ORIENTE OIL STUDY

**REGIONAL PETROLEUM GEOCHEMISTRY
OF CRUDE OILS FROM THE ORIENTE,
PUTUMAYO AND MARANON BASINS**

**GEOMARK
RESEARCH, INC.**

A PROSPECTUS

SUMMARY

GeoMark Research, Inc. has completed a regional study of crude oils of the Oriente, Putumayo, and Maranon/Santiago Basins in response to increased exploration interest in this important area of South America. The purpose of this effort was to define more clearly the hydrocarbon potential of the region by presenting a large, single set of oil analyses. These data are the main basis for portraying source families and sub-families and the ensuing petroleum systems. Particular emphasis was placed on four issues of exploration importance.

- Identification of the number and nature of the sources (or source kitchens) responsible for the generation of the oils.
- Clarification of the times during which the various sources were providing oils to reservoir.
- Consideration of the origin and history of heavy versus light oils present in the basins.
- Consideration of the relationship of the Oriente oils to CO2 rich gases present in some of the fields and observed in well tests.

New perceptions are also be postulated on the petroleum systems of the existing fields. Emphasis was placed on enhancing existing field reserves through a better understanding of the origin of the oils. Risks associated with hanging wall traps and footwall closures in relationship to the origin of the oils and gases were analyzed

The cost of the study is US $37,500. The study is complete and available for immediate delivery.

INTRODUCTION

The 100,000 km^2 Oriente Basin is located within the chain of prolific Andean foreland basins that extend from Venezuela to Chile. Total discovered reserves are of the order of 85,000 MMBO of which 3,200 MMBO are contained in the Oriente Basin (1). Output, which is currently 350,000 BOPD, is expected to peak at almost 470,000 BOPD in 1997 before declining. Ecuador is projected to become a net importer by 2007 (2). Nine new Seventh Round blocks were offered at the end of January 1994. Eight of these blocks occupy the 400 km by 50 km Sub-Andean Zone to the west of the main productive acreage (3). This is an area of considerable opportunity, but significant risks.

Marine Cretaceous shales and marls of the Napo are generally assumed to be the source rocks for the oils of the Oriente Basin. The occurrence of multiple compositional families of oils in the area indicates that the identity of the source(s) is more complex than usually believed. Sands of the Hollin, Napo, and basal Tena Formations are the main reservoir units (Figure 1). Fractured Napo limestones may form important secondary reservoir intervals in some parts of the Oriente.

Many fields in this region are related to low relief compressive features whose origins may predate the main Andean orogenic events. These fields were found following the advance of seismic techniques in the late 1960's and early 1970's (4). Earlier exploration concentrated on surface expressed structures present within the Sub-Andean Zone (5). Although good quality sands were often found, many of the oils were biodegraded due to meteoric water ingress.

Recent work suggests the Oriente Basin oils are delivered from a former source area or areas located west of the Sub-Andean Zone in the region now occupied by the eastern Andean ranges (4). Modern basin simulation techniques were be employed to evaluate the possibility that deeper parts of the contemporary Oriente Basin might also be considered as active source areas. Considerable progress has been made in elucidating the tectonic history of the Andes in relation to Hollin and Napo deposition. A clearer picture of the evolution and exploration potential of the Sub-Andean Zone is emerging (7).

GeoMark has assembled a significant collection of oil samples from the Oriente, Putumayo, and Maranon/Santiago Basins for the purpose of accelerating progress in understanding this deceptively complex area. Ten of the oils are from, or immediately adjacent to, the Sub-Andean Zone (Figure 1).

Each oil sample was characterized by a detailed analytical program that includes bulk compositional data, quantitative biomarker analysis of terpanes and steranes, and determination of stable carbon isotope composition of saturate and aromatic hydrocarbon fractions. Using data from the oils, basin simulation techniques, cluster, and principal component analyses, we accomplished the following.

- Determined the number of genetically distinctive oil families and sub-families in each producing region.
- Mapped the stratigraphic and geographic distribution of the oil families. Identify areas that contain mixed oils. Distinguish basins/areas with single oil families from those containing multiple oil families. Compare families among basins.
- Utilized geochemical characteristics of the oil families to deduce their depositional source facies, level of thermal maturity, and degree of preservation.
- Determined the most likely source unit(s) in each basin by comparing the distribution of oil families and their inferred source facies with regional stratigraphy, burial history, and available source rock data.
- Estimated migration directions by comparing oil family distributions with the location of known or suspected depocenters.
- Utilized the geographic, stratigraphic, and structural distribution of source rocks in conjunction with knowledge of oil relationships to identify, map, and rank the petroleum systems in the basins.
- Determined the effects of long- and short-range migration on oil composition in relationship to field sizes or numbers.
- Evaluated the effects of secondary alteration on oil composition, producibility, and potential value of the oils.

The final interpretive report is compiled and available for immediate delivery.

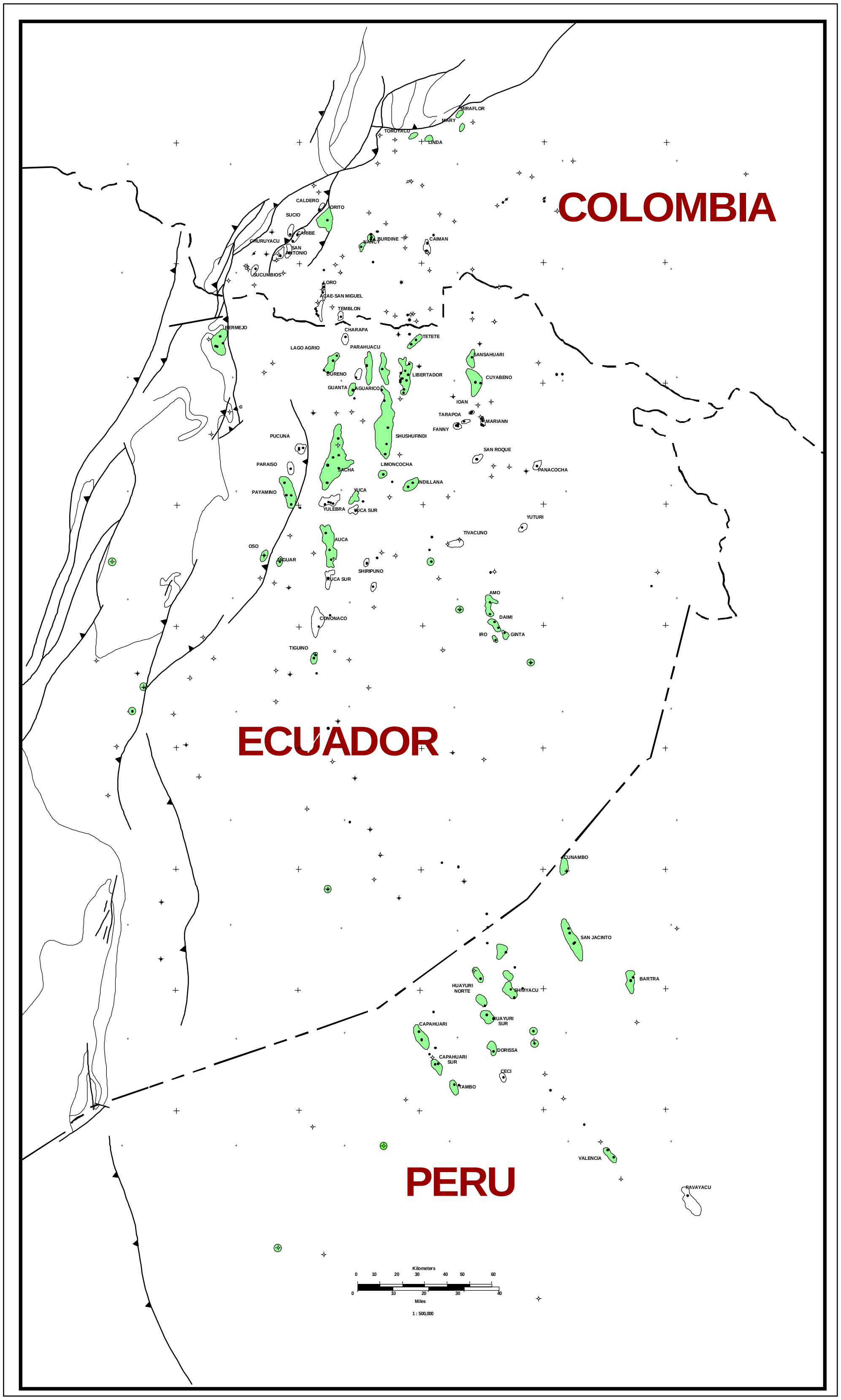

Figure 1. Location of crude oil samples selected for analysis.

METHODOLOGY AND EXPLORATION APPLICATIONS

A regional oil study is an efficient way of identifying, evaluating, and comparing various petroleum systems in areas where substantial production has been established. This kind of study is particularly useful for comparing the remaining potential of the basins, predicting the distribution of particular hydrocarbon plays, and for better understanding nearby and analogous areas.

Regional petroleum systems within the study area have been evaluated by determining the number of effective source units within a region from the number of compositionally distinct oil families. This was achieved using multivariate statistical analysis techniques. The source facies of each oil family was then inferred from the oil geochemistry (e.g., Zumberge, 1987 and Moldowan *et al*., 1985). Conclusions were reached regarding source lithology, anoxicity, salinity, organic input (marine, non-marine, or marginal marine), and thermal maturity using molecular and bulk compositional data.

The predicted source facies was compared to the stratigraphy, structure, and burial history of the basins to determine the most probable source units. The aerial extent and maturity of the source units was combined with knowledge of the distribution of the oil families to ascertain the most likely location of oil generating depocenters and migration directions.

The relative potential of the petroleum systems in each basin was ranked by incorporating geological information on source thickness, sedimentary environment, and source potential of the various source units. The results were evaluated in an effort to identify areas where particular petroleum systems may exist but have been overlooked or poorly tested.

ANALYTICAL PROGRAM

The following techniques were be employed in the analysis of the oils.

- API gravity
- Percent sulfur
- Nickel/Vanadium concentration
- C15+ vs <C15
- Deasphalting
- Liquid chromatography (%Sat/%Aro/%NSO)
- Capillary GC of whole crudes
- Stable carbon isotopes for both saturate and aromatic hydrocarbon fractions
- GC/MS of branched/cyclic fraction for terpane/sterane distributions (quantitative)

In addition, GC/MS analyses of aromatic hydrocarbons and stable hydrogen isotopic analyses were performed on selected samples.

PRESENTATION OF RESULTS

Results of the study are be presented in both analytical and interpretive formats to insure that all findings are accessible to explorationists and research personnel. All of the analytical data were provided in hard copy and on magnetic media.

Analytical data are presented within **Data Volumes,** and are included the following:

- **Physical property data**
- **Liquid chromatographic data**
- **Gas chromatographic results**
- **Stable carbon isotope data**
- **GC/MS mass chromatograms**
- **PC data base** (Microsoft Access I)

A synthesis and interpretation of all information is presented in a comprehensive **Final Report**. For each basin studied, the **Final Report** includes sections for:

- Regional geology
- Differentiation of oil families and oil mixing
- Interpretation
- Inferred oil/source correlations
- Oil generation and migration migration by multivariate statistics

PARTICIPATION & TIMING

The cost of this study is US $37,500.00. The study is complete and available for immediate delivery.

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APPENDIX A
OILS SELECTED FOR ANALYSIS

Colombia:

Orito (2 Samples)
Nancy
Burdine
Mary (2 Samples)

Ecuador:

Indilland
Culebra
Yuca (4 Samples)
Cononaco
Auca (4 Samples)
Shushufindi (3 Samples)
Sacha (4 Samples)
Aguarico (3 Samples)
Limoncocha (2 Samples)
Shuara (3 Samples)
Daimi (3 Samples)
Oso
Jaguar
Coca (6 Samples)
Payamino (6 Samples)
Tetete (2 Samples)
Danta
Fanny
Maranacu (3 Samples)
Tapi
Cuyabeno (4 Samples)
Sansahuari (2 Samples)
Bermejo
Secoya (3 Samples)
Carabobo
Atacapi (2 Samples)
Guanta
Amo (6 Samples)
Ginta (2 Samples)
Bogi (3 Samples)
Iro (4 Samples)
Tiguino (5 Samples)
Oglan (4 Samples)
Pungarayacu (2 Samples)
Nashino (3 Samples)
Shushuqui (2 Samples)
Lago Agrio (3 Samples)
Lorocochi S. (4 Samples)

Peru:

San Jacinto (4 Samples)
Corrientes (7 Samples)
Shiviyacu (3 Samples)
Dorissa (3 Samples)
Huasaga (3 Samples)
Capahuari (4 Samples)
Barta (6 Samples)
Jibaro
Jibarito
Phillips
Sun
Cunambo
Tambo
Huayuri Sur
Huayuri Norte (2 Samples)
Valencia (2 Samples)
Tompatero
Capahuari Sur (3 Samples)
Forestal (3 Samples)
Nuevo Esperanza (2 Samples)
Yanayacu (2 Samples)
Dominguza (4 Samples)
Piuntza
Putuime