

PETROLEUM SYSTEMS OF THE MEDITERRANEAN

**REGIONAL PETROLEUM GEOCHEMISTRY
OF CRUDE OILS FROM BASINS OF THE
MEDITERRANEAN SEA**

GEOMARK
RESEARCH, INC.

A PROSPECTUS

EXECUTIVE SUMMARY

GeoMark Research, Inc. has completed a regional crude oil study of the Mediterranean. This study consists of the detailed geochemical analysis of 300 oil samples located throughout southern Europe and North Africa. The study is being offered on a non-exclusive basis to participating companies.

Each of the oils analyzed for this study (a list is provided in Appendix A, map shown as Figure 1) was characterized by a detailed analytical program which includes quantitative biomarker analysis of terpanes and steranes and determination of stable carbon isotope composition of both saturate and aromatic hydrocarbon fractions. This information, integrated with a geological synthesis, allowed us to accomplish the following:

- Determine the number of genetically distinct oil families in the various basins.
- Map the stratigraphic and geographic distribution of the oil families and distinguish basin areas with single oil families (single sources) from those with multiple oil families (multiple sources).
- Utilize geochemical characteristics of the oil families to deduce their source facies, thermal maturity level, and degree of preservation.
- Determine the most likely source unit(s) in each basin by comparing the distribution of oil families and their inferred source facies with regional stratigraphy, and available source rock data.
- Estimate migrational directions by comparing oil family distributions with the location of known oil kitchens.
- Utilize the geographic, stratigraphic, and structural distribution of source rocks and genetically related oils to identify, map, and rank the petroleum systems in each basin and in the region as a whole.
- Identify underdeveloped and/or undiscovered exploration opportunities.

All of the analytical data generated from the oils have been compiled along with interpretive reports. The interpretive reports includes full color, wall-size maps showing the distribution of oil family and associated petroleum systems.

The study is immediately available to participating companies. The cost of the study is US\$42,000.00, but the data can be purchased in sections.

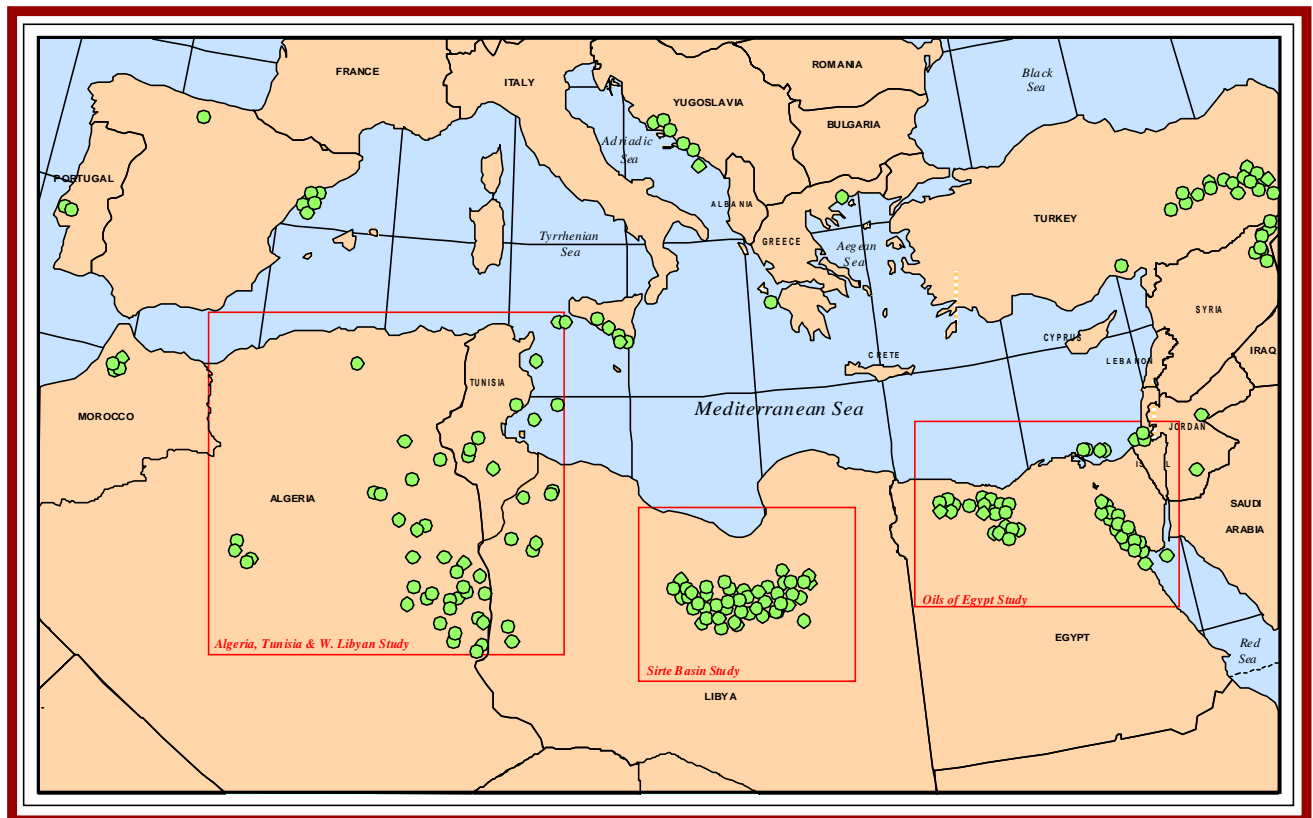


Figure 1. Location map showing distribution of samples analyzed for this study.

INTRODUCTION

The purpose of the study was to geochemically evaluate crude oil samples from the Mediterranean region in order to predict source rock depositional environments, related oil families, thermal histories, and probable subsurface migrational directions. The field locations of the analyzed crude oil samples included in this study are shown in Figure 1. A detailed sample list is presented in Appendix A.

METHODOLOGY AND EXPLORATION APPLICATIONS

Crude oils from the entire Mediterranean Sea region were geochemically evaluated in order to 1) determine the number and members of genetically related families: 2) predict the depositional environment and/or other characteristics of the corresponding source rock units, and 3) determine the thermal history of oils within each family. All the oils were analyzed with respect to bulk (e.g., API Gravity, % Sulfur, metal content), molecular (e.g., n-paraffin, sterane, and terpane biomarkers) and stable carbon isotopic parameters. The results were assessed using multivariate techniques including cluster and principal component analyses.

The results of this study have enabled us to develop an understanding of the source history of the Sirte Basin. This new understanding will enhance future exploration efforts in the region, and we feel confident, become the basis for the future development of the region.

ANALYTICAL PROGRAM

The following techniques were employed on each of the oil samples:

- API Gravity
- % Sulfur
- C15+ vs. <C15+
- Deasphalting
- Liquid Chromatography (%Sat %Aro %NSO)
- Capillary GC of Whole Crudes
- Stable Carbon Isotopes for both Sat and Aro Hydrocarbon Fractions
- GC/MS of Saturates for Terpane/Sterane Distributions (quantitative)

PRESENTATION OF RESULTS

Results of the study are presented in both analytical and interpretive formats to insure that all findings are readily accessible to explorationists and research personnel. All of the analytical data are provided in hard copy and on personal computer disks. Raw data results of the whole oil chromatographic and gas chromatographic/mass spectrographic results are available on mini-tape cassettes.

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

- physical property data
- liquid chromatographic data
- gas chromatographic results
- stable carbon isotope data
- GC/MS mass chromatograms.

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

- regional geology,
- differentiation of oil families
by multivariate statistics,
- inferred oil/source correlations,
- oil generation and migration,
- interpretation of oil characteristics,
- overall exploration potential.

PARTICIPATION

The cost of the study is US \$42,000. The reports are completed and available for immediate delivery.

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- ZUMBERGE J.E.** (1987) Prediction of source rock characteristics based on terpane biomarkers in crude oils: A multivariate statistical approach. *Geochim. Cosmochim. Acta*, **51**, 1625-1637.

APPENDIX A

Samples Analyzed for the Sirte Basin

| Field | Well | Depth | Age | Formation | Field | Well | Depth | Age | Formation |
|---------------|------|-------|------------------|-----------|----------------|-----------|------------|--------------|-----------|
| Nafoora | | 2257' | Eocene | Tamit-H | Ora | 3 | 8948' | | Lidam |
| Nafoora | | 5421' | Paleocene | Najah | Facha | 1 | 3076' | Eocene | Gir, LI-G |
| Nafoora | | 3049' | Eocene | Tamet | Sarir | | | | |
| Nafoora | | 2159' | Eocene | Nafoora | Bel Hedan | | 7100' | L.Ordovician | Samah |
| Nafoora | | 8496' | Cretaceous | Tagrifet | Khuff | | | | |
| Nafoora | | 9974' | | Bahi | A-1-92 | | | | |
| Nafoora | | 9874' | Jurassic | Amal | E-1-92 | | | | |
| Gialo | | 2725' | Eocene | Gialo | E-5A-92 | | | | |
| Gialo | | 2256' | Oligocene | | E-6-92 | | | | |
| Amal | | 9715' | Jurassic | Amal | Amal | B22-12 | 5891-5971' | Eocene | Mesdar |
| Sarir | | 7746' | | | Rakb | A1-12 | 9877-9895' | Cretaceous | |
| Sarir | | 8030' | | | Amal | B1-12 | 9832-9867' | Jurassic | Amal |
| | | 3100' | | | Hagfa | A1A-13 | 7377-7409' | Eocene | |
| Beda | | 3900' | Pre U.Cretaceous | Hofra | Hagfa | A1A-13 | 7810-7856' | Paleocene | Hofra |
| | | 3147' | | | Hofra | A2-11 | 3018-3044' | Paleocene | Dahra B |
| Gialo | | 2735' | Eocene | Gialo | Amal | B2-12 | 9789-9809' | Jurassic | |
| Bel Hedan | | 7100' | Ord./Cam. | | Ed Dib | G1-11 | 8106' | Cretaceous | |
| Samah | | 6300' | Ord./Cam. | | Neggazza | C1-57 | 6210-6223' | Cretaceous | |
| | | 5478' | | | Muelah | D1-57 | 8235-8272' | Cretaceous | |
| Waha | | 6500' | Cretaceous | | Kalash | K1-12 | 8703-8720' | Ypresian | |
| Dahra | | 3667' | | PL7 | Ora | I1-13 | 5447-5481' | Paleocene | |
| Zaggut | | 6400' | Paleocene | | Ora | I1-13 | 7610-7649' | Jurassic | |
| Etel | | 7015' | Quaternary | Etel | Farigh | M1-12 | 10500' | U.Cretaceous | Rakb |
| Ora | | 4900' | | M59 | Mabruk | A13-17 | 3272' | Paleocene | Dahra B |
| Facha | 1 | 4281' | Paleocene | Mabruk A | Raguba | E7-20 | 5695-5728' | L.Cretaceous | Waha |
| Ora | | 8360' | | Aintobi | Zelten | C2-6 | 5770-5927' | Paleocene | Ruaga C |
| Ora | | 7326' | Cretaceous | B | Idris | A-103 | 9400' | Paleocene | U.Sabil |
| Ora | | 7058' | U.Cretaceous | Sirte | DST #1 | RRR 1 #11 | | Paleocene | Farrud |
| Hofra | 1 | 2000' | Paleocene | Dahra B | Hofra | A2-11 | 3042-3099' | Paleocene | |
| Dahra | 1 | | | | Haram | #3 | 4885' | Cretaceous | Tagrifet |
| | | 4720' | | | Kotla | 47-C | | U.Cretaceous | Kalash |
| Concession 59 | 3 | | Eocene | Gialo | Haram | 47-S | | U.Cretaceous | Kalash |
| Umm Farud | | | Paleocene | Dahra B | Augila-Nafoora | | | Jurassic | Amal |
| Khuff | 3 | 5534' | Cretaceous | ANF | Defa | 59-B | | | Defa |
| Ed Dib | 1 | 3698' | Eocene | Gir, LI-A | Gialo | 59-E | | Eocene | Gialo |
| Ed Dib | 1 | 2666' | Eocene | Gir, LI-P | Bel Hedan | V-59 | | | |
| Farrud | 1 | 3245' | Paleocene | Mabruk A | | | | | |

APPENDIX A

Samples Analyzed for Egypt

| Basin | Well | Basin | Well |
|----------------|-------------------|----------------|---------------------|
| Gulf of Suez | Ras Bakr-24 | Western Desert | Umbaraka-8X |
| Gulf of Suez | Umm el Yusr-25 | Western Desert | Yidma-5 |
| Gulf of Suez | E. Belayim-33 | Western Desert | Alamein |
| Gulf of Suez | W. Belayim-4 | Western Desert | Umbaraka-3X |
| Gulf of Suez | Gharib-97 | Western Desert | Umbaraka-7X |
| Gulf of Suez | July-16 | Western Desert | Alamein-1X |
| Gulf of Suez | Ramadan 6-13 | Western Desert | Umbaraka |
| Gulf of Suez | El Morgan-64 | Western Desert | Razzak |
| Gulf of Suez | Shuheir Bay-1 | Western Desert | El Alamein |
| Gulf of Suez | GS-382-1B | Western Desert | Salam-3X |
| Gulf of Suez | Ras Budran | Western Desert | 33-4 |
| Gulf of Suez | Amal-6 | Western Desert | Abu Gharadig-1 |
| Gulf of Suez | GS277-1 | Western Desert | Abu Gharadig-3 |
| Gulf of Suez | July-1 | Western Desert | Abu Gharadig-3 |
| Gulf of Suez | El Morgan-1 | Western Desert | Razzak-1 |
| Gulf of Suez | El Morgan-1 | Western Desert | Razzak-1 |
| Gulf of Suez | Ramadan-1 | Western Desert | Razzak-1 |
| Gulf of Suez | Sidki-1 | Western Desert | Razzak-1 |
| Gulf of Suez | October A1 | Western Desert | Razzak-1 |
| Gulf of Suez | October A1 | Western Desert | Razzak-15 |
| Gulf of Suez | October F1 | Western Desert | Razzak-13 |
| Gulf of Suez | October J-4B | Western Desert | Razzak-13 |
| Gulf of Suez | July-5 | Western Desert | 19-2 |
| Gulf of Suez | GM-404 Hilal A2 | Western Desert | 9-13-1 |
| Gulf of Suez | GS-315 (Badri) C1 | Western Desert | Sheiba 18-1 |
| Nile Delta | Tineh-1 | Western Desert | Qarum West 34/15 W1 |
| Nile Delta | Tineh-1 | Western Desert | Qarum West 34/15 W1 |
| Nile Delta | Mango-1 | Western Desert | 33-1 |
| Nile Delta | Mango-1 | Western Desert | Abu Gharadig-5 |
| Nile Delta | Mango-1 | Western Desert | Abu Gharadig-12 |
| Nile Delta | Mango-1 | Western Desert | Meleiha-10X |
| Western Desert | Alamein-7 | | |

APPENDIX A

Samples Analyzed for the Algeria-Tunisia Study

| Basin | Well | Country | Basin | Well |
|---------------|-----------------------|---------|-------------------|-------------------|
| Bas Sahara | Hassi Messaoud-15 | Algeria | Saharan Atlas | Oued Gueterini |
| Ghadames | Edjeleh | Algeria | Bas Sahara | Guellala |
| Ghadames | Edjeleh | Algeria | Illizi | Stah? |
| Ghadames | Tin Fouye | Tunisia | Bas Sahara | Makrerouga-1 |
| Ghadames | Tin Fouye | Tunisia | Bas Sahara | Makrerouga-1 |
| Ghadames | Zarzaitaine | Tunisia | Sahel | Djebiniana-1 |
| Bas Sahara | Hassi Messaoud | Tunisia | Sahel | Magrouba-1 |
| Bas Sahara | El Borma | Tunisia | Sahel | Magrouba-1 |
| Bas Sahara | Gassi Touil-6 | Tunisia | Sahel | Sidi el Itayem-1 |
| Bas Sahara | Rhourde el Baguel-605 | Tunisia | Sahel | Sidi el Itayem-3 |
| Bas Sahara | Hassi Messaoud | Tunisia | Sahel | Sidi el Itayem-27 |
| Bas Sahara | Hassi Messaoud | Tunisia | Sahel | Sidi Behara-1 |
| Bas Sahara | Hassi Messaoud | Tunisia | Sahel | Mahares-1 |
| Bas Sahara | Hassi R'Mel | Tunisia | Pelagian Platform | Isis-1 |
| Cuvet de Sbaa | Dechaira-1 | Tunisia | Pelagian Platform | Isis-2 |
| Reggane | Inzegmir-101 | Tunisia | Pelagian Platform | Ashtart |
| Ghadames | Alrar Nord-101 | Tunisia | Pelagian Platform | Oudna-1 |
| Bas Sahara | Rhourde el Baguel-3 | Libya | Western | F-90 |
| Ghadames | Tin Fouye-13 | Libya | Western | D-3-23 |
| Ghadames | West Ihansatene-1 | Libya | Western | F-1-90 |
| Ghadames | Tan Emellel-1 | Libya | Western | F-7-90 |
| Ghadames | Tan Emellel-3 | Libya | Western | F-8-90 |
| Ghadames | Tamadanet-101 | Libya | Western | Q-1-23 |
| Ghadames | Guelta-101 | Libya | Ghadames | B2-1 |
| Ghadames | Guelta-103 | Libya | Ghadames | HI-1 |
| Bas Sahara | Gassi Touil-3 | Libya | Ghadames | HI-1 |
| Bas Sahara | Ektaia-101 | Morocco | | Sidi Rhalem |
| Ghadames | Oued Ahara-101 | Morocco | | MO-2 |
| Ghadames | Tesselit-101 | Morocco | | Mescala |
| Ghadames | In Adaoui-101 | Morocco | | Mescala |
| Ghadames | Ohanet-105 | Morocco | | Zrar Inferier |
| Ghadames | Askarene-101 | | | |

APPENDIX A

Samples Analyzed for Southern Europe

| Country | Basin | Well | Country | Basin | Well |
|---------|-------------------|-------------|----------|---------------|--------------------|
| Turkey | E. Turkey | Kahta | Italy | Sicily | Vega-10 |
| Turkey | E. Turkey | Kurkan | Italy | Sicily | Gela-32 |
| Turkey | E. Turkey | Sahaban | Italy | Sicily | Cozzo Disi Mine E2 |
| Turkey | E. Turkey | S. Sahaban | Italy | Sicily | Cozzo Disi Mine E5 |
| Turkey | E. Turkey | Kayakoy | Italy | Sicily | Ragusa-51 |
| Turkey | E. Turkey | W. Kayakoy | Italy | Sicily | Ragusa |
| Turkey | E. Turkey | Cemberlitas | Italy | Sicily | Mila |
| Turkey | E. Turkey | Akpinar | Italy | Sicily | Mila |
| Turkey | E. Turkey | Molcabir | Italy | | Tabiano-4 |
| Turkey | E. Turkey | Adiyaman | Greece | | Thasos E1 |
| Turkey | E. Turkey | Yenikoy | Greece | | Prinos |
| Turkey | E. Turkey | West Firat | Greece | | Crete Seep |
| Turkey | E. Turkey | Sincain | Greece | | |
| Turkey | E. Turkey | Cukurtas | Greece | | |
| Turkey | E. Turkey | Karakus | Greece | | Zakinthos Seep |
| Turkey | E. Turkey | Beykan | Spain | Tarragona | Angula |
| Turkey | E. Turkey | Barbes | Spain | Tarragona | Amposta Marino E3 |
| Turkey | E. Turkey | Selmo | Spain | Tarragona | Amposta Marino B2 |
| Turkey | E. Turkey | Raman | Spain | Tarragona | Amposta Marino C3 |
| Turkey | E. Turkey | Malatepe | Spain | Tarragona | Ayoluengo |
| Turkey | E. Turkey | Garzan | Spain | Tarragona | Tarragona B12 |
| Turkey | E. Turkey | Magrip | Spain | Tarragona | Tarragona F1 |
| Turkey | E. Turkey | Camurlu | Spain | Tarragona | Castellon B5 |
| Turkey | E. Turkey | G. Dincer | Spain | Tarragona | Casablanca |
| Turkey | E. Turkey | B. Kozluca | Spain | Tarragona | Casablanca-6 |
| Turkey | E. Turkey | B. Raman | Spain | Tarragona | Casablanca |
| Turkey | E. Turkey | Bulgurdag | Spain | Tarragona | Ayoluengo |
| Syria | E. Syria | Babasi-3 | Spain | Tarragona | Casablanca |
| Syria | E. Syria | Derik-1 | Spain | Tarragona | Casablanca |
| Syria | E. Syria | Al Holl-1 | Spain | Tarragona | Casablanca |
| Syria | E. Syria | Jebissa-207 | Spain | Tarragona | Mantanazo A2 |
| Syria | E. Syria | Leilak | Portugal | Lusitanian | Abadia 1A |
| Syria | E. Syria | Naour-1 | Portugal | Lusitanian | Abadia 14A1 |
| Syria | E. Syria | Oudeh-108 | Portugal | Lusitanian | Torres Veedras-4 |
| Syria | E. Syria | Oudeh-111 | Portugal | Lusitanian | Abadia-17 |
| Syria | E. Syria | Rumelan-35 | Portugal | Lusitanian | Sismaria |
| Syria | E. Syria | Rumelan-106 | Croatia | | JJ-3 |
| Syria | E. Syria | Souedie-403 | Croatia | | Skrip RD95 |
| Syria | E. Syria | Saida-6 | Croatia | | Vrgorac RD31 |
| Syria | E. Syria | Tishrin-24 | Croatia | | Radosic RD312 |
| Syria | E. Syria | Tishrin-24 | Croatia | | Misijen RD48 |
| Syria | E. Syria | Ullyan-20 | Croatia | | Vinisce RD318 |
| Syria | E. Syria | Zarabeh-6 | Croatia | | Vrgorac RD27 |
| Syria | E. Syria | Souedie | Turkey | | Pasinler |
| Iraq | Kurdish Mountains | Ain Zalah-2 | Turkey | | Cakirbey |
| Iraq | Kurdish Mountains | Alan-1 | Turkey | | Cankiri |
| Italy | Sicily | Ragusa-20 | Turkey | Kurdish Mnts. | District 5 |
| Italy | Sicily | Gela-9 | Turkey | E. Turkey | Bulgurdag |