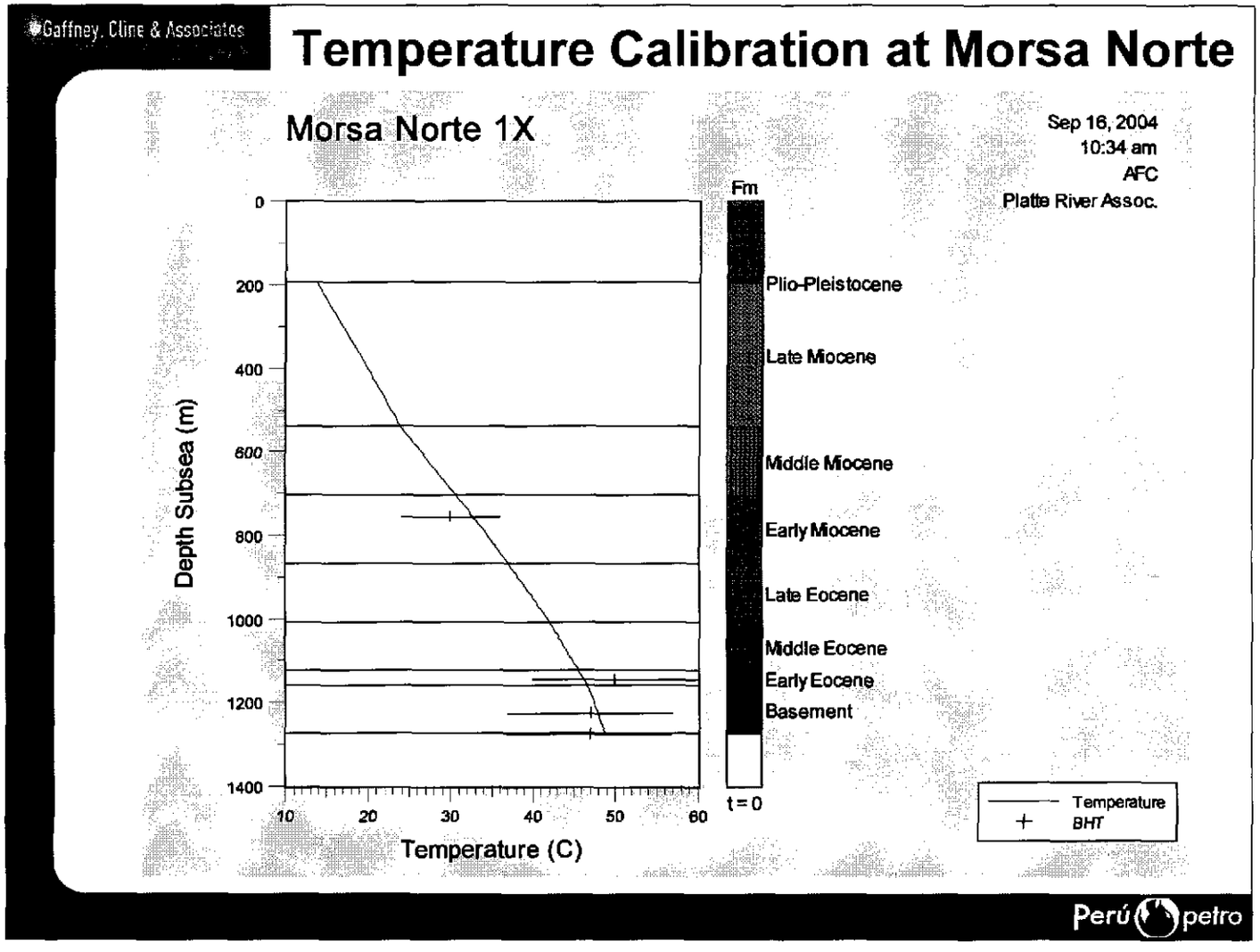
Heat flow calculated in this study from the Lobos 1X well was consistent with the 45 mW/m2 regional average.



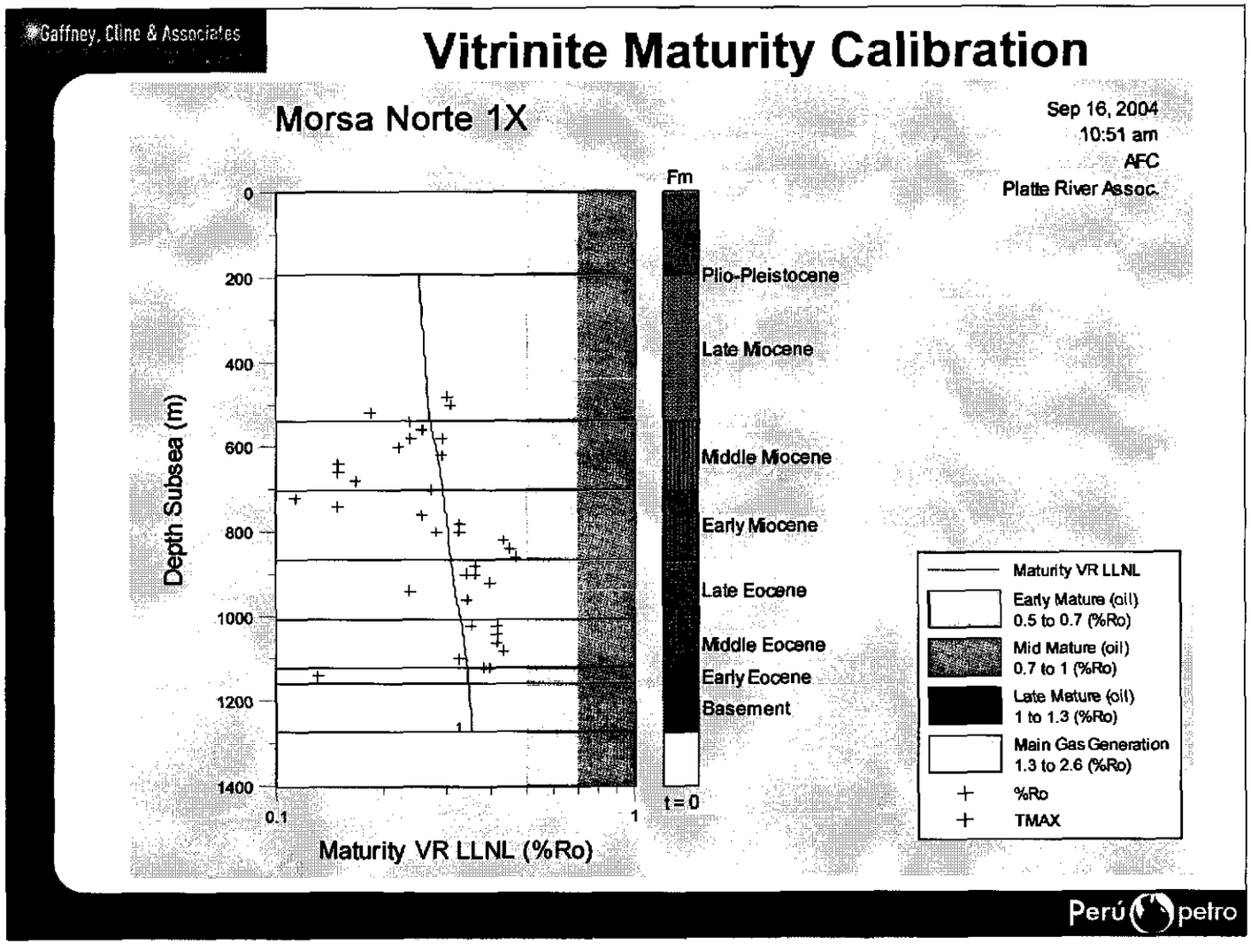
Heat flow data at the south end of the Salaverry basin are also consistent with the 45 mW/m2 regional average.



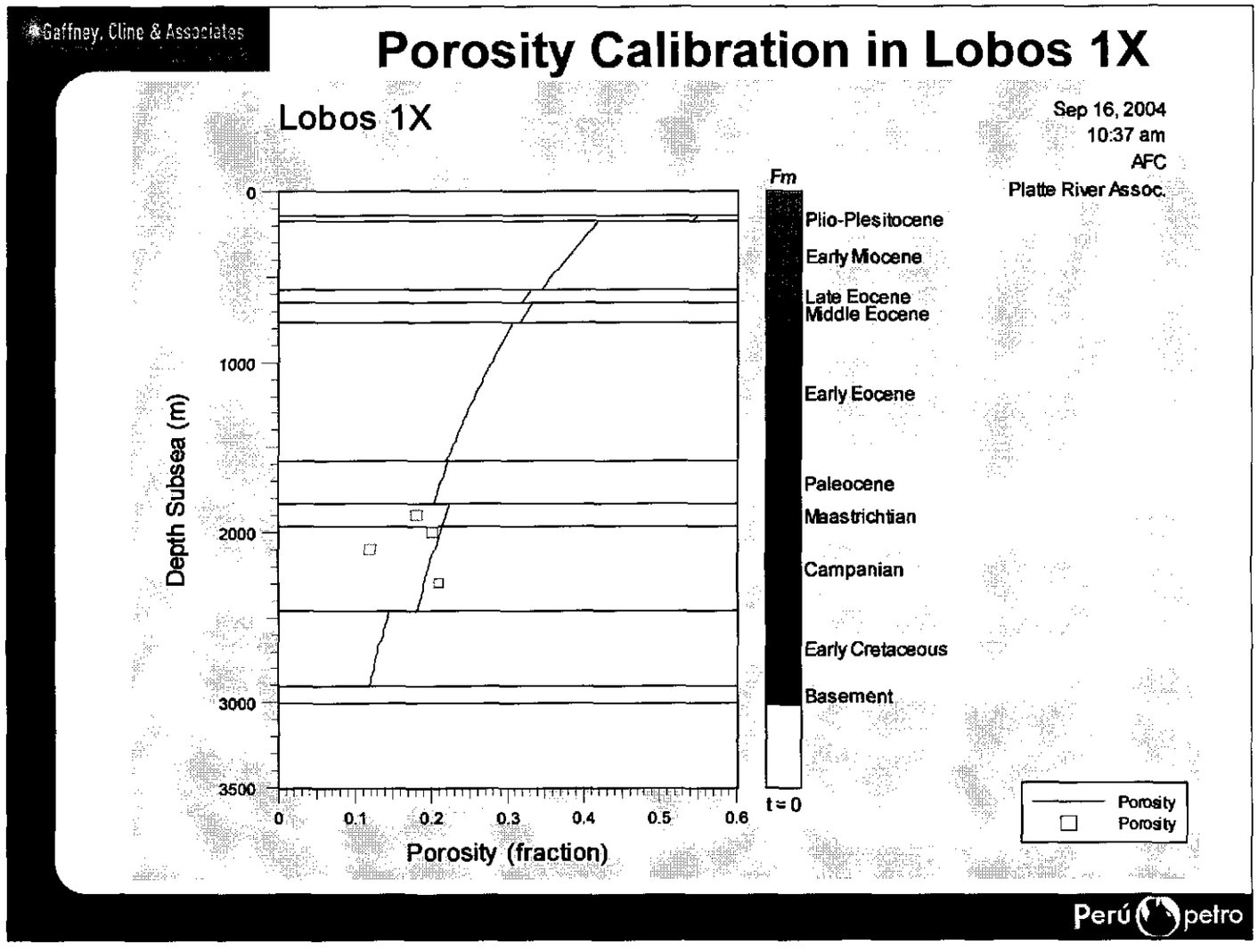
A calibration curve for porosity behavior with compaction. Deviations can be associated with diagenesis in the rock.



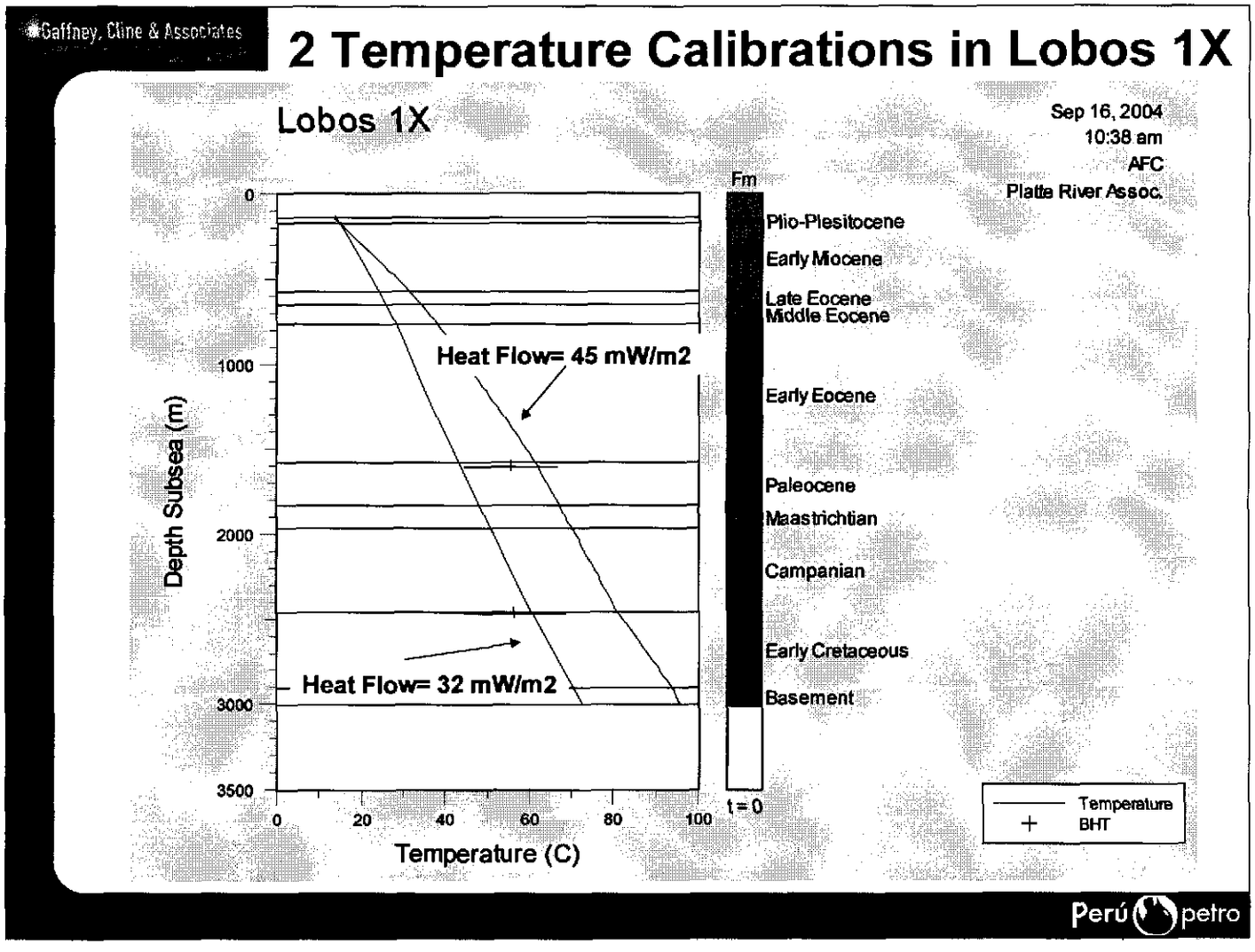
Calibration curve of temperature vs. depth showing a good fit of the BHT data in crosses and calculated data in red line.



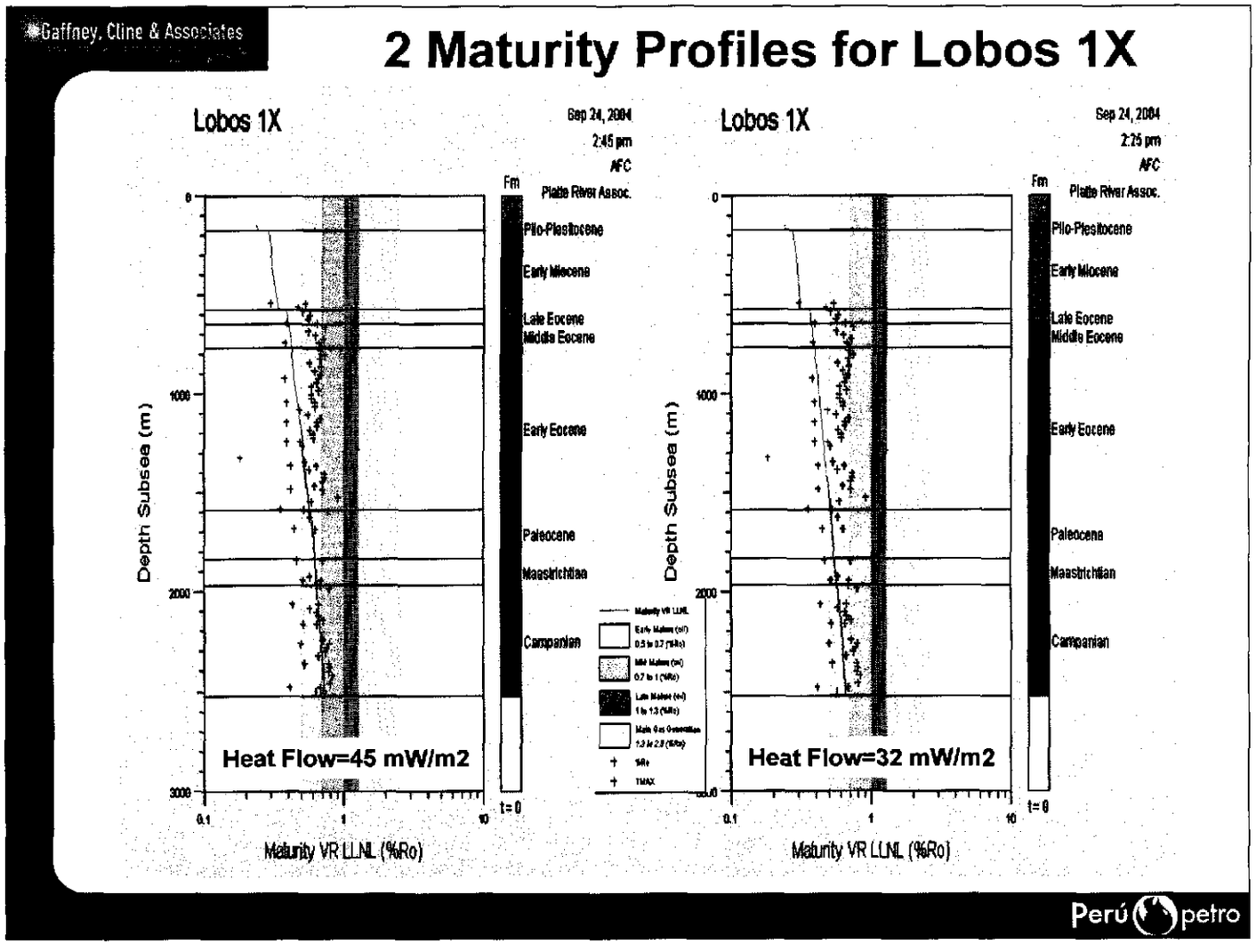
Maturity adjustment of the measured data (crosses) and calculated data showing a good adjustment with the vitrinite profile (red crosses). Tmax (blue crosses) maturity index shows more dispersion compared with the vritrinite data.



A calibration curve for porosity behavior with compaction. Deviations can be associated with diagenesis in the rock.



Two different values for BHT's were collected for the heat flow from electric logs. A first attempt to fit the data indicates a heat flow of approximately 45 mw/m2. A second run forcing a calibration on the deeper temperature gives 32mW/m2 for the heat flow. The next figure compares the impact of those measurements on the maturity estimates.



The run on the left was calculated with a heat flow of 45 mW//m2 with BHT and lithologies from the well, which is considered a good estimation for offshore Peru. The model run with only 32mW/m2 produced a maturity profile that is only slightly less mature. Therefore, for this study a value of 45 mW/m2 was assigned to the area, which is compatible with data obtained from the ODP studies.

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Section 3: Selection of Kerogen Type for Modeling Oil Generation

- **Geochemical data indicates:**
  - **Low Sulfur oils – probably a non-carbonate source rock**
  - **Marine organic matter input, derived from biomarker interpretation**
  - **Some contribution from terrigenous sources may flavor the kerogen facies distribution**
  - **Oil maturation level around 0.75 – 0.8 %Ro equivalent derived from biomarker interpretations**

Perú petro

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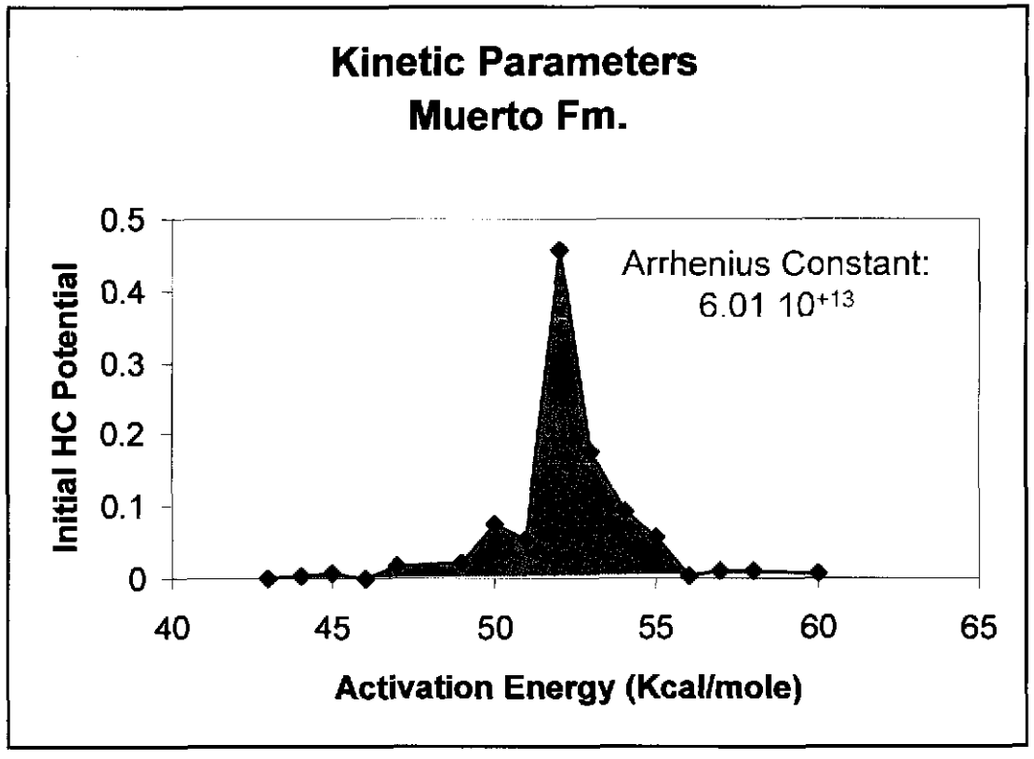
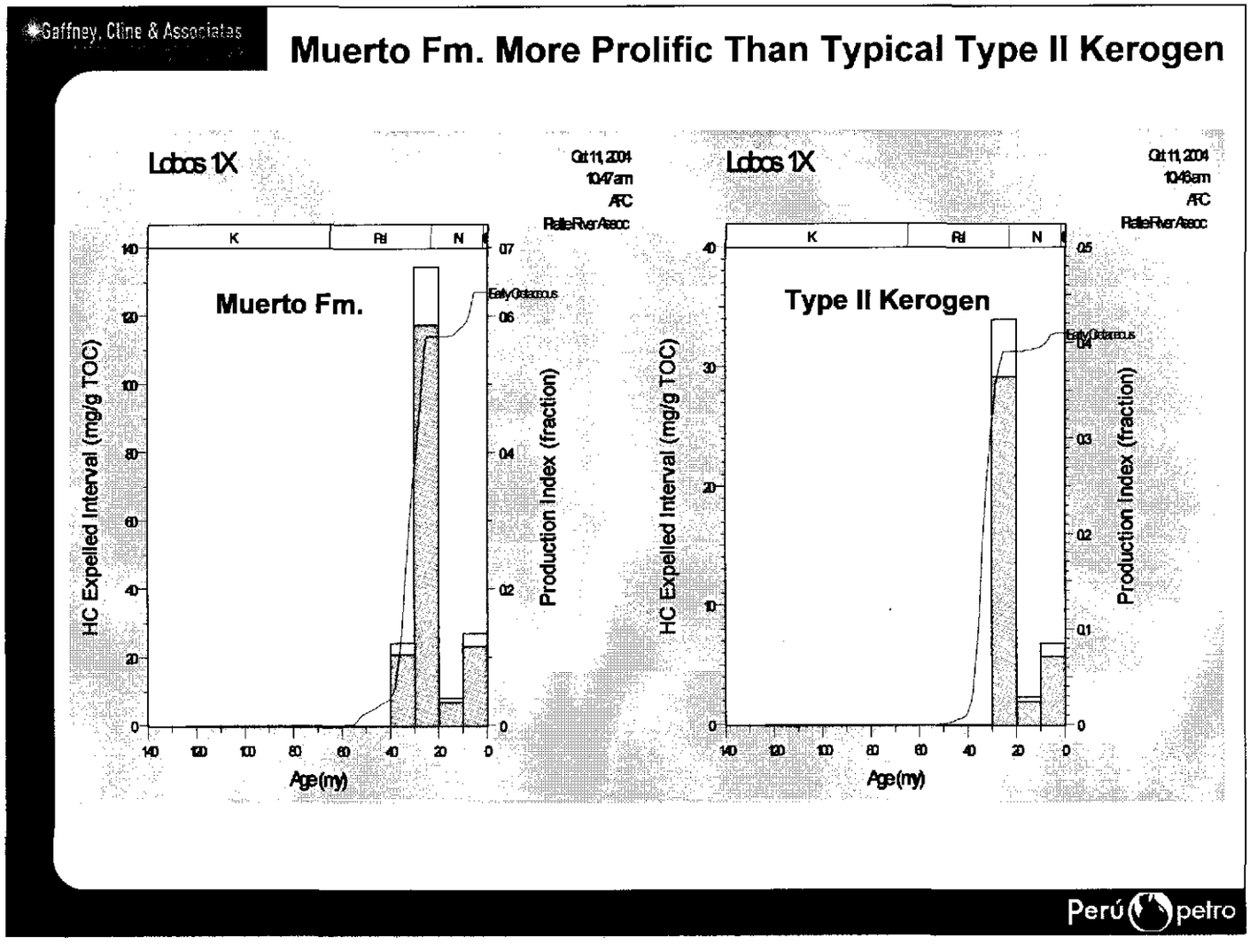
Activation Energy Analogous to Other Cretaceous Source Rocks in South America

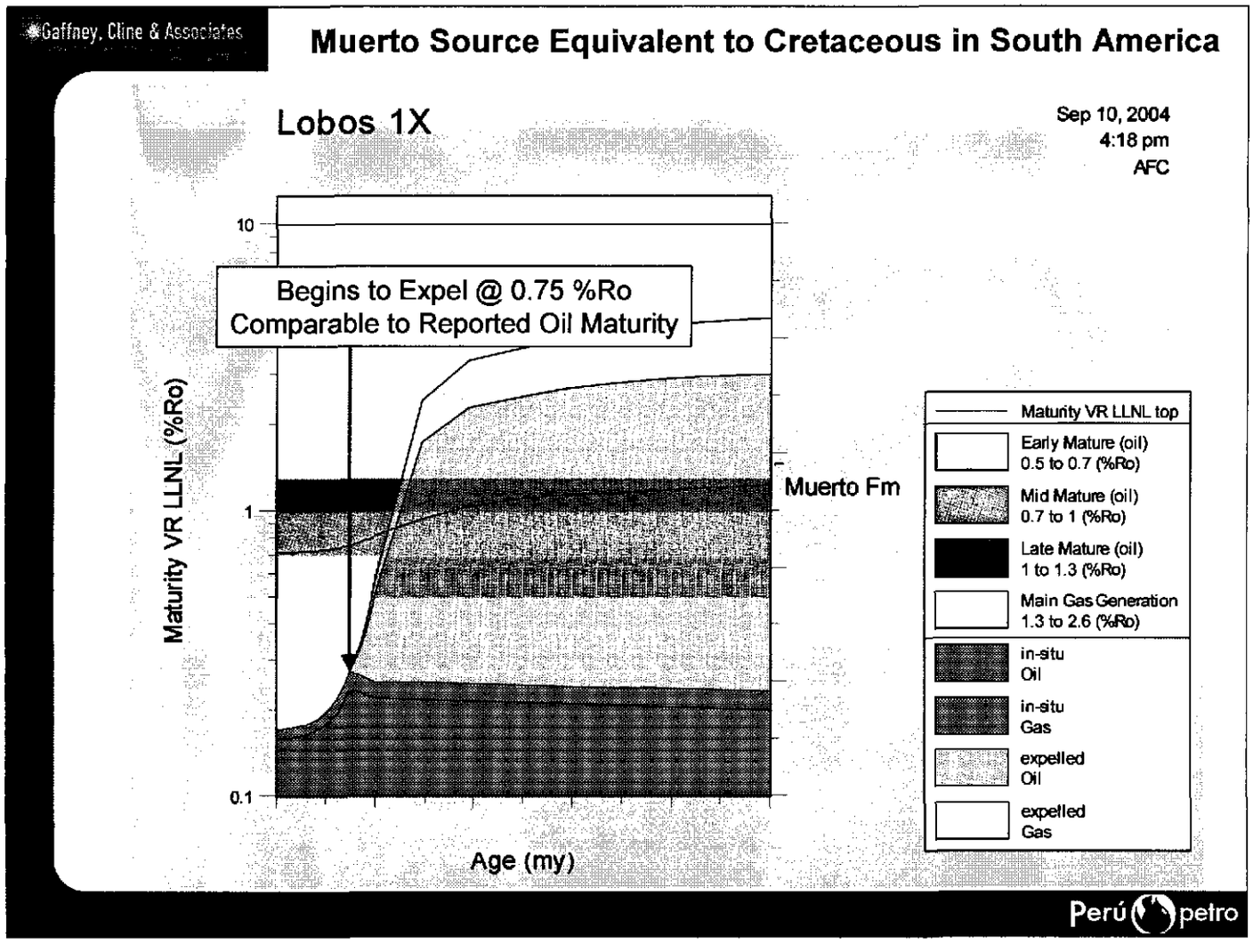


Perú petro

This figure depicts the distribution of the activation energies selected to represent a Cretaceous source rock for offshore Peru, similar to other source rocks for the Cretaceous in South America.



Comparison of oil generation and expulsion between a typical type II kerogen (Burham 1989) and that modeled for Muerto Fm. Based on analogous Cretaceous clastic source rocks from South America. The brown line represents the Pyrolysis Rock Eval production index calculated from the kinetic properties of each kerogen. Notice the enormous differences in behavior between the two kerogens under the same geological conditions. Muerto Fm. kerogen expels hydrocarbons earlier and is more prolific than the standard Type II kerogen.



Kinetics for the Muerto Fm. were adapted from reported data on Cretaceous source rocks from the northern part of South America. Its evolution is comparable with the reported maturity from the oils and impregnation in the Trujillo Basin.

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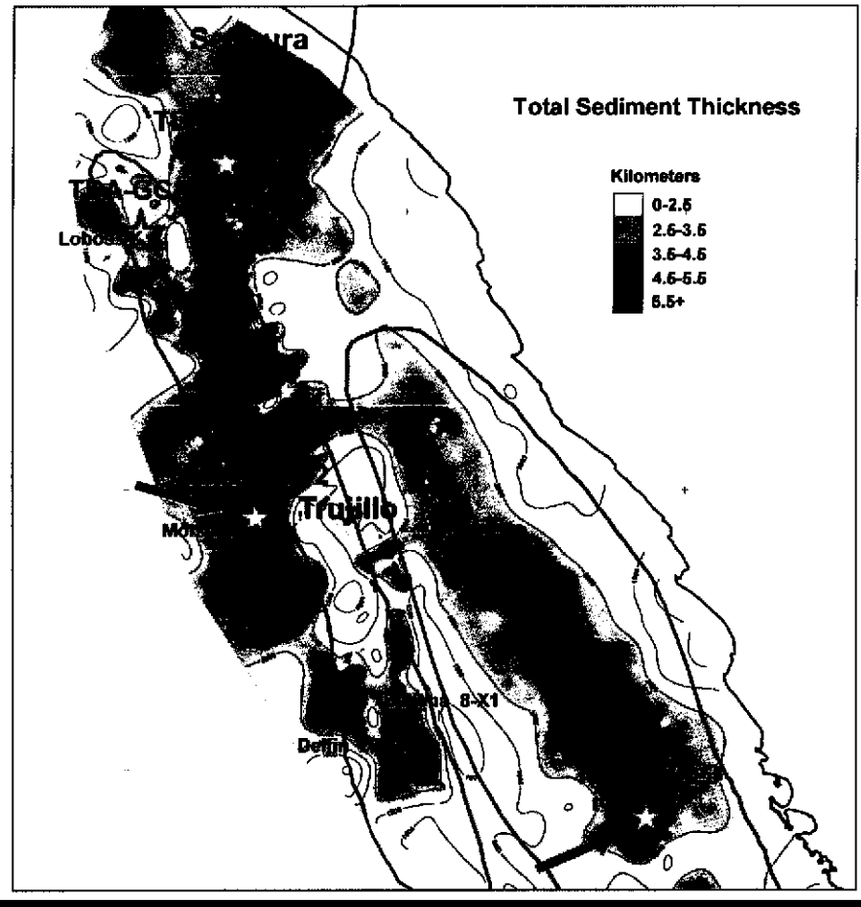
Section 4: Selection of Modeling Locations

- **Five Locations Based On:**
  - **Potential presence of source rock intervals**
  - **Based on the better locations for oil generation (i.e. thickest total sediment)**
  - **2 locations in Trujillo, 1 in Sechura, 1 in Salaverry, 1 in Pisco**

Perú petro

Gaffney, Cline & Associates

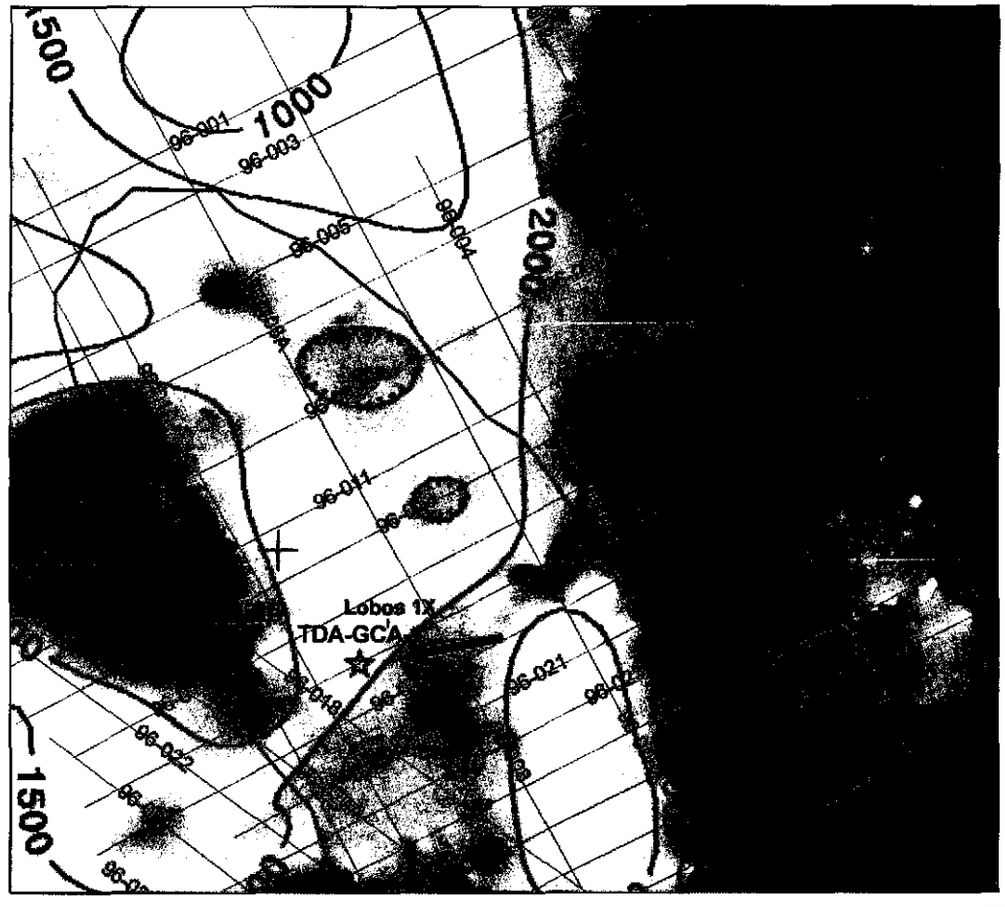
4 Modeled Locations in Trujillo, Sechura and Salaverry Basins



Perú petro

Gaffney, Cline & Associates

TDA-GCA-1 at SP 2400 on Line 96-017

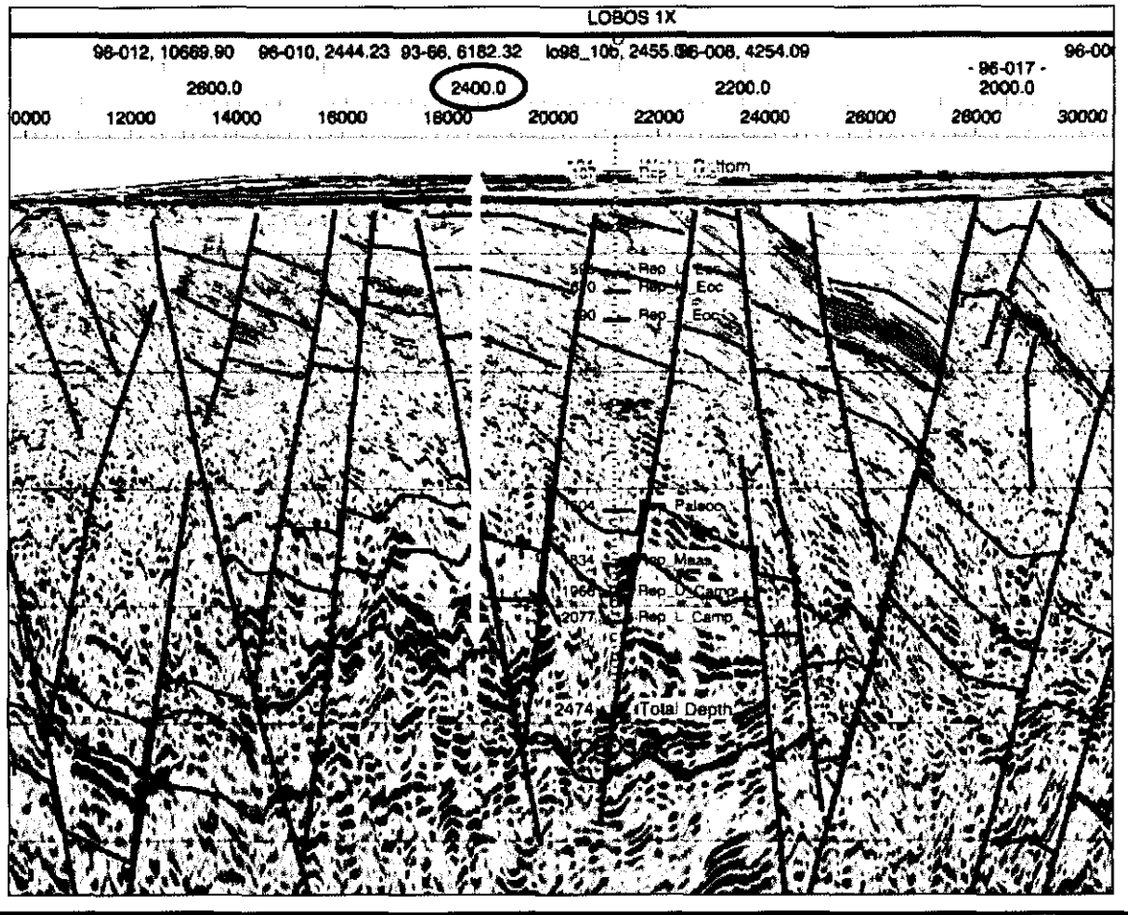


Perú petro

Gaffney, Cline & Associates

TDA-GCA-1 at SP 2400 on Line 96-017

2,000 meters of sediment at shotpoint 2400



Perú petro

Gaffney, Cline & Associates

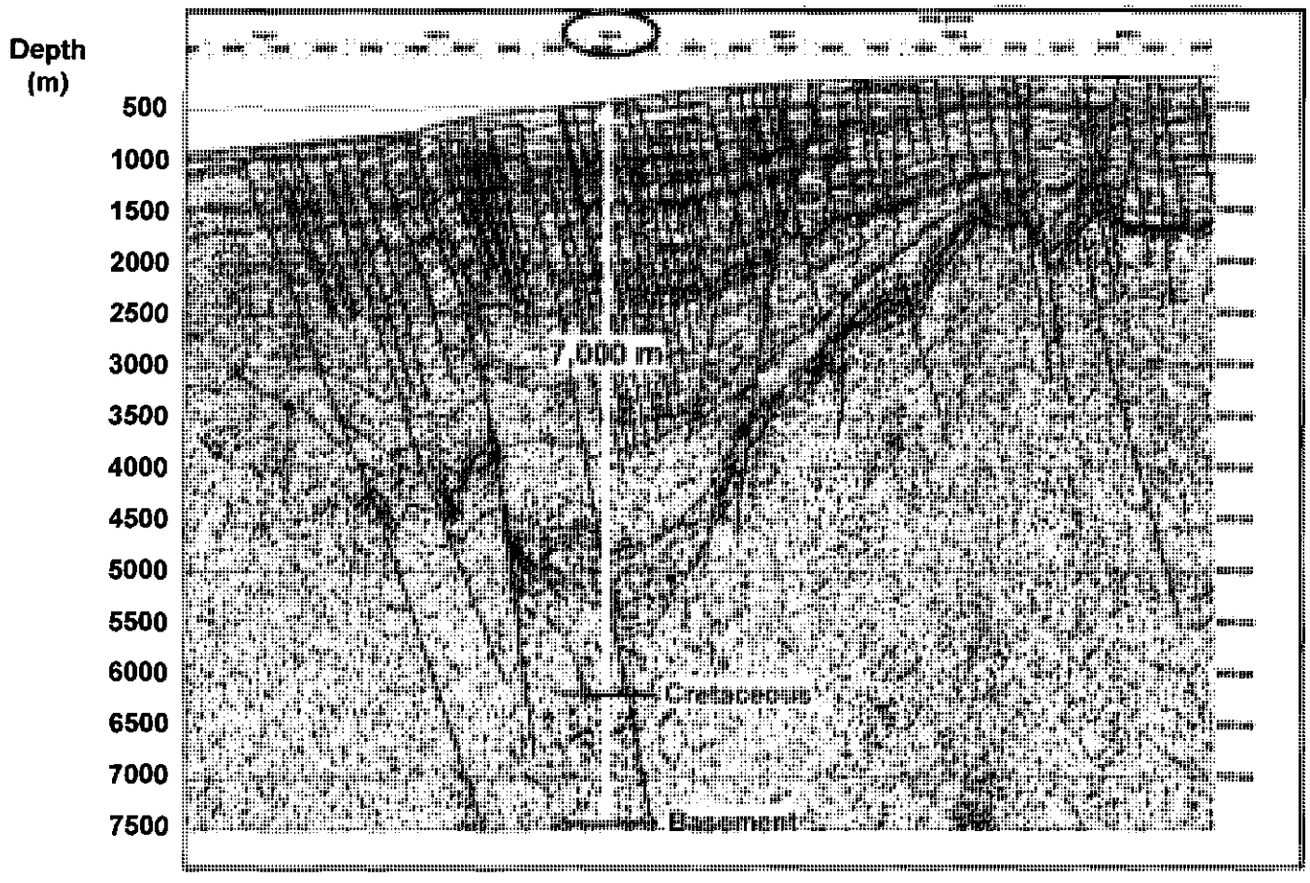
TDA-GCA-2 at SP 1800 on Line 93-39

Perú petro

Here is a detailed look at the TDA-GCA-2 maturation modeling location. It shows a much thicker section. Note that the actual thickness shown on the seismic line is 7,000 meters, but the gridding interval for this map was too large to show the narrowest part of this trough.

Gaffney, Cline & Associates

TDA-GCA-2 at SP 1800 on Line 93-39



Perú petro

Gaffney, Cline & Associates

TDA-GCA-3 at SP 10470 on Line 93-68

Perú petro

Gaffney, Cline & Associates

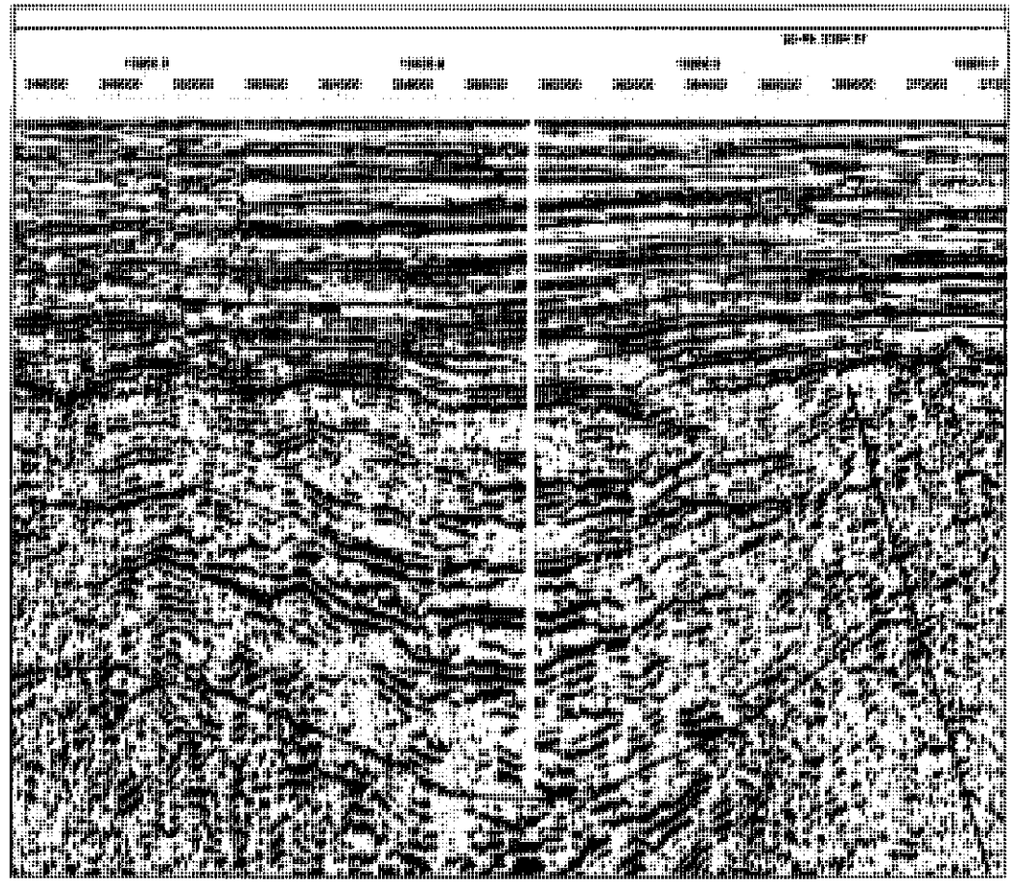
TDA-GCA-3 at SP 10470 on Line 93-68

4,000 meters of sediment at shotpoint 10470

Eocene

Paleocene

Cretaceous



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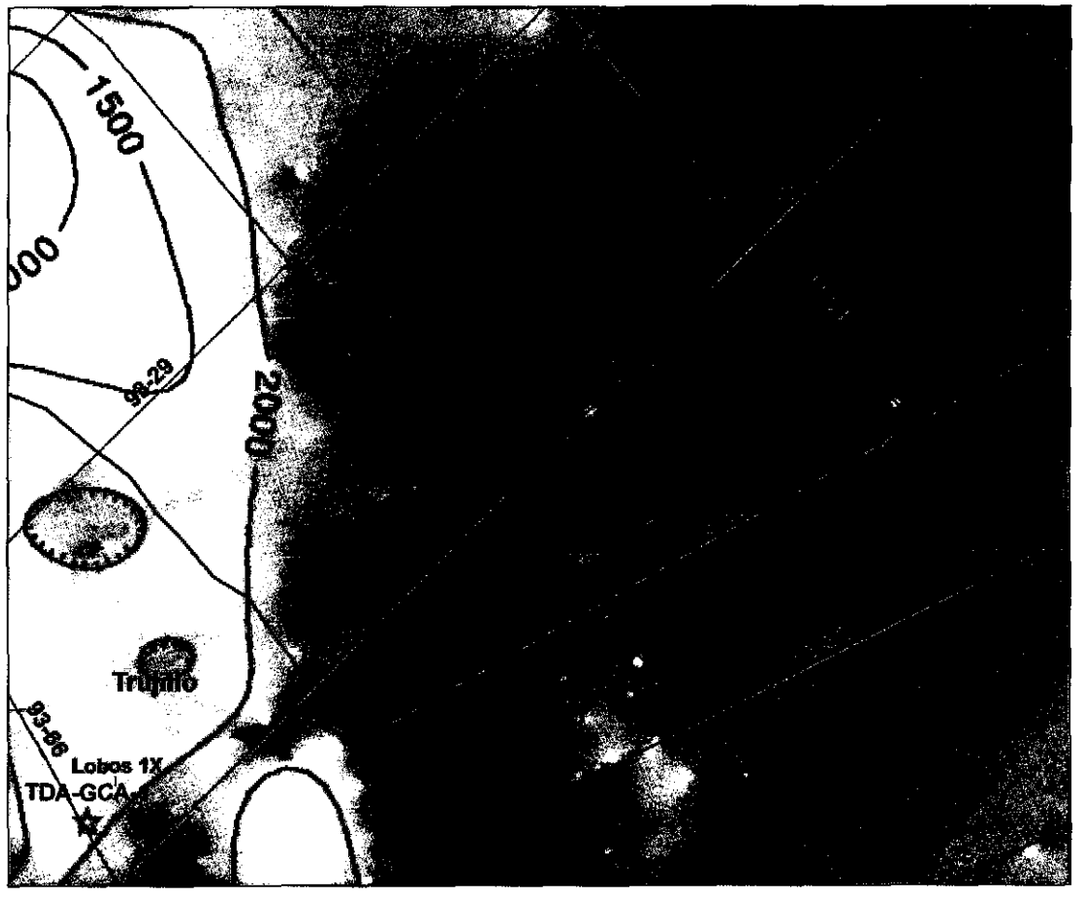
Gaffney, Cline & Associates

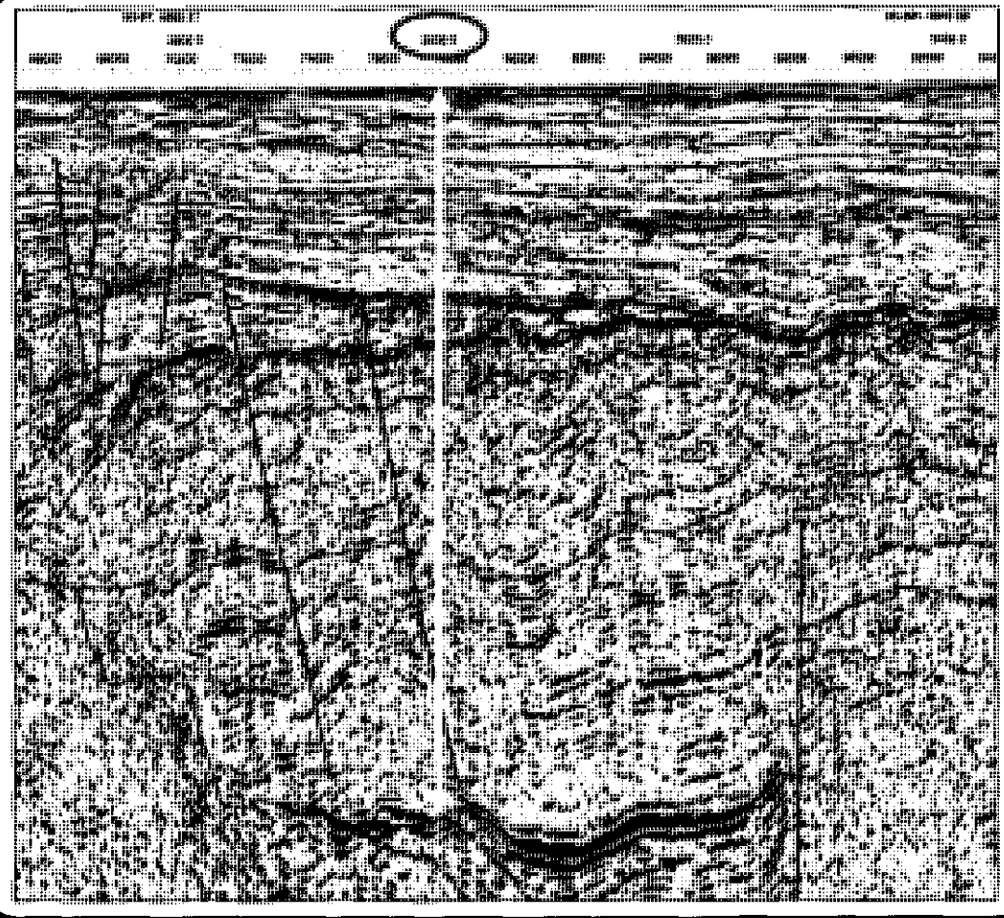
TDA-GCA-4 at SP 3000 on Line 93-30



Perú petro

Gaffney, Cline & Associates

TDA-GCA-4 at SP 3000 on Line 93-30



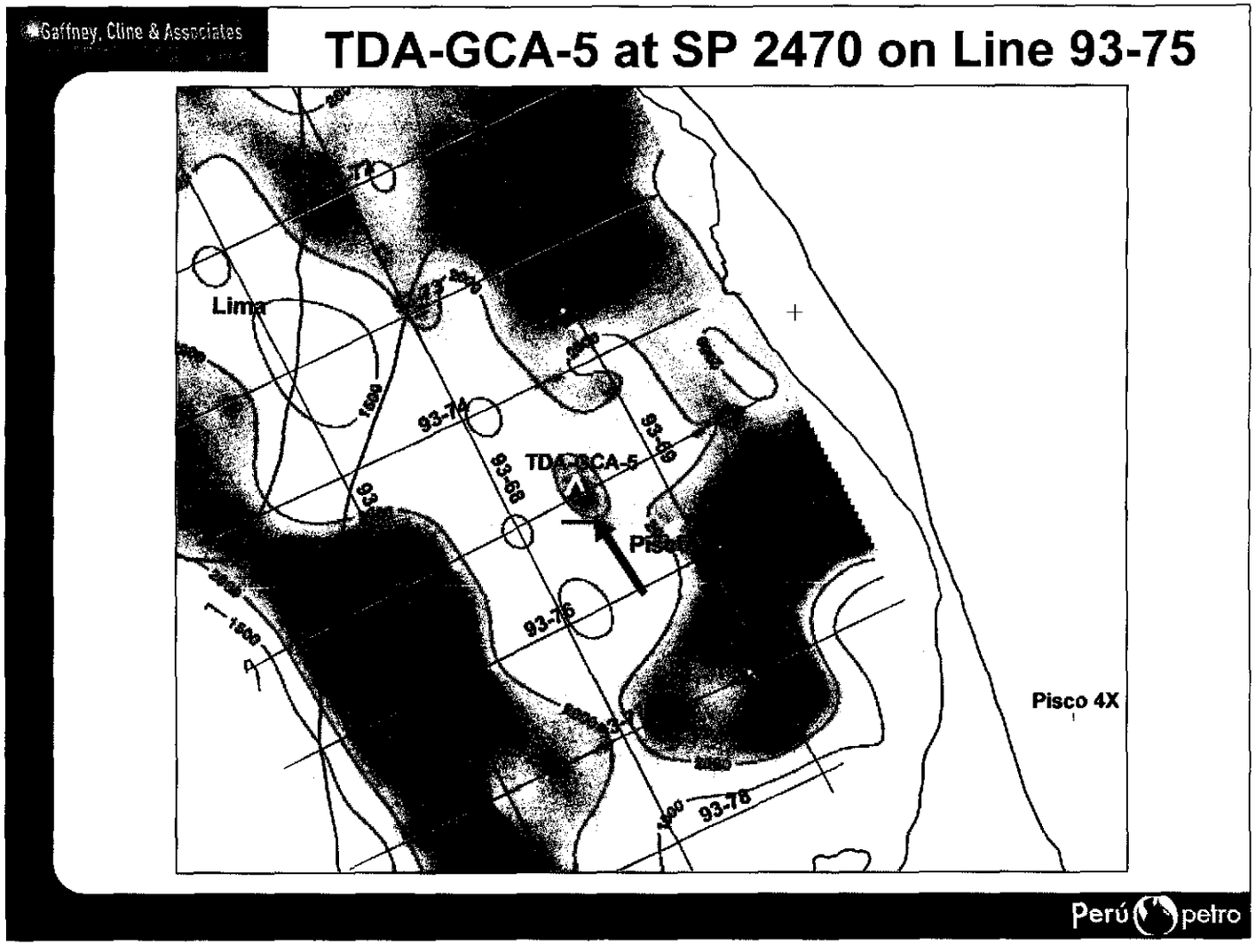
Almost 5,000 meters of sediment at shotpoint 3000

Eocene

Paleocene

Cretaceous

Perú petro



The total sediment thickness at this location is approximately 2,750 meters, but is localized enough to have been "smeared" by the map gridding process. That is why there are no 2,000-meter or 2,500-meter contours near this location. Nevertheless, the maturation modeling results will be representative of the even thicker intervals to the west, north and east.

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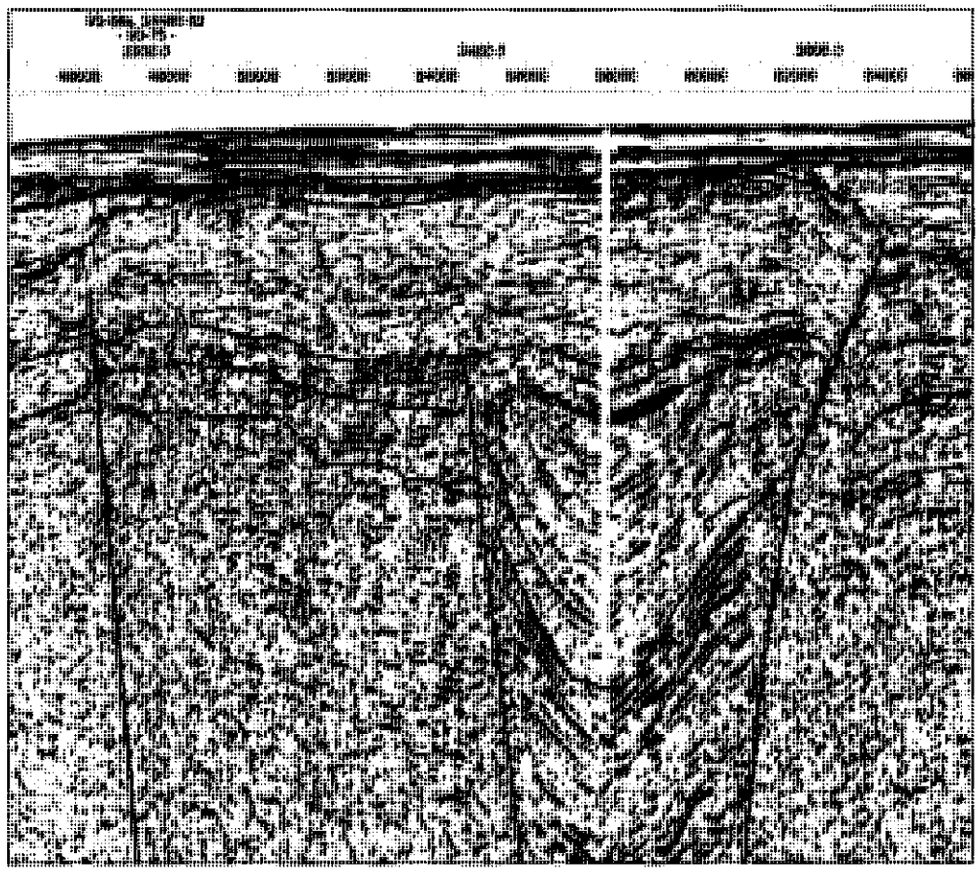
TDA-GCA-5 at SP 2470 on Line 93-75



2,750 meters of sediment at shotpoint 3000

Eocene

Paleocene

Cretaceous

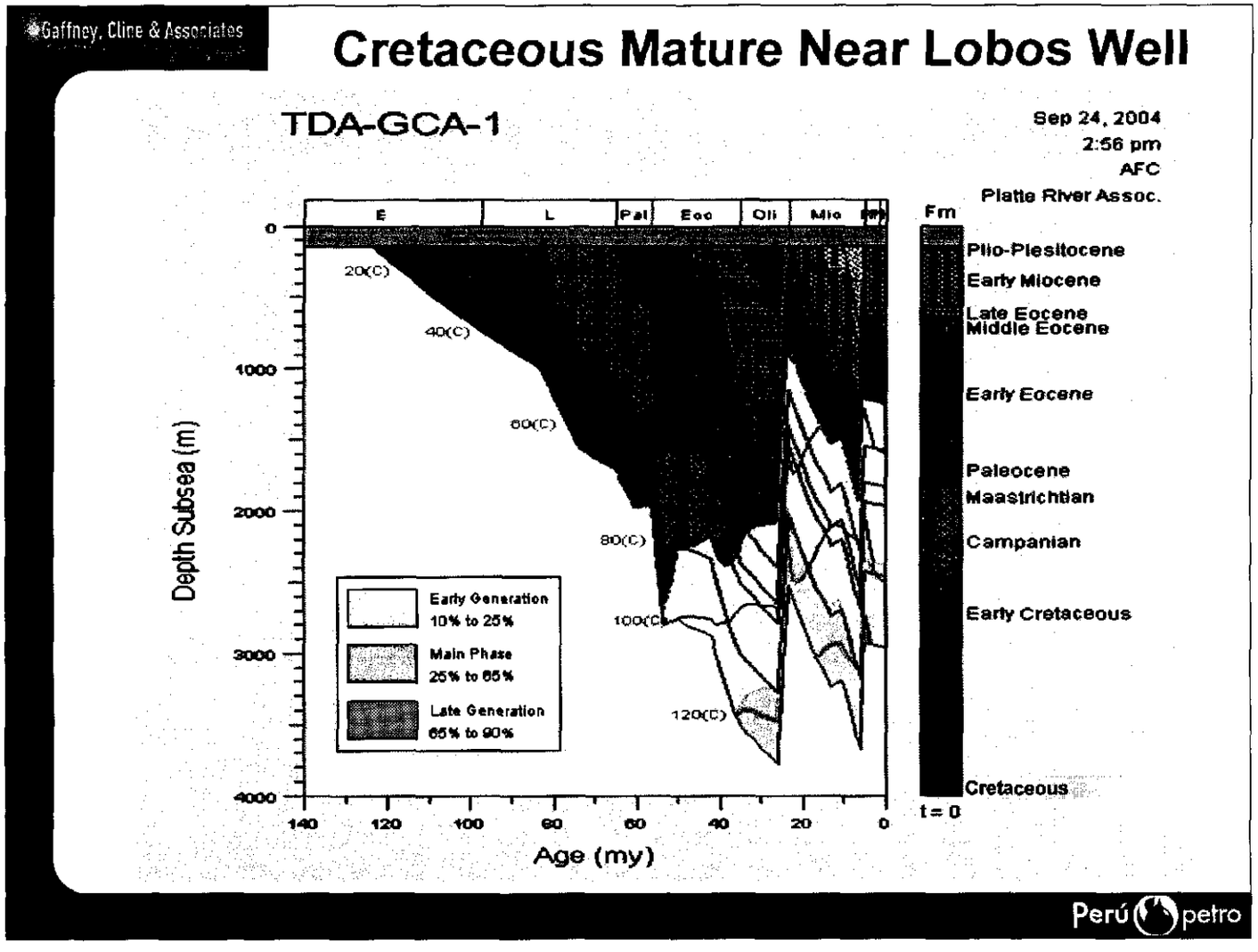
Perú petro

Gaffney, Cline & Associates

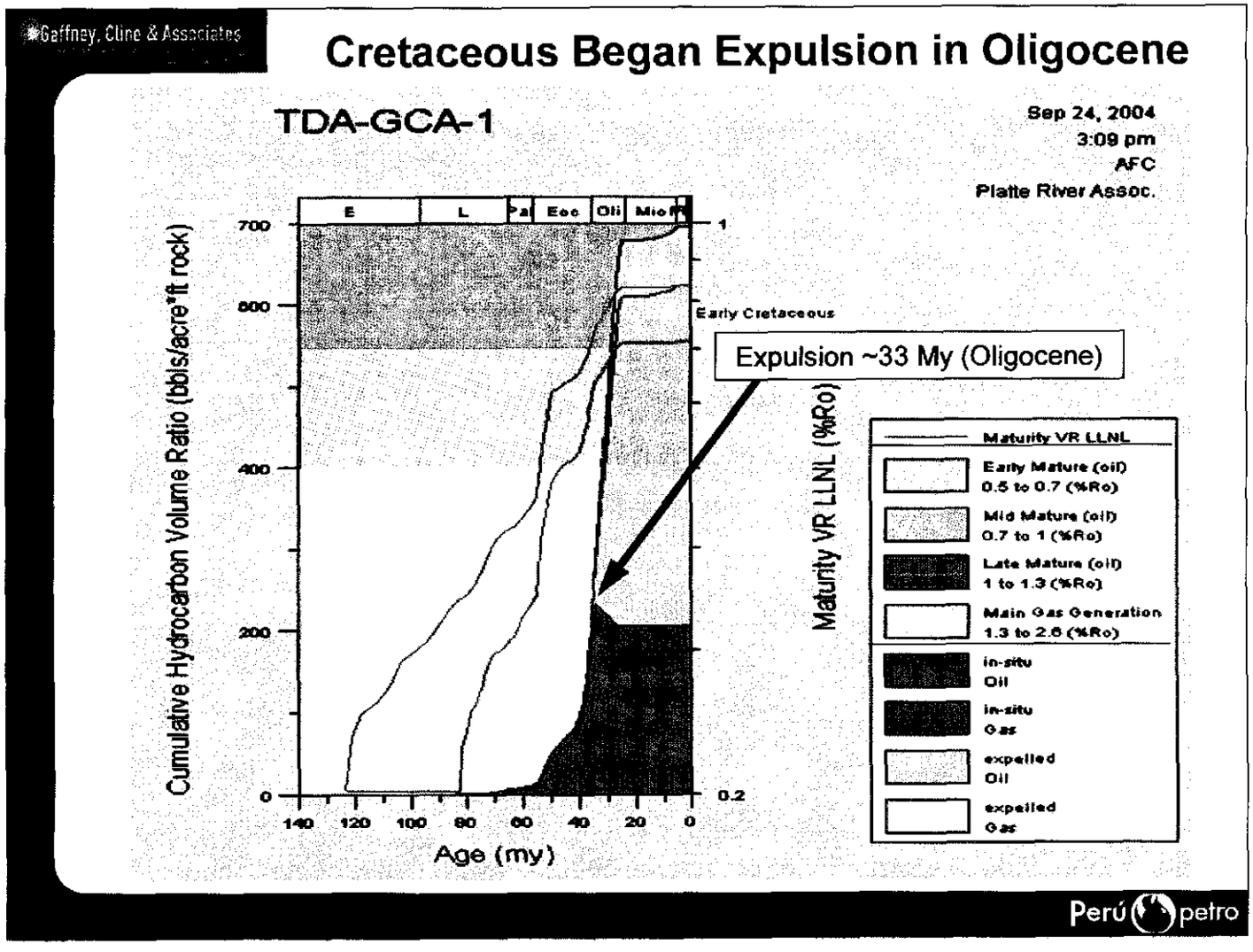
Section 5: Oil Generation Modeling in the Trujillo Basin

- The model includes three source rocks:
  - Early Cretaceous (Muerto Fm.): Kerogen Type II (Cretaceous of South America)
  - Early and Late Eocene: Kerogen Type II-III (marine with strong influence of terrigenous organic matter)

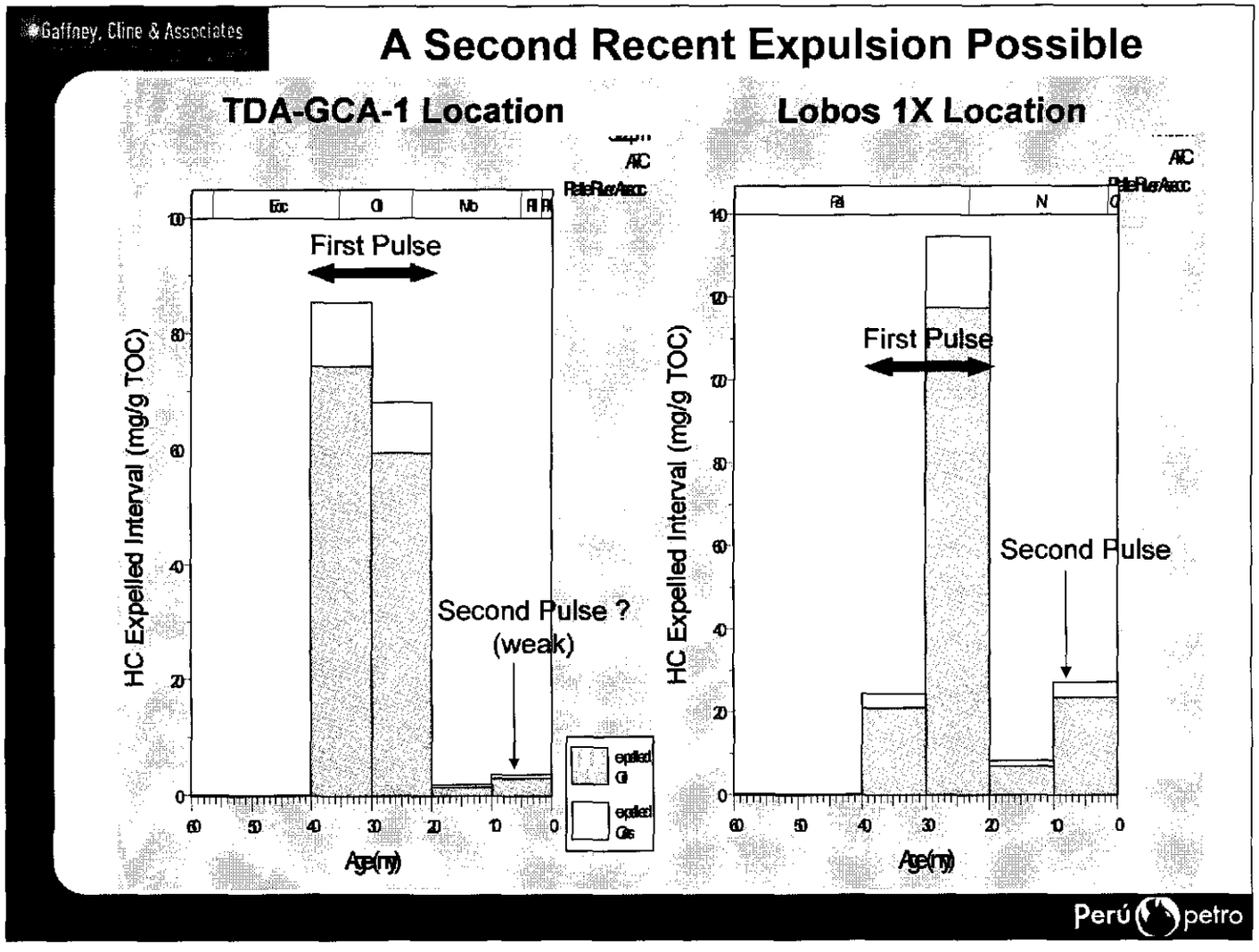
Perú petro



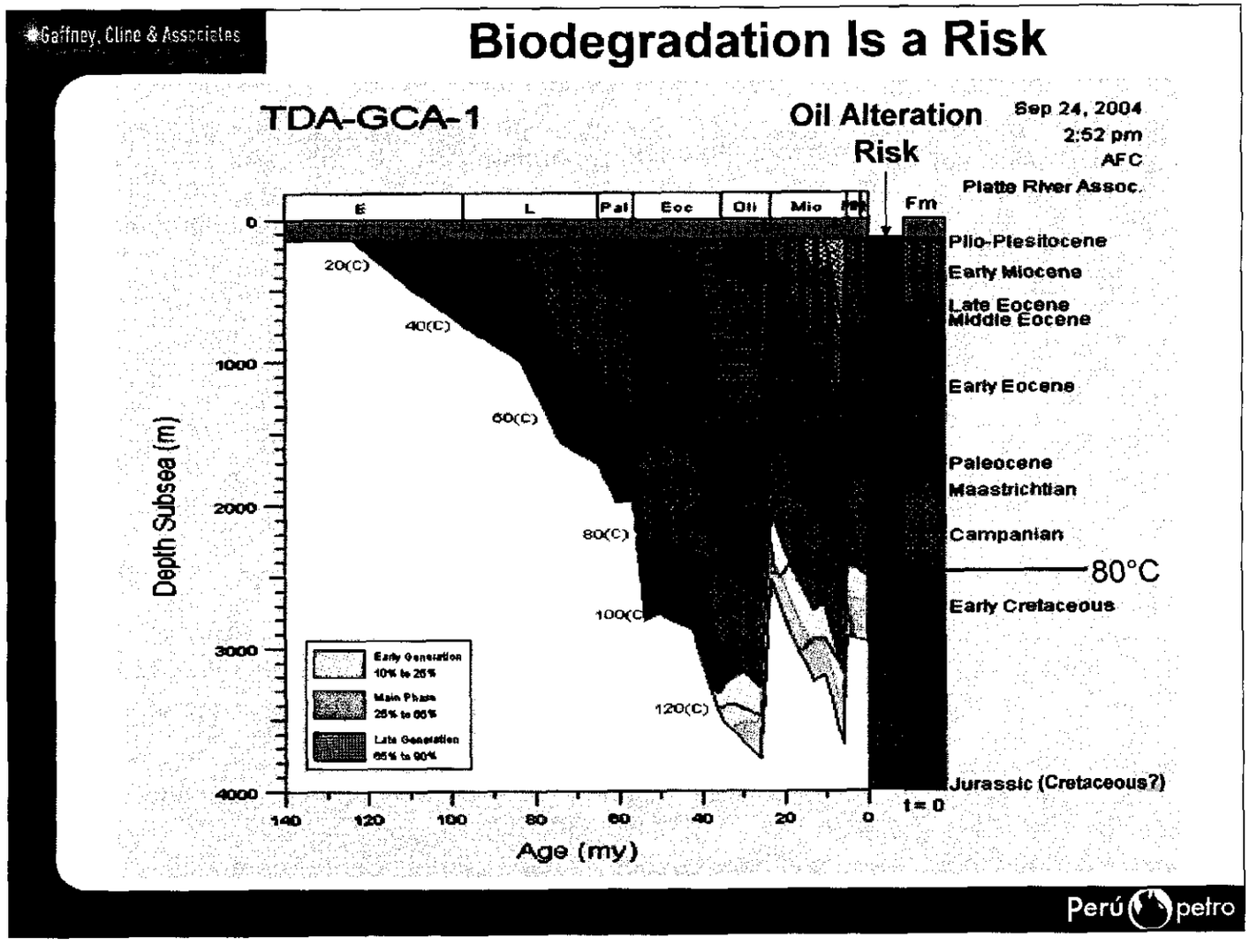
This location is near the Lobos well, which had traces of heavy oil shows in the sandier intervals in the Lower Eocene, Paleocene and Cretaceous. Notice that the Tertiary section above the Early Eocene in this location is not mature enough to generate and expel hydrocarbons. The Cretaceous is mostly in the main phase of hydrocarbon generation.



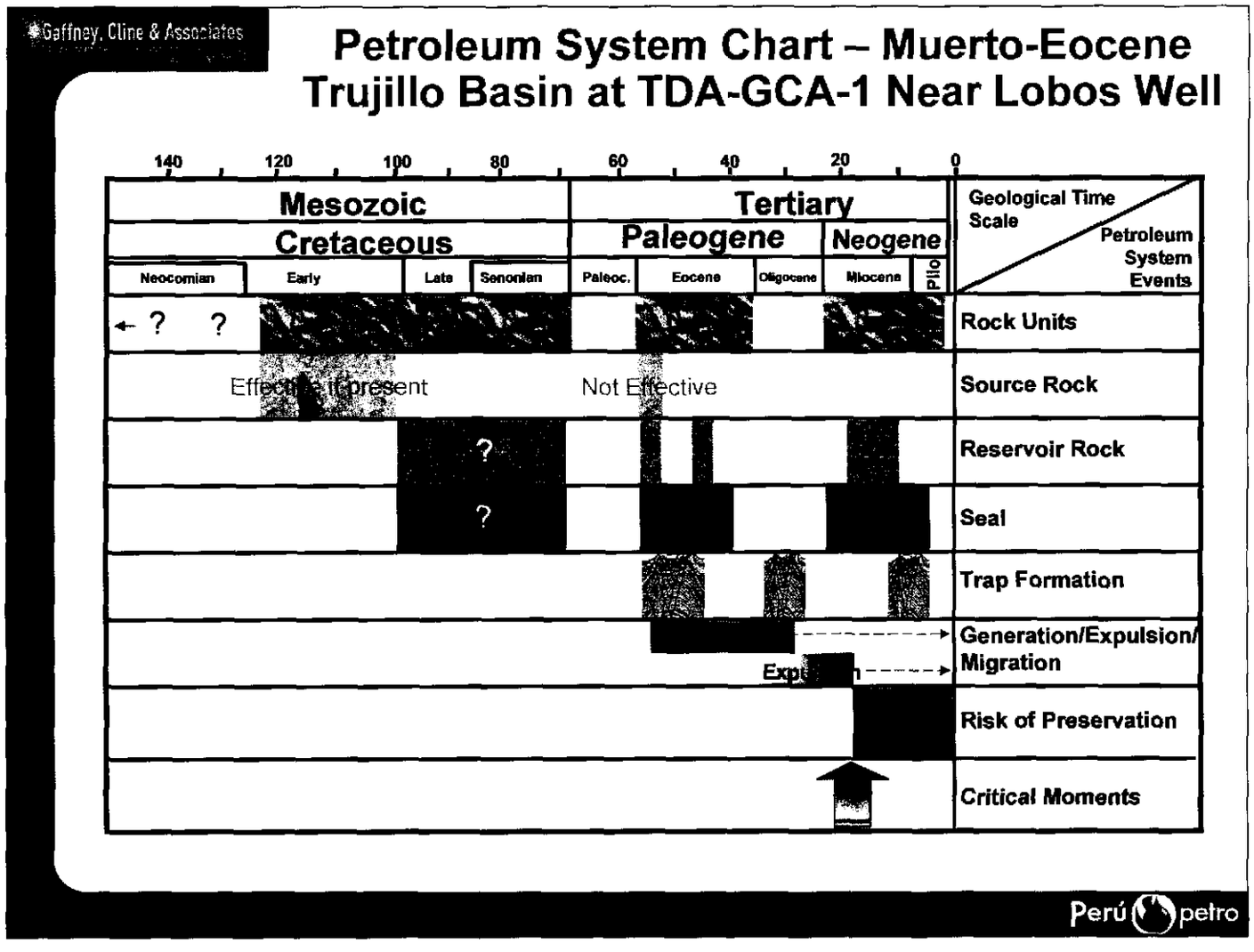
Based on the thickness at least 1,000 meters of Cretaceous section (around 600m already penetrated in Lobos 1X well) the oil expulsion began around Oligocene time from the Muerto Fm. or its equivalent Cretaceous source rock at this location. Today, this interval may be still generating and expelling oil. Sensitivity analysis with variations of +/- 5 mW/m2 does not drastically affect the interpretation of the oil generation history.



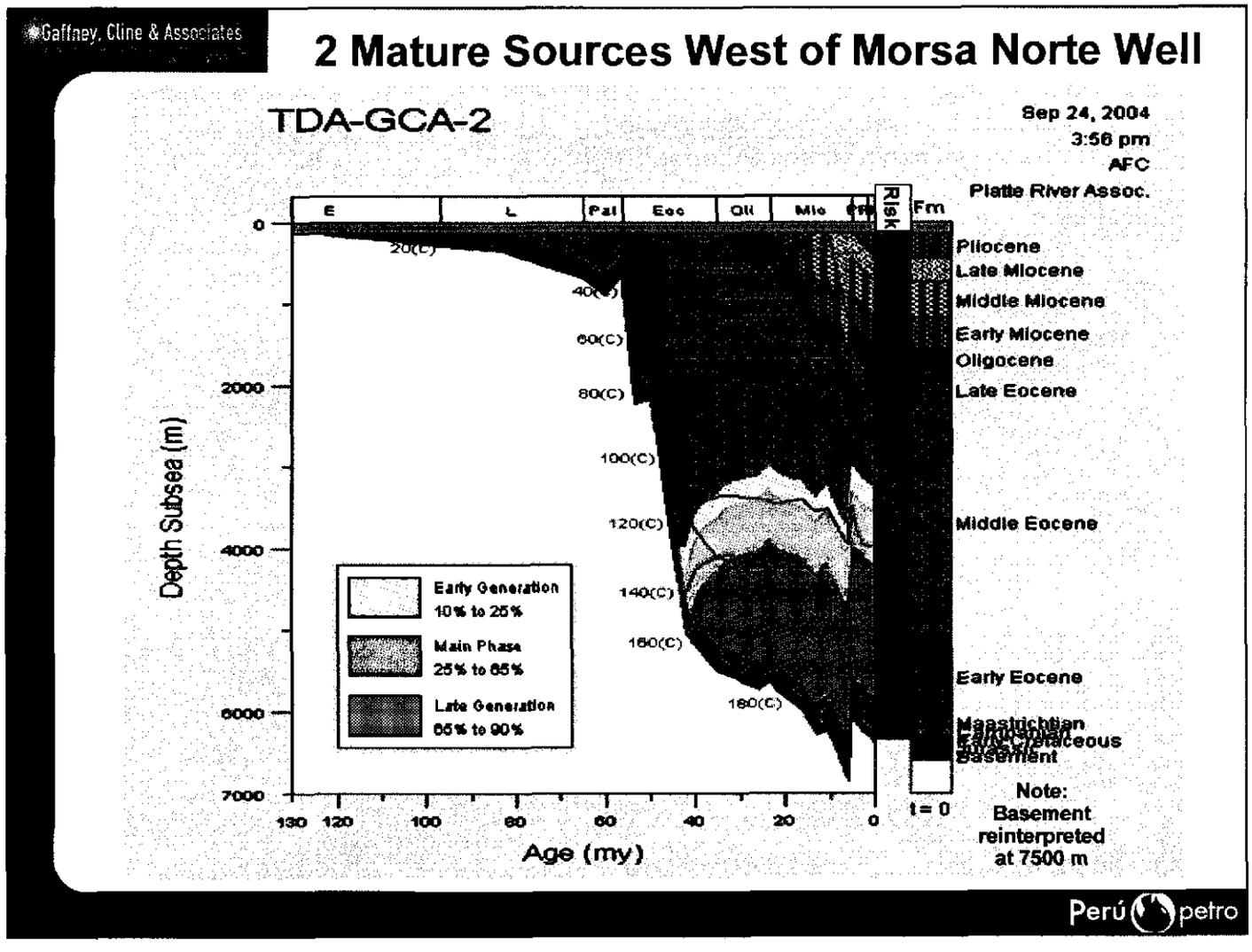
Based on the expulsion evolution from the Muerto formation, it is possible to infer a main pulse of oil migration between 40 and 20 My, and a second small pulse in recent time. This recent pulse is more pronounced at the Lobos 1X well location, where the Cretaceous is somewhat thicker and deeper than at the modeled location.



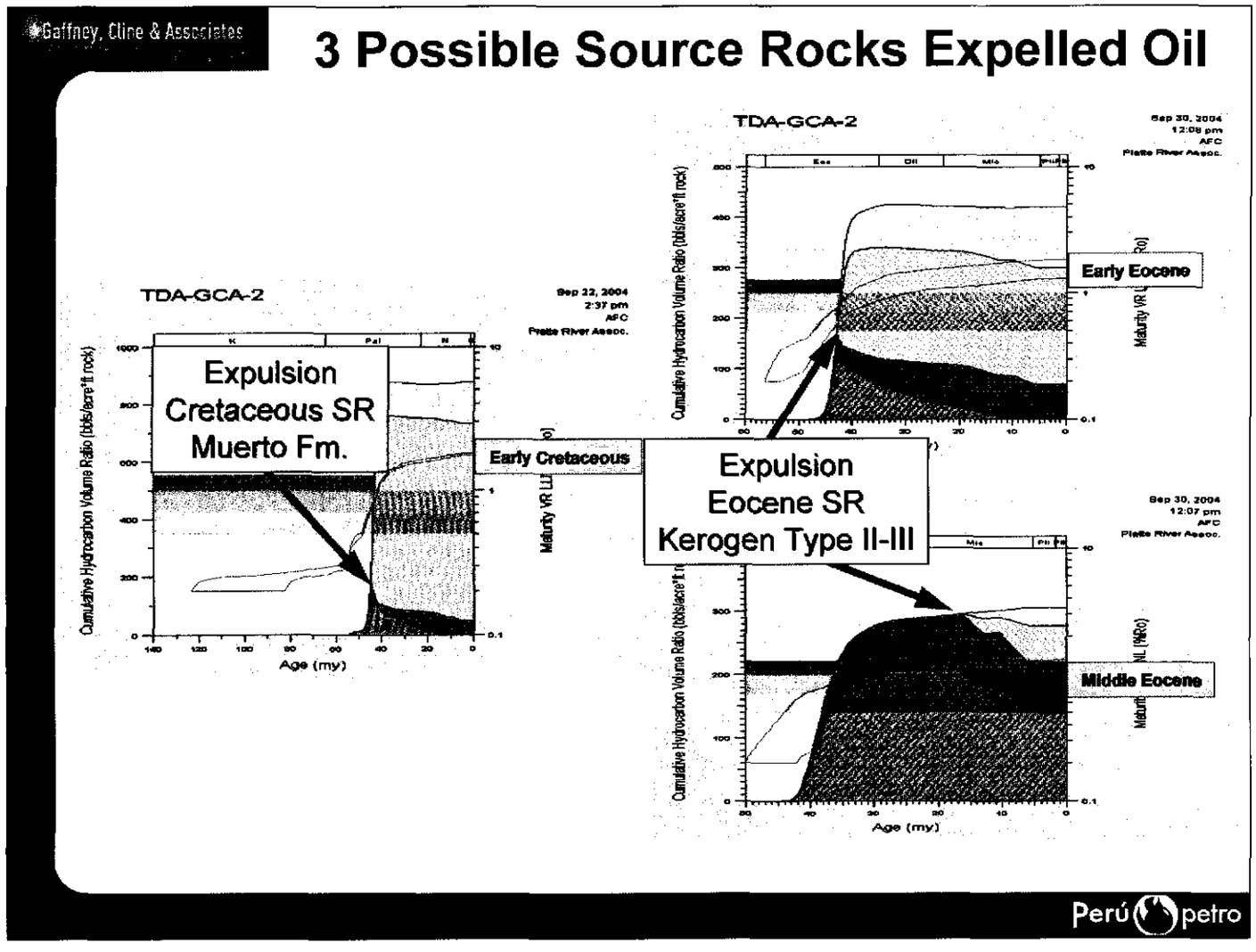
All of the oil in Tertiary and Late Cretaceous reservoirs is in the zone of potential biodegradation. Any oil potentially trapped in the source rock Cretaceous section would be preserved from biodegradation.



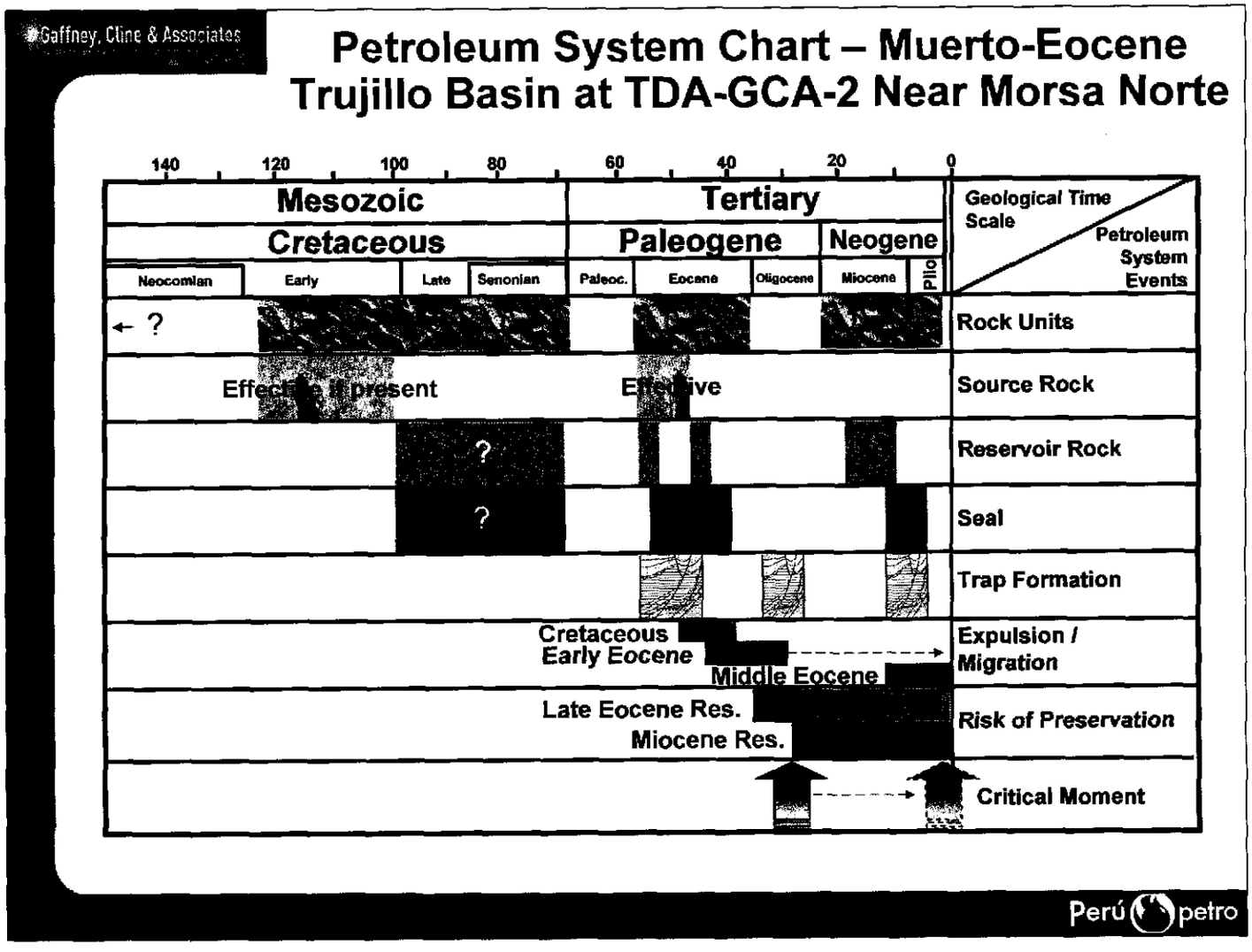
If a Cretaceous source rock is present, then it might have generated hydrocarbons. Cretaceous source rock generation and expulsion of hydrocarbons varies in time, depending on the thickness of the Cretaceous section in the seismic interpretation. Almost certainly by Middle Eocene time, but possibly as early as Late Eocene, source rock may have been generating and expelling hydrocarbons. A critical moment was assigned to the entry of the main Eocene reservoir into the biodegradation window occurring below 80 C. Another critical moment was assigned based on the end of the oil expulsion available to migrate to the potential traps in the area.



Location TDA-GCA-2 is located in the deep trough west of the Morsa Norte well. Oil was observed in this well while cementing the 20" casing. It most likely came from the Miocene. Thick Tertiary deposition at the TDA-GCA-2 modeled location enabled potential Eocene and Cretaceous source rocks to generate oil as early as the Eocene. Note that the seismic was reinterpreted subsequent to this analysis, putting basement another 1000 meters deeper, which only enhances the maturation picture.



A typical mixed type II-III kerogen as Eocene source rock would have expelled hydrocarbons under the modeled thermal conditions. The Cretaceous and Early Eocene source rocks were likely rapidly exhausted. Any oil might have migrated to traps at that time, otherwise it was lost. Middle Eocene oil is an exception.



The Cretaceous source rock generated and expelled hydrocarbons almost instantly at Middle Eocene time, but the Middle Eocene source rock may have generated and expelled hydrocarbons as late as Pliocene, if adequate source rock was present. Critical moments are assigned to the end of oil generation from the Cretaceous/Early Eocene source rock pair, but if a source is present in the Middle Eocene interval, fresh oil might have been available to the traps.

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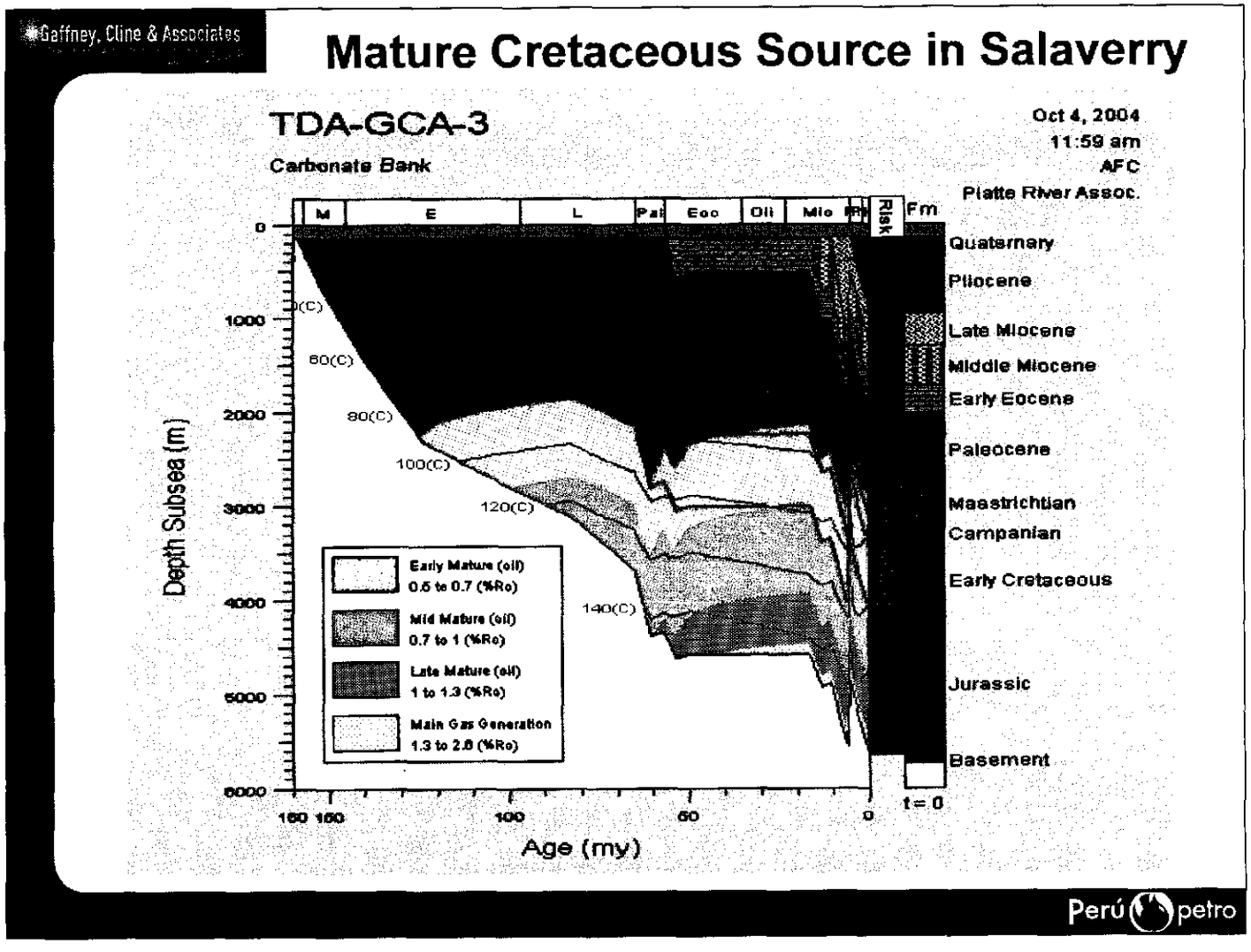
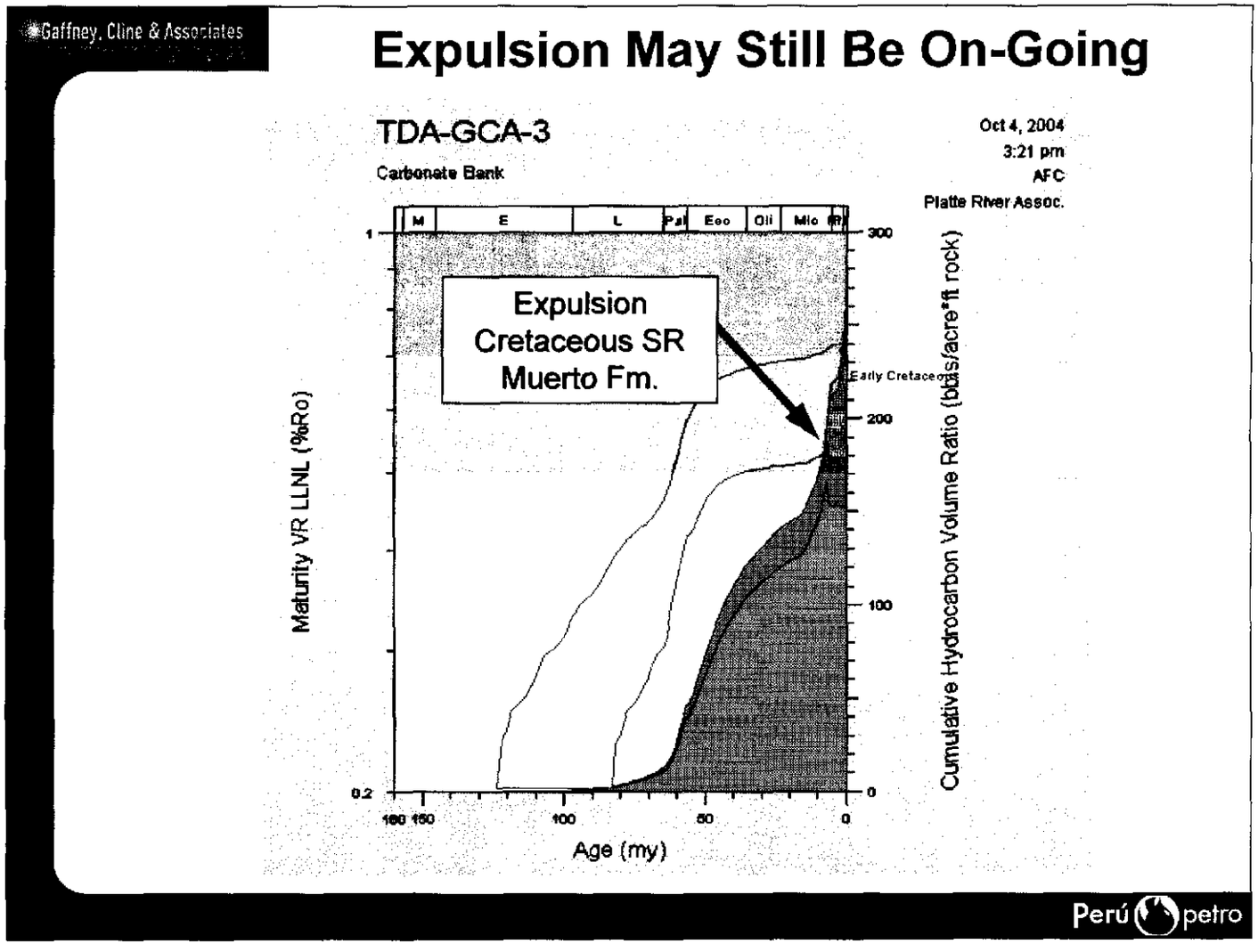
Section 5: Oil Generation Modeling in the Salaverry Basin

- This model also includes three source rocks:
  - Early Cretaceous (Muerto Fm.): kerogen type II (Cretaceous of South America)
  - Early and Late Eocene: kerogen type II-III (marine with strong influence of terrigenous organic matter)

Perú petro



The 4,000-meter total sediment thickness at this location was sufficient to push the Early Cretaceous possible source into early maturity in Eocene time. Late Cretaceous and Eocene possible source intervals did not likely achieve maturity.



Oil expulsion may have started at Late Miocene time. Cretaceous source rock, if present, may still be generating and expelling hydrocarbons.

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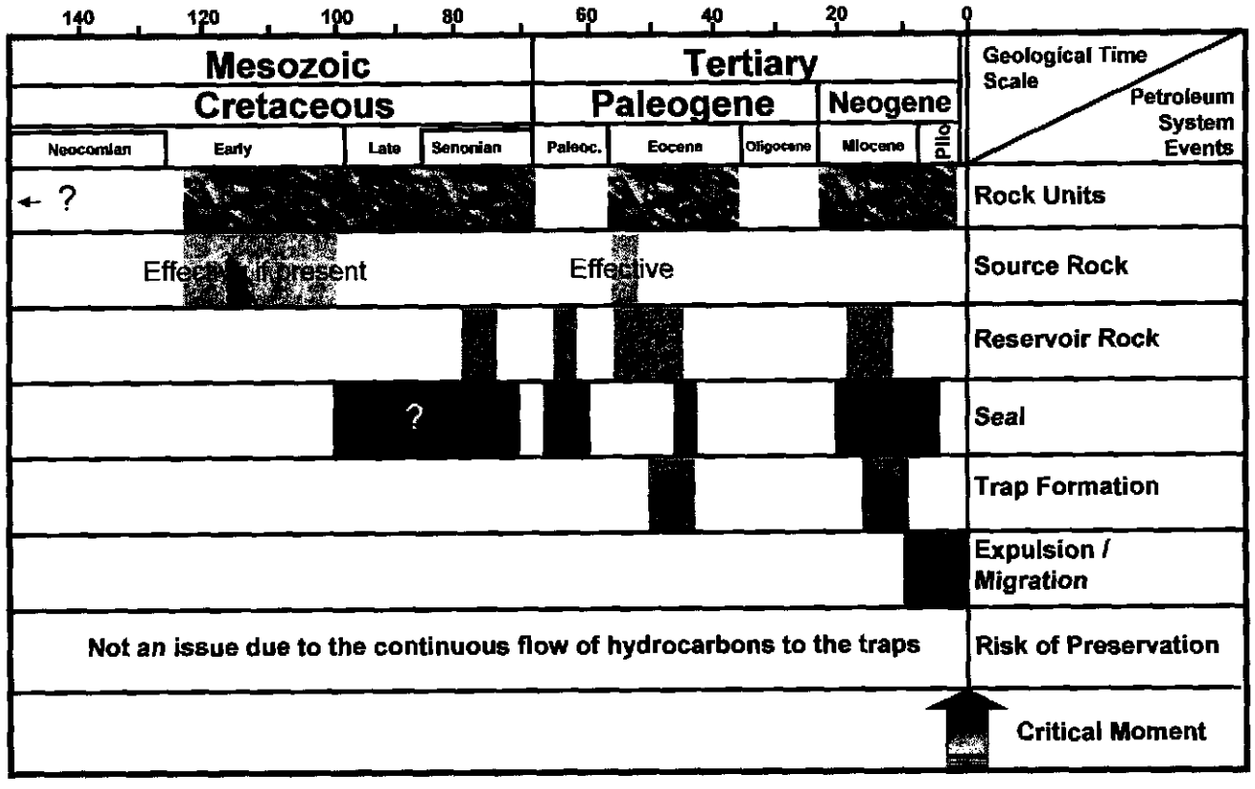
Petroleum System Chart – Muerto-Eocene Salaverry Basin at TDA-GCA-3 Location



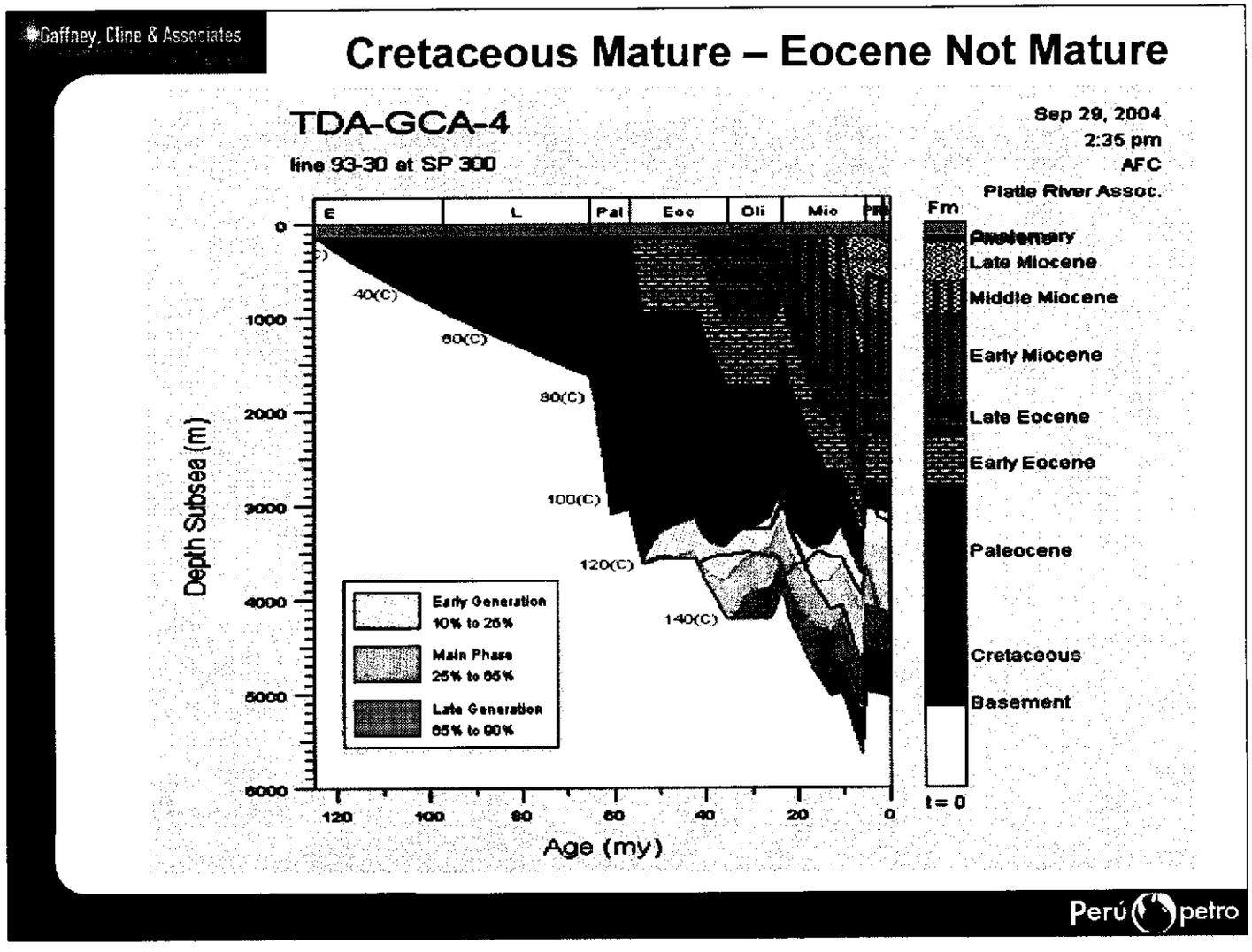
Perú petro

Gaffney, Cline & Associates

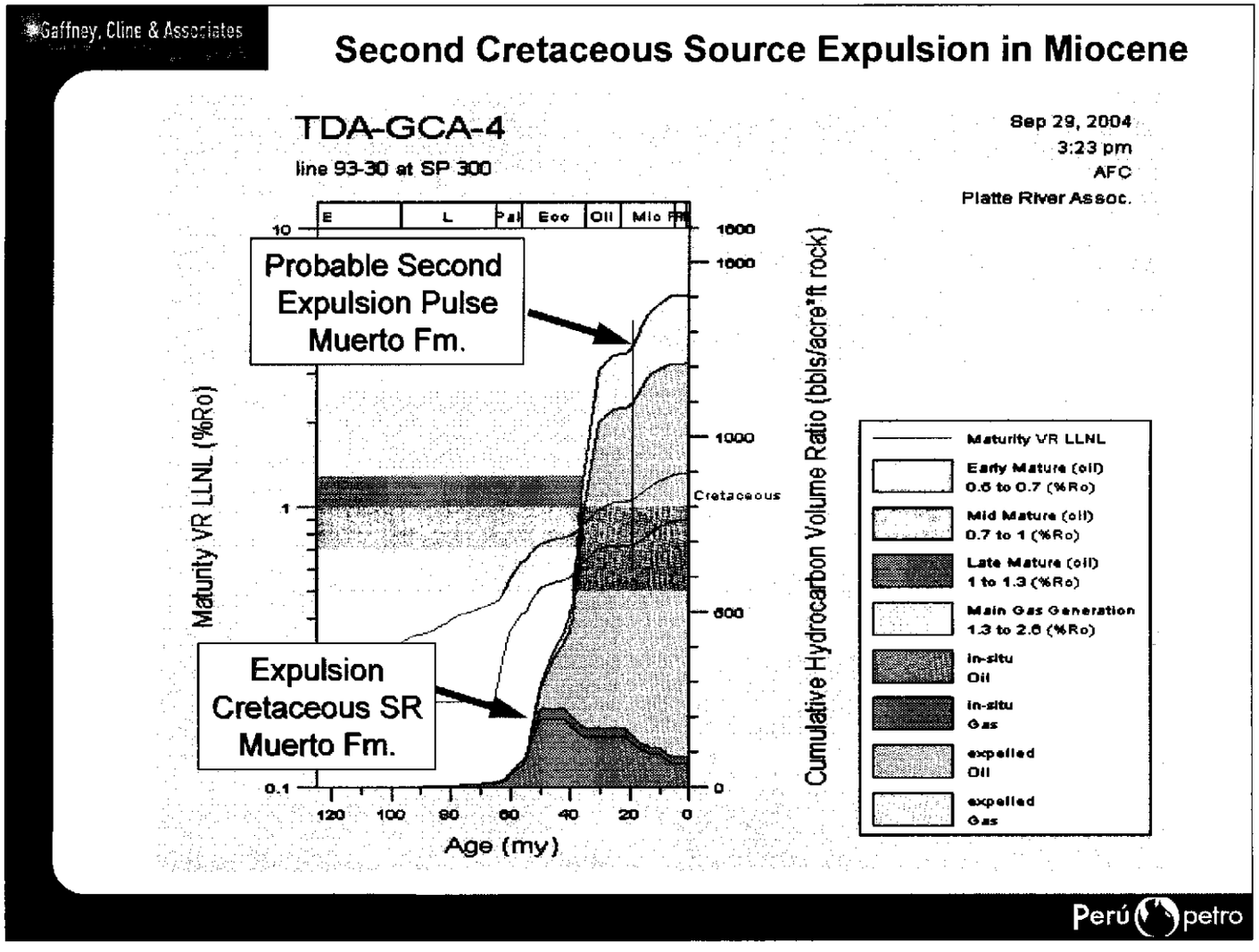
Section 6: Oil Generation Modeling in the Sechura Basin

- This model also includes three source rocks:
  - Early Cretaceous (Muerto Fm.): kerogen type II (Cretaceous of South America)
  - Early and Late Eocene: kerogen type II-III (marine with strong influence of terrigenous organic matter)

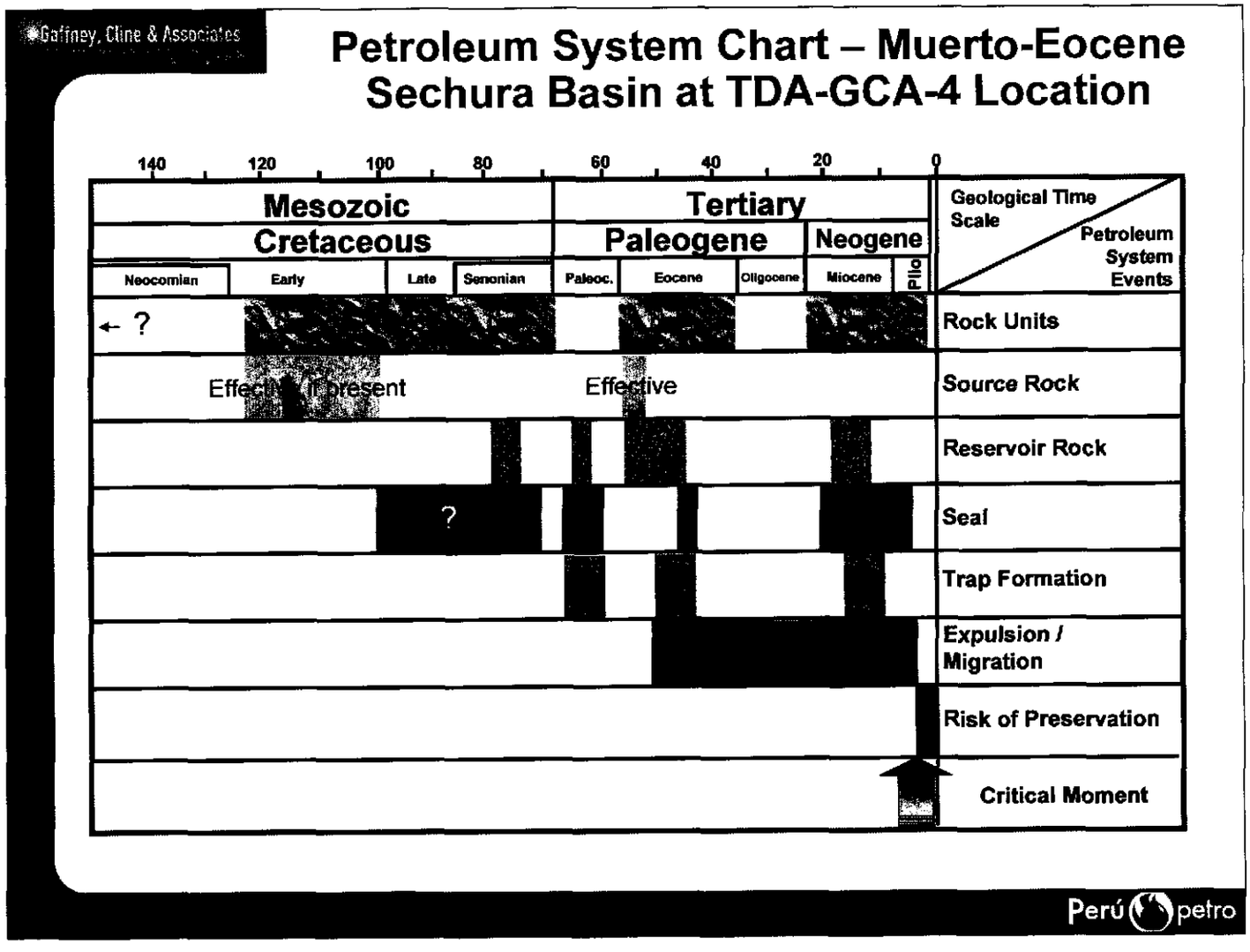
Perú petro



A possible Cretaceous source rock moved into the oil window in Eocene time, and would now be over-mature. Owing to the thick Paleocene section, the Eocene is not close to the necessary maturation level in order to be considered a potential source rock for this area.



Oil expulsion began at Eocene time and a reactivation and second expulsion pulse may had occur during Miocene time from a mature source rock that can be associated with the phenomenon observed in Lobos 1X of a second pulse of light oil/condensate.

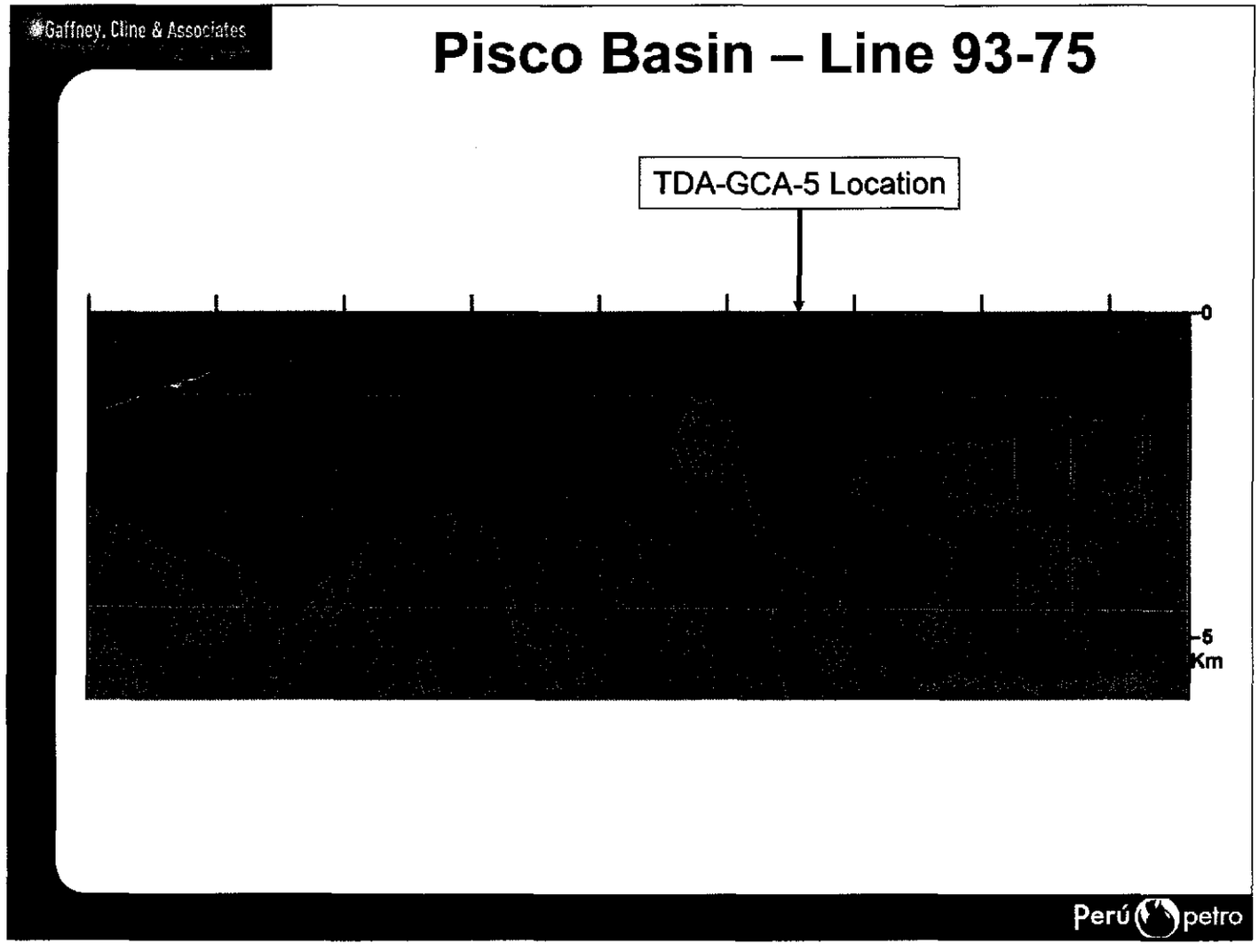

Gaffney, Cline & Associates
Petroleum System Chart – Muerto-Eocene
Sechura Basin at TDA-GCA-4 Location
140
120
100
80
60
40
20
0
Mesozoic
Tertiary
Cretaceous
Paleogene
Neogene
Neocomian
Early
Late
Senonian
Paleoc.
Eocene
Oligocene
Miocene
Plio
Geological Time Scale
Petroleum System Events
← ?
Rock Units
Effective
Source Rock
Reservoir Rock
?
Seal
Trap Formation
Expulsion / Migration
Risk of Preservation
Critical Moment
Perú petro

Gaffney, Cline & Associates

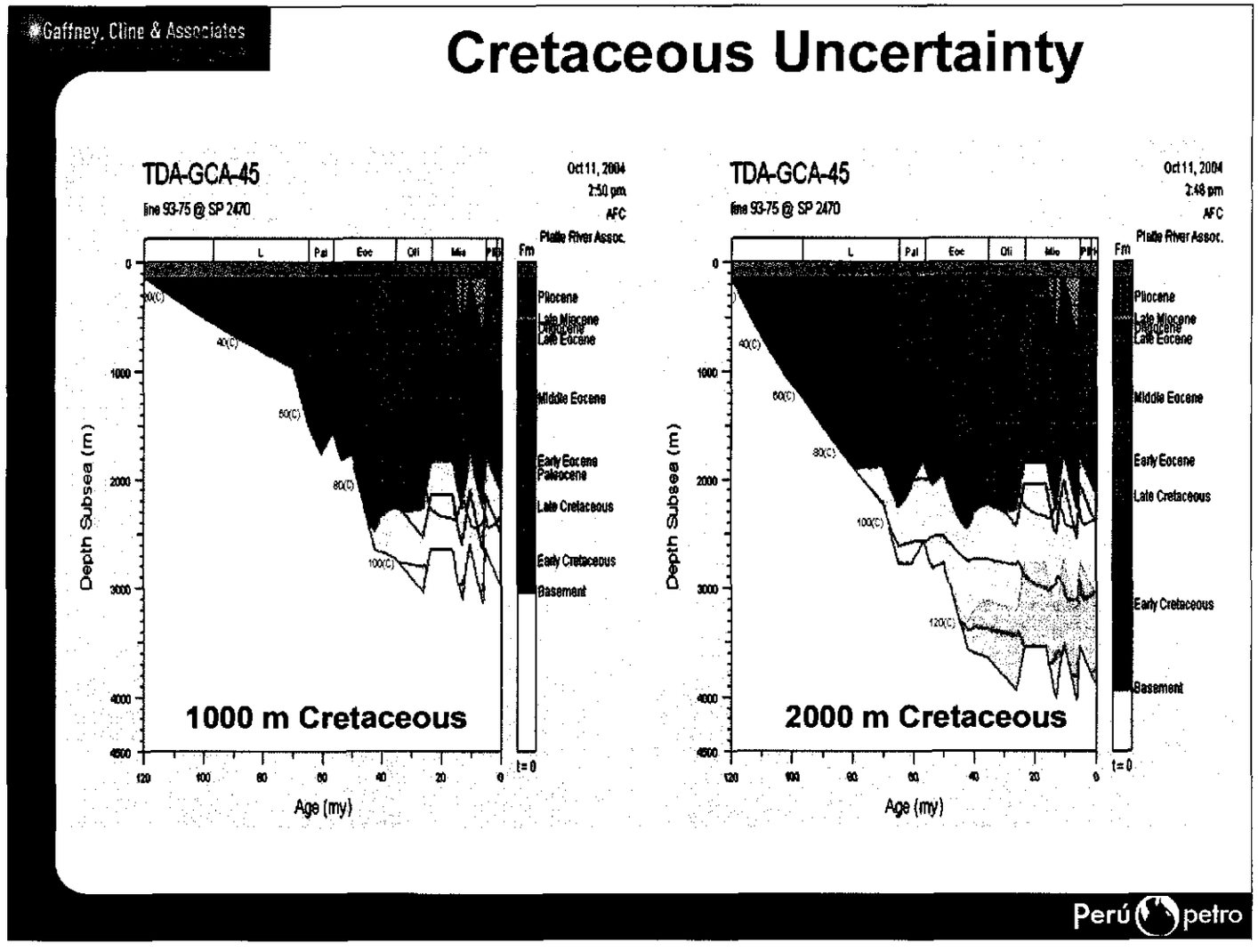
Section 6: Oil Generation Modeling in the Pisco Basin

- Due to the uncertainties on most of the geological parameters for the petroleum systems acting in Pisco Basin, a risked approximation to the oil evolution using BasinRisk from Platte River Associates was utilized

Perú petro



For the Pisco basin model, we selected a location where a potential Cretaceous source rock occurs and the thickness is the maximum interpreted for the basin in order to have the best conditions for oil generation. At the same time, source rocks were considered to be a viable scenario in the Early and Late Eocene intervals.



The Cretaceous was "jump correlated" through just two long strike lines from the Trujillo and Salaverry basins to the Pisco Basin. Therefore, the actual presence of possible Cretaceous source rock, and its thickness, is uncertain. The depth converted line 93-75 shows slightly less than 1,500 meters of Cretaceous at location TDA-GCA-5. The two maturation profiles above show how the generation picture changes if this thickness were increased or decreased by 500 meters. However, even at 1,000 meters thick, the Cretaceous source enters the oil window in Eocene time. If it were 2,000 meters thick, it would have entered the oil window in Miocene time.

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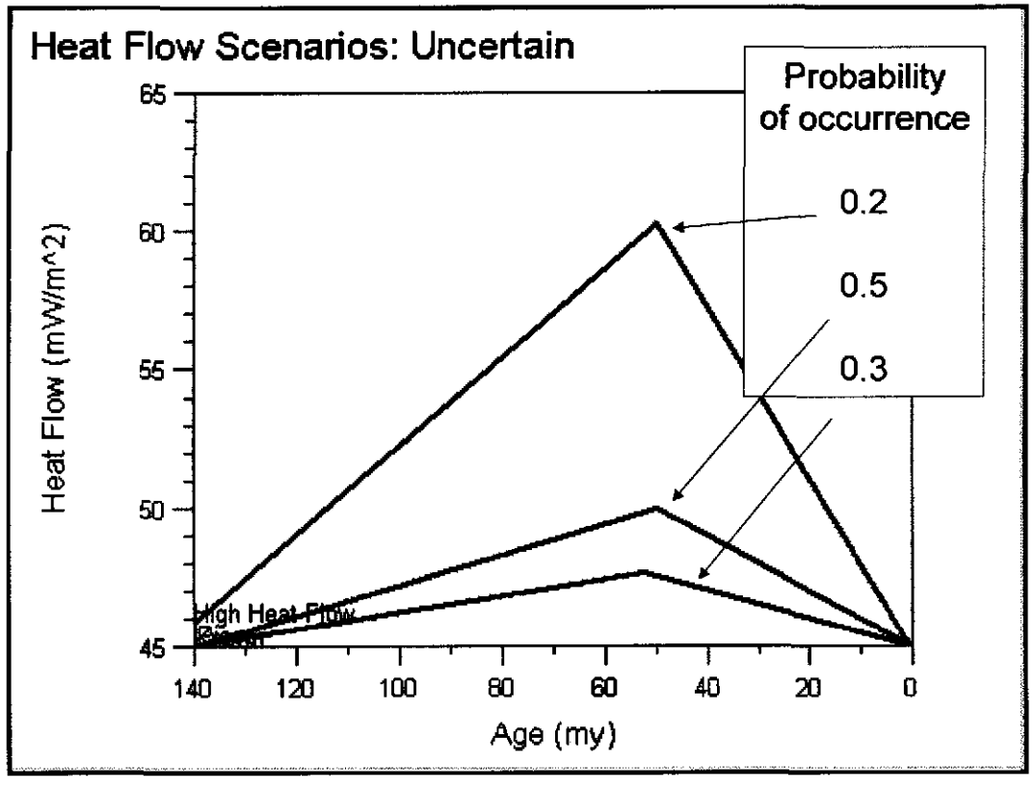
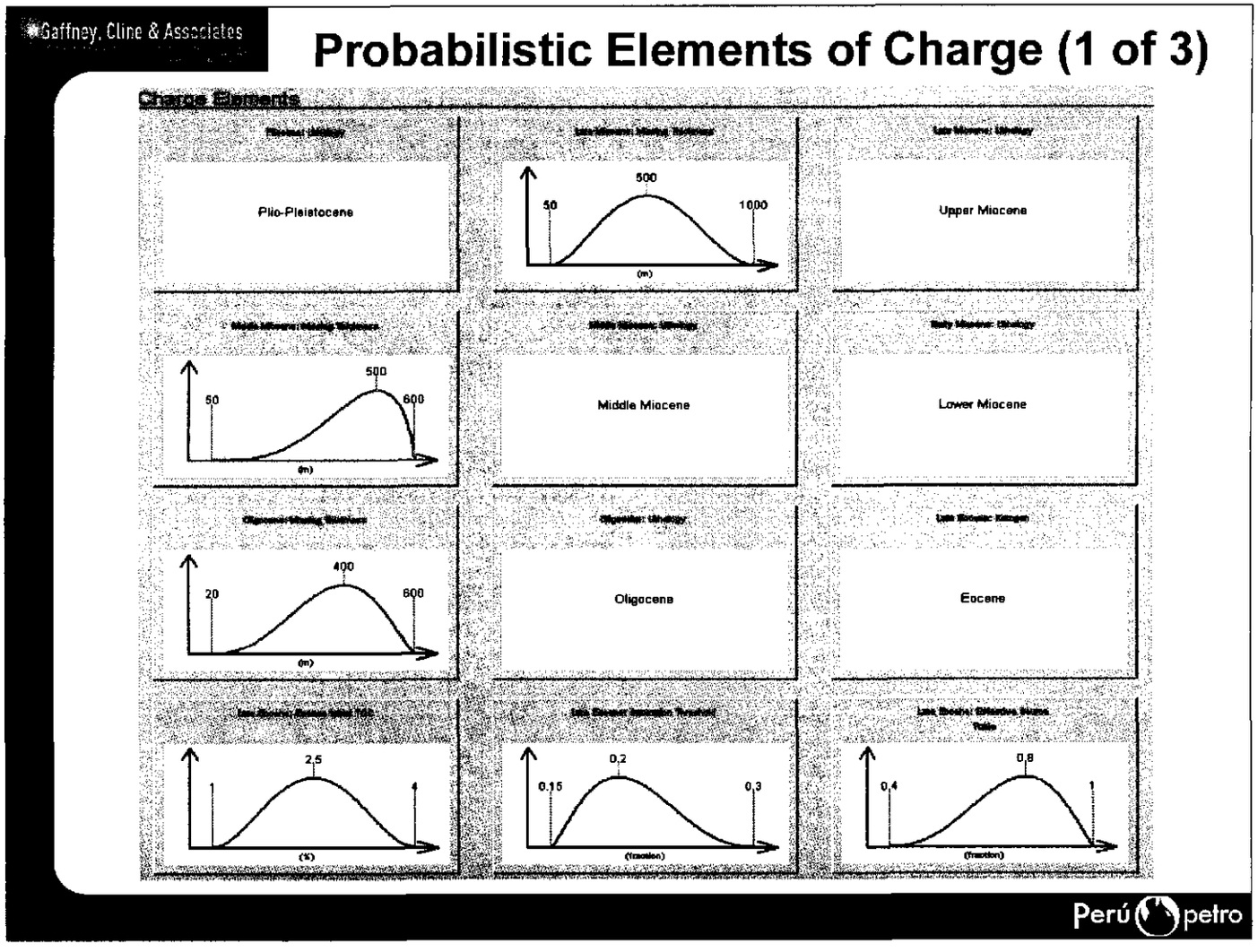
Probabilistic Range for Heat Flow



Perú petro

This is a graphical representation of the 3 different scenarios run in BasinRisk in the Pisco Basin.



Most of the parameters involved in modeling the oil generation/expulsion/migration simulation were subjected to a beta-pert distribution of each value based on geological considerations derived from the seismo-stratigraphic interpretations. Lithologies were considered non-variant and similar to the equivalents in the Trujillo and Salaverry basins.

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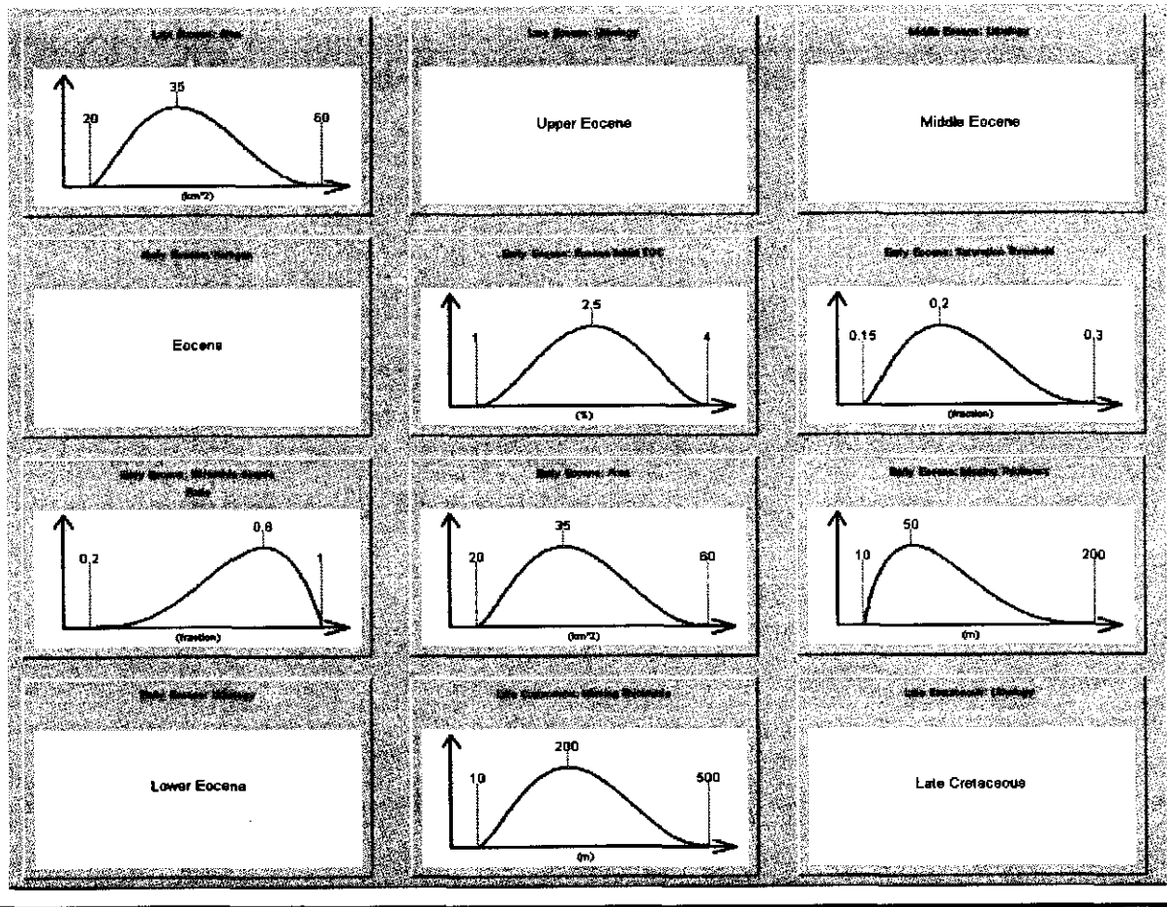
Probabilistic Elements of Charge (2 of 3)



Perú petro

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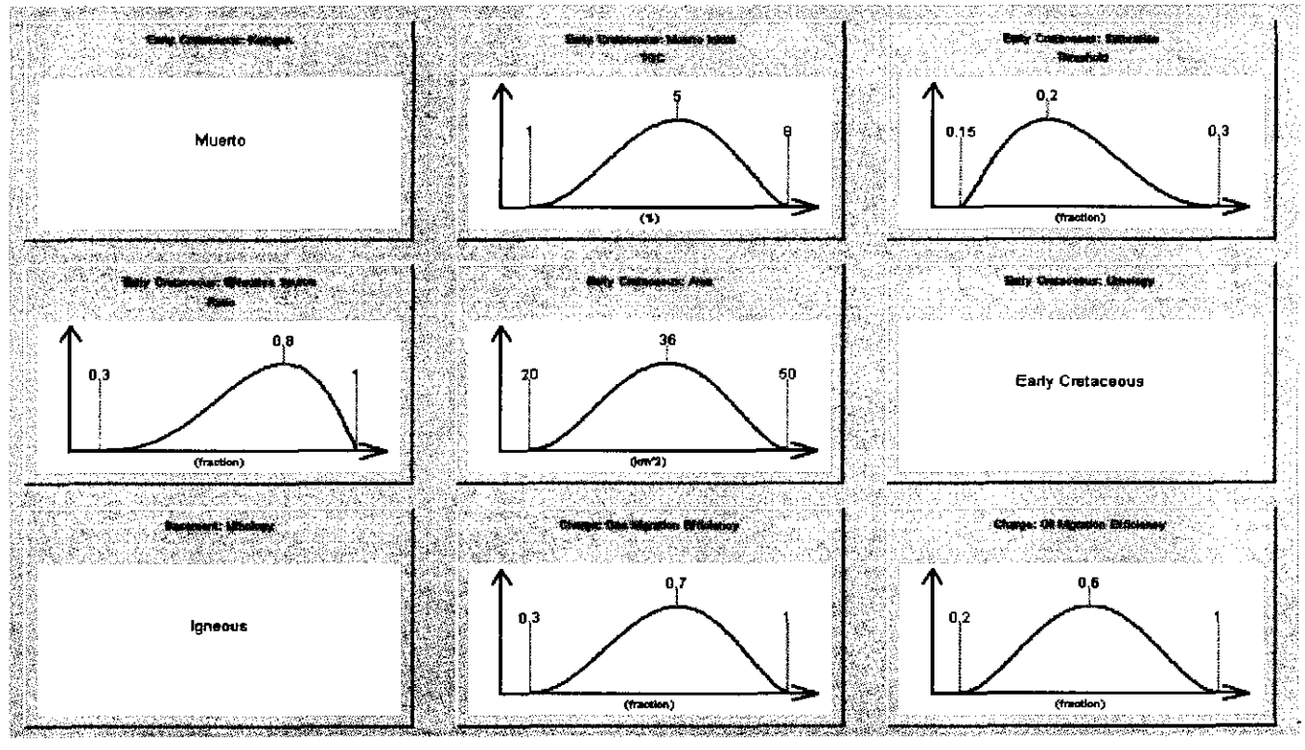
Probabilistic Elements of Charge (3 of 3)



Perú petro

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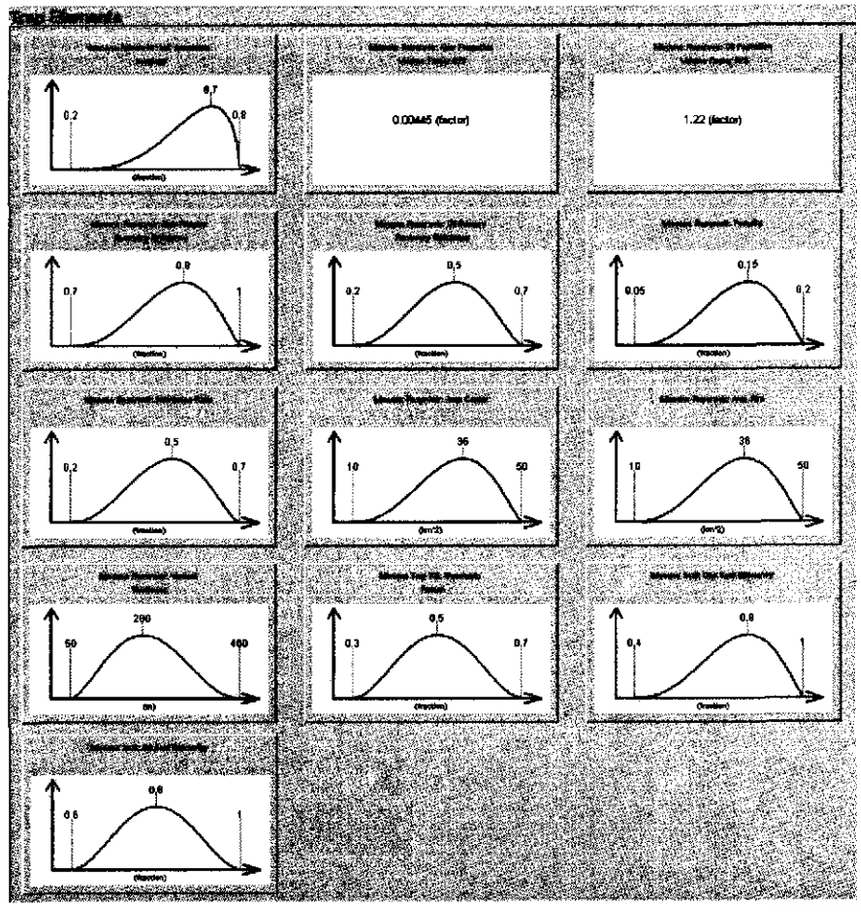
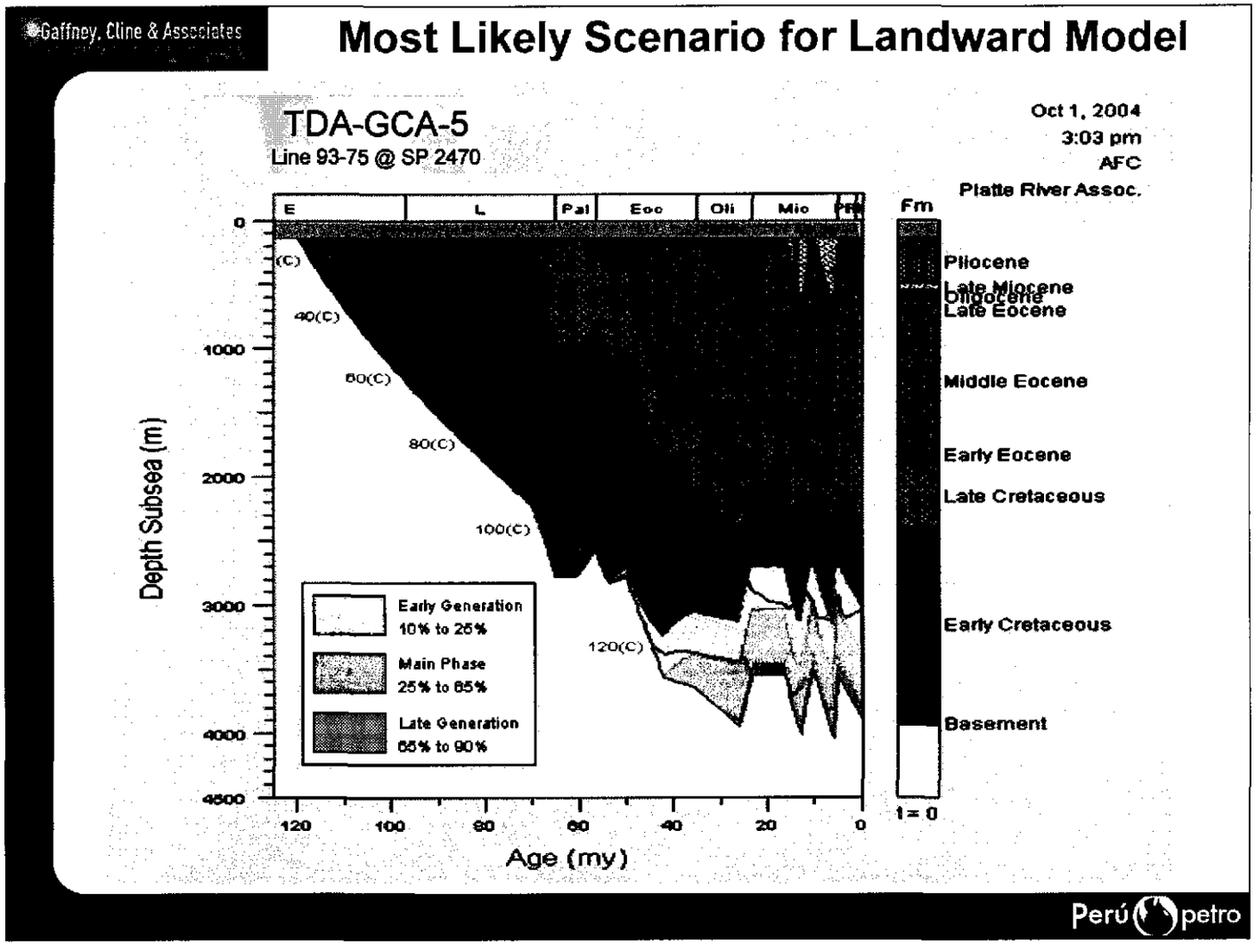
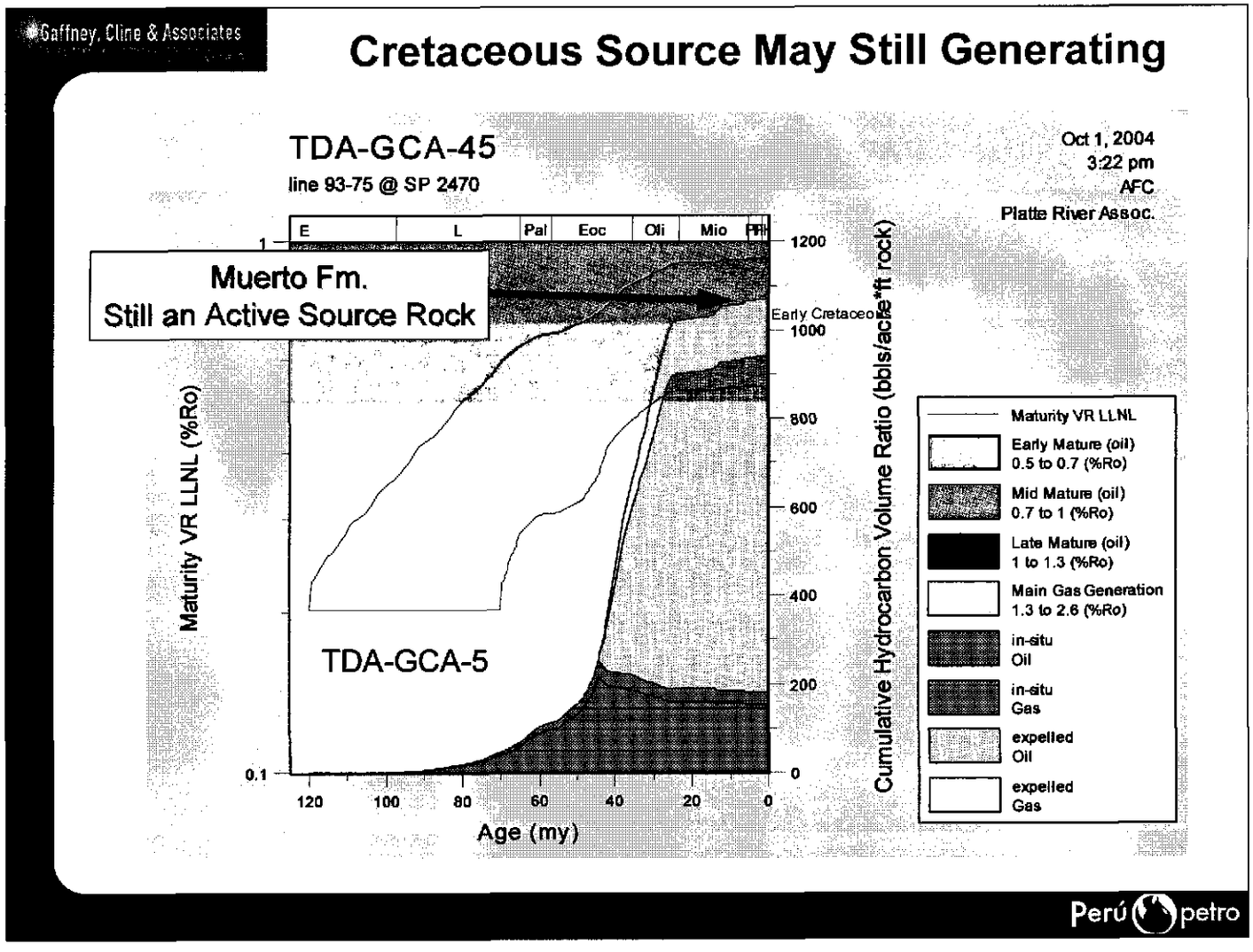
Trap Presence and Volume



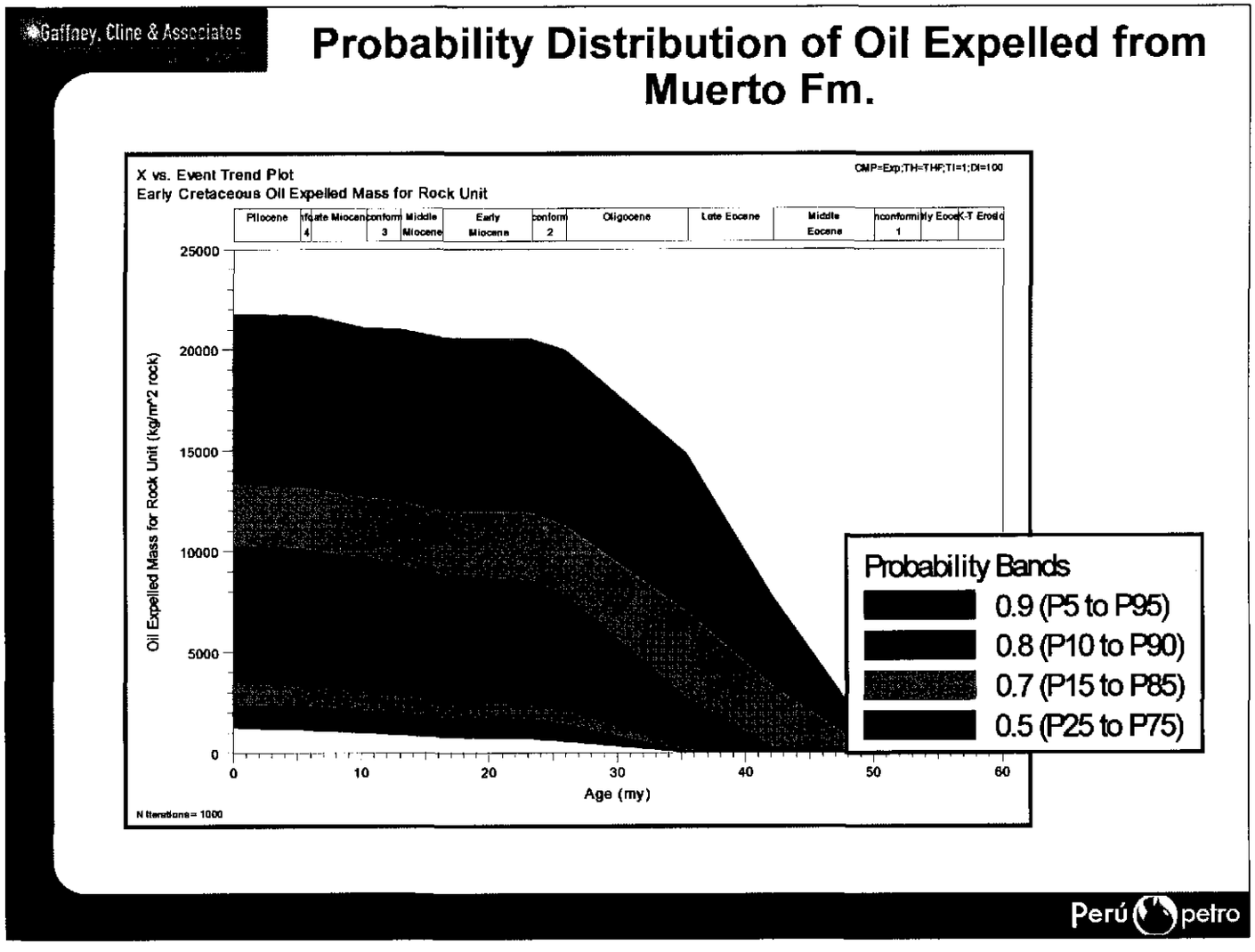
Perú petro



A potential source rock in the Early Cretaceous (Muerto Fm.) may be in the generative stage, but any potential source rock at Eocene level did not attain the adequate level of thermal maturation for oil generation.



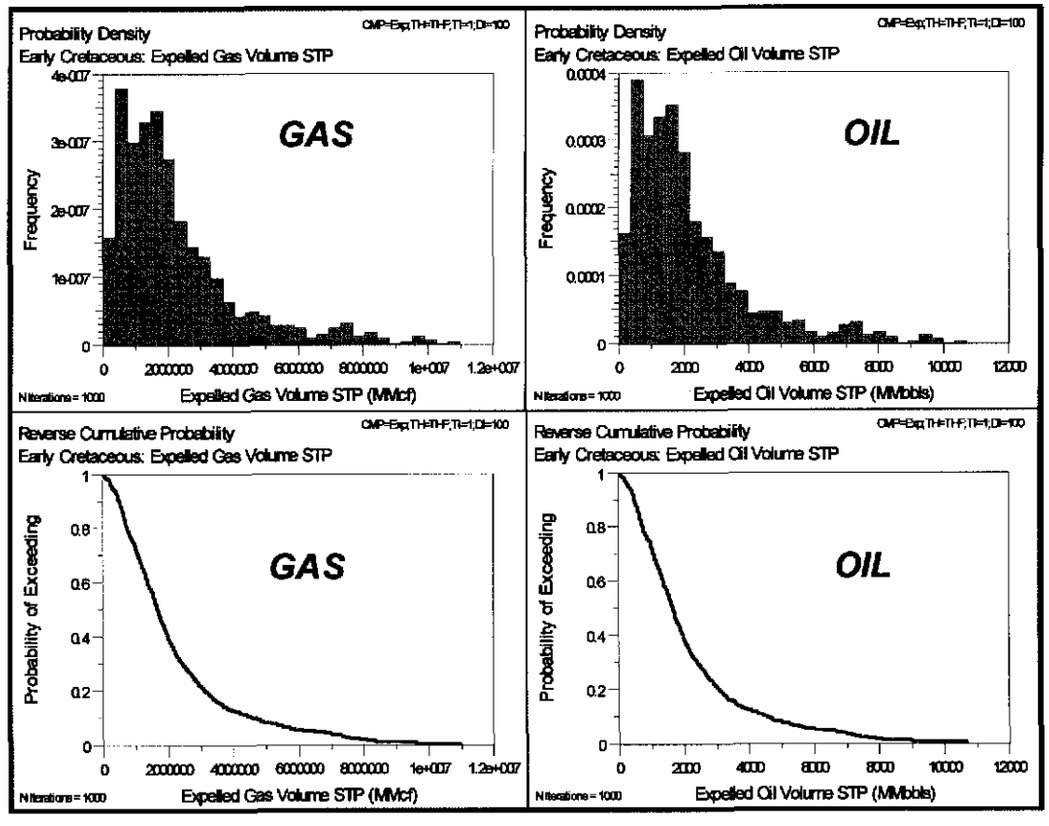
The early Cretaceous Muerto Fm. may still be generating and expelling hydrocarbons today.



A plot of the distribution of the bands of probability for oil expulsion from Muerto Formation in Pisco Basin.

Gaffney, Cline & Associates

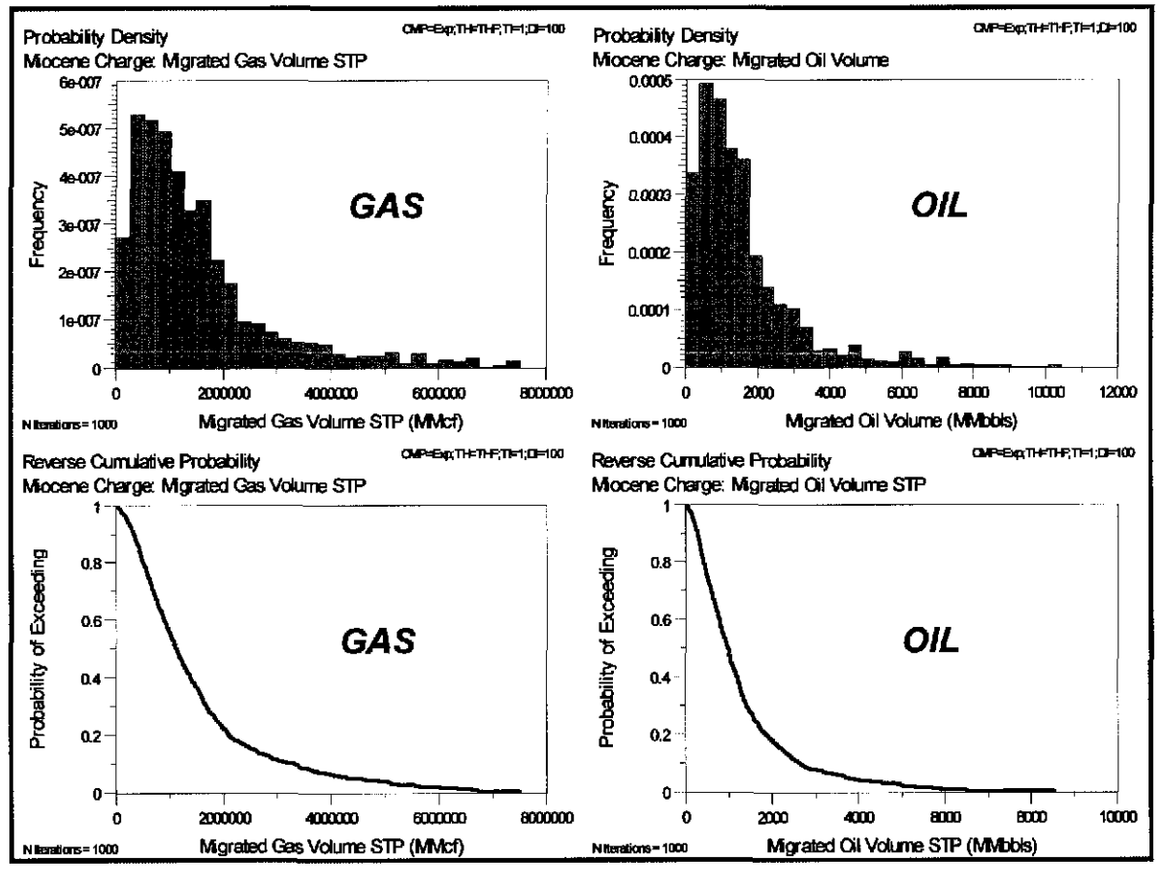
Probability Distribution of Hydrocarbons Expelled from a Cretaceous Source Rock



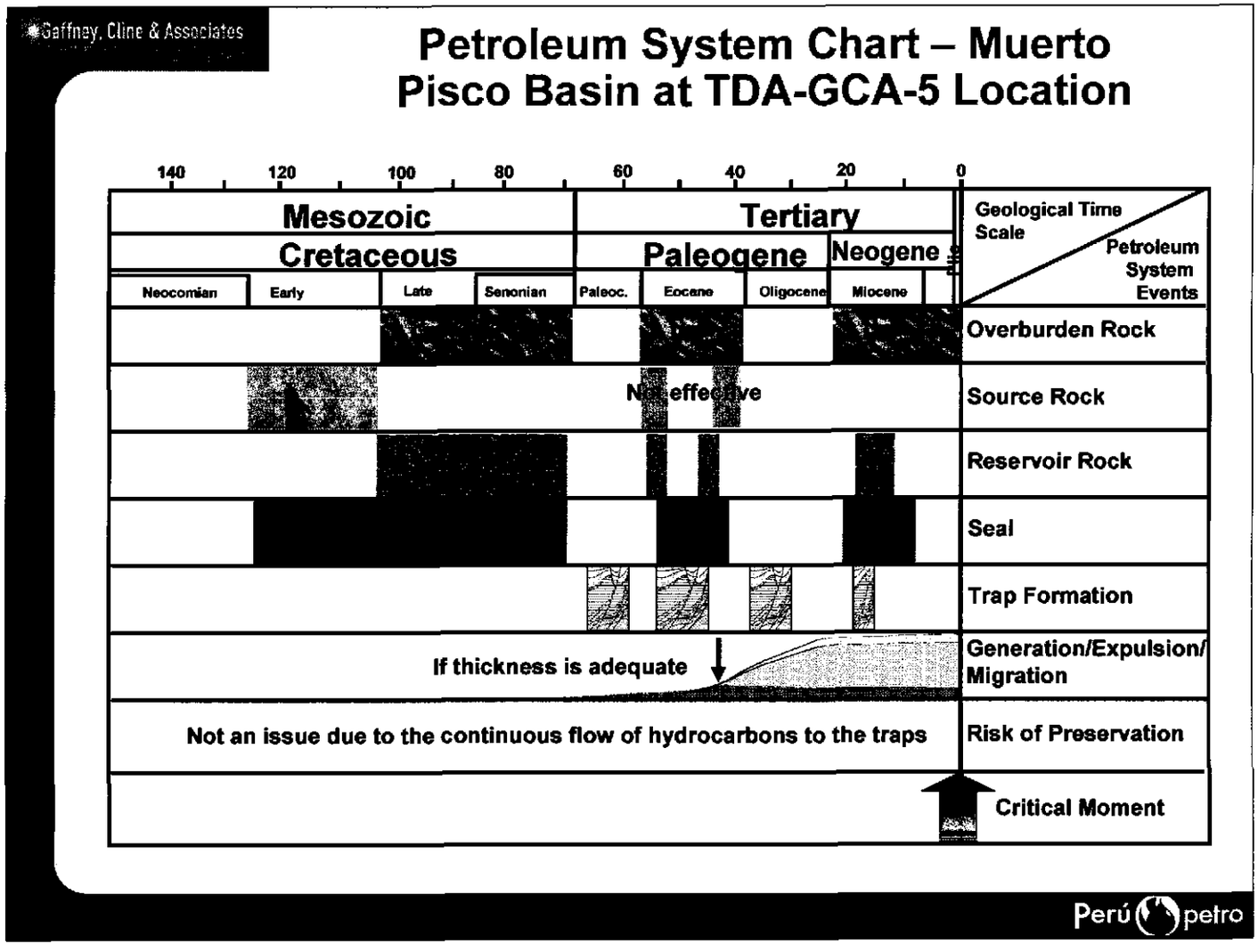
Perú petro

Gaffney, Cline & Associates

Distribution of Hydrocarbons Available to Miocene Traps



Perú petro



Little is known about the stratigraphy of the Pisco basin. Strong deformation segments the basin and inversion probably destroyed some early traps. Inferred Eocene source rocks are likely immature. Inferred Cretaceous source rocks may have matured prior to the formation of traps in the Oligocene and Miocene time. The blue arrow on the generation event line represents the beginning of hydrocarbon expulsion and migration to the available traps. Traps formed at Oligocene and Miocene times have a higher risk of receiving hydrocarbons, due to a timing issue between the beginning of the expulsion of the hydrocarbons around 40 Ma ago and the creation of the traps after the beginning of the expulsion. Nevertheless, these later traps may have been sufficiently charged by expulsion that may have continued to the present

APPENDIX J

ENVIRONMENTAL REPORT

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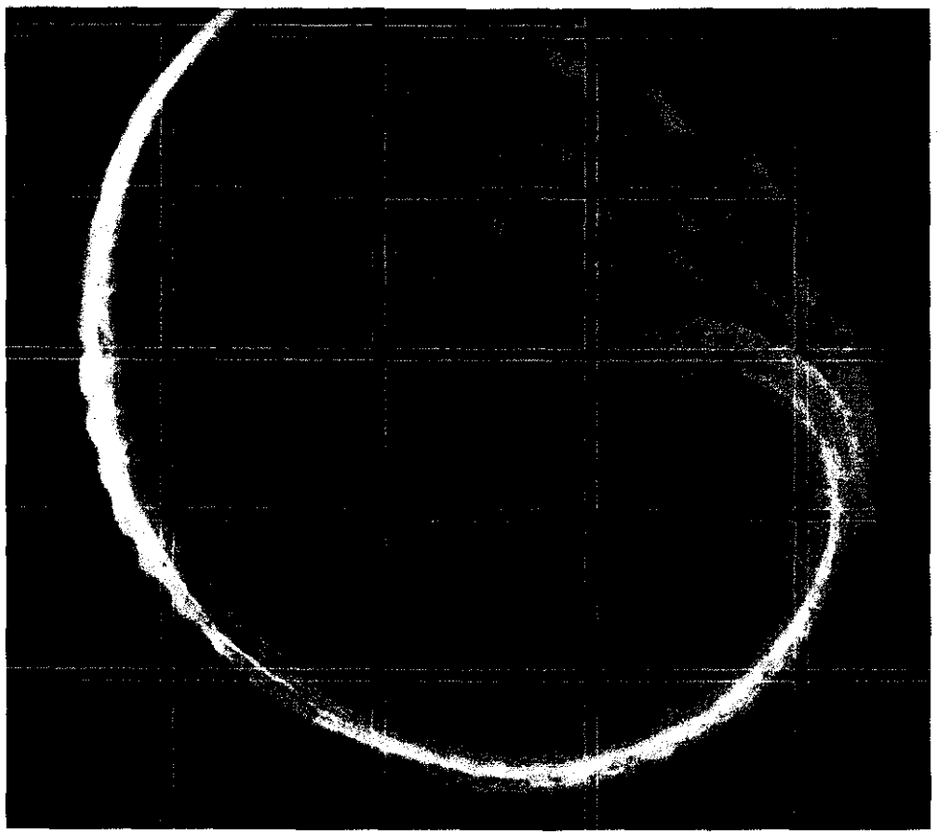

Environmental Characterization of the Hydrocarbon Exploration Areas in the Peruvian Offshore Sedimentary Basins

ERM Peru

October 1, 2004

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1 *INTRODUCTION*

We are conscious of the great efforts the Peruvian government is making in connection with the planning of activities related to the hydrocarbon sector, particularly regarding the spreading of information on requirements for accessing exploration and production areas. In order to preserve the ecosystem and lessen uncertainties to potential investors, requirements of social and environmental information to be submitted are increasing in number and complexity on a daily basis.

The oil and gas industry's impact and interference are not only felt upon the environment but also upon other productive activities, such as fishing and tourism.

Information on the Peruvian continental platform is scarce, and further investigation and systematization is needed so that it can be utilized. Lack of information on the subject and these areas hinders the license and permit granting by the government, specifically information required for the studies on environmental impact.

The general scope of ERM's work is to create a cartographic database useful for the exploitation of the whole oceanfront. It includes text and charts that refer to the seashore environment's most relevant aspects, with special attention to the sedimentary basins. Biodiversity components, fishing activity and oceanography, as well as the social and economic situation on the coast, are considered, and, as a result, the environmental complexity level for the different areas has been determined.

ERM would like to especially thank PERUPETRO for its support in the gathering of information necessary for the completion of this project.

2 *SCOPE OF WORK*

- to process and synthesize all the available and significant social and economic information on exploration projects for hydrocarbon areas in sedimentary basins of the Peruvian continental shelf
- to set up the levels of environmental requirements for exploration activities (drilling and seismic) on the Peruvian continental shelf
- to advise potential investors on legal requirements to carry out exploration activities on the Peruvian continental shelf
- to define the environmental complexity levels for every basin and provide information on the possible consequences and problems associated with activities in these areas

3 *CHARACTERISTICS OF HYDROCARBON EXPLORATION OPERATIONS*

A sound knowledge of underground geological structures in very different climates is needed when searching for oil and natural gas. Once an area is selected, different types of geophysical exploration are carried out and an accurate assessment is made of underground formations, such as seismic and exploratory drilling.

3.1 *SEISMIC PROSPECTION*

Seismic prospecting provides information on the general features of underground structure. Measures are obtained by means of vibrating or percussion features generating shock waves by blast or by underwater explosive discharges of compressed air (air cannons).

The time elapsed between the beginning of the shock wave and the echo's return is used to determine the depth of the reflecting substrata. Due to their capability to generate three-dimensional images, the recent usage of supercomputers has notably improved the evaluating of data resulting from seismic testing.

When prospection and measurements indicate the existence of strata that might contain oil, exploratory wells are drilled to determine the presence of oil or gas and their commercial viability and accessibility.

3.2 *EXPLORATION WELLS*

Once geological data and geophysical prospections have been analyzed, exploration wells are drilled. Drilling platforms support drilling towers, the tools and all the equipment necessary for high seas or inland waters operations. Ships, or floating or submersible barges, can serve as platforms. Platforms can also be set up on steel supports, such as those used in shallow waters, or be large floating gravity platforms, made of reinforced concrete, for use in deep waters. Once the drilling is finished, sea platforms can work as a support for the production equipment.

Basic drilling equipment consists of: a tower, a drilling tube, a large capacity cathead to lower and raise the drilling tube, a table or platform for turning the tubing and the drill head, a mixer, a mud pump, and a motor to push the turning platform and the cathead around.

The drilling platform serves as a basis for the workers to tie in and out the tubing sections used to deepen the hole. As the hole deepens, the tube increases in length and the string drillpipe is suspended from the tower. When a drill head needs to be removed, the entire string drillpipe is removed from the well, detaching every section and rearranging them vertically within the tower. Once the new drill head is placed, the process is inverted and the pipe is again inserted into the hole to permit the drilling to continue.

The drilling mud is a liquid made of water, oil and clay with chemical additives (for example: formaldehyde, lime, sodium hydracid, baryte). Often, caustic soda is added to control the drilling mud pH (acidity) and neutralize potentially dangerous additives and completion liquids. Drilling mud is injected into the well under pressure from the mixing tank in the drilling platform, through the drilling pipe up to the drill head. The mud then moves upward between the outside of the drilling pipe and the hole walls, reaching the surface where it is filtered and recycled. The drilling mud is utilized to refrigerate and lubricate the drill head, lubricate the pipe and expel the crushed rock fragments from the hole. It is also used to control the flow coming out of the well by covering the hole walls and putting up resistance to the gas, oil or water pressure the drill head meets.

The coating consists of a heavy pipe made of special steel that covers the well hole. It prevents the collapse of the hole walls and stops mud from leaking into fresh water strata during drilling operations. The coating also seals water-saturated sands and high-pressure gas areas. Initially, it is used near the surface and then cemented to lead the drilling pipe. After pumping a milk of cement through the pipe, the cement is pressured to move upwards between the coating and the well walls. Once the cement sets, the coating is placed and the drilling is resumed with a smaller diameter drill head.

4 *WORK ORGANIZATION*

This project is organized as follows:

1. General information on the Peruvian oceanfront, which is the total area under survey.
2. Completed and compiled social and environmental information systematized in 5 main subjects: Biodiversity, Protected Natural Areas, Social and Environmental Aspects, Oceanography, Legal Background and Legal Requirements.
3. Results of calculations made to determine the environment's complexity in each of the sedimentary basins.
4. Conclusions and final considerations on the analysis.
5. Glossary of terms related to the subject, acronyms listing and consulted bibliography.
6. Charts and pictures with detailed information on areas and/or main activities are contained in the annexes. A booklet has been prepared on GIS operation.

5 *SOCIAL AND ENVIRONMENTAL BASINS*

5.1 *GENERAL FEATURES OF THE PERUVIAN SEA*

The Peruvian coast line stretches between latitudes 03°24´S and 18°20.8´S, having an approximate extension of 1 200 nautical miles (nm), with a South (S) and Southeast (SE) orientation; the area North of Cabo Blanco is excepted as it shows a Southwest orientation (SW).

The varied and abundant flora and fauna in the continental platform appear as a consequence of the interacting of several climatic and oceanographic factors producing the emergence of coastal areas. This upward movement is permanently taking place with great intensity.

Emergence is the result of the wind's action dragging waters far off the coast. The vacant spaces are taken by subsurface waters rich in nutriments but relatively cold, poor in oxygen and of a moderate salinity. The superficial layers are thus fertilized, contributing to phytoplankton production, the first link in the trophic chain.

The most important emergence areas facing the Peruvian coast are: Bahía Independencia (Independence Bay) and San Juan (14°-15°S) , Paita and Punta falsa (5°-6°S), Pimentel and Chicama (7°-8°S) and Huacho-Callao (11°-12°S). Waters feeding the coastal emergence proceed from the CSSE North of the 8°S, from the SPS up to 15°S, and from the Warm Waters from the Sub Antarctic Region up to 14°S.

This process is affected by the "El Niño" phenomenon, which causes a reduction of the atmospheric pressure in the Eastern South Pacific (South America Coast) and an increase in Oceania, producing:

- An overall increase of the sea surface temperature, largely in the Eastern and Central sectors of the Equatorial Pacific,

- An increase in the air temperature and a decrease of the atmospheric pressure in the Eastern South Pacific coast (South America Coast), and

- A decline of sea emergences and a sea level increase in our coasts.

Oceanographic Aspects:

The Peruvian coast line stretches between latitudes 03°24´S and 18°20.8´S, having an approximate extension of 1 200 nm, with a South (S) and Southeast (SE) orientation; the area North of Cabo Blanco is excepted as it shows a Southwest orientation (SW).

The continental platform shows smooth slopes, with abundant and varied flora and fauna, with a maximum width of 65 nm between 7° and 10°S and a minimum width of 3 nm south of 15°S.

Southeast trade winds are dominant in the Peruvian coast, being more intense during the winter season and weaker in the summer time, with medium speeds of 4 meters per second (m/s). However, local winds blow near the coast and bays, these being generally sporadic and of a short duration, sometimes having a direction opposite to that of the Southeast trade winds.

Sea water temperature in the Peruvian coasts is very high in the summertime and very low in winter. Temperatures generally increase towards the Equator and to the West, giving way to area and latitude gradients. February and March have the maximum temperatures, going up to 25°-26°C beyond the 150 nm and to 17°-18°C in the coast south of 14°S. Minimum temperatures occur in August and September due to the intensification of the Southeast trade winds and the coast emergence. At this time, the coast strip (within the 50 nm) shows values between 13° and 17°C, while the 19°C isotherm is found beyond the 150 nm.

Salinity generally varies according to latitude. High salt concentrations are present in the subtropical region where evaporation is intense, while low concentrations are found in the tropics where rainfall is dominant. On average, concentrations in the Peruvian sea are between 33.22 to 35.6 grams per liter (g/l) in summer and 33.8 to 35.44 g/l in winter; these concentrations may change due to meteorological and topographic factors.

The Peruvian coast is affected by different types of water masses, such as:

- Cold Coastal Waters (CCW), characterized by their relatively low temperatures and high contents of nutriment. These waters are produced by the Peruvian Coastal Stream (PCS) and by emergence in the coast. They are located within 30 nm during the summer and within 50-60 nm in winter, with temperatures between 14° and 18°C and salinities from 34.8 g/l to 35.0 g/l.

- Surface Subtropical Waters (SSW) show high temperatures (18°C) and great concentrations of salts (35.1 g/l), stretching all along the Peruvian coast outside the CCW area. Under normal conditions they can reach 50 meters (m) deep.

- Surface Equatorial Waters (SEW) are linked to high temperatures and low salinities. Their location in summer is north of 6°S . In winter, temperatures range from 19° to 25°C and salinities from 34.0 g/l to 34.8 g/l, reaching between 15 and 25 m deep.

- Surface Tropical Waters (STW) are normally located North of 4°S with temperatures exceeding 25°C and salinities lower than 34.0 g/l.

Sea flow at the Peruvian coast is complex, the Humboldt Stream being the main surface stream. The Humboldt Stream splits into two other streams: the Peruvian Coastal Stream (PCS), flowing between the coast and 78°W with an average speed of 5 to 15 centimeters per second (cm/s), its intensity decreasing as it moves northwards, then increasing again during the winter, carrying 6 million m3/s (cubic meters per second) of water; and the Peruvian Oceanic Stream (POS), stronger than the PCS, flowing northwards, outside of 82°W, carrying 8 million m3/s. Both streams join in a single flow between July and October.

Between the PCS and the POS, the Subsurface Peruvian Stream (SPS) flows at a speed slightly over 20 cm/s at Punta Falsa (False Point), carrying equatorial waters towards the south. The Cromwell Stream Southern Extension (CSSE) stretches along the coast up to Pimentel-Chicama, joining later the SPS.

In Peru, coastal emergence takes place permanently and with great intensity. Emergence is the result of the wind's action, dragging waters far off the coast. The vacant spaces are taken by subsurface waters rich in nutriments but relatively cold, poor in oxygen and of a moderate salinity. The superficial layers are thus fertilized, contributing to phytoplankton production, the first link in the trophic chain.

The most important emergence areas in facing the Peruvian coast are: Bahía Independencia (Independence Bay) and San Juan (14°-15°S) , Paita and Punta falsa (5°-6°S), Pimentel and Chicama (7°-8°S) and Huacho-Callao (11°-12°S). Waters feeding the coastal emergence proceed from the CSSE North of the 8°S, from the SPS up to 15°S and from the Warm Waters of the Subantarctic Region up to 14°S.

Location of the area under survey:

The area covers the Peruvian oceanfront and includes maximum depths between 5,000 and 7,000 m.

There are eight oceanic zones available for Hydrocarbon Exploration and Exploitation License Contracts. Among these, Pisco, Sechura, Talara and Tumbes Progreso partially occupy offshore areas. See Map 1

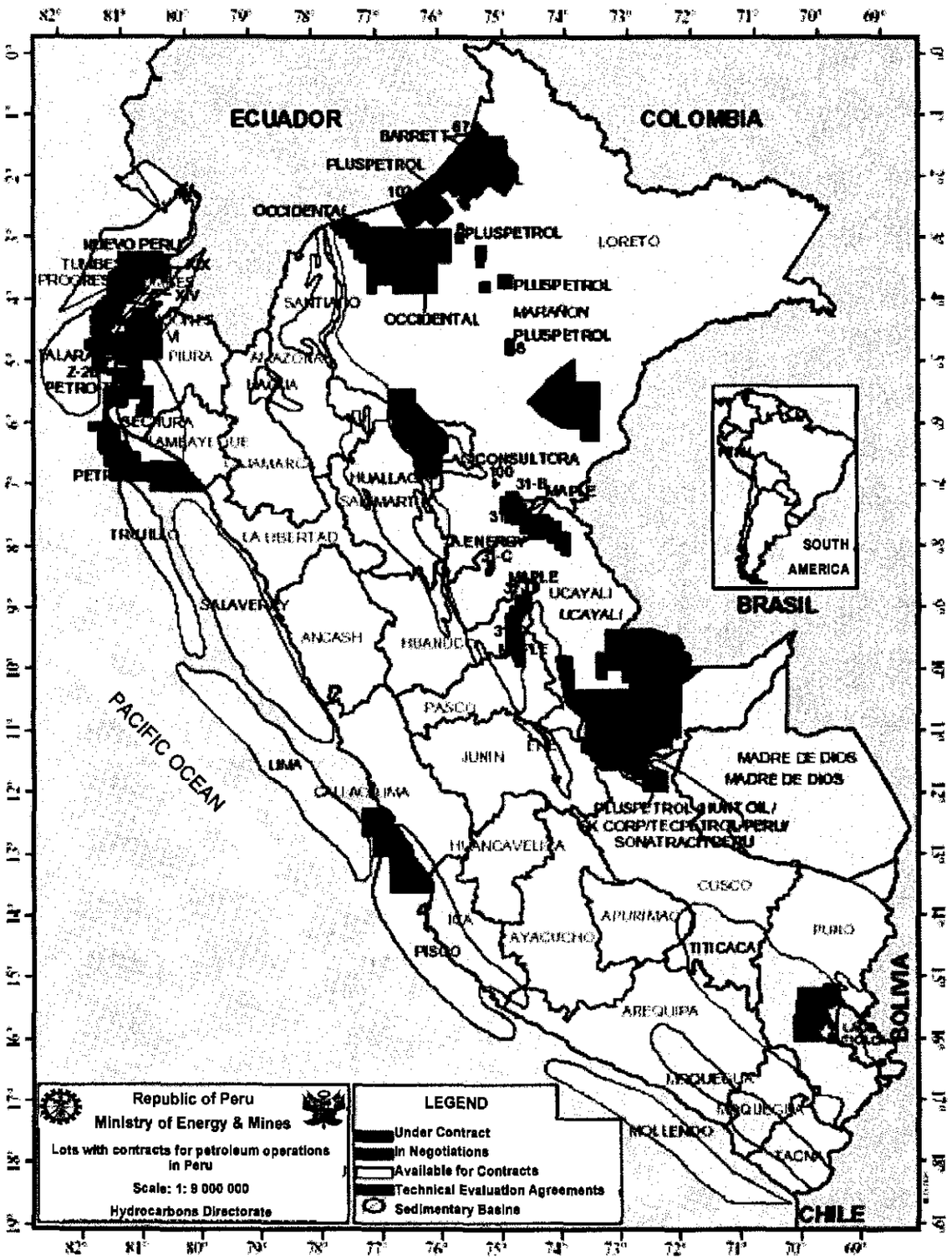
Their Northern boundary is set by the following points:

Longitude 82° W, Latitude 3° 45′ S
Longitude 80° 25′ W, Latitude 3° 45′ S

Their Southern boundary:

Longitude 72° 60′ W, Latitude 18° 50′ S
Longitude 70° 37′W, Latitude 18° 50' S

Map 1: Hydrocarbon Exploration Zones



July 2004

5.2 BIOLOGICAL DIVERSITY

5.2.1 Introduction

According to Pulido (1991), the ecological decline of the Peruvian sea starts in the fifties with the fishing of the anchovy (*Engraulis ringens*) for industrial purposes. This condition worsened in 1972-73 due to the effects of "El Niño", which produced a drastic reduction of the anchovy population.

Quoting Castro (1986), Pulido (1991) mentions a decrease to critical levels was recorded for the guano birds populations after El Niño 1982-83. Such was the case for the guanay (*Phalacrocorax bougainvilli*), as well as other species, including the chuita (*Phalacrocorax gaimardi*), the common pardela (*Puffinus griseus*), the large salteador (*Catharacta skua*), the zarcillo (*Larosterna inca*) and the gross beak falaropo (*Phalaropus fulicarius*). Other sea mammal populations were also modified, such as the delicate seawolf (*Arctocephalus australis*) and the chusco sea wolf (*Otaria byronia*).

Among the large cetaceans (misticets), and as a result of indiscriminate hunting, all the members of the Balaenopteridae family (*Balaenoptera musculus*, *B. physalus*, *B. edeni*, *B. borealis*, *B. acutorostrata* and *Megaptera novaeangliae*) are considered threatened species. Likewise, many odontocets species (*Delphinidae, Kogiidae, Ziphiidae and Physeteredidae* families) are listed as in vulnerable situation or included in the CITES (2003), Appendix 2, because of incidental hunting and fishing.

The situation for sea turtles is quite similar. According to IMARPE records (1987), around 22,000 turtles were captured only in the Pisco area. This represents the greatest Chelonia capture recorded for the Peruvian seashore (Aranda and Chandler, 1989 quoted by Pulido, 1991). During the last years, several different species, in spite of being protected, continue to be subject to illegal extraction.

On the other hand, marine biodiversity is also affected by a whole range of anthropogenic pollution processes carried out along the seashore, such as those caused by continuous industrial and domestic dumping.

For this reason, and owing to the progressive loss of diversity, a number of initiatives arose aimed at its preservation. By means of different, internationally renowned conventions, meetings and similar events, different threatened flora and fauna species have been identified, thus establishing categories and terminology related to their protection.

In the case of Peru, and in order to preserve the high biological diversity typical of certain areas in that territory, including the ecological, social and economic implications deriving from it, the Government, in order to guarantee this diversity, officially created a series of natural area categories.

Biodiversity is affected, to a greater or lesser extent, by hydrocarbon exploration activities, such as seismic prospecting or drilling, carried out in sedimentary basins. The purpose of this work is to determine the environmental vulnerability of each one of the basins established, based on historical information available at scientific institutions, government agencies and NGOs.

The Peruvian Outcropping System is one of the most productive marine ecosystems in the world, considered a part of the cold sea eco-region of the Peruvian current (Humboldt Stream), which includes the eastern Pacific ocean from latitude 5° south in Peru up to the central part of Chile.

5.2.2 Methodology and Parameter Characterization

Environmental characterization of sedimentary basins is based on the analysis of specific bibliography referred to abundance and distribution of birds, tortoises and marine mammals and key species of the Peruvian coastline, as well as identification of protected areas included in SINANPE or which could potentially be protected owing to their ecological and/or economic importance.

Gathering the information available at institutes and government agencies, such as IMARPE or INRENA, the attributes which had previously been established were identified and characterized by the presence of vulnerable areas, marine mammals, birds, marine tortoises and key species in each one of the sedimentary basins, considering the geographical area where they belong or the areas which are sufficiently close to be influenced by the future activities taking place.

5.2.2.1 Bird fauna

The attribute "birds" has been divided into two categories: coastal birds (belonging to the shore line, the continental shelf and insular clusters) and oceanic birds (more frequently registered further out than 60 nautical miles). This division has been made considering the migrating capacity of this zoological group and its natural history, and it proves useful when determining the presence of species of both categories in each basin.

The information has come from publications on surveys, census and other population estimates, published by IMARPE, INRENA and NGOs, as well as from information collected from international forums, such as the International Unity for the Preservation of Nature (List of Threatened Species, 2003), the Convention on International Trade of Threatened Species belonging to Wild Flora and Fauna, 2003, and the Convention on Preservation of Wild Animal Migratory Species (also known as the Bonn or CMS).

Concerning identification of species in each basin, the data is for reference purposes and corresponds to the field records collected by GEA Peru (1999) and taken from updated bibliography. The common names in Spanish follow Mazar, Barnett and Pearman classification criteria (2001) and the rest of the nomenclature is based on the Sybley-Monroe system with modifications. It is important to point out that distribution of oceanic birds can also include the areas close to the shore while that for coastal birds is more restricted and includes islands.

Once the presence of the different groups of coastal and oceanic birds in the established basins had been determined, including migratory ones and taking the known geographical distribution as a reference, a list was drawn up emphasizing the importance of each species in accordance to intrinsic characteristics, such as: whether coastal or oceanic, whether resident or migratory, their conservation status based on different international sources and the List of Peru's threatened species (Supreme Decree 013 - 99-AG), as shown in Chart 1 (Annex 1).

Two types of marine bird groups exist: coastal (stretch of coastline, continental shelf and islands) and oceanic. Different bird species have become specialized in taking advantage of the organisms living along the coastal area, either on beaches or cliffs,

others feeding on the resources available on the surface of the water, and those which obtain their food from deeper areas, catching their prey at sea.

Marine birds have been registered in all seas and oceans throughout the world; therefore, conservation-relative problems of these organisms should be treated globally. Not less than 97 marine bird species (from a total of 337) are in danger of becoming extinct, representing 29% of the world total.

A considerable number of species migrate to Peru. Sixty-five percent of the species listed in Chart 1 (APPENDIX I) are migratory and mostly come from the Northern Hemisphere. To a lesser or greater degree, all of these migrate at some time of the year. 40 species or subspecies identified from this bird ratio have their breeding areas in the Northern Hemisphere, and they migrate south in the winter to later return the following year.

Worldwide, twenty percent of marine birds are in danger of becoming extinct, as compared to an estimated 12% for birds in general; however, marine birds tend to have a longer life cycle than land birds. This low reproductive percentage means that it takes them more time to replace the loss of individuals. For example, some albatross lay one egg every two years.

Ninety-five percent of the marine bird species nest in colonies. For population evaluation purposes, a colony is defined as a group of birds which nest together and search for food outside their breeding grounds. A colony can be anything from 10 to thousands of pairs.

The most abundant marine birds in the Peruvian current are the guano producing birds (Jahncke, 1998), which basically consume anchovies (Jahncke and Goya, 1997 and 1998). Together with the guano birds and other endemics, other species of marine birds move offshore searching for food. Such is the case of the camanay (blue footed booby) (*Sula nebouxii*), the pardelas (terns) and petrels (family of *Procellaridae*), albatross (*Diomedeidae* family) tempest petrels (*Oceanitidae* family) and phalarope (*Phallaropus sp.*). Although these birds fly in search of food in the sea in Perú, anchovies are not the only food they consume.

There is very little information available about the food consumed by diverse marine bird species which spread to the Humboldt stream; however, there are registers of the camanay (blue footed booby) feeding on anchovies and other fish (Jahncke et al 1998). It is estimated that in the seas off the shores of Peru, pardelas (terns) feed on anchovies (Brown 1981), while the albatross and some petrels feed specially on squid. Jhancke and Goya (1998) have determined that the variations in the diets of guanayes and piqueros (booby birds) reflect changes in the relative abundance of anchovies, and could be good indicators of the resources which can be found in the Peruvian sea.

Owing to their predatory condition and vast distribution, marine birds are greatly affected by oceanographic changes, which cause alterations in food distribution. The "Niño" has been the most important oceanographic alteration in the Peruvian sea (Arntz and Farbach, 1996), and during its most intense moments there have been significant decreases in guano producing populations (Jahncke 1998), as well as drastic changes in feeding habits (Jhancke and Goya 1998). Additionally, the distribution of guano birds spreads south, while other tropical marine bird species come nearer to the Peruvian coast, this being considered an indicator of oceanographic changes (Jhancke et al 1998[a]).

The Peruvian shore's most representative guano birds are the guanay cormorant (*Phalacrocorax bougainvilli*), the Peruvian booby bird (*Sula variegata*), the pelican (*Pelecanus thagus*) and the camanay (blue footed booby) (*Sula nebouxii*). Guano extraction is a strong economic activity on some islands of the coast. Guano producing birds are distributed all along the Peruvian coast. The guanay and the piquero (booby) are from the island of Lobos de Tierra, although they have been reportedly seen as far as Ecuador. Guano bird distribution is influenced, to a lesser or greater degree, by cold coastal waters and by the resources typical in this mass of water, the anchovies and the múnida (squat or red lobster). The camanay (blue footed booby) is a tropical species distributed between Mexico and Peru (Harrison 1988), but on the Peruvian shoreline its register limits it to the northern zone, its reproduction being carried out on the islands of Lobos de Tierra and Lobos de Afuera (Murphy 1936, Brown 1981), the latter being its southern limit.

Far from the coast, species composition changes with a higher register of subtropical and oceanic birds, storm petrel (*Oceanodroma sp.*) being the most abundant. These small birds feed on surface plankton, which is similar to what happens with the *Phalaropus sp.*, which also feeds on microorganisms. That is why their distribution is different to that of fish-eating birds. The Galapagos albatross has also been registered on the Peruvian coast, although they nest on the island of La Española, which belongs to that cluster of islands (Harrison, 1988). Currently, six species of albatross are facing a bigger threat of extinction than was previously estimated, as a consequence of trawler fishing. Twenty-one albatross species are in danger of becoming extinct, compared to the 16 species catalogued in the Red List of 2000. On the other hand, some migratory birds, such as terns, keep close to anchovy shoals, and therefore, are often registered in the coastal area.

According to the Ramsar Convention (1991), moist lands have been defined as "extensions of marshes, swamps and peat bogs, or surfaces covered in water, natural or artificial, permanent or temporary, swamped or flowing, fresh, brackish or salty, including extensions of marine water with a depth of not more than 6 meters at low tide". Because these ecosystems are so productive, they are home to numerous bird populations. Many species, at some time of their life cycle live in the moist lands, either to nest, rest or feed. An emblematic example of the role played by moist lands is the case of migratory beach birds which travel every year, sometimes thousands of kilometers, from their nesting areas in the Northern Hemisphere to the moist lands in South America, where they concentrate in numerous flocks.

a. Coastal birds

The most representative of these are beach birds, chorlo (plover, curlew or sandgrouse), and migratory or resident seagulls. Their diverse shapes and sizes are characteristic, as well as the relative length of their legs and beak, to catch their prey.

The *Spheniscideae* family of penguins is specially adapted to aquatic life: dense plumage, thick layer of body fat and small wings. These anatomical and functional modifications as a consequence of high specialization cannot be compared with those of other marine bird species.

Seagulls (Larus genus) and terns (Sterna genus) are considered a group of "opportunist birds". They can be found on coasts, rivers, lagoons, esters and swamps, not being specialized in their travels, flights or diving, thus taking advantage of all the possible resources of the stretch of shoreline.

Birds from the continental shelf and islands have become adapted to life in relatively shallow waters. Among them are the fragata and the piqueros (booby), distinctly qualified as marine species due to their distribution out into the open sea; while pelicans and cormorants can be found closer to the coast, even in continental waters.

The Sulidae family piqueros (booby) is a species which indicates the existence of shoals of anchovies or sardines. Pelicanidae pelicans are unmistakable due to their great size and beak which carries an expandable pouch under its lower jaw. They are very sociable birds, forming numerous colonies in tropical and subtropical zones.

Cormorants are not known because of their flight abilities but known because of their aptitude for fishing and immersion. Their economic importance, together with the piquero (booby), should be highlighted. Their habitats are the coasts of Chile and Perú; their droppings make up guano.

b. Oceanic birds

Open sea birds live in the ocean and feed exclusively on anything available in the ocean, depending on the continent only for nesting. The type of prey is directly related to the size of the bird. Enormous albatross from the Diomedeidae family, such as the "erring albatross" and Diomedea exulans, feed on fish measuring half a meter long; tempest seagulls feed on the larvae of crustaceans.

c. Marine turtles (Quelonia)

Marine turtles have been registered in Peru all along the coast, owing to their great migrating capacity.

The information was taken from a collection of sources from national institutions, such as IMARPE and INRENA and NGOs, as well as from international forums such as the International Unity for the Preservation of Nature (List of Threatened Species, 2003), Convention on International Trade of Threatened Species belonging to Wild Flora and Fauna, CITES 2003, and the Convention on Preservation of Wild Animal Migratory Species (Bonn Convention or CMS).

5.2.2.2 Marine turtles

The presence of turtles in sedimentary basins was estimated from information available in the FAO Catalogue of Species, Volume 11, Section on Marine Turtles of the World, and from field observations reported by the Marine Turtle Group - Peru (GTM-Peru), 2001.

Owing to their vast distribution and low population indexes, marine turtles have not been registered frequently in the Peruvian sea. In Chart # 2 (APPENDIX I) the species are mentioned, highlighting some characteristics, such as: whether they are coastal or oceanic, resident or migratory, their conservation status according to different international sources, and if identified in the list of Threatened Species of Perú (Supreme Decree 013 – 99-AG). Little is known of the marine turtle species registered in territorial waters. There exists information on the presence of the olive ridley turtle and the green seaturtle all along the coastline obtained either by observing stranded specimens or their remnants (carapaces) found in great number on beaches. Reports have been obtained about the Galapagos turtle in the southern coastline of the country; whereas, the hawksbill seaturtle, because of its distribution and behavior, belongs to the northern zone of the country. The loggerhead seaturtle has also been sighted in the southern

coast of Peru, undergoing incidental capture (bycatch) by the fishing trawlers operating from the center to the south of the shoreline. Seemingly, marine turtles use territorial waters as their migratory corridors or as habitats in which to reproduce and feed (Turtles of Peru Group, 2001).

Marine turtles have suffered severe persecution for their meat and carapaces, and are therefore considered to be in danger of extinction. If protection programs are not stepped up, many of the species mentioned hereunder are in danger of disappearing.

a. Olive ridley turtle (Lepidochelys olivacea)

Also known as the "white turtle", it is the most numerous and smallest of the marine turtles in the eastern Pacific, having a carapace of 60/70 cm long in adult specimens. Basically pelagic, it feeds on small fish, crustaceans and invertebrate creatures. It moves between Costa Rica and Mexico in the north and Peru in the south, extending lengthwise around 2000 miles. During various months before their nesting season between January and March, they concentrate thickly just west of the Gulf of Tehuantepec and in another group off the shores of Peru but in a more spread out fashion. White turtle sightings are three times more frequent than that of the other four species together; however, population decreases have been reported in Costa Rica and Guatemala, although other group studied in the coasts of the Pacific have kept stable and are even thought to be growing.

b. Black seaturtle (Chelonia mydas agassizii)

They are also known as "dark turtle" or "green turtle" of the eastern Pacific, and migrate from Mexico to Central America and southern Colombia. Individuals marked in Galapagos have been recovered on the continental coast from Peru to Costa Rica.

Apparently, part of the population remains all year round on Galapagos. Most sightings occur in the south, between 10° (South Latitude) and 85° (West Latitude) and in the band all along the 5° (North Latitude). Nesting beaches on Galapagos have registered population increases during the November-January period, before the peak of the reproduction season. Currently, a larger number of individuals have been reported on Galapagos and a decrease in Mexico.

c. Hawksbill seaturtle (Eretmochelys imbricata)

This is a more tropical species. Female adults measure 60-95 cm. Its carapace is commercially valuable; therefore, it has been intensely hunted. Adults are associated with coral reefs and hard seabeds where they establish their territories, feeding on sponges, small crustaceans, etc. Owing to this preference of habitat, adults are rarely affected by fishing carried out closer to the surface.

Their reproductive migrations are long and their feeding area is more limited than that of other species. They can be sighted in Peru during January and March, and dense populations have been registered. Populations are diminishing as a consequence of the high demand for their carapaces.

d. Leatherback turtle (Dermochelys coriacea)

They are also known as "baula", "7 filos" (sharp edge), "7 keels" or "7 skins". It is the largest marine turtle in existence. One can weigh nearly a ton and measure 2 meters long. It is the only marine turtle without a carapace, having a thick layer of skin in its place which looks like leather. Adults feed on medusa and other invertebrate creatures.

Seemingly, it prefers the waters over the continental slope and those of the continental shelf. They nest in Mexico and Costa Rica and migrate from Central California to Southeast Asia, traveling the Eastern Pacific Ocean. Their survival status is extremely serious and investigators suggest they could possibly become extinct during the next 20 years.

e. Loggerhead seaturtle (Caretta caretta)

These are the big headed or loggerhead seaturtles. They possess a bone carapace and have a very large head. Adults can grow to be one meter long. Young specimens feed in open pelagic habitats, usually on prey living near the surface; as they grow older they move to less deep waters where they feed on mollusks. They migrate from Japan to Baja California over a period of a few years, apparently crossing the Pacific Ocean. They have been registered in the warm waters off the shores of Peru between January and April, but it has not yet been determined if they stay there all year round. Individuals sighted south of the Eastern Pacific could be from Australia. A relatively small population has been estimated.

5.2.2.3 Marine mammals

The attribute "marine mammals" includes three taxonomic units: marine Cetacea, Pinnipedia and Fissipedia. For the Cetacea order, the suborder Mysticeti and Odontoceti have been considered. Categorization was carried out based on the differences and similarities between taxonomic groups, especially in reference to geographical distribution.

It is important to point out that cetaceans typically register probabilistic presence and abundance in very specific zones because they are highly migratory organisms, whose migrations derive from their life history (biology and behavior). However, the possibility of sighting the 28 species reported in the Peruvian sea is high.

According to the geographical distribution of the groups under study herein and bearing in mind the layout of the sedimentary basins, a list was drawn up with the probable presence of species in each basin. (CHART # 3, APPENDIX I). To do this, an evaluation of the characteristics of the basins was carried out (latitude, distance from the coast, depth, among others) and they were overlapped on a geographic map with the characteristics corresponding to marine mammals (feeding zones, dwellings, migration routes, behavior and latitudinal distribution).

Additionally, a list was drawn up containing the species with their respective category or legal protection status (UICN, National List, CITES, Red List, etc.) which can be seen in CHART # 4 (APPENDIX I).

The term "marine mammals" includes, according to most authors, 5 different groups: misticeto and odontoceto cetacea (whales, dolphins and common porpoises), sirenides (manaties and dudongos), pinnipedia (sea lions and seals) and marine fissipedia (polar bear and otters). It is important to mention that this term does not necessarily imply a systematic or taxonomic relationship between the species making up these groups but they do have one thing in common: most of them obtain their food directly from the sea.

Twenty eight species of marine mammals have been registered in the Peruvian sea distributed in 4 taxonomic groups (misticetos, odontocetos, pinnipedia and fissipedia), but very few of them have been evaluated and studied very deeply, and therefore, the

information concerning basic biology, life history, zoogeography and etiology of most species, especially cetacea (whales, dolphins and common porpoises) is scarce in Peru.

a. Cetacea

All whales, dolphins and porpoises belong to the main zoological group called Cetacea. These are mammals whose body shape (anatomy) and functions (physiology) have been drastically modified to adapt to living in water. The breathing system is made up of one or two orifices which have moved to the upper part of the head in order to facilitate breathing while swimming, the front extremities have converted to pectoral fins and the back extremities have disappeared.

Two suborders of cetaceans are recognized: cetaceans with "beards" or mistycetis (sub order *Mistyceti*) and cetaceans with teeth or odontoceti (sub order *Odontoceti*).

The misticeti cetaceans have 800 or more cornea plaques or "beards" implanted in the gums of the upper jaw which are used to filter food, basically zooplankton and school of small fish. The water is taken in through the mouth and forced out via the superimposed flounces of the "beards".

As opposed to the misticeti the odontoceti cetaceans have teeth after birth. Teeth numbers of these vary between 2 and 250 and in some of the female species remain hidden in the gums all through their lives. The cetaceans with teeth have only one breathing orifice. In this group we can include dolphins and porpoises, as well as certain whale species (sperm whale and the killer whale).

Off the Peruvian coast, 25 species of cetaceans have been identified of which 6 belong to the Balaenopteridae family (suborder *Misticeti)* and 19 to the families *Physeteridae, Kogiidae, Ziphiidae, Delphinidae* and *Phocoenidae* (suborder *Odontoceti*).

With respect to the Balaenopteridae family, all the species included in this category (*Balaenoptera acutorostrata*, *B. physalus*, *B. edeni*, *B. musculus*, *B. borealis* y *Megaptera novaeangliae*) are found all along the Peruvian coasts in shallow as well as deep waters, though *B. edeni* y *B. acutorostrata* can generally be seen near the coast line. According to life history and details of sightings, it can be established that this family is distributed in the 8 established sedimentary basins from Tumbes-Progreso up to Mollendo.

The distribution of the odontoceti is greater, covering shallow and deep waters. The diversity of the species reported in Peru (see Table # 4, APPENDIX I) is characterized by its different customs and behaviors.

The record of odontoceti in the Peruvian sea is limited to some sightings during marine mammal's evaluations, historical data of incidental fishing and specific studies of a determined species. Nonetheless, the vast majority of this suborder are characterized by being easily sighted in their habitat, except for a few that have timid behaviour and no acrobatic display.

The conservation and/or protection categories cover all the cetaceans registered in Peru, classifying them as vulnerable, in danger of extinction or under risk (UICN, 1996); or in the categories of protection, investigation and conservation (CITIES). It must be pointed out that many of these species are in a little known or indeterminate situation, as well as on the list of endangered species list of UICN (1996) and in the Red Book of Threatened Species (Klinowska, 1991).

b. Pinnipedia

The pinnipedia are highly specialized aquatic carnivores who live in saltwater habitats though some can be found in fresh water. There are about 34 species of pinnipedia grouped in 3 families (Otariidae, Phocidae y Odobenidae). All the species are amphibious and the *otaridae* are the most agile and mobile on land.

All the pinnipedae have hair and use their grease reserves for thermoregulation. Structurally, they have two pairs of extremities known as forward and back fins, long mustaches, nasal openings at the front of the snout and small ear openings (sometimes missing). The pinnipedia move each year, some gradually over weeks or months and others dramatically in a short time. In a lot of the species the newly born (pups) are born with a hair covering that is different in colour and size from the juveniles and adults.

The representatives of the Otariidae family are characterized with having a small external ear and a small head that ends in a cone shaped snout. They can move on their four extremities since the front ones are relatively large and the back ones can fold forwards. Thus they can swim, trot, jump and climb. They also have palms in their extremities.

The marine lions, or wolves, belong to the Otariidae family. In Peru, we can find two species: the chusco or one hair sea wolf (*Otaria byronia*) and the delicate or two hair sea wolf (*Arctocephalus australis*). Both species are considered vulnerable according to Ministerial Resolution No. 1082-90-AG and can only be subject to monitoring and scientific evaluation in accordance with the endangered species of CITIES and the conservation policies of the South Pacific Permanent Commission. Nonetheless, the National List of Endangered Species (Supreme Decree 013-99-AG) considers the delicate wolf (*A. australis*) in danger of extinction (See Table # 4, APPENDIX I).

The chusco sea wolf (*O. byronia*) can be found all along the Peruvian coast, covering the area between the Talara and Mollendo basins. Rivas and Shreiber (1997) determined, based on colonies monitored during February, June and September 1997, the existence of a fairly constant quantity of individuals were distributed in order of importance among the isles of Lobos de Tierra, Lobos de Afuera, Macabí and Guañape.

They also mention that a maximum of 12,000 species, with a considerable amount of individuals, were recorded in January 1997 on Palomino Island, opposite Callao. Near the Lima Basin, they spotted important colonies of chusco wolves on the isles of Huampanú, Mazorca, Palomino and Pachacamac; and in the Pisco basin and surroundings, they saw guano deposits and important colonies living on islands such as Chincha Island, Ballestas Island, San Gallán Island, Morro Quemado and Punta San Juan

In the southern zone, they point out two important colonies based on Punta Atico y Punta Coles, near the Mollendo basin.

Apart from presenting colonies of numerical importance, according to the distribution of the species the most sensitive basins referring to the chusco sea wolf would be Salaverry and Pisco, and to a lesser degree, though not least important, the Lima and Mollendo basins. It must be mentioned that the *O. byronia nave* been found moving up to 70 miles off the coast.

The delicate wolf (*A. australis*) can be found mainly in the Pisco basin, principally on Islas Chincha, Isla San Gallán, Punta Arquillo and Punta San Juan. Likewise, in the southern area there are significant colonies in Punta Atico and Punta Coles. Even

though these two potential areas are outside of the Mollendo basin, there is a great probability that the theoretical distribution area is bigger.

c. Fissipedia (marine)

This suborder, Fissipedia, corresponds to a group of carnivorous mammals (Cornivora order) made up of land, marine and sweet water organisms. Among the marine fissipedia, we find 3 species grouped in 2 families: *Mustelidae* (2) and *Ursidae* (1).

The Mustelidae families of mammals have long, very flexible, bodies (1 to 1.8 m in length), short ears, and thick and velvety hair. Their short legs have feet with five fingers joined by an interdigital membrane, with the back legs longer than the front. The tail is long and rounded, tapering to the end.

In Peru, the Lutra feline species can be found (marine cat, chingungo, huallaque or sea otter) belonging to the Mustelidae family. These mammals live in the cold waters of the Peruvian current feeding off the fish and crustaceans they catch while swimming. They can be found in the Departments of Ica, Arequipa, Moquegua and Tacna, with Lima the probable northern boundary. However, the Pisco basin would be the only one holding this species, since the Lima and Mollendo basins are far from the coastal strip.

The marine cat, *L. felinaz,* was under heavy hunting pressure given its valuable skin, which placed the species on the border of extinction, causing Ministerial Resolution No. 1082-90-AG to place it on the endangered list of the UICN (1996), the National List DS 013-99-AG and The Peru Red Book (Pulido 1991). The CITES list places it in Category 1 (protected species), while the Permanent Commission for the South Pacific places it as species that requires urgent conservation policies. (Chart 4, APPENDIX I).

5.2.2.4 Key species

Key species are those organisms of significant ecologic or economic importance which are conspicuous for their condition to maintain several species via a trophic net.

Within this attribute, 3 taxonomic groups were included: wild flora, pelagic fish and marine invertebrates.

Taking into account the geographic distribution for the mentioned group and using a map with the sedimentary basins established in the marine area, a list was generated of the presence/absence of key species in each basin. (Table 5, APPENDIX I). For this, the characteristics of each basin was appraised (latitude, distance from the coast, depth, etc.) and the key species were transplanted onto a geographic map (area of distribution, latitudinal gradient).

Wild flora

a. Red Mangrove (Rhizophora mangle)

This species, which is amply distributed worldwide, is characterized for its development in flooded areas (wet-land) with saltwater invasion. The aerial roots, in the shape of piles, gives support in a very dynamic area with little sediment base, given the variable currents and water levels. These roots are home to a great diversity of invertebrate mollusks; in the foliage there lives numerous bird species. The mangrove is the basis of the swamp ecosystem, supporting all its biogenesis. The role of this ecosystem is transcendental, and it has been determined that many marine species remain in this

area of saltwater during some of the phases of their life cycle. The distribution of the mangrove is exclusive to the Tumbes-Progreso basin.

Pelagic fish

a. Anchovy (Engraulis ringens)

Anchovy is a species of vital importance, given its role in the trophic net of the Peruvian sea. It constitutes the food base for the guano producing birds, commercially important fish and marine mammals. From an economic point of view, the fishing industry, based along the coast, depends on the landing of anchovies for the production of fish flour and oil. It has been determined that this resource is distributed from Punta Needle (Peru) up to Talcahuano (Chile), which would place it in the Talara, Sechura, Trujillo, Salaverry, Lima, Pisco and Mollendo basins.

b. Sardines (Sardinops sagax sagax)

This species competes with the one mentioned above when referring to an ecological niche. During "El Niño", when the anchovies move south, the sardines replace them in the ecotrophic system. The economic importance of this species is as raw material for the canning industry. The distribution of the sardine in the southwest pacific includes the coasts of Ecuador, Peru and Chile, and covering 200 miles in a longitudinal direction. As with the anchovy, the distribution of the sardine goes from Bahia Sechura up to Ilo and would cover the Talara and Salaverry basins.

c. Vinciguerria (Vinciguerria lucetia)

It has been determined that this species is of pelagic habits in a mesopelagic environment, found from Paita up to Sama, generally in areas far from the coast (past the 1,000m isobath). The biggest concentrations were spotted between Matarani and Sama (30 to 100 nm from the coast), Pimentel (33 to 94 nm from the coast), Punta Mackarels (58 to 70 nm from the coast), Pisco (30 to 42c nm from the coast) and Huarmey (48 to 84 nm from the coast). It is estimated that the ecotrophic importance of the *vinciguerria* in the oceanic province is comparable to the anchovy in the coastal area. The potential for this species, as well as its biological and ecological attributes, are still under evaluation but already considered a non-exploited resource with a high potential. According to the survey results, the distribution of the resource would cover the Salaverry, Pisco and Mollendo basins.

Marine invertebrates

a. Jumbo Flying Squid (Dosidicus gigas)

The Jumbo Flying Squid, or "giant squid", is an oceanic pelagic species of relatively recent fishing activity. It has been determined that it constitutes the basic diet for several species of marine mammals acting as predatory control on the anchovy population. It can be found from San Diego, California (USA) up to Valparaiso (Chile). The resource shoals are very mobile, given their peculiar patterns of movements, so it is considered an opportunistic species. The areas that have recorded the greatest capture volumes correspond to the Talara and Mollendo basins.

b. Múnida (Pleuroncodes monodon)

This crustacean is also considered a potential resource. The surveys have demonstrated that it constitutes a fundamental part of the diet of sea birds and wolves, pointing out its

predatory effect on the anchovy larvae. At the same time, it is important as an indicator of water mass (Warm waters sub Antarctic ATSA) monitored during oceanographic evaluations. The presence of the species has been reported from Isla Lobos de Afuera in Peru up to southern Chile, and the principal congregations can be found in the Pisco and Mollendo basins.

5.3 SENSITIVE AREAS

Areas that can be considered sensitive are those zones that due to their special conditions, be it uniqness or very fragile ecosystems or resources with economic potential, justify the taking of measures which address their management and conservation. For evaluation purposes, 2 types of sensitive areas were identified: on one hand, those zones with a category of "National Area Protected by the State" ("Area Nacional Protegida por el Estado") or belonging to then National System of Protected Natural Areas by the State (SINANPE), and on the other hand, potential areas. This second category encompasses the points and guano islands, including the two miles of adjacent sea given its ecological and economical importance, and its possible inclusion in the SINANPE.

Both the Santuario Nacional los Manglares de Tumbes and the Reserva Nacional de Paracas are categorized as "Area Natural Protegida por el Estado" and are under the INRENA administration.

5.3.1 Methodology

In order to identify the sensitive areas on the map, the seven studied basins were grouped in three zones (north, center and south) considering their latitudinal placement. Given the highly diversified recorded biology, with the ecological, economic and social implications thus derived, the Pisco basin was studied separately. The north zone included Tumbes-Progreso, Talara and Sechura basins, all with continental extensions. The Trujillo, Salaverry and Lima basins were placed in the center zone, while the Mollendo basin was placed in the south zone.

According to the proponed zoning, the following naturally protected and potential areas were identified.

The relation of identified sensitive areas (both protected and potential) are shown on Table # 6 (APPENDIX I).

a. North Zone

One area of the state protected category was identified, the Santuario Nacional los Manglares de Tumbes in the Tumbes-Progreso basin. In the Sechura basin, two zones were considered: the Virrila estuary and the San Pedro mangroves, which would qualify as potential areas. No sensitive areas were identified in the Talara basin.

b. Center Zone

The Salaverry basin includes the Guañape Norte and Guañape Sur guano islands; however, given their proximity to the continental flank, the following areas were also considered potential: islas Macabí, Chao, Corcovado, Santa, Ferrol and Blanca Norte, and the points Culebras, Colorado y Litera. The Trujillo and Lima basins, which are only oceanic, did not record sensitive areas.

c. *Pisco Basin*

The Pisco basin includes the potential areas Isla Asia and Punta Lomitas as well as the Reserva Nacional de Paracas, a state protected area. The guano islands Chincha and Ballestas, insular groups near the reserve and under PROABONOS administration, were categorized as potential areas.

d. *South Zone*

The South Zone includes includes the Mollendo basin; it's oceanic and without determined sensitive areas.

5.3.2 *National Sanctuary Manglares of Tumbes*

The Sanctuary covers an area of 2,972 hectares on the North East coast of Peru, District and Province of Zarumilla, Tumbes Department and extends between the coordinates 03° 24' – 03° 27' LS and 80° 13' – 80° 19' LW. It was established as a protected area on March 2, 1988, by Supreme Decree No. 018-88-AG, and considered a RAMSAR site in March 1992.

It is characterized as a very particular area given the great diversity of its flora and fauna species both land based as well as aquatic. It makes up the only representative sample of the mangrove ecosystem in the country and includes the "red mangrove" *Rhizophora mangle,* the "red mangrove" *Rhizophora harrisonii,* the "black mangrove" *Avicennia germinans,* the "white mangrove" *Laguncularia racemosa* and the "silver buttonwood mangrove" *Conocarpus erectus.* All shelter aquatic invertebrates of economic importance, resident and migrating birds and the "American crocodile" *Crocodylus acutus,* which is in danger of extinction.

Fifty seven species of birds have been recorded, of which 8 live exclusively in this ecosystem: the "clapper rail" *Rallus longirostris,* the "gray-necked wood-rail" *Aramides axillaries,* the "mangrove black-hawk" *Buteogallus subtilis*, the "Yellow-crowned Night-heron" *Nyctanassa violaceus,* the "bare-throated tiger-heron" *Tigrisoma mexicacum,* the "white ibis" *Eudocimus albus,* the "yellow warbler" *Dendroica petechia* and the "great-tailed grackle" *Quiscalus mexicanus.*

The biological diversity also includes 105 fish species, 33 snail species, 34 crustacean species and 24 bivalve molusc species, the majority of commercial importance such as "Black Clam" *Anadara tuberculosa*, the "small mangrove cockle" *Anadara similis*, the "large mangrove cockle" *Anadara grandis*, the "Striped Shell" *Chione subrugosa*, the "pen shell" *Atrina maura* and the "mangrove mussel" *Mytella guyanensis.* Among the crustaceans we may find the "Red Crabs" *Ucides occidentalis* and 4 species of crayfish of the Penaeus type (*P. vannamei, P. stylirostris, P. occidentalis* and *P. californiensis*).

5.3.3 *National Reserve of Paracas*

The high primary production in the Paracas bay leads to the presence of significant quantities of land and aquatic fauna, among which we find a large population of sea wolves, high records of guano birds and an abundance of migratory birds.

Geographically, the Reserve is located in the District of Paracas, Pisco Province, Ica Department and Los Libertadores – Wari Region. It covers an area of 335,000 hectares, of which 117,406 correspond to the continent and islands and 217,594 to marine waters, extending between 13° 47' - 14° 17' LS and 76° 00' - 76° 30' LW. It was established on

September 25, 1975, by Supreme Decree No. 1281-75-AG and considered a RAMSAR site from January, 1997.

By creating the Reserve, special protection is awarded to certain species in danger of extinction, as well as promoting the rational use of the hydrobiological resources of commercial importance and the conservation of the cultural and historical heritage. The biological diversity in this protected area is due to the variety of the existing habitats, the configuration of the coastal line of its beaches, the different types of marine substratum and the influence of the cold Peruvian current. Bahía de Paracas constitutes the principal ambience of the Reserve that sustains an abundant ornithological resident and migratory fauna of the first order, and it is a place of refuge, feeding and nesting for several species. Given its great latitudinal extent, the Reserve coastline is made up of closed beaches, small islands and a chain of guano islands that support bird and marine mammal populations.

Three hundred and thirty taxons of macro benthonic invertebrates have been identified, mostly mollusks, as well as 193 fish species, 216 bird species (between resident and migratory), 2 species of marine wolves, 4 species of sea turtles and 1 specie of marine otter. The Reserve is also a place where whales and porpoises pass through.

The relationship of the endangered species, both vulnerable as well as in danger of extinction, are show on Table # 7 (APPENDIX I).

5.3.4 Potential areas

The points and guano islands are home to particular ecosystems, with characteristic areas of significant biodiversity, as well as constituting guano extraction centers, a natural fertilizer of high commercial value. The majority of the points and islands are under the administration of PROABONOS but there is at least one initiative to incorporate them to the SINAPE. Additionally, 2 areas have been identified as of potential condition and are under study to be included in the system, the San Pedro mangroves and the Virrila estuary.

a. Guano points

These coastal outcrops have guano bird and sea wolf populations. The Culebras, Colorado and Litera points have been considered, as well as Punta Lomitas in the Pisco basin. Along with the resident groups of guanay (*Phalacrocorax bougainvilli*), piquero (*Sula variegata*) and chusco sea wolf (*Otaria byronia*), there are records of delicate sea wolf (*Arctocephalus australis*) and sea otter (*Lutra felina*) in Punta Lomitas.

b. Guano islands

Aside from sheltering guano birds and marine mammals, the islands create sites for egg laying by fish and invertebrates, and are part of the migration corridors used by cetaceans. The islands contemplated in the Salaverry basin are Macabí, Guañape Norte, Guañape Sur, Chao, Corcovado, Santa, Ferrol, Blanca Norte, Culebras, and Colorado y Litera. Their main characteristics are reproduction centers of pikeman and guanay, and a station for the chusco sea wolf. These species can also be found in the Pisco basin islands (Asia, Chinchas and Ballestas), though with greater biological diversity. On the Chincha islands, we may find the delicate sea wolf, and on the Ballestas, the Humboldt penguin (*Spheniscus humboldtii*).

c. *San Pedro mangroves*

The San Pedro mangroves are important because of the diversity of birds and being the southern limit of the distribution of this type of ecosystem in the South Pacific.

The area, also known as "Caleta San Pedro" or "Playa San Pedro" (05° 30'- 5° 34' LS; 80° 41' - 80° 53' LW), has an approximate area of 1,500 hectares, of which 350 to 400 are covered by mangroves. According to the Mapa Ecologico del Peru, the area belongs to the tropical, premountain, superarid desert typical of the plains of the north coast. The relief varies from flat in the mangroves to slightly ondulated in the outlying areas due to the dunes.

The San Pedro mangroves are a vegetable association composed of "jeli salado" or "black mangrove" *Avicennia germinans*, which develops on both banks of the mouth of the Sechura River, covering some 7 km of the last stretch. This association represents the southern limit of the distribution of the mangrove on the coast of the South Pacific. Aside from the fishermen dedicated to the fishing of the striped mullet *Mugil sp.*, there is an experimental station dedicated to the exploitation of crabs.

d. *Virrila Estuary*

The importance of this estaury lies in the fact that it is the winter home to 27.2% of the border birds that fly by the Peruvian coasts and to 14.3% of those that arrive to South America (Morrison and Ross, 1989). The estuary (05°45' - 05°54' LS; 80°42' - 80°52' LW) is 78 km to the southwest of Piura, near the fishing, village of Parachique. It has a total area of approximately 7,000 hectares, of which 1,300 correspond to a lake and 5,700 to premountain superarid desert. The relief is mainly flat with slight undulations due to dunes.

The estuary arises from the incursion of seawater into the continent via a branch that occasionally receives sweet water from a branch of the river Piura that used to flow into it. There are two theories about the origins of the estuary bed, one of fluvial origins and the other as a product of a geological fault. The estuary extends 30 km inland and is up to 1.5 km wide in some areas. It presents muddy sea zones, sandy zones, and coastal dunes with vegetation bathed by salty waters.

Nearby, there are fishermen that catch striped mullet *Mugil sp.*, while on the other side, near the Virrila Bridge, there are installations dedicated to salt mining and to breeding *Artemia sp.* and crayfish *Penaeus sp.* Three kilometers to the east, there is a private enterprise dedicated to the cultivation of artemias and seaweed.

5.4 FISHING AND EXPLOITATION OF HYDROBIOLOGICAL RESOURCES

5.4.1 Fishing sector

The fishing sector greatly contributes to the generation of foodstuffs, jobs and currency for the country, representing in economic terms between 11 and 20% of total national exports (US$639-1,400 million) and between 2 and 4% of IGP. (CHART # 8, APPENDIX I). However, exports mainly concentrate on fish meal, which is subject to market fluctuations and has a substitute product, soy flour. This makes it a vulnerable sector, not only due to price variations at an international level but also because of the environmental changes that determine the extraction level of resources.

Peru has been recognized as a world power in this aspect and is, according to FAO figures, second in the extraction of this resource worldwide after China, with around 53% landing value and 9.5% world total. The resource-rich Peruvian sea is home to very many species; 1,070 fish species, 1,170 mollusk species and 464 crustacean species have been identified. However, its high extraction figures are directly related to the capture of one species: the anchovy (*Engraulis ringens*), representing 70 - 90% of the country's fishing and 70 - 88% of fishing at a world level. (CHART # 9, APPENDIX I). The reason for this abundance is the exceptional conditions of Peru's sea, temperatures, system of currents, and, mainly, the presence of outcrop zones which constantly supply this species with food. When environmental changes occur such as the one generated by the "El Niño", the capture of this species is strongly reduced from around 6 to 8 million tons to 1.2 million tons. During those years, this species has been replaced by others, such as sardines (*Sardinops sagax sagax*), samasa (long nose anchovy) (*Anchoa nasus*) and jurel (jack mackerel) (*Trachurus picturatus murphyi*), but none of these reach such high figures. All these pelagic species are employed by the industrial sector mainly for the production of fish meal and oil, and are exported to be made up into poultry and pig feed, and to a lesser degree, for aquiculture.

All along the country, fishing varies according to availability of resources. The main industrial landing ports are: Chimbote, Coishco, Pisco, Paita, Chancay, Chicama and Ilo, with a landing volume of between 0.5 and 2 million tons annual average, while the main fish landing coves for direct human consumption are: Paita, Talara, Laguna Grande, Puerto Rico, Parachique, Cancas and Huacho, with figures which vary between 2 and 12 thousand tons (IMARPE, 2000).

5.4.1.1 Artisan fishing

Artisan fishing comprises all economic units dedicated to extraction, harvesting, and hydrobiological resource culture in the sea, rivers and lakes on a small scale. The species extraction activity uses a predominance of manual labor and ships not exceeding 15 m lengthwise and 32.6 tons hold capacity. Artisan fishing also includes species culture activities, such as, the scallop and en la sierra trout and their harvesting, which is usually carried out manually (Seafood: shellfish, Shrimp: common prawn, Prawn: shrimp larvae, etc).

In Perú, artisan fishing is centered on resource extraction for direct human consumption, presenting the characteristic that it does not use resource detection systems, nor on-board preservation systems. This restricts the search for extraction zones far from the coast and the possibility of preserving the resource in good condition once it has been extracted.

a. Characteristics

The most important characteristics of artisan fishing, of which all of the sector's aspects are based, are diversity and informality. It is estimated that artisan fishing contributes between 1.78% and 4% of the total of hydrobiological resource capture and around 50% capture for direct human consumption in the country. Ships represent between 8.7% and 16% of total hold capacity.

Total capture volumes obtained are nearly four times less than hold capacity, and this can be explained by the decrease in the last few years of resources close to the coast to such an extent that some ships do not use their holds but place their produce in isothermal boxes.

b. Volumes

Taking into account the statistics published by IMARPE, it was determined that the landed volume of species typical of artisan fishing was 509,105 tons, based on an annual average (1994-1999 period).

c. Fishing Zone

According to information published by IMARPE, the main fishing zones are: Tumbes (between Puerto Pizarro and Cancas), Piura (between Máncora and Negritos, Colán and Chulliyachi, Parachique and Puerto Rico), Lambayeque (between San José and Cherrepe), La Libertad (between Pacasmayo and Puerto Morín), Ancash and North of Lima (Santa and Supe), Lima (Caleta Vidal and Callao), Central and South Lima (between Chucuito and Cerro Azul), Ica (between Tambo de Mora and San Juan), Arequipa, Ilo and Tacna.

Due to lack of instruments for navigation and detection, lack of diversification of fishing gear and methods, fishing zones for the artisan fleet are limited to their center of operations with the exception of the fleet using boulters (espineles) which operate up to 60 - 80 miles out.

d. Most Important Species

There are many species of fish captured for the local market using artisan methods, such as: the coco (Peruvian banded croaker) (*Paralonchurus peruanus*), Perico (common dolphin fish) (*Coryphaena hippurus*), jurel (jack mackerel) (*Trachurus picturatus murphyi*), Peruvian Rock Seabass (Peruvian rock seabass) (*Paralabrax humeralis*), striped mullet (*Mugil cephalus*), cachema (Peruvian weakfish) (*Cynoscion analis*), mackerel (*Odonthestes regia regia*), bereche (Pacific drum) (*Larimus pacificus*), Peruvian Grunt (brownstriped grunt) (*Anisotremus sp.*), cojinova (rainbow trout) (*Seriolella violacea*), striped tuna (*Sarda sarda chilensis*), lorna (*Sciaena deliciosa*), machete (Pacific menhaden) (*Ethmidium maculatum*), grouper (*Epinephelus sp.*), shark (*Isurus sp.*), toyo (humpback smooth-hound) (*Mustelus whitneyi*), tramboyo (scaled blenny) (*Labrisomus philippii*), etc.

Among shellfish extracted from the sea are the barnacle rock shell (*concholepas concholepas*), squid (*loligo gahi*), crab (*cancer sp.*), snail (*stramonita chocolate*), mussel (*aulacomya ater*), scallops (*argopecten purpuratus*), black clam (*anadara tuberculosa*), lobster (*panulirus gracilis*), prawn (*litopenaeus vannamei*), jumbo flying squid (*dosidiscus gigas*), octopus (*octopus mimus*), etc.

e. Rigging

This type of fishing uses different gear, e.g.: trawler, cerco (purse seine), espinel, palangre (long liners), buceo, (harpoon, trinche), pinta, trap, etc. and are used according to the zone and the species which are to be extracted.

The most common fishing gear and methods used by artisan fishermen are: purse seine nets (40.2%), pinta (20.6%), cerco (purse seine) (14.4%), shellfish extraction (5.1%), espineles (3.5%), and others (16.2%), which include chinchorreros, macheros camaroneros and shore fishermen.

5.4.1.2 Industrial Fishing

Industrial fishing is carried out with ships with a hold of over 32.6 metric tons (mt), fitted with modern fishing gear and systems, which can be on a greater or lesser scale depending on the capacity and size of the ship (General Fishing Law, 2001). Industrial fishing extraction activity is not included in the artisan fishing category.

Industrial fishing in Peru is abundant and not very diverse, capturing fish which are generally used in the production of fish meal and oil (anchovy and sardine), preserves (anchovy, sardine, tuna, Bonita, mackerel, jurel, etc.), frozen (hake, sardine, jurel, jack mackerel, etc.) and fresh (deep water cod, corbina, Paraqueet, common dolphin fish, jurel, jack mackerel, etc.).

a. Rigging

The Peruvian fishing fleet uses fishing methods such as the cerco (purse seine), trawl, palangre (long liner) and lamplight fishing (to fish squid). The classification of Peruvian fishing ships has been carried out according to the information obtained from PRODUCE. (Chart # 10, APPENDIX I).

According to the Ministry of Production - Customs - National Fishing Society, there are 350 industrial fishing facilities throughout Peru and approximately 40% of them produce fish meal and oil. It is estimated that 140 plants process fish flour and 102 process fish preserves.

b. Fishing for Direct Human Consumption

The most important species used for direct human consumption are the jurel (jack mackerel), the hake, the false flying fish, the mackerel and the Bonita. These species, among others, are processed for internal consumption and for export in the following manner:

Canned: these products consist of cooked meat, packed with salt and water, oil or an appropriate sauce in hermetically sealed containers and subjected to industrial sterilization for its preservation. The main objective of producing fish preserves is to obtain safe, good quality and profitable products. The process used for the production of preserves includes cleaning and eviscerating, cooking, cutting into filets, and packing and sealing the fish into cans; and later, the process of washing, sterilizing, cooling, and (finally) labeling the cans. Packaging of preserves is carried out in glass, aluminum or tinplate containers. (H.Farro, 1996).

Frozen: This process includes drastically cooling the product until the liquids inside the cells are frozen and then maintaining at a temperature of around -18°C. Freezing permits the preservation of the products for as long as they are stored at sufficiently low

temperature as all microbial activity is stopped at a temperature of -18°C. The methods which are used most frequently when freezing are: with brine, by air, and by contact, depending on the type of heat transmission during the freezing process. (H.Farro, 1996).

Curing or salt drying: this is prepared following a combined procedure of drying and salting, the main characteristics being the elimination of part of the water contained in the meat of the fish, partially substituted with salt. There are three types of salting: dry, moist and in brine.

The Ministry of Production has advised that during the years 2000-2003, the average processed tonnage for landed fish was higher for frozen goods (173,320 tons) than for preserves (156,457 tons) and curing (28,027 tons). However, the highest landed levels were for fish meal and oil (5,566,928 tons), as has been mentioned before. (Chart # 10, APPENDIX I).

c. Fishing for Indirect Human Consumption

The main species used in the production of fish meal and oil are: anchovy, sardine, jurel (jack mackerel) and samasa (long nose anchovy). Landing of these resources showed an average figure of 8,114,481 tons during 1993-2002. (Chart # 11, APPENDIX I).

d. Fish Meal and Oil

Fish meal is the industrial product obtained by reducing the moisture and fat contents of fish, without additives, except those used to maintain the original quality of the product. This fish meal is used to make balanced food for poultry, pigs, and aquiculture. Fish oil is obtained as a sub-product of fish pressing during the production of fish meal and from which practically all solids in suspension and water have been eliminated by a mechanical process. The uses given to this oil and its price depend on its purity, clear color and low content of fatty acids. (H.Farro, 1996).

5.4.1.3 Most Important Species in The Peruvian Fishing Industry And Their Distribution Area

a. Anchovy (Engraulis ringens)

Anchovy is a short living and fast growing species, measuring 20 cm total length and weighing 27.3 g. It has a 6 month reproductive cycle and reaches sexual maturity during its first year of life when it reaches a length of 12 cm. Its biological cycle consists of a main spawn in the winter-spring months and a secondary spawn in the summer months of the following year. It lives in coldish waters, with temperatures ranging from 14°C to 22°C, salinity between 3.49% and 3.51%, and a depth of up to 70 meters. Its distribution goes from Punta Needle (Perú) up to Talcahuano (Chile). Although its fisheries can mainly be found in the ports of Chimbote, Huarmey, Supe, Huacho, Callao, Pisco and Ilo, its capture is carried out all along its distribution area, from Latitude 4° South up to the southern boundary. Generally, in the north and central regions, fishing is carried out in a stretch of coast of 30 to 50 miles and no more than 20 miles in the south.

b. Sardine (Sardinops sagax sagax)

Similarly to the anchovy, the sardine is a pelagic species distributed from Bahía Sechura to Ilo (Peru) and Galapagos islands (Ecuador). (Chirichigno, 1974). The main landing places in Peru are Paita, Parachique, Santa Rosa and Chimbote.

c. *Hake (Merlucius gayi peruanus)*

The Peruvian hake is a bentho-demersal species found all along the continental shelf, from 00°30'S (Ecuador) to 13°56' Pisco (Peru) (Chirichigno, 1974), from shallow waters to waters as deep as 600 meters and over, with most concentrations found at 150 to 250 m. The place of distribution varies according to the seasons of the year in relation to the extent of the Cronwell Subsurface Countercurrent (CSSC) or Subsurface Peruvian Countercurrent (CPSS). Thus, during the winter it is possible to find the hake between 06 and 08°S, while in the summer and fall, it extends to 12 and 14°S. During the "El Niño" event it was possible to find it south of 15°S and even south of 18°S, and in the 1997-1998 "Niño", the assumption was that the extent of hake distribution had spread deeper and had extended south of 18°S because the presence of CSSC was reported in the North of Chile. This resulted in dispersion of the species and the traditional fishing places could be found further away, meaning that the fleet was taken from 04-05°S to 06-08°S during the second six months of 1997 and beginning of 1998. Normally, the areas with highest concentrations (ton/km or ton/nm) are those corresponding to 05 and 06°S, with higher densities at 03, 04 and 07°S; lower densities can be found at 08 and 09°S.

d. *Jurel (jack mackerel) (Trachurus symmetricus murphyi)*

The jurel (jack mackerel) is distributed from the Islas de Afuera (Peru) up to Talcahuano (Chile) and Galapagos islands. The jurel, similarly to all other creatures living in the sea, depend greatly on the oceanographic and climatic changes which occur. These determine their habitat, reproductive processes, feeding and migration. In the case of this species in particular, placed among the so called transZONEls, its distribution (or place where it dwells) goes from the eastern coast of the Pacific Ocean (coasts of Chile and Peru), up till the Australian and New Zealand coast. When climatic conditions give rise to the climatic-oceanographic event known as the "Niño", ocean temperatures change near the coast of Chile and Peru, and the jurel changes its distribution, trying to keep up its normal habitat. This process is increased when a very intense "Niño" occurs, such as the one which took place in 1982-83, and especially so during the most intense of them all, which occurred in 1997-98.

e. *Mackerel (Scomber japonicus)*

This fish generally lives in a pelagic-coastal ecosystem, preferably in warm waters; however, it can be found in the open sea during its reproduction season. This species mostly spawns in waters with temperatures ranging from 15 to 20° C, and the temperature in which it occurs depends on the latitude in which the individual is found. Its size at its first sexual maturity is a 26 cm horquilla length. Scomber japonicus mackerel is distributed from Manta (Ecuador) to Valparaiso (Chile) and Galapagos islands.

f. *Scallops (Argopecten purpuratus)*

The scallop is a filtrating mollusk with gills which serve the double purpose of breathing and trapping its food. It can be found in coastal waters between 3 and 20 m, in soft sludge to hard sand seabeds, and in seashell beds typically containing algae. They can be found in waters with temperature ranging from 14 to 20°C, and during the "Niño" phenomenon, it has been known to suffer temperatures as high as 25°C, with no apparent problems. The main scallop producing shoals in Peru are found in Bahía Independencia (Ica) and Bahía Sechura (Piura), followed in order of importance by Paracas, Samanco, Huacho, Tortugas and Pucusana, and sporadically, extracted in Isla

Asia, Isla Pachacamac, Isla San Lorenzo, Isla Don Martín, Culebras, Los Chimús and Lagunillas.

g. Edible or white shrimp (Litopenaeus vannamei)

This species is distributed from Punta Abreojos, Southern Baja California and Gulf of California (Mexico) up to Paita (Peru). It is a benthonic species living on the continental shelf at a depth ranging between 5 and 30 m, and occasionally even at 45 m. (Méndez, G., 1981).

h. Coarse squid or jumbo flying squid (Dosidicus gigas)

This giant or coarse squid (Jumbo Flying Squid) is an oceanic pelagic species migrating towards the coast searching for food as well as for reproduction purposes. It is vastly distributed in eastern Pacific waters, from Mexico to Chile, and the areas which concentrate them most are off the coasts of Perú and Mexico. In Peru, they are extracted both industrially and by artisan fishing, the first being the most important, starting up in 1991 with 190 to 500 TRN squid ships, fitted with automatic fishing machines with poteras and attracting lights; the second is mainly carried out up north at 6°S, on board artisan fishing vessels of 2 to 8 ton hold capacity, using purse seine nets and hand operated poteras. Major catches of this resource are for the years 1991 to 1995, when 80,000 to 200,000 annual tons where registered. This species has a high growth rate and can grow very large, its mantle measuring over 1 meter long, and can weigh over 25 kilograms (kg. Coarse squid are distributed from San Diego, Isla San Clemente, California (USA) to Valparaiso (Chile). In Perú, it can be found between Talara and Ite. (Alamo and Valdivieso, 1997).

5.4.1.4 Potential species

a. Panama lightfish (Vinciguerria lucetia)

This species is distributed in a large part of the evaluated area from Paita to Sama, generally in areas far from the coast (beyond 1,000 m isobath). Major concentrations of this species were registered between Matarani and Sama (30 to 100 nm from the coast), Pimentel (33 to 94 nm from the coast), Punta Mackarels (58 to 70 nm from the coast), Pisco (30 to 42 nm from the coast) and Huarmey (48 to 84 nm from the coast). This species has shown unusual abundance owing to the presence of high salinity waters, which has reduced the area available for distribution. Estimated biomass was 11,125,176 tons with a confidence level of 16.19%.

b. Squat lobster/red lobster (Pleuroncodes monodon)

The Demersal species is distributed between Isla Lobos de Afuera in Perú and Chiloé in Chile. Its characteristic is that it lives on soft sea bottoms or semi-hard ones, at a depth ranging from 50 to 350 m, making up abundant concentrations.

Sizes fluctuate between 9.5 and 51.1 millimeter (mm). Between 1995 and 1999, they fluctuated between a cephalic-thoracic length of 13 mm and 51 mm, with average male sizes between 34.6 mm and 41.2 mm, and females, 31.4 mm and 39.4 mm. This species carries out daytime vertical and seasonal migrations, and it sporadically adopts pelagic behavior.

5.4.1.5 Aquiculture

Animal marine aquiculture is an activity aimed at producing and fattening organism in the water. This activity has become a dynamic sector, growing annually to the rate of 7 to 8% and reaching worldwide levels of nearly 30% fishing production.

Aquiculture in Perú is an economic activity with a relatively small level of growth when comparing it to neighboring countries such as Ecuador, Chile and Brazil. Its growth in Peru belongs mainly to the marine area, and concentrates on two species: edible shrimp (*Penaeus vannamei*) and Scallops (scallop) (*Argopecten purpuratus*). Because of its biological requirements, the main breeding areas for edible shrimp are centered in the north of Perú (Tumbes and Piura) and are carried out in mangrove zones or nearby areas. Scallops (scallop) breeding is carried out all along the coast and breeding centers are located in the departments of Lambayeque, Ancash, Lima and Ica.

Marine aquiculture production in Peru has varied between 4,000 and 10,000 annual tons and mainly consists of two species: edible shrimp and Scallops (scallop). Production volumes for the edible shrimp were strongly cut back due to the white spotted virus, which cut production figures from 4,312 tons in 1999 to 615 in 2000. Owing to aquiculture, breeding of this species recovered in 2003. For the Scallops (scallop), aquiculture has enabled its constant growth from 1993 to the present, reaching 7,312 tons in 2003. Oysters and micro-algae have appeared sporadically in production values. (Chart # 12, APPENDIX I).

5.4.2 Methodology

The information on fishing activities occurring within the area of sedimentary basins and their surroundings is based on an analysis of general information and landing statistics, published essentially by institutions such as IMARPE (Institute of the Sea in Perú) and PRODUCE (Vice-ministry of fisheries).

Tables were prepared based on this information, and from these, the levels of fishing importance were established for each basin. For practicality reasons, the basins were ordered in Groups or Zones on the coast of Peru, thus: Northern Zone (Tumbes-Progreso, Talara and Sechura), Central Zone (Trujillo, Salaverry and Lima), Pisco Zone (Pisco basin), and Sourthern Zone (Mollendo basin).

Statistical information on artisan fishing was obtained from the total of marine fishing landings in Peru for the years 1994 - 1999, considering the species which characterize this activity. Likewise, this information was used to obtain the percentage of species representing industrial fishing because no specific information exists by landed species for each separate landing place for artisan and industrial fishing.

Landings in global figures for product and zone were found in the annual reports publilshed by PRODUCE for the years 2000-2003.

5.4.3 Characterization by Sedimentary Basin

5.4.3.1 Type of fishing activity for each area under study

a. Northern Zone:

This zone includes the Tumbes-Progreso, Talara and Sechura basins, and Departments of Tumbes, Piura and Lambayeque.

Artisan fishing. Considered landing ports and/or fishing coves: El Algarrobo, Puerto Pizarro, Bocana, Caleta Cruz, Caleta Grau, Zorritos, Bocapán, Acapulco, Punta Mero, Punta Cancas, Punta Negra, Mancora, Los Organos, El Ñuro, Cabo Blanco, Lobitos, Talara, Negritos, Paita, Parachique, San José, Pimentel, Santa Rosa and Pacasmayo. The most representative species are: Striped Muller (striped mullet), Ayanque, Bagre (catfish), Peruvian Rock Seabass (seabass), Skip Jack, Bonita, and Paraqueet (common dolphin fish). (Chart # 13, APPENDIX I).

The average catch volumes and totals between 1995 - 1999 were 262,600 tons for fish and 26,489 tons for invertebrates.

Industrial landing for direct human consumption in the northern zone is mainly aimed at production of frozen products with hake as its raw material and the False Flyer (false flying fish) as its substitute. The jurel (jack mackerel), mackerel, and in some cases, sardines, are used for the production of canned products. The main processing center is Paita reaches average figures of 115,000 tons of frozen products and 44,000 tons of canned.

For indirect human consumption (fish meal and oil) the fish used are anchovy, sardines and samasa (long nose anchovy). Production figures are 700,000 tons with an average 570,000 tons in Paita.

Aquiculture: Aquiculture in the northern zone of the country, specifically in Tumbes, aims at edible shrimp using coastal zones or mangroves. In the Piura area, Scallops are bred because the area is one of the most important natural shoals for this species. Likewise, there are 3 aquiculture demonstration centers belonging to FONDEPES, La Tuna Carranza, and Virilá and Chérrepe.

La Tuna Carranza - Tumbes Aquiculture Centre

Situated in Puerto Pizarro, province and department of Tumbes, this Aquiculture Center started up in 1996 with a concession of 120 hectares. Its principle aim is to install, operate and develop aquiculture in Tumbes, determine the technical-economic feasibility of developing diversified farming of edible shrimp-oysters (*Litopenaeus vannamei-Crossostrea gigas*), develope the technique to breed the Black Clam (black clam) (*Anadara tuberculosa*) and develope a bioecological model for the rational handling of the american crocodile (*Crocodylus acutus*).

Virrila – Piura Aquiculture Centre

Located in Virrilá, province of Sechura, department of Piura, the Centre was initiated in 1995 and is carried out in an area of 126 hectares. The original species were Artemia (*Artemia sp*) and prawns (*Litopenaeus vannamei, L. Californiensis y L. stylirostris)*.

With salinity variations a sweet water species is projected, the tilapia.

Cherrepe – Lambayeque Agriculture Center

This project is located in the Creek Cherrepe, Lambayeque, and counts on a marine area of 10 hectares and a land area of 5 hectares. The objective of the project is to establish the technical and economic bases for the advantage of marine algae from the Gracilariosis lemanaiformis (gracilaria, pelillo or hair of Indian) species, as well as to create an occupation alternative and work source for the community of artisan fishermen and interested companies.

b. Central Zone

This zone consists of the Trujillo, Salaverry and Lima Basins: Departaments: South zone of the Lambayeque, La Libertad, Ancash and Lima departments.

Artisan Fishing: Ports and/or fishing coves: Chicama, Huanchaco, Huanchaquito, Salaverry, Mori Creek, Coishco, Chimbote, Samanco, Casma, Snakes, Huarmey, Puerto Chico, Supe Caleta Vidal, Végueta, Carquin, Huacho, Chancay, Ancon, Callao, TPZ Callao, Artesanal, Chorrillos, Pucusana, Chilca and Cerro Azul.

Predominantely represented species: Bonita, Lorna, Machete, Pejerrey, Striped Muller, Tuna, etc. (CHART # 14, APPENDIX I). The average volumes and totals 1995 - 1999 were 194,272 tons (fish) and 7,991 tons (invertebrate).

Industrial Fishing: Ports: Salaverry, Chimbote, Coishco, Culebras, Huarmey, Supe, Vidal, Vegueta, Huacho, Carquín, Chancay, Callao and Pucusana.

The predominant species: Anchovy, Sardine, Jurel and Mackarel. (CHART # 14, APPENDIX I). Average volumes were 3,443,720 tons, which includes frozen, cured, canned, flour and oil, during Years 2000 - 2003. (CHART # 15, APPENDIX I).

Fishing Areas: In Peru, the Central Zone represents the greater volume of fishing and processing for indirect human consumption, reaching annual production volumes averaging 3.3 million tons of flour and fish oil. This is followed by canned (103,000 tons average) and frozen (11,000 tons average) productions.

Aquiculture. In 2001, in the departments of Lambayeque, Ancash and Lima, a request of 1,546 hectares for cultivation of Scallops (Argopecten purpuratus) was made. (CHART # 13 APPENDIX 1). This is not counting the levels of production in this zone. Nevertheless, it is emphasized that the existence of an area for handling this species is in the Tortugas, Casma zone, which was worked by the artisan fishermen with scientific collaboration of the Agraria University.

El FONDEPES has, in this particular zone, the Aquicultre Center La Arena, located in the Playa La Arena, Casma, Ancash which counts on a marine concession of 16 land facilities. It was designed to develop marine cultures to a scale that allowed suitable technical and commercial evaluations, and to generate, or to adapt, technologies of these cultures for transference to the private sector. The species that are being cultivated are: Scallops (*Argopecten purpuratus*), Pacific Oyster (*Crassostrea gigas*) and experimental culture of fish, such as the Peruvian Grunt (*Anisotremus scapularis*), the Peruvian Rock Seabass (*Paralabrax humeralis*), the Parrot Fish (*Oplegnatus insignis*), the Pompano (*Oligoplites mundus*), Chalapo Clinid (*Labrisomus philippii*), Red Morwong (*Cheilodactylus variegatus*) and the Mero (*Epinephelus sp.*).

c. *Pisco Zone*

The Pisco Zone is located in the Pisco Basin, department of Ica.

Artisan Fishing: Ports and/or fishing coves: Tambo de Mora, Pisco, El Chaco, San Andrés, Lagunillas, Laguna Grande, Rancherío, San Juan de Marcona and Lomas.

The port of Pisco, as the Tambo de Mora, displays significant volumes of extraction of ocean species, which projects the fishing industry to increase from 92 to 100% of the total catch, in as much as in the port of San Andrés the fishing catch is more diversified and mainly targeted towards direct human consumption.

The San Andrés, the Chaco, Lagunillas and Laguna Grande ports have a strong mollusk and crustacean population varying between 9.5% and 100%. Meanwhile, the La Puntilla and El Chaco-Lagunillas ports do not have logs of regular distribution, which are used for fishing products distribution.

Species: The predominatly extracted are the Striped Muller, the Pejerrey, Cabinza Grunt, Cojinova, Jack Mackerel, Bonita, Lorna, Peruvian Rock Seabass, among others. The extraction of seafood covers certain species, such as; Scallops, Snail, Octopus, Mussel, Crabs, among others. (Market Analysis # 16, APPENDIX I).

Seaweed dehydration is an activity that has recently begun and is projected to generate income and employment in Pisco and Nazca.

The average capture volume between the years 1995 - 1999 was 21,536 tons fish and 14,059 tons invertebrate.

Rigging: Artisan boats have a capacity of 2 to 4 tons and use seine nets. It is possible to observe distribution of 10 to 20 tons of "bolichitos de bolsillo ", which use ring nets. It is in this zone that marine divers are an important part of the invertebrae fishing efforts.

Industrial Fishing: Ports: Tambo de Mora , Pisco /San Andres

Species: Anchovy, Sardine, Jack Mackerel, Mackarel and Machete.

Fishing Areas: The captured volume averaged 613,719 metric tonnes, including frozen, cured, canned, flour and oil during years 2000 – 2003. (CHART # 15, APPENDIX I).

Products

Direct Human Consumption: The central zone has a greater volume of distribution of canned products. The average for years 2000 – 2003 was 103,835 tons, with fluctuating volumes from a low of 38,000 metric tonnes (2002) and a high of 138 metric tons (2003). The average distribution volumes from 2000 - 2003 for frozen and cured products were 11,672 metric tonnes and 2,281 metric tonnes. (CHART # 15, APPENDIX I).

Indirect Human Consumption: The central zone received the highest level of unloading for the production of flour and fish oil. The average volumes for ports in recent years fluctuated between the 125,000 and 684,000 tons. (CHART # 15, APPENDIX I).

Aquiculture: The aquiculture in the Pisco zone centers on the production of scallops (*Argopecten purpuratus*) in suspension systems and depth systems. This zone has private aquatic centers in Bahia Paracas and special concessions with the National Reserve of Bahia Paracas in Bahia Independencia, managed by artisan fishing associations. The area solicited for the cultivation of scallops in this zone during 2001

had 323 habitants; many of the special concessions have been inactivated and adjustments are in progress.

The levels of production and extraction will be considerable if the cultivating system continues to depend on seed harvesting, the oceanographic conditions and the level of contamination of the bordering zones.

d. South Zone

The South Zone consists of the Mollendo Basin and Departments of Arequipa, Moquegua and Tacna.

Artisan Fishing: Ports and/or fishing coves considered: Chala, Atico, La Planchada, Ocoña, Camana, Quilca, Matarani, Mollendo, Ilo, Ite, Meca, Vila Vila and the Yarada.

Predominantly represented species are: Bonita, Perico, Corvina, Shark, Peruvian Rock Seabass, Lorna, etc. (CHART # 17 APPENDIX I).

The average volume and totals during 1995 – 1999 are 30,697 tons of fish and 3,967 tons of invertebrae.

Rigging: Hoop, ring, trap, fishing net and harpoon.

Industrial Fishing: Ports: Atico, La Planchada, Mollendo, Matarani and Ilo.

Species: Anchovy, Sardine, Jack Mackerel, Mackarel and Samasa

Fishing areas

The captured volume average was 616,566 tons (frozen, cured, canned, and flour and oil) during 2000 – 2003. (CHART # 15, Apendix I).

Direct Human Consumption: If the levels of distribution of frozen (9,595 tons) and canned (9,417 tons) are similar to 2003, it's noted that frozen production will show a greater average volume (8,203 tons).

Indirect Human Consumption: The Ilo and Matarani ports in this zone concentrate in the distribution of flour processing and fish oil. Nevertheless, the 2003 volumes show variability for the year to be extremely high.

Industrial ships usually operate between Atico and the deep south of the coast, and in rare cases, 50 to 60 miles off the coast.

Aquiculture: The acquiculture in the South zone is related to the cultivation of oysters. In the Morro Sama zone (Tacna), the FONDEPES constructed a pilot center for the turbot (*Scophthalmus maximus*) and red abalone of California (*Haliotis rufescens*). Its main objective was to adapt a cultivation technology to the environmental conditions of the southern coast of Peru and to develop the cultivating techniques for native species similar to the ones mentioned, such as the lenguado (*Paralichthys adspersus*) and the Barnacle Rock Shell (*Concholepas concholepas*). Although the level of pilot production was minimal, this center has demonstrated the feasibility of cultivation in coastal zones. Similar projects have been successful in Chile and may be an alternative for future cultivations.

5.5 PRINCIPAL SOCIO-ECONOMIC ASPECTS

5.5.1 Introduction

Peru has three great geographic areas: the coast, the sierras, and the forest/jungle. The Peruvian coast is the most populated area in Peru. The tendency to population increase along the coast from the last 50 years of the last century has not been concluded. This process is accompanied by another contrary one: the demographic evacuation of the Andes, operating a rural/urban phenomenon in such a manner that two thirds of the population is concentrated in cities, particularly along the coast. Of the ten cities with greater population, six are in this region. We focused on Lima, the capital city with nearly eight million habitants, Trujillo, Chiclayo and Piura in the northern coast with a population of half a million, and Chimbote and Tacna, with a population of nearly a quarter million. Nevertheless, the coast is also inhabited by an important number of nuclei areas with smaller populations that go from "fishermen coves", villages, annexes, and farming areas, to summer beach towns that have a fluctuating population. In this case, the south coast of Lima has a fast process of "urbanization" in the summer beach areas.

The entire coast is united via land through the Pan-American Highway, which also unites Peru with the rest of the Pacific Coast countries of South America.

Considering the type of possible offshore operations, the smaller population centers will be most sensitive and, as a result, have been chosen to consider occupational impacts in populated areas.

5.5.2 Methodology

The socio-economic sensitivty evaluation of the coast, with regards to future offshore exploration and exploitation of hydrocarbon basins work, consider two key aspects: space occupancy and population socio-economic characteristics.

For the present study effects, the area of possible impact would be from the coast to two miles inland, divided into four zones:

ZONE 1. From the border with Ecuador to the Eten district (Prov. De Chiclayo, Departament of Lambayeque)

ZONE 2. From the district of Lagunas (Prov. De Chiclayo, Departament of Lambayeque) to the Cerro Azul district (Cañete Province, Departamento of Lima).

ZONE 3. From the district of San Luis (Cañete Province, Departament of Lima) to the Camana district (Camana Provice, Departament of Ica).

ZONE 4. From the Sam Pastor district (Camana Province, Departament of Arequipa) to the Chile border.

In this aspect, the following occupation factors have been considered:

a. Occupations in populated areas

Density of populated areas: number of populated areas by square kilometer.

Proportion of smaller populated areas: the criterion is to consider units with less than 10 dwellings that are located on the seaboard.

Demographic: measure growth rate at district level (81-93) for each zone.

Occupation by gender: measured using the Masculinity Index (how many males per 100 females exist).

b. For the socio-economic characteristic aspect of the population:

As socio-economic indicators, the following factors are considered:

Type of populated area: proportion of populated rural areas over the total of populated ares in that zone.

c. Predominant economic activity of the PEA

The information comes from official data of the National Institute of Statistics and Information:

- Pre-census data for 1999
  - Data on populated areas
  - Number of homes in populated areas
  - Digital database georeferenced of populated areas
- Data from the National Census Bureau 19931
  - Number of districts per zone
  - Population by district
  - Population of sexes per district
  - PEA occupied per district
  - Growth rate (Census 1981, Census 1993)

Additional sources:

- IGN 2002: Political Map of Peru. Scale 1/1000000.
- Ministry of Transport Communications, Home and Construction May 1999: Peru network. Digital information.

5.5.3 Analysis of Socioeconomic Sensitivity

For the sensitivity evaluation, the indicated factors were analyzed from Figure #20, APPENDIX I:

- Density of Populated Areas: considered to be of maximum density and maximum sensitivity.

- Populated areas with less than 10 homes: the size indicates its importance and sensitivity, impacting future projects. A greater proportion of populated units with lower number of homes mean maximum sensitivity.

- Demographics: a major intercensal annual growth of the population, greater degree of sensitivity.

- Occupations in the area by gender: types of projects with major sensitivity.

- Type of populated area: measured by rural proportion. A greater number of populated areas mean greater sensitivity.

- Main economic activity: the predominance of the PEA in productive activities in agriculture and fishing, which are considered highly sensible.

In Appendix I, you will find the following tables and figures:

- Table # 21: populated areas and number of homes
- Table # 22: populated areas, according to Urban-Rural
- Table # 23: Populated areas, according to category
- Figure # 24: CCPP by zone and number of homes
- Figure # 25: CCPP by zone, according to category
- Figure # 26 : PEA Zone 1, PEA Zone 2, PEA Zone 3, PEA Zone 4

5.5.4 Results of Degree of Sensitivity by Zones

In the application of the values for each one of factors, the range is from 0 to 12; the significance of sensitivity here is in relation to the value obtained. A final range socioeconomic sensitivity was created:

0 to 3 = 1 (low)

4 to 6 = 2 (average)

7 to 9 = 3 (high)

10 to 12 = 4 (very high)

The final results are the following:

Table # 27 Degree of Sensitivity per Zones

Factors	Zone 1	Zone 2	Zone 4	Zone 4
Density of populated centers	0	2	1	1
CCPP proportion w/less than 10 homes	0	1	1	2
Demographic Tendency	1	2	1	2
Masculine Index	0	1	1	0
Types of populated centers	0	1	1	0
Principal economic activity	2	1	1	1
Total	**3**	**8**	**6**	**6**
Degree of sensitivity	**1**	**3**	**2**	**2**

As shown in the table above, Zone 1 is of Low sensitivity, Zone 2 is of High sensitivity, and Zones 3 and 4 of the Average sensitivity.

5.5.5 Analysis of Released Degree of Sensitivity by Zones

a. Zone 1

Zone 1 is located in the extreme part of Peru. It has 95 populated areas, with a population of approximately 296,190, located in 22 districts of 3 departments (Tumbes, Puira and Lambayeque). A third of the populated areas have between 50 and 499 homes. Of the 4 zones analyzed, the least number of populated rural areas is located 2 miles off the coast; however, at district level there is a large population number in agriculture or fishing (36% of PEA). The areas with greater populations are Talara

(nearly 85,000 habitants and the center of petroleum activity, according to old data) and in the Peruvian north, Paita (66,000 habitants) and Negritos (15,000 habitants).

b. Zone 2

This zone includes "the small" north and the central part of the coast. Here is where the city of Lima, the capital of Peru, is located. This zone has the major number of populated areas (376), which corresponds to 56 districts in the departments of Lambayeque, La Libertad, Ancash and Lima.

Neverthess, a quarter of the populated areas has less than 10 households that correspond to small fishing ports, particularly to the north of Lima, and summer beach areas to the south of Lima. Here you will also find the largest and most luxurious homes pertaining to the upper and middle-class. It is the only zone that has populated areas with more than 50,000 houses. The estimated population within two miles off coast is a bit more than three-and-a-half-million people. Additionally, in this zone you will find the coastal city of Chimbote, a main fishing port of Peru, where the Peruvian steel company is located. The ports of Huarmey, Supe, Huacho, Chancay and Cerro Azul are located there, as well. Between these points are located the port of Callao, the most important Peruvian port, with an approximate population of 750,000 people.

In spite of their existence, the greater number of populated areas is rural. Two-thirds of the Active Economic Population is non-certified workers, tied to tertiary activities (serices and commercial).

c. Zone 3

Here, there is an approximate population of 170,000 in 170 populated areas belonging to 24 districts in 3 departments (Lima, Ica and Arequipa). It is known for having large cities, the greater concentrations located in Pisco (56,000 habitants) near the Paracas Reserve and in fishing zones like San Andrés and Camana (15,000 habitants). In the Pisco-Paracas section are some small and medium port terminals, several of the main fishing companies, a liquefaction plant from the Camisea Project, fuel storage tanks from Grana and Montero, and other industrial facilities. Additionally, in Zone 3, you will find agricultural activities, like in the valleys of Cañete, Pisco, Ica, Yauca, Ocoña and, very importantly, Majes (in its opening it took the name of Camana).

More than half of the PEA (60%) holds non-certified jobs and almost one-fourth of the employees are in agriculture and fishing. In the study done, it is the most rural of the four zones and the one with the least amount of registered annual growth, tending to the depopulations of some zones.

d. Zone 4

This zone is the least populated of the 4 studied. It has a population of approximately 160,000 people, located in 89 populated areas that belong to 12 districts in 3 departments (Arequipa, Moquegua and Tacna). In this zone, more than 40% of the populated areas have less than 10 households each. 88% of the populated areas are rural in nature.

The principal cities depend on ports such as Ilo, population of approximately 82,000 habitants (department of Moquegua) and dedicated to mining by the Southern Peru miners. We also found the Matarani port (department of Arequipa) and the city of Mollendo with 36,000 habitants characterized as being summer ports. Between Camana

and Tacna exists several summer ports, such as, La Punta, Los Cerrillos, Mollendo, Mejia and Boca del Rio.

More than half of the PEA (58%) have developed non-certified jobs, and a fourth of the population is dedicated to agriculture and fishing.

5.6 *OCEANOGRAPHY*

This part consists of figures and tables that summarize the oceanographic information available for the Peruvian sea and area of the Pacific Ocean corresponding to the latitudes of Peru.

5.6.1 *Methodology*

The compilation of oceanographic information was based on a web search of oceanographic parameters considered relevant, accessing sites on organisms, and national and international institutions. The oceanographic parameters considered are the following ones:

a) Bathymetry
b) Superficial Sediments
c) Oceanic Currents
d) Superficial Sea Temperature
e) Salinity
f) Dissolved Oxygen
g) Waves, Maximum Altitudes
h) Winds
i) Tsunamis
j) Other Global Oceanographic Models

Once a suitable Web site was found, the search began with general details, discarding the irrelevant information.

The exception was the information on tides obtained by consulting the Table of Tides produced by the Direction of Hydrography and Navigation of Peru.

The national and international institutions consulted from which relevant information was obtained are numbered in each section.

5.6.1.1 *Bathymetry*

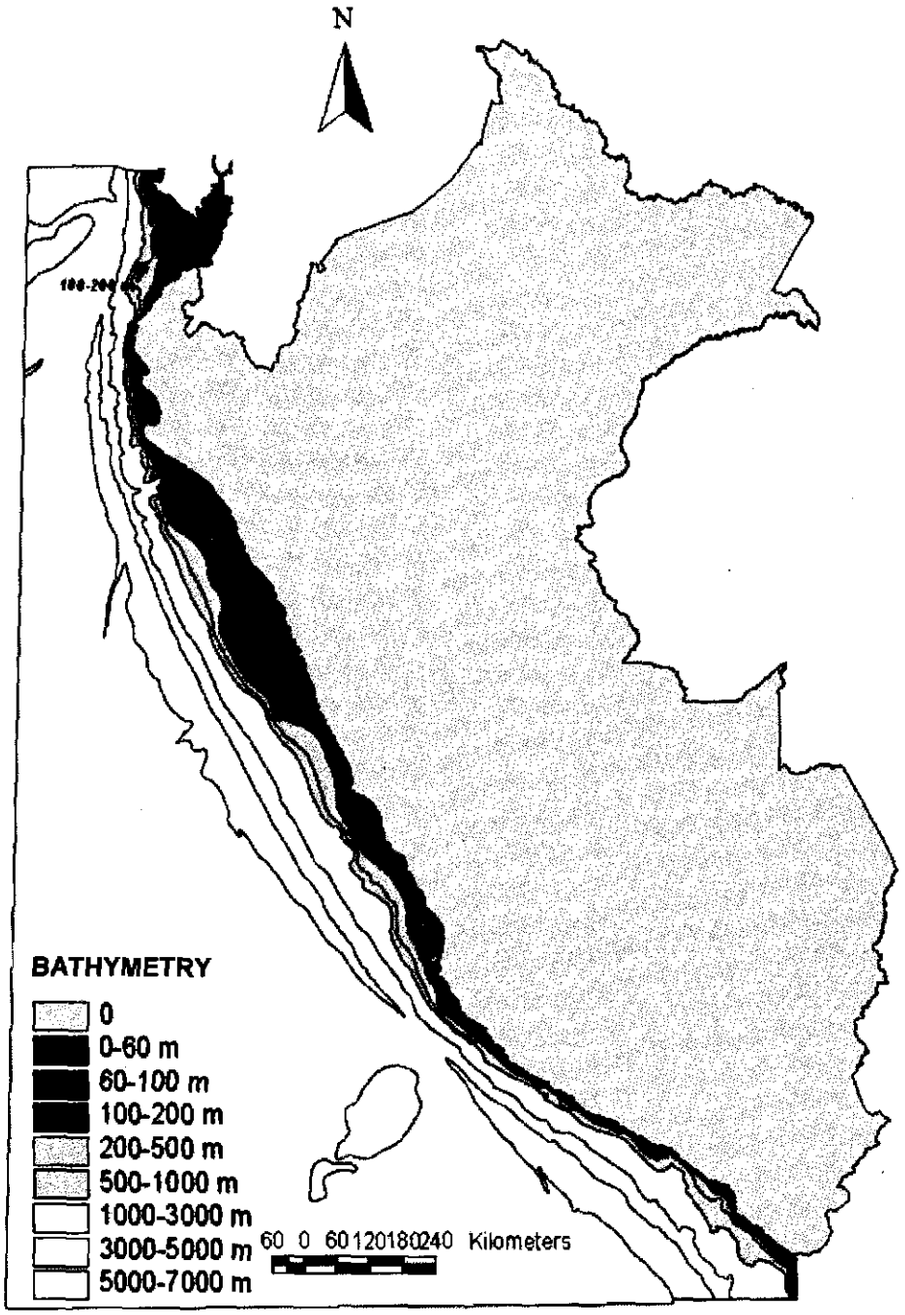
The depths data for the front of Peru come from measurements in a database known as the GEBCO Digital Atlas. GEBCO is maintained by British Oceanographic Data Center (BODC). The last update (2003) of the data set has a grid spacing of 1 minute latitude by 1 minute longitude. The website is: www.bodc.ac.uk/projects/gebco .

Figure # 28 shows the bathymetry of the coast of Peru and part of the Pacific Ocean. The dominion shown covers from 2°S and 83°W (left superior edge) 19°S and 83.5°W (left inferior edge).

The most salient characteristic of submarine topography bordering to the coasts of Peru is the Peru-Chile sink hole, also denominated is the Atacama sink hole. It is located about 160 km from the coast of Peru. Its maximum depth is 8,065 m, its approximate longitude is 5,900 km and its average width is 64 km, having an approximated surface of

590,000 km^2. The sink hole is a result of the subduction of the east edge of the Nazca slab underneath the South American slab.

Figure #28: Peru Bathymetry



5.6.1.2 Superficial Sediments

Information on types of superficial sediments comes from samples grouped and analyzed by the IMARPE - PROCOPA. The website is http://www.imarpe.gob.pe

Figure #29: Superficial sediments. Continental Peru – from Tumbes to Callao

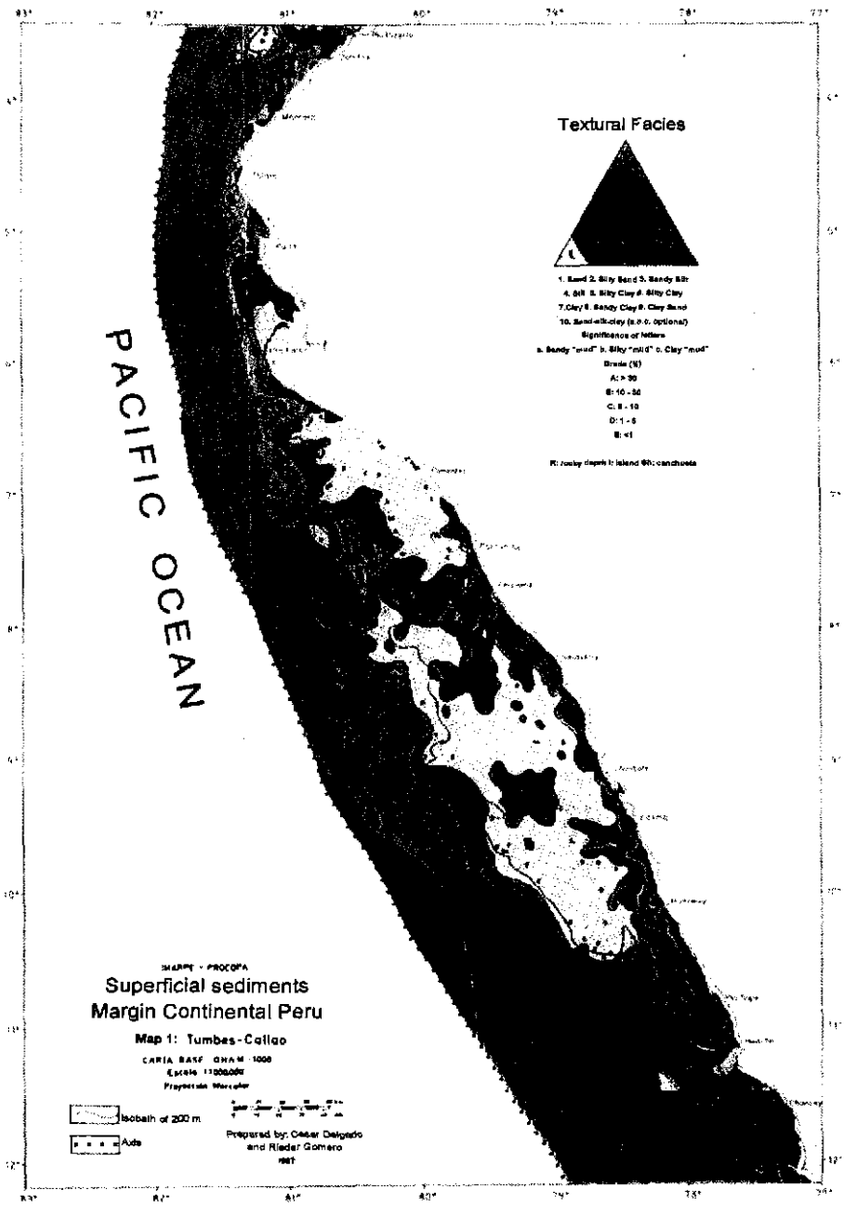
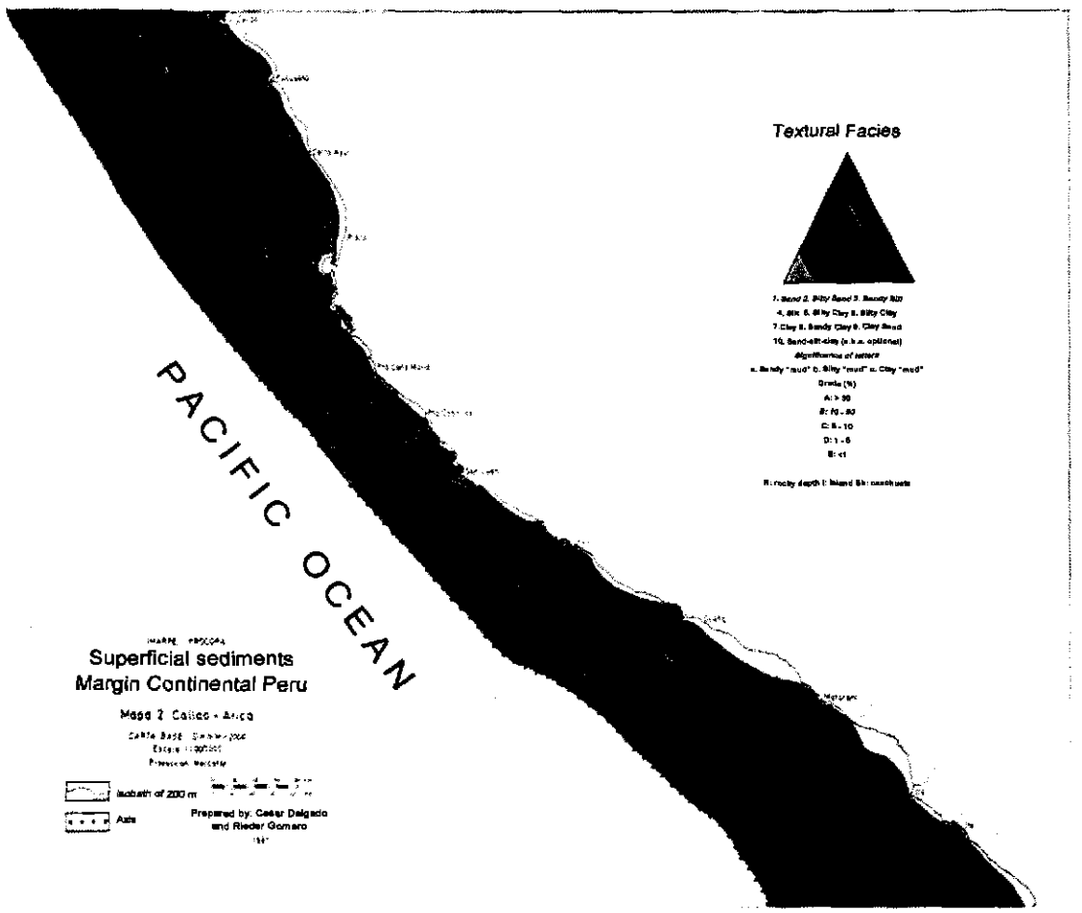


Figure #30: Superficial sediments. Continental Peru – from Callao to Arica



5.6.1.3 Oceanic Currents

Information on the oceanic currents is provided by the global model, Global Model MITgcm. The coastal currents are not well represented by the model.

The MITgcm model (General MIT Circulation Model) is a numerically designed model for the study of the atmosphere, oceans and climate. Its forumulation is non-hydrostatic, which allows the simulation of a wide range. The data name is ECCO 2 JPL.

ECCO (Estimating the Circulation and Climate of the Ocean) is a consortium formed by Jet Propulsion Laboratory (JPL), Massachusetts Institute of Technology (MIT) and Scripps Institution of Oceanography (SIO). This information may be found on the website: MITgcm: http://mitgcm.org and ECCO: http://www.ecco-group.org

Figures 31 to 34 display the annual average values of currents (1980 to 2000), to 4 depths (5 meters (m), 25 m, 75 m and 105 m).

The currents determined by the model, global MITgcm, show different patterns according to the analyzed depth layer. The currents near the surface (5 m depth) can be explained according to the wind field zone, direction W/NW. The average current intensity is 0.1

m/s. The deepest layers display differences with respect to the superficial currents because the wind dominates the system. The currents direction changes with the depth, as it can be observed in the figures, and the intensity diminishes to values of 0.02-0.03 m/s.

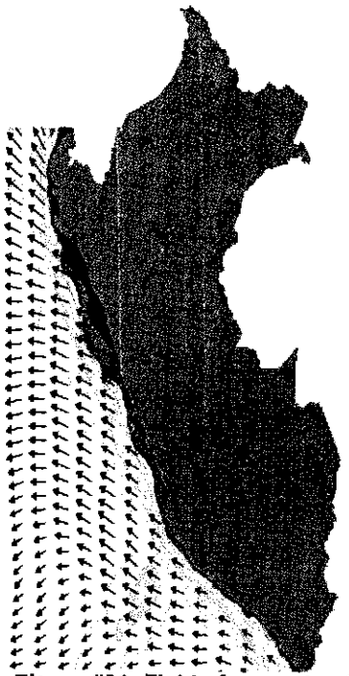


Figure #31: Field of currents - 5m depth

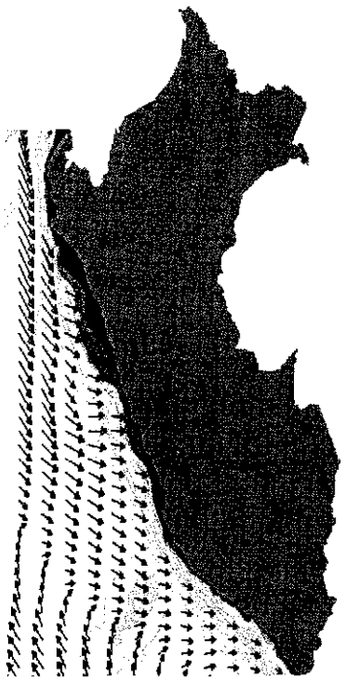


Figure #33: Field of currents - 75m depth

Figure #32: Field of currents - 25m depth

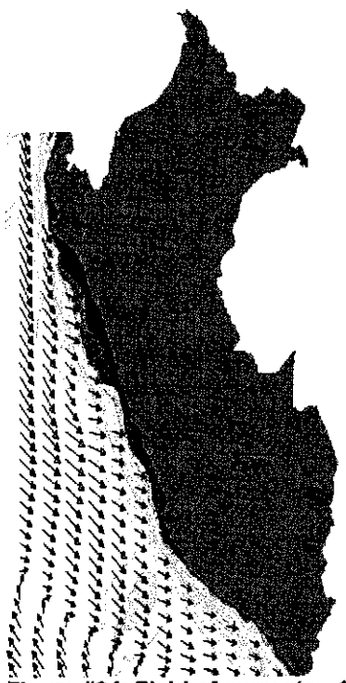


Figure #34: Field of currents - 105m depth

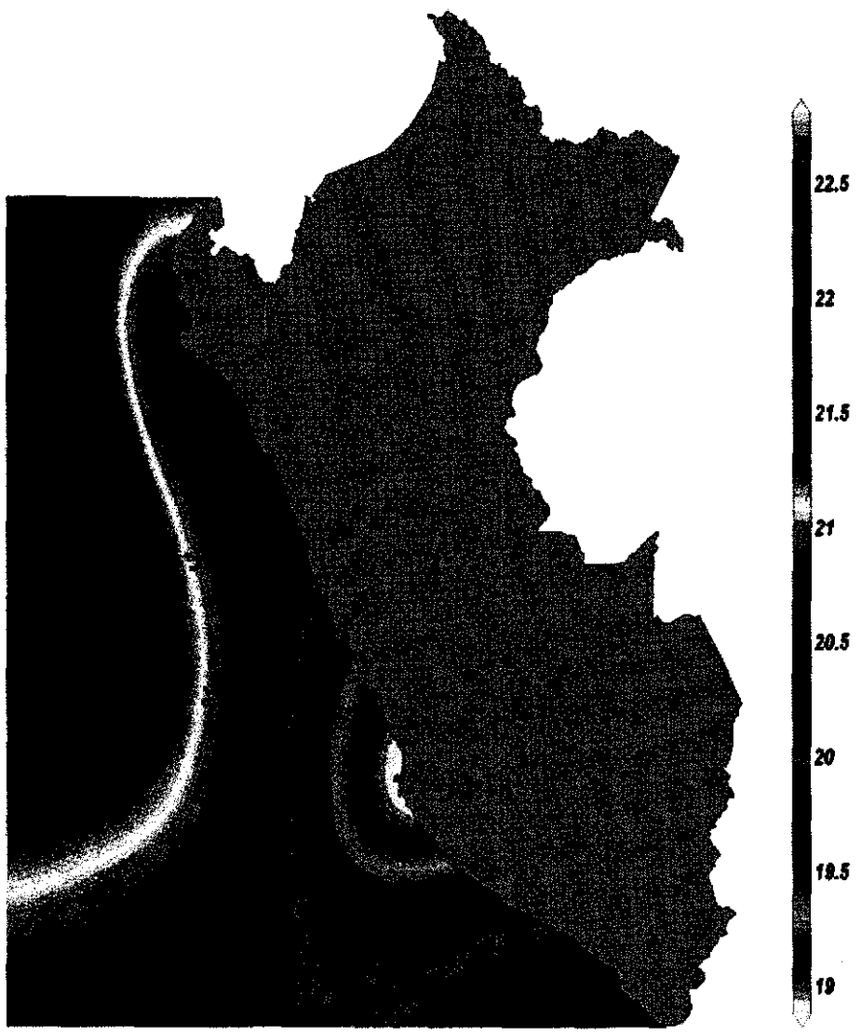
5.6.1.4 Superficial Sea Temperature

The information on the superficial sea temperature comes from measurements throughout the years. The data comes from the World Ocean Database 2001, which is an update of the Seth World Ocean Database 1998.

This data shows a wide range of variables, historical as well as modern, and can be found in the website http://www.nodc.noaa.gov.

The Figure # 35 shows the average annual temperature. It ranges from approximately 19°C to 23°C. The temperature increases towards the north and towards the coast. The observed minimum values can be found near the coast are between 15° and 12° S.

Figure #35: Superficial sea temperature (C°)



5.6.1.5 Salinity

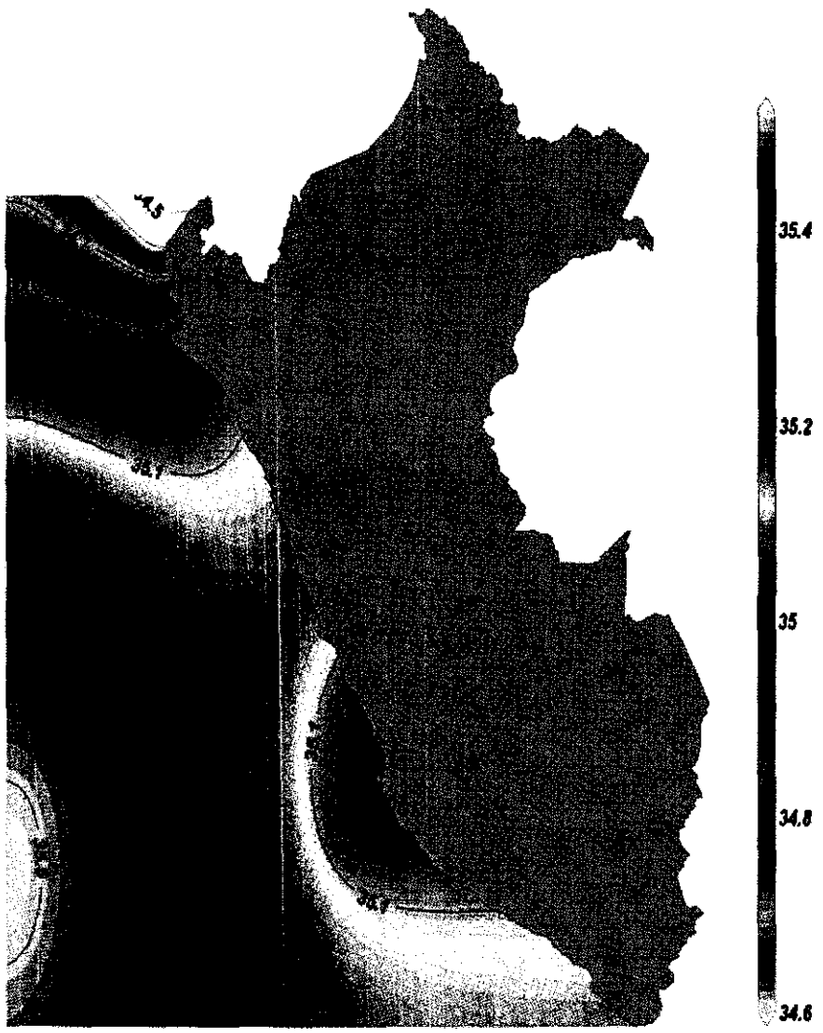
The salinity information comes from measurements made throughout the years. The data corresponds to the World Ocean Database 2001, which is an update of the World Ocean Database 1998. The website is http://www.nodc.noaa.gov.

The salinity annual average for the interest region varies between 34.5 g/l and 35.5 g/l.

In nearly all the coastal strip, the salinity does not present significant changes, maintaining an average value between 35 and 35.1 g/l. The North coast shows a gradient of diminution of salinity, reaching 34.5 g/l to 2° S. At greater distances of the coast, the salinity increases, obtaining values of 35.5 g/l. The zone that surrounds to the Pisco Bay presents a local minimum with smaller to 35 g/l.

The North coast shows a gradient of salinity diminution, reaching 34.5 g/l to 2° S. At greater distances from the coast the salinity increases, obtaining values of 35.5 g/l. The zone that surrounds the Bay of Pisco shows a local minimum with values less than 35 g/l.

Figure #36: Superficial salinity (UPS)

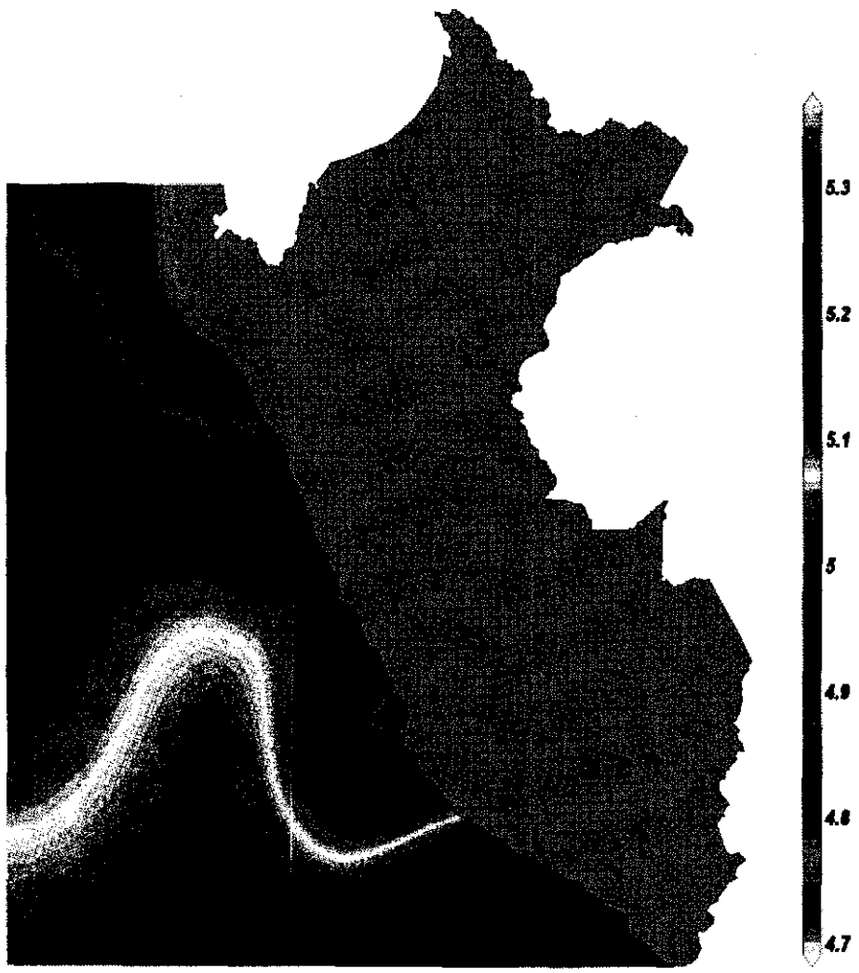


5.6.1.6 Dissolved Oxygen

The dissolved oxygen information comes from measurements throughout the years. The data comes from the World Ocean Database 2001, which is an updated version of the Seth World Ocean Database 1998. The website is http://www.nodc.noaa.gov

In the Figure # 37, the distribution of dissolved oxygen is observed. It increases towards the south, with maximum of 5.5 mg/l observed in the south coast of Peru and a minimum of 4.7 mg/l in the north, of the same.

Figure #37: Dissolved oxygen (mg/l).



5.6.1.7 Waves, Peak Altitudes

Wave information comes from observations made from ships throughout the years. The data corresponds to COADS (Comprehensive Ocean Atmospheric Data Set).

The COADS data is the greater one and used more with regard to superficial oceanographic data. The database is composed as much by historical data (from 1854) as by modern data.

The project is led by NOAA (National Oceanic and Atmospheric Administration) and the NCAR (National for Center Atmospheric Research).

The product is Surface Marine Gridded Climatology (SMGC) and consists of climatologic correspondence (monthly average) derived from the COADS data. The correspondence summarizes data from 1854 to 1997 in one grille, with a 1 degree resolution of latitude by 1 degree of longitude. This information can be found in the following websites:

COADS: http://www.cdc.noaa.gov/coads/
SMGC: http://navy.ncdc.noaa.gov

Figures # 38 thru 40 show the peak altitude of waves (in feet), by month, for all Peru platforms and a great part of the Nazca (up to 90W) plate.

The highest values are registered in the month of September, reaching values of up to 12-15 feet. These maximums are registered offshore, in a parallel area to the coastline that begins in 9°S and 84°W, and ends at 14°S and 81°W.

Figure #38: Climatology of peak altitudes of waves (feet). Maps for the months of January, February, March and April.

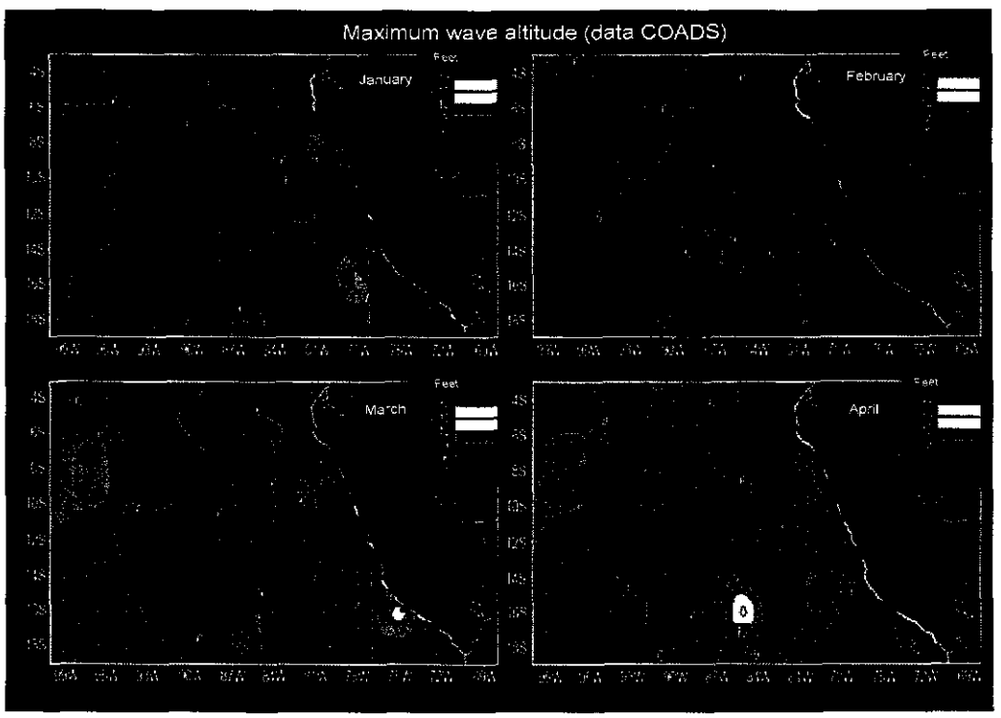


Figure #39: Climatology of peak altitudes of waves (feet). Maps for the months of May, June, July and August.

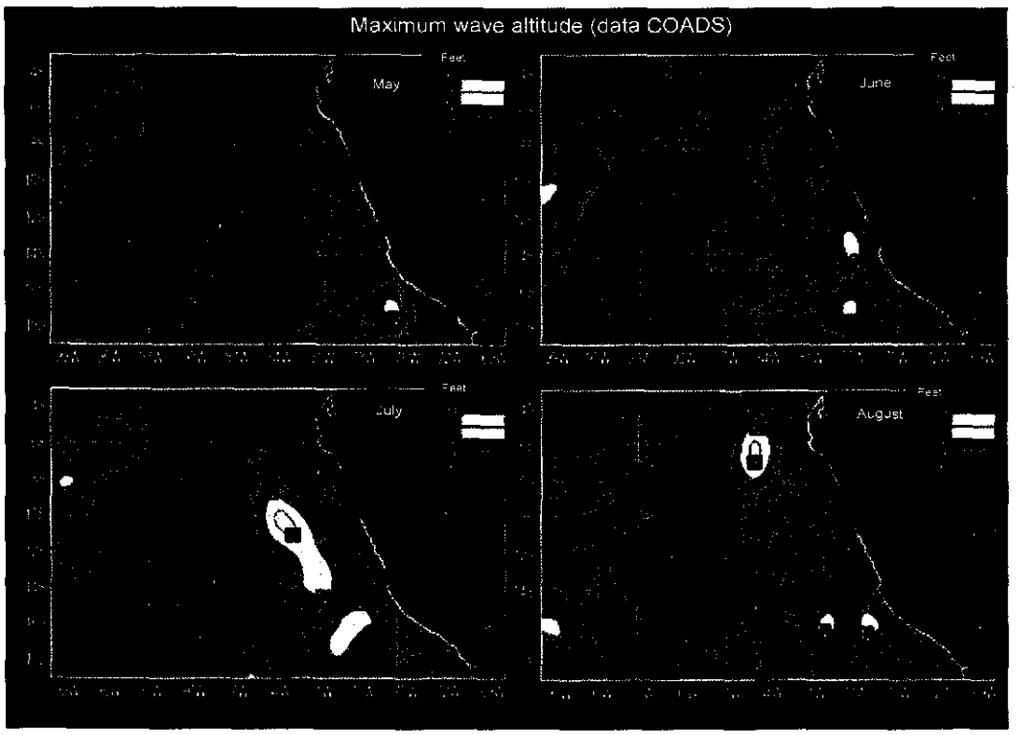
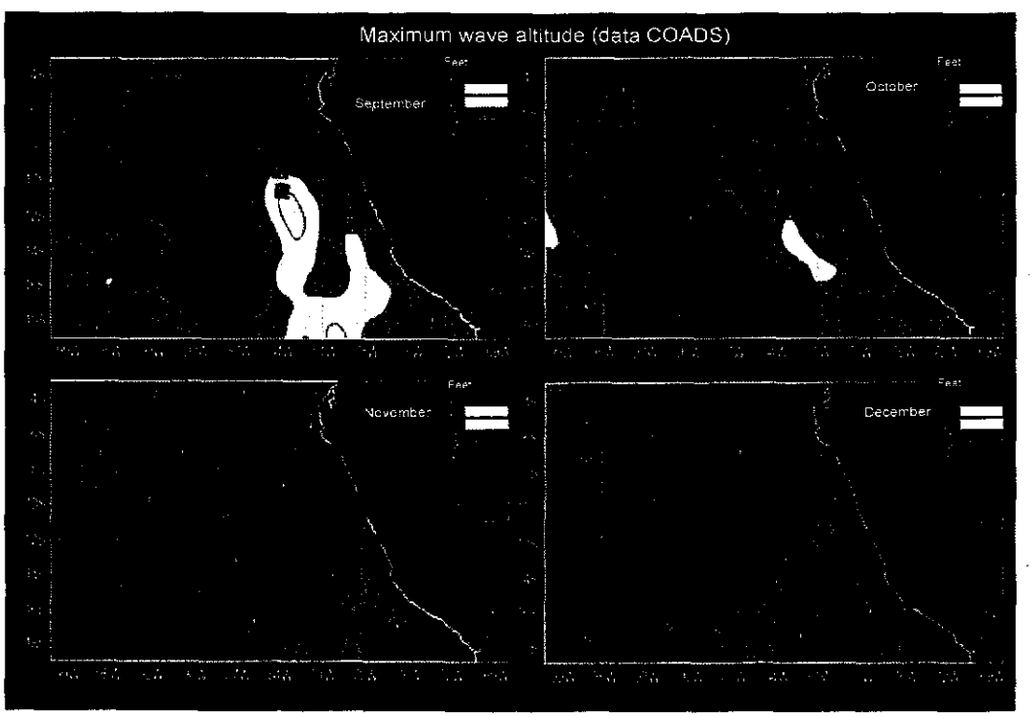


Figure #40: Climatology of peak altitudes of waves (feet). Maps for the months of September, October, November and December.

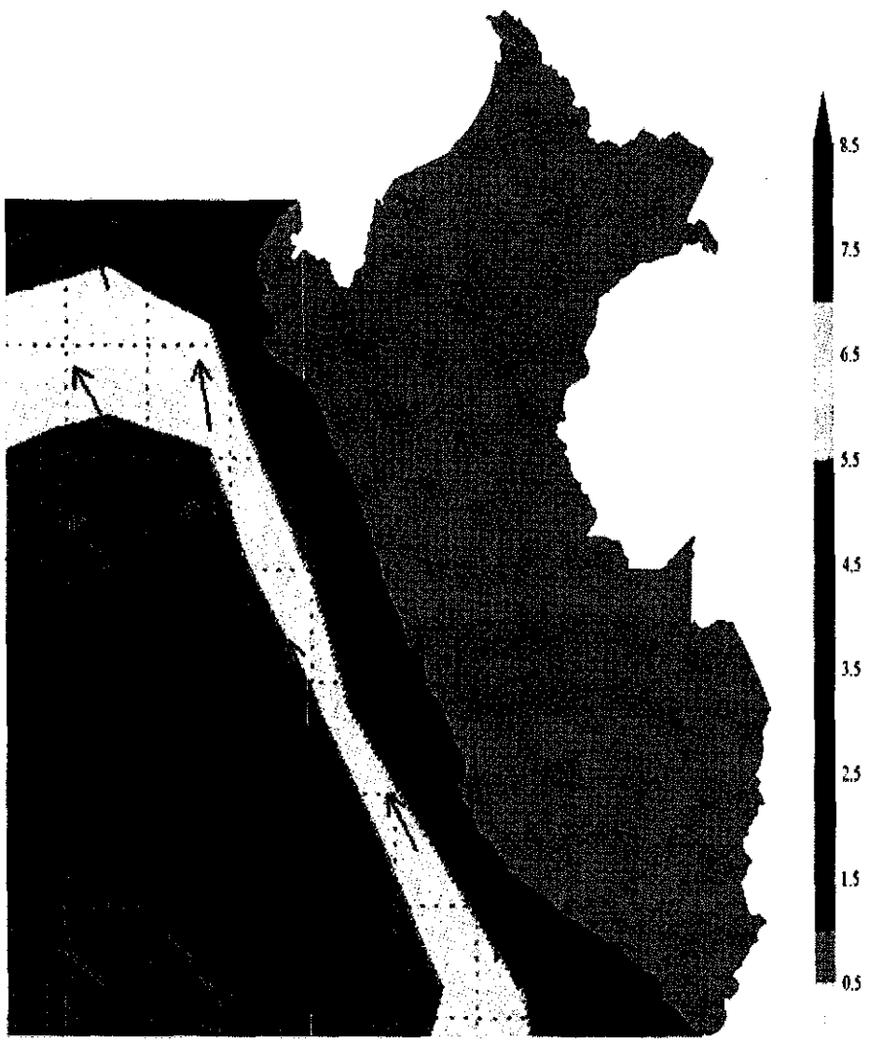


5.6.1.8 Winds

Wind information comes from the mathematical modeling of the global climate. In this case, the data corresponds to the global model: NCEP, data: NCEP Reanalysis Electronic Atlas. It can be found on the web site: http://www.cdc.noaa.gov.

In Figure # 41, the average winds are observed (1968-1996) for all the coast of Peru. They show average NW winds, with average maximum of 8.5 m/s in offshore zone, and minimum near null in the regions near the coasts.

Figure #41: Wind intensity (m/s) and direction.



5.6.1.9 Tides

The tides information comes from the Tables of Tides produced by the Direction of Hydrography and Navigation of Peru. CHART # 42 summarizes the main location of the stations of tides, and parameters: maxima high water, average high water, maxima low tide, average low tide, average amplitude average and full amplitude.

CHART # 42 SUMMARY OF THE DOMINANT CHARACTERISTICS OF THE TIDES OFF IN THE COAST OF PERU.
THE HEIGHTS ARE REFERRED WITH THE LOCAL DATUM LEVEL. SMALL VARIATIONS OF THE HEIGHTS CAN BE FOUND - INDICATED IN THE TABLE - ACCORDING TO YEARLY PREDICTIONS.

Place	Latitute	Longitude	High water maximum (m)	High water medium (m)	Low tides maximum (m)	Low tides Medium (m)	Amplitude average(m)	Amplitude full (m)
Zorritos	3°39'16.4"	80°39'16.1"	2.16	1.67	-0.33	-0.20	1.43	1.83
Lobitos	4°26'11.2"	81°16'7.1"	1.95	1.43	-0.36	-0.18	1.25	1.62
Talara	4°34'14.6"	81°16'7.4"	1.92	1.43	-0.60	-0.17	1.22	1.58
Paita	5°4'2.6"	81°7'2.8"	1.83	1.32	-0.39	-0.14	1.16	1.49
Bayovar	5°47'19.2"	81°3'1.4"	1.74	1.22	-0.39	0.14	1.07	1.37
I. Lobos de Tierra	6°24'10.4"	80°51'20.5"						
I. Lobos de fuera	6°55'23"	80°43'17.5"						
Eten	6°56'22.6"	79°52'21"	1.40	1.02	-0.21	0.14	0.91	1.19
Malabrigo	7°41'16.8"	79°26'10.8"	1.31	0.93	-0.21	0.14	0.82	1.07
Salaverry	8°13'5.7"	78°48'20.1"	1.34	0.96	-0.15	0.20	0.76	1.01
Chimbote	9°4'2.6"	78°37'15.8"	1.37	0.99	-0.03	0.29	0.70	0.94
Huarmey	10°5'2.6"	78°10'4.3"	1.22	0.79	-0.21	0.14	0.67	0.88
Supe	10°47'19.5"	77°44'18.4"						
Huacho	11°7'2.9"	77°36'15.3"	1.07	0.69	-0.24	0.09	0.61	0.79
Callao	12°3'1.2"	77°9'3.6"	1.16	0.78	-0.09	0.24	0.55	0.73
Pisco	13°43'17.2"	76°13'6.2"	1.04	0.66	-0.24	0.09	0.58	0.76
San Juan	15°20'9"	75°9'4.1"	1.09	0.65	-0.15	0.07	0.55	0.73
Lomas	15°34'13.6"	74°51'20.5"						
Atico	16°13'5.7"	73°51'21.2"						
Quilca	16°42'17.5"	72°25'11"						
Matarani	16°55'22.9"	72°6'2.8"	1.18	0.72	-0.15	0.07	0.64	0.82
Mollendo	17°1'0.9"	72°0'0.9"						
Ilo	17°38'15.6"	71°20'8.3"	1.24	0.81	-0.15	0.07	0.70	0.88

5.6.1.10 Tsunamis

The information on the tsunamis tides comes from the Atlas of Natural Disasters of Peru, Areas of Floods in Case of Tsunamis, produced by Hydrography and Navigation of Peru.

CHART # 43 displays a summary by locale, containing the location coordinates, population, population activities, flood levels and a history of tsunamis.

Chart. 43. CHARACTERIZATION OF ZONES VULNERABLE TO TSUNAMIS OR TIDAL WAVES.

Place	Latitude	Longitude	Population (2002)	Hab/Km²	Main activities of the population	Characterization of the beach and the nearby topography	Marine under currents	Quota (m)	Number of tsunamis registered and their repetition trends
Pimentel Harbor	6°53'21.2"	79°55'22"	*21767*	*327.20*	Fishery and harbor work.	The beach is spreader along a reef or a strong wave breaker. The submarine terrace topography show low depths, given that along a mile of beach, the terraces measure up to 10 meters.	*Close to 0.3 knots with a drift towards the northeast.*	*5*	*No registration of occurrence. Period > 500 years*
Eten Harbor	*6°55'22.4"*	*79°52'20.8"*	*2579*	*178.10*	Fishery and harbor work.	The beach from the Santa Rosa Creek is low and sandy for 4 miles until it reaches Punta Eten. The submarine terrace topography gradually decreases from the beach onwards, and a 12 meter edge of the sand bank is found approximately 1.5 miles from the beach which develops along its contours. The terraces are clean from hindrance and the water depth quite stable.	*Close to 0.3 knots with a drift towards the northeast.*	*4*	*No registration of occurrence. Period > 500 years*
La Punta – Callao	12°3'1.6"	77°8'4"	*424833*	*9147.6 0*		The submarine topography in La Punta at its farthest South presents little water, which directly contributes to deform even more given the deviation of the wave motion system and accentuating its uneven physiognomy. Since there is as well, a dragging of sedimentary material, an extensive stone bank has derived gaining an almost triangular shape.		*7*	*1586, 1687, 1746, 1806, 1940, 1960, 1964, 1966, 1968, Feb.1996, Nov.1996, and 2001*
Pacasmayo Harbor	7°23'10"	79°34'13.7"	*29218*	*947.40*		This harbor was established approximately 3.5 miles southeast of the Jequetepeque river mouth, where the coast extends westward and then pushes forward towards the South and Southwest.	*In the anchor zone: between 0.5 and 0.7 knot with a drift towards the northeast.*	*Bet-ween 4 y 6*	*No registration of occurrence. Period > 500 years*
San Juan de Marcona Harbor	15°21'8.9"	75°9'4.3"	*13781*	7.05		The submarine terrace is regular and deep with 20-meter edge of the sand bank which is found a bit further from a quarter of a mile from the beach.	*In the anchor zone: between 0.4 and 0.6 knot with a drift towards the northeast. Piers: 0.8 to 1.1 knots with a drift towards the North.*	*7*	*1992, 1996 y 2001*
Zorritos Harbor	3°40'16"	80°39'16"	*14383*	*12.00*		The slope of the submarine terrace is uniform and spreader. The bottom is composed mainly of sand.	*Barely significant intensities with a drift towards the Northeast.*	*7*	*No registration of occurrence. Period > 500 years*
Supe Harbor	10°47'19. 6"	77°44'18.1"	*11387*	*989.3*		*Sand beach with no hindrance.*	*Barely significant currents*	*7*	*Same Tsunamis as for Puerto Callao*

Place	Latitude	Longitude	Population (2002)	Hab/Km²	Main activities of the population	Characterization of the beach and the nearby topography	Marine under currents	Quota (m)	Number of tsunamis registered and their repetition trends
									but minor magnitude.
Pisco Harbor	13°42'17.3"	76°13'5.3"	61287	2458.5		The submarina terrace gradually decreases and the 10 meter edge of the sand bank extends along the western side, 3 miles from the coastline in front of tha Pisco Harbor and 1 mile in front of the San Andrés Beach.	Between 0.2 y 0.6 knots. The direction varies according to the Bay configuration.	7	1868, 1992, 1996 and 2001
Chimbote Harbor	9°4'2.2"	78°36'15.2"	304900		Employees from the Siderurgical Plant, Plant SIMA in Chimbote and the fishery industry.		Harbor: Barely significant. Maneuver Zone: between 0.6 and 1.2 knots.	Bet-ween 4.5 and 6.5	Last registration: 1996
Puerto Malabrigo	7°42'16.8"	79°26'10.6"	7000		Fishery and harbor work.	Found established approximately 12 miles South, southeast of Punta Puémapein a broad gulf clearly defined which cuts the coast at this distance. This harbor is preserved on the austral side by a projection that goes into the sea for 3 miles, showing lots of stones close to the beach.		6	No registration of occurrence. Period > 500 years
Huacho Harbor	11°7'2.9"	77°36'15.2"				The Huacho Bay is a gulf that cuts the coast between Puntas Carquín on the North and Huacho on the South. The eastern side shows a deep hollow or gorge of average height, in front of which a narrow tongue of beach extends.	The marine currents on Huacho Harbor vary with respect to their deviations, but with a trend towards the northeast reaching values of 1 knot.	10	Same Tsunamis as for Puerto Callao but minor magnitude.
Cerro Azul Harbor	13°1'0.8"	76°29'11.6"				In the harbor zone, the submarine terrace configuration is spreader, which explains considerable breakings at any tide level. The 5 meter edge of the sand bank withdraws at an average distance of 370 meters from the marina, sensibly approaching towards Punta Fraile and the 10 meter sand bank edge withdraws from the border, at a distances that fluctuates between 740 and 1300 m. Los bottoms in this zone are made of gravel and sand.	Barely significant currents.	4	1868, 1992, 1996 and 2001

Place	Latitude	Longitude	Population *(2002)* *Hab/Km²*	Main activities of the population	Characterization of the beach and the nearby topography	Marine under currents	Quota *(m)*	Number of tsunamis registered and their repetition trends
Salaverry Harbor	8°13'5.4"	78°59'23.6"			*From Beach Las Delicias, the coast appears low and as a sand beach, towards the Southeast with an extension of 4 miles, at which end forms a gulf or cavity limited by a low height mount (Peak Carretas). The submarine terraces highlights diminish uniformly with no major dangers, the 5 meter sand bank edge runs along the beaches at a distance of 400 meters...*	*A drift predominates towards the northeast with approx. Intensities of 0.5 knots in the external Bay. Within the wave breaker some current a considerable value develop tending South.*	*3*	*Last registration: 1996*
Vila Vila Creek	*18°6'3.1"*	*70°43'17.8"*			*Small creek, rocky, dirty and at its terrace, a sand beach.*		*7.5*	*1868, 1992, 1996 and 2001*

5.6.1.11 Other Global Oceanographic Models

With different degrees of development, there is available other global models and/or database, with support capabilities for the development of hydrocarbon investigations on the oceanic front.

The models available are as follows:

OCCAM

Ocean Circulation and Climate Advanced Modelling Project

Southampton Oceanography Centre, United Kingdom

Website: http://www.soc.soton.ac.uk/JRD/OCCAM/welcome.html

Some model details are as follows:

- Space coverage: global
- Space resolution: 1/4 latitude x 1/4 longitude
- Levels: 36, 20m wide near the surface, 255m wide at 5500m in depth
- Topography: DBDB5
- Time: 14 year simulation

The available data includes potential surface temperature, salinity and velocity (all of the parameters equal to a 15 day period).

The OCCAM is a model of primitive equations of a global scale. This is based on GFDL MOM of Bryan-Cox-Semtner but includes free surface and improved advection schemes. The model was initiated with a set of Levitus (average temperature and salinity fields). The surface forces average monthly ECMWF winds.

HYCOM

Hybrid Coordinate Ocean Model

Rosenstiel School of Marine and Atmospheric Science – University of Miami

Website: http://hycom.rsmas.miami.edu/index.shtml

Some model details are as follows:

- Space coverage: Pacific Ocean
- Space resolution: 1/12 latitude x 1/12 longitude

The available data includes the east-west Barotropic velocity component, the north-south Barotropic velocity, mixture depth, east-west component velocity, north-south component velocity, mixture layer salinity, mixture layer temperature, heat flow, and salt flow.

The most salient characteristic of the model is the use of hybrid coordinates. These coordinates extend the geographic range of model application, including a same simulation of deep and coastal water areas.

POCM

Parallel Ocean Circulation Model

MIT Center for Meteorology and Physical Oceanography and the Naval Postgraduate School

Website: http://www.oc.nps.navy.mil/~rtt/POCM_info.html

Some model details are as follows:

- Space coverage: Global
- Space resolution: 1/4 latitude x 1/4 longitude (on average)
- Time: 10 year simulation (1987-1996)

The data available includes East-West speed component, the North-South speed component, vertical speed component, salinity, temperature, and open surface height.

The Parallel Ocean Circulation Model descends from the Bryan/Cox/Semtner family, specifically designed to run in a matrix of computers parallel to the CM5.

ECCO (MITgcm)

Estimating the Circulation and Climate of the Ocean (MIT General Circulation Model)

Jet Propulsion Laboratory (JPL) - Massachusetts Institute of Technology (MIT) - Scripps Institution of Oceanography (SIO).

Website : http://ecco.jpl.nasa.gov

Some model details are as follows:

- Space coverage: Global
- Space resolution: varies, according to data information
- Time: varies, according to data information

The available data includes the typical oceanographic variables (speed, temperature, salinity, etc.) and more specific variables.

Data access site: http://ecco.jpl.nasa.gov/las/servlets/dataset

MITgcm is a numeric model designed to study the atmosphere, the ocean and the climate. Its non-hydrostatic formulation allows a phenomenon simulation in a wide scale range.

The OSU TOPEX/Poseidon

Oregon State University

Website: http://www.coas.oregonstate.edu/research/po/research/tide/global.html

Some details of this model are the following:

- Space coverage: Global
- Space resolution: 1/4 latitude x 1/4 longitude

TPXO.6 is a global tides model. This model adjusts by minimum squared units, the Laplace tides equation and data on TOPEX/Poseidon orbits. The model calculates eight primary components (M2, S2, N2, K2, K1, O1, P1, Q1) and long period components (Mf, Mm).

5.7 *ENVIRONMENTAL LEGAL FRAME APPLICABLE TO HYDROCARBON ACTIVITIES OFFSHORE*

The general environmental legal frame applicable to private initiative in the Peruvian territory, including territorial waters, is defined by the Peruvian 1993 Political Constitution, the Environmental and Natural Resources Code, Legislative Decree 613 published in 1990, the General Health Law 26842; as well as other specific regulations from the Frame Law on Growth on Private Investment, Legislative Decree 757, approved in 1991. With regard to marine activities, the Law on Control and Surveillance of marine, river and lake activities, Law 26620, also applies.

Organic Law on Hydrocarbons, Law 26221, a specific environmental frame was established in 1993, and is regulated by Supreme Decree 046-93-EM (modified by Supreme Decree 009-95-EM), Regulation for the Environmental Protection of Hydrocarbons activities, and complemented by other specific norms, such as the Regulation on Activities of Exploration and Exploitation of Hydrocarbons from 2004, approved by Supreme Decree 032-2004-EM.

Additionally, to the mandatory legal norms, the Ministry of Energy and Mining published in 2001 the Guide for Oil Operations Offshore, approved through Directive Resolution 011-2001-EM/DGAA, which includes guidelines to be considered by the contracting companies.

Both the general and the specific environmental legal frames, applicable to offshore hydrocarbon activities, are explained in this document.

5.7.1 *General Legal Frame for Offshore Hydrocarbon Activities*

Article 66 in the Political Constitution establishes that natural resources, renewable and non-renewable (which include hydrocarbons) are patrimony of the Nation; and the State is sovereign to use them and benefit from them. As well, it is established that by organic law, the conditions of use must be set, as well as its granting to private entrepreneurship.

Article 66 has been regulated by the Organic Law on Sustainable Use of Natural Resources, Law 26821, consistent with a legal frame of the Organic Law on Hydrocarbons, Law 26221, which establishes license and services contracts; or through other authorized forms of legal agreements on behalf of the Ministry of Energy and Mining, as well as those through which the right of exploration and exploitation of hydrocarbons is granted. According to Article 8 of this Law, hydrocarbons at their source are property of the State, being PERUPETRO S.A., the entity that grants the right of property on the extracted hydrocarbons.

According to what was noted in the Regulation of Hydrocarbons Exploration and Exploitation Activities from 2004, approved by Supreme Decree 032-2004-EM, Hydrocarbons Exploration and Exploitation include the specific activities of search and discovery of hydrocarbons, including geological work, exploratory and development of oil wells perforation, as well as the activities concerning hydrocarbons production.

In Peru, those entitled to develop productive activities are subject to a regulatory frame that defines their responsibilities before the State and before third parties, regarding

possible impacts of such activities that could affect the environment, the health and the wellbeing of the people. Therefore, the Peruvian General Environmental Legal Frame establishes that administrative responsibility is independent from any civil or penal responsibility which could derive from the same facts, according to Article 117 from the Code of Environment and Natural Resources, Legislative Decree 613 (from here on Environmental Code).

Article 87 of Law 26221, establishes that natural and juridical persons, nationals or foreigners, who carry-out hydrocarbon activities must comply with all regulations on the environment. In case the regulations included are not fully complied, the Supervision Agency of the Energetic Investment (OSINERG) will carry out the suitable sanctions, to the extent that the Ministry of Energy and Mining can even terminate a contract prior to the related report by OSINERG.

The Ministry of Energy and Mining is in charge of dictating the environmental regulations for hydrocarbon activities.

Aside from the indicated norms, the Law on Control and Surveillance of Marine, River and Lake Activities, Law 26620 regulates some aspects of marine activities, without excluding competence to the Ministry of Energy and Mining, nor OSINERG, as competent environmental authorities regarding hydrocarbon activities. The scope of application of this Law, according to Article 2, among others, includes the adjacent sea to the Peruvian shores and its bank for a distance of 200 nautical miles, including the naval artifacts and installations placed offshore, except for those placed within harbor development areas, which is the case of marine platforms for the development of hydrocarbon activities.

Sanctions are diverse and progressive, from a warning to the highest economic sanction, which is the one referring to spills and other severe damages against the environment, being established (through a modifying norm, Ministry Resolution 087-2001-EM/VME) that such sanction may vary between 1 - 10,000 UIT (Unit for General Tax, 1 UIT equals approximately US$1,000.00). Additionally, the activity causing the sanction could be forbidden, holding those responsible to compensate those affected and obliging them to restore the affected area immediately.

5.7.2 Environmental Aspects of Offshore Hydrocarbon Activity

Regarding environmental general aspects, Articles 34 and 87 of Law 26221 establish that exploitation and economic revenue from hydrocarbons must be carried out according to technical and economic principles, generally accepted and used by the hydrocarbons international industry, without underestimating the compliance of environment protection legislations. Whoever develops hydrocarbon activities must comply with all environment protection regulations.

Following the enforcement of Law 26221, the Ministry of Energy and Mining published in 1993 the Regulatory Frame for the Protection of the Environment in Hydrocarbon Activities, Supreme Decree 046-93-EM, in order to establish norms and national regulations for the development of activities concerning exploration, exploitation, transformation, transportation, commerce, storage and related to the use of hydrocarbon resources.

5.7.2.1 Environnmental Standards

With regard to this, in the case of hydrocarbon activities, the Regulation on Environmental Protection for Hydrocarbon Activities, approved through Supreme Decree

046-93-EM, and modified by Supreme Decree 09-95-EM, establishes in Article 11, that the Environment Management Plan, which is a constitutive part of the Environmental Impact Research, should include proposals on limitations to emissions to be enforced regarding those cases which do not include established standards.

The norms which established contamination parameters for fluids produced from hydrocarbon activities, Supreme Decree 030-96-EM-DGAA indicates in Article 7 that with regard to those not regulated in this norm, enforcement must be according to standing legislation (if any) or be technically demonstrated that its spill into a reception body will not cause negative effects on heath nor environment.

A subsequent norm, the National Regulation for the Approval of Environmental Quality Standards and Maximum Limitations Allowed, approved by Supreme Decree 044-98-PCM, has pointed out that the competent field could use for any specific case an international standard, CONAM and prior coordination with the involved fields. For such effect, CONAM must keep an updated registration of those standards which have been used in the country.

5.7.2.2 Quality of Water

The health authority is responsible to observe the preservation of water quality, assuring that strict compliance takes place according to the general regulations referring to dumping waste materials of any nature that could contaminate the waters. Such functions are carried out by DIGESA at the national level and by the Regional Health headquarters at the regional levels.

As well, it corresponds to the health authority to keep an official registration of all waste material dumping, both in marine or land waters of the country. All dumping into national territory waters must be previously supported by a sanitary authorization of residue water dumping, which will require in advance an adequate treatment system. All requests to dump residues must be previously considered and analyzed, include the corresponding eye inspections and verifications of the quality of the waste materials dumped, and followed by periodic inspections to confirm the compliance of all standing regulations.

DIGESA must approve those Projects to install industrial drainage treatment systems in land or marine waters of the country.

The quality standards of water bodies in general are conditioned to established parameters given the types of reception bodies. These standing parameters exist today and are the following:

REGULATION OF TITLES I, II, AND III FROM THE GENERAL WATER LAW
(S.D. 261-69-AP, MODIFIED BY S.D. 007-83-SA AND BY S.D. 003-2003-SA)

CHAPTER IV

CLASIFICATION OF WATER FLOWS AND THE COASTAL ZONES OF THE COUNTRY

Article 81. - Regarding the effects of the application of the current regulation, the quality of the bodies of water being land or marine in the country will be classified according to their uses as follows:

I. Domestic surplus waters with simple disinfection.

II. Domestic surplus waters with equivalent treatment to combined processes of mixture and coagulation, sedimentation, filtration and chlorination, approved by the Ministry of Health.

III. Waters to irrigate vegetables consumed raw and animal drinks.

IV. Waters for recreational zones of primary contact (bathrooms and related).

V. Waters in fishing areas of bivalve mollusks.

VI. Waters of preserved areas for water fauna, and recreational and commercial fishery.

Article 82. - For water protection purposes, given different uses, the following limit values shall be enforced:

I- Bacteriological Limits (*) (values in n.m.p./100 thousand)

Uses

Parameter	I	II	III	IV	V	VI
Total Coliforms	8.8	20,000	5,000	5,000	1,000	20,000
Fæcal Coliforms	0	4,000	1,000	1,000	200	4,000

(*) Taken as maximum value in 80% of 5 or more monthly samples.

II. - Limits to oxygen biochemical demand (obd)

5 days, 20° C and of dissolved oxygen (d.o.) values in mg/1

Uses

Parameter	I	II	III	IV	V	VI
O.B.D	5	5	15	10	10	10
D.O.	3	3	3	3	5	4

III. - Limits of potentially dangerous substances

Values en mg/m^3

Uses (2)

Parameter	I	II	III	V	VI
Selenium	10	10	50	5	10
Mercury	2	2	10	0.1	0.2
PCB	1	1	1+	2	2
Esteres Estalatos	0.3	0.3	0.3	0.3	0.3
Cadmium	10	10	50	0.2	4
Chrome	50	50	1,000	50	50
Nickel	2	2	1+	2	**
Copper	1,000	1,000	500	10	*
Lead	50	50	100	10	30
Zinc	5,000	5,000	25,000	20	**
Cyanide (Cn)	Cyanide WAD 80	Cyanide WAD 80	Cyanide WAD 100	Free Cyanide 22	Free Cyanide 22
Phenols	0.5	1	1+	1	100
Sulfurs	1	2	1+	2	2
Arsenics	100	100	200	10	50
Nitrates (N)	10	10	100	N.A.	N.A.

NOTES:

*	-	*96-hour tests LC50 multiplied by 0.1*
**	-	*96-hour tests LC50 multiplied by 002.*
LC50	-	*Lethal doses to provoke 50% dead or immobilized species of the BIO TEST.*
1+	-	*Values to be determined. In case one suspects the presence, values from column V will be applied provisionally.*
(2)	-	*for the use of waters, IV does not apply.*
NA	-	*Value not applicable.*

PESTICIDES. - For each specific use, it will be applied as a limit, the criteria of quality of waters established by the United States Environmental Protection Agency.

IV.-Limits to substances or potentially harmful parameters (values in mg/1) (Applicable in Uses I, II, III, IV, V)

Parameters		I & II	III	IV
E.H.M.	(1)	1.5	0.5	0.2
A.S.S.B.	(2)	0.5	1.0	0.5
C.A.E.	(3)	1.5	5.0	5.0
C.C.E.	(4)	0.3	1.0	1.0

(1) Extractible Hexane Material. (Mainly Fat).
(2) Active substances in Methylene Blue (Mainly detergents).
(3) Column Extract of active carbon through alcohol. (According to the slow flow method)
(4) Column Extract of active carbon through chloroform. (According to the slow flow method)

Regarding temperature, the Ministry of Health will determine in each case, the maximum temperatures for short exposition of a weekly average.

Following what was established by water regulations, literal (d) of Article 21 in the Legislation for Environmental Protection of Hydrocarbon Activities, it is forbidden to dump industrial and domestic waste material in the bodies of water. In order to comply with established parameters in water regulations, literal (c) of the quoted article indicates that other liquid and water residues produced in the development of hydrocarbon activities must be treated before the discharge into superficial waters.

The Legislation for Environmental Protection of Hydrocarbon Activities shows some of the methods to be used: desegregation by gravity, flotation, flocculation, biodegradation, sedimentation, and neutralization, and leaving it to the criteria of the designer to choose the most adequate among the methods available.

It is true that efforts have been made to establish contamination parameters among different fields; however, currently only the limits established by the relevant field authorities prevail. In what concerns hydrocarbon activities, one can rely on legislation that has established maximum allowable limits for effluents produced from the exploitation and commerce of liquid hydrocarbon activities and its derived products.

This norm establishes limits for specific parameters, and regarding those non- regulated, it states that all standing norms must be enforced in the country or, by request of OSINERG, it must be technically demonstrated that its discharge into a reception body will not cause negative effects on health, nor the environment. Such limits are the following:

Maximum allowed levels of emission of liquid effluents for hydrocarbon activities:

Parameter PH	Value at any given time More than 5.5 and less than 9	Average year value More than 5.5 and less than 9
Oils and fats (mg/l) for discharges in the Sea	50	30
Oils and fats (mg/l)) for discharges in continental waters	30	20
Barium (mg/l)	5.0	3.0
Lead (mg/l)	0.4	0.2

Regarding regulated parameters, the rule states that the levels established in the column "values at any given time" must never be exceeded in any given sample. The average annual concentrations should never exceed the levels established in the column "value at any given time".

On the other hand, this norm establishes that any discharge of effluents should never change the temperature of the reception body by more than 3°C, bearing in mind a ratio of 500 m given the focus point of emission.

Regarding chloride concentrations, a quality limit of the reception body has been determined in relation to the presence of chlorides, establishing that if the body presents a concentration higher than 250 mg/l, the effluent could increase such concentration by no more than 10 mg/l.

As a safety measure, the environmental regulation of the field indicates that perforation platforms placed in the sea or lakes must include a gathering/recollection system of residue waters, chemical products and fuels that may be spilled there.

The administrative sanctions for the violation of these water regulations are applied by the technical manager of the irrigation district, and can vary in severity between 0.2 and 1,000 UIT.

5.7.2.3 Air Quality

The national Standards of Environmental Quality for Air, approved by Supreme Decree 074-2001-PCM, include maximum levels of concentration for the following seven contaminants: Sulfur Dioxide (SO_2), particle material with a diameter less than or equal to 10 micrometers (PM-10), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ozone (O_3), Lead (Pb) and Hydrogen Sulfur (H_2S). As well, this norm establishes transit values for four of the seven mentioned contaminants (Sulfur Dioxide, PM-10, nitrogen Dioxide and Ozone). The cities or zones that exceed such values must establish specific action plans so that in a period no longer than five years, it is ensured that no limits will be exceeded.

Supreme decree 074-2001-PCM
National Standards of Environmental Quality of Air
(All the values are concentrations in micrograms per cubic meter;
(NE means Not Exceed)

CONTAMINANTS	PERIOD	STANDARD FORM VALUE	STANDARD FORM FORMAT	ANALYSIS METHOD
Sulfur Dioxide	Yearly	80	Year Arithmetic measure	Fluorescence UV (automatic method)
	24 hours	365	NE more than once per year	
PM-10	Yearly	50	Year Arithmetic measure	Inertial segregation/ filtration (Gravimetry)
	24 hours	150	NE more than thrice per year	
Carbon monoxide	8 hours	10000	Mobile average	Non dispersed infrared (NDIR) (Automatic method)
	1 hour	30000	NE more than once per year	
Nitrogen Dioxide	Yearly	100	Year Arithmetic measure	Chemiluminescence's (Automatic method)
	1 hour	200	NE more than 24 times per year	
Ozone	8 hours	120	NE more than 24 times per year	Photometry UV (Automatic method)
Lead	Yearly [1]			Method for PM10 (Spectrophotometry of atomic absorption)
	Monthly	1.5	NE more than 4 times per year	
Hydrogen Sulfur	24 hours [2]			Fluorescence UV (automatic method)

[1] Or equivalent approved method
[2] To be determined according to what was established in Article 5 of the current regulation.

Transit Values

CONTAMINANTS	PERIOD	Standard Form VALUE	Standard Form FORMAT	ANALYSIS METHOD
Sulfur dioxide	Yearly	100	Year Arithmetic measure	Fluorescence UV (automatic method)
PM-10	Yearly	80	Year Arithmetic measure	Inertial segregation / filtration (Gravimetric)
	24 hours	200	NE more than 3 times per year	
Nitrogen Dioxide	1 hour	250	NE more than 24 timer per year	Chemiluminescence's (Automatic method)
Ozone	8 hours	160	NE more than 24 times per year	Photometry UV (Automatic method)

Reference Values

Contaminants	Period	Standard Form Value	Analysis Method
PM-2.5	Yearly	15	Inertial segregation / filtration (Gravimetric)
	24 hours	65	

On the other hand, regarding atmospheric contamination, Article 43 of Supreme Decree 046-93-EM, indicates that companies should be held accountable with the following: a) The burning of crude oil, gas, oil waste products or any other material must be done under controlled and tolerable conditions, without any significant emission of smoke; and b) the maximum allowed concentration of contaminants in the air beyond the limits of industrial installations is established in Table 2 of the same Supreme Decree 046-93-EM.

TABLE 2 –SUPREME DECREE 046-93-EM.
MAXIMUM ACCEPTABLE CONCENTRATION OF CONTAMINANTS IN THE AIR

Parameter	Suggested limits
Conventional Contaminants	
Particles, average 24 h	120 ug/m^3
Carbon Monoxide, average 1h/8h	35 mg/m^3/15 mg/m^3
Acid Gases	
Sulfur Hydrate Acid (H_2S), average 1 h	30 ug/m^3
Sulfur Dioxide (SO_2), average 24 h	300 ug/m^3
Nitrogen Oxides (NO_x), average 24 h	200 ug/m^3
Organic Compounds	
Hydrocarbons, average 24 h	15000 ug/m^3

In order to standardize the gas composition and the contaminants, the emission targets are expressed in relation to the dry cubic meters of combustion at 25°C and 101.3 Kpa (atmospheric pressure) and 11% of oxygen in the out coming gas.

5.7.2.4 Applicable Regulations on Sea Contamination

Article 34 from Supreme Decree No. 046-93-EM establishes that to avoid sea contamination, all perforation platforms must have a recollection system for waste water, chemical products and spilled fuels. This regulation is complemented by the Offshore Guide of Fuel Operations (it is not mandatory, just proposed guidelines by the authorities), approved by directive resolution No. 011-2001-EM/DGAA.

Aside from the approved regulations by the Ministry of Energy and Mining, the General Direction of Captainships and Coastguards (DICAPI), the Peruvian Sea authority, has approved legal regulations referring to sea contamination supported by the International Agreement to prevent Contamination by Ships, as well as other national regulations enforced by law, which is listed below.

a. International Agreement to Prevent Contamination by Ships

The Peruvian State has subscribed the International Agreement to prevent Contamination by Ships, 1973 (MARPOL, 1973) by the International Conference on Sea Contamination called by Intergovernmental Consulting Marine Organization, -ICMO in London, the 2nd of November, 1973. The Agreement was approved for Peru through Law Decree 22703. The 1978 Protocol was also approved by Law Decree 22954.

It is important to point out that according to Article 2 (Definitions) from the International Agreement to Prevent Contamination by Ships; the platforms operating in marine environments are included under the concept of "Ship".

b. Agreement on Prevention of Sea Contamination by Dumping Waste Disposal and Other Related Materials

The Agreement on Prevention of Sea Contamination by Dumping Waste Disposal and Other Related Material according to the Multisector Technical Consulting Commission on issues on the International Marine Organization, was approved for Peru by Legislative Resolution 27873 in 2002, and ratified through Supreme Decree 003-2003-RE, January 17th, 2003.

c. Agreement for Protection of Marine Environment and the Coastal Zone of the South East Pacific

The Agreement for Protection of Marine Environment and the Coastal Zone of the South East Pacific was approved by the government of Peru through Legislative Resolution 24926 dated November 7th, 1988, and subscribed together with the governments of Chile, Colombia, Ecuador and Panama. This Agreement establishes that member countries should adopt measures to prevent, reduce and control contamination.

d. International Code for Ships Operational Security Management of the Prevention of Contamination, ICSM

The Directive Resolution 001-98-DGC published on the 13th of February, 1998 enforces the mandatory compliance of the International Code to Control Operational Security of the Ship and Prevent Contamination, which was approved through Resolution A.741 (18) of the International Marine Organization. The Code applies, among others, to cargo navels and to mobile open-sea units of perforation with a gross tonnage equal to or over 500.

e. Regulations by the Peruvian Marine Authority

Article A.010201 (3) from the set of rules on marine, river and lake activities assigns the Direction of Captainships and Coastguards (DICAPI) the role to demand compliance on behalf of international treaties and agreements ratified by the government, as well as the related legislation, for each jurisdiction in order to dictate complementary legislation which might be additionally required. DICAPI, given its condition as marine national authority, is the leading agency in order to implement the National Contingency Plan to control and fight against fuel spills and other contaminant substances in the marine environments, approved by Supreme Decree 003-86-MA dated February 5th, 1986 and modified through Supreme Decree 051-DE/MGP dated August 2nd, 1993.

Aside from the general arrangements established in Law 26620, Law of Control and Supervision of Marine, River and Lake Activities and its set of rules approved through Supreme Decree 028-DE-MGP, DICAPI has approved the following legislation referring to sea contamination, most of them supported by the International Agreement to prevent Contamination by Ships.

DICAPI through Directive Resolution 0238-95-DCG approved "Technical Regulations to Prevent and Control the Discharge of Waste Material, Oily Blends and Others in Marine Areas through either floating or fixed Platforms". According to this legislation, it is indicated among other obligations that all perforation platforms designed for the exploration, exploitation and recollection of oil hydrocarbons must include filtering/sedimentation tanks to recollect residues and oily blends, as well as waste storage recipients generated onboard. It also indicated that the residue and oily blends reception tank must be placed at the first level of the platform, and that the residues that are stored onboard must be handed over at the reception facilities placed inland for storage and further treatment.

DICAPI also approved Directive Resolution 0510-99/DCG, "Regulations to Prevent and Control Contamination through Waste material coming from Ships". According to these regulations, solid waste is defined as all sort of organic residues (except for fresh fish expressed in any or its portions) as well as residues resulting from domestic or routine work on the Ship (meaning oil platforms as well) under normal service conditions, which periodically take place. This regulation forbids the discharge of waste in the open sea, except in those cases specified by this regulation. This regulation also includes "the Elaboration Guidelines Plan for Waste Management".

Finally, DICAPI approved Directive Resolution 0069-98-DGC, "Regulations to Prevent and Control Contamination for Dirty Water as a result of Ships".

5.7.2.5 Sea Operations

The contracting oil company should implement regulations and procedures for sea operations, as well as the publishing of instruction booklets with the security procedures, according to what was established in Article 23 of the Regulation of Exploration and Exploitation of Hydrocarbon Activities, Supreme Decree 032-2004-EM.

Explosives are forbidden to be used in the sea, except for exceptional cases, for which an authorization by the General Direction of Energetic Environmental Issues (DGAAE) is mandatory, which may demand as well to include additional technical concepts on behalf of other related authorities. This has been established in Article 61 of the Regulation for Hydrocarbon Exploitation and Exploration Activities, Supreme Decree 032-2004-EM. Law 26620, Control and Surveillance of Marine, River and Lake Activities regulate what concerns control and surveillance under the marine authority regarding activities that take place in the marine, river and lake environments of Peru.

According to Law 26620 and its regulations approved by Supreme Decree 028-DE/MGP, all fixed or permanent constructions placed partly or totally in marine areas that cannot be removed nor be destroyed or modified, including under this concept, piers, wharfs, shipyards, breakwaters, wave breakers, jetties/cliffs, embankments, dry docks, fixed platforms, submarine tubes and similar, must be supported by a right of use in marine zones. As well, it is under the jurisdiction of the General Direction of Marine Transportation to authorize the construction, modification, and operation of marine infrastructure (such as piers) as well as any other type of work related to gaining more terrain in marine areas, areas whose use must have been previously authorized, bearing in mind aspects of safety and marine environmental protection.

It is the General Direction of Captainships and Coastguards, given its jurisdiction and in coordination with the competent fields, who is in charge of surveillance and enforcement of the related legislation to protect and preserve the marine environment and that of the shore strip according to the standing legislation, as well as the international agreements ratified by the Peruvian State (F-010102, Regulation of the Law of Control and Surveillance for Marine, River and Lake Activities, Supreme Decree 028-DE/MGP). This is how DICAPI may restrict or forbid the transit or permanence of navels and the development of certain activities in areas which demand protection from risk of contamination, according to related regulations approved by other fields (F-010108, Regulation of the Law on Control and Surveillance of Marine, River and Lake Activities, Supreme Decree 028-DE/MGP).

5.7.2.6 Maritime Platforms

Specific regulations and safety requirements of marine platforms have been included in articles 162, 163 and 164 of the Regulation of Exploration and Exploitation of Hydrocarbon Activities, Supreme Decree 032-2004-EM. This norm indicates in case of absence of a national law to apply, the norms API-RP-57 and API-RP-14G will apply accordingly.

5.7.2.7 Marine Fauna

According to Articles 58 and 59 of the Regulation for Hydrocarbons Exploration and Exploitation Activities, Supreme Decree 032-2004-EM, it is mandatory for contracting companies to minimize all disturbances, real or potential, to marine life and avoid

operating in nesting zones for marine birds, including those areas for marine mammals' reproduction,

Additionally, Supreme Decree 046-93-EM forbids all illegal fishing activities and collection of wild fauna species.

Supreme Decree 034-2004-AG approved a categorization for threatened species in the wild life for the Peruvian case, which includes some marine species declared in danger of extinction.

Peru subscribed the Biodiversity Agreement, approving it through Legislative Resolution 26181. The standing Constitution includes a special article on biological diversity in Article 68, which indicates that the State has the obligation to promote its conservation and protected natural areas. Following this guideline, Article IX in the Preliminary Title of the Code for the Environment and Natural Resources establishes that no consideration or circumstance whatsoever can legitimize or excuse any actions that could imply the extinction of any species or subspecies, vegetable or animal.

Following the contents of the United Nations Agreement on Biological Diversity, the Peruvian State approved the National Strategy for Biological Diversity in Peru, Supreme Decree N° 102-2001-PCM, and proclaimed the Law on Conservation and Sustainable Use of Biological Diversity, Law 26839. According to Article 4, the State is sovereign to adopt measures for the conservation and sustainable use of biological diversity, conserve ecosystems and species diversity, as well as ensuring the environmental process on which the survival of such species depend. It also indicates in literal (d) of Article 3 that the conservation and sustainable use of biological diversity implies to promote the country's economic development through the sustainable use of the biological diversity components and promote a fair share of the benefits, which derive from this use.

The regulation of the Law on Conservation and Sustainable Use of Biological Diversity was approved through Supreme Decree 068-2001-PCM.

5.7.2.8 Protected Natural Areas

According to the Law on Protected Natural Areas, Law 26834 and its regulations, Supreme Decree 038-2001-AG, the Protected Natural Areas (PNA) are the continental and/or marine areas in the national territory, clearly recognized and declared as such, including their categories and zoning to conserve biological diversity and other values associated to the cultural, landscape and scientific interests, as well as for its contribution to the sustainable development of the country. This contributes to the patrimony of the Nation, and its natural condition must be ensured perpetually.

The PNA integrated the National System of Protected Natural Areas by the State (SINANPE), whose management consists of public institutions from the Central Government, federal governments and town halls, private institutions and local populations who act, intervene and participate, direct or indirectly in the management and development of such areas.

The good use of natural resources (including hydrocarbons) in PNAs can only be authorized if such are compatible with the category, the zoning and the master plan of the area. The good use of resources shall never harm the compliance of the purposes for which such areas were established. The approval of the Environmental Impact Paper (EIP) for hydrocarbon Projects within PNA depend on the characterization for each area and the purpose for which such were created. That is why DGAAE depends on a

favorable technical concept from the National Institute of National Resources (INRENA) in order to be able to approve such Projects.

The PNA are divided in two groups, those of indirect use and those of direct use. The PNA of indirect use are those that allow non-manipulative scientific research, recreation and tourism in zones appropriately designed and run for these purposes. It is forbidden in these areas to extract natural resources or modify or transform the natural environment. The areas of indirect use are National Parks, National Sanctuaries and Historic Sanctuaries. The PNA of direct use are those that allow use and extraction of resources, mainly for the local populations from those zones and places, and for those resources defined in the management plan of the particular areas. Any other use or activity developed must be compatible with the objective established for that area. The areas of direct use are National Reservations, Landscape Reservations, Wild Life Shelters, Commune Reservations, Protection Forests, Hunting Landmarks, and Regional Conservation Areas.

Currently, the only PNA that exists in the marine scope is the National Reservation of Paracas, declared as such through Supreme Decree 1281-75-AG, on the 25th of September 1975, including within its landmark a coastal zone and 217,594 hectares of marine waters and islands.

5.7.2.9 Use of navels and airplanes

The use of navels and airplanes for hydrocarbons exploitation and exploration is regulated by DICAPI) or the General Direction of Civil Aviation (DGAC), given whether it concerns navels or planes, according to the Regulation for Hydrocarbon Exploration and Exploitation Activities, Supreme Decree No. 032-2004-EM.

5.7.2.10 Dangerous Materials Management

a. Chemical Substances

According to Article 30 of the Regulation for Hydrocarbon Exploration and Exploitation Activities, Supreme Decree 032-2004-EM, regarding the management of chemical substances, including acid for batteries, it is required to include an emergency station to attend any possible incident. On the other hand, Article 75 in the same regulation indicates that the use, management and disposition of chemical substances must be done according to the guidelines of Safe Management of Chemical Substances (SHOC).

b. Radioactive Material

Article 20 in Supreme Decree 046-93-EM establishes that the use of radioactive material in hydrocarbon activities must be authorized by the Nuclear Energy Institute of Peru (PNEI), and the rules and guideline indicated by this institution must be followed.

All companies that carry out practices, which expose with ionizing radiations or any other source of radiation, must have the corresponding authorization from PNEI, before beginning operations. The granting of such authorization for radioactive material used is ruled by Law 28028, the Regulations Law on the use of Ionizing Radiation Sources, through Supreme Decree 009-97-EM, Regulation on Radiology Safety, as well as through a recent regulation on Authorizations, Prosecution, Control, Warnings and Sanctions in Law 28028, approved by Supreme Decree 041-2003-EM. The purpose of these norms is to establish fundamental requirements to protect against ionizing radiation and for the safety of radioactive sources that may cause such exposition.

According to these norms, every person who proposes to carry out operations with radioactive material must apply for the relevant authorizations by the PNEI.

c. Explosives

The use of dynamite and other explosives in the sea is only allowed for technical purposes and must be justified and approved within the EIP, following what is indicated in Article 27 of Supreme Decree 046-93-EM. As well, the contracting company must convey with all specific legal norms, approved in Law Decree 25707, which declare in emergency, the civilian use of explosives and related material, as it is stated in the regulation approved in the Supreme Decree 086-92-PCM.

d. Fuel Storage

Environmental management of fuel storage is considered in Articles 72, 73, and 74 of the Regulation for Hydrocarbon Exploration and Exploitation Activities, Supreme Decree 032-2004-EM.

Additionally, Article 116 in Supreme Decree 052-93-EM, Safety Regulation for Hydrocarbon Storage, establishes that installations for hydrocarbons storage with marine terminals must include water and ballast reception and treatment systems accordingly to what was stated in the Agreement MARPOL 73/78.

5.7.2.11 Residue Management in General

Article 104 of the General Health Law, Law 26842, establishes that it is forbidden to discharge contaminative waste or other substances into the water, without having taken previous purification precautions, as it is enforced by the sanitary regulations and those of environmental protection.

Article 21 in Supreme Decree 046-93-EM, establishes the following general guidelines for residue management: a) Organic waste must be processed using sanitary landfills, incinerators, biodegradation or other environmentally accepted methods, b) inorganic solid waste must be recycled or transported and buried in a sanitary landfill, c) liquid waste and residue waters must be treated before the discharge to be held accountable according with quality limits in the general Law of Waters; and, d) it is forbidden to discharge industrial or domestic waste material in the sea.

Article 35 in Supreme Decree 046-93-EM also establishes measures about waste management that must be enforced in the perforation platforms placed in the sea. Among other measures, water-based perforation fluids and particles contained therein, excepting fluids mixed with toxic chemical additives or hydrocarbons in any form or concentration, can be discharged without treatment at a depth of 3 meters or below in the sea or lake. The served waters in the platforms must be recollected and treated before being discharged in the sea. On the other hand, inorganic waste material, industrial waste, domestic and non-combustibles must be taken towards the continent for its adequate treatment in firm soil. Organic waste materials must be processed using incinerators, biodegradation or other environmentally accepted methods before being discharged in the sea; otherwise, they must be transferred to firm land and their disposal followed to a sanitary landfill.

Aside from the specific norms for the hydrocarbons field applicable to solid residue management, it must be taken in consideration the general frame established in the Law for Solid Residues, Law 27314, and its regulation approved by Supreme Decree 057-2004-PCM.

Article 6 in Law 27314 establishes that actions and management of industrial origin solid residues that take place within productive areas, or industrial installations, or especially used for the development of such activities, are regulated, prosecuted and sanctioned by the corresponding regulation and prosecution ministries or public institutions.

In this regard, it is pointed out that the generator, the service company, the operator or any other person who intervenes in the handling of these residues will be responsible for their safe management, safely and environmentally adequate, according to what is stated in Law 27314, as well as the corresponding regulations and technical norms.

Sanctions regarding infringements committed within the related productive areas, Article 49 of Law 27314 states that those with jurisdiction to apply sanctions are the authorities in the productive and services fields, as well as the regulatory and prosecution institutions, leaving it clear that no person can be punished by more than one authority for the same cause.

5.7.2.12 Perforation Residues Management in Platforms

Article 33 in Supreme Decree 046-93-EM establishes that in case that perforation residues may result in contamination, the perforation platforms placed in the sea must have an adequate storage capacity for such residues for its further treatment before discharge into the sea, or transferred to firm soil for its disposal and destruction with methods that warranty full accomplishment of quality limits.

Although it is not a mandatory norm, the Offshore Oil Operations Guide, approved by Directive Resolution 011-2001-EM/DGAA, in 2001, carries guidelines referring to residue management in platforms.

As well, the "Norms to Prevent and Control Contamination by Wastes proceeding from Ships" apply; they were approved by Directive Resolution 0510-99/DCG. According to these regulations, solid waste is defined as all sorts of organic residues (except for fresh fish expressed in any of its portions) as well as residues resulting from domestic or routine work on the Ship (meaning oil platforms as well) under normal service conditions, which periodically take place. This regulation forbids the discharge of waste in the open sea, except in those cases specified by this regulation. This regulation also includes "the Elaboration Guidelines Plan for Waste Management".

5.7.2.13 Solid Residues Management

Residues management, according to Article 78 in the Regulation of Hydrocarbon Exploration and Exploitation Activities, Supreme Decree 032-2004-EM, should be monitored and properly registered according to what was established in the Environmental Management Plan.

The General Solid Residues Law, Law 27314 establishes among others, the following guidelines:

- Adopt measures to minimize residues by reducing their maximum generated volume and more dangerous characteristics, and by using technologies, methods, practices, production and commerce procedures which favor the minimization and the re-use of solid residues. Such guidelines are found in numerals 2 and 5 of Article 4 in Law 27314.

- Promote selective management of solid residues and allow for a joint management when there are no significant sanitary or environmental risks, found in numeral 7 of article 4 of Law 27314.

- Establish a joint responsibility system and an exhaustive solid residue management from its generation to its final disposal, shown in numeral 3 of Article 4 in Law 27314.

- Harmonize land use planning policies and those of solid residue handling in order to ensure an adequate management, as well as identifying the appropriate areas for placing the related infrastructure for treatment, transference and final disposal of residues. This policy guideline is found under numeral 11 of Article 4 in Law 27314.

In order to establish a broad system of solid residues management, Article 21 in Law 27314 forces authorities, including those of specific fields, to promote the adoption of solid residues management systems and expand management guides to better respond to the technical characteristics of each type of residue, the local area that generates it, public health, environmental safety and technical economic viability.

In case of hydrocarbon activities, the prosecution jurisdiction is under OSINERG, as we will see following. It is important to point out that a holistic management of solid residues should be audited according to the norms established in article 34 of Law N° 27314. The generators, operators and service officers of solid residues should allow easy entry to their installations and access to related technical and administrative documents to authorized auditors.

5.7.2.14 Dangerous Solid Residues Management

Article 22 of Law 27314 defines dangerous solid residues definition for Peruvian legislation as follows: those solid residues which by their characteristics or manipulation are or may become of significant risk for public health or the environment. As well, it adds in paragraph 22.2 that without counteracting to international regulations standing for the country or specific national regulations, solid residues are considered dangerous when they present at least one of the following characteristics: auto combustion ability, explosive ability, corrosion, reactivity, toxicity, radioactivity or pathogenicity. Finally, the regulation of the General Law on Solid Residues indicates in its Annex 4 a list of residues considered dangerous according to the Agreement of Basilea. The list was approved though Legislative Resolution 26234 without limiting its quantity.

Regarding manipulation of dangerous solid residues, the norm states that the responsibility is objective and it is regulated according to what is established in Article 1970 of the Civil Code and legislative Decree 295.

The joint responsibility system mentioned previously indicates that with respect to dangerous residues, if it is decided to employ a service company to run the procedure for solid residues management, the responsibility of the generator ends when it is gathered, being then the service company held responsible for any consequence derived from the manipulation of such residues. However, Article 23.3 in Law 27314 establishes the generator will be held responsible if it is demonstrated that his negligence or deceit contributed to produce any damage. This responsibility prevails during the operation management of the entire process of dangerous solid residues, up to a term of no longer than 20 years, counting from the final disposal onwards.

It is important to point out that Article 25 of the General Law on Solid Residues establishes that competent field authorities may determine whether the service companies should call for an insurance policy to cover the related management

operations. Such option has not yet been implemented, even though Article 145 from the regulations of the General Law on Solid Residues warns as a severe fault.

While Peruvian Law 28256 regulates land transportation, specific regulations have not yet been developed for the transportation of dangerous materials and residues. This law determines that the Ministry of Transportation and Communication (MTC), enforces, among other laws, as mandatory: (i) keep a "registration of all units of transportation of dangerous residues" and a "national registration of drivers with special driving license for the transportation of dangerous material/residues". Currently, such registration does not exist. (ii) Authorize and check the transportation of dangerous residues in industrial activities of the transportation service companies registered. For the case of registration procedures, currently there is still no procedure designed to obtain such authorization from the MTC. As well, the Law indicates two special obligations for those entitled to develop activities which produce dangerous residues: (i) hiring only transportation companies registered and authorized by the MTC (Article 8). This obligation should be understood as "on hold" until the company initiates their operations registration with the MTC. (ii) Request, and if necessary, demand, from the companies to be hired to transport dangerous residues/materials a contingency plan that must be approved by the related field (Article 9), understanding that "related field" means the authority who regulates and controls that specific economic activity.

5.7.2.15 Use of Marine Areas

Law 26620, Law of Control and Surveillance of Marine, River and Lake Activities, regulates these related activities which are under the jurisdiction of the marine authority in Peruvian territory.

According to Law 26620 and its regulations, approved by Supreme Decree 028-DE/MGP, all fixed or permanent constructions placed fully or partly in marine areas, that can not be removed without being destroyed or modified, including under this concept, piers, wharfs, shipyards, breakwaters, wave breakers, jetties/cliffs, embankments, dry docks, fixed platforms, submarine tubes and similar, must have the right of use for the related marine area. As well, it corresponds to the General Direction of Marine Transportations to authorize the construction, modification and operation of marine installations such as piers, as well as any work oriented towards gaining more terrain in marine areas, areas whose right of use must have been previously given, bearing in mind issues of safety and environmental protection.

It is the General Direction of Captainships and Coastguards, given its jurisdiction and in coordination with the competent fields, the one in charge of surveillance and enforcement of the related legislation to protect and preserve the marine environment and that of the shore strip according to the standing legislation, as well as the international agreements ratified by the Peruvian State (F-010102, Regulation of the Law of Control and Surveillance for Marine, River and Lake Activities, Supreme Decree 028-DE/MGP). This is how DICAPI may restrict or forbid the transit or permanence of navels and the development of certain activities, in areas which demand protection from risk of contamination, according with related regulations approved by other fields (F-010108, Regulation of the Law on Control and Surveillance of Marine, River and Lake Activities, Supreme Decree 028-DE/MGP).

5.7.3 Formal Obligations

5.7.3.1 Environmental Impact Study

According to Article 10, Regulation for Environmental Protection of Hydrocarbon Activities, Supreme Decree 046-93-EM, before the beginning of any hydrocarbon activity, or their extension, the responsible party for the Project is obliged to present an Environmental Impact Paper (EIP) or a preliminary environmental impact paper (PEIP). The main objective of these environmental studies is to reduce to its minimum unnecessary environmental degradation. An environmental study seeks to depict any adverse environmental impact during the planning stage of the Project in order for such type of impacts to be solved or avoided. The EIP and PEIP have similar objectives and elements; however, they are different in the degree of information detail that each contains.

The PEIP, according to what is stated in the related title of definitions in the Regulation for Environmental Protection of Hydrocarbon Activities, are studies developed with available bibliographic information and replaces the paper EIP in those cases where the activities do not involve intensive or extensive use of the terrain, such as aero photography, aero magnetometry surface geology, or low impact activities developed in non fragile ecosystems. They are applicable to relatively small Projects, which imply little interaction with sensitive natural environments or with resident human groups and where the related mitigating measures are well understood and rapidly applied.

Whereas, an EIP must be carried out when the magnitude and nature of the Project is of such importance that, quite probably, there will be a significant impact, or when there is no clear certitude on the magnitude and severeness of the possible impacts.

It must be considered that once the regulation of the Law on the National System of the Environmental Impact Evaluation, Law 27446, is approved, the Energy and Mining field should adapt an environmental evaluation process to the general process established in the related law.

a. The National System for Environmental Impact Evaluation

Law 27446, from the 23rd of April 2001, created the National System for Environmental Impact Evaluation (EIES) as the general legal frame applicable to the evaluation of Environmental Impact. This norm stands today; however, this same Law indicated that specific field norms will continue to apply as long as they do not contradict this new norm.

Law 27446 created a mandatory environmental certification that each ministry gives to the new investment Projects which have gained the corresponding approval. Law 27446 has not yet been regulated; once it is, no investment Project can begin operating without previously being granted an environmental certification. The norm clearly indicates that once the related regulation is enacted the investment Projects that could cause any negative environmental impact can not begin execution; no authority can approve, authorize, allow, concede or habilitate them, if previously, an environmental certification was not granted by resolution of the corresponding authority.

To obtain this certification, the categorization established in this norm must consider the Project's environmental impact. This is how the following categories have been established:

- Category I. For those Projects whose execution does not cause negative environmental impacts of significant relevance. In this case, an environmental impact declaration is required.

- Category II. Includes the Projects whose execution could originate moderate environmental impacts and whose environmental effects can be eliminated or minimized through the adoption of easily applicable measures. They require a semi-detailed EIP.

- Category III. Includes Projects, whose characteristics, importance and/or placement can produce significant negative environmental impact either quantitative or qualitative, requiring a deep analysis to review the impacts and propose the corresponding environmental management strategy. In this case, it requires a detailed EIP.

To determine the placement of a Project under a specific category, it is mandatory to apply the protection criteria indicated in the norm which refers, among others, to the people's health, the integrity and quality of the ecosystems involved and the natural and cultural resources.

The norm establishes that the contents of an EIP should include a description of the action proposed, the background of its area of influence, the identification and characterization of impacts during the Project, the environmental management strategy (including according to each case, the environmental management plan, the contingencies plan and withdrawal plan) as well as the citizens participation plan and the follow-up, surveillance and control plans. An executive summary must be attached for an easier comprehension. The authorized agencies to develop EIP's should be registered before competent authorities, the payment for these services remaining an obligation of the Project holder.

b. Activities Subject to Environmental Impact Evaluation

The specific field regulation states that all hydrocarbon activities are subject to environmental evaluation procedures. Also subject to these procedures, are the extensions of any of these activities. In other regulations, it has been established that this rule is applicable to extensions of more than 50% of the production but, in this case, the rule applies in a broader sense.

If a Project is executed by stages, there can be an EIP per stage. The same baseline paper could be used (whose contents show in the following heading) only if the original geographic limits are not trespassed.

c. Contents of an EIP

The Environmental Impact Paper for Hydrocarbon Activities must include:

- A baseline study that describes the natural resources of the area, the geographic aspects, and the social, economic and cultural aspects of the populations found in the area of influence of the Project. It serves to determine the environmental situation and the degree of contamination of the area in which the Project will take place.

- A detailed description of the Project proposed.

- A description and technical evaluation of the foreseeable effects, direct and indirect, on the physical and social environments, short and long term, regarding each one of the hydrocarbon activities.

- An Environmental Management Plan to reduce to an acceptable level the identified negative effects.

- A Withdrawal Plan of the area must be considered from the planning stage. The withdrawal guidelines should begin implementation as the Project begins execution. In order for a withdrawal to take place, an approval of the withdrawal plan is required, following described procedures.

The EIP should also include a Social Impact Study (SIS). The SIS is not a different document from the EIP but part of 3 chapters of the EIP: those concerning the environment description, the foreseeable impacts and the control and mitigation of the Project impacts. Therefore, the EIP has 3 components:

- Socioeconomic Baseline

- Foresight and Evaluation of Impacts

- Mitigation and Monitoring measures. These social management measures summarizes the Community Relations Plan, which seek to regulate the relations among populations and companies, and help to solve social problems faced by the field with settled communities in their areas of influence.

The respective Guide recommends a Consultation Plan to be developed to establish guidelines and mechanisms for adequate communication with the local population. This Plan consists of a series of activities that allows different interest groups to receive updated information of the Project and express their concerns and opinions. Its objective is to optimize the required information for decision-making purposes, to propel positive socioeconomic impacts and mitigate the negative.

d. EIP Approval Procedure

Supreme Decree 053-99-EM established proceedings oriented towards homologizing and unifying administrative procedures before the General Direction of Environmental Issues. It indicates that if observations were not communicated to the Project holder within the following period of time, approval will be granted:

- PEIP: in the term of 45 calendar days.

- EIP: in the term of 90 calendar days.

It is important to point out that these are maximum terms; the General Direction for Enviormental Issues (DGAA) could finish the evaluation within a shorter term, although the terms established for citizen participation must be observed. Hence, this term should include the consultation for the approval procedure of the environmental papers presented to MEM, through public audience, according to the standing regulation for citizen participation.

The EIP requires at least 45 days for citizen participation. Within 10 calendar days from document submission to MEM, a meeting date will be scheduled for public audience. The meeting information will be published in the Official Newspaper "el Peruano" and a local paper at least 20 days prior to the meeting. This means that, at most, the audience

will take place within the coming month. The norm establishes that within 15 calendar days from the date of the audience, any interested citizen may consult the EIP and bring about documents with their opinions and suggestions.

In the case of PEIPs and EIPs that are not subject to public audience (which are detailed later) ads must be published within 10 calendar days following the submission of the paper to MEM. Interested people could then present their comments during 25 calendar days once the ad is published. Citizen participation in EIPs that is not subject to public audience would be of 35 days.

Aside from the terms for the preliminary evaluation by DGAAE (before General Direction for Environmental Issues, DGAA) Supreme Decree 053-99-EM established that if there were observations to some of the papers such authority should notify the Project holder of the activity so that within a term of no longer than 90 days, he or she could solve the observed issues. Once the observations are solved, DGAAE has a term of 30 days to deliver; if not, the papers will be approved. This is how the maximum term that could require the approval of an EIP could be no longer than 210 days.

In January 2002, MEM issue a norm to address the conflicts regarding the fulfillment of the evaluation terms of environmental papers and the terms to which oil contracts are obliged, specifying that administrative terms for environmental evaluations are not considered as contract terms within the terms stated in the Organic Law of Hydrocarbons. Therefore, both terms should be added in order to prevent any restriction that may inhibit contract obligations from being fulfilled on behalf of the Project holder.

e. Previous Opinions from Other Environmental Authorities

If it is true that different fields can see from their specific scope of jurisdiction that many environmental issues from the energy and mining fields overlap with theirs. Specific norms are available to enforce consultation on behalf of any other field authority from the National Institute of Natural Resources (INRENA).

Additionally, Supreme Decree 056-97-PCM, modified through Supreme Decree 061-97-PCM, established in November, 1997, that a technical opinion from INRENA should be required piror to EIP approval by a competent authority, given that different fields were authorizing productive activities which could modify the natural state of natural resources under their specific scope of work (water, soils, flora, and fauna). This could be accomplished by such competent field authority presenting a copy of the EIP to INRENA within the required term of 20 days to deliver. If INRENA does not respond within this term, it is understood that there were no observations to the environmental paper presented.

We must point out that the TUPA of the Ministry of Energy and Mining (MEM) approved Supreme Decree 025-2002-EM which includes, as one of the most important requirements for the approval of an EIP, the requirement to present a certification that verifies a copy of the EIP was taken to INRENA. This is a way to reduce dilatation of the terms and allow INERENA the opportunity to provide their authoritive opinion about how to best regulate that specific activity.

On the other hand, it should be pointed out that if the Project develops within Protected Natural Areas, it has been established such opinion must be necessarily favorable in order for the Project to be approved by the competent authority. The objective is, in this case, to ensure that the use of the resource does not prevent the purposes for which such areas were created from being fulfilled.

f. Citizen Participation

The Citizens Consultation and Participation Regulation, approved by Ministry Resolution 596-2002-EM-DM, regulates citizen participation within the approval of EIPs of hydrocarbon Projects. This legal frame establishes that it is mandatory to submit to public knowledge all EIPs presented to DGAAE. Participation is verified through previous workshops, the publishing of the papers and through public audiences. It indicates, that if is possible, the audiences should take place in the nearby towns close to the area of the Project.

Ministry Resolution 596-2002-EM-DM establishes that prior to the public audience, 2 digital and printed copies of the EIP, plus an executive summary, must be presented to the DGAAE, to the corresponding Regional Office of Energy and Mines (DREM) and to the District Municipality of the place where the public audience will be held. The executive summary should allow the interested to get a clear idea of: the Project, place and area, infrastructure, terms of execution, manpower requirements, type of resource to be exploited and in what quantity, characteristics of the zone, possible direct or indirect impactsm and the legal frame that supports the EIP.

Within 30 calendar days following the public audience, the interested public may consult the EIP and bring comments to the DGAAE or the DREM where the Project will be implemented.

5.7.3.2 Contingency Plan

Article 23 from Supreme Decree 046-93-EM establishes that the one responsible for hydrocarbon activities should present before OSINERG a Contingency Plan for Oil Spilling and Emergencies, which should be updated at least once a year.

The same Supreme Decree 046-93-EM defines Contingency Plan as the plan made to prevent oil spilling, and other emergencies, such as fires and natural disasters. It indicates that it must include, among other information, the following: (i) notification procedures to be followed when incidents are reported; (ii) personnel training procedures in emergency and immediate response techniques; (iii) general description of the area of operations; (iv) list of the grantees considered part of the immediate response organization, including medical, services support and logistics.

5.7.3.3 Environmental Management Plan (EMP)

According to the environmental norms applicable to hydrocarbon activities, the EMP should be included in the EIP presented to DGAAE for its approval prior to initiating operations. Supreme Decree 046-93-EM clearly indicates that the EIP must include a detailed EMP whose execution avoids trespassing maximum tolerable levels and reduces to an acceptable level the foreseeable negative effects indicated in the previous paragraph.

For those which have not been given fixed standards by the authority, Article 11 of Supreme Decree 046-93-EM, indicates that the EMP should include proposals on the methods and measures to be used and the emission limits to be enforced in order to eliminate or minimize waste disposal, and minimize their contaminant effects. To allow for a quick recovery of the affected area, the EMP should determine the best practices applicable to each case.

Articles 49 and 50 of the Regulation of the Exploration and Exploitation Hydrocarbon Activities, Supreme Decree 032-2004-EM, establishes that the EMP should include prevention and control measures over environmental impacts and internal audit activities.

5.7.3.4 Withdrawal Plan

When the exploration or exploitation activities end in the hired area, measures contained in the withdrawal plan should be implemented in accordance with Article 68 in the Regulation of the Exploration and Exploitation Hydrocarbon Activities, Supreme Decree 032-2004-EM.

Article 56 of the Regulation for Environmental Protection in Hydrocarbon Activities, approved by Supreme Decree 046-93-EM, establishes that once adopted, within a term of 45 calendar days from the public decision to end their hydrocarbon activities, a withdrawal plan from the area must be presented that should be consistent with the withdrawal guidelines contained in the EIP. This plan should keep in mind the future use that will be given to the area, the current geographical conditions and the original ecosystem conditions, and propose the necessary actions to comply with an environmentally responsible withdrawal, including a timetable for its execution. Aside from what has been mentioned above, the Regulation of the Exploration and Exploitation Hydrocarbon Activities establishes specific norms for withdrawal from the installations and the areas which were part of these activities.

5.7.3.5 Emergency Stations for Chemical Substances Management

Article 30 in the Regulation of the Exploration and Exploitation Hydrocarbon Activities, Supreme Decree 032-2004-EM, addresses chemical substances management (including acid for batteries) and requires at least one emergency station to attend any incident.

5.7.3.6 Emergency Plan for Tank Ships

Directive Resolution 0160-96/DCG establishes that all Peruvian flag tank ships of 150 tons of gross capacity (TGC) or more and all Peruvian ships 400 TGC or more should carry an "Onboard Emergency Plan for Hydrocarbon Contamination" approved by the General Direction of Captainships and Coastguards who acts as the National Marine Authority. It further establishes that foreign tank ships of 150 TGC or more and all foreign flag ships of other types, 400 TGC or more, should also have the referred Emergency Plan (approved by competent authority in the flag's country) as a requirement in order to be admitted into Peruvian waters, with the exception of emergency cases. The guidelines to comply with Directive Resolution 0160-96/DCG have been published in the official newspaper, El Peruano, July 19, 1996.

This obligation originates from Rule 26, Annex 1 of Agreement MARPOL 73/78, which became valid the 4th of April, 1995.

5.7.3.7 Inventory and Registration of Use of Combustibles and Contaminants

According to Article 73 of the Regulation of the Exploration and Exploitation Hydrocarbon Activities, Supreme Decree 032-2004-EM, the contracting companies should keep an inventory of the volumes of combustibles and possible contaminants stored. A registration of use and storage must be kept of all combustibles, lubricants and chemical substances; contaminant combustible must be registered.

5.7.3.8 Obligations to Be Reported

a. Monitoring of Emissions and Effluents

The entitled of hydrocarbon activities are obliged to carry a systemic sampling system of emissions and effluents, using technologies and methods adequate to the environment of the area. According to the definition included in the Regulation of the Environmental Protection for Hydrocarbon Activities, Supreme Decree 046-93-EM, the monitoring program is a systematic sampling, with methods and technologies adequate to the environment where the sampling is taking place, based on protocols published by MEM, to evaluate the environmental quality and that of the effluents and emissions discharged in that environment. As well, the monitoring protocol has been defined by Supreme Decree 046-93-EM as the document where specific procedures are established for mandatory implementation in order to obtain similar results among the different hydrocarbon companies.

The monitoring protocols of air quality and emissions for the Hydrocarbon and Water Quality Fields have been approved by Directive Resolution 026-94-EM/DGAA and Directive Resolution 043-99-EM-DGAA.

Those responsible for hydrocarbon activities must establish in the EIP a control measure for each liquid effluent to determine the daily concentration of each one of the regulated parameters and the volume of discharge in cubic meters. It is mandatory to set record analysis results according to the monitoring. The sampling should be monthly and results reported every three months in March, June, September and December, These monitoring reports can be handed in the last working day of the month following the executed trimester.

b. Yearly Environmental Report

According to Article 9 of the Regulation for Environmental Protection of Hydrocarbon Activities, Supreme Decree 046-93-EM, those responsible for hydrocarbon Projects should present, before the 31st of March of each year, a report subscribed by an environmental auditor who certifies fulfillment of the standing environmental regulations, as well as the recommendations included in the EIP's. This same report should include a consolidated report of the emissions and effluents monitoring in the installations.

c. Withdrawal

Article 69 of the Regulation of the Exploration and Exploitation Hydrocarbon Activities, Supreme Decree 032-2004-EM requires the withdrawal from any exploration or exploitation hydrocarbon activity be reported to PERUPETRO SA and OSINERG 30 days before the term of execution.

d. Dmage to Animal Species

According to Article 63 of the Regulation of the Exploration and Exploitation Hydrocarbon Activities, Supreme Decree 032-2004-EM, the evidence of death, or significant damage to animal species, should be reported immediately to DGAAE and OSINERG.

e. Combustible Leakage or Contamination

Any conmbustible leakage or contamination to the soil or water should be reported to OSINERG and to the Ministry of Energy and Mining, calling for immediate cleaning to

prevent any contamination threat, according with Article 72 of the Regulation of the Exploration and Exploitation Hydrocarbon Activities, Supreme Decree 032-2004-EM.

f. Environmental Accidents

According to Articles 80 and 81 of the Regulation of the Exploration and Exploitation Hydrocarbon Activities, Supreme Decree 032-2004-EM, every environmental accident must be reported to OSINERG and to the Ministry of Energy and Mining within 24 hours of occurance. Following this, a broader report should be presented within the next 72 hours. A more detailed report explaining the envioronmental damage and the measures taken to mitigate it must be given to both agencies within the next 15 calendar days.

In general, environmental accidents are considered to be: spilling and/or hydrocarbon leakages, inappropriate waste disposals, fauna loss, and other incidents that affect the environment.

g. Year Declaration of Solid Residues Management

A Solid Residues Management Declaration detailing the volume of generation, the characteristics of the management given and the solid residues management plan to be executed in the following period should be sent annually by the generators of solid residues to the authority of their field. In case of hydrocarbon activites, the Declaration is sent to the Ministry of Energy and Mining. This obligation was established in Article 37.1 of Law 27314 and the format has been approved through the Annex of Supreme Decree 057-2004-PCM.

h. Dangerous Solid Residues Management Manifest

With respect to dangerous residues, both the generator and the solid residues service company involved in its transportation, treatment and final disposal should subscribe a Dangerous Solid Residues Management Manifest for each transference operation towards the final disposal place, provided it is found within the scope of the granted concession or the corresponding contract area. Article 37.2° of Law 27314 establishes this obligation and was approved through the Annex of Supreme Decree 057-2004-PCM.

5.7.4 Environmental Authorities

The Frame Law for Growth of Foreign Investment, Legislative Decree 757, established that the environmental authority at the national level is the ministry of the corresponding field to which the activity of the related company belongs, and it established a field characterization for the environmental initiatives at the national level. The environmental authority for hydrocarbon activities is the Ministry of Energy and Mining. However, since its foundation was altered in 1996, OSINERG controls hydrocarbon activities as explained below.

Although the Ministry of Energy and Mining and OSINERG share faculties as field environmental authorities for hydrocarbon activities, this does not exclude the participation of other authorities in their respective competencies, such is the case of DICAPI, INRENA and DIGESA, among other authorities.

In June 2004, a Frame Law for the National System of Environmental Management was published (Law 28245) seeking to strengthen coordination among the different authorities with environmental competencies to ensure their cooperative fulfillment of all responsibilities.

Following, find a set of agencies with their respective environmental jurisdictions and scopes of influence for the Project:

5.7.4.1 Ministry of Energy and Mining

Article 33 of Law 26221 establishes that the Ministry and Energy and Mining dictates norms related to the technical aspects of installations and operations for exploration and exploitation of surfaces, including soils and safety.

Inside the Ministry of Energy and Mining, there are 2 agencies with faculties over hydrocarbon activities. On one side, there is the General Direction of Hydrocarbons (DGH) and on the other, the General Direction of Energetic Environmental Issues (DGAAE).

a. General Direction of Hydrocarbons -DGH

The DGH is in charge of policy design and evaluation for the Sub-sector of Hydrocarbons. They regulate and issue the necessary statutes for the Hydrocarbons Sub sector, promote hydrocarbon activities for: exploration, exploitation, storage, processing, transportation, refining, distribution, trading, and safety, and promote the development of the environment in accordance with Supreme Decree 25-2003-EM, which approved the Regulation of Organizations and Functions of the Ministry of Energy and Mining.

b. General Direction of Energetic Environmental Issues - DGAAE

DGAAE's main objectives are to design and evaluate policy, govern and issue the necessary hydrocarbons regulations, and promote activities oriented toward environmental conservation and protection in the development of Energy activities. Additionally, DGAAE promotes the strengthening of the relations between field companies and civil societies involved with activities in the Energy field. Specific functions to this direction was established in Supreme Decree 025-2003-EM.

DGAAE evaluates and approves the environmental papers to which the Project holders of the activity are obliged, regulates environmental and social impacts (deriving evaluations from the activities of the field) and establishes preventive and corrective measures in case they are needed to control such impacts. In the cases of accusations about field trespassing, it evaluates environmental legislation rulings and proposes the equivalent sanctions.

5.7.4.2 Supervision Agency of the Energetic Investment- OSINERG

OSINERG, created in 1996 through Law 26734, is the control agency for the activities developed by companies in the electric and hydrocarbon sub sectors. It ensures that all legal and technical regulations are implemented in the respective activities, including those referring to environmental protection.

In cases of standing legislation, imminent danger to public health or when a severe risk to the environment can be detected, Complementary Law of Institutional Strengthening of OSINERG, Law 27699, entitles OSINERG to decide on the removal of installations, paralyze works, or suspend (definite or temporarily) those hydrocarbon activities not rightly approved. OSINERG has a Scale of Fines and Sanctions, approved through Ministry Resolution 176-99-EM/SG, and application guidelines, approved by a resolution from the General Management Office of Supervision Agency of the Energetic Investment, OSINERG 429-2001-OS-GG.

OSINERG does not participate in EIP evaluation or approval but controls the fulfillment of the agreement, including the operations involved for EIPs to occur.

5.7.4.3 National Institute of Natural Resources - INRENA

INRENA was created through Law 25902. Its main objective is the management and rational broad use of renewable natural resources and ecological environments to obtain sustainable development. It promotes and supports the sustainable use of renewable natural resources for the development of the Agrarian field. It relies on General Directions for Waters and Soils, Forestry, Protected Natural Areas, Wild Life and Rural Environments. As a decentralized organ, it includes regional operating units established at the national level.

5.7.4.4 General Direction of Environmental Health – DIGESA

The General Law of Health, Law Nº 26842, has entrusted the Ministry of the Field with the following attributions in environmental matters:

a) Dictate the necessary measures to minimize and control risks to safeguard the health of the people, which may be derived from elements, factors and environmental agents, according to what is established by law for each case.

b) Dictate prevention and control measures necessary to stop acts, or facts, which may cause environmental contamination, when they represent risk or damage to public health.

c) Dictate sanitary norms to regulate waste and contaminant substance discharges into water, air or soil when proper precautions were not adopted.

d) Dictate norms related to dangerous substances, including product qualifications, toxicity conditions and limits, information requirements, packing, bottling, baling, transportation, labeling, and any other required aspects to control risks and prevent damage to public health that could possibly be caused by those substances and products.

The organ within the Ministry of Health in charge of these tasks (environmental protection, sanitary improvement, food hygiene and occupational health) is the General Direction of Environmental Health (DIGESA). DIGESA was created through Legislative Decree 584, which was outlawed and replaced by the Law of the Health Ministry, Law 27657, which establishes DIGESA as one of the leading organs in the Ministry of Health. DIGESA's main purpose is to propose to the high direction a national policy and pertinent regulations to protect the health of populations at risk caused by environmental and occupational alterations.

5.7.4.5 Genreal Direction of Captainships and Coastguards - DICAPI

According to Law 26620, Law of Control and Surveillance of Marine, River and Lake Activities, and its regulation approved through Supreme Decree 028-DE/MGP, the General Direction of Captainships and Coastguards will authorize the construction, modification and operation of marine installations, including those tasks oriented towards gaining terrains in marine areas (areas whose use has been previously granted) bearing in mind issues of safety and marine environmental protection.

The Marine Authority enforces Law 26620 and its regulations, as well as the regulations of competent fields, the Agreements, and other international instruments ratified by the

Peruvian State, referring to the scope of the current law. The Marine Authority is influenced by the general Director of Captainships and Guard coasts, which relies on the Fort Captainships and the Coastguards Units to carry out its tasks.

The following are the functions of the General Direction of Captainships and Coastguards, according to Article 3 of Law 26620: (i) demand enforcement of Law 26620 and its regulations. (ii) Observe the safety of human lives in the sea, rivers and navigated lakes. (iii) Control marine traffic in sovereign waters and national jurisdictions. (iv) Exert control and surveillance to prevent and fight the effects of sea, rivers and navigated lake contamination, and generally, all that may cause ecological damage within the scope of their competence, subject to national regulations and international agreements on these matters, without excluding those tasks whose exercise correspond to other fields of the Public Administration, accordingly to the standing legislation on such matters. (v) Administer and operate coastal radio stations according to the standing regulations on the matter. (vi) Coordinate with the National Port Authority those cases that require special safety conditions for navigation permits that are established in the regulations of the Law on the National Port System. (vii) Other duties as established by the regulation of the current Law.

5.7.4.6 Peruvian Institute of Nuclear Energy - IPEN

IPEN is the national authority in charge of regulation and control of activities that involve exposition ionizing radiations.

IPEN is the authority entitled to grant the corresponding registrations and licenses for the use of radioactive material, according to what is established in Law 28028, Law of Regulation of the Use of Ionizing Radiation Sources, and by Supreme Decree 009-97-EM, Radiological Safety Regulation.

5.7.4.7 National Environmental Council- CONAM

The National Environmental Council (CONAM) by its creation law, Law 26410, modified by Law 28245, National Environmental Management System Law, becomes the National Environmental Authority and the leading agent of the National System of environmental Management. The environmental policy formulated by CONAM is of mandatory enforcement.

According to what is established in Article 8 of Law 28245, CONAM has as main objectives: planning, promoting, coordinating, regulating, sancting and supervising all actions oriented towards environmental protection. Additionally, CONAM contributes to conservation of natural patrimony and controls and observes full enforcement of environmental obligations, including solving and resolving the controversies among public agencies.

As indicated in Article 4 of Law 26410, modified by Article 9 of Law 28245, among the main tasks of CONAM are: design, coordinate and lead the National Environmental Policy, lead the national System of Environmental Management, lead the elaboration and revision processes of Environmental Quality Standards (ECA) and the Maximum Allowed Limits (LMP), lead the National System of Environmental Impact Evaluation, comment legislative initiatives on environmental matters, among others, and resolve at the last administrative level, undesirable resources addressed against resolutions or administrative acts regarding environment and natural resources.

5.7.4.8 PERUPETRO S.A

According to the Law of Functions and Organization of PERUPETRO S.A., Law 26225 and Law 26221, Organic Law of Hydrocarbons, the social objective of this state enterprise of private law is, among others, to promote investment in the activities of exploitation and exploration of hydrocarbons, including to negotiate, promote and supervise the agreements on technical evaluation and hydrocarbon contracts with private companies. The social by-law of PERUPETRO S.A. has been approved by Supreme Decree 048-93-EM.

Supervision by PERUPETRO S.A. refers to the contracting obligations that companies acquire with this state-owned enterprise when subscribing license and service contracts and conracts relating to environmental issues.

5.7.4.9 Institute of the Sea of Peru -IMARPE

According to what was established in the Law of the Institute of the Sea of Peru, approved by Legislative Decree 95, and the Regulation of Functions and Organization of IMARPE, approved by Supreme Decree 009-2001-PE, this state agency studies the environment and marine diversity, evaluates the fishery resources and provides information and advice on the decision-making for fishery, aquiculture and the protection of the marine environment. IMARPE does not exercise control, inspection or prosecution; its purpose is strictly scientific and technical. However, in some cases, it collaborates with the authorities in the protection of the marine environment.

As the Law of Functions and Organization of the Ministry of Production was published, Law 27789, IMARPE ascribes to the Ministry of Production as Public Decentralized Organism.

5.7.5 List of Legal Applicable Norms

Following, find detailed the legal norms applicable to offshore hydrocarbon activities that have been included in this document. Although additional norms could be quoted, we included only those related with hydrocarbon activities offshore or those of particular interest that illustrates the legal environmental frame.

General Frame

- Articles 66 to 69 from the Political Constitution of Peru, 1993.
- Code for the Environment and Natural Resources, Legislative Decree 613.
- General Health Law 26842.
- Frame Law for the Growth of Private Investment, Legislative Decree 757.
- Law 28245, Frame Law of the Environmental Management National System.

Hydrocarbon Activities

- Organic Law of Hydrocarbons, Law 26221.
- Regulation of Functions and Organization of the Ministry of Energy and Mining, Supreme Decree 25-2003-EM.
- Law 26734, Law of Creation of OSINERG.
- Complementary Law for Institutional Strengthening of OSINERG, Law 27699
- TUPA of the Ministry of Energy and Mining, approved by Supreme Decree 025-2002-EM.

- Regulation for the Environmental Protection in Hydrocarbon Activities, Supreme Decree 046-93-EM. Supreme Decree 009-95-EM, modified Articles 6, 15, 46, g, transitory Disposition and Tables 3 and 4.
- 2004 Regulation of Hydrocarbon Exploration and Exploitation Activities, approved by Supreme Decree 032-2004-EM.

Administrative Infringements and Sanctions

- Infringement Typification and Scale of Fines and Sanctions of OSINERG, Directive Council Resolution, Osinerg 028-2003-OS/CD and 054-2004-OS/CD.
- Scale of Fines and Sanctions of OSINERG, Ministry Resolution 176-99-EM/SG.
- Guidelines to Apply the Scale of Fines and Sanctions approved by Ministry Resolution 176-99-EM/SG, Resolution Osinerg 429-2001-OS-GG.
- Ministry Resolution 087-2001-EM/VME, modifies the numeral of the APPENDIX IV of the Scale of Fines and Sanctions of OSINERG, establishing a maximum top of 10,000 UIT.

Environmental Evaluation

- Law of the National System of Environmental Impact Evaluation, Law No. 27446.
- Regulations are established to formalize administrative procedures before the general Direction of Environmental Issues, Supreme Decree 053-99-EM.
- For cases in which Environmental Impact Papers approval require technical reports from INRENA, Supreme Decree 056-97-PCM, modified by Supreme Decree 061-97-PCM.
- Citizen Consultation and Participation Regulation as a procedure to approve EIP's, approved by Ministry Resolution 596-2002-EM-DM.

National Standards of Environmental Quality and Maximum Limits Admitted

- National Regulation for the approval of Environmental Quality Standards and Maximum Limits Admitted, Supreme Decree 044-98-PCM.
- Regulation of Titles I, II, and III of the general Law on Waters, Supreme Decree 261-69-AP, modified by Supreme Decree 007-83-SA and Supreme Decree 003-2003-SA.
- National Standards of Environmental Quality for Air, Supreme Decree 74-2001-PCM, June 24, 2001.
- Maximum acceptable concentration of contaminants in the air for hydrocarbon activities, Table 2 of Supreme Decree 046-93-EM.
- Maximum Admitted Limits for Liquid Effluents of Hydrocarbon Activities, Directive Resolution 030-96-EM/DGAA.

Dangerous Materials

- Regularization Law for the use of ionizing radiation Sources, Law 28028.
- Radiology Safety Regulation, Supreme Decree 009-97-EM.
- Regulation of Authorizations, Prosecution, Control, Infringements and Sanctions of Law 28028, Regularization Law for the Use of Ionizing Radiation Sources, Supreme Decree 041-2003-EM.
- Law Decree 25707 declares in a state of Emergency the Use of civil-use Explosives and related.
- Regulation of the Declaration of a state of emergency for the Use of civil-use Explosives and related, approved by Supreme Decree 086-92-PCM.
- Safety Regulation for Hydrocarbon Storage, Supreme Decree 052-93-EM.

Protection to Biological Diversity

- Agreement on Biological Diversity, approved for Peru through Legislative Resolution 26181.
- National Strategy for Biological Diversity of Peru, Supreme Decree 102-2001-PCM.
- Law on Conservation and Sustainable Use of Biological Diversity, Law 26839.
- Regulation of Law on Conservation and Sustainable Use of Biological Diversity, Supreme Decree 068-2001-PCM.
- Law on Protected Natural Areas, Law 26834.
- Regulation of Law on Protected Natural Areas, Supreme Decree 038-2001-AG.
- Categorization of threatened Species of the Wild Life for Peru, Supreme Decree 034-2004-AG.

Residue Management

- General Law of Solid Residues, Law 27314.
- Regulation of the General Law of Solid Residues, Supreme Decree 057-2004-PCM.
- Technical Norms to Prevent and Control the Discharge of Residues, Oily Mixtures and Others in marine Areas on behalf of Fixed or Floating Platforms Directive Resolution 0238-95-DCG.
- Norms to Prevent and Control Contamination by Waste originating in Ships, Directive Resolution 0510-99-DCG.
- Norms to Prevent and Control Contamination by Dirty Waters coming from Ships, directive Resolution 0069-98-DCG.

Marine Environment

- Law of Control and Surveillance of Marine, River and Lake Activities, Law 26620.
- Regulation of Law of Control and Surveillance of Marine, River and Lake Activities, approved by Supreme Decree 028-DE-MGP.
- Law of the National Institute of Peru, Legislative Decree 95.
- Regulation of functions and Organization of IMARPE, Supreme Decree 009-2001-PE.
- Directive Resolution 0160-96/DCG, establishes that every tank ship must have an "Onboard Emergency Plan for cases of Contamination by Hydrocarbons".
- International Agreement to Prevent Contamination by Ships, 1973 (MARPOL 1973), approved, for Peru, by Law Decree 22703. The 1978 Protocol also approved by Law Decree 22954.
- Convention on Prevention of sea Contamination by Discharge of Waste and Other Material approved for Peru by Legislative Resolution 27873 and then ratifies its adhesion, through Supreme Decree 003-2003-RE from January 17th, 2003.
- Agreement for the Protection of Marine Environment and the Coastal Shore of the Southeast Pacific approved for Peru through Legislative Resolution 24926.
- International Code of Management for Operational Safety of the Ship and the Prevention of Contamination, Code IGS, approved by Directive Resolution 001-98-DCG.

Environmental Guides and Monitoring Protocols

- Guide of Offshore Oil Operations, Directive Resolution 011-2001-EM/DGAA (it is not a mandatory norm).

- Monitoring Protocols and Quality of Air and Emissions for the Sub sector of Hydrocarbons, Directive Resolution 026-94-EM/DGAA
- Monitoring Protocol on Quality of Water for the Sub sector of Hydrocarbons, Directive Resolution 043-99-EM-DGAA.

6 *DEGREE OF ENVIRONMENTAL COMPLEXITY*

6.1 *OBJECTIVE*

The objective is to estimate the LEVEL OF ENVIRONMENTAL COMPLEXITY (LEC) of the area given the actions derived from the exploration of hydrocarbons through seismic methods (air canyons) and perforations.

Because of the distribution of biological resources and its exploitation, the bathymetry and marine sediments and the natural reserve assignations, among other aspects, are not uniformly distributed in the oceanfront of Peru; NCA (Department for Level of Complexity) will also have a distribution in the space.

6.2 *METHODOLOGY*

The methodology applied has been adopted from the Guide of Environmental Licensing of Activities for Oil Exploration – Seismic and Perforation, 2003 as published by the Brazilian Institute for Environment and Renewable Resources (IBAMA).

The biological, social and oceanographic aspects relevant for the calculation of NCA are included in Chart 44.

As it shows on the Chart mentioned, biological diversity has been recognized as of great importance, given the resource itself or aspects related to it, including the current and the potential exploitation.

The presence of natural areas, fishery and aquiculture, and marine sediments and bathymetry has been recognized as factors of environmental influence.

The procedure to calculate NCA is the following: weight of biodiversity (between 1 and 4, according to the degree of sensitiveness) is multiplied by the assigned weight of the Protected Natural Areas (between 0, absence and 1, presence). To the result obtained the product of biodiversity weight times that of fishery and aquiculture is added, and then so on with bathymetry, social aspects and sediments. The total sum obtained – that can only be a maximum of 56 – is then normalized so that it fits in the 6 categories that show in Chart 45.

Chart 44. SUMMARY OF THE CONTENTS OF BIODIVERSITY AND THE ASSIGNED WEIGHTS FOR THE CALCULATION OF NCA

ASPECTS	CATEGORIES	Weight per Categories	Weight per Attribute	Total Weight Assigned (Normalized)
BIODIVERSITY				
ATRIBUTE: MARINE MAMMALS	Mysticets	0-1	0-4	1-4
	Odontocets	0-1		
	Pinnipeds	0-1		
	Fissipeds (marines)	0-1		
ATRIBUTE: MARINE TURTTLES	General	0-1	0-1	
ATRIBUTE:BIRDS	Oceanic	0-1	0-2	
	Coastal	0-1		
ATRIBUTE: KEY SPECIES	Vinicingue	0-0.5	0-3	
	Mangrove tree	0-0.5		
	Anchovy	0-0.5		
	Munida	0-0.5		
	Squid	0-0.5		
	Sardine	0-0.5		
PROTECTED NATURAL AREAS	Include protected areas formerly speaking, intangible areas, capes and islands	0-1	0-1	**0-1**
FISHERY AND AQUICULTURE				
ATRIBUTE: FISHERY PER TYPE	Height	0-1	0-3	**1-4**
	Industrial	0-1		
	Artisan	0-1		
ATRIBUTE: FISHERY PER SPECIES	Merluce/Hake and flyer	0-1	0-4	
	Jumbo Flying Squid	0-1		
	Jurel/(carangoid sea fish) and horse mackerel	0-1		
	Anchovy and sardine	0-1		
ATRIBUTE: AQUICULTURE	General	0-1	0-1	
BATHYMETRY	Less than 60 m	4	1-4	**1-4**
	From 60 to 100 m	3		
	From 100 to 200 m	2		
	Greater than 200 m	1		
SOCIALS	General		1-4	**1-4**
SEDIMENTS	Fines (clays, muds)	1	0.5-1	**0.5-1**
	Sands	0.5		

Chart No. 45 DEGREE OF ENVIRONMENTAL COMPLEXITY

S	Simple
1	Moderate
2	Significant
3	High
4	Very high
5	[illegible]

6.3 *RESULTS*

Biodiversity

The attributes considered for the calculation of this factor were 4 (Marine Mammals, Turtles, Birds and Key Species).

The category, marine mammals, included as parameters the categories of Odontocets, Mysticets, Pinnipedia and Fissipedia. Marine turtles are a unique category. Birds are divided into oceanic and coastal, while Key Species include Mangrove, Anchovy, sardine, vinciguerria, squid and munida.

The Pisco Basin was the one which presented the highest degree of importance in this aspect (very high or 4) given that it presents almost the total number of factors considered sensitive.

The Basins of Talara, Sechura, Salaverry, Lima and Mollendo present a high degree of importance (3), being Mollendo the most sensitive of all, and Lima the least sensitive, within this category. In these zones, the distribution of marine mammal species and some other key species are dominate.

The Trujillo and the Tumbes-Progreso Basins present a moderate degree of importance because of the oceanic character of the first basin and the absence of key species in the second one.

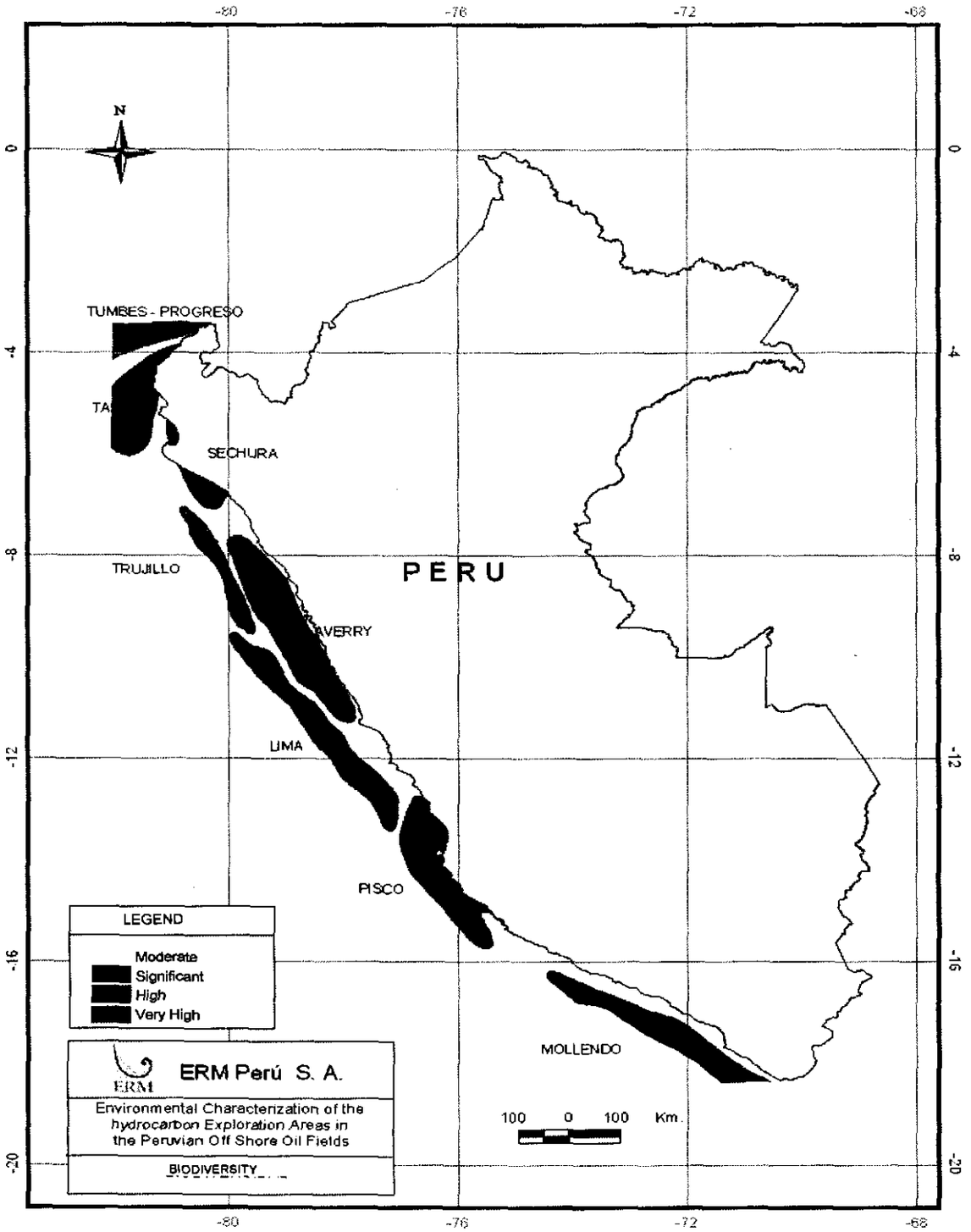
The summary of assigned weights is shown on Chart 46.

CHART 46 EVALUATION OF THE ATTRIBUTES OF BIODIVERSITY IN SEDIMENTARY BASINS

ATRIBUTES	CATEGORIES	NORTH ZONE			CENTRAL ZONE				
		Tumbes – Progreso	Talara	Sechura	Trujillo	Salaverry	Lima	Pisco	Mollendo
Marine Mammals	Mysticets	1	1	1	1	1	1	1	1
	Odontocets	1	1	1	1	1	1	1	1
	Pinnipeds	0	1	1	1	1	1	1	1
	Fissipeds (marines)	0	0	0	0	0	0	1	0
Marine Turtles		1	1	1	1	1	1	1	1
Birds	Oceanic	1	1	1	1	1	1	1	1
	Coastal (including islands)	1	1	1	0	1	0	1	1
Key Species	Anchovy	0	0	0.5	0	0.5	0.5	0.5	0.5
	Sardine	0	0.5	0.5	0.5	0.5	0.5	0	0
	Squid	0	0.5	0	0	0	0	0.5	0.5
	Munida	0	0	0	0	0	0	0.5	0.5
	Vinciguerria	0	0	0	0	0	0	0.5	0.5
	Mangrove	0.5	0	0	0	0	0	0	0
Total Diversity		5.5	7	7	5.5	7	6	9	8
Total Value (Over scale of 4)		**2**	**3**	**3**	**2**	**3**	**3**	**4**	**3**

Scale of Evaluation	
0 – 2	1 (moderate)
3 - 5	2 (significant
6 - 8	3 (high)
9 - 10	4 (very high)

Figure #46: Biodiversity Distribution by Basins



Protected Areas

The criterion for this point is the inclusion or overlap of these zones in sedimentary basins. In the coastal zone of Peru, there are only two areas under protection regime by the government. These are in the zones corresponding to the Basin of Pisco and Tumbes. There are, however, some particular initiatives which have been received by the State in order to incorporate palm tree capes and islands administered by PROABONOS as the system of protected areas. Biodiversity sheltered in these geographic spots, especially in regards to birds, shows in the values obtained. In the zone of Pisco, the National Reservation of Paracas is found, while in the Basin Tumbes-Progreso, the existence of a National Sanctuary has a direct relation with the assigned value to the attribute of coastal birds and the presence of red mangrove (*Rhizophora mangle)*. This organism by itself sustains an entire particular ecosystem and of focused distribution.

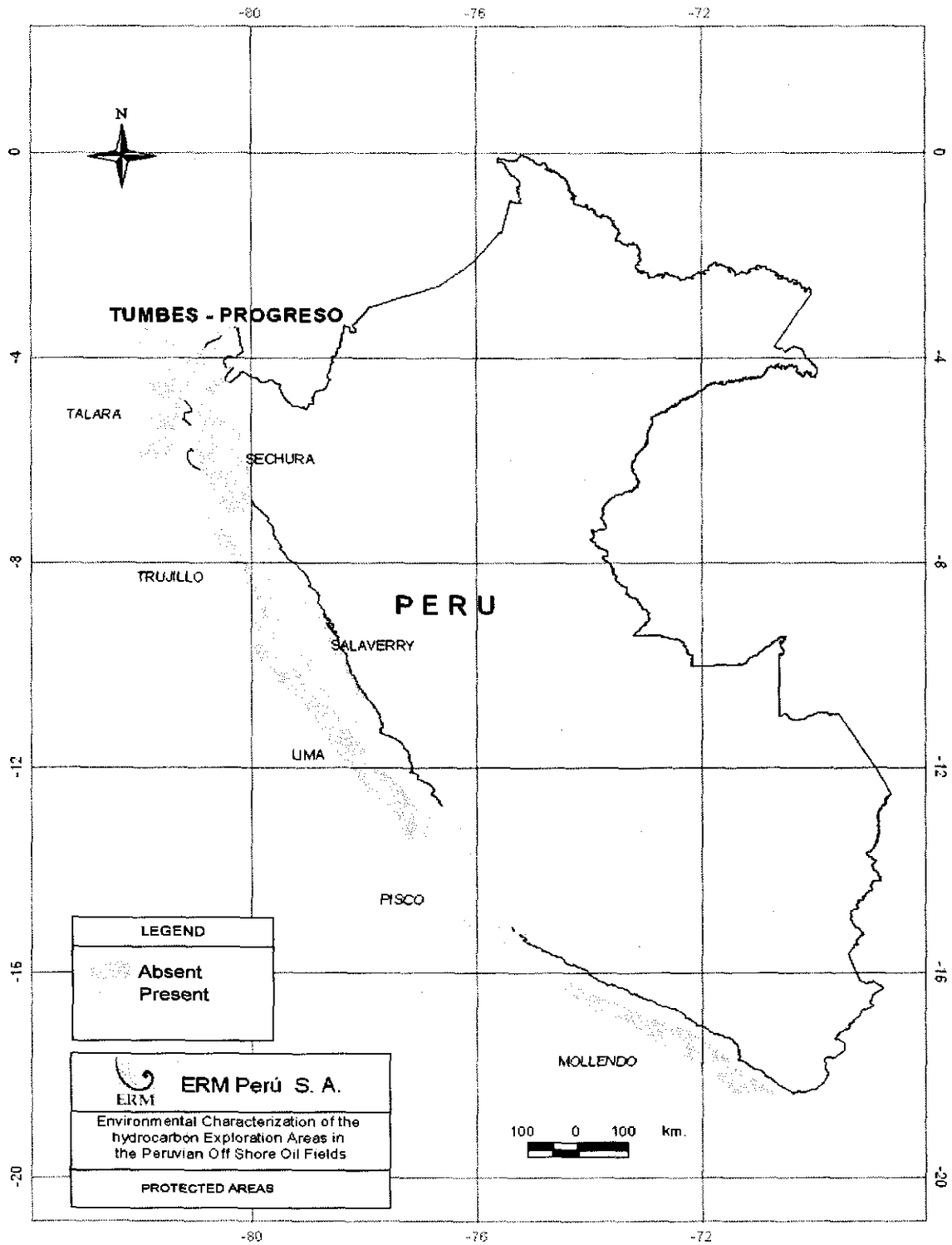
Basins Salaverry, Talara and Sechura register a medium importance given the levels of sensitivity (closeness or inclusion of the coastal strip), although only the first is considered as potential because located close by are several capes and islands to be incorporated by SINANPE.

Basins Mollendo, Trujillo and Lima are the least sensitive at this point given their condition of eminently oceanic zones.

A summary of the assigned weights is presented in Chart 47.

CHART 47 ATTRIBUTE STANDARIZATION SENSITIVE AREAS IN SEDIMENTARY BASINS

		NORTH ZONE			CENTRAL ZONE				
ATTRIBUTE	CATEGORIES	Tumbes – Progreso	Talara	Sechura	Trujillo	Salaverry	Lima	Pisco	Mollendo
SENSITIVE AREAS	Protected Natural Areas	1	0	0	0	0	0	1	0
	Potential Areas	0	0	0	0	1	0	0	0


-80
-76
-72
N
0
-4
-8
-12
-16
-20
TUMBES - PROGRESO
TALARA
SECHURA
TRUJILLO
PERU
SALAVERRY
UMA
PISCO
MOLLENDO
LEGEND
Absent
Present
ERM
ERM Perú S. A.
Environmental Characterization of the hydrocarbon Exploration Areas in the Peruvian Off Shore Oil Fields
PROTECTED AREAS
100 0 100 km.

Fishery and Sustainable Use of Hydro biological Resources

The attributes considered for the calculation of this factor are 3: (i) Type of fishery, Artisan, Industrial and Height. (ii) Main Species fished (anchovy and sardine, Jurel/ (carangoid sea fish) and horse mackerel, merluce/hake and flyer fish and Squid. (iii) Zones in which aquiculture takes place. In the northern zone, integrated by Basins Tumbes-Progreso, Talara and Sechura artisan fishery present the highest degree of species diversification as well as the highest levels of fish and invertebrates disembarkments (26,260 tons and 26,489 tons, respectively). Industrial fishery is more diverse, showing additionally an occasional capture of height species such as Squid and tuna. Among industrial products destined for direct human consumption, the frozen is the one that provides greater values (149,213 tons average).

The Talara Basin does not have aquicultivated areas, which is not the same case for Basin Tumbes-Progreso where it is possible to find a great number of shrimp cultivation sites in zones near the coast using marine waters bombing systems.

It is possible to find Scallops cultivation sites in the Sechura Basin given that around Sechura Bay one of the main productive banks of this species is found. There is 3 demo aquiculture sites.

Acknowledging the above, it is considered that these 3 Basins present a high degree of sensitivity.

In the central zone, integrated by the Trujillo, Salaverry and Lima Basins, there is a minor degree of fishery diversification, which is mainly industrial fishery oriented towards the production of jams and flour. However, in the Salaverry Basin, turtle- wise, there is a Scallops cultivation area which brings a greater degree of importance. The Basins of Trujillo and Lima present a medium and low degree of diversity respectively.

The zone of Pisco, in a similar way to those of the North, present a strong source of artisan fishery, although in a minor proportion. Industrial fishery is mainly concentrated on anchovy, which is considered a key species given the extraction volume, as well as its importance within the food chain of other species. This is the zone where the National Reservation of Paracas is found, which is the only marine reservation on the coast. As well, in this zone is where the main natural Scallops bank is found, which is used for its seed recollection for further cultivation. The degree of sensitivity of Pisco is high.

The Mollendo zone presents a high degree of sensitivity, thanks to its important levels of artisan and industrial fishery. On the other hand, in its coastal strip there are some demonstration aquiculture sites.

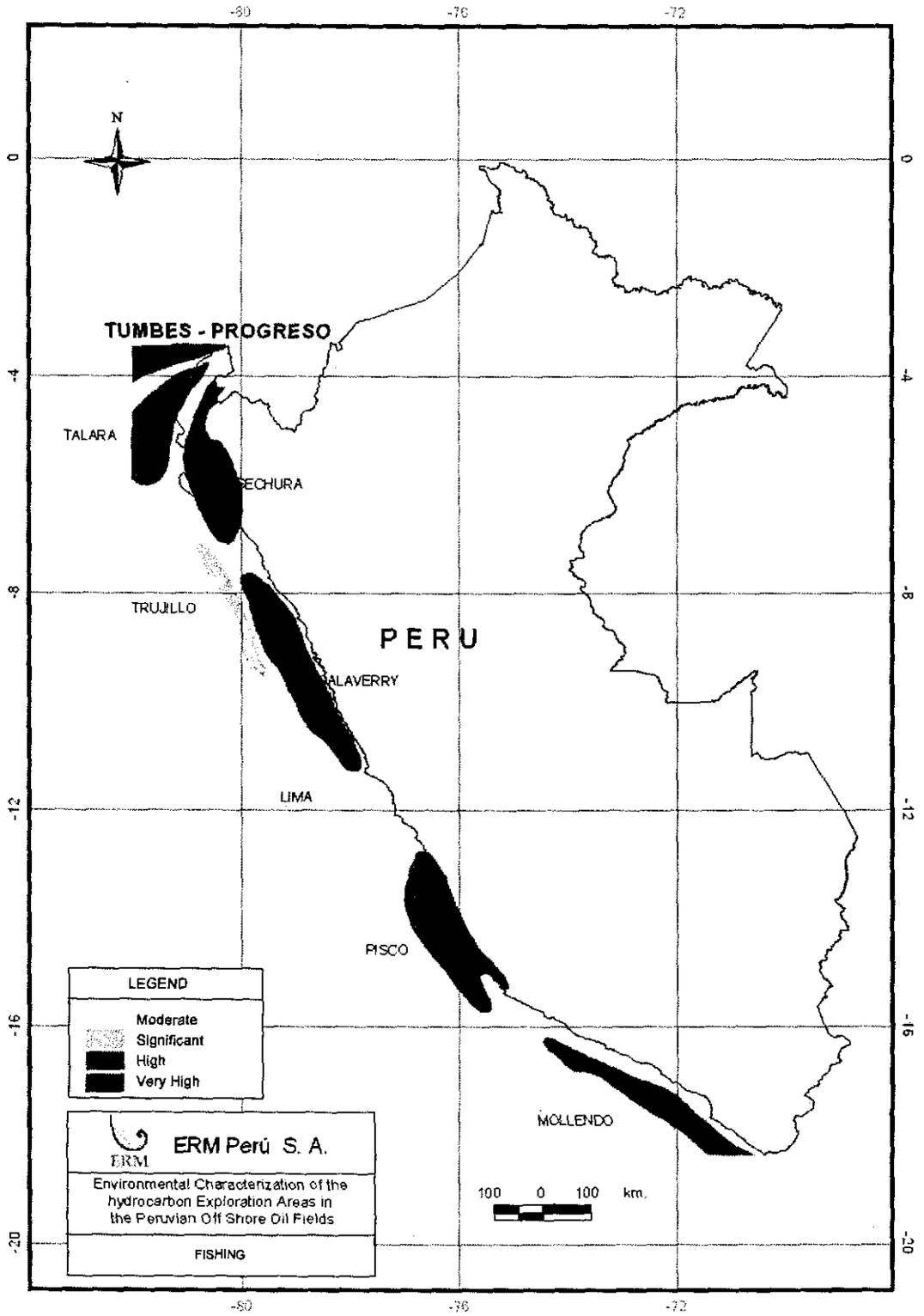
The summary of the assigned weights are shown in Chart 48.

CHART # 48 VALUATION OF FISHING ACTIVITIES AND HYDROBILOGICAL ADVANTAGES

Fishing Zone	Tumbes-Progreso	Talara	Sechura	Trujillo	Salaverry	Lima	Pisco	Mollendo
Type of Fish								
Artesanal	1	1	1	0	1	0	1	1
Industrial	1	1	1	1	1	1	1	1
Height	1	1	0	0	0	0	0	0
Species of Fish								
Anchovy & sardine	0	1	1	1	1	1	1	1
Merluza & Volador	1	1	0	0	0	0	0	0
Squid	0	1	0	0	0	0	1	1
Jack Mackerel & Mackarel	0	0	1	1	1	0	1	1
Agriculture and Drive zones								
Agricultural zones	1	0	1	0	1	0	1	0
Diversity Total	5	6	5	3	5	2	6	5
On Scale 4	3	3	3	2	3	1	3	3

Valuation Scale	
0 – 2	1 (moderate)
3 - 4	2 (significant)
5 - 6	3 (high)
7 - 8	4 (very high)

Figure #48: Fishing Distribution



The figures which include the bathymetry, the distribution of sediments and socioeconomic aspects are displayed in the Figures # 49, 50 and 51.

Figure #49: Bathymetry

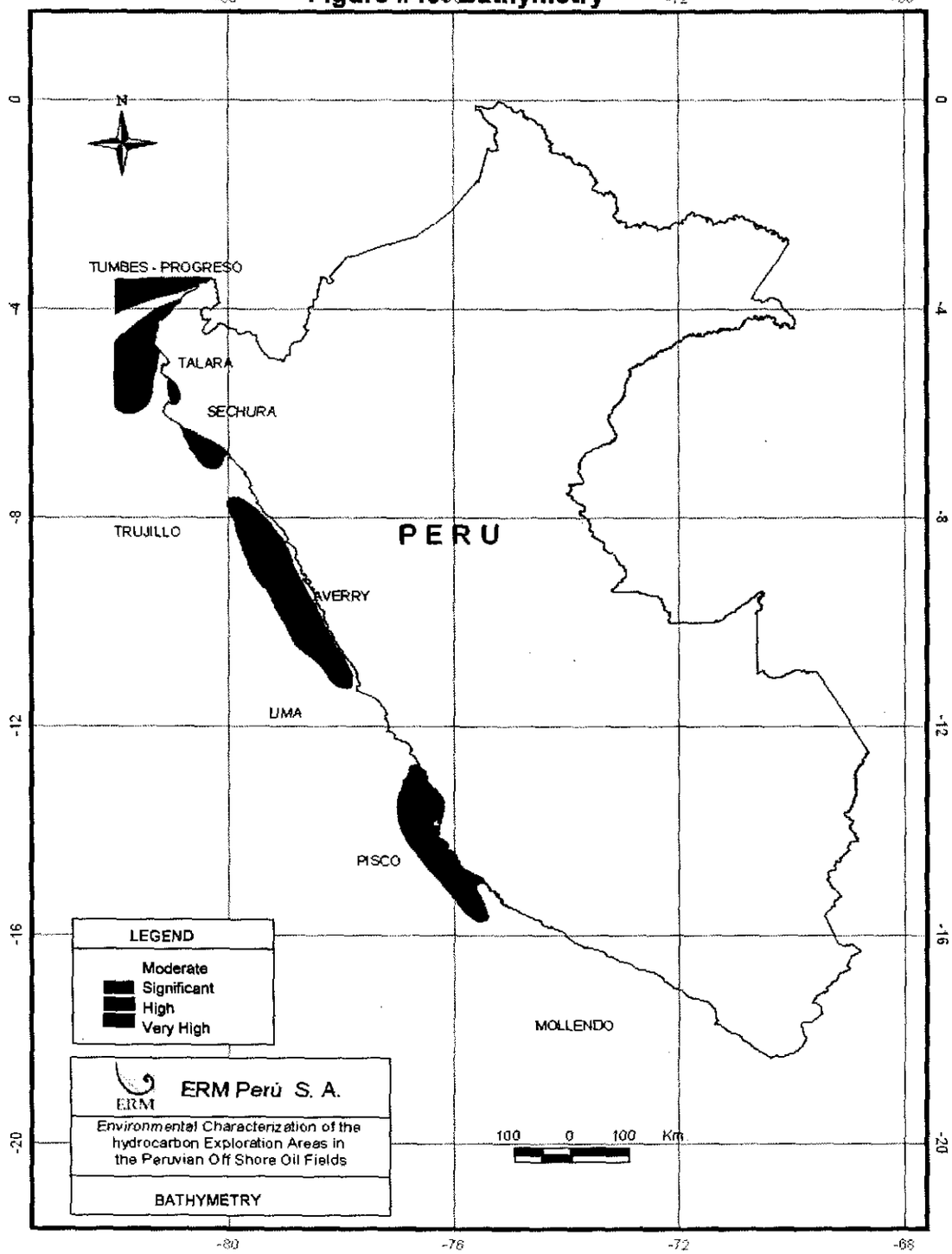


Figure #50: Distribution of sediments

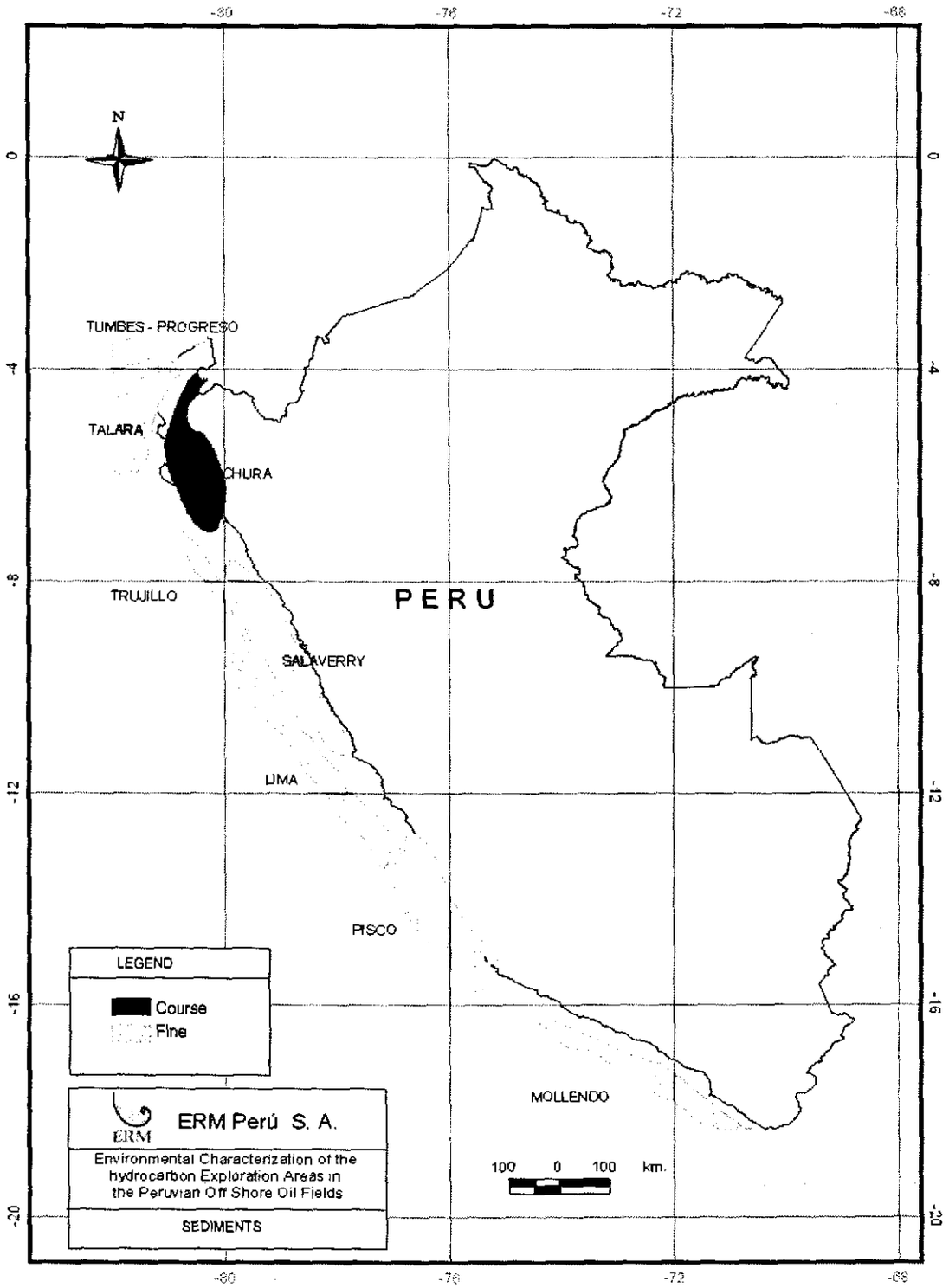
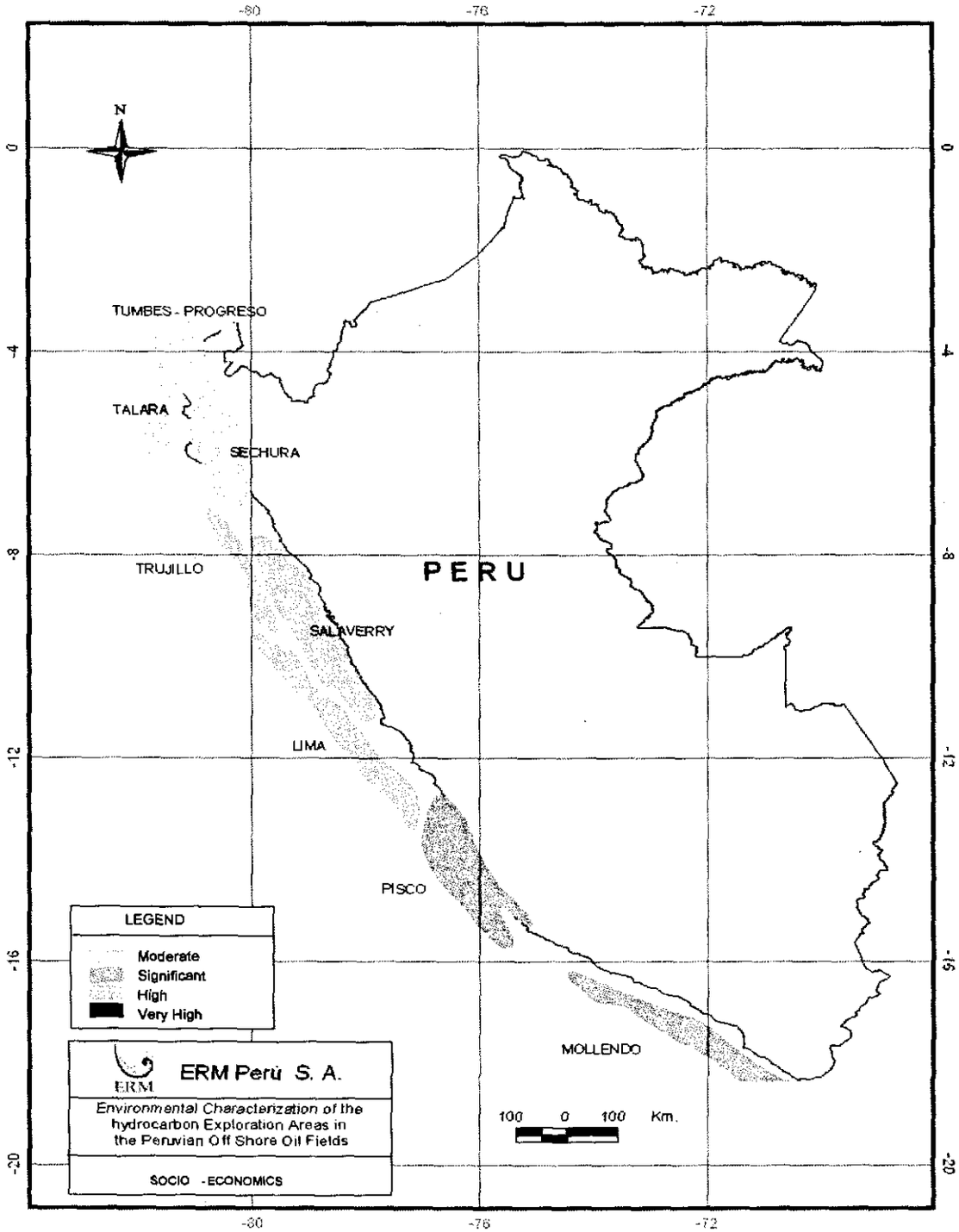


Figure #51: Socio-economic aspects



7 *CONCLUSIONS*

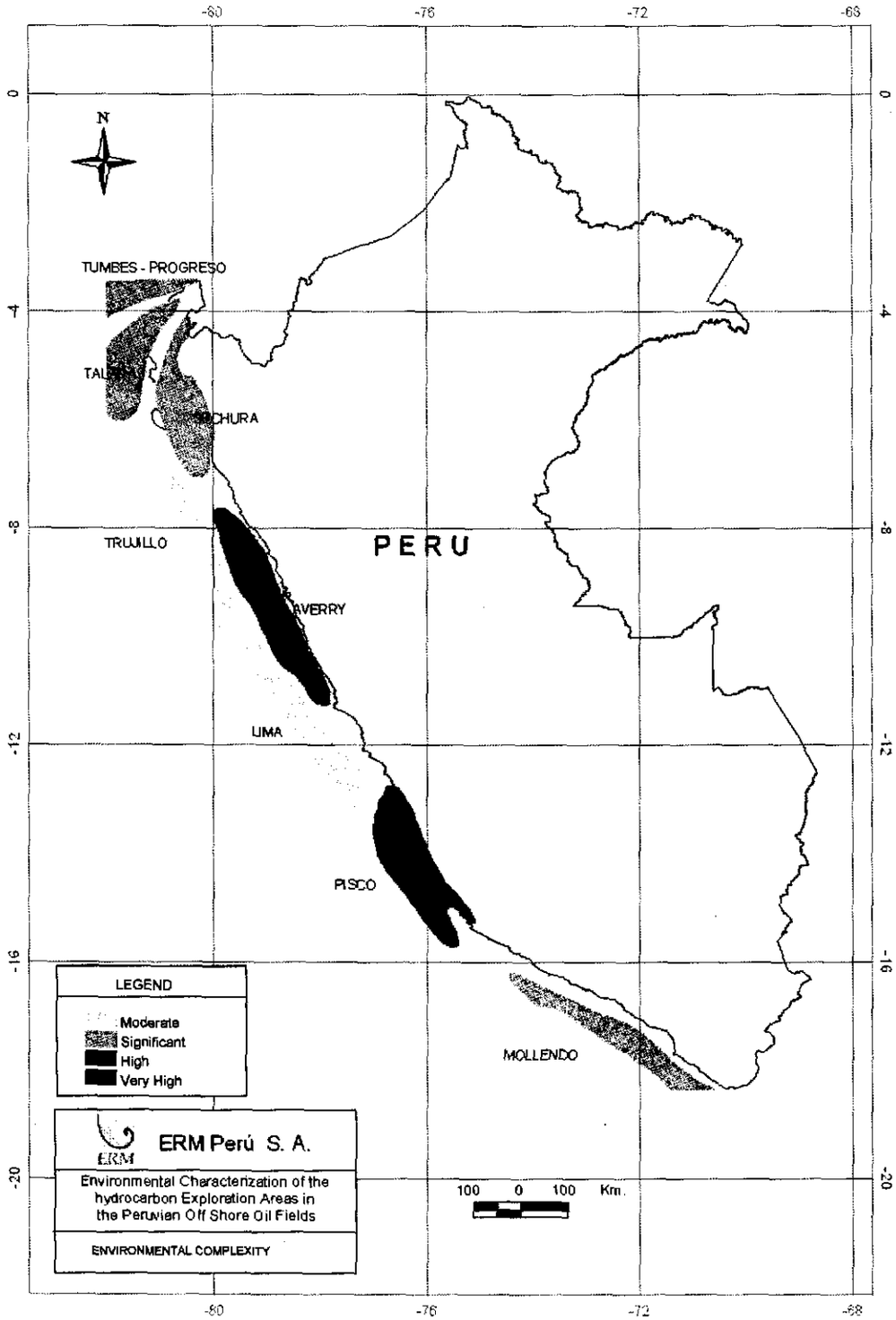
The biological, social and fishing inpacts have been evaluated as the natural areas, including the importance of water depth and ocean bottom sediment type as they impact offshore seismic and drilling activities.

The following CHART # 52 summarizes the levels of environmental complexity by exploration sedimentary basin.

CHART # 52 Summary with levels of environmental complexity by sedimentary basin

Tumbes-Progreso	Talara	Sechura	Trujillo	Salaverry	Lima	Pisco	Mollendo	Basin
2	2	2	1	3	1	4	2	NCA
Significant	**Significant**	**Significant**	**Moderate**		**Moderate**		**Significant**	**Description**

Figure #52: Distribution of Level of Environmental Complexity



8 *FINAL CONSIDERATIONS*

Regardless of the complexity of the environmental values displayed for the different zones, the environmental application authority of Peru will require an Environmental Impact Study (EIA) for the prospective tasks. The EIA must be approved before beginning each task.

The contents of the EIA will include a description of the actions to be taken, the identification and characterization of the impacts during the project, the environmental strategy (including an Environmental Plan, Contingency Plan, Compensation Plan, and an Abandonment Plan), as well as plans for citizen participation, implementation, monitoring and control.

It should be considered that the undertaking of the EIA will require field and office studies. Field studies are to include biological and oceanographic aspects, at small and intermediate water depths. These types of studies require prior planning and field time to be able to discriminate between influences caused by local variation, biological or oceanographic aspects.

The difference between environmental complexity levels will manifest in different phases, licensing and environmental approval of the Project. The following factors should be considered:

Environmental Diagnosis

The environmental diagnosis is the document by which the environmental application authority presents after observation. Requirements for managing measures and environmental monitoring, according to their criteria, are not included in the EIA nor must be adhered to for granting the operations' environmental licenses.

International Organizations

International organizations, which grants credits for projects that have environmental incidence, require the borrowers to adhere to environmental regulations, which may be independent, or require application authority.

These organizations contract a consultanting company or environmental specialists to examine the EIA contents and report their conclusions.

Local and International Non-Governmental Organizations (NGOs)

In general, the EIAs are reviewed by local and international NGOs in preservation of Peru's natural resources that, according to their own standards and requirements, could arise from the local population, require corrections, measures and/or additional studies until operation abandonment.

Industrial and Artisan Fishing and Aquiculture

The differenct factors that conform to the fishing activities (industrialists), artisans (fishermen), and the aquiculture, have a particular interest in the preservation and management of fishings resources, which may, or may not, be in favor of different socio-economic aspects.

Project Level Definition

A clear description of the project, complete and with sizable detail will be necessary to carry out the environmental evaluations with considerable certainty and fact.

Level of Depth of Environmental Studies

Taking into consideration that the regulations that exist in EIA do not determine the levels of depth that the EIA should have for a zone of certain environmental complexity, the determination of this level of depth will have left a criteria of the people responsible for the environmental studies. Nevertheless, EIAs with a high level of depth will be required in zones with a high degree of environmental complexity on the part of the different factors previously numbered.

9 *GLOSSARY OF TERMS. BASIC DEFINITIONS*

Commission of the South Pacific (CPPS). - Created in Santiago of Chile, August 18, 1952, by the Governments of Chile, Ecuador and Peru. The legal function and position the CPPS was consecrated by means of a subscribed agreement on January 14, 1966. The function of the CPPS is to impel the process of identification and coordinating interests that the state members share about the sea. It focuses on the special emphasis put on the preservation of the sea, order of fishing and sustainable advantage of marine resources under the jurisdiction of the states of the Southeastern Pacific. As complement to its activities, in 1981, the CPPS established the Action Plan for the Protection of the Sea and Coastal Areas of the Southeastern Pacific, integrated, in addition to the state members of the CPPS, by the Republic of Panama. The Plan that counts on the financial support of the United National Program for the Enviroment (PNUMA) has an objective to protect and preserve the region against all types and sources of contamination, recognizing the economic value, social and cultural sea value.

INRENA.- Acronym for the National Resources Institute. Public office decentralized by the Minister of Agriculture with technical autonomy and administration, in charge of protected natural areas of the country.

The Red Book of Biodiversity.- Publications by investigators, government agencies, NGOs and instutions, which include evaluated species and classified in diverse categories, which are described to a qualitative and quantitative level, and emphasizing the conservation status which are: in critical danger (CR), in danger (IN), vulnerable (VU) and under risk (LR).

PROABONOS. - Acronym of Special Project for the Advantage of Originating Installments of Marine Birds. Organization responsible for points and islands and who have potential gain in the country.

National Reserve. - Area designated to the protection and propagation of species of the wild whose conservation is of national interest. The resources are provided / made by the State.

National Sanctuary. - Area where the habitat is protected with intangible character, a species or a community of flora and wild fauna, as well as natural formations of scientific interest given its national importance. The establishment of new human rights groups to take advantage of the natural resources is prohibited, with the exception of communities and ancestral groups established by legislation. The last ones have a right to exercise

their uses and traditional practices by compatible means with the primary objectives in the area.

SINANPE. - Acronym of National System of Natural Areas Protected by the State, at the moment, administered by the INRENA according to Decree Law N° 25902 emitted the 25 of November of 1992.

Site RAMSAR. - Term applied to the wetlands whose roll and diversity are recognized at an international level. Reference is made to the convention established in the city of Ramsar (Iran), where the condition of the wetlands, like habitat of aquatic birds, was stipulated, defining them as fragile ecosystems and in a lost progressive situation, there being a high priority of conservation.

10 ACRONYMS

ANP	Área Natural Protegida (Protected Natural Area)
CONAM	Consejo Nacional del Ambiente (National Environmental Counsel)
DGAAE	Dirección General de Asuntos Ambientales Energéticos, Ministerio de Energía y Minas (General Office for Envirnmental Issues, Ministry of Energy & Mines)
DGH	Dirección General de Hidrocarburos, Ministerio de Energía y Minas (General Office of Hidrocarbons, Ministry of Energy and Mines)
DICAPI	Dirección General de Capitanías y Guardacostas, Ministerio de Defensa (General Office of the Coastguard and Captainshipes, Ministry of Defense)
DHN	Dirección de Hidrografía y Navegación (Office of Higraphy and Navegation)
DIGESA	Dirección General de Salud Ambiental, Ministerio de Salud (General Office of Environmental Health, Ministry of Health)
DREM	Dirección Regional de Energía y Minas (Regional Office of Energy and Mines)
ECA	Estándar Nacional de Calidad Ambiental (National Standards of Environmental Quality)
EIA	Estudio de Impacto Ambiental (Study on Environmetal Impact)
EIAP	Estudio de Impacto Ambiental Preliminar (Preliminary Study on Environmental Impact)
IMARPE	Instituto del Mar del Perú (Ocean Institute of Peru)
INRENA	Instituto Nacional de Recursos Naturales (National Institute of Natural Resources)
IPEN	Instituto Peruano de Energía Nuclear (Peruvian Institute of Nuclear Energy)
LMP	Límite Máximo Permisible (Allowable Maximum Limit)
MARPOL 73/78	Convenio Internacional para Prevenir la Contaminación por los Buques (Internacional Treaty for the Prevention of Contamination by Ships)
MTC	Ministerio de Transportes y Comunicaciones (Minstry of Transportation and Communication)
OMI	Organización Marítima Internacional (Internacional Maritime Organization)
OSINERG	Organismo Supervisor de Inversión en Energía (Supervisor of Energy Invesments)
PERUPETRO	PERUPETRO S.A.
PMA	Plan de Manejo Ambiental (Envirnmental Handling Plan)
SEIA	Sistema Nacional de Evaluación del Impacto Ambiental (National System of Environmental Impact Evaluation)
SINANPE	Sistema Nacional de Áreas Naturales Protegidas por el Estado (National System of Natural Areas Protected by the State)
TUPA	Texto Único de Procedimientos Administrativos (Administrative Procedures Text)

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12 APPENDICES

APPENDIX 1 CHARTS & TABLES

CHART # 1 RELATIONSHIP OF MARINE BIRDS REGISTERED IN PERU

N°	Species	Common Name	Tumbes – Progreso Baisn	Talara Basin	Sechura Basin	Trujillo Basin	Salaverry Basin	Lima Basin	Pisco Basin	Mollendo Basin	Coastel	Ocean	Resident	Migrant	IUCN, 2003	National List, DS 013-99-AG	CITES	Endemic	Reproduction (Peru)
1	*Spheniscus humboldti*	Humboldt Penguin	?	?	*		*		*		*		*		LR	E	1	*	*
2	*Rollandia rolland*	Zambullidor Duck							*		*		*						
3	*Podiceps major*	Large Duck							*		*		*						
4	*Podilymbus podiceps*	Heavy Tipped Zambullidor Duck							*		*		*						
5	*Diomedea epomophora*	Albatross			*	*	*	*	*			*		*	LR				
6	*Diomedea irrorata*	Galapagos Albatross	*	*	*	*	*	*	*		*	*		*	LR				
7	*Diomedea melanophrys*	Black BROS Albatross		*	*	*	*	*	*			*		*					
8	*Diomedea bulleri*	Buller Albatross						*	*			*		*	LR				
9	*Diomedea cauta*	White Front Albatross							*			*		*					
10	*Diomedea chrysostoma*	Gray Head Albatross						*	*			*		*	LR				
11	*Diomedea exulans*	Nomadic Albatross				*	*	*	*			*		*	VU				
12	*Macronectes giganteus*	Giant Antartic Seagull		*	*	*	*	*	*		*	*		*					
13	*Fulmarus glacialoides*	Silver Seagull		*	*	*	*	*	*			*		*					
14	*Daption capense*	Checkered Seagull	*	*	*	*	*	*	*	*		*		*	R				
15	*Pterodroma phaeopygia*	Dark Rump Seagull	*	*	*	*	*					*		*	EN				
16	*Pterodroma cookii*	Cook Seagull	*	*	*	*	*	*	*			*		*	VU				
17	*Pterodroma defilippiana*	Masatierra Seagull	*	*	*	*	*	*	*			*		*	VU				
18	*Pterodroma externa*	White Collar Seagull	*	*	*	*	*	*	*			*		*					
19	*Pachyptila desolata*	Wide Blue Beak Seagull							*	*		*		*					
20	*Pachyptila belcheri*	Narrow Blue Beak Seagull							*	*		*		*					
21	*Procellaria cinerea*	Gray Seagull	*	*	*	*	*	*	*			*		*					
22	*Procellaria aequinoctialis*	White Chin Seagull	*	*	*	*	*	*	*			*		*					
23	*Puffinus creatopus*	Pink Footed Shearwater	*	*	*	*	*	*	*		*	*		*	VU				
24	*Puffinus bulleri*	Buller's Shearwater	*	*	*	*	*	*	*		*	*		*	LR				
25	*Puffinus griseus*	Gray Shearwater	*	*	*	*	*	*	*		*	*		*					
26	*Oceanites oceanicus*	Storm Petrel	*	*	*	*	*	*	*	*	*	*		*					
27	*Oceanites gracilis*	White Vented Storm-Petrel	*	*	*	*	*	*	*			*		*	DD				
28	*Pelagodroma marina*	White Face Storm Petrel	*	*	*	*	*	*	*			*		*					
29	*Fregetta tropica*	Black Bellied Storm Petrel						*	*			*		*					
30	*Oceanodroma tethys*	White Tail Swallow	*	*	*	*	*	*	*		*	*			LR				
31	*Oceanodroma markhami*	Gray Storm Swallow	*	*	*	*	*	*	*		*	*	*		DD				*
32	*Oceanodroma melania*	Black Storm Swallow	*	*								*		*					
33	*Oceanodroma hornbyi*	Collar Storm Swallow	*	*	*	*	*	*	*			*		*	DD				
34	*Pelecanoides garnotii*	Peruvian Pelican	*	*	*	*	*	*	*		*		*		EN	EN			*

N°	Species	Common Name	Tumbes – Progreso Baisn	Talara Basin	Sechura Basin	Trujillo Basin	Salaverry Basin	Lima Basin	Pisco Basin	Mollendo Basin	Coastal	Ocean	Resident	Migrant	IUCN, 2003	National List, DS 013-99-AG	CITES	Endemic	Reproduction (Peru)
35	*Phaethon aethereus*	Tropical Bird Red Beak	*	*	*	*	*	*	*		*	*		*					
36	*Pelecanus thagus*	Pelican	*	*	*	*	*	*	*	*	*	*	*	*		VU			?
37	*Sula nebouxii*	Blue-footed Booby	*	*	*	*	*	*	*		*	*	*	*		VU			
38	*Sula variegata*	Peruvian Booby	*	*	*	*	*	*	*	*	*	*	*	*		VU			
39	*Sula dactylatra*	Masked Booby	*	*	*	*	*	*	*	*	*	*	*	*		VU			
40	*Phalacrocorax olivaceus*	Olivaceous Cormorant	*	*	*		*		*		*		*	*		VU			
41	*Phalacrocorax bougainvillii*	Sea Duck	*	*	*	*	*	*	*	*	*	*	*	*		VU			
42	*Phalacrocorax gaimardi*	Red-legged Cormorant	*	*	*	*	*	*	*		*		*		LR	VU			*
43	*Fregata magnificens*	Magnificent Frigate Bird	*	*	*	*	*				*	*	*	*					
44	*Casmerodius albus*	Great White Egret	*	*	*		*		*				*	*			3		
45	*Egretta thula*	Small White Egret	*	*	*		*		*				*	*					
46	*Egretta caerulea*	Blue Egret	*	*	*		*		*				*						
47	*Egretta tricolor*	Tricolor Egret	*	*	*		*		*				*						
48	*Butorides striatus*	Green Egret	*	*	*		*		*				*						
49	*Bubulcus ibis*	Cattle Egret	*	*	*		*		*				*	*			3		
50	*Nycticorax nycticorax*	Black Crowned Night Heron	*	*	*		*		*				*	*					
51	*Ixobrychus exilis*	Dwarf Egret							*				*						
52	*Jabiru mycteria*	Jabiru Stork	*										*			VU	1		
53	*Theristicus melanopis*	Black Face Ibis							*					**		VU			
54	*Plegadis ridgwayi*	Puni Ibis					*		*				*	*					
55	*Phoenicopterus chilensis*	Pisco Flamingo	*	*	*		*		*				*	**		VU	2		
56	*Anas bahamensis*	Bahama Pintail	*	*	*		*		*		*		*	**			1		
57	*Anas georgica*	Yellow Billed Pintail							*		*		*	**			1		
58	*Anas versicolor*	Silver Teal Duck							*		*		*	**			1		
59	*Anas discors*	Blue Wing Teal Duck							*		*		*	**			1		
60	*Anas cyanoptera*	Cinnamon Teal Duck	*	*	*		*		*		*		*	**			1		
61	*Netta erythrophthalma*	Brown Headed Duck							*		*		*	**		EN	1		
62	*Oxyura jamaicensis*	Ruddy Duck							*		*		*	**			1		
63	*Vultur gryphus*	Andes Condor							*		*		*	**		VU	1		
64	*Coragyps atratus*	Black Vulture	*	*	*		*		*		*		*	**					?
65	*Cathartes aura*	Turkey Vulture	*	*	*		*		*		*		*						*
66	Geranoetus melanoleucus	Black Chest Eagle	*	*	*		*		*		*		*	*					
67	*Buteo polysoma*	Red Beak Hawk	*	*	*				*		*		*	*					
68	*Buteo platypterus*	Broad-winged Hawk							*		*		*	*					
69	*Parabuteo unicinctus*	Harris Hawk	*	*	*				*		*		*	*					

N°	Species	Common Name	Tumbes – Progreso Baisn	Talara Basin	Sechura Basin	Trujillo Basin	Salaverry Basin	Lima Basin	Pisco Basin	Mollendo Basin	Coastal	Ocean	Resident	Migrant	IUCN, 2003	National List, DS 013-99-AG	CITES	Endemic	Reproduction (Peru)
70	*Circus cinereus*	Field Hawk	*	*	*				*		*		*	*					
71	*Pandion haliaetus*	Fishing Eagle	*	*	*	*	*	*	*		*		*	*			2		
72	*Falco peregrinus*	Pilgrim Falcon	*	*	*	*	*	*	*		*		*	*		VU	1		
73	*Falco sparverius*	American Falcon	*	*	*				*		*		*	*					
75	*Rallus limicola*	Virginia Rail (small Chicken)							*		*		*						
76	*Gallinula chloropus*	Moor Hen (Water Chicken)							*		*		*						
78	*Fulica ardesiaca*	Andes Coot							*		*		*						
79	*Haematopus palliatus*	Ameican Oyster catcher	*	*	*		*		*		*		*			R			
80	*Haematopus ater*	Black Oyster catcher	*	*	*		*		*		*		*			R			
81	*Vanellus resplendens*	Andean Lapwing	*	*	*		*		*		*			*					
82	*Pluvialis squatarola*	Black Bellied Plover	*	*	*		*		*		*			*					
83	*Pluvialis dominica*	Golden Plover	*	*	*		*		*		*			*					
84	*Charadrius semipalmatus*	Semiplalmated Plover	*	*	*		*		*		*			*					
85	*Charadrius alexandrinus*	Snow Plover	*	*	*		*		*		*		*				1		
86	*Charadrius alticola*	Puna Plover	*	*	*		*		*	*	*		*				1		
87	*Charadrius collaris*	Collared Plover							*		*			*					
88	*Charadrius vociferus*	Double Collared Plover	*	*	*		*		*		*		*						
89	*Charadrius wilsonia*	Heavy Beak Plover	*	*	*		*		*		*			*					
90	*Charadrius modestus*	Rufous-Chested Dotterel	*	*	*		*		*		*			*					
91	*Oreopholus ruficollis*	Tawny-throated Dotterel							*		*			*					
92	*Aphriza virgata*	Surf Plover	*	*	*		*		*		*			*					
93	*Arenaria interpres*	Ruddy Turnstone	*	*	*		*		*		*			*					
94	*Tringa solitaria*	Solitary Sandpiper	*	*	*		*		*		*			*					
95	*Tringa flavipes*	Minor Yellow Legs Sandpiper	*	*	*		*		*		*			*					
96	*Tringa melanoleuca*	Greater Yellow Legs Sandpiper	*	*	*		*		*		*			*					
97	*Actitis macularia*	Spotted Sandpiper	*	*	*		*		*		*			*					
98	*Heteroscelus incanus*	Wandering Tattler	*	*	*		*		*		*			*					
99	*Catoptrophorus semipalmatus*	White Wing Sandpiper	*	*	*		*		*		*			*					
100	*Calidris canutus*	Red Knot Sandpiper	*	*	*		*		*		*			*					
101	*Calidris minutilla*	Least Sandpiper	*	*	*		*		*		*			*					
102	*Calidris bairdii*	Baird Sandpiper	*	*	*		*		*		*			*					
103	*Calidris fuscicollis*	White Rump Sandpiper	*	*	*		*		*		*			*					
104	*Calidris melanotos*	Pectoral Sandpiper	*	*	*		*		*		*			*					
105	*Calidris pusilla*	Semipalmated Sandpiper	*	*	*		*		*		*			*					

N°	Species	Common Name	Tumbes – Progreso Baisn	Talara Basin	Sechura Basin	Trujillo Basin	Salaverry Basin	Lima Basin	Pisco Basin	Mollendo Basin	Coastal	Ocean	Resident	Migrant	IUCN, 2003	National List, DS 013-99-AG	CITES	Endemic	Reproduction (Peru)
106	*Calidris mauri*	Occidental Sandpiper	*	*	*		*		*		*			*					
107	*Calidris alba*	White Sanpiper	*	*	*		*		*		*			*					
108	*Calidris alpina*	Red Sandpiper	*	*	*		*		*		*			*					
109	*Calidris ferruginea*	Whimbrel Sandpiper	*	*	*		*		*		*			*					
110	*Calidris himantopus*	Stilt Sandpiper	*	*	*		*		*		*			*					
111	*Tryngites subruficollis*	Buff-Breasted Sanpiper	*	*	*		*		*		*			*					
112	*Philomachus pugnax*	Combatant Sandpiper	*	*	*		*		*		*			*					
113	*Bartramia longicauda*	Bartram Sandpiper	*	*	*		*		*		*			*					
114	*Micropalama himantopus*	Stilt Sandpiper	*	*	*		*		*		*			*					
115	*Numenius phaeopus*	Whimbrel	*	*	*		*		*		*			*					
116	*Limosa haemastica*	Hudsonian Godwit	*	*	*		*		*		*			*					
117	*Limosa fedoa*	Godmar	*	*	*		*		*		*			*					
118	*Limnodromus scolopaceus*	Long-billed Dowitchers	*	*	*		*		*		*			*					
119	*Limnodromus griseus*	Short Billled Dowitcher	*	*	*		*		*		*			*					
120	*Himantopus mexicanus*	Stork	*	*	*		*		*		*			*					
121	*Phalaropus fulicaria*	Gray Phalarope	*	*	*	*	*	*	*	*	*			*					
122	*Phalaropus lobatus*	Red Neck Phalarope	*	*	*	*	*	*	*		*			*					
123	*Phalaropus tricolor*	Wilson Phalarope	*	*	*	*	*	*	*		*			*					
124	*Burhinus superciliaris*	Peruvian Thick Knee	*	*	*		*		*		*			*					
125	*Catharacta chilensis*	Chilean Skua	*	*	*	*	*	*	*	*	*			*					
126	*Catharacta maccormicki*	South Pole Skua	*	*	*	*	*	*	*	*	*			*					
127	*Stercorarius pomarinus*	Salteador pomarino	*	*	*	*	*	*	*	*	*			*					
128	*Stercorarius parasiticus*	Parasitic Jaeger	*	*	*	*	*	*	*	*	*			*					
129	*Stercorarius longicaudus*	Long Tail Skua	*	*	*	*	*	*	*	*	*			*					
130	*Larus modestus*	Gray Gull	*	*	*	*	*	*	*	*	*			*					
131	*Larus belcheri*	Peruvian Gull	*	*	*	*	*	*	*	*	*						1		*
132	*Larus dominicanus*	Dominican Gull	*	*	*	*	*	*	*	*	*					VU	1		*
133	*Larus atricilla*	Laughing Gull	*	*	*	*	*	*	*	*	*			*					
134	*Larus cirrocephalus*	Gray Hooded Gull	*	*	*	*	*	*	*	*	*						1		*?
135	*Larus serranus*	Andes Gull	*	*	*	*	*	*			*			*		VU			
136	*Larus pipixcan*	Franklin Gull	*	*	*	*	*	*	*		*			*					
137	*Larus sabini*	Sabine Gull	*	*	*	*	*	*	*	*	*			*					
138	*Larus furcatus*	Swallow-tailed Gull	*	*	*	*	*	*	*	*	*			*					
139	*Chlidonias niger*	Black Tern	*	*	*				*		*			*					
140	*Gelochelidon nilotica*	Gullbilled Tern	*	*	*				*		*			*					
141	*Sterna hirundinacea*	South American Tern	*	*	*	*	*	*	*	*	*			*					

N°	Species	Common Name	Tumbes – Progreso Baisn	Tacara Basin	Sechura Basin	Trujillo Basin	Salaverry Basin	Lima Basin	Pisco Basin	Mollendo Basin	Coastal	Ocean	Resident	Migrant	IUCN, 2003	National List, DS 013-99-AG	CITES	Endemic	Reproduction (Peru)
142	*Sterna hirundo*	Common Tern	*	*	*	*	*	*	*	*	*			*					
143	*Sterna paradisea*	Artic Tern	*	*	*	*	*	*	*	*	*			*					
144	*Sterna trudeaui*	White Head Tern							*		*			*					
145	*Sterna fuscata*	Black Tern	*	*					*		*			*					
146	*Sterna lorata*	Peruvian Tern	*	*	*	*	*	*	*	*	*								*
147	*Sterna maxima*	Real Tern	*	*	*	*	*	*	*	*	*			*					
148	*Sterna elegans*	Elegant Tern	*	*	*	*	*	*	*	*	*		*	*	LR				
149	*Sterna sandvicensis*	Sandwich Tern	*	*	*	*	*	*	*	*	*			*					
150	*Sterna antillarum*	Smal Tern	*	*	*	*	*	*	*	*	*			*					
151	*Larosterna inca*	Inca Tern	*	*	*	*	*	*	*	*	*					VU			*
152	*Rynchops niger*	Black Skimmer	*	*	*		*		*		*			*		VU			
153	*Cinclodes taczanowskii*	Cinclodes	*	*	*		*		*		*								*
154	*Geositta peruviana*	Coastal Miner	*	*	*				*		*								
155	*Brotogeris pyrrhopterus*	Macareno dolphin fish	*								*				EN				

IUCN, 1996	Lista Perú (DS 013-99-AG)
EN In danger of extinction	E Extinction Routes
VU Vulnerable	V Vulnerable
DD Deficient Data	R Rare
LR / NT At Risk	I Indeterminable

CHART # 2 MARINE TURTLE REGISTERD IN PERU

N°	SPECIES	COMMON NAME	Tumbes – Progreso Basin	Talara Basin	Sechura Basin	Trujillo Basin	Salaverry Basin	Lima Basin	Pisco Basin	Mollendo Basin	Coastal	Ocean	Resident	Migran	IUCN, 1996	Bonn Commission	National List, DS 013-99-AG	CITES
1	*Chelonia mydas agassizii*	Black Turtle/Green Turtle	*	*	*	*	*	*	*	*			?	*	EN	*	V	1
2	*Caretta caretta*	Large Head Turtel	*	*	*	*	*	*	*	*				*	EN	*	V	1
3	*Eretmochelys imbricata*	Sea Turtle	*	*	*	*	*	*	*	*				*	CR	*	V	1
4	*Lepidochelys olivacea*	Sea Turtle (golfina)	*	*	*	*	*	*	*	*			?	*	EN	*	V	1
5	*Dermochelys coriacea*	Leather Back Turtle	*	*	*	*	*	*	*	*				*	CR	*	V	1

IUCN, 1996	National List (DS 013-99-AG)
CR Critically in danger	EN Extinction Routes
EN In danger of extinction	V Vulnerable
VU Vulnerable	R Rare
DD Deficient data	I Indeterminable
LR/nt At risk	

CHART # 3 IDENTIFICATIONS OF THE BASINS & ATTRIBUTES

	BASIN	ATTRIBUTES	CHARACTERISTICS
NORTH ZONE	Tumbes - Progreso	Sensitive Areas	National Sanctuary Manglares de Tumbes
		Endangered Species	Tumbes Crocodile (*Crocodylus acutus*) and Marine Turtles (Ver CHART # 2.)
			Coastal Birds and Ocean Bires (Ver CHART # 1
			Cetáceos from suborden Mysticeti, Cetáceos from suborder Odontoceti and Pinnípedos (see CHART # 4.)
		Key Species	Red Mangrove (*Rhizophora mangle*)
	BASIN	ATTRIBUTES	CHARACTERISTICS
	Talara	Sensitive Areas	Not identified
		Endangered Species	Marine Turtles (see CHART # 2.)
			Coastal Birds and Ocean Birds (see CHART # 1)
			Cetáceos from suborder Mysticeti, Cetáceos from suborder Odontoceti and Pinnípedos (see CHART # 4)
		Key Species	Sardine (*Sardinops sagax sagax*), Squid (*Dosidicus gigas*)
	BASIN	ATTRIBUTES	CHARACTERISTICS
	Sechura	Sensitive Areas	Study of the Virrilá, Manglares de San Pedro
		Endangered Species	Marine Turtles (see CHART # 2)
			Coastal Birds and Ocean Birds (see CHART # 1)
			Cetáceos from suborder Mysticeti, Cetáceos from suborder Odontoceti and Pinnípedos (see CHART # 4)
		Key Species	Sardine (*Sardinops sagax sagax*), Anchovy (*Engraulis ringens*)
	BASIN	ATTRIBUTES	CHARACTERISTICS
CENTRAL ZONE	Trujillo	Sensitive Areas	Not identified
		Endangered Species	Marine Turtles (see CHART # 2.)
			Coastal Birds and Ocean Birds (see CHART # 1)
			Cetáceos from suborder Mysticeti, Cetáceos from suborder Odontoceti and Pinnípedos (see CHART # 4)
		Key Species	Sardine (*Sardinops sagax sagax*)
	BASIN	ATTRIBUTES	CHARACTERISTICS
	Salaverry	Sensitive Areas	Macabí Island, Guañape North Island, Guañape South Island, Chao Island, Corcovado Island, Santa Island, Ferrol Island, Blanca North Island, Point Culebras, Point Colorado, Point Litera
		Endangered Species	Marine Turtles (see CHART # 2)
			Coastal Birds and Ocean Birds (see CHART # 1)
			Cetáceos from suborden Mysticeti, Cetáceos from suborden Odontoceti and Pinnípedos (see CHART # 4)
		Key Species	Anchovy (*Engraulis ringens*), Sardine (Sardinops sagax sagax)
	BASIN	ATTRIBUTES	CHARACTERISTICS
	Lima	Sensitive Areas	Not identified
		Endangered Species	Marine Turtles (see CHART # 2.)
			Coastal Birds and Ocean Birds (see CHART # 1)
			Cetáceos from suborder Mysticeti, Cetáceos from suborder Odontoceti and Pinnípedos (see CHART # 4)
		Key Species	Anchovy (*Engraulis ringens*), Sardine (Sardinops sagax sagax)

	BASIN	ATTRIBUTES	CHARACTERISTICS
	PISCO		
		Sensitive Areas	National Reserve of Paracas, Asia Island, Chincha Island, Ballestas Island, Point Lomitas
		Endangered Species	Marine Turtles (see CHART # 2.)
			Coastal Birds and Ocean Birds (see CHART # 1)
			Cetáceos from suborder Mysticeti, Cetáceos from suborder Odontoceti, Pinnípedos and Marine Fissipedos (See CHART # 4)
		Key Species	Anchovy (*Engraulis ringens*), Vinciguerria (Vinciguerria lucetia), Múnida (*Pleuroncodes monodon*), Squid (*Dosidicus gigas*)
	BASIN	**ATTRIBUTES**	**CHARACTERISTICS**
SOUTH ZONE	**Mollendo**	Sensitive Areas	Not identified
		Endangered Species	Marine Turtles (see CHART # 2)
			Coastal Birds and Ocean Birds Oceánicas (see CHART # 1)
			Cetáceos from suborder Mysticeti, Cetáceos from suborder Odontoceti Pinnípedos (See CHART # 4)
		Key Species	Anchovy (*Engraulis ringens*), Vinciguerria (Vinciguerria lucetia), Squid (*Dosidicus gigas*), Múnida (*Pleuroncodes monodon*)

CHART # 4 MARINE MAMMALS REGISTERED IN PERU

N°	SPECIES	COMMON NAME	Tumbes – Progreso Basin	Talara Basin	Sechura Basin	Trujillo Basin	Salaverry Basin	Lima Basin	Pisco Basin	Mollendo Basin	Resident	Migrant	IUCN, 1996	National List, DS 013-99-AG	CITES 2003	South Pacific Commision, 1998-2002	Red Book – Peru, 1991	Red Book (Klinowska, 1991)
			ORDER Cetacea				**SUBORDER *Mysticeti***											
1	*Megaptera novaeangliae*	Yubarta Whale	*	*	*	*	*	*	*	*	*	*	VU		1	*		V
2	*Balaenoptera physalus*	Fin Whale, Rorcual	*	*	*	*	*	*	*	*	*	*	VU		1			V
3	*Balaenoptera musculus*	Blue Whale, Rorcual	*	*	*	*	*	*	*	*	*	*	EN		1			E
4	*Balaenoptera edeni*	Brydei Whale	*	*	*	*	*	*	*	*	*	*	DD		1			I
5	*Balaenoptera borealis*	Rorcual de Rudolphi Whale	*	*	*	*	*	*	*	*	*	*	VU		1			V
6	*Balaenoptera acutorostrata*	Minke Whale	*	*	*	*	*	*	*	*	*	*	LR		1			I
			ORDER Cetacea				**SUB-ORDER Odontoceti**											
7	*Physeter macrocephalus*	Cachalote, Sperm Whale	*	*	*	*	*	*	*	*	*	*			1	*		I
8	*Orcinus orca*	Orca, Tonina	*	*	*	*	*	*	*	*	*	*	LR		2			I
9	*Grampus griseus*	Gray Dolphin, Risso	*	*	*	*	*	*	*	*	*	*	DD		2			I
10	*Globicephala macrorhynchus*	Short Fin Whale	*	*	*	*	*	*	*	*	*	*	LR		2			I
11	*Globicephala melas*	Long Fin Whale			*	*	*	*	*	*	*	*	DD					I
12	*Kogia simus*	Dward Whale	*	*	*	*	*	*	*	*	*	*	DD		2			I
13	*Kogia breviceps*	Small Head Whale	*	*	*	*	*	*	*	*	*	*	DD		2			I
14	*Mesoplodon grayi*	Gray Tip Whale							*	*	*	*	DD		2			I

CHART # 4 MARINE MAMMALS REGISTERED IN PERU

		ORDER **Cetacea** SUB-ORDER **Odontoceti**																
15	*Mesoplodon peruvianus*	Peruvian Tip Whale	*	*	*	*	*	*	*		*	*	DD		2	*		I
16	*Ziphius cavirostris*	Cuvier Tip Whale	*	*	*	*	*	*	*	*	*	*	DD		2			I
17	*Pseudorca crassidens*	False Commmon Orca	*	*	*	*	*	*	*	*	*	*			2			I
18	*Peponocephala electra*	Melon head Dolphin	*	*	*	*	*	*	*	*	*	*	DD		2			I
19	*Phocoena spinipinnis*	Throny Marsopa Whale	*	*	*	*	*	*	*	*	*	*	DD	P	2			I
20	*Lagenorhynchus obscurus*	Black Dolphin			*	*	*	*	*	*	*	*	DD	P	2	*		I
21	*Steno bredanensis*	Long Beak Dolphin	*	*	*	*	*	*	*	*	*	*	DD		2			I
22	*Stenella coeruleoalba*	Stried Dolphin	*	*	*	*	*	*	*	*	*	*	LR		2			I
23	*Tursiops truncatus*	Bottle Nose Dolphin, Aduncus	*	*	*	*	*	*	*	*	*	*	DD	P	2	*		I
24	*Delphinus delphis*	Common Dolphin	*	*	*	*	*	*	*	*	*	*	DD	P	2	*		I
25	*Delphinus capensis*		?	?	?	?	?	?	*	?	*	*		P	2	*		I
		ORDER **Carnivora** SUB-ORDER **Pinnipedia**																
26	*Arctocephalus australis*	Sea Lion Small, Cochapuma		*	*	*	*	*	*	*	*			E	2	*		
27	*Otaria byronia*	Sea Lion Large, Cochapuma		*	*	*	*	*	*	*	*			V	2	*		
		ORDER **Carnivora** SUB-ORDER **Fissipedia (Marine)**																
28	*Lutra felina*	Marine Cat, Chingungo, Marine Nutria							*		*		EN	E	1	*	E	

CATEGORIES	IUCN Threatened Category	Peru List (DS 013-99-AG)	CITES	Red Book –Klinowska, 1991
	EN In danger of extinction	E In danger of extinction	(1) Protectedspecies	E In danger of extinction
	VU Vulnerable	V Vulnerable	(2) Permitted for monitoring and scientific evaluation	V Vulnerable
	DD Deficient data	R Rare	(3) proposed for conservation	R Rare
	LR At Risk	I Indetermined		I Indeterminde
	Red Book – Peru, 1991	South Pacific Comisión 1998 – 2002		
	E In danger of extinction	(*) Urgent need of marine *ariega*		
	V Vulnerable	Conservation politics		
	R Rare			
	I Indetermined			

CHART # 5 KEY SPECIES IN SEDIMENTARY BASINS

N°	SPECIES	COMMON NAME	Tumbes – Progreso Basin	Talara Basin	Sechura Basin	Trujillo Basin	Salaverry Basin	Lima Basin	Pisco Basin	Mollendo Basin
		Flora Silvestre								
1	*Rhizophora mangle*	Red Mangrove	*							
		Pelagic Fish								
2	*Engraulis ringens*	Anchovy			*		*	*	*	*
3	*Sardinops sagax sagax*	Sardine		*	*	*	*	*		
4	*Vinciguerria lucetia*	Vinciguerria							*	*
		Marine Invertebrae								
5	*Dosidicus gigas*	**Squid**		*					*	*
6	*Pleuroncodes monodon*	**Múnida**							*	*

CHART # 7 REGISTERED ENDANGERED SPECIES IN PROTECTED AREAS

PROTECTED AREA	SPECIES IN DANGER OF EXTINCTION	VULNERABLE SPECIES
National Sancutary of Manglares de Tumbes	Cocodrilo de Tumbes "*Crocodylus acutus*", Perro conchero o Mapache " *ariega cancrivorus*"(Tumbes Crocodile)	Flamenco *"Phoenicopterus chilensis"*, Dominican Gull *"Larus dominicanus"*, Pelícano *"Pelecanus thagus"*, ariega *"Sula nebouxii"*, Macareño dolphin fish *"Brotogeris pyrrhopterus"*, Small sea turtle *"Lepidochelys olivacea"*, Green turtle *"Chelonia agassizzii"*, Leatherback turtle *"Dermochelys coriacea"*, Espátula rosada. *"Ajaia ajaja"*
National Reserve of	Lobo fino *"Arctocephalus australis"*, Gato marino *"Lutra arieg"*, Potoyunco *"Pelecanoides garnottii"*, Pingüino de Humboldt *"Spheniscus humboldti"* (Fine Wolf; Marine Cat; Humbolt Pinguin)	Chusco Wolf"*Otaria byronia"*, Flamenco *"Phoenicopterus chilensis"*, Dominican Gull *"Larus dominicanus"*, Pelícano *"Pelecanus thagus"*, Piquero *"Sula ariegate"*, Guanay *"Phalacrocorax bougainvilli"*, Sea Cuervo *"Phalacrocorax olivaceus"*, Chuita *"Phalacrocorax gaimardi"*, Small sea turtle *"Lepidochelys olivacea"*, Green turtle"*Chelonia mydas"*, Leatherback turtle *"Dermochelys coriacea"*

CHART # 6 SENSITIVE AREAS IN THE SEDIMENTARY BASINS

TUMBES PROGRESO BASIN		
Protected Natural Areas	**Location**	**Extension (Ha)**
National Sanctuary of Los Manglares de Tumbes	03° 24' – 3° 27' LS ; 80° 13' – 80° 19' LW	2972
SECHURA BASIN		
Potential Areas	**Location**	**Extension (Ha)**
Estuario de Virrilá	05° 45' – 5° 54' LS ; 80° 42' – 80° 52' LW	7000
Manglares de San Pedro	05° 30' – 5° 34' LS ; 80° 41' – 80° 53' LW	1500
SALAVERRY BASIN		
Potentitial Areas	**Location**	**Extension (Ha)**
Island Macabí	07° 47' 30" LS – 79° 30' 10" LW	7.78
Island Guañape Norte	08° 32' 00" LS – 78° 58' 30" LW	34.87
Island Guañape Sur	08° 34' 00" LS – 78° 59' 00" LW	26.17
Island Chao	08° 46' 20" LS – 78° 48' 00" LW	15.33
Island Corcovado	08° 56' 50" LS – 78° 42' 00" LW	3.75
Island Santa	09° 09' 20" LS – 78° 39' 50" LW	142.42
Island Ferrol	09° 08' 28" LS – 78° 37' 40" LW	23.55
Island Blanca Norte	09° 06' 15" LS – 78° 37' 45" LW	227.50
Punta Culebras	09° 57' 00" LS – 78° 14' 20" LW	56.00
Punta Colorado	10° 30' 20" LS – 77° 58' 15" LW	17.53
Punta Litera	10° 34' 10" LS – 77° 54' 50" LW	82.00
PISCO BASIN		
Protected Natural Areas	**Location**	**Extenion (Ha)**
National Reserve of Paracas	13° 47' – 14° 17' LS ; 76° 00' – 76° 30' LW	335000
Potential Areas	**Location**	**Extenion (Ha)**
Island Asia	12° 47' 40" LS – 76° 37' 02" LW	70.86
Islands Chincha	13° 39' 48" LS – 76° 25' 05" LW	156.46
Islands Ballestas	13° 44' 45" LS – 76° 24' 10" LW	32.37
Punta Lomitas	14° 42' 45" LS – 75° 51' 05" LW	6.90

CHART # 8. VALUE OF FISHING EXPORTS (MM DOLLARS) EXPORT PARTICIPATION AT THE NATIONAL LEVEL (1997 – 2002)

Products	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%
Traditional Products	1,125.90	16.62	413.70	7.23	602.00	30.79	954.60	46.92	926.50	28.50	891.10	15.90
Flour	1,030.80	15.21	395.40	6.91	533.70	27.30	874.00	42.04	835.40	25.70	821.70	14.66
Oil	95.10	1.40	18.30	0.32	68.30	3.49	80.60	3.88	91.10	2.80	69.40	1.24
Non-Traditional Products	275.00	4.06	225.40	3.94	190.90	9.76	177.10	8.52	197.50	6.08	164.60	2.94
Canned	63.90	0.94	40.60	0.71	42.80	2.19	44.20	2.13	43.20	1.33	25.40	0.45
Frozen	200.30	2.96	176.90	3.09	134.80	6.90	114.30	5.50	129.30	3.98	116.70	2.08
Cured	3.40	0.05	3.80	0.07	4.10	0.21	7.40	0.36	6.70	0.21	5.30	0.09
Others	7.40	0.11	4.10	0.07	9.20	0.47	11.20	0.54	18.30	0.56	17.20	0.31
Total fishing sector	1,400.90	20.68	639.10	11.16	792.90	40.56	1,131.70	54.43	1,124.00	34.57	1,055.70	18.83
National	6,775.25		5,725.84		6,041.92		6,882.19		6,956.25		7,608.24	
* PBI National	33,452.29	4.19	33,312.86	1.92	33,774.00	2.35	34,787.14	3.25	34,856.86	3.22	36,669.43	2.88

Source: ADUANAS–yearly statistics-PRODUCE 2002

* exchange rate US$1 =S/. 3.5

CHART # 9. FISHING THROUGHOUT THE NATION (Ton) BETWEEN1993-2002

Species – Fish		Years									
Common Name	Scientific Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Needle	*Strongylura exilis*										
Anchovy	*Engraulis ringens*	7,009,534	9,800,223	6,558,108	7,463,147	5,927,599	1,206,322	6,740,225	9,575,717	6,358,217	8,104,729
Tuna	*Thunnus albacares*	3,573	269	914	953	908	12,747	2,784	2,548	4,175	5,967
Ayanque	*Cynoscion analis*	9,676	5,248	8,902	7,475	5,501	10,795	8,558	5,995	4,107	3,147
Bonita	*Sarda sarda chilensis*	36,976	31,125	28,331	23,059	17,731	5,130	948	434	1,287	865
Mackarel	*Scomber japonicus*	29,504	44,115	44,259	49,221	206,183	401,903	527,729	73,263	176,202	32,698
Cabinza Grunt	*Isacia conceptionis*	987	505	1,342	1,955	1,892	2,079	2,791	3,251	3,293	5,606
Peruvian Rock Seabass	*Paralabrax humeralis*	3,647	3,104	5,837	4,954	2,769	2,554	3,278	4,373	2,001	1,522
Peruvian Grunt	*Anisotremus scapularis*	416	185	890	194	379	266	318	183	307	-
Coco	*Paralonchurus peruanus*	7,550	3,788	5,543	4,263	2,737	4,363	6,063	5,729	4,167	1,886
Cojinova	*Seriolella violacea*	2,795	8,892	7,698	3,704	388	505	1,589	1,473	3,192	2,192
Eel	*Genypterus maculatus*	640	639	1,631	1,121	-	425	2	560	554	1,033
Corvina	*Cilus gilberti*	1,369	602	704	733	606	1,068	1,268	1,056	576	2
Jack Macakerl	*Trachurus picturatus murphyi*	130,681	196,771	376,600	438,736	649,751	386,946	184,679	296,579	723,733	154,219
Lenguado	*Paralichthys adspersus*	1,195	732	1,559	528	203	230	263	177	313	256
Striped Muller	*Mugil cephalus*	14,711	16,964	16,601	13,916	13,264	29,075	20,843	26,314	24,189	19,472
Lorna	*Sciaena deliciosa*	4,098	4,275	4,353	7,920	2,211	5,027	5,695	3,692	3,295	5,242
Machete	*Ethmidium maculatum*	5,860	4,348	3,140	5,769	7,135	39,311	25,848	19,014	9,085	9,829
Merluza	*Merluccius gayi peruanus*	88,700	135,705	181,182	234,915	177,953	82,365	37,121	83,361	125,065	46,251

CHART # 9. DISTRIBUTION OF MARINE FISHING THROUGHOUT THE NATION (Ton) BETWEEN1993-2002

Species - Fish		Years									
Common Name	Scientific Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Pejerrey	*Odontesthes regia regia*	1,395	2,207	2,357	3,802	5,184	45	6,692	11,215	7,528	11,220
Golden Dolphin fish	*Coryphaena hippurus*	3,084	3,325	6,598	1,558	4,648	21,104	2,084	11,159	28,025	29,787
Pintadilla	*Cheilodactylus variegatus*	111	95	93	283	411	90	236	335	260	356
Striped	*Myliobatis peruvianus*	3,632	1,658	1,841	1,126	1,177	1,477	2,789	4,026	2,034	2,502
Samasa	*Anchoa nasus*	63,420	39,844	189,389	59,639	24,703	706,167	11,242	3,868	137,098	6,022
Sardine	*Sardinops sagax sagax*	1,461,759	1,551,833	1,265,658	1,056,413	625,143	908,291	187,824	226,294	60,298	6,853
Shark	*Prionace glauca*	1,212	548	694	1,506	1,915	4,335	2,951	4,307	3,618	3,433
Tollo	*Mustelus sp.*	8,747	3,431	4,125	3,230	3,166	8,038	2,892	4,042	4,648	7,015
Total		8,895,272	11,860,431	8,718,349	9,390,120	7,683,577	3,840,658	7,786,712	10,368,965	7,687,267	8,462,104

CHART # 9. DISTRIBUTION OF MARINE FISHING THROUGHOUT THE NATION (Ton) BETWEEN1993-2002

Seafood		Years									
Common Name	Scientific Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Crabs	*Cancer sp.*	1,027	1,383	2,553	1,605	303	752	11,397	1,794	1,568	2,838
Lobster	*Panulirus sp.*	14	52	168	52	12	669	496	278	62	20
Prawn	*Penaeus sp.*	9,270	9,610	10,877	92,245	15,648	22,329	7,255	1,852	5,988	4,129
Abalonee	*Sinum cymba*	2,919	2,557	1,361	2,728	4,323	830	1,970	1,405	522	686
Clam	*Gari solida*	668	643	569	411	236	152	338	956	949	978
Calamari	*Loligo spp.*	1,316	1,215	7,766	10,250	3,806	287	1,353	24,548	18,738	6,490
Crabs	*Cancer spp.*	1,027	1,383	2,553	1,605	303	752	9,746	-	1,568	2,838
Snail	*Thais chocolata*	2,871	2,504	3,686	2,215	7,098	3,110	4,525	2,768	4,995	2,349
Scallops	*Argopecten purpuratus*	3,032	1,333	3,544	2,487	4,009	24,546	30,141	11,810	6,272	7,732
Mussel	*Aulacomya ater*	5,976	7,203	11,204	6,023	9,669	15,106	14,612	13,370	15,600	15,658
Macha	*Mesodesma donacium*	1,513	1,070	1,200	1,060	1,061	578	-	10	-	85
Squid	*Dosidiscus gigas*	140,355	209,970	109,155	8,138	16,061	547	54,648	53,795	71,834	146,390
Others		1,806	1,225	1,567	1,810	4,375	7,339	5,495	5,828	3,026	2,395
Total		171,794	229,103	142,605	36,727	50,941	53,247	122,828	114,490	123,504	185,601

Source: *Anuario Produce – 2002*

CHART # 10 Hidrobiological Resources by Production Type (ton)

PRODUCT: FROZEN

ZONES	PORT	YEARS 2000	2001	2002	2003	Annual Average
NORTH ZONE	Talara					
	Zorritos	1,124	925	-	-	1,025
	Bayovar	4,178	11,032	14,833	13,867	10,978
	Caleta Cruz	14,834	15,138	16,669	15,707	15,587
	Paita	92,184	141,420	123,990	106,277	115,968
	Parachique	-	-	255	1,956	1,106
CENTRAL ZONE	Callao	4,240	6,928	3,196	11,983	6,587
	Casma	-	70	75	-	73
	Chancay	-	-	-	206	206
	Chicama	-	77	-	-	77
	Chimbote	6,279	317	68	764	1,857
	Huarmey	-	866	1,150	1,862	1,293
	Samanco	1,778	2,026	576	4,227	2,162
PISCO	Pisco	1,366	187	317	534	601
	San Andrés	-	133	396	560	363
	San Juan Marcona	-	33	38	-	36
SOUTH ZONE	Ilo	1,966	1,850	-	1,669	1,828
	Matarani	-	1,062	2,684	1,551	1,766
	Mollendo	-	412	1,019	2,500	1,310
	Tacna	3,400	4,915	5,909	3,875	4,525
	Total annual	5,366	8,239	9,612	9,595	8,203
	Others	6,447			6,918	3,341
	Total	137,796	187,391	171,175	174,456	167,705

CHART # 10 Hidrobiological Resources by Production Type (ton)

PRODUCTO: CURED

ZONES	PORT	YEARS 2000	2001	2002	2003	Annual Average
NORTH ZONE	Zorritos	-	83	77	-	80
	Paita	9,872	4469	2,022	-	5,454
	Parachique	-	-	1527	-	1,527
	San José	1,810	1358	4472	-	2,547
	Santa Rosa	9,636	12700	13129	-	11,822
	Sechura	-	3584	-	-	3,584
CENTRAL ZONE	Callao	71	74	51	96	73
	Casma	-	-	-	-	-
	Chicama	-	-	-	-	-
	Chimbote	4,936	2022	1875	-	2,944
	Huarmey	-	-	-	-	-
PISCO	Pisco	1,721	3,131	3,428	4472	3,188
	San Andrés	-	-	-	-	-
	San Juan Marcona	-	64	90	201	118
	Tambo de Mora	569	1,598	1,187	2,131	1,371
SOUTH ZONE	Ilo	-	-	-	-	-
	Matarani	-	-	-	-	-
	Mollendo	-	3,209	3,809	5,465	4,161
	Tacna	365	66	107	-	179
	Total annual	365	3,275	3,916	5,465	3,255
	Other	4,153	2368	108	-	2,210
	Total	33,133	34,729	31,882	12,366	28,027

CHART # 10 Hidrobiological Resources by Production Type (ton)

PRODUCT: CANNED

ZONES	PORTS	YEARS 2000	2001	2002	2003	Annual Averag
NORTH ZONE	Bayovar	-	-	-	-	-
	Caleta Cruz	-	-	-	-	-
	Santa Rosa	-	7	-	-	7
	Zorritos	-	-	-	-	-
	Paita	85,911	56571	17,471	18,824	44,694
	Parachique	5,049	810	360.8	658	1,719
CENTRAL ZONE	Callao	5,204	6316	4,668	6,731	5,730
	Huacho	2,563	2742	2,381.78	2,495	2,545
	Chancay	720	749	1,010.46	193	668
	Coishco	81,124	58452	16,875.85	70,318	56,692
	Chimbote	31,752	44831	13,361.09	57,292	36,809
	Huarmey	4,023	-	-	-	4,023
	Samanco	-	-	-	1,178	1,178
	Supe	45	316	-	-	181
PISCO	Pisco	1,224	694	635	671	806
	San Andrés	-	201	271.79	367	280
	Tambo de Mora	-	-	-	-	-
SOUTH ZONE	Ilo	1,921	1667	968	7,617	3,043
	Matarani	-	-	-	-	-
	Mollendo	2,338	1149	1,258	1,011	1,439
	Tacna	1,118	-	522	789	810
	Total annual	**5,377**	**2,616**	**2,747**	**9,417**	**5,089**
	Others	-	405	-	-	405
	Total	222,992	174,910	59,783	168,144	156,457

CHART # 10 Hidrobiological Resources by Production Type (ton)

PRODUCT: FLOUR & OIL

ZONES	PORTS	YEARS 2000	2001	2002	2003	Annual Average
NORTH ZONE	Bayovar	250,071	170,643	198,763	345,617	241,274
	Caleta Cruz	0	0	-	0	0
	Paita	706,561	591,829	387,089	588,659	568,535
	Parachique	299,440	184,583	167,895	300,158	238,019
	Samanco	126,067	117,486	41,181	108,944	98,420
	Salaverry	11,152	624	149	330,125	85,513
	Santa Rosa	-	5	-	0	3
CENTRAL ZONE	Chimbote	1' 635,960	1' 542,508	1,179,544	57,004	618,274
	Coishco	493,341	535,200	444,344	796,524	567,352
	Huarmey	192,334	233,009	210,192	151,831	196,842
	Pucusana	-	21,131	22,252	331,767	125,050
	Vegueta	428,977	331,638	324,532	87,510	293,164
	Supe	435,870	349,043	402,236	116,272	325,855
	Huacho	266,075	182,050	217,148	251,773	229,262
	Callao	684,381	348,685	452,069	103,958	397,273
	Casma	212,494	208,132	167,984	154,790	185,850
	Chancay	1' 093,107	580,043	711,325	257,668	516,345
	Chicama	1' 012,550	715,079	653,735	1' 160,219	684,407
PISCO	Pisco	1' 112,251	501,478	867,009	20,782	463,090
	Tambo de Mora	508,602	184,122	337,861	8,801	259,847
SOUTH ZONE	Ilo	270,513	219,174	908,569	1,563	349,955
	Matarani	60,235	60,661	154,088	143,013	104,499
	Mollendo	37,712	44,036	66,192	-	49,313
	La Planchada	19,685	52,043	91,075	8,681	42,871
	Atico	55,056	34,848	151,583	21,348	65,709
	Total annual	**443,201**	**410,762**	**1,371,507**	**174,605**	**600,019**
	Total	5,058,566	5,665,542	8,156,815	4,186,788	5,766,928

CHART # 11 DISTRIBUTION OF MARITIME RESOURCES FOR INDIRECT HUMAN CONSUMPTION ACCORDING TO SPECIES IN TON

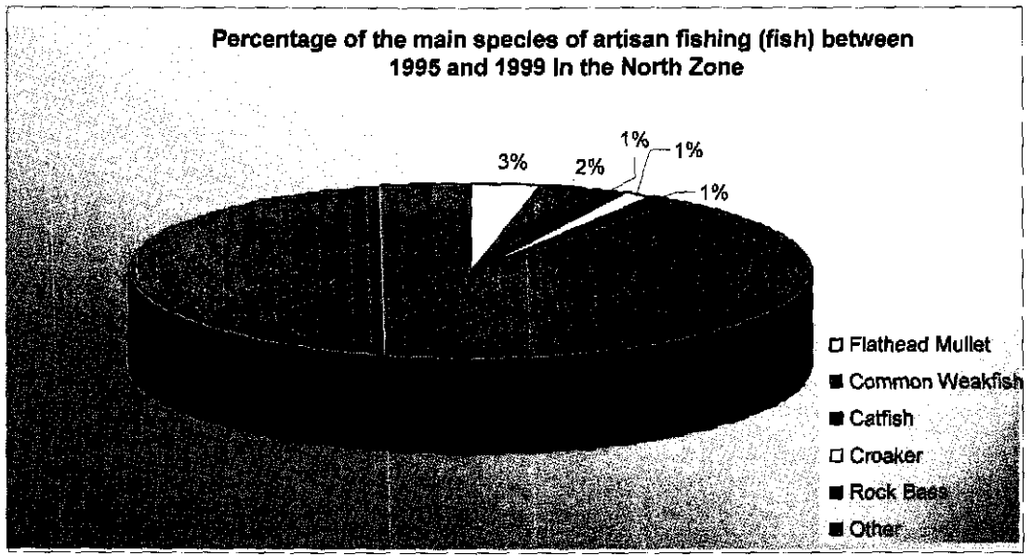
Species		YEARS									
Common Name	Scientific Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Anchovy	*Engraulis ringens*	7,008,508	9,799,498	6,557,743	7,460,420	5,923,005	1,205,537	6,731,987	9,555,607	6,347,871	8,082,897
Mackarel	*Scomber japonicus*	6,572	19,510	19,928	35,694	150,729	354,525	469,364	37,319	130,534	6,637
Jack Macaker	*Trachurus picturatus murphyi*	55,146	99,802	272,515	343,430	488,406	302,466	132,789	153,425	512,798	48,642
Machete	*Ethmidium maculatum*	3,592	2,414	1,570	72	3,413	18,433	21,156	9,560	-	-
Sardine	*Sardinops sagax sagax*	1,340,063	1,395,117	1,061,346	835,699	339,864	751,295	31,886	82,241	8,387	1,191
Samasa	*Anchoa nasus*	-	-	189,308	59,637	24,703	705,895	11,127	3,801	1,365,121	6,011
Others		80,521	49,426	48,212	33,908	64,529	64,529	115,741	40,530	50,169	11,437
Total		8,494,402	11,365,767	8,150,622	8,768,860	6,994,649	3,402,680	7,513,852	9,882,483	8,414,680	8,156,815

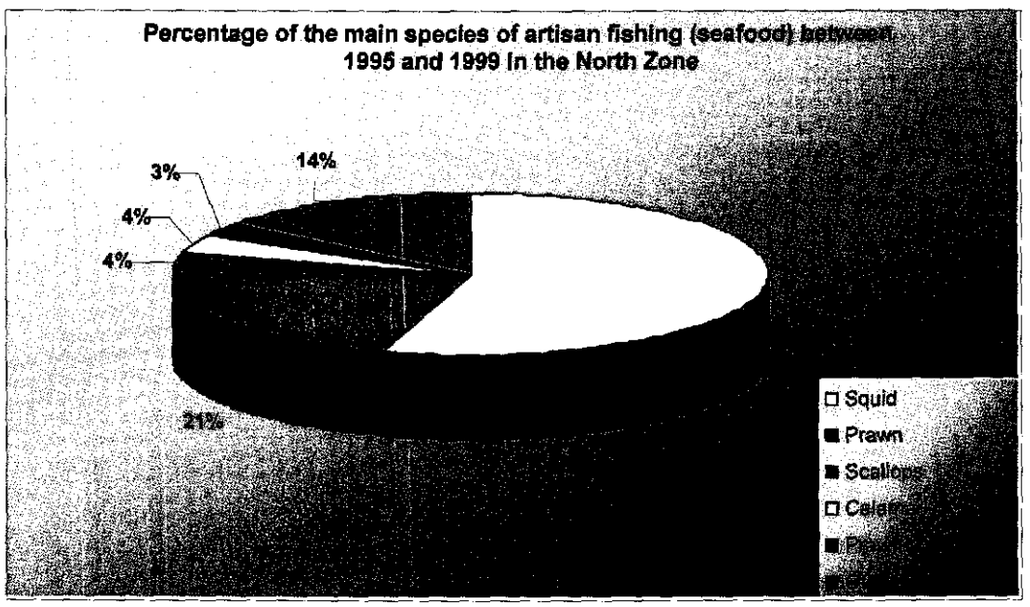
"0" = value less than 0.5 metric tonnes
Source: PRODUCE – web page
(-) no information

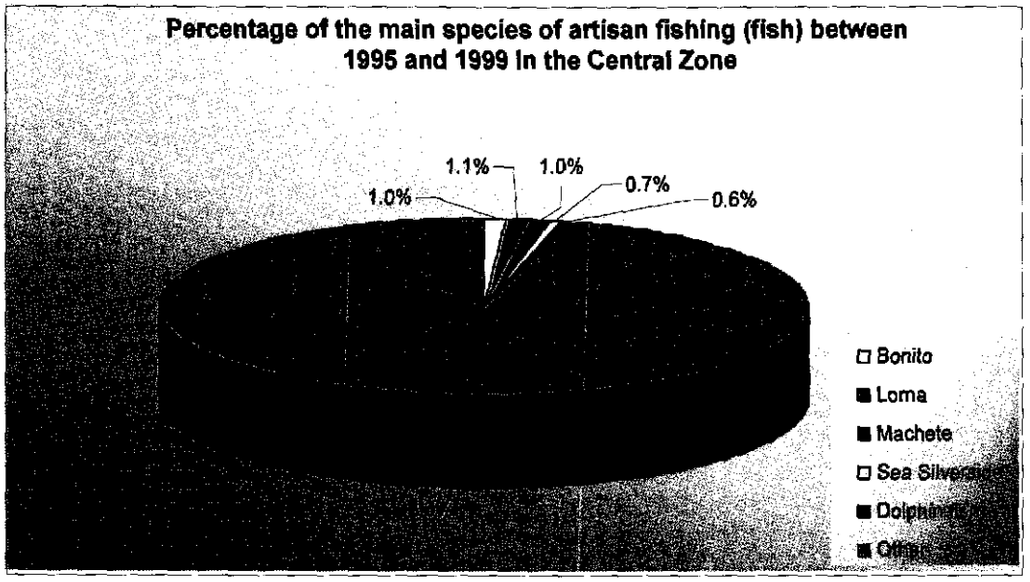
CHART # 12 MARINE PRODUCTS – ACCORDING TO SPECIES (1994 -2003)

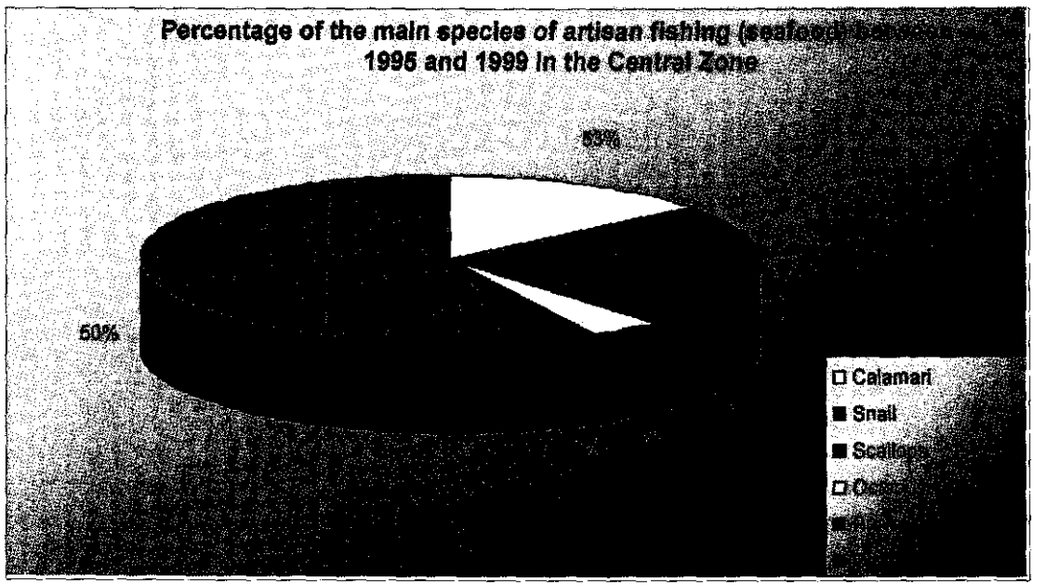
Species		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Prawn	*Litopenaeus vannamei*	4,620	4,836	5,258	6,080	3,462	4,312	615	731	2,592	2,691
C. de abanico	*Argopecten purpuratus*	615	431	1,027	465	1,905	2,640	3,916	3,914	5,701	7,312
Oysters	*Crassostrea gigas*	-	-	-	14	8	7	5	11	9	1
Seaweed	*Gracilaria sp.*	-	4	64	63	0	53	11	-	-	-
TOTAL		5,235	5,271	6,349	6,622	5,375	7,012	4,547	4,656	8,302	10,004

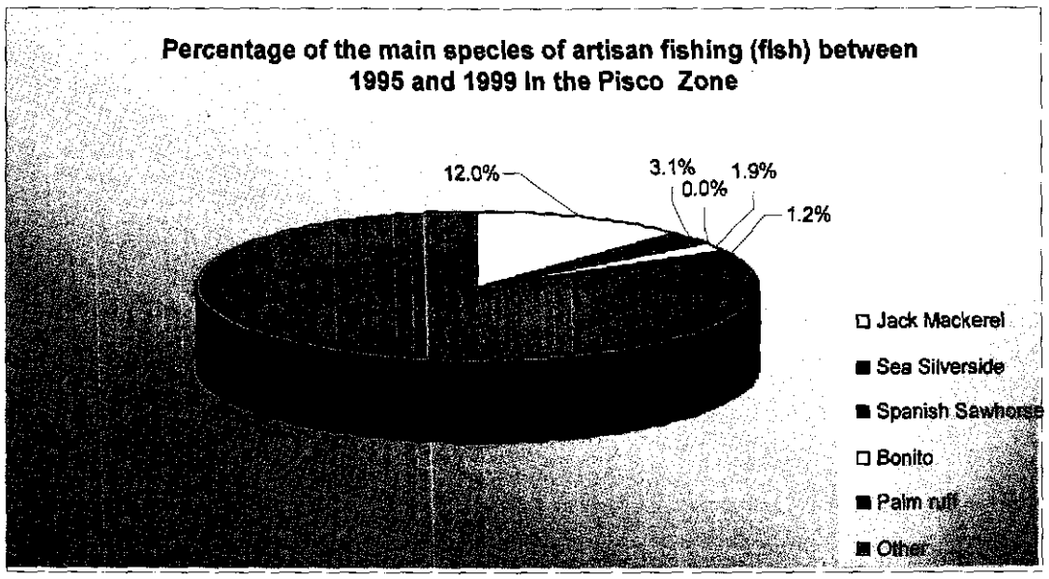
FIGURE 1. THE MAIN SPECIES THAT SUSTAINS ARTISAN FISHING

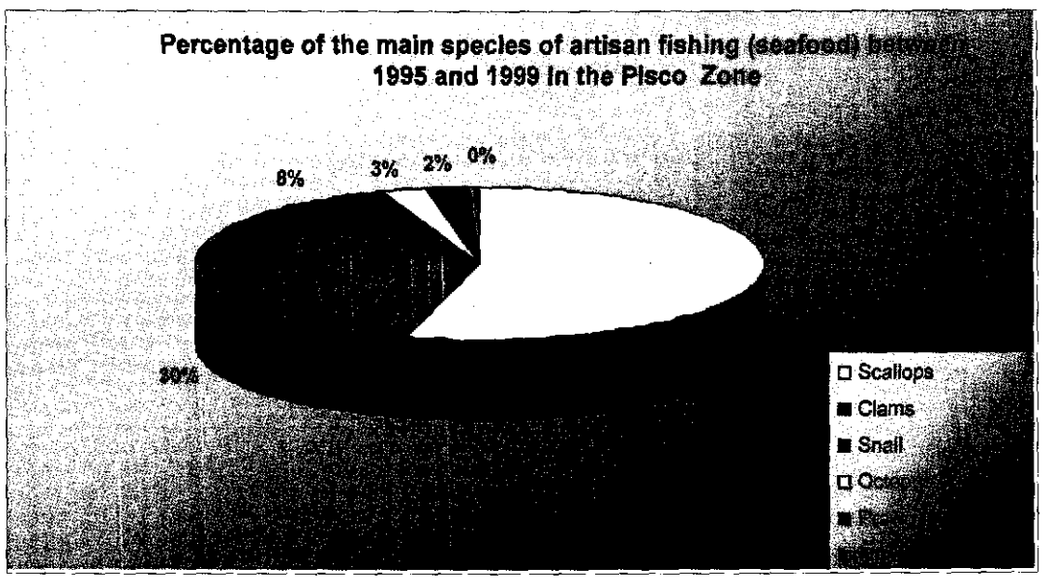


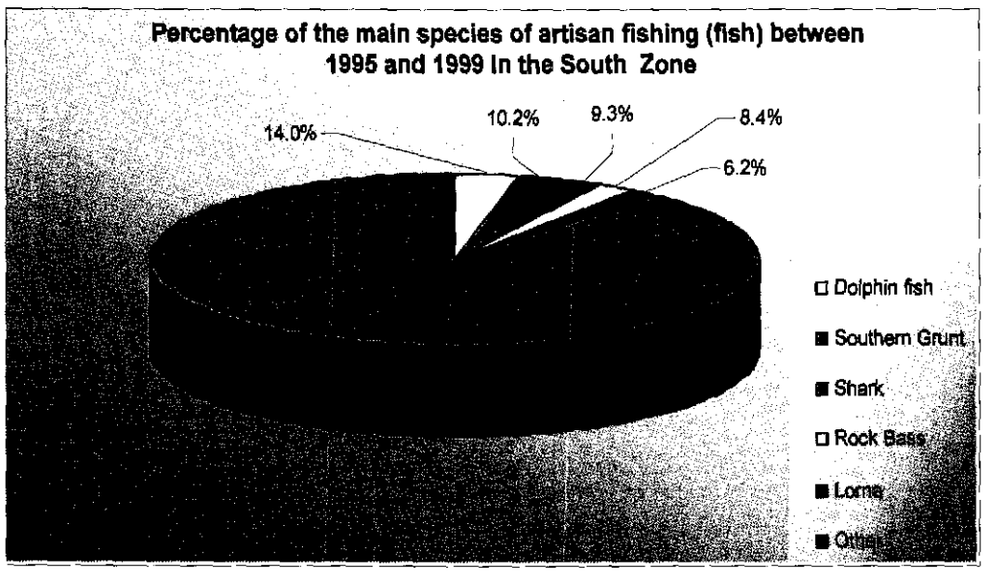



Percentage of the main species of artisan fishing (fish) between 1995 and 1999 in the Central Zone
1.1%
1.0%
1.0%
0.7%
0.6%
Bonito
Loma
Machete


Percentage of the main species of artisan fishing (seafood
1995 and 1999 in the Central Zone
50%
Calamari
Snail


Percentage of the main species of artisan fishing (fish) between
1995 and 1999 in the Pisco Zone
12.0%
3.1%
0.0%
1.9%
1.2%
Jack Mackerel
Sea Silverside
Spanish Sawhorse
Bonito
Palm ruff
Other


Percentage of the main species of artisan fishing (seafood)
1995 and 1999 in the Pisco Zone
8%
3%
2%
0%
Scallops
Clams
Snail


Percentage of the main species of artisan fishing (fish) between 1995 and 1999 in the South Zone
14.0%
10.2%
9.3%
8.4%
6.2%
Dolphin fish
Southern Grunt
Shark
Rock Bass
Lorna

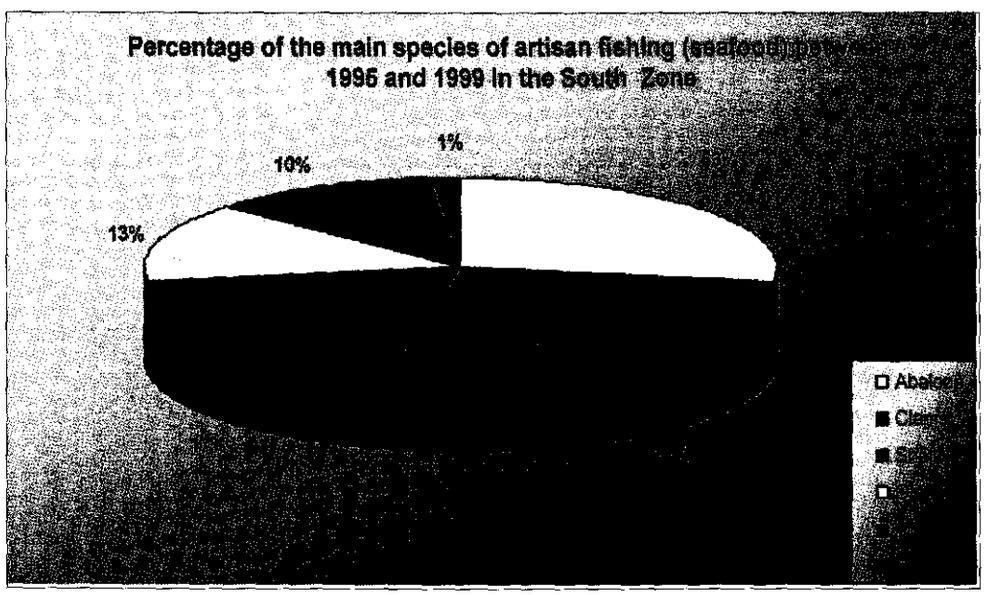

Percentage of the main species of artisan fishing (seafood) between 1995 and 1999 in the South Zone
1%
10%
13%

CHART # 13 DISTRIBUTION OF HIDROBIOLOGICAL RESOURCES IN BETWEEN FISHING COVES EL ALGARROBO AND PACASMASYO (Ton). NORTH ZONE

Common Name	Scientific Name	1994	1995	1996	1997	1998	1999	Total	Annual Average
Fish	Total	1,082,328	1,203,511	1,881,425	960,102	2,282,555	959,081	7,286,674	1,457,335
Anchovy	*Engraulis ringens*	51,621	257,330	737,073	351,511	205	511,941	1,858,060	538,249
Sardine	*Sardinops sagax sagax*	821,800	554,023	773,561	169,736	415	5,724	1,503,459	546,960
Needle	*Strongylura exilis*	185	373	1,168	97	1,187,963	362	1,189,963	340,016
Jack Mackarel	*Trachurus picturatus murphyi*	106,109	226,054	190,185	185,565	314,097	57,799	973,700	293,358
Mackarel	*Scomber japonicus*	10,552	19,632	20,129	120,269	228,885	225,316	614,231	177,002
Merluza	*Merluccius gayi peruanus*	49,179	113,366	124,734	88,915	69,056	27,073	423,144	127,924
Vocador/False Flyer	*Prionotus stephanophrys*	13	983	439	26,415	290,274	1	318,112	90,891
Samasa	*Anchoa nasus*	0	0	0	0	139,099	0	139,099	39,743
Sierra	*Scomberomorus sierra*	360	339	501	125	552	56,698	58,215	16,684
Machete	*Ethmidium maculatum*	2,702	3,118	3,884	537	15,337	9,562	32,438	9,654
Bereche	*Larimus pacificus*	122	36	4,143	515	2,896	19,934	27,524	7,881
Striped Muller	*Mugil cephalus*	8,875	2,811	4,051	3,429	7,527	6,264	24,082	8,148
Ayanque/cachema	*Cynoscion analis*	4,042	3,784	4,293	1,633	4,152	6,839	20,701	6,492
Bagre	*Galeichthys spp.*	184	112	302	142	777	10,765	12,098	3,483
Coco/suco	*Paralonchurus peruanus*	2,707	1,923	3,130	907	1,106	3,260	10,326	3,337
Peruvian Rock Seabass	*Paralabrax humeralis*	1,473	3,325	1,433	1,408	1,083	3,048	10,297	3,152
Skip Jack	*Katsuwonus pelamis*	109	68	406	490	6,403	2,145	9,512	2,733
Bonita	*Sarda chiliensis chiliensis*	11,041	2,146	309	1,989	850	278	5,572	3,169
Golden Dolphin Fish	*Coryphaena hippurus*	1,957	1,497	253	181	2,046	307	4,284	1,504
Tuna	*Thunnus spp.*	328	657	762	1,604	239	1,698	4,960	1,464
Angel Fish	*Squatina armata*	133	207	401	201	3,742	346	4,897	1,418
Lorna	*Sciaena deliciosa*	1,642	2,121	1,225	366	68	48	3,826	1,328
Ray	*Urotrygon spp.*	189	161	562	1,347	378	1,666	4,114	1,202
Corvina	*Cilus gilberti*	143	3,340	201	43	137	215	3,936	1,145
Ocean Whitefish	*Caulolatilus affinis*	805	1,276	1,506	388	100	167	3,437	1,097
Tollo	*Mustelus whitneyi*	1,629	1,066	962	340	1	438	2,807	1,035
Minor	*Selene peruviana*	544	118	479	303	642	1,792	3,334	1,030
Shark	*Isurus oxyrinchus*	13	215	950	80	801	1,154	3,200	916
Pampano	*Trachinotus paitensis*	436	381	361	82	471	1,519	2,814	866

CHART # 13 DISTRIBUTION OF HIDROBIOLOGICAL RESOURCES IN BETWEEN FISHING COVES EL ALGARROBO AND PACASMASYO (Ton). NORTH ZONE

Comon Name	Scientific Name	1994	1995	1996	1997	1998	1999	Total	Annual Average
Eel	*Genyonemus [illegible]*	253	759	840	466	153	415	2,633	788
Golden Croaker	*Menticirrhus [illegible]*	278	636	980	205	615	172	2,608	785
Pelagic fish	*Clupeoids [illegible]*	781	0	7	1	1,811	0	1,819	631
Red Bridge	*Hydrolagus [illegible]*	778	363	193	115	42	22	735	321
Cabinza chunk	*Isacia [illegible]*	82	60	725	213	6	72	1,076	319
Colorado Corvina	*Sciaenops [illegible]*	257	500	211	43	12	114	880	288
Peruvian Chunk	*Anisotremus scapularis*	102	169	238	61	173	293	934	281
Lenguado	*Paralichthys adspersus*	410	196	188	58	61	196	699	258
Guitar	*Rhinobatos planiceps*	82	45	20	55	107	616	843	253
Mero	*Alphodon [illegible]*	71	75	246	87	91	85	584	177
Mojarrilla	*Graffias [illegible]*	212	154	118	53	11	104	440	156
Trambollo	*Labrisomus [illegible]*	4	2	3	3	0	472	480	138
Robalo	*Centropomus spp.*	12	26	45	8	53	67	199	59
Grape Eyes	*Hemilutjanus [illegible]*	27	24	45	51	34	29	183	56
Cazón	*Galeorhinus galeus*	82	17	39	23	31	13	123	44
Fortuna	*Sciaena [illegible]*	5	5	18	35	48	38	144	42
Pejerey	*Odontesthes regia regia*	0	0	67	0	0	0	67	19
Pintanilla	*Cheilodactylus variegatus*	8	16	37	5	1	0	59	18
Pez espada	*Xiphias gladius*	7	0	2	2	2	11	17	6
Lenguado	*Hippoglossina [illegible]*	4	2	0	0	4	1	7	3
Deep sea Bacalao	*Urophycis [illegible]*			0	0	0	2	2	1
Others		66,602	197,717	106,760	188,007	16,492	208,250	717,226	214,436
SEAFOOD	TOTAL	31,159	22,101	10,847	25,869	16,504	52,451	158,931	26,489
Squid	*Dosidicus gigas*	23,642	11,565	4,831	15,707	5	31,073	86,823	14,471
Prawn	*Litopenaeus spp.*	5,246	3,600	3,119	5,967	13,363	1,820	33,135	5,523
Scallops	*Argopecten purpuratus*	97	3,878	125	632	158	906	5,796	966
Calamari	*Loligo gahi*	102	2,500	0	2,846	17	135	5,600	933
Crabs	*Cancer spp.*	0	15	23	17	34	4,727	4,816	803
Others		2,072	543	2,749	700	2,907	13,790	22,761	3,794
Octopus	*Octopus mimus*	13	3	15	66	283	3,131	3,511	585
Clam	*Gari solida*	0	0	2,374	1	0	0	2,375	396
Snail	*Thais chocolata*	79	87	172	498	239	114	1,189	198

CHART # 13 DISTRIBUTION OF HIDROBIOLOGICAL RESOURCES IN BETWEEN FISHING COVES EL ALGARROBO AND PACASMASYO (Ton). NORTH ZONE

Common Name	Scientific Name	1994	1995	1996	1997	1998	1999	Total	Annual Average
Lobster	*Panulirus gracilis*	22	9	13	38	600	419	1,101	184
Mejillón	*Protothaca thaca*	0	0	0	0	814	0	814	136
Shell	*Chione spp.*	0	0	9	88	3	187	287	48
Abalone	*Sinum cymba*	1,934	21	141	0	19	3	2,118	353
Barnacle Rock Shell	*Concholepas concholepas*	0	0	0	0	0	64	64	11
Black Clam	*Anadara tuberculosa*	0	0	0	0	30	9	39	7
Macha	*Mesodesma donacium*	0	16	15	0	0	0	31	5
Lapa	*Fisurella spp.*	0	10	0	0	0	0	10	2
Mussel	*Aulacomya ater*	0	0	0	0	0	0	0	0
Striped Shell	*Chione subrugosa*	0	0	0	0	0	0	0	0
Others		24	397	10	9	919	9,863	11,222	1,870
Erizo	*Loxechinus albus*	0	0	0	0	0	0	0	0
Hard Shell		6	2	0	1	0	1	10	2
Turtle	*Chelonia mydas*	6	2	0	1	0	1	10	2
Mammals		18	7	2	2	0	0	29	5
Tonino	*Phocoena spinipinnis*	18	7	2	2	0	0	29	5
Vegetation		0	0	0	2	0	0	2	0
Algie	*Chondracanthus chamissoi*	0	0	0	2	0	0	2	0

Industrial Fishing Species
Artisan Fishing Species

CHART # 14 DISTRIBUTION OF HIDROBIOLOGICAL RESOURCES BETWEEN FISHING COVES CHICAMA Y CERRO AZUL (Ton)
CENTRAL ZONE

Common Name	Scientific Name	1994	1995	1996	1997	1998	1999	Total	Annual Average
Fish	Total	7,345,529	4,694,793	6,029,321	3,950,475	1,962,625	5,314,210	29,296,953	4,882,826
Anchovy	*Engraulis ringens*	6,752,831	3,913,447	5,638,431	3,021,108	346,455	4,618,139	24,290,411	4,048,402
Sardine	*Sardinops sagax sagax*	507,898	628,795	199,750	468,613	805,958	262,755	2,873,769	478,962
Jack Mackarel	*Trachurus picturatus murphyi*	42,921	91,817	131,196	161,797	14,241	23,273	465,245	77,541
Mackarel	*Scomber japonicus*	6,166	10,381	11,871	37,435	142,513	160,699	369,065	61,511
Merluza	*Merluccius gayi peruanus*	17,384	14,626	22	1,823	1,542	10	35,407	5,901
[illegible]	[illegible]	783	568	100	10,699	640	25	12,815	2,136
[illegible]	[illegible]	2,298	3,188	3,671	937	2,010	2,025	14,129	2,355
[illegible]	[illegible]	1,014	834	1,980	1,878	5,788	587	12,081	2,014
[illegible]	[illegible]	392	1,488	4,079	2,939	2	3	8,903	1,484
[illegible]	[illegible]	70	161	438	1,789	4,542	317	7,317	1,220
[illegible]	[illegible]	1,253	958	485	788	2,129	424	6,037	1,006
[illegible]	[illegible]	8	2	20	17	4,661	149	4,857	810
[illegible]	[illegible]	71	448	126	939	2,348	727	4,659	777
[illegible]	[illegible]	371	659	1,190	594	860	531	4,205	701
[illegible]	[illegible]	141	228	97	921	1,845	883	4,115	686
[illegible]	[illegible]	0	0	0	1,183	1,577	282	3,042	507
[illegible]	[illegible]	167	80	174	432	1,618	356	2,827	471
[illegible]	[illegible]	0	0	0	0	0	2,208	2,208	368
[illegible]	[illegible]	120	1,644	1	4	119	179	2,067	345
Peruvian Rock Sandpiper	[illegible]	100	57	85	90	532	482	1,346	224
[illegible]	[illegible]	218	206	432	58	88	13	1,015	169
[illegible]	[illegible]	276	235	388	16	9	55	979	163
[illegible]	[illegible]	15	12	14	105	329	376	851	142
[illegible]	[illegible]	104	55	85	166	196	75	681	114
[illegible]	[illegible]	188	86	66	74	86	63	563	94
[illegible]	[illegible]	27	23	118	128	42	106	444	74
[illegible]	[illegible]	12	12	33	73	97	56	283	47
[illegible]	[illegible]	0	0	0	0	37	225	262	44
[illegible]	[illegible]	41	31	38	23	81	36	250	42
[illegible]	[illegible]	0	6	2	0	115	107	230	38
[illegible]	[illegible]	0	0	4	57	81	42	184	31
[illegible]	[illegible]	0	0	0	0		125	125	25
[illegible]	[illegible]	0	110	0	0	4	20	134	22
[illegible]	[illegible]	19	8	11	14	45	14	111	19
[illegible]	[illegible]	0	0	0	6	77	12	95	16
[illegible]	[illegible]	0	6	1	1	84	2	94	16
[illegible]	[illegible]	21	31	28	3	1	4	88	15
[illegible]	[illegible]	0	0	9	1	40	17	67	11
[illegible]	[illegible]	0	0	0	38	6	17	61	10

Common Name	Scientific Name	1994	1995	1996	1997	1998	1999	Total	Annual Average
Guitar	*Rhinobatos planiceps*	2	9	9	14	12	15	61	10
Cazón	*Galeorhinus galeus*	7	3	7	7	17	5	46	8
Ocean Whitefish	*Caulolatilus affinis*	0	0	43	1	0	1	45	8
Tramboito	*Labrisomus philippii*	0	0	10	18	8	8	44	7
Fortuno	*Sciaena nivoiana*	0	0	0	5	29	0	34	6
Mero	*Alphestes multiguttatus*	1	0	32	0	1	0	34	6
Lengueta	*Hippoglossina bollmani*	0	0	0	0	9	5	14	2
Angel Fish	*Squatina armata*	1	1	5	1	2	3	13	2
Robalo	*Centropomus spp.*	0	0	0	1	1	1	3	1
Golden Corvina	*Micropogonias altipinnis*	0	0	0	0	2	0	2	0
Grape Eyes	*Hemilutjanus macrophthalmos*	1	0	0	0	1	0	2	0
Others		10,608	24,578	34,270	235,679	621,745	238,753	1,165,633	194,272
SEAFOOD		5,170	12,864	5,926	3,518	12,350	8,118	47,946	7,991
Calamari	*Loligo gahi*	261	4,115	1,842	70	0	142	6,430	1,072
Snail	*Thais chocolata*	1,526	2,026	769	1,182	432	764	6,699	1,117
Scallops	*Argopecten purpuratus*	36	87	8	14	1,949	1,666	3,760	627
Octopus	*Octopus mimus*	73	89	118	178	1,095	187	1,740	290
Prawn	*Penaeus spp.*	4	5	2	0	1,587	2	1,600	267
Others		2,585	6,432	2,963	1,759	6,175	4,059	23,973	3,996
Squid	*Dosidicus gigas*	336	0	34	111	159	266	906	151
Crab	*Cancer spp.*	2	1	65	128	43	35	274	46
Clam	*Gari solida*	0	10	14	9	2	205	240	40
Abalone	*Sinum cymba*	0	3	0	0	67	54	124	21
Barnacle Rock Shell	*Concholepas concholepas*	1	1	31	39	0	8	80	13
Erizo	*Loxechinus albus*	0	0	0	0	0	59	59	10
Lapa	*Fisurella spp.*	13	6	19	13	0	2	53	9
Lobster	*Panulirus gracilis*	3	6	4	0	5	3	21	4
Shell	*Chione spp.*	1	3	0	0	6	1	11	2
Mejillón	*Protothaca thaca*	0	0	0	0	1	9	10	2
Macha	*Mesodesma donacium*	1	2	4	0	0	1	8	1
Mussel	*Aulacomya ater*	0	1	0	0	0	0	1	0
Striped Shell	*Chione subrugosa*	0	0	0	1	0	0	1	0
Black Clam	*Anadara tuberculosa*	0	0	0	0	0	0	0	0
Others		328	77	53	14	829	655	1,956	326
Hard Shell		0	0	0	2	1	0	3	1
Turtle	*Chelonia mydas*	0	0	0	2	1	0	3	1
Mammals		1	0	0	0	6	3	10	2
Tonino	*Phocoena spinipinnis*	1	0	0	0	7	3	11	2
Vegetation		0	0	0	0	1	0	1	0
Algie	*Chondracanthus chamissoi*	0	0	0	0	0	0	0	0

Industrial Fishing Species

Artisan Fishing Species

CHART # 15 SUMMARY OF MAIN FISHING ACTIVITIES WITHING THE ANALYZED BASINS

BASIN	ATTRIBUTE	CHARACTERISTICS					
NORTH ZONE – Tumbes Progreso	Artisan Fishing	**Principal Species:**					
		Fish:	Striped Muller, Ayanque, Bagre, Peruvian Rock Seabass, Skip Jack, Bonita, dolphin fish etc.				
		Invertebrea:	Squid, Scallops, Calamari, Crabs, Octopus, Clam, Snail, etc.				
		Volumes					
		Fish:	Annual Average (1994 – 1999)			262,600 t.	
		Invertebrea:	Annual Average (1994 – 1999)			26,489 t.	
	Industrial Fishing	Pelagic : Anchovy, Sardine, Needle, Jack Mackarel & Mackarel					
		Demersalles	Merluza & False Flyer				
		Others :	Tuna, Squid (Ocasionales)				
		Percentage per species (1994 – 1999)					
		Anchovy	24.6%	Jack Mackerel	13.4%	False Flyer	4.20%
		Sardine	25.0%	Mackarel	8.1%	Others	3.40%
		Needle	15.5%	Merluza	5.8%		
		Type of production in metric tonnes (Annual Average 2000 – 2003)					
		Frozen	149,213				
		Cured	16,185				
		Canned	46,416				
		Flour and oil	1'231,760				
	Deep Sea Fishing	Characteristics					
		Tuna, Sword fish, etc					
	Aquaculture	Principal Species:		Prawn			
		Cultivation Zone:	Manglares				
		Area of Cultivation:	información no disponible				
		Volumes:	información no disponible				
		Aquatic Center			La Tuna Carranza*		
		Cultivated Sspecie	Prawns, Oysters, Black Shell				

BASIN	ATTRIBUTE	CHARACTERISTICS					
NORTH ZONE – Talara	Artisan Fishing	**Principal Species:**					
		Fish:	Striped Muller, Ayanque, Bagre, Peruvian Rock Seabass, Skip Jack, Bonita, dolphin fish etc.				
		Invertebrea:	Squid, Scallops, Calamari, Crabs, Octopus, Clam, Snail, etc.				
		Volumes					
		Fish:	Annual Average (1994 – 1999)			262,600 t.	
		Invertebrea:	Annual Average (1994 – 1999)			26,489 t.	
	Industrial Fishing	**Principal Species:**					
		Pelagic:	Anchovy, Sardine, Needle, Jack Mackarel & Mackarel				
		Demersalles	Merluza & False Flyer				
		Others :	Tuna, Squid (Ocasionales)				
		Percentage per species (1994 – 1999)					
		Anchovy	24.6%	Jack Mackarel	13.4%	False Flyer	4.20%
		Sardine	25.0%	Mackarel	8.1%	Others	3.40%
		Needle	15.5%	Merluza	5.8%		
		Type of production at metric tonnes (Annual Average 2000 – 2003)					
		Frozen	149,213				
		Cured	16,185				
		Canned	46,416				
		Flour and oil	1'231,760				
	Deep Sea Fishing	Principal Species:					
		Tuna, Sword Fish, etc.					
	Aquaculture	Not identifiable					

BASIN	ATTRIBUTE	CHARACTERISTICS					
NORTH ZONE – Sechura	Artisan Fishing	**Principal Species:**					
		Fish:	Striped Muller, Ayanque, Bagre, Peruvian Rock Seabass, Skip Jack, Bonita, Dolphin fish etc.				
		Invertebrae	Squid, Scallops, Calamari, Crabs, Octopus, Clam, Snail, etc.				
		Volumes					
		Fish:	Annual Average (1994 – 1999)			262,600 t.	
		Invertebrae:	Annual Average (1994 – 1999)			26,489 t.	
	Industrial Fishing	**Principal Species:**					
		Pelagic:	Anchovy, Sardine, Needle, Jurel y Mackarel Merluza y False Flyer				
		Demersalles					
		Others :	Tuna, Squid (Ocasionales)				
		Percentage by species (1994 – 1999)					
		Anchovy	24.6%	Jack Mackarel	13.4%	False Flyer	4.20%
		Sardine	25.0%	Mackarel	8.1%	Others	3.40%
		Needle	15.5%	Merluza	5.8%		
		Distribution by type of production in metric tonnes (Annual Average 2000 – 2003)					
		Frozen	149,213				
		Cured	16,185				
		Canned	46,416				

		Deep-Sea Fishing	Flour and oil	1'231,760		
			Principal Species:			
			Tuna Fish, Sword Fish, etc			
		Aquiculture	Principal species	Scallops,Punta negra, Yasila, Punta Blanca		
			Area of Cultivation	100 Has.		
			Volumes:	N/A		
			Aquatic Center	Virrilây & Chérrepe		
			Cultivated species	Artemia, Prawn & Gracilaria		
	BASIN	ATTRIBUTE	CHARACTERISTICS			
CENTRAL ZONE	Trujillo	Artisan Fishing	**Principal Species:**			
			Fish:	Bonita, Lorna, Machete, Pejerrey, Dolphin Fish, Striped Muller, Tuna, etc.		
			Invertebrae	Squid, Calamari, Scallops, Octopus, Prawn, etc.		
			Volmenes			
			Fish:	Annual Average (1994 – 1999)		**194,272 t.**
			Invertebrae:	Annual Average (1994 – 1999)		**7,991 t.**
		Industrial Fishing	**Principal Species:**			
			Pelagic:	Anchovy, Sardine, Jack Mackarel & Mackarel		
			Demersalles	Merluza & False Flyer		
			Others :	N/A		
			Percentage by Species (1994 – 1999)			
			Anchovy	86.6%	Mackarel	1.3%
			Sardine	10.3%	Merluza	0.1%
			Jurel	1.7%		
			Distribution by type of production at metric tonnes (Annual Average 2000 – 2003)			
			Frozen	11,672		
			Cured	2,281		
			Canned	103,835		
			Flour and oil	3'327,985		
		Deep-Sea Fishing	Void			
		Aquiculture	Principal species	Not done		
			Cultivation Zone			
			Area of cultivation:			
			Volumes:			
			Aquatic Center			
			Cultivated Species:			
	BASIN	ATTRIBUTE	CHARACTERISTICS			
CENTRAL ZONE	Salaverry	Artisan Fishing	Principal species:			
			Fish	Bonita, lorna, machete, pejerrey, Dolphin Fish, Striped Muller, Tuna, etc.		
			Invertebrae	Squid, Calamari, Scallops, Octopus, Prawn, etc.		
			Volumes			
			Fish:	Annual Average (1994 – 1999)		**194,272 t.**
			Invertebrae:	Annual Average (1994 – 1999)		**7,991 t.**
		Industrial Fishing	**Principales especies**			
			Pelagic:	Anchovy, Sardine, Jurel & Mackarel		
			Demersalles	Merluza & False Flyer		
			Others :	N/A		
			Porcentage by Species (1994 – 1999)			
			Anchovy	86.6%	Mackarel	1.3%
			Sardine	10.3%	Merluza	0.1%
			Jurel	1.7%		
			Distribution by type of production en metric tonnes (Annual Average 2000 - 2003)			
			Frozen	11,672		
			Cured	2,281		
			Canned	103,835		
			Flour and oil	3'327,985		
		Deep-Sea Fishing	Void			
		Aquiculture	Principal species		Scallops	
			Cultivation Zone:	Ba. Samanco, Salinas, Guaynumá, Tortugas, etc.		
			Area of cultivation:	1241	Has.	
			Volumes:	N/A		
			Aquatic Center:		La Arena	
			Cultivated species	Scallops, Oysters & fish		

	BASIN	ATTRIBUTE	CHARACTERISTICS			
CENTRAL ZONE	Lima	Artisan Fishing	*Principal Species*			
			Fish	Bonita, lorna, machete, pejerrey, dolphin fish, Striped Muller, Tuna, etc.		
			Invertebrea:	Squid, Calamari, Scallops, Octopus, Prawn, etc.		
			Volumes			
			Fish:	Annual Average (1994 - 1999)		**194,272 t.**
			Invertebrae:	Annual Average (1994 - 1999)		**7,991 t.**
		Industrial Fishing	**Principal Species**			
			Pelagic:	Anchovy, Sardine, Jack Mackarel & Mackarel		
			Demersalles	Merluza & False Flyer		
			Others :	N/A		
			Percentage by Species (1994 - 1999)			
			Anchovy	86.6%	Mackarel	1.3%
			Sardine	10.3%	Merluza	0.1%
			Jack Macakerl	1.7%		
			Distribution by type of production in metric tonnes (Annual Average 2000 - 2003)			
			Frozen	11,672		
			Cured	2,281		
			Canned	103,835		
			Flour and oil	3'327,985		
		Deep-Sea Fishing	Void			
		Agriculture	**Not identifiable**			

	BASIN	ATTRIBUTE	CHARACTERISTICS			
SOUTH ZONE	Pisco	Artisan Fishing	*Principal Speices*			
			Fish	Jack Mackaerel, Pejerrey, Cabinza Grunt, Bonita, Cojinova Striped Muller,Lorna, Peruvian Rock Seabass, etc.		
			Invertebrae:	Scallops, Mussel,Snail, Octopus, Crabs, Clam, Erizo, Abalone, etc.		
			Volumes			
			Fish	Annual Average (1994 - 1999)		**21,536 t.**
			Invertebrae:	Annual Average (1994 - 1999)		**14,059 t.**
		Industrial Fishing	**Principal Species**			
			Pelagic	Anchovy, Sardine, Jack Mackarel, Mackarel & Machete		
			Demersalles	Not registered		
			Others :	Not registered		
			Percentage by species (1994 - 1999)			
			Anchovy	97.6%	Mackarel	0.3%
			Sardine	1.3%	Machete	0.2%
			Jack Mackerel	0.7%	False Flyer	0.1%
			Distribution by type of production in metric tonnes (Annual Average 2000 - 2003)			
			Frozen	891		
			Cured	4,648		
			Canned	1,016		
			Flour and oil	607,164		
		Deep Sea Fishing	Void			
		Aquiculture	Principal species		Scallops	
			Cultivation Zone	Ba. Paracas, Ba. Independencia		
			Area of cultivation	*0.00*		
			Volumes:	N/A		
			Aquatic Center		None	
			Cultivated Species		None	

CHART # 16 DISTRIBUTION OF HIDROBIOLOGICAL RESOURCES BETWEEN FISHING COVES LOMAS TAMBO DE MORA AND SAN JUAN DE MARCONA (Ton). PISCO ZONE

Common Nam	Nombre Cientifico	1994	1995	1996	1997	1998	1999	Total	Promedio Anual
FISH		1,553,772	1,420,448	781,879	1,420,955	595,428	976,314	6,748,796	1,124,799
Anchovy	*Engraulis ringens*	1,368,394	1,414,622	713,710	1,370,637	403,668	940,732	6,211,763	1,035,294
Sardine	*Sardinops sagax sagax*	181,619	4,224	20,532	4,070	152,507	5,241	368,193	61,366
Mackarel	*Scomber japonicus*	38	7	3,376	6,487	9,725	820	20,453	3,409
Samasa	*Ancho nasus*	0	0	0	0	0	19,172	19,172	3,195
Jack Mackarel	*Trachurus picturatus murphyi*	42	114	14,847	125	82	328	15,538	2,590
Pejerrey	*Odontesthes regia regia*	2,526	477	664	294	1	91	4,053	676
Cabinza Grunt	*Isacia conceptionis*	86	91	621	497	149	1,071	2,515	419
Bonita	*Sarda chiliensis chiliensis*	76	104	13	145	1,180	54	1,582	264
Cojinoba/Palmera	*Seriolella violacea*	247	81	616	162	113	84	1,303	217
Striped Muller	*Mugil cephalus*	234	133	213	96	130	163	969	162
Lorna	*Sciaena deliciosa*	60	96	201	149	75	282	863	144
Peruvian Rock Seabass	*Paralabrax humeralis*	114	53	98	112	78	375	830	138
Pampano	*Trachinotus paitensis*	3	1	4	21	222	139	390	65
Ray Eagle	*Myliobatis peruvianus*	9	74	109	62	69	47	370	62
Machete	*Ethmidium maculatum*	0	8	29	18	202	88	341	57
Ayanque/cachema	*Cynoscion analis*	6	2	8	42	65	172	315	53
Eel	*Genypterus maculatus*	1	1	20	8	19	261	310	52
Pintadilla	*Chellodactylus variegatus*	32	28	59	104	31	41	295	49
Lenguado	*Paralichthys adspersus*	15	7	66	17	40	146	291	49
Sierra	*Scomberomorus sierra*	0	0	0	2	177	42	221	37
Stripe	*Urotrygon spp.*	99	0	9	28	13	42	190	32
Golden Dolphin Fish	*Coryphaena hippurus*	0	1	5	39	126	0	171	29
Shark	*Isurus oxyrinchus*	0	0	0	36	108	3	147	25
Cocoisucó	*Paralonchurus peruanus*	6	3	3	12	45	70	139	23
Tollo	*Mustelus whitneyi*	15	10	28	26	34	8	123	21
Trembello	*Labrisomus philippii*	27	24	23	21	14	12	121	20
Skip Jack	*Katsuwonus pelamis*	0	0	0	23	61	3	107	18
Corvina	*Cilus gilberti*	9	6	37	16	23	7	98	16
Mero	*Alphestes multiguttatus*	0	0	94	1	0	0	95	16
Mojarrilla	*Stellifer minor*	6	5	13	13	16	22	75	13
Bacalao de profundidad	*Dissostichus eleginoides*	0	0	0	0	0	73	73	12
Guitar	*Rhinobatos planiceps*	20	2	12	18	3	5	60	10
Peruvian Grunt	*Anisotremus scapularis*	11	9	16	17	3	3	59	10
Grape Eyes	*Hemilutjanus macrophthalmos*	5	3	6	3	4	3	24	4
Tuna	*Thunnus spp.*	0	0	17	0	6	0	23	4
Needle	*Strongylura exilis*	0	0	0	0	1	15	16	3
Flying fish	*Cypselurus heterurus*	0	0	8	5	0	0	13	2
Sword Fish	*Xiphias gladius*	0	0	0	10	0	0	10	2
Mirror	*Selene peruviana*	0	0	2	1	0	5	8	1
Bagre	*Galeichthys spp.*	0	0	0	4	0	2	6	1
Citeen Whitefish	*Caulolatilus affinis*	0	0	0	0	0	2	2	0
Pomfret	*Seriola nivellana*	0	1	0	0	0	0	1	0
Angel Fish	*Squatina armata*	0	0	0	0	0	0	0	0
Bereche	*Larimus pacificus*	0	0	0	0	0	0	0	0
Cazon	*Galeorhinus galeus*	0	0	0	0	0	0	0	0
Golden Corvina	*Micropogonias altipinnis*	0	0	0	0	0	0	0	0
Lenguete	*Hippoglossina bollmani*	0	0	0	0	0	0	0	0
Merluza	*Merluccius gayi peruanus*	0	0	0	0	0	0	0	0
Robalo	*Centropomus spp.*	0	0	0	0	0	0	0	0
Vocador/False Flyer	*Prionotus stephanophrys*	0	0	0	0	0	0	0	0
Others		72	261	26,420	37,636	26,358	6,691	97,438	16,240
FISH		9,392	8,741	7,292	11,375	29,848	21,613	88,261	14,710
Scallops	*Argopecten purpuratus*	1,423	3,880	330	414	22,117	17,487	45,651	7,609
Mussel	*Aulacomya ater*	5,333	3,286	4,521	7,174	4,275	1,982	26,571	4,429
Snail	*Thais chocolata*	903	904	818	2,141	1,344	1,232	7,342	1,224
Octopus	*Octopus mimus*	282	172	259	233	1,163	156	2,265	378
Crabs	*Cancer spp.*	468	247	496	393	239	305	2,148	358
Clam	*Gari solida*	655	112	123	256	117	81	1,344	224
Erizo	*Loxechinus albus*	13	98	434	0	22	11	578	96
Abalone	*Sinum cymba*	11	20	158	261	11	0	461	77
Macha	*Mesodesma donacium*	49	0	0	277	111	0	437	73
Shell	*Chione spp.*	1	0	0	0	204	95	300	50

Common Nam	Nombre Cientifico	1994	1995	1996	1997	1998	1999	Total	Promedio Anual
Barnacle Rock Shell	*Concholepas concholepas*	2	6	57	138	9	14	226	38
Lapa	*Fisurella spp.*	79	12	66	27	4	30	218	36
Mejillón	*Protothaca theca*	0	0	6	59	21	49	135	23
Squid	*Dosidicus gigas*	110	0	0	0	0	0	110	18
Prawn	*Penaeus spp.*	0	0	0	0	92	0	92	15
Lobster	*Panulirus gracilis*	0	0	0	0	2	0	2	0
Calamari	*Loligo gahi*	0	0	0	0	2	0	2	0
Black Clam	*Anadara tuberculosa*	0	0	0	0	0	0	0	0
Striped Shell	*Chione subrugosa*	0	0	0	0	0	0	0	0
Others		63	4	24	2	115	171	379	63
Hard Shell		0	0	0	0	1	0	1	0
Tortuga	*Chelonia mydas*	0	0	0	0	1	0	1	0
Mammals		0	0	2	0	1	0	3	1
Tonino	*Phocoena spinipinnis*	0	1	2	0	1	0	4	1
Vegetation		0	1	0	29	795	641	1,466	244
Algie	*Chondracanthus chamissoi*	0	0	0	29	795	641	1,465	244

Industrial Fishing Species
Artisan Fishing Species

CHART # 17 DISTRIBUTION OF HIDROBIOLOGICAL RESOURCES BETWEEN FISHING COVES LOMAS AND LA YARADA (Ton). SOUTH ZONE

Common Name	Scientific Name	1994	1995	1996	1997	1998	1999	Total	Annual Average
FISH		859,680	943,508	230,177	1,361,699	360,717	549,649	4,325,430	720,905
Anchovy	*Engraulis ringens*	836,203	939,033	211,211	1,370,637	137	539,371	3,896,592	649,432
Sardine	*Sardinops sagax sagax*	2,386	1,542	865	273	44,436	969	50,471	8,412
Jack Mackarel	*Trachurus picturatus murphyi*	2,277	885	10,816	125	10,771	1,141	26,015	4,336
Mackarel	*Scomber japonicus*	318	666	425	6,487	1,838	824	10,558	1,760
Machete	*Ethmidium maculatum*	276	47	4,569	16	1,010	324	6,242	1,040
Vocador/False Flyer	*Prionotus stephanophrys*	0	0	0	0	1,940	734	2,674	446
Golden Dolphin Fish	*Coryphaena hippurus*	1,226	364	317	1,035	2,163	427	5,532	922
Corvina	*Cilus gilberti*	3,806	14	43	16	49	94	4,022	670
Shark	*Isurus oxyrinchus*	598	140	573	855	987	719	3,672	612
Peruvian Rock Seabass	*Paralabrax humeralis*	2,095	17	28	112	279	767	3,299	550
Lorna	*Sciaena deliciosa*	573	40	301	149	652	720	2,435	406
Peruvian Grunt	*Anisotremus scapularis*	1,533	3	12	17	481	2	2,048	341
Pejerrey	*Odontesthes regia regia*	498	70	261	826	24	256	1,935	322
Samasa	*Anchoa nasus*	0	0	0	0	0	1,918	1,918	320
Cojinoba/Palmera	*Seriolella violacea*	1,102	396	110	162	70	61	1,901	317
Ray	*Urotrygon spp.*	1,667	3	97	35	22	19	1,843	307
Cabinza Grunt	*Isacia conceptionis*	157	109	316	497	174	457	1,709	285
Tollo	*Mustelus whitneyi*	1,557	4	28	19	12	21	1,641	274
Pintadilla	*Cheilodactylus variegatus*	1,294	56	16	25	5	14	1,410	235
Bonita	*Sarda chiliensis chiliensis*	377	28	5	198	568	70	1,246	208
Deep Sea Bacalao	*Dissostichus eleginoides*	0	0	0	0	737	3	740	123
Cecolsuco	*Paralonchurus peruanus*	431	1	6	12	114	125	689	115
Striped Muller	*Mugil cephalus*	348	16	33	98	9	44	548	91
Segre	*Galeichthys spp.*	0	0	0	4	502	28	534	89
Flying fish	*Cypselurus heterurus*	199	40	69	122	14	45	489	82
Needle	*Strongylura exilis*	0	0	0	16	0	394	410	68
Sword Fish	*Xiphias gladius*	303	1	1	11	4	2	322	54
Grape Eyes	*Hemilutjanus macrophthalmos*	216	0	1	1	2	1	221	37
Skip Jack	*Katsuwonus pelamis*	1	0	0	26	169	1	197	33
Eel	*Genypterus maculatus*	115	3	6	8	12	9	153	26
Pampano	*Trachinotus paitensis*	0	0	37	29	8	94	168	28
Lenguado	*Paralichthys adspersus*	47	11	4	17	11	15	105	18
Guitar	*Rhinobatos planiceps*	75	0	0	18	0	0	93	16
Ayanque/cachema	*Cynoscion analis*	2	0	0	42	29	12	85	14
Eagle Ray	*Myliobatis peruvianus*	0	0	1	9	6	9	25	4
Merluza	*Merluccius gayi peruanus*	0	19	5	0	0	0	24	4
Sierra	*Scomberomorus sierra*	0	0	0	0	17	8	25	4
Ocean Whitefish	*Caulolatilus affinis*	0	0	0	0	0	10	10	2
Trambello	*Labrisomus philippii*	0	0	0	3	0	1	4	1
Angel Fish	*Squatina armata*	0	0	0	0	0	2	2	0
Mero	*Alphestes multiguttatus*	0	0	1	0	1	0	2	0
Tuna	*Thunnus spp.*	0	0	0	0	1	0	1	0
Corvina dorada	*Micropogonias altipinnis*	0	0	1	0	0	0	1	0
Mirror	*Selene peruviana*	0	0	0	1	0	0	1	0
Mojarrilla	*Stellifer minor*	0	0	0	0	1	0	1	0
Bereche	*Larimus pacificus*	0	0	0	0	0	0	0	0
Cazón	*Galeorhinus galeus*	0	0	0	0	0	0	0	0
Fortuno	*Seriola rivoliana*	0	0	0	0	0	0	0	0
Lenguleta	*Hippoglossina bollmani*	0	0	0	0	0	0	0	0
Robalo	*Centropomus spp.*	0	0	0	0	0	0	0	0
Others		5,828	81,532	1,723	37,658	13,300	4,764	144,775	24,129
FISH		2,128	1,274	2,927	7,752	5,176	4,544	23,801	3,967
Abalone	*Sinum cymba*	1,459	708	377	2,048	606	551	5,749	958
Mussel	*Aulacomya ater*	265	239	562	745	1,560	1,911	5,282	880
Snail	*Thais chocolata*	40	126	589	1,331	1,243	705	4,034	672
Octopus	*Octopus mimus*	23	70	431	569	1,287	599	2,979	497
Macha	*Mesodesma donacium*	101	28	309	2,019	0	0	2,457	410
Barnacle Rock Shell	*Concholepas concholepas*	177	17	243	418	206	220	1,281	214
Erizo	*Loxechinus albus*	22	1	276	406	151	299	1,155	193
Lapa	*Fisurella spp.*	13	45	69	104	28	103	362	60
Others		19	33	18	94	68	105	337	56
Clam	*Gari solida*	9	0	48	8	12	43	120	20
Crabs	*Cancer spp.*	0	0	1	10	5	2	18	3
Prawn	*Penaeus spp.*	0	3	0	0	8	0	11	2
Calamari	*Loligo gahi*	0	4	3	0	0	0	7	1

Common Name	Scientific Name	1994	1995	1996	1997	1998	1999	Total	Annual Average
Scallops	*Argopecten purpuratus*	0	0	1	0	2	4	7	1
Shell	*Chione spp.*	0	0	0	0	0	2	2	0
Lobster	*Panulirus gracilis*	0	0	0	0	0	0	0	0
Black Clam	*Anadara tuberculosa*	0	0	0	0	0	0	0	0
Striped Shell	*Chione subrugosa*	0	0	0	0	0	0	0	0
Mejillón	*Protothaca thaca*	0	0	0	0	0	0	0	0
Squid	*Dosidicus gigas*	0	0	0	0	0	0	0	0
Hard Shell		0	0	0	0	0	0	0	0
Turtle	*Chelonia mydas*	0	0	0	0	0	0	0	0
Mammals		80	0	0	3	0	0	83	14
Tonino	*Phocoena spinipinnis*	80	0	0	3	0	0	83	14
Vegetation		106	0	0	0	0	0	106	18
Algie	*Chondracanthus chamissoi*	106	0	0	0	0	0	106	18

Barcos Cal - Poteros	164,713	80,808
Barcos ArtFac (Merluza)	-	41,564

Industrial Fishing Species

Artisan Fishing Species

CHART # 18 PERUVIAN FISHING FLEET CHARACTERISTICS

Type of Fleet	Units	Cubic Meters
Ring	645	172,500
Dragging	68	9,700
Multipurpose	24	3,600
Palangreras	05	800

CHART# 19 Places with Shellfish Potential

Place	Department	Has.
Cherrepe	Lambayeque	10
Huayuná	Ancash	171.14
Ba.	Ancash	521.27
Isla	Ancash	64.66
Playa Q.	Ancash	51.76
Los	Ancash	16.5
Casma	Ancash	30.83
Salinas	Ancash	190.8
Isla	Lima	59.5
Ba.	Lima	28.8
San	Lima	223
Playa el	Lima	60.8
Playa La	Lima	117
Total		**1546.06**

CHART # 20 SOCIO-ECONOMIC FACTORS FOR THE SENSITIVITY ANALYSIS

Factor	Intervals	Value	Scale
Density of populated areas	Above 0.2 CCPP per Km2	2	High
	Between 0.1 & 0.2 CCPP per Km2	1	Medium
	Less than 0.1 CCPP per Km2	0	Low
Less than 10 households	From 80 to 100%	4	Very High
	From 60 to 80%	3	High
	From 40 to 60%	2	Medium
	From 20 to 40%	1	Low
	From 0 to 20%	0	Nulo
Demographic tendency	Over 2.4	2	High
	Between 1.5 & 2.4	1	Medium
	Less than 1.5	0	Low
Types of populated areas	Less than 75% of the CCPP rurals	0	Low
	More than 75% of the CCPP rurals	1	High
Gender	Females	1	High
	Males	0	Low
Principal Economica Activity	Fishing and Agricultura (%)	2	High
	Non-Descrip work(%)	1	Medium
	Other (%)	0	Low

CHART #21 POPULATED AREAS ADN NO. OF HOMES

Total No. Of Populated Areas		
ZONE 1	(Zarumilla - Eten)	95
ZONE 2	(Lagunas - Cerro Azul)	376
ZONE 3	(San Luis - Camaná)	170
ZONE 4	(Samuel Pastor - Tacna)	89
TOTAL		730

TOTAL NO. OF HOMES		
ZONE 1	(Zarumilla - Eten)	59238
ZONE 2	(Lagunas - Cerro Azul)	714734
ZONE 3	(San Luis - Camaná)	35303
ZONE 4	(Samuel Pastor - Tacna)	32366
TOTAL		841641

Source: INEI, Precenso 1999

CHART # 22 POPULATED AREAS (URBAN/RURAL)

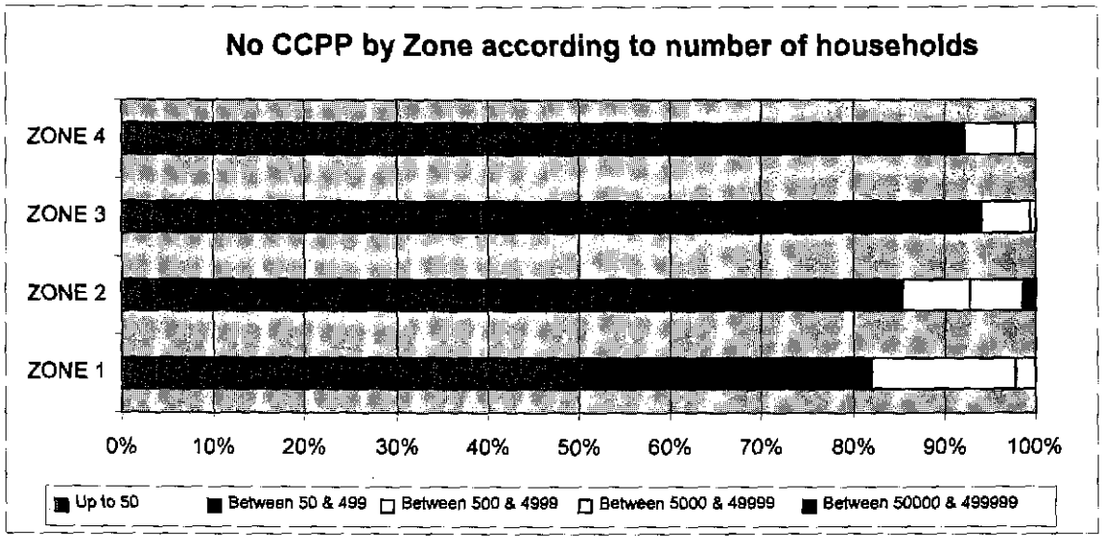
		No. Of areas according to classification	
		Urban	Rural
ZONE 1	(Zarumilla - Eten)	31	64
ZONE 2	(Lagunas - Cerro Azul)	80	296
ZONE 3	(San Luis - Camaná)	19	151
ZONE 4	(Samuel Pastor - Tacna)	11	78
TOTAL		141	589

Source: INEI, Precenso 1999

CHART # 23 POPULATED AREAS, ACCORDING TO CATEGORY

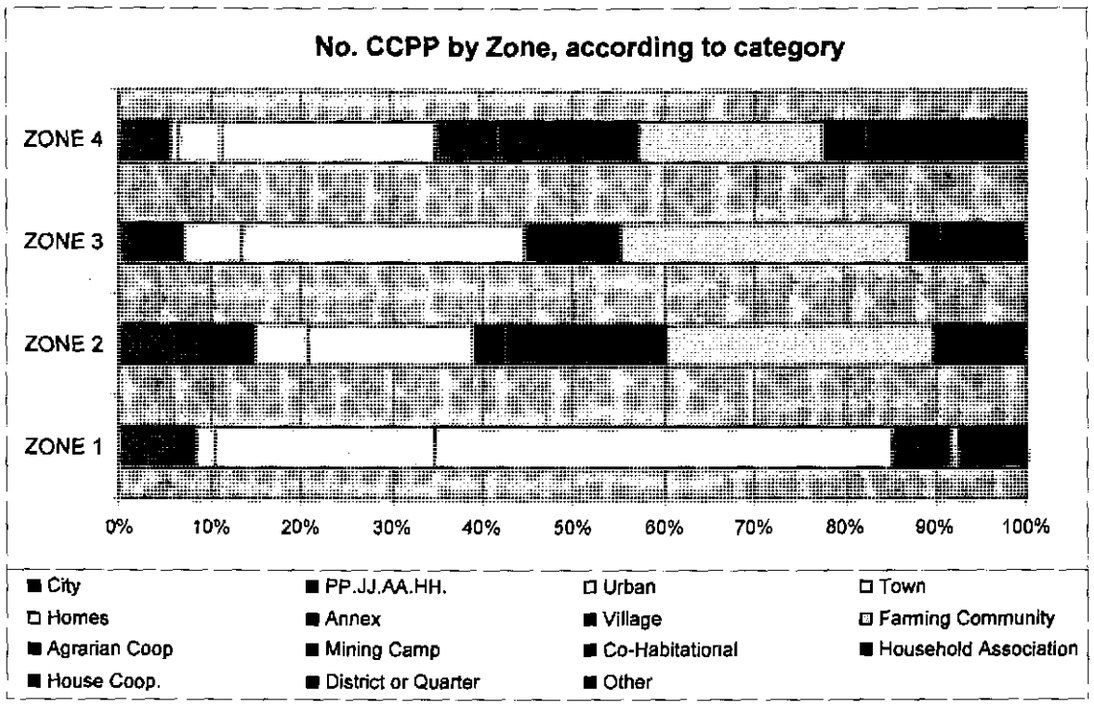
	No. Of populated areas by category				
	ZONE 1 (Zarumilla - Eten)	ZONE 2 (Lagunas - Cerro Azul)	ZONE 3 (San Luis - Camana)	ZONE 4 (Samuel Pastor - Tacna)	TOTAL
CITY	6	41	5	3	55
PP.JJ.AA.HH.	2	15	7	2	26
URBAN	2	0	0	1	3
TOWN	23	22	11	4	60
CASERIO	48	69	53	21	191
ANNEXED	5	76	18	17	116
VILLAGE	1	4	0	3	8
FARMING	1	110	54	18	183
AGRARIAN COOP.	0	1	0	3	4
MINING FIELD	1	0	4	1	6
CO-HABITANTS	0	5	2	0	7
HOME ASOCCIATION	0	4	3	3	10
HOME COOP.	0	2	0	0	2
QUARTERS	0	0	0	1	1
OTHERS	6	27	13	12	58

CHART # 24 CCPP BY ZONE AND NUMBER OF HOUSEHOLDS



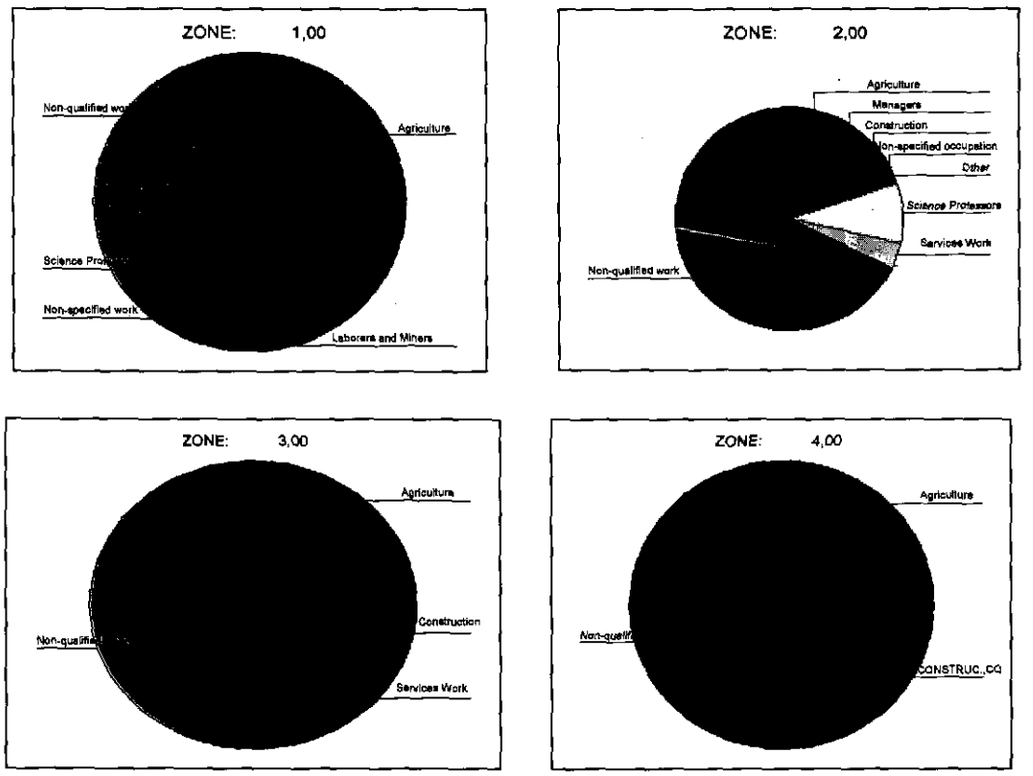
Source: INEI, Pre-Census Data 1999

CHART # 25 CCPP BY ZONE ACCORDING TO CATEGORY



Source: INEI, Pre-Census Data 1999

CHART # 26. PEA ACTIVITIES ZONE 1, PEA ZONE 2, PEA ZONE 3, PEA ZONE 4



Source: INEI, Peru: Map of unsatisfied basic necessities in household at the district level, Tomo IV, 1994

APPENDIX K

ECONOMICS

The tables in Appendix K summarize the capital and operating cost schedules, the production profiles, the cashflows, NPV (at 10%) and IRR for twelve "type discovery" scenarios that cover the full range of exploration opportunity sizes in the Peru offshore basins. Each case was run twice – one with the production based royalty method, and another with the economic based royalty method.

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Tumbes/Talara
Prospectivity	Downside

Avg. Royalty Rate:	**15.96%**
Income Tax Rate:	**30.00%**

Economic Based Royalty Method

$ / BOE Capex	**6.20**
$ / BOE Opex	**2.83**

Reserves Included in Cash Flows

	Liquids MMBBL	Gas BCF	Total MMBOE
Field	**25.0**	**0.0**	**25.0**
Contractor	**25.0**	**0.0**	**25.0**

Petroleum Rent* Distribution (undiscounted)

Gov. Take	**44.14%**
Cont. Take	**55.86%**

Petroleum Rent = Total revenue - total cost

Present value as at: Jan - 01 - 05
NPV SUMMARY

Discount Rate %	Before Taxes NPV $ MM	After Taxes NPV $ MM
0.00%	**404.64**	**292.94**
5.00%	**190.95**	**131.53**
10.00%	**90.45**	**56.83**
15.00%	**41.17**	**21.19**
20.00%	**16.36**	**4.00**
25.00%	**3.73**	(4.16)
IRR	***27.5%***	***22.0%***

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	0.61	0.05	0.00	-0.66	0.00	-0.66	-0.66	-0.58
2006	0.00	$30.00	0.00	$2.00	0.00	2.45	0.05	0.00	-2.50	0.00	-2.50	-3.16	-2.47
2007	0.00	$30.00	0.00	$2.00	0.00	5.25	0.05	0.00	-5.30	0.00	-5.30	-8.46	-5.95
2008	0.00	$30.00	0.00	$2.00	0.00	7.97	0.05	0.00	-8.02	0.00	-8.02	-16.47	-10.53
2009	0.00	$30.00	0.00	$2.00	0.00	17.77	1.05	0.00	-18.82	0.00	-18.82	-35.30	-19.89
2010	0.00	$30.00	0.00	$2.00	0.00	19.43	1.05	0.00	-20.48	0.00	-20.48	-55.78	-28.74
2011	0.00	$30.00	0.00	$2.00	0.00	40.84	1.05	0.00	-41.89	0.00	-41.89	-97.66	-44.49
2012	1.10	$30.00	0.00	$2.00	32.85	38.14	2.97	1.64	-9.90	0.06	-9.96	-107.62	-47.75
2013	2.19	$30.00	0.00	$2.00	65.70	7.15	5.86	3.29	49.40	15.28	34.12	-73.50	-38.05
2014	3.65	$30.00	0.00	$2.00	109.50	8.80	9.72	5.48	85.51	27.70	57.81	-15.69	-23.76
2015	3.10	$30.00	0.00	$2.00	93.08	3.30	8.27	4.65	76.85	14.47	62.38	46.69	-10.35
2016	2.64	$30.00	0.00	$2.00	79.11	0.00	7.04	12.56	59.51	8.87	50.64	97.33	-0.88
2017	2.24	$30.00	0.00	$2.00	67.25	3.30	6.00	16.81	41.14	3.67	37.46	134.80	5.21
2018	1.91	$30.00	0.00	$2.00	57.16	0.00	5.11	13.96	38.09	2.36	35.73	170.52	10.26
2019	1.62	$30.00	0.00	$2.00	48.59	0.00	4.36	12.15	32.08	0.56	31.52	202.04	14.13
2020	1.38	$30.00	0.00	$2.00	41.30	0.00	3.71	10.32	27.26	8.10	19.16	221.20	16.18
2021	1.17	$30.00	0.00	$2.00	35.10	0.00	3.17	8.78	23.16	6.87	16.29	237.49	17.69
2022	0.99	$30.00	0.00	$2.00	29.84	0.00	2.71	7.46	19.67	5.90	13.77	251.27	18.80
2023	0.85	$30.00	0.00	$2.00	25.36	0.00	2.31	6.34	16.71	5.01	11.70	262.96	19.62
2024	0.72	$30.00	0.00	$2.00	21.56	0.00	1.98	5.39	14.19	4.26	9.93	272.90	20.23
2025	0.61	$30.00	0.00	$2.00	18.32	0.00	1.69	4.58	12.05	3.62	8.44	281.33	20.68
2026	0.52	$30.00	0.00	$2.00	15.56	0.00	1.45	3.89	10.23	3.07	7.16	288.49	21.01
2027	0.32	$30.00	0.00	$2.00	9.71	0.00	0.93	2.43	6.35	1.90	4.44	292.94	21.19
2028	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	292.94	21.19
2029	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	292.94	21.19
2030	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	292.94	21.19
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	292.94	21.19
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	292.94	21.19
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	292.94	21.19
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**292.94**	**21.19**
Total	25.00	$30.00	0.00	2.00	750.00	155.00	70.63	119.73	404.64	111.71	292.94		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Tumbes/Talara
Prospectivity	Downside

Avg. Royalty Rate:	**5.25%**
Income Tax Rate:	**30.00%**

Production Based Royalty Method

$ / BOE Capex	**6.20**
$ / BOE Opex	**2.83**

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	**25.0**	**0.0**	**25.0**
Contractor	**25.0**	**0.0**	**25.0**

Petroleum Rent* Distribution (undiscounted)	
Gov. Take	**33.53%**
Cont. Take	**66.47%**

** Petroleum Rent = Total Revenue - total cost*

Present value as at: Jan - 01 - 05		
NPV SUMMARY		
	Before Taxes	**After Taxes**
Discount Rate %	**NPV $ MM**	**NPV $ MM**
0.00%	**484.97**	**349.16**
5.00%	**228.00**	**157.46**
10.00%	**108.48**	**69.45**
15.00%	**50.35**	**27.62**
20.00%	**21.22**	**7.41**
25.00%	**6.41**	**(2.29)**
IRR	**29.0%**	**23.4%**

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	0.61	0.05	0.00	-0.66	0.00	-0.66	-0.66	-0.58
2006	0.00	$30.00	0.00	$2.00	0.00	2.45	0.05	0.00	-2.50	0.00	-2.50	-3.16	-2.47
2007	0.00	$30.00	0.00	$2.00	0.00	5.25	0.05	0.00	-5.30	0.00	-5.30	-8.46	-5.95
2008	0.00	$30.00	0.00	$2.00	0.00	7.97	0.05	0.00	-8.02	0.00	-8.02	-16.47	-10.53
2009	0.00	$30.00	0.00	$2.00	0.00	17.77	1.05	0.00	-18.82	0.00	-18.82	-35.30	-19.89
2010	0.00	$30.00	0.00	$2.00	0.00	19.43	1.05	0.00	-20.48	0.00	-20.48	-55.78	-28.74
2011	0.00	$30.00	0.00	$2.00	0.00	40.84	1.05	0.00	-41.89	0.00	-41.89	-97.66	-44.49
2012	1.10	$30.00	0.00	$2.00	32.85	38.14	2.97	1.64	-9.90	0.06	-9.96	-107.62	-47.75
2013	2.19	$30.00	0.00	$2.00	65.70	7.15	5.86	3.39	49.30	15.25	34.05	-73.57	-38.07
2014	3.65	$30.00	0.00	$2.00	109.50	8.80	9.72	6.34	84.64	27.44	57.21	-16.37	-23.93
2015	3.10	$30.00	0.00	$2.00	93.08	3.30	8.27	5.17	76.34	14.31	62.02	45.65	-10.60
2016	2.64	$30.00	0.00	$2.00	79.11	0.00	7.04	4.23	67.84	11.37	56.47	102.12	-0.04
2017	2.24	$30.00	0.00	$2.00	67.25	3.30	6.00	3.48	54.47	7.67	46.79	148.92	7.56
2018	1.91	$30.00	0.00	$2.00	57.16	0.00	5.11	2.88	49.17	5.69	43.48	192.40	13.71
2019	1.62	$30.00	0.00	$2.00	48.59	0.00	4.36	2.43	41.80	3.48	38.32	230.72	18.42
2020	1.38	$30.00	0.00	$2.00	41.30	0.00	3.71	2.06	35.52	10.58	24.94	255.67	21.08
2021	1.17	$30.00	0.00	$2.00	35.10	0.00	3.17	1.76	30.18	8.97	21.20	276.87	23.05
2022	0.99	$30.00	0.00	$2.00	29.84	0.00	2.71	1.49	25.64	7.69	17.95	294.82	24.51
2023	0.85	$30.00	0.00	$2.00	25.36	0.00	2.31	1.27	21.78	6.53	15.25	310.07	25.58
2024	0.72	$30.00	0.00	$2.00	21.56	0.00	1.98	1.08	18.50	5.55	12.95	323.02	26.37
2025	0.61	$30.00	0.00	$2.00	18.32	0.00	1.69	0.92	15.72	4.71	11.00	334.02	26.95
2026	0.52	$30.00	0.00	$2.00	15.58	0.00	1.45	0.78	13.35	4.00	9.34	343.36	27.38
2027	0.32	$30.00	0.00	$2.00	9.71	0.00	0.93	0.49	8.29	2.49	5.80	349.16	27.62
2028	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	349.16	27.62
2029	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	349.16	27.62
2030	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	349.16	27.62
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	349.16	27.62
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	349.16	27.62
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	349.16	27.62
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**349.16**	**27.62**
Total	25.00	$30.00	0.00	2.00	750.00	155.00	70.63	39.40	484.97	135.80	349.16		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Tumbes/Talara
Prospectivity	Base

Avg. Royalty Rate:	**19.25%**
Income Tax Rate:	**30.00%**

Economic Based Royalty Method

$ / BOE Capex	**4.50**
$ / BOE Opex	**2.16**

Reserves Included in Cash Flows

	Liquids MMBBL	Gas BCF	Total MMBOE
Field	**50.0**	**0.0**	**50.0**
Contractor	**50.0**	**0.0**	**50.0**

Petroleum Rent* Distribution (undiscounted)

Gov. Take	**46.36%**
Cont. Take	**53.64%**

Petroleum Rent = Total revenue - total cost

Present value as at: Jan - 01 - 05
NPV SUMMARY

Discount Rate %	Before Taxes NPV $ MM	After Taxes NPV $ MM
0.00%	**878.34**	**626.09**
5.00%	**403.00**	**279.64**
10.00%	**193.84**	**128.21**
15.00%	**95.06**	**57.74**
20.00%	**45.86**	**23.50**
25.00%	**20.42**	**6.46**
IRR	***34.9%***	***28.4%***

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	1.08	0.05	0.00	-1.13	0.00	-1.13	-1.13	-0.98
2006	0.00	$30.00	0.00	$2.00	0.00	3.02	0.05	0.00	-3.07	0.00	-3.07	-4.20	-3.30
2007	0.00	$30.00	0.00	$2.00	0.00	8.92	0.05	0.00	-8.97	0.00	-8.97	-13.17	-9.20
2008	0.00	$30.00	0.00	$2.00	0.00	4.61	1.05	0.00	-5.66	0.00	-5.66	-18.83	-12.44
2009	0.00	$30.00	0.00	$2.00	0.00	23.24	1.05	0.00	-24.29	0.00	-24.29	-43.12	-24.51
2010	0.00	$30.00	0.00	$2.00	0.00	24.43	1.05	0.00	-25.48	0.00	-25.48	-68.59	-35.53
2011	0.00	$30.00	0.00	$2.00	0.00	32.57	1.05	0.00	-33.62	0.00	-33.62	-102.21	-48.17
2012	1.46	$30.00	0.00	$2.00	43.80	27.22	3.06	2.19	11.33	6.22	5.11	-97.10	-46.49
2013	2.92	$30.00	0.00	$2.00	87.60	24.55	6.04	4.38	52.64	19.90	32.73	-64.36	-37.19
2014	5.48	$30.00	0.00	$2.00	164.25	20.77	11.25	8.21	124.01	39.48	84.54	20.17	-16.29
2015	4.93	$30.00	0.00	$2.00	147.83	15.10	10.13	12.90	109.69	22.68	87.01	107.18	2.41
2016	4.43	$30.00	0.00	$2.00	133.04	21.50	9.13	33.26	69.15	12.59	56.57	163.75	12.98
2017	3.99	$30.00	0.00	$2.00	119.74	0.00	8.22	26.92	84.60	14.64	69.96	233.71	24.35
2018	3.59	$30.00	0.00	$2.00	107.76	4.50	7.41	26.94	68.92	10.37	58.55	292.26	32.63
2019	3.23	$30.00	0.00	$2.00	96.99	4.50	6.68	24.25	61.57	8.05	53.51	345.77	39.20
2020	2.91	$30.00	0.00	$2.00	87.29	4.50	6.02	21.82	54.95	16.19	38.77	384.54	43.35
2021	2.62	$30.00	0.00	$2.00	78.56	4.50	5.42	19.64	49.00	14.81	34.19	418.73	46.52
2022	2.36	$30.00	0.00	$2.00	70.70	0.00	4.89	17.68	48.14	14.01	34.13	452.86	49.28
2023	2.12	$30.00	0.00	$2.00	63.63	0.00	4.41	15.91	43.32	12.67	30.65	483.51	51.44
2024	1.91	$30.00	0.00	$2.00	57.27	0.00	3.97	14.32	38.98	11.48	27.50	511.01	53.12
2025	1.72	$30.00	0.00	$2.00	51.54	0.00	3.58	12.89	35.07	10.41	24.66	535.67	54.43
2026	1.55	$30.00	0.00	$2.00	46.39	0.00	3.23	11.60	31.56	9.47	22.09	557.76	55.45
2027	1.39	$30.00	0.00	$2.00	41.75	0.00	2.92	10.44	28.39	8.52	19.88	577.63	56.24
2028	1.25	$30.00	0.00	$2.00	37.58	0.00	2.64	9.39	25.55	7.66	17.88	595.51	56.87
2029	1.13	$30.00	0.00	$2.00	33.82	0.00	2.38	8.45	22.98	6.90	16.09	611.60	57.36
2030	1.02	$30.00	0.00	$2.00	30.46	0.00	2.15	7.61	20.69	6.21	14.49	626.09	57.74
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	626.09	57.74
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	626.09	57.74
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	626.09	57.74
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**626.09**	**57.74**
Total	50.00	$30.00	0.00	2.00	1,500.00	225.00	107.87	288.79	878.34	252.25	626.09		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Tumbes/Talara
Prospectivity	Base
Avg. Royalty Rate:	**5.67%**
Income Tax Rate:	**30.00%**

Production Based Royalty Method

$ / BOE Capex	**4.50**
$ / BOE Opex	**2.16**

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	**50.0**	**0.0**	**50.0**
Contractor	**50.0**	**0.0**	**50.0**

Petroleum Rent* Distribution (undiscounted)

Gov. Take	**34.25%**
Cont. Take	**65.75%**

** Petroleum Rent = Total Revenue - total cost*

Present value as at: Jan - 01 - 05
NPV SUMMARY

	Before Taxes	**After Taxes**
Discount Rate %	**NPV $ MM**	**NPV $ MM**
0.00%	**1,082.16**	**768.76**
5.00%	**492.51**	**342.29**
10.00%	**236.01**	**157.73**
15.00%	**116.12**	**72.49**
20.00%	**56.91**	**31.23**
25.00%	**26.47**	**10.69**
IRR	***36.7%***	***30.3%***

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capitel Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	1.08	0.05	0.00	-1.13	0.00	-1.13	-1.13	-0.98
2006	0.00	$30.00	0.00	$2.00	0.00	3.02	0.05	0.00	-3.07	0.00	-3.07	-4.20	-3.30
2007	0.00	$30.00	0.00	$2.00	0.00	8.92	0.05	0.00	-8.97	0.00	-8.97	-13.17	-9.20
2008	0.00	$30.00	0.00	$2.00	0.00	4.61	1.05	0.00	-5.66	0.00	-5.66	-18.83	-12.44
2009	0.00	$30.00	0.00	$2.00	0.00	23.24	1.05	0.00	-24.29	0.00	-24.29	-43.12	-24.51
2010	0.00	$30.00	0.00	$2.00	0.00	24.43	1.05	0.00	-25.48	0.00	-25.48	-68.59	-35.53
2011	0.00	$30.00	0.00	$2.00	0.00	32.57	1.05	0.00	-33.62	0.00	-33.62	-102.21	-48.17
2012	1.46	$30.00	0.00	$2.00	43.80	27.22	3.06	2.19	11.33	6.22	5.11	-97.10	-46.49
2013	2.92	$30.00	0.00	$2.00	87.60	24.55	6.04	4.79	52.22	19.78	32.44	-64.65	-37.27
2014	5.48	$30.00	0.00	$2.00	164.25	20.77	11.25	10.81	121.42	38.70	82.72	18.07	-16.82
2015	4.93	$30.00	0.00	$2.00	147.83	15.10	10.13	9.38	113.22	23.74	89.48	107.54	2.41
2016	4.43	$30.00	0.00	$2.00	133.04	21.50	9.13	8.15	94.26	20.12	74.14	181.69	16.27
2017	3.99	$30.00	0.00	$2.00	119.74	0.00	8.22	7.11	104.41	20.58	83.82	265.51	29.89
2018	3.59	$30.00	0.00	$2.00	107.76	4.50	7.41	6.21	89.64	16.59	73.06	338.57	40.22
2019	3.23	$30.00	0.00	$2.00	96.99	4.50	6.68	5.44	80.37	13.70	66.68	405.25	48.41
2020	2.91	$30.00	0.00	$2.00	87.29	4.50	6.02	4.77	72.00	21.30	50.70	455.95	53.83
2021	2.62	$30.00	0.00	$2.00	78.56	4.50	5.42	4.20	64.44	19.44	45.00	500.95	58.01
2022	2.36	$30.00	0.00	$2.00	70.70	0.00	4.89	3.70	62.12	18.20	43.91	544.86	61.56
2023	2.12	$30.00	0.00	$2.00	63.63	0.00	4.41	3.26	55.96	16.47	39.50	584.36	64.33
2024	1.91	$30.00	0.00	$2.00	57.27	0.00	3.97	2.88	50.41	14.91	35.50	619.86	66.50
2025	1.72	$30.00	0.00	$2.00	51.54	0.00	3.58	2.58	45.38	13.51	31.87	651.74	68.20
2026	1.55	$30.00	0.00	$2.00	46.39	0.00	3.23	2.32	40.84	12.25	28.58	680.32	69.52
2027	1.39	$30.00	0.00	$2.00	41.75	0.00	2.92	2.09	36.74	11.02	25.72	706.04	70.55
2028	1.25	$30.00	0.00	$2.00	37.58	0.00	2.64	1.88	33.06	9.92	23.14	729.19	71.36
2029	1.13	$30.00	0.00	$2.00	33.82	0.00	2.38	1.69	29.75	8.92	20.82	750.01	71.99
2030	1.02	$30.00	0.00	$2.00	30.46	0.00	2.15	1.52	26.79	8.04	18.75	768.76	72.49
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	768.76	72.49
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	768.76	72.49
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	768.76	72.49
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**768.76**	**72.49**
Total	50.00	$30.00	0.00	2.00	1,500.00	225.00	107.87	84.98	1,082.16	313.40	768.76		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Tumbes/Talara
Prospectivity	Upside

Avg. Royalty Rate:	**21.17%**
Income Tax Rate:	***30.00%***

Economic Based Royalty Method

$ / BOE Capex	**4.13**
$ / BOE Opex	**1.62**

Reserves Included in Cash Flows			
	Liquids	Gas	Total
	MMBBL	BCF	MMBOE
Field	***75.0***	***0.0***	***75.0***
Contractor	**75.0**	**0.0**	**75.0**

Petroleum Rent* Distribution (undiscounted)

Gov. Take	**47.39%**
Cont. Take	**52.61%**

Petroleum Rent = Total revenue - total cost

Present value as at: Jan - 01 - 05		
NPV SUMMARY		
	Before Taxes	**After Taxes**
Discount Rate %	**NPV $ MM**	**NPV $ MM**
0.00%	**1,341.98**	**956.72**
5.00%	**619.42**	**434.77**
10.00%	**305.22**	**208.60**
15.00%	**157.17**	**102.97**
20.00%	**82.88**	**50.76**
25.00%	**43.74**	**23.86**
IRR	***44.7%***	***37.1%***

Year	**Oil**	**Oil Price**	**Gas Prodn**	**Gas Price**	**Gross Revenue**	**Capital Cost**	**Operating Cost**	**Royalty**	**Pre Tax Cash Flow**	**Corp. Taxes**	**After Tax Net Cash Flow**	**Cum AT Cash Flow**	**Cum. Net Disc.@15%**
	MMBBL	**$US/bbl**	**BCF**	**$US/mcf**	**$ MM**	**$ MM**	**$ MM**	**$ MM**	**$ MM**	**30.00%**	**$ MM**	**$ MM**	**$ MM**
2005	0.00	$30.00	0.00	$2.00	0.00	0.69	0.05	0.00	-0.74	0.00	-0.74	-0.74	-0.64
2006	0.00	$30.00	0.00	$2.00	0.00	1.96	0.05	0.00	-2.01	0.00	-2.01	-2.75	-2.16
2007	0.00	$30.00	0.00	$2.00	0.00	3.75	0.05	0.00	-3.80	0.00	-3.80	-6.56	-4.67
2008	0.00	$30.00	0.00	$2.00	0.00	15.65	1.05	0.00	-16.70	0.00	-16.70	-23.26	-14.22
2009	0.00	$30.00	0.00	$2.00	0.00	16.47	1.05	0.00	-17.52	0.00	-17.52	-40.78	-22.93
2010	0.00	$30.00	0.00	$2.00	0.00	24.28	1.05	0.00	-25.33	0.00	-25.33	-66.11	-33.88
2011	0.00	$30.00	0.00	$2.00	0.00	17.78	1.05	0.00	-18.83	0.00	-18.83	-84.94	-40.96
2012	1.83	$30.00	0.00	$2.00	54.75	33.40	2.89	2.74	15.72	8.61	7.11	-77.83	-38.63
2013	3.65	$30.00	0.00	$2.00	109.50	25.21	5.71	5.48	73.11	24.31	48.80	-29.04	-24.76
2014	8.21	$30.00	0.00	$2.00	246.38	37.15	12.74	12.32	184.16	59.06	125.10	96.06	6.16
2015	7.39	$30.00	0.00	$2.00	221.74	45.21	11.48	55.43	109.61	26.11	83.50	179.56	24.11
2016	6.65	$30.00	0.00	$2.00	199.56	41.66	10.34	46.13	101.43	22.90	78.53	258.09	38.79
2017	5.99	$30.00	0.00	$2.00	179.61	25.51	9.31	44.71	100.08	19.79	80.29	338.39	51.84
2018	5.39	$30.00	0.00	$2.00	161.65	17.19	8.39	40.41	95.66	17.24	78.42	416.80	62.92
2019	4.85	$30.00	0.00	$2.00	145.48	4.08	7.56	36.37	97.47	16.11	81.36	498.16	72.92
2020	4.36	$30.00	0.00	$2.00	130.93	0.00	6.81	32.73	91.39	25.33	66.06	564.22	79.98
2021	3.93	$30.00	0.00	$2.00	117.84	0.00	6.14	29.46	82.24	23.59	58.66	622.88	85.43
2022	3.54	$30.00	0.00	$2.00	106.06	0.00	5.53	26.51	74.01	21.69	52.32	675.20	89.66
2023	3.18	$30.00	0.00	$2.00	95.45	0.00	4.99	23.86	66.60	19.88	46.72	721.92	92.94
2024	2.86	$30.00	0.00	$2.00	85.91	0.00	4.50	21.48	59.93	17.98	41.95	763.87	95.50
2025	2.58	$30.00	0.00	$2.00	77.32	0.00	4.05	19.33	53.93	16.18	37.75	801.62	97.51
2026	2.32	$30.00	0.00	$2.00	69.58	0.00	3.66	17.40	48.53	14.56	33.97	835.60	99.08
2027	2.09	$30.00	0.00	$2.00	62.63	0.00	3.30	15.66	43.67	13.10	30.57	866.16	100.30
2028	1.88	$30.00	0.00	$2.00	56.36	0.00	2.98	14.09	39.29	11.79	27.51	893.67	101.27
2029	1.69	$30.00	0.00	$2.00	50.73	0.00	2.69	12.68	35.36	10.61	24.75	918.42	102.02
2030	1.52	$30.00	0.00	$2.00	45.65	0.00	2.43	11.41	31.81	9.54	22.27	940.69	102.61
2031	1.10	$30.00	0.00	$2.00	32.88	0.00	1.77	8.22	22.89	6.87	16.02	956.72	102.97
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	956.72	102.97
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	956.72	102.97
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**956.72**	**102.97**
Total	75.00	$30.00	0.00	2.00	2,250.00	310.00	121.60	476.42	1,341.98	385.26	956.72		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Tumbes/Talara
Prospectivity	Upside

Avg. Royalty Rate:	**6.31%**
Income Tax Rate:	**30.00%**

Production Based Royalty Method

$ / BOE Capex	**4.13**
$ / BOE Opex	**1.62**

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	**75.0**	**0.0**	**75.0**
Contractor	**75.0**	**0.0**	**75.0**

Petroleum Rent* Distribution (undiscounted)	
Gov. Take	**34.51%**
Cont. Take	**65.49%**

** Petroleum Rent = Total Revenue - total cost*

Present value as at: Jan - 01 - 05		
NPV SUMMARY		
	Before Taxes	**After Taxes**
Discount Rate %	**NPV $ MM**	**NPV $ MM**
0.00%	**1,676.37**	**1,190.79**
5.00%	**769.02**	**539.50**
10.00%	**377.39**	**259.12**
15.00%	**194.20**	**128.89**
20.00%	**102.85**	**64.74**
25.00%	**54.98**	**31.73**
IRR	**47.2%**	**39.6%**

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	0.69	0.05	0.00	-0.74	0.00	-0.74	-0.74	-0.64
2006	0.00	$30.00	0.00	$2.00	0.00	1.96	0.05	0.00	-2.01	0.00	-2.01	-2.75	-2.16
2007	0.00	$30.00	0.00	$2.00	0.00	3.75	0.05	0.00	-3.80	0.00	-3.80	-6.56	-4.67
2008	0.00	$30.00	0.00	$2.00	0.00	15.65	1.05	0.00	-16.70	0.00	-16.70	-23.26	-14.22
2009	0.00	$30.00	0.00	$2.00	0.00	16.47	1.05	0.00	-17.52	0.00	-17.52	-40.78	-22.93
2010	0.00	$30.00	0.00	$2.00	0.00	24.28	1.05	0.00	-25.33	0.00	-25.33	-66.11	-33.88
2011	0.00	$30.00	0.00	$2.00	0.00	17.78	1.05	0.00	-18.83	0.00	-18.83	-84.94	-40.96
2012	1.83	$30.00	0.00	$2.00	54.75	33.40	2.89	2.74	15.72	8.61	7.11	-77.83	-38.63
2013	3.65	$30.00	0.00	$2.00	109.50	25.21	5.71	6.34	72.25	24.05	48.19	-29.64	-24.93
2014	8.21	$30.00	0.00	$2.00	246.38	37.15	12.74	19.13	177.35	57.02	120.33	90.69	4.81
2015	7.39	$30.00	0.00	$2.00	221.74	45.21	11.48	16.43	148.62	37.81	110.81	201.50	28.63
2016	6.65	$30.00	0.00	$2.00	199.56	41.66	10.34	14.15	133.42	32.50	100.92	302.42	47.49
2017	5.99	$30.00	0.00	$2.00	179.61	25.51	9.31	12.21	132.57	29.53	103.04	405.46	64.24
2018	5.39	$30.00	0.00	$2.00	161.65	17.19	8.39	10.57	125.49	26.19	99.30	504.76	78.27
2019	4.85	$30.00	0.00	$2.00	145.48	4.08	7.56	9.18	124.67	24.27	100.40	605.16	90.61
2020	4.36	$30.00	0.00	$2.00	130.93	0.00	6.81	7.99	116.14	32.76	83.38	688.54	99.52
2021	3.93	$30.00	0.00	$2.00	117.84	0.00	6.14	6.96	104.74	30.34	74.40	762.94	106.43
2022	3.54	$30.00	0.00	$2.00	106.06	0.00	5.53	6.09	94.44	27.82	66.62	829.56	111.82
2023	3.18	$30.00	0.00	$2.00	95.45	0.00	4.99	5.33	85.13	25.44	59.69	889.25	116.01
2024	2.86	$30.00	0.00	$2.00	85.91	0.00	4.50	4.68	76.73	23.02	53.71	942.96	119.29
2025	2.58	$30.00	0.00	$2.00	77.32	0.00	4.05	4.12	69.14	20.74	48.40	991.36	121.86
2026	2.32	$30.00	0.00	$2.00	69.58	0.00	3.66	3.63	62.30	18.69	43.61	1,034.97	123.88
2027	2.09	$30.00	0.00	$2.00	62.63	0.00	3.30	3.20	56.12	16.84	39.29	1,074.26	125.46
2028	1.88	$30.00	0.00	$2.00	56.36	0.00	2.98	2.83	50.55	15.17	35.39	1,109.65	126.69
2029	1.69	$30.00	0.00	$2.00	50.73	0.00	2.69	2.54	45.50	13.65	31.85	1,141.50	127.66
2030	1.52	$30.00	0.00	$2.00	45.65	0.00	2.43	2.28	40.94	12.28	28.66	1,170.16	128.42
2031	1.10	$30.00	0.00	$2.00	32.88	0.00	1.77	1.64	29.47	8.84	20.63	1,190.79	128.89
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,190.79	128.89
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,190.79	128.89
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,190.79**	**128.89**
Total	75.00	$30.00	0.00	2.00	2,250.00	310.00	121.60	142.03	1,676.37	485.58	1,190.79		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Trujillo-Salaverry-Sechura
Prospectivity	Downside

Avg. Royalty Rate:	19.89%
Income Tax Rate:	30.00%
Economic Based Roylaty Method	

$ / BOE Capex	3.10
$ / BOE Opex	2.59

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	50.0	0.0	50.0
Contractor	50.0	0.0	50.0

Petroleum Rent* Distribution (undiscounted)

Gov. Take	46.79%
Cont. Take	53.21%

** Petroleum Rent = Total Revenue-Total Cost*

Present value as at: Jan - 01 - 05 NPV SUMMARY	Before Taxes	After Taxes
Discount Rate %	NPV $ MM	NPV $ MM
0.00%	917.60	647.14
5.00%	484.73	333.98
10.00%	263.09	175.25
15.00%	145.16	91.98
20.00%	80.40	47.12
25.00%	43.91	22.47
IRR	44.2%	36.2%

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	0.74	0.05	0.00	-0.79	0.00	-0.79	-0.79	-0.68
2006	0.00	$30.00	0.00	$2.00	0.00	2.94	0.05	0.00	-2.99	0.00	-2.99	-3.78	-2.95
2007	0.00	$30.00	0.00	$2.00	0.00	7.93	0.05	0.00	-7.98	0.00	-7.98	-11.76	-8.19
2008	0.00	$30.00	0.00	$2.00	0.00	9.56	0.05	0.00	-9.61	0.00	-9.61	-21.37	-13.69
2009	0.00	$30.00	0.00	$2.00	0.00	37.53	0.05	0.00	-37.58	0.00	-37.58	-58.95	-32.37
2010	0.00	$30.00	0.00	$2.00	0.00	15.84	0.05	0.00	-15.89	0.00	-15.89	-74.84	-39.24
2011	0.00	$30.00	0.00	$2.00	0.00	25.65	0.05	0.00	-25.70	0.00	-25.70	-100.54	-48.90
2012	2.92	$30.00	0.00	$2.00	87.60	26.77	4.65	4.38	51.80	19.49	32.30	-68.23	-38.34
2013	4.38	$30.00	0.00	$2.00	131.40	12.68	12.23	6.57	99.93	31.79	68.14	-0.09	-18.97
2014	5.48	$30.00	0.00	$2.00	164.25	6.02	16.37	8.21	131.65	40.49	91.15	91.06	3.56
2015	8.50	$30.00	0.00	$2.00	255.03	4.54	16.37	63.76	168.35	42.23	126.12	217.18	30.67
2016	6.89	$30.00	0.00	$2.00	206.57	0.74	16.54	51.64	137.65	32.44	105.21	322.39	50.33
2017	5.58	$30.00	0.00	$2.00	167.32	3.74	13.25	41.83	108.51	23.98	84.52	406.91	64.07
2018	4.52	$30.00	0.00	$2.00	135.53	0.37	10.62	33.88	90.66	18.27	72.39	479.30	74.30
2019	3.66	$30.00	0.00	$2.00	109.78	0.00	8.51	27.45	73.83	13.22	60.61	539.91	81.75
2020	2.96	$30.00	0.00	$2.00	88.92	0.00	6.82	22.23	59.87	17.89	41.98	581.89	86.24
2021	2.40	$30.00	0.00	$2.00	72.03	0.00	5.47	18.01	48.55	14.49	34.05	615.94	89.40
2022	1.94	$30.00	0.00	$2.00	58.34	0.00	4.40	14.59	39.36	11.81	27.55	643.50	91.63
2023	0.80	$30.00	0.00	$2.00	24.00	0.00	3.53	6.00	14.47	4.34	10.13	653.62	92.34
2024	0.00	$30.00	0.00	$2.00	0.00	0.00	2.76	0.00	-2.76	0.00	-2.76	650.86	92.17
2025	0.00	$30.00	0.00	$2.00	0.00	0.00	2.21	0.00	-2.21	0.00	-2.21	648.65	92.05
2026	0.00	$30.00	0.00	$2.00	0.00	0.00	1.51	0.00	-1.51	0.00	-1.51	647.14	91.98
2027	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	647.14	91.98
2028	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	647.14	91.98
2029	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	647.14	91.98
2030	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	647.14	91.98
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	647.14	91.98
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	647.14	91.98
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	647.14	91.98
Remainder	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	647.14	91.98
Total	50.03	$30.00	0.00	2.00	1,500.77	155.03	129.60	298.54	917.60	270.45	647.14		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin Trujillo-Salaverry-Sechura
Prospectivity Downside

Avg. Royalty Rate: 6.33%
Income Tax Rate: 30.00%
Production Based Royalty Method

$ / BOE Capex	3.10
$ / BOE Opex	2.60

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	50.0	0.0	50.0
Contractor	50.0	0.0	50.0

Petroleum Rent* Distribution (undiscounted)	
Gov. Take	34.95%
Cont. Take	65.05%

** Petroleum Rent = Total Revenue-Total Cost*

Present value as at: Jan - 01 - 05 NPV SUMMARY	Before Taxes	After Taxes
Discount Rate %	NPV $ MM	NPV $ MM
0.00%	1,120.14	790.87
5.00%	572.15	395.88
10.00%	302.48	203.09
15.00%	163.36	104.83
20.00%	88.82	53.06
25.00%	47.69	25.14
IRR	*43.9%*	*36.4%*

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	0.74	0.05	0.00	-0.79	0.00	-0.79	-0.79	-0.68
2006	0.00	$30.00	0.00	$2.00	0.00	2.94	0.05	0.00	-2.99	0.00	-2.99	-3.78	-2.95
2007	0.00	$30.00	0.00	$2.00	0.00	7.93	0.05	0.00	-7.98	0.00	-7.98	-11.76	-8.19
2008	0.00	$30.00	0.00	$2.00	0.00	9.56	0.05	0.00	-9.61	0.00	-9.61	-21.37	-13.69
2009	0.00	$30.00	0.00	$2.00	0.00	37.53	0.05	0.00	-37.58	0.00	-37.58	-58.95	-32.37
2010	0.00	$30.00	0.00	$2.00	0.00	15.84	0.05	0.00	-15.89	0.00	-15.89	-74.84	-39.24
2011	0.00	$30.00	0.00	$2.00	0.00	25.65	0.05	0.00	-25.70	0.00	-25.70	-100.54	-48.90
2012	1.83	$30.00	0.00	$2.00	54.75	26.77	4.65	2.74	20.59	10.13	10.46	-90.08	-45.48
2013	3.65	$30.00	0.00	$2.00	109.50	12.68	12.23	6.34	78.26	25.29	52.97	-37.11	-30.43
2014	7.30	$30.00	0.00	$2.00	219.00	6.02	18.37	16.14	178.48	54.54	123.93	86.82	0.21
2015	7.30	$30.00	0.00	$2.00	219.00	4.54	18.37	16.14	179.95	45.71	134.24	221.06	29.06
2016	6.57	$30.00	0.00	$2.00	197.10	0.74	16.54	13.90	165.92	40.92	125.00	346.06	52.43
2017	5.26	$30.00	0.00	$2.00	157.68	3.74	13.25	10.22	130.47	30.57	99.90	445.96	68.66
2018	4.20	$30.00	0.00	$2.00	126.14	0.37	10.62	7.61	107.55	23.34	84.21	530.17	80.56
2019	3.36	$30.00	0.00	$2.00	100.92	0.00	8.51	5.72	86.69	17.08	69.61	599.78	89.12
2020	2.69	$30.00	0.00	$2.00	80.73	0.00	6.82	4.34	69.57	20.80	48.77	648.55	94.33
2021	2.15	$30.00	0.00	$2.00	64.59	0.00	5.47	3.32	55.79	16.67	39.13	687.68	97.97
2022	1.72	$30.00	0.00	$2.00	51.67	0.00	4.40	2.58	44.69	13.41	31.28	718.96	100.49
2023	1.38	$30.00	0.00	$2.00	41.33	0.00	3.53	2.07	35.74	10.72	25.01	743.97	102.25
2024	1.10	$30.00	0.00	$2.00	33.07	0.00	2.84	1.65	28.57	8.57	20.00	763.97	103.47
2025	0.88	$30.00	0.00	$2.00	26.45	0.00	2.29	1.32	22.84	6.85	15.99	779.96	104.32
2026	0.60	$30.00	0.00	$2.00	18.07	0.00	1.59	0.90	15.57	4.67	10.90	790.87	104.83
2027	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	790.87	104.83
2028	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	790.87	104.83
2029	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	790.87	104.83
2030	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	790.87	104.83
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	790.87	104.83
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	790.87	104.83
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	790.87	104.83
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**790.87**	**104.83**
Total	50.00	$30.00	0.00	2.00	1,500.00	155.03	129.84	94.99	1,120.14	329.27	790.87		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Trujillo-Salaverry-Sechura
Prospectivity	Base

Avg. Royalty Rate:	21.64%
Income Tax Rate:	30.00%
Economic Based Royalty Method	

$ / BOE Capex	2.54
$ / BOE Opex	1.84

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	250.0	0.0	250.0
Contractor	250.0	0.0	250.0

Petroleum Rent* Distribution (undiscounted)	
Gov. Take	47.31%
Cont. Take	52.69%

** Petroleum Rent = Total Revenue-Total Cost*

Present value as at: Jan - 01 - 05 NPV SUMMARY	Before Taxes	After Taxes
Discount Rate %	NPV $ MM	NPV $ MM
0.00%	4,782.62	3,375.05
5.00%	2,336.87	1,622.47
10.00%	1,194.18	808.25
15.00%	628.76	409.17
20.00%	335.73	205.26
25.00%	178.25	97.85
IRR	44.5%	37.3%

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	1.92	0.05	0.00	-1.97	0.00	-1.97	-1.97	-1.71
2006	0.00	$30.00	0.00	$2.00	0.00	5.38	0.05	0.00	-5.43	0.00	-5.43	-7.40	-5.82
2007	0.00	$30.00	0.00	$2.00	0.00	41.87	0.05	0.00	-41.92	0.00	-41.92	-49.32	-33.38
2008	0.00	$30.00	0.00	$2.00	0.00	40.21	0.05	0.00	-40.26	0.00	-40.26	-89.58	-56.40
2009	0.00	$30.00	0.00	$2.00	0.00	78.85	0.05	0.00	-78.90	0.00	-78.90	-168.48	-95.63
2010	0.00	$30.00	0.00	$2.00	0.00	58.44	0.05	0.00	-58.49	0.00	-58.49	-226.97	-120.91
2011	0.00	$30.00	0.00	$2.00	0.00	85.91	0.05	0.00	-85.96	0.00	-85.96	-312.93	-153.23
2012	3.65	$30.00	0.00	$2.00	109.50	79.84	10.69	5.48	13.50	18.98	-5.48	-318.41	-155.02
2013	10.95	$30.00	0.00	$2.00	328.50	68.48	19.95	16.43	223.64	78.61	145.04	-173.37	-113.79
2014	27.38	$30.00	0.00	$2.00	821.25	55.13	49.76	41.06	675.30	209.86	465.44	292.06	1.26
2015	27.38	$30.00	0.00	$2.00	821.25	45.99	49.76	205.31	520.19	130.64	389.56	681.62	84.99
2016	27.38	$30.00	0.00	$2.00	821.25	28.22	49.76	205.31	537.96	132.26	405.70	1,087.32	160.82
2017	27.38	$30.00	0.00	$2.00	821.25	22.92	49.76	205.31	543.26	132.55	410.71	1,498.03	227.57
2018	23.27	$30.00	0.00	$2.00	698.06	5.46	42.32	174.52	475.77	109.33	366.44	1,864.46	279.36
2019	19.78	$30.00	0.00	$2.00	593.35	5.46	36.00	148.34	403.55	87.56	316.00	2,180.46	318.19
2020	16.81	$30.00	0.00	$2.00	504.35	5.46	30.57	126.09	342.24	101.40	240.83	2,421.29	343.93
2021	14.29	$30.00	0.00	$2.00	428.70	5.46	26.00	107.17	290.06	86.45	203.62	2,624.91	362.85
2022	12.15	$30.00	0.00	$2.00	364.39	0.00	22.12	91.10	251.16	74.92	176.26	2,801.17	377.09
2023	10.32	$30.00	0.00	$2.00	309.73	0.00	18.78	77.43	213.52	63.73	149.79	2,950.96	387.62
2024	8.78	$30.00	0.00	$2.00	263.27	0.00	15.97	65.82	181.48	54.23	127.25	3,078.21	395.39
2025	7.46	$30.00	0.00	$2.00	223.78	0.00	13.59	55.95	154.25	46.17	108.08	3,186.29	401.13
2026	6.34	$30.00	0.00	$2.00	190.22	0.00	11.56	47.55	131.10	39.33	91.77	3,278.06	405.37
2027	5.39	$30.00	0.00	$2.00	161.68	0.00	9.84	40.42	111.42	33.43	78.00	3,356.06	408.51
2028	1.32	$30.00	0.00	$2.00	39.45	0.00	2.46	9.86	27.13	8.14	18.99	3,375.05	409.17
2029	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,375.05	409.17
2030	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,375.05	409.17
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,375.05	409.17
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,375.05	409.17
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,375.05	409.17
Remainder	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,375.05	409.17
Total	250.00	$30.00	0.00	2.00	7,500.00	635.00	459.23	1,623.15	4,782.62	1,407.57	3,375.05		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Trujillo-Salaverry-Sechura
Prospectivity	Base

Avg. Royalty Rate:	12.88%
Income Tax Rate:	30.00%
Production Based Royalty Method	

$ / BOE Capex	2.54
$ / BOE Opex	1.84

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	250.0	0.0	250.0
Contractor	250.0	0.0	250.0

Petroleum Rent* Distribution (undiscounted)	
Gov. Take	40.65%
Cont. Take	59.35%

** Petroleum Rent = Total Revenue-Total Cost*

Present value as at: Jan - 01 - 05 NPV SUMMARY	Before Taxes	After Taxes
Discount Rate %	NPV $ MM	NPV $ MM
0.00%	5,439.97	3,835.19
5.00%	2,624.72	1,823.97
10.00%	1,326.81	901.09
15.00%	692.44	453.74
20.00%	367.31	227.36
25.00%	194.29	109.08
IRR	45.0%	37.9%

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	1.92	0.05	0.00	-1.97	0.00	-1.97	-1.97	-1.71
2006	0.00	$30.00	0.00	$2.00	0.00	5.38	0.05	0.00	-5.43	0.00	-5.43	-7.40	-5.82
2007	0.00	$30.00	0.00	$2.00	0.00	41.87	0.05	0.00	-41.92	0.00	-41.92	-49.32	-33.38
2008	0.00	$30.00	0.00	$2.00	0.00	40.21	0.05	0.00	-40.26	0.00	-40.26	-89.58	-56.40
2009	0.00	$30.00	0.00	$2.00	0.00	78.85	0.05	0.00	-78.90	0.00	-78.90	-168.48	-95.63
2010	0.00	$30.00	0.00	$2.00	0.00	58.44	0.05	0.00	-58.49	0.00	-58.49	-226.97	-120.91
2011	0.00	$30.00	0.00	$2.00	0.00	85.91	0.05	0.00	-85.96	0.00	-85.96	-312.93	-153.23
2012	3.65	$30.00	0.00	$2.00	109.50	79.84	10.69	6.34	12.63	18.72	-6.09	-319.01	-155.22
2013	10.95	$30.00	0.00	$2.00	328.50	68.48	19.95	29.39	210.68	74.72	135.96	-183.06	-116.57
2014	27.38	$30.00	0.00	$2.00	821.25	55.13	49.76	131.83	584.53	182.63	401.90	218.84	-17.23
2015	27.38	$30.00	0.00	$2.00	821.25	45.99	49.76	131.83	593.67	152.88	440.99	659.83	77.56
2016	27.38	$30.00	0.00	$2.00	821.25	28.22	49.76	131.83	611.44	154.30	457.14	1,116.97	163.00
2017	27.38	$30.00	0.00	$2.00	821.25	22.92	49.76	131.83	616.74	154.60	462.14	1,579.11	238.11
2018	23.27	$30.00	0.00	$2.00	698.06	5.46	42.32	99.66	550.62	131.79	418.84	1,997.95	297.31
2019	19.78	$30.00	0.00	$2.00	593.35	5.46	36.00	75.75	476.14	109.33	366.81	2,364.76	342.39
2020	16.81	$30.00	0.00	$2.00	504.35	5.46	30.57	57.91	410.41	121.85	288.56	2,653.31	373.22
2021	14.29	$30.00	0.00	$2.00	428.70	5.46	26.00	44.55	352.69	105.23	247.45	2,900.77	396.22
2022	12.15	$30.00	0.00	$2.00	364.39	0.00	22.12	34.49	307.79	91.90	215.88	3,116.65	413.66
2023	10.32	$30.00	0.00	$2.00	309.73	0.00	18.78	26.87	264.08	78.90	185.18	3,301.83	426.67
2024	8.78	$30.00	0.00	$2.00	263.27	0.00	15.97	21.08	226.22	67.65	158.57	3,460.40	436.36
2025	7.46	$30.00	0.00	$2.00	223.78	0.00	13.59	16.64	193.55	57.96	135.59	3,595.99	443.57
2026	6.34	$30.00	0.00	$2.00	190.22	0.00	11.56	13.23	165.43	49.63	115.80	3,711.79	448.92
2027	5.39	$30.00	0.00	$2.00	161.68	0.00	9.84	10.58	141.27	42.38	98.89	3,810.68	452.89
2028	1.32	$30.00	0.00	$2.00	39.45	0.00	2.46	1.97	35.02	10.51	24.51	3,835.19	453.74
2029	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,835.19	453.74
2030	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,835.19	453.74
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,835.19	453.74
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,835.19	453.74
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,835.19	453.74
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3,835.19**	**453.74**
Total	250.00	$30.00	0.00	2.00	7,500.00	635.00	459.23	965.80	5,439.97	1,604.78	3,835.19		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Trujillo-Salaverry-Sechura
Prospectivity	Upside

Avg. Royalty Rate:	21.79%
Income Tax Rate:	30.00%

Economic Based Royalty Method

$ / BOE Capex	2.47
$ / BOE Opex	1.28

Reserves Included in Cash Flows

	Liquids MMBBL	Gas BCF	Total MMBOE
Field	500.0	0.0	500.0
Contractor	500.0	0.0	500.0

Petroleum Rent* Distribution (undiscounted)

Gov. Take	45.67%
Cont. Take	54.33%

** Petroleum Rent = Total Revenue-Total Cost*

Present value as at: Jan - 01 - 05
NPV SUMMARY

Discount Rate %	Before Taxes NPV $ MM	After Taxes NPV $ MM
0.00%	9,858.60	6,966.78
5.00%	4,654.02	3,250.76
10.00%	2,351.08	1,611.70
15.00%	1,244.11	829.19
20.00%	677.65	433.03
25.00%	373.72	223.66
IRR	50.0%	42.4%

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	3.70	0.05	0.00	-3.75	0.00	-3.75	-3.75	-3.26
2006	0.00	$30.00	0.00	$2.00	0.00	14.84	0.05	0.00	-14.89	0.00	-14.89	-18.64	-14.52
2007	0.00	$30.00	0.00	$2.00	0.00	53.41	0.05	0.00	-53.46	0.00	-53.46	-72.10	-49.67
2008	0.00	$30.00	0.00	$2.00	0.00	61.36	0.05	0.00	-61.41	0.00	-61.41	-133.52	-84.79
2009	0.00	$30.00	0.00	$2.00	0.00	89.74	0.05	0.00	-89.79	0.00	-89.79	-223.31	-129.43
2010	0.00	$30.00	0.00	$2.00	0.00	79.06	0.05	0.00	-79.11	0.00	-79.11	-302.42	-163.63
2011	0.00	$30.00	0.00	$2.00	0.00	132.40	0.05	0.00	-132.45	0.00	-132.45	-434.87	-213.43
2012	7.30	$30.00	0.00	$2.00	219.00	197.76	13.32	10.95	-3.03	25.63	-28.67	-463.54	-222.80
2013	18.25	$30.00	0.00	$2.00	547.50	118.00	23.10	27.38	379.03	131.55	247.48	-216.06	-152.45
2014	54.75	$30.00	0.00	$2.00	1,642.50	112.14	69.47	82.13	1,378.76	431.75	947.01	730.95	81.64
2015	54.75	$30.00	0.00	$2.00	1,642.50	113.15	69.47	410.63	1,049.25	276.41	772.84	1,503.79	247.75
2016	43.80	$30.00	0.00	$2.00	1,314.00	109.51	55.61	328.50	820.37	203.64	616.73	2,120.52	363.03
2017	43.80	$30.00	0.00	$2.00	1,314.00	70.48	55.61	328.50	859.41	207.97	651.44	2,771.96	468.90
2018	43.80	$30.00	0.00	$2.00	1,314.00	50.35	55.61	328.50	879.54	210.04	669.50	3,441.45	563.52
2019	37.23	$30.00	0.00	$2.00	1,116.90	21.52	47.30	279.23	768.86	172.22	596.64	4,038.10	636.85
2020	31.65	$30.00	0.00	$2.00	949.37	5.56	40.23	237.34	666.23	192.99	473.24	4,511.33	687.42
2021	26.90	$30.00	0.00	$2.00	806.96	0.00	34.22	201.74	571.00	166.46	404.53	4,915.87	725.01
2022	22.86	$30.00	0.00	$2.00	685.92	0.00	29.12	171.48	485.32	142.86	342.46	5,258.33	752.68
2023	19.43	$30.00	0.00	$2.00	583.03	0.00	24.78	145.76	412.50	122.64	289.85	5,548.18	773.05
2024	16.52	$30.00	0.00	$2.00	495.57	0.00	21.03	123.89	350.65	104.97	245.68	5,793.86	788.06
2025	14.04	$30.00	0.00	$2.00	421.24	0.00	17.89	105.31	298.04	89.41	208.63	6,002.49	799.15
2026	11.94	$30.00	0.00	$2.00	358.05	0.00	15.23	89.51	253.31	75.99	177.32	6,179.81	807.34
2027	10.14	$30.00	0.00	$2.00	304.34	0.00	12.92	76.09	215.34	64.60	150.74	6,330.55	813.39
2028	8.62	$30.00	0.00	$2.00	258.69	0.00	10.99	64.67	183.03	54.91	128.12	6,458.66	817.87
2029	7.33	$30.00	0.00	$2.00	219.89	0.00	9.36	54.97	155.56	46.67	108.89	6,567.56	821.18
2030	6.23	$30.00	0.00	$2.00	186.91	0.00	7.97	46.73	132.21	39.66	92.55	6,660.11	823.62
2031	5.30	$30.00	0.00	$2.00	158.87	0.00	6.78	39.72	112.37	33.71	78.68	6,738.76	825.43
2032	4.50	$30.00	0.00	$2.00	135.04	0.00	5.78	33.76	95.50	28.65	66.85	6,805.62	826.76
2033	3.83	$30.00	0.00	$2.00	114.78	0.00	4.92	28.70	81.17	24.35	56.82	6,862.43	827.75
Remainder	7.03	$30.00	0.00	$2.00	210.94	0.00	9.14	52.73	149.06	44.72	104.35	6,966.78	829.19
Total	500.00	$30.00	0.00	2.00	15,000.00	1,233.00	640.20	3,268.20	9,858.60	2,891.82	6,966.78		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin Trujillo-Salaverry-Sechura
Prospectivity Upside

Avg. Royalty Rate: 16.43%
Income Tax Rate: 30.00%
Production Based Royalty Method

$ / BOE Capex	2.47
$ / BOE Opex	1.28

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	500.0	0.0	500.0
Contractor	500.0	0.0	500.0

Petroleum Rent* Distribution (undiscounted)	
Gov. Take	43.52%
Cont. Take	56.48%

** Petroleum Rent = Total Revenue-Total Cost*

Present value as at: Jan - 01 - 05 NPV SUMMARY	Before Taxes	After Taxes
Discount Rate %	NPV $ MM	NPV $ MM
0.00%	10,661.62	7,528.90
5.00%	4,923.08	3,439.11
10.00%	2,440.50	1,674.29
15.00%	1,270.15	847.42
20.00%	681.23	435.54
25.00%	369.87	220.96
IRR	*49.0%*	*41.6%*

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	3.70	0.05	0.00	-3.75	0.00	-3.75	-3.75	-3.26
2006	0.00	$30.00	0.00	$2.00	0.00	14.84	0.05	0.00	-14.89	0.00	-14.89	-18.64	-14.52
2007	0.00	$30.00	0.00	$2.00	0.00	53.41	0.05	0.00	-53.46	0.00	-53.46	-72.10	-49.67
2008	0.00	$30.00	0.00	$2.00	0.00	61.36	0.05	0.00	-61.41	0.00	-61.41	-133.52	-84.79
2009	0.00	$30.00	0.00	$2.00	0.00	89.74	0.05	0.00	-89.79	0.00	-89.79	-223.31	-129.43
2010	0.00	$30.00	0.00	$2.00	0.00	79.06	0.05	0.00	-79.11	0.00	-79.11	-302.42	-163.63
2011	0.00	$30.00	0.00	$2.00	0.00	132.40	0.05	0.00	-132.45	0.00	-132.45	-434.87	-213.43
2012	7.30	$30.00	0.00	$2.00	219.00	197.76	13.32	16.14	-8.22	24.08	-32.30	-467.17	-223.98
2013	18.25	$30.00	0.00	$2.00	547.50	118.00	23.10	66.28	340.13	119.88	220.25	-246.92	-161.38
2014	54.75	$30.00	0.00	$2.00	1,642.50	112.14	69.47	328.50	1,132.38	357.83	774.55	527.62	30.08
2015	54.75	$30.00	0.00	$2.00	1,642.50	113.15	69.47	328.50	1,131.38	301.05	830.32	1,357.95	208.55
2016	43.80	$30.00	0.00	$2.00	1,314.00	109.51	55.61	262.80	886.07	223.35	662.72	2,020.67	332.42
2017	43.80	$30.00	0.00	$2.00	1,314.00	70.48	55.61	262.80	925.11	227.68	697.43	2,718.10	445.77
2018	43.80	$30.00	0.00	$2.00	1,314.00	50.35	55.61	262.80	945.24	229.75	715.49	3,433.59	546.89
2019	37.23	$30.00	0.00	$2.00	1,116.90	21.52	47.30	223.38	824.70	188.97	635.73	4,069.32	625.02
2020	31.65	$30.00	0.00	$2.00	949.37	5.56	40.23	169.94	733.63	213.21	520.42	4,589.74	680.63
2021	26.90	$30.00	0.00	$2.00	806.96	0.00	34.22	127.68	644.86	188.62	456.24	5,045.98	723.03
2022	22.86	$30.00	0.00	$2.00	685.92	0.00	29.12	96.72	560.08	165.29	394.79	5,440.77	754.93
2023	19.43	$30.00	0.00	$2.00	583.03	0.00	24.78	73.56	484.69	144.30	340.39	5,781.16	778.85
2024	16.52	$30.00	0.00	$2.00	495.57	0.00	21.03	56.28	418.27	125.26	293.01	6,074.17	796.75
2025	14.04	$30.00	0.00	$2.00	421.24	0.00	17.89	43.32	360.02	108.01	252.02	6,326.19	810.14
2026	11.94	$30.00	0.00	$2.00	358.05	0.00	15.23	33.56	309.27	92.78	216.49	6,542.67	820.14
2027	10.14	$30.00	0.00	$2.00	304.34	0.00	12.92	26.17	265.25	79.58	185.68	6,728.35	827.60
2028	8.62	$30.00	0.00	$2.00	258.69	0.00	10.99	20.54	227.16	68.15	159.01	6,887.36	833.16
2029	7.33	$30.00	0.00	$2.00	219.89	0.00	9.36	16.23	194.30	58.29	136.01	7,023.37	837.29
2030	6.23	$30.00	0.00	$2.00	186.91	0.00	7.97	12.91	166.03	49.81	116.22	7,139.60	840.36
2031	5.30	$30.00	0.00	$2.00	158.87	0.00	6.78	10.33	141.76	42.53	99.23	7,238.83	842.64
2032	4.50	$30.00	0.00	$2.00	135.04	0.00	5.76	8.32	120.95	36.28	84.66	7,323.49	844.33
2033	3.83	$30.00	0.00	$2.00	114.78	0.00	4.92	6.73	103.13	30.94	72.19	7,395.68	845.58
Remainder	**7.03**	**$30.00**	**0.00**	**$2.00**	**210.94**	**0.00**	**9.14**	**11.49**	**190.31**	**57.09**	**133.22**	**7,528.90**	**847.42**
Total	500.00	$30.00	0.00	2.00	15,000.00	1,233.00	640.20	2,465.17	10,661.62	3,132.73	7,528.90		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Pisco
Prospectivity	Downside
Avg. Royalty Rate:	**20.63%**
Income Tax Rate:	**30.00%**

Economic Based Royalty Method

$ / BOE Capex	**2.85**
$ / BOE Opex	**2.15**

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	**100.0**	**0.0**	**100.0**
Contractor	**100.0**	**0.0**	**100.0**

Petroleum Rent* Distribution (undiscounted)

Gov. Take	***46.71%***
Cont. Take	**53.29%**

* Petroleum Rent = Total revenue - total costs

Present value as at: Jan - 01 - 05
NPV SUMMARY

Discount Rate %	Before Taxes NPV $ MM	After Taxes NPV $ MM
0.00%	**1,881.34**	**1,332.41**
5.00%	**890.36**	**618.76**
10.00%	**442.11**	**298.02**
15.00%	**226.56**	**145.62**
20.00%	**117.76**	**70.10**
25.00%	**60.77**	**31.60**
IRR	***43.9%***	***36.0%***

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	0.38	0.05	0.00	-0.43	0.00	-0.43	-0.43	-0.37
2006	0.00	$30.00	0.00	$2.00	0.00	1.51	0.05	0.00	-1.56	0.00	-1.56	-1.98	-1.55
2007	0.00	$30.00	0.00	$2.00	0.00	5.27	0.05	0.00	-5.32	0.00	-5.32	-7.30	-5.04
2008	0.00	$30.00	0.00	$2.00	0.00	4.89	0.05	0.00	-4.94	0.00	-4.94	-12.24	-7.87
2009	0.00	$30.00	0.00	$2.00	0.00	27.46	1.05	0.00	-28.51	0.00	-28.51	-40.76	-22.05
2010	0.00	$30.00	0.00	$2.00	0.00	40.53	1.05	0.00	-41.58	0.00	-41.58	-82.33	-40.02
2011	0.00	$30.00	0.00	$2.00	0.00	84.30	1.05	0.00	-85.35	0.00	-85.35	-167.69	-72.11
2012	1.83	$30.00	0.00	$2.00	54.75	71.72	3.91	2.74	-23.62	0.86	-24.48	-192.17	-80.11
2013	3.65	$30.00	0.00	$2.00	109.50	19.90	7.75	5.48	76.38	27.12	49.27	-142.90	-66.11
2014	10.95	$30.00	0.00	$2.00	328.50	21.31	23.12	16.43	267.65	85.55	182.10	39.19	-21.10
2015	10.95	$30.00	0.00	$2.00	328.50	3.79	23.12	49.55	252.05	59.36	192.69	231.89	20.32
2016	9.86	$30.00	0.00	$2.00	295.65	0.38	20.78	73.91	200.59	43.44	157.14	389.03	49.69
2017	8.87	$30.00	0.00	$2.00	266.09	3.38	18.71	66.52	177.48	36.80	140.68	529.71	72.56
2018	7.98	$30.00	0.00	$2.00	239.48	0.19	16.84	59.87	162.58	31.97	130.61	660.31	91.02
2019	7.18	$30.00	0.00	$2.00	215.53	0.00	15.17	53.88	146.48	27.14	119.34	779.65	105.68
2020	6.47	$30.00	0.00	$2.00	193.98	0.00	13.66	48.49	131.82	39.48	92.35	872.00	115.55
2021	5.82	$30.00	0.00	$2.00	174.58	0.00	12.30	43.64	118.63	35.52	83.12	955.12	123.27
2022	5.24	$30.00	0.00	$2.00	157.12	0.00	11.08	39.28	106.76	32.03	74.73	1,029.85	129.31
2023	4.71	$30.00	0.00	$2.00	141.41	0.00	9.98	35.35	96.08	28.82	67.25	1,097.10	134.04
2024	4.24	$30.00	0.00	$2.00	127.27	0.00	8.99	31.82	86.46	25.94	60.52	1,157.63	137.74
2025	3.82	$30.00	0.00	$2.00	114.54	0.00	8.10	28.64	77.81	23.34	54.47	1,212.09	140.63
2026	3.44	$30.00	0.00	$2.00	103.09	0.00	7.30	25.77	70.02	21.01	49.01	1,261.11	142.89
2027	3.09	$30.00	0.00	$2.00	92.78	0.00	6.57	23.19	63.01	18.90	44.11	1,305.21	144.67
2028	1.91	$30.00	0.00	$2.00	57.25	0.00	4.09	14.31	38.85	11.66	27.20	1,332.41	145.62
2029	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,332.41	145.62
2030	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,332.41	145.62
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,332.41	145.62
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,332.41	145.62
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,332.41	145.62
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,332.41**	**145.62**
Total	100.00	$30.00	0.00	2.00	3,000.00	285.00	214.79	618.87	1,881.34	548.93	1,332.41		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Pisco
Prospectivity	Downside

Avg. Royalty Rate:	**7.37%**
Income Tax Rate:	**30.00%**

Production Based Royalty Method

$ / BOE Capex	**2.85**
$ / BOE Opex	**2.15**

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	100.0	0.0	100.0
Contractor	100.0	0.0	100.0

Petroleum Rent* Distribution (undiscounted)

Gov. Take	**35.57%**
Cont. Take	**64.43%**

* Petroleum Rent = Total revenue - total costs

Present value as at: Jan - 01 - 05
NPV SUMMARY

	Before Taxes	After Taxes
Discount Rate %	**NPV $ MM**	**NPV $ MM**
0.00%	**2,279.09**	**1,610.84**
5.00%	**1,069.73**	**744.32**
10.00%	**528.14**	**358.25**
15.00%	**270.05**	**176.06**
20.00%	**140.75**	**86.19**
25.00%	**73.39**	**40.43**
IRR	***45.9%***	***38.0%***

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	0.38	0.05	0.00	-0.43	0.00	-0.43	-0.43	-0.37
2006	0.00	$30.00	0.00	$2.00	0.00	1.51	0.05	0.00	-1.56	0.00	-1.56	-1.98	-1.55
2007	0.00	$30.00	0.00	$2.00	0.00	5.27	0.05	0.00	-5.32	0.00	-5.32	-7.30	-5.04
2008	0.00	$30.00	0.00	$2.00	0.00	4.89	0.05	0.00	-4.94	0.00	-4.94	-12.24	-7.87
2009	0.00	$30.00	0.00	$2.00	0.00	27.46	1.05	0.00	-28.51	0.00	-28.51	-40.76	-22.05
2010	0.00	$30.00	0.00	$2.00	0.00	40.53	1.05	0.00	-41.58	0.00	-41.58	-82.33	-40.02
2011	0.00	$30.00	0.00	$2.00	0.00	84.30	1.05	0.00	-85.35	0.00	-85.35	-167.69	-72.11
2012	1.83	$30.00	0.00	$2.00	54.75	71.72	3.91	2.74	-23.62	0.86	-24.48	-192.17	-80.11
2013	3.65	$30.00	0.00	$2.00	109.50	19.90	7.75	6.34	75.52	26.86	48.66	-143.51	-66.28
2014	10.95	$30.00	0.00	$2.00	328.50	21.31	23.12	29.39	254.68	81.66	173.02	29.51	-23.51
2015	10.95	$30.00	0.00	$2.00	328.50	3.79	23.12	29.39	272.20	65.40	206.80	236.31	20.94
2016	9.86	$30.00	0.00	$2.00	295.65	0.38	20.78	25.05	249.45	58.10	191.34	427.65	56.70
2017	8.87	$30.00	0.00	$2.00	266.09	3.38	18.71	21.41	222.59	50.33	172.26	599.91	84.70
2018	7.98	$30.00	0.00	$2.00	239.48	0.19	16.84	18.35	204.09	44.42	159.67	759.58	107.26
2019	7.18	$30.00	0.00	$2.00	215.53	0.00	15.17	15.77	184.59	38.57	146.01	905.59	125.21
2020	6.47	$30.00	0.00	$2.00	193.98	0.00	13.66	13.59	166.72	49.95	116.78	1,022.37	137.69
2021	5.82	$30.00	0.00	$2.00	174.58	0.00	12.30	11.75	150.53	45.09	105.44	1,127.82	147.49
2022	5.24	$30.00	0.00	$2.00	157.12	0.00	11.08	10.18	135.87	40.76	95.11	1,222.92	155.17
2023	4.71	$30.00	0.00	$2.00	141.41	0.00	9.98	8.84	122.59	36.78	85.81	1,308.74	161.20
2024	4.24	$30.00	0.00	$2.00	127.27	0.00	8.99	7.69	110.58	33.18	77.41	1,386.15	165.93
2025	3.82	$30.00	0.00	$2.00	114.54	0.00	8.10	6.71	99.73	29.92	69.81	1,455.96	169.64
2026	3.44	$30.00	0.00	$2.00	103.09	0.00	7.30	5.87	89.92	26.98	62.94	1,518.90	172.55
2027	3.09	$30.00	0.00	$2.00	92.78	0.00	6.57	5.15	81.06	24.32	56.74	1,575.64	174.83
2028	1.91	$30.00	0.00	$2.00	57.25	0.00	4.09	2.88	50.28	15.08	35.20	1,610.84	176.06
2029	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,610.84	176.06
2030	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,610.84	176.06
2031	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,610.84	176.06
2032	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,610.84	176.06
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,610.84	176.06
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,610.84**	**176.06**
Total	100.00	$30.00	0.00	2.00	3,000.00	285.00	214.79	221.12	2,279.09	668.26	1,610.84		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Pisco
Prospectivity	Base
Avg. Royalty Rate:	**21.35%**
Income Tax Rate:	**30.00%**

Economic Based Royalty Method

$ / BOE Capex	**2.35**
$ / BOE Opex	**1.71**

Reserves Included in Cash Flows

	Liquids MMBBL	Gas BCF	Total MMBOE
Field	**200.0**	**0.0**	**200.0**
Contractor	**200.0**	**0.0**	**200.0**

Petroleum Rent* Distribution (undiscounted)

Gov. Take	**46.59%**
Cont. Take	**53.41%**

* Petroleum Rent = Total revenue - total costs

Present value as at: Jan - 01 - 05
NPV SUMMARY

Discount Rate %	Before Taxes NPV $ MM	After Taxes NPV $ MM
0.00%	**3,906.65**	**2,752.95**
5.00%	**1,837.39**	**1,275.36**
10.00%	**924.18**	**626.12**
15.00%	**486.64**	**317.80**
20.00%	**263.23**	**162.55**
25.00%	**143.52**	**80.97**
IRR	***47.7%***	***39.7%***

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	1.28	0.05	0.00	-1.33	0.00	-1.33	-1.33	-1.15
2006	0.00	$30.00	0.00	$2.00	0.00	3.58	0.05	0.00	-3.63	0.00	-3.63	-4.96	-3.90
2007	0.00	$30.00	0.00	$2.00	0.00	33.17	0.05	0.00	-33.22	0.00	-33.22	-38.18	-25.74
2008	0.00	$30.00	0.00	$2.00	0.00	12.78	1.05	0.00	-13.83	0.00	-13.83	-52.01	-33.65
2009	0.00	$30.00	0.00	$2.00	0.00	66.33	1.05	0.00	-67.38	0.00	-67.38	-119.38	-67.15
2010	0.00	$30.00	0.00	$2.00	0.00	26.92	1.05	0.00	-27.97	0.00	-27.97	-147.36	-79.24
2011	0.00	$30.00	0.00	$2.00	0.00	75.43	1.05	0.00	-76.48	0.00	-76.48	-223.84	-107.99
2012	3.65	$30.00	0.00	$2.00	109.50	61.53	6.21	5.48	36.29	21.45	14.84	-209.00	-103.14
2013	10.95	$30.00	0.00	$2.00	328.50	77.73	18.52	16.43	215.83	82.28	133.55	-75.45	-65.18
2014	21.90	$30.00	0.00	$2.00	657.00	35.46	36.97	32.85	551.71	170.24	381.48	306.03	29.12
2015	20.08	$30.00	0.00	$2.00	602.25	29.40	33.91	150.56	388.38	96.42	291.97	598.00	91.87
2016	18.25	$30.00	0.00	$2.00	547.50	18.01	30.66	136.88	361.96	86.11	275.84	873.84	143.43
2017	16.43	$30.00	0.00	$2.00	492.75	14.50	27.71	123.19	327.35	74.87	252.48	1,126.32	184.47
2018	13.87	$30.00	0.00	$2.00	416.10	3.47	23.42	104.03	285.18	60.34	224.84	1,351.16	216.24
2019	12.48	$30.00	0.00	$2.00	374.49	3.47	21.09	93.62	256.30	51.61	204.70	1,555.86	241.40
2020	11.23	$30.00	0.00	$2.00	337.04	3.47	18.99	84.26	230.31	68.28	162.03	1,717.89	258.71
2021	10.11	$30.00	0.00	$2.00	303.34	3.47	17.07	75.83	206.96	61.73	145.24	1,863.13	272.21
2022	9.10	$30.00	0.00	$2.00	273.00	0.00	15.37	68.25	189.38	56.54	132.84	1,995.97	282.94
2023	8.19	$30.00	0.00	$2.00	245.70	0.00	13.84	61.43	170.44	50.93	119.51	2,115.48	291.34
2024	7.37	$30.00	0.00	$2.00	221.13	0.00	12.46	55.28	153.39	45.88	107.51	2,222.98	297.91
2025	6.63	$30.00	0.00	$2.00	199.02	0.00	11.23	49.75	138.04	41.34	96.70	2,319.68	303.05
2026	5.97	$30.00	0.00	$2.00	179.12	0.00	10.11	44.78	124.23	37.27	86.96	2,406.64	307.07
2027	5.37	$30.00	0.00	$2.00	161.21	0.00	9.11	40.30	111.80	33.54	78.26	2,484.90	310.21
2028	4.84	$30.00	0.00	$2.00	145.09	0.00	8.20	36.27	100.61	30.18	70.43	2,555.32	312.67
2029	4.35	$30.00	0.00	$2.00	130.58	0.00	7.39	32.64	90.54	27.16	63.38	2,618.70	314.59
2030	3.92	$30.00	0.00	$2.00	117.52	0.00	6.66	29.38	81.48	24.44	57.03	2,675.74	316.10
2031	3.53	$30.00	0.00	$2.00	105.77	0.00	6.00	26.44	73.32	22.00	51.33	2,727.06	317.28
2032	1.78	$30.00	0.00	$2.00	53.40	0.00	3.07	13.35	36.98	11.09	25.89	2,752.95	317.80
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,752.95	317.80
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2,752.95**	**317.80**
Total	200.00	$30.00	0.00	2.00	6,000.00	470.00	342.35	1,281.00	3,906.65	1,153.70	2,752.95		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Pisco
Prospectivity	Base

Avg. Royalty Rate:	**9.79%**
Income Tax Rate:	**30.00%**

Production Based Royalty Method

$ / BOE Capex	**2.35**
$ / BOE Opex	**1.71**

Reserves Included in Cash Flows	Liquids MMBBL	Gas BCF	Total MMBOE
Field	**200.0**	**0.0**	**200.0**
Contractor	**200.0**	**0.0**	**200.0**

Petroleum Rent* Distribution (undiscounted)	
Gov. Take	**37.75%**
Cont. Take	**62.25%**

* Petroleum Rent = Total revenue - total costs

Present value as at: Jan - 01 - 05		
NPV SUMMARY		
	Before Taxes	**After Taxes**
Discount Rate %	**NPV $ MM**	**NPV $ MM**
0.00%	**4,600.01**	**3,238.30**
5.00%	**2,130.63**	**1,480.63**
10.00%	**1,057.75**	**719.61**
15.00%	**551.18**	**362.98**
20.00%	**295.91**	**185.42**
25.00%	**160.69**	**92.99**
IRR	***48.5%***	**40.6%**

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	1.28	0.05	0.00	-1.33	0.00	-1.33	-1.33	-1.15
2006	0.00	$30.00	0.00	$2.00	0.00	3.58	0.05	0.00	-3.63	0.00	-3.63	-4.96	-3.90
2007	0.00	$30.00	0.00	$2.00	0.00	33.17	0.05	0.00	-33.22	0.00	-33.22	-38.18	-25.74
2008	0.00	$30.00	0.00	$2.00	0.00	12.78	1.05	0.00	-13.83	0.00	-13.83	-52.01	-33.65
2009	0.00	$30.00	0.00	$2.00	0.00	66.33	1.05	0.00	-67.38	0.00	-67.38	-119.38	-67.15
2010	0.00	$30.00	0.00	$2.00	0.00	26.92	1.05	0.00	-27.97	0.00	-27.97	-147.36	-79.24
2011	0.00	$30.00	0.00	$2.00	0.00	75.43	1.05	0.00	-76.48	0.00	-76.48	-223.84	-107.99
2012	3.65	$30.00	0.00	$2.00	109.50	61.53	6.21	6.34	35.42	21.19	14.23	-209.60	-103.34
2013	10.95	$30.00	0.00	$2.00	328.50	77.73	18.52	29.39	202.86	78.39	124.48	-85.13	-67.96
2014	21.90	$30.00	0.00	$2.00	657.00	35.46	36.97	89.91	494.66	153.12	341.54	256.41	16.47
2015	20.08	$30.00	0.00	$2.00	602.25	29.40	33.91	77.66	461.29	118.29	343.00	599.41	90.19
2016	18.25	$30.00	0.00	$2.00	547.50	18.01	30.66	66.28	432.55	107.29	325.26	924.67	150.99
2017	16.43	$30.00	0.00	$2.00	492.75	14.50	27.71	55.76	394.78	95.10	299.68	1,224.35	199.69
2018	13.87	$30.00	0.00	$2.00	416.10	3.47	23.42	42.49	346.72	78.80	267.92	1,492.27	237.56
2019	12.48	$30.00	0.00	$2.00	374.49	3.47	21.09	35.99	313.94	68.90	245.04	1,737.31	267.67
2020	11.23	$30.00	0.00	$2.00	337.04	3.47	18.99	30.57	284.00	84.39	199.61	1,936.92	289.00
2021	10.11	$30.00	0.00	$2.00	303.34	3.47	17.07	26.04	256.76	76.66	180.09	2,117.01	305.74
2022	9.10	$30.00	0.00	$2.00	273.00	0.00	15.37	22.24	235.39	70.35	165.05	2,282.06	319.07
2023	8.19	$30.00	0.00	$2.00	245.70	0.00	13.84	19.05	212.81	63.64	149.17	2,431.24	329.56
2024	7.37	$30.00	0.00	$2.00	221.13	0.00	12.46	16.36	192.31	57.56	134.75	2,565.99	337.79
2025	6.63	$30.00	0.00	$2.00	199.02	0.00	11.23	14.09	173.70	52.04	121.66	2,687.65	344.25
2026	5.97	$30.00	0.00	$2.00	179.12	0.00	10.11	12.17	156.84	47.05	109.79	2,797.43	349.33
2027	5.37	$30.00	0.00	$2.00	161.21	0.00	9.11	10.53	141.56	42.47	99.09	2,896.53	353.31
2028	4.84	$30.00	0.00	$2.00	145.09	0.00	8.20	9.14	127.74	38.32	89.42	2,985.94	356.43
2029	4.35	$30.00	0.00	$2.00	130.58	0.00	7.39	7.96	115.23	34.57	80.66	3,066.60	358.88
2030	3.92	$30.00	0.00	$2.00	117.52	0.00	6.66	6.94	103.92	31.18	72.74	3,139.35	360.80
2031	3.53	$30.00	0.00	$2.00	105.77	0.00	6.00	6.07	93.70	28.11	65.59	3,204.93	362.31
2032	1.78	$30.00	0.00	$2.00	53.40	0.00	3.07	2.67	47.66	14.30	33.36	3,238.30	362.98
2033	0.00	$30.00	0.00	$2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,238.30	362.98
Remainder	**0.00**	**$30.00**	**0.00**	**$2.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3,238.30**	**362.98**
Total	200.00	$30.00	0.00	2.00	6,000.00	470.00	342.35	587.64	4,600.01	1,361.71	3,238.30		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	Pisco
Prospectivity	Upside

Avg. Royalty Rate:	**21.66%**
Income Tax Rate:	**30.00%**

Economic Based Royalty Method

$ / BOE Capex	**2.20**
$ / BOE Opex	**1.56**

Reserves Included in Cash Flows			
	Liquids	Gas	Total
	MMBBL	BCF	MMBOE
Field	350.0	0.0	350.0
Contractor	350.0	0.0	350.0

Petroleum Rent* Distribution (undiscounted)

Gov. Take	**45.87%**
Cont. Take	**54.13%**

* Petroleum Rent = Total revenue - total costs

Present value as at: Jan - 01 - 05		
NPV SUMMARY		
	Before Taxes	**After Taxes**
Discount Rate %	**NPV $ MM**	**NPV $ MM**
0.00%	**6,908.62**	**4,879.70**
5.00%	**3,179.07**	**2,222.18**
10.00%	**1,588.87**	**1,091.28**
15.00%	**840.54**	**562.13**
20.00%	**461.12**	**296.42**
25.00%	**257.70**	**155.95**
IRR	***51.7%***	***43.7%***

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	1.48	0.05	0.00	-1.53	0.00	-1.53	-1.53	-1.33
2006	0.00	$30.00	0.00	$2.00	0.00	5.93	0.05	0.00	-5.98	0.00	-5.98	-7.50	-5.85
2007	0.00	$30.00	0.00	$2.00	0.00	57.27	0.05	0.00	-57.32	0.00	-57.32	-64.83	-43.54
2008	0.00	$30.00	0.00	$2.00	0.00	25.19	1.05	0.00	-26.24	0.00	-26.24	-91.06	-58.54
2009	0.00	$30.00	0.00	$2.00	0.00	62.58	1.05	0.00	-63.63	0.00	-63.63	-154.69	-90.17
2010	0.00	$30.00	0.00	$2.00	0.00	63.10	1.05	0.00	-64.15	0.00	-64.15	-218.84	-117.91
2011	0.00	$30.00	0.00	$2.00	0.00	46.26	1.05	0.00	-47.31	0.00	-47.31	-266.15	-135.69
2012	7.30	$30.00	0.00	$2.00	219.00	122.57	11.34	10.95	74.15	35.11	39.04	-227.11	-122.93
2013	18.25	$30.00	0.00	$2.00	547.50	77.67	28.14	27.38	414.31	137.02	277.29	50.18	-44.11
2014	32.85	$30.00	0.00	$2.00	985.50	79.40	50.83	49.28	805.99	255.12	550.87	601.05	92.06
2015	32.85	$30.00	0.00	$2.00	985.50	75.29	50.83	246.38	613.00	159.97	453.03	1,054.08	189.44
2016	29.57	$30.00	0.00	$2.00	886.95	63.51	45.77	221.74	555.94	139.32	416.61	1,470.70	267.30
2017	26.61	$30.00	0.00	$2.00	798.26	41.62	41.21	199.56	515.86	122.95	392.91	1,863.60	331.16
2018	23.95	$30.00	0.00	$2.00	718.43	31.15	37.11	179.61	470.57	107.05	363.51	2,227.11	382.54
2019	21.55	$30.00	0.00	$2.00	646.59	14.77	33.41	161.65	436.75	94.62	342.14	2,569.25	424.58
2020	19.40	$30.00	0.00	$2.00	581.93	2.22	30.09	145.48	404.13	117.28	286.85	2,856.10	455.24
2021	17.46	$30.00	0.00	$2.00	523.74	0.00	27.04	130.93	365.76	107.12	258.64	3,114.75	479.27
2022	15.71	$30.00	0.00	$2.00	471.36	0.00	24.35	117.84	329.17	97.29	231.88	3,346.63	498.01
2023	14.14	$30.00	0.00	$2.00	424.23	0.00	21.93	106.06	296.24	88.28	207.97	3,554.59	512.62
2024	12.73	$30.00	0.00	$2.00	381.80	0.00	19.74	95.45	266.61	79.89	186.71	3,741.31	524.03
2025	11.45	$30.00	0.00	$2.00	343.62	0.00	17.78	85.91	239.93	71.98	167.95	3,909.26	532.95
2026	10.31	$30.00	0.00	$2.00	309.26	0.00	15.98	77.32	215.97	64.79	151.18	4,060.44	539.94
2027	9.28	$30.00	0.00	$2.00	278.33	0.00	14.39	69.58	194.36	58.31	136.06	4,196.49	545.40
2028	8.35	$30.00	0.00	$2.00	250.50	0.00	12.96	62.63	174.92	52.48	122.44	4,318.94	549.68
2029	7.52	$30.00	0.00	$2.00	225.45	0.00	11.67	56.36	157.42	47.23	110.19	4,429.13	553.03
2030	6.76	$30.00	0.00	$2.00	202.91	0.00	10.51	50.73	141.67	42.50	99.17	4,528.30	555.65
2031	6.09	$30.00	0.00	$2.00	182.62	0.00	9.47	45.65	127.49	38.25	89.25	4,617.55	557.70
2032	5.48	$30.00	0.00	$2.00	164.35	0.00	8.53	41.09	114.74	34.42	80.32	4,697.86	559.30
2033	4.93	$30.00	0.00	$2.00	147.92	0.00	7.68	36.98	103.26	30.98	72.28	4,770.14	560.56
Remainder	**7.48**	**$30.00**	**0.00**	**$2.00**	**224.26**	**0.00**	**11.69**	**56.07**	**156.51**	**46.95**	**109.56**	**4,879.70**	**562.13**
Total	350.00	$30.00	0.00	2.00	10,500.00	769.99	546.79	2,274.60	6,908.62	2,028.92	4,879.70		

PeruPetro Contract Model
Project Cash Flow Analysis

Basin	**Pisco**
Prospectivity	**Upside**
Avg. Royalty Rate:	**12.95%**
Income Tax Rate:	**30.00%**

Production Based Royalty Method

$ / BOE Capex	**2.20**
$ / BOE Opex	**1.56**

Reserves Included in Cash Flows

	Liquids MMBBL	Gas BCF	Total MMBOE
Field	350.0	0.0	350.0
Contractor	350.0	0.0	350.0

Petroleum Rent* Distribution (undiscounted)

Gov. Take	**40.41%**
Cont. Take	**59.59%**

* Petroleum Rent = Total revenue - total costs

Present value as at: Jan - 01 - 05
NPV SUMMARY

Discount Rate %	Before Taxes NPV $ MM	After Taxes NPV $ MM
0.00%	7,823.55	5,520.15
5.00%	3,517.06	2,458.77
10.00%	1,721.92	1,184.42
15.00%	894.67	600.02
20.00%	483.05	311.77
25.00%	266.02	161.77
IRR	*51.1%*	*43.4%*

Year	Oil MMBBL	Oil Price $US/bbl	Gas Prodn BCF	Gas Price $US/mcf	Gross Revenue $ MM	Capital Cost $ MM	Operating Cost $ MM	Royalty $ MM	Pre Tax Cash Flow $ MM	Corp. Taxes 30.00%	After Tax Net Cash Flow $ MM	Cum AT Cash Flow $ MM	Cum. Net Disc.@15% $ MM
2005	0.00	$30.00	0.00	$2.00	0.00	1.48	0.05	0.00	-1.53	0.00	-1.53	-1.53	-1.33
2006	0.00	$30.00	0.00	$2.00	0.00	5.93	0.05	0.00	-5.98	0.00	-5.98	-7.50	-5.85
2007	0.00	$30.00	0.00	$2.00	0.00	57.27	0.05	0.00	-57.32	0.00	-57.32	-64.83	-43.54
2008	0.00	$30.00	0.00	$2.00	0.00	25.19	1.05	0.00	-26.24	0.00	-26.24	-91.06	-58.54
2009	0.00	$30.00	0.00	$2.00	0.00	62.58	1.05	0.00	-63.63	0.00	-63.63	-154.69	-90.17
2010	0.00	$30.00	0.00	$2.00	0.00	63.10	1.05	0.00	-64.15	0.00	-64.15	-218.84	-117.91
2011	0.00	$30.00	0.00	$2.00	0.00	46.26	1.05	0.00	-47.31	0.00	-47.31	-266.15	-135.69
2012	7.30	$30.00	0.00	$2.00	219.00	122.57	11.34	16.14	68.96	33.55	35.41	-230.74	-124.12
2013	18.25	$30.00	0.00	$2.00	547.50	77.67	28.14	66.28	375.41	125.35	250.06	19.32	-53.03
2014	32.85	$30.00	0.00	$2.00	985.50	79.40	50.83	181.54	673.73	215.44	458.28	477.60	60.25
2015	32.85	$30.00	0.00	$2.00	985.50	75.29	50.83	181.54	677.84	179.42	498.42	976.02	167.38
2016	29.57	$30.00	0.00	$2.00	886.95	63.51	45.77	150.78	626.89	160.61	466.28	1,442.30	254.53
2017	26.61	$30.00	0.00	$2.00	798.26	41.62	41.21	125.49	589.93	145.17	444.76	1,887.06	326.81
2018	23.95	$30.00	0.00	$2.00	718.43	31.15	37.11	104.68	545.50	129.53	415.96	2,303.02	385.60
2019	21.55	$30.00	0.00	$2.00	646.59	14.77	33.41	87.51	510.89	116.86	394.03	2,697.05	434.03
2020	19.40	$30.00	0.00	$2.00	581.93	2.22	30.09	73.33	476.28	138.93	337.36	3,034.41	470.08
2021	17.46	$30.00	0.00	$2.00	523.74	0.00	27.04	61.60	435.09	127.92	307.18	3,341.59	498.62
2022	15.71	$30.00	0.00	$2.00	471.36	0.00	24.35	51.88	395.13	117.08	278.05	3,619.63	521.09
2023	14.14	$30.00	0.00	$2.00	424.23	0.00	21.93	43.81	358.49	106.95	251.54	3,871.17	538.76
2024	12.73	$30.00	0.00	$2.00	381.80	0.00	19.74	37.10	324.96	97.40	227.56	4,098.73	552.67
2025	11.45	$30.00	0.00	$2.00	343.62	0.00	17.78	31.49	294.35	88.30	206.04	4,304.78	563.62
2026	10.31	$30.00	0.00	$2.00	309.26	0.00	15.98	26.81	266.47	79.94	186.53	4,491.31	572.23
2027	9.28	$30.00	0.00	$2.00	278.33	0.00	14.39	22.89	241.06	72.32	168.74	4,660.05	579.01
2028	8.35	$30.00	0.00	$2.00	250.50	0.00	12.96	19.60	217.95	65.38	152.56	4,812.61	584.34
2029	7.52	$30.00	0.00	$2.00	225.45	0.00	11.67	16.82	196.96	59.09	137.87	4,950.48	588.53
2030	6.76	$30.00	0.00	$2.00	202.91	0.00	10.51	14.48	177.92	53.37	124.54	5,075.02	591.82
2031	6.09	$30.00	0.00	$2.00	182.62	0.00	9.47	12.50	160.65	48.20	112.46	5,187.48	594.40
2032	5.48	$30.00	0.00	$2.00	164.35	0.00	8.53	10.82	145.01	43.50	101.51	5,288.99	596.43
2033	4.93	$30.00	0.00	$2.00	147.92	0.00	7.68	9.38	130.85	39.26	91.60	5,380.58	598.02
Remainder	**7.48**	**$30.00**	**0.00**	**$2.00**	**224.26**	**0.00**	**11.69**	**13.20**	**199.38**	**59.81**	**139.57**	**5,520.15**	**600.02**
Total	350.00	$30.00	0.00	2.00	10,500.00	769.99	546.79	1,359.67	7,823.55	2,303.40	5,520.15		

APPENDIX L

CONTRACTORS AND SUBCONTRACTORS

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CONTRACTOR AND SUBCONTRACTOR IDENTIFICATION

The contractors and subcontractors listed below were part of the diverse team that was necessary to produce this study.

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