

WESTERN AUSTRALIA OIL STUDY

**REGIONAL PETROLEUM GEOCHEMISTRY
AND CORRELATION OF CRUDE OILS
FROM BASINS OF WESTERN AUSTRALIA**

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and

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PROSPECTUS

EXECUTIVE SUMMARY

Western Australia and its continental shelf are believed to contain substantial quantities of undiscovered oil, condensate and gas. Because of this, the region will continue to receive a high level of exploration and investment. To assist this activity, GEOMARK RESEARCH in conjunction with the Australian Geological Survey Organisation (AGSO) is performing a regional assessment of Western Australia utilizing the detailed analysis of a suite of crude oil samples representative of the productive and frontier basins, both onshore and offshore. The purpose of the study is to identify and characterize each of the petroleum systems which have sourced oil, and to predict their importance to future exploration.

Each of the oils is being 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 known source rock data, should allow us to accomplish the following:

- Determine the number of genetically distinct oil families in each producing region.
- Characterize oils of known Paleozoic origin for comparison with oils of unknown age.
- Map the stratigraphic and geographic distribution of the oil families and distinguish 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 area by comparing the distribution of oil families with published source facies, regional stratigraphy, burial history, and source rock information.
- Estimate migrational directions by comparing oil family distributions with the location of known oil kitchens.
- Utilize the geographic, stratigraphic, and structural distribution of oils to identify, map, and rank the petroleum systems in each basin and in the region as a whole.

The analytical data generated from the oils will be issued during the course of the study. An interpretive report will be issued at the completion of the project. The interpretive report will include maps showing the a) distribution of oil families, b) interpreted source kitchens, and c) inferred migration pathways and associated petroleum systems. The cost of the study to original participants is US \$42,500. Participants are not required to contribute samples.

INTRODUCTION

Although many geochemical studies have been performed in Australia, a thorough integrated evaluation of the petroleum systems active within each of the various basins on the Australian continent and continental shelf has not been reported.

In large, geologically complex areas such as Western Australia, where substantial production has been established, a mega-regional oil geochemistry study is an excellent way of identifying, evaluating and comparing the various petroleum systems that have contributed to reserves. A regional oil study approach is particularly useful for comparing the remaining potential of productive basins and for predicting the distribution of undiscovered oil from identified hydrocarbon systems.

To assist in a further understanding of Western Australian petroleum systems, GEOMARK RESEARCH in conjunction with the Australian Geological Survey Organisation (AGSO) is initiating a regional crude oil study of the petroliferous basins both onshore and offshore Western Australia. The study will involve the analysis of at least 140 oil samples distributed throughout the geographic and stratigraphic confines of the various basins.

The oil fields selected for analysis are listed in Appendix A. A basin map of Western Australia shown in Figure 1 illustrates the geographic distribution of the selected samples.

The regional petroleum systems within the study area will be evaluated by first determining the number of effective source units within a region by establishing the number of compositionally distinct oil families. The source facies of each oil family will then be deduced from the oil geochemistry (e.g., Summons *et al.*, 1987, 1988, 1995; Zumberge, 1987; Moldowan *et al.*, 1985; Peters and Moldowan, 1993). Conclusions will be reached regarding source lithology, anoxicity, salinity, organic input (marine, non-marine or marginal marine) and thermal maturity using a variety of parameters based on detailed and bulk composition. In some cases it may be possible to bracket the age of the source from the oil data. The thermal histories of the oil samples will also be estimated based on molecular parameters.

The predicted source facies will be compared to the stratigraphy, sedimentology, and burial history of each basin to determine the most probable source units. Estimations of the areal extent and burial depth of the source units will then be combined with the geographic and stratigraphic distributions of their associated oil families to predict the location of the various oil kitchens and the most probable migration directions.

The relative potential of the petroleum systems in each basin (Bradshaw *et al.*, 1994) will be ranked by incorporating geological information on regional tectonics, source thickness and sedimentary environment, and source potential of the various source units (Scott, 1994). The results will be evaluated in an effort to identify areas where particular petroleum systems may exist but have been overlooked or poorly tested.

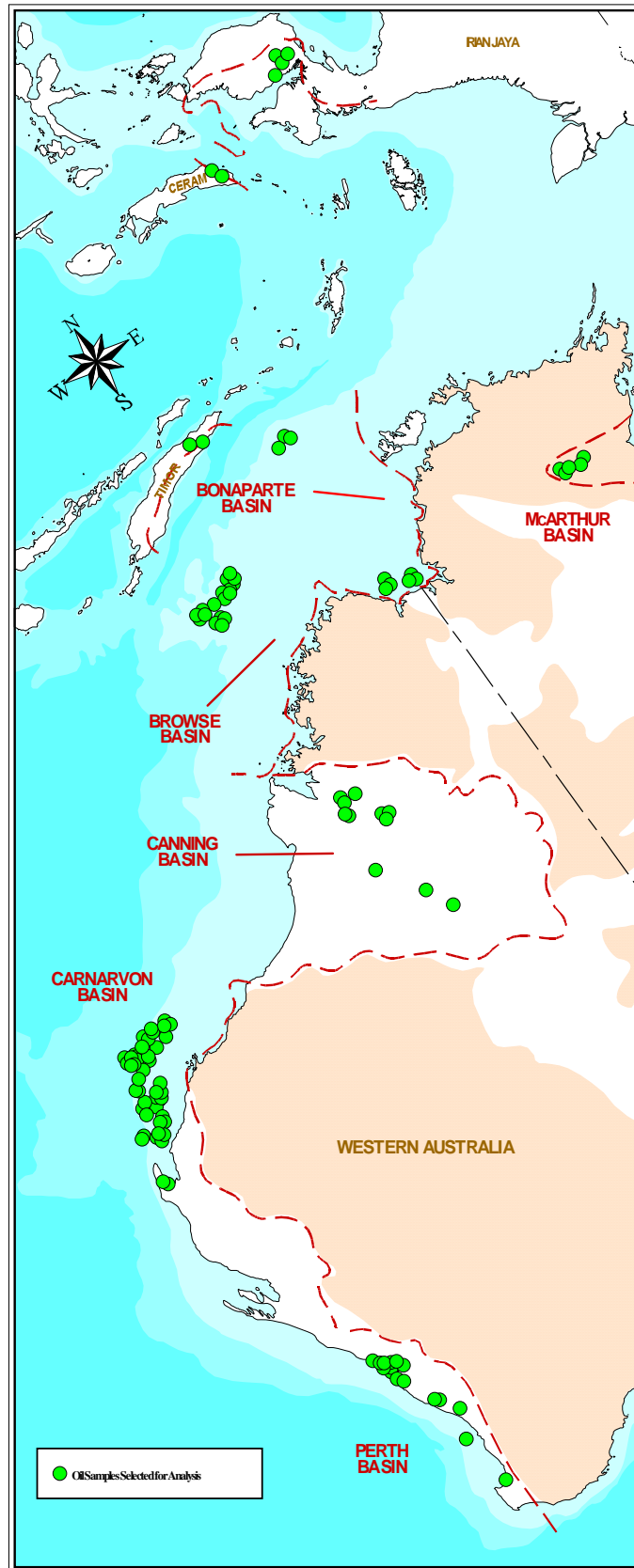


Figure 1. Location map showing samples analyzed for this study.

ANALYTICAL PROGRAM

- API gravity
- % Sulfur, % Nickel and % Vanadium
- Deasphalting (% Asph)
- Liquid chromatography (% Saturates, % Aromatics, and % NSO's)
- Molecular sieve to concentrate br/cyclic fraction
- Detailed C₇ gas chromatography
- Capillary gas chromatography of whole crudes
- Stable carbon isotopes for both Sat and Aro hydrocarbon fractions
- GC/MS (SIM) of Br/Cyc for terpane/sterane distributions (quantitative)
- GC/MS/MS (MRM) for increased selectivity of biomarker determinations on selected samples
- Individual n-alkane isotope profiles on selected samples

STATE-OF-THE-ART ANALYSES

In addition to the standard and widely accepted compositional, isotope and biomarker correlation tools, this study includes C₇ (light hydrocarbon) data for each oil that is amenable to this analysis. Mango (1987, 1990, 1992a,b, 1994) has hypothesised C₇ hydrocarbons are formed as a result of steady-state catalytic processes within the source rock. This idea is based on the striking invariance of ratios of certain isoheptanes in a large suite of oils and condensates. The work of Mango and follow up by BeMent *et al.*, (1994) and ten Haven (1995) also proposes that the light hydrocarbons carry information about source, mixing of crude oils and temperature of expulsion. Thompson (1983) has proposed that the light hydrocarbons are informative of secondary alteration effects such as evaporative fractionation. The high potential value of a light hydrocarbon tool in the Australian setting stems from the prevalence of light oils and condensates, particularly in Western Australian fields, since these petroleum generally have low contents of conventional biomarkers.

Compound-specific isotope analysis (CSIA) is another new correlation method that offers considerable potential as a source-specific tool applicable to light oil, condensate and gas. It has recently been used in a Perth Basin study and found to discriminate oils from Triassic sources from those of Jurassic and Cretaceous sources (Summons *et al.*, 1995). The individual n-alkane ¹³C profiles for some selected oils will also be included in the study.

PRESENTATION OF RESULTS

Results of the study will be 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 will be provided in hard copy and on magnetic media.

Analytical data will be presented within **Basin Data Volumes**, and will include the following:

- physical property data
- liquid chromatographic data
- gas chromatographic results
- C7 alkane quantitation
- stable carbon isotope data
- GC/MS mass chromatograms
- selected GC/MS/MS mass chromatograms.

A synthesis and interpretation of all information will be presented in a comprehensive **Final Report**. For each of the basins studies, the **Final Report** will include sections for:

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

A sample geochemical summary sheet for Rough Range-1, the first WA oil discovery, is attached.

PARTICIPATION

The cost of the study is US \$42,500.

TIMING

The study is complete and available for immediate delivery.

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APPENDIX A

Samples Analyzed for this Study

Basin	Well	Basin	Well	Basin	Well
Bonaparte	Barnett-2	Carnarvon/Barrow	Spar-1	Carnarvon/Dampier	Goodwyn-3
Bonaparte	Barnett-2	Carnarvon/Barrow	Barrow-1	Carnarvon/Dampier	Goodwyn-4
Bonaparte	Petrel-4	Carnarvon/Barrow	Barrow Deep-1	Carnarvon/Dampier	Goodwyn-4
Bonaparte/Petrel	Barnett-2	Carnarvon/Barrow	Barrow Island-15	Carnarvon/Dampier	Goodwyn-5
Bonaparte/Petrel	Barnett-2	Carnarvon/Barrow	Barrow Island-17	Carnarvon/Dampier	Goodwyn-7
Bonaparte/Petrel	Barnett-2	Carnarvon/Barrow	Chervil-4	Carnarvon/Dampier	Gorgon-1
Bonaparte/Petrel	Turtle-1	Carnarvon/Barrow	Elder-1	Carnarvon/Dampier	Lambert-1
Bonaparte/Petrel	Turtle-2	Carnarvon/Barrow	Flinders Shoal-1	Carnarvon/Dampier	Lambert-1
Bonaparte/Petrel	Turtle-2	Carnarvon/Barrow	Harriet-A3	Carnarvon/Dampier	North Gorgon-1
Bonaparte/Timor	Talbot-1	Carnarvon/Barrow	Harriet-A5	Carnarvon/Dampier	North Rankin-4
Bonaparte/Vulcan	Challis-1	Carnarvon/Barrow	Harriet-B2	Carnarvon/Dampier	North Rankin-A
Bonaparte/Vulcan	Challis-3	Carnarvon/Barrow	Harriet-B3	Carnarvon/Dampier	Rankin-1
Bonaparte/Vulcan	Challis-7	Carnarvon/Barrow	Hilda-1A	Carnarvon/Dampier	Talisman-1
Bonaparte/Vulcan	Challis-8	Carnarvon/Barrow	Maitland-1	Carnarvon/Dampier	Talisman-1
Bonaparte/Vulcan	Jabiru	Carnarvon/Barrow	North Herald-3	Carnarvon/Dampier	Talisman-1
Bonaparte/Vulcan	Jabiru-1A	Carnarvon/Barrow	Saladin-1	Carnarvon/Dampier	Tidepole-1
Bonaparte/Vulcan	Jabiru-8A	Carnarvon/Barrow	Saladin-2	Carnarvon/Dampier	West Tryal Rocks-2
Bonaparte/Vulcan	Jabiru-11	Carnarvon/Barrow	Saladin-3	Carnarvon/Dampier	West Tryal Rocks-3
Bonaparte/Vulcan	Puffin-2	Carnarvon/Barrow	Chinook-1	Carnarvon/Dampier	Legendre-1
Bonaparte/Vulcan	Puffin-3	Carnarvon/Barrow	Griffin-1	Carnarvon/Exmouth	Rough Range-1
Bonaparte/Vulcan	Puffin-1	Carnarvon/Barrow	Pasco-1	Carnarvon/Exmouth	Rough Range-1A
Bonaparte/Vulcan	Puffin-2	Carnarvon/Barrow	Australind-1	Carnarvon/Exmouth	Rough Range-1
Bonaparte/Vulcan	Skua-2	Carnarvon/Barrow	Barrow Island-1	Carnarvon/Exmouth	Leatherback-1
Bonaparte/Vulcan	Skua-3	Carnarvon/Barrow	Barrow Island-X53J	Carnarvon/Exmouth	Leatherback-1
Bonaparte/Vulcan	Skua-8	Carnarvon/Barrow	Crest-1	Perth	Dongara-14
Bonaparte/Vulcan	Skua-9	Carnarvon/Barrow	Barrow Island-F81FL	Perth	Erregulla-1
Bonaparte/Vulcan	Sunrise-1	Carnarvon/Barrow	Flinders Shoal-1	Perth	Gage Roads-1
Bonaparte/Vulcan	Sunrise-1	Carnarvon/Barrow	Barrow Island-L64MA	Perth	Gingin-1
Bonaparte/Vulcan	Swan-1	Carnarvon/Barrow	Yammaderry-2	Perth	Mondarra-1
Bonaparte/Vulcan	Swan-3	Carnarvon/Barrow	Rosette-1	Perth	Mondarra-2
Bonaparte/Vulcan	Troubadour-1	Carnarvon/Barrow	Campbell-1	Perth	Mondarra-3
Browse	North Scott Reef-1	Carnarvon/Barrow	Tanami-1	Perth	Mount Homer-1
Canning	Blina-2	Carnarvon/Barrow	Bambra-2	Perth	North Erregulla-1
Canning	Blina-5	Carnarvon/Barrow	Bambra-1	Perth	Walyering-1
Canning	Dodonea-1	Carnarvon/Beagle	Nebo-1	Perth	Walyering-2
Canning	Janpam North-1	Carnarvon/Dampier	Cossack-1	Perth	Whicher Range-1
Canning	Lloyd-1	Carnarvon/Dampier	Cossack-1	Perth	Woodada-3
Canning	Meda-1	Carnarvon/Dampier	Wanaea-1	Perth	Yardarino-1
Canning	Mirbelia-1	Carnarvon/Dampier	Wanaea-2	Perth	Yardarino-1
Canning	Pictor-2	Carnarvon/Dampier	Wanaea-4	Perth	Yardarino-1
Canning	Sundown-1	Carnarvon/Dampier	East Spar-1	Perth	Dongara-4
Canning	Sundown-4	Carnarvon/Dampier	East Spar-1	Perth	Dongara-14
Canning	West Terrace-1	Carnarvon/Dampier	Echo-1	Perth	Dongara-4
Canning	West Terrace-2	Carnarvon/Dampier	Angel-1	Perth	Erregulla-1
Canning	Blina-1	Carnarvon/Dampier	Angel-2	Bintuni	Jagiro-4
Carnarvon/Barrow	Flag-1	Carnarvon/Dampier	Angel-3	Bintuni	Mogoi-41
Carnarvon/Barrow	Harriet-A6	Carnarvon/Dampier	Central Gorgon-1	Bintuni	Wasian-24
Carnarvon/Barrow	Hilda-1A	Carnarvon/Dampier	Dockrell-1	Bintuni	Wirriagar
Carnarvon/Barrow	Pasco-1	Carnarvon/Dampier	Dockrell-1	Seram	Bula-2Y5
Carnarvon/Barrow	Saladin-8	Carnarvon/Dampier	Dockrell-1	Seram	Nief East-1
Carnarvon/Barrow	Sinbad-1	Carnarvon/Dampier	Eaglehawk-1	Timor	Aliambata-Seep
Carnarvon/Barrow	South Pepper-1	Carnarvon/Dampier	Egret-1	Timor	Paulaca-Seep
Carnarvon/Barrow	South Pepper-8	Carnarvon/Dampier	Goodwyn-1		
Carnarvon/Barrow	South Pepper-10	Carnarvon/Dampier	Goodwyn-1		