

ARGENTINA GEOCHEMICAL STUDY

**GEOCHEMISTRY AND EXPLORATION
SIGNIFICANCE OF CRUDE OILS
FROM THE ARGENTINE REPUBLIC**

**GEOMARK
RESEARCH, INC.**

PROSPECTUS

GEOCHEMISTRY AND EXPLORATION SIGNIFICANCE OF CRUDE OILS FROM THE ARGENTINE REPUBLIC

Introduction

GeoMark Research, Inc. has completed a detailed, country-wide investigation of the geochemistry of 300 crude oils from Argentina. This effort represents the completion of a series of successful projects undertaken by GeoMark focusing on Subandean basins of South America (Zumberge *et al.*, 1993; Illich *et al.*, 1994; Schiefelbein *et al.*, 1995; Schiefelbein *et al.*, 1996; Zumberge *et al.*, 1996; and Schiefelbein *et al.*, 1997).

The interpretative importance of large numbers of oil samples has been demonstrated in previous Subandean studies undertaken for Venezuela, Colombia, Ecuador, Peru and Bolivia. Oil geochemistry efficiently estimates the limits of petroleum systems. Differences in crude oil composition, sometimes dismissed as normal compositional variations, are often sufficient to establish the existence of multiple sources, source facies, oil mixing, multiple source depocenters, and under-explored systems. This knowledge profoundly contributes to the definition of the petroleum systems in the individual basins, and re-emphasizes the importance of understanding the age of source deposition, time of migration, and overall character of the petroleum systems operating within a basin or region. Some of these systems represent mixing of two or more “end-member” systems. Tertiary, Cretaceous, Jurassic, Permian, Carboniferous, Devonian, and possibly Silurian-aged sources are represented by oils included in previous studies.

Refinements to the definition and description of the petroleum systems of Argentina will contribute to the more efficient development of existing plays, and offer the possibility for identification of unknown or underdeveloped opportunities. Detailed, data-based appreciation of petroleum systems is as essential in exploration as is knowledge of structural and stratigraphic relationships.



Figure 1. Location map showing distribution of crude oil samples in GeoMark's Argentina Oil Study.

Oil Geochemistry

Enormous insight into the complexity of petroleum systems present in a basin can be gained by analysis and interpretation of a large collection of representative oils. The complexity provides an improved basis for describing the evolution of the basin and constrains interpretation of its history. **Table 1** provides a list of oils that have been included in the Argentine project. The distribution of these oils is shown on a map of the area (**Figure 1**). Each oil has been characterized by an analytical program that includes bulk compositional data, quantitative analysis of aromatic and saturate (terpanes and steranes) biomarkers, and determinations of stable isotope compositions of the saturate and aromatic hydrocarbon fractions. Rigorous comparison and classification of geochemical data was accomplished using cluster and principal component analyses (Zumberge, 1987). These statistical techniques are “setup” in a manner that permitted predictions regarding depositional environments of the source rocks. Characteristics of source rock environments to which the oils are attributed are defined in terms of key geochemical parameters -- this reduces ambiguity associated with the use of general lithologic descriptions like marl, carbonate, and shale. Data from the oil geochemistry was used to evaluate the following important exploration issues:

- The number of sources (or source facies) responsible for the oils
- The number of depocenters (“kitchens”) for the oils derived from a common source
- Identification of secondarily altered oils and assignment of these to their proper compositional families
- Identification and evaluation of oil mixing (and polyhistory oils)
- Maturity of oils and condensates
- Identification of underdeveloped and/or underexplored petroleum systems.

A special effort was made in the study of the Argentine samples to compare thermal maturities of the oils. Knowledge of the distribution of relative maturities of oils belonging to the same compositional family was important.

The complete study is available at a cost of US \$37,500.00. The study is available for immediate delivery.

Presentation

Data from the project are organized in an *interpretative volume* and into several *data volumes*. The *interpretative volume* contains discussions of the regional geologic setting of the oils, discussions of the oil geochemistry, and an integrated interpretation of the significance of the oils. Analytical data for the oils are provided in hardcopy *data volumes* and digitally. The digital data are presented in a database constructed using Access™ and can be displayed using ArcView™ geographic information system (GIS). The oil data include the following:

- Physical property data (API gravity, % Sulfur, Ni/V ratios)
- C₁₅₊ fraction versus <C₁₅₊ fraction
- Deasphalting
- Liquid chromatography (% Saturates, % Aromatics, and % NSO's)
- Capillary gas chromatography of whole crude oil
- Stable carbon isotopic composition of C₁₅₊ saturate and aromatic hydrocarbons
- Quantitative GC/MS analysis of C₁₅₊ saturate hydrocarbons for terpane and sterane distributions
- Qualitative GC/MS of aromatic hydrocarbon fraction

Participation

The complete study is available at a cost of US \$37,500.00.

Timing

The study is available for immediate delivery.

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APPENDIX A

Samples Analyzed for this Study

<u>AUSTRAL</u>	<u>NEUQUEN</u>	<u>NEUQUEN</u>	<u>SAN JORGE</u>
<p>Campo Indio - 17 Sur Arroyo Candelaria - TFSA CA X-1 Puesto Peter - SC APP X-1 Puesto Peter - SC APP X-1 An Aike - SC AAA X-1 Campo Boleadoras - SC ACBO X-P10 Campo Boleadoras - SC ACBA X-P7 Campo Boleadoras - 14 Campo Boleadoras Sur Arroyo Gamma - AGS X-1 Campo Indio - 12 La Porfiada - x-1 La Paz - 3 Laguna del Oro - 4 Laguna del Oro - 5 Laguna del Oro - 6 La Esperanza Estancia La Maggie Dos Hermanos - 22 La Porfiada - x-1 La Carmen - SC ALCA X-7 Campo Indio - 9</p> <p><u>MALVINAS</u> Cíclon - X-1 Salmon - x-1 Salmon - x-1; A-7434 Salmon - x-1; B-7434 Calamar - CMA-12 Ca x1 Krill - X-1 Salmon - x-2 Cíclon - C.es-1 Cíclon - C.es-1 Salmon - x-2</p> <p><u>CUYO</u> Puesto Cercado - x-2 Punta de las Bardas - PB-26 Cruz de Piedra Vaca Muertas - VM48-17 Atamisqui Norte - 1 Vaca Muertas - VM-131 Vaca Muertas - 52 Vaca Muertas - VM-24 Chanares Herrados Vizcacheras Vizcacheras - VI-246 Vizcacheras - VI-279 T-78 TR-1013 T-25 T-74 TR-1001 TR-24 TR-17 T-24</p> <p><u>NEUQUEN</u> Lindero Este - 1 Rio Negro Norte - Estancia Vieja x-1 Rio Negro Norte - Estancia Vieja x-1 Rio Negro Norte - Estancia Vieja x-1 Rio Negro Norte - Estancia Vieja x-1 Rio Negro Norte - Estancia Vieja x-1 Rio Negro Norte - Estancia Vieja x-1 Estancia Vieja - 1 Rio Negro Norte - PFOX-1 Puesto Hernandez - PH-250 Cerro Granito - CG-9</p>	<p>Divisadero - NQ-39 Lindero Atravesado - LA-33 Lindero Atravesado - LA-41 Rio Negro Norte - OX-1 Las Minas Anticline - Seep El Sosneado - S-23 El Sosneado - S-36 El Sosneado - S-35 Vega Grande - VG-2 El Medanito - 2001 El Medanito - 2018 El Salitral - Sa a-1004 El Trapial - ET-48 El Trapial - ET-48 Agua del Cajon - ADC-47 Cutral-Co - A-77 Borde Colorado Este Cutral-Co - A-22 El Sauce El Porvenir Agua del Cajon - SN x-2 Agua del Cajon - SC x-1 Agua del Cajon - ADC-42 Piedras Blancas - PB-24 Piedras Blancas - PB-40 Piedras Blancas - PB-71 Piedras Blancas - PB-39 Piedras Blancas - PB-84 Lomas de Ocampo - LO-2 Bajo del Palenque - BDP-7 Medanito - 397 Medanito - 644 Medanito - 596 Medanito - 375 Medanito - 643 Medanito - 1129 Medanito - 1034 Medanito - 322 Medanito - 309 Medanito - 1045 Medanito - 672 Medanito - 1133 Medanito - 1123 Catriel Oeste - 177 Medanito - 619 Catriel Oeste - RCO-187 Catriel Oeste - RCO-253 Catriel Oeste - RCO-93 El Caracol - EC-21 El Caracol - EC-20 El Caracol - EC-4 Charco Bayo - CB-43 Charco Bayo - CB-64 Charco Bayo - CB-147 Charco Bayo - CB-151 Charco Bayo - CB-85 Charco Bayo - CB-134 Charco Bayo - CB-23 Charco Bayo - CB-134 Charco Bayo - CB-23 Charco Bayo - CB-1 Charco Bayo - CB III Al Norte del a D. - GU-1006 Entre Lomas - EL-8 Catriel Oeste - RC-204 Medanito - 480 Centenario - 47 Centenario - 52</p>	<p>Centenario - 64 Centenario - NQCE-70 Centenario - 103 Centenario - 1013 Centenario - 1023 Alquitrán PCR2 - Outcrop Comodoro 1/Rivadavia - Outcrop Brea 3 - Outcrop Puesto Espinosa - PE-2 Puesto Espinosa - PE-3 Puesto Espinosa - PE-11 Puesto Lopez - PL-1016 Bajo Barda Gonzalez - BBG-X1 Huincul - H-115 Puesto Prado - x-1 Puesto Prado - x-1 Rio Negro Norte - Estancia Vieja x-1 Salitral - SA 1024 Salitral - SA 1039 Salitral - SA 1046 Salitral - SA 1039 Salitral - SA 1046 Salitral - SA 1024 LP-Medanito - LP2055 LP-Medanito - LP2034 LP-Medanito - LP2013 LP-Medanito - LP2040</p> <p><u>NIHUAU</u> Las Minas Anticline</p> <p><u>NOROESTE</u> Caimencito - 23 Caimencito - x-2 Jujuy - Seep M. Del Tineo - 10 M. Del Tineo - 18 M. Del Tineo - 19 Puesto Guardian - 20 Pozo Escondido - x-1 Canada Grande - 12 Puesto Guardian - 20 El Vinalar - 2 Palmer Largo - 18 Caimancito - 30 Kaufman N. Puesto Climaco Salta - 11 Jujuy - Seep M. Del Tineo - 10 M. Del Tineo - 18 M. Del Tineo - 19 Puesto Guardian - 20 Pozo Escondido - x-1 Canada Grande - 12 Puesto Guardian - 20 El Vinalar - 2 Palmer Largo - 18 Caimancito - 30 Kaufman N. Puesto Climaco Salta - 11</p> <p><u>SAN JORGE</u> P Del Castillo - PC-173 P Del Castillo - PC-1093 P Del Castillo - PC-1103 El Valle - PC-1080</p>	<p>Kolvel Kayke - KK-105 Las Flores - PLF-802 Rio Chico - RCH x-1 Diadema - Planta Desi Perca - CHP x-1 Las Flores - LF a 27 Colhue Huapi - CH a 17 Diadema Arg - G 74 Los Guanacos - PG x-2 Km.8 (Burmeister) - B-32 Km.8 (Stephenson) - ST-3 Km.8 (Don Alberto) - DA-253 Cerro Tortuga - CT-89 Las Flores - LF-10 Cerro Tortuga - CT x-4 Diadema - F-136 Diadema - K-24 Cerro Tortuga - CT-91 Cerro Tortuga - CT-90 Rio Chico - RCH x-4 Diadema - F-92 Diadema - G-64 Rio Chico - RCH x-1 Valle Hermosa - VH-46 Las Flores - LF-1 Diadema - G-14 Diadema - I-49 Norte Rio Chico - El Jefe x-1 Las Flores - LF-21 Diadema - L-56 Las Heras - LH-1009 Canadon Minerales - CM-1001 Canadon Leon - CL-3006 Las Heras - LH-784 Cerro Grande - CG-148 Canadon Leon - CL-3001 Las Heras - LH-785 Piedra Clavada - PC-2005 Canadon Minerales - CM-3 Canadon Leon - CL-3007 Cerro Wenceslao - CW-1054 Canadon Leon - CL-1454 Las Heras - LH-1019 Piedra Clavada - PC-207 Cerro Wenceslao - CW-4 Cerro Wenceslao - CW-1027 Canadon Leon - CL-3047 Cerro Wenceslao - CW-1057 Piedra Clavada - PC-159 Canadon Minerales - CM-202 Canadon Minerales - CM-3033 Canadon Minerales - CM-1 Piedra Clavada - PC-72 Pampa del Castillo - PC-90 Kolvel Kaike-El Valle - EV-1051 Canadon Seco - CS2125 Canadon Seco - CS975 Canadon Seco - CS161 Canadon Seco - CS650 Canadon Seco - CS864 Canadon Leon - CL1932 Canadon Leon - CL1935 Canadon Leon - CL3026 Canadon Leon - 4002 Flamenco - x-1 Mata Magallanes Oeste - xp-7</p>