OILS OF AUSTRALIA STUDY

REGIONAL PETROLEUM GEOCHEMISTRY AND CORRELATION OF CRUDE OILS FROM AUSTRALIA'S SEDIMENTARY BASINS

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A Proposal

EXECUTIVE SUMMARY

Australia and its continental shelf are believed to contain substantial quantities of undiscovered oil, condensate and gas. Because of this, the continent 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) has performed a regional assessment of 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 was 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 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 known source rock data, allowed 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 are presented along with an interpretive report. The interpretive report includes 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 is US $52,500.

INTRODUCTION

Although many basin-scale geochemical studies have been performed in Australia, a comprehensive evaluation of the petroleum systems active across the continent has not been carried out.

In the east, substantial production has been established in the Gippsland, Cooper and Bowen Basins. In more recent times, the Northwest Shelf has become the focus of extensive and successful exploration. Despite this activity, many areas, particularly along the promising northern and southern continental margins, remain under-explored. In this environment, 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 Australian petroleum systems, GEOMARK RESEARCH in conjunction with the Australian Geological Survey Organisation (AGSO) has performed a continent-wide crude oil study of the petroliferous basins both onshore and offshore. The study will involve the analysis of over 300 oil samples distributed throughout the geographic and stratigraphic confines of the various basins. The sample suite comprises the predominantly marine Mesozoic oils of the western and northwestern provinces and the predominantly Paleozoic, Mesozoic and Tertiary terrestrially-sourced oils of the Eastern Australian Basins. Selected samples from the Proterozoic and Paleozoic rocks of the Centralian and McArthur Basins (Summons *et al*., 1988, 1994) were also included.

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

The regional petroleum systems within the study area were 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 was 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 were 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 was possible to bracket the age of the source from the oil data. The thermal histories of the oil samples were also be estimated based on molecular parameters.

The predicted source facies were 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 were then 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.

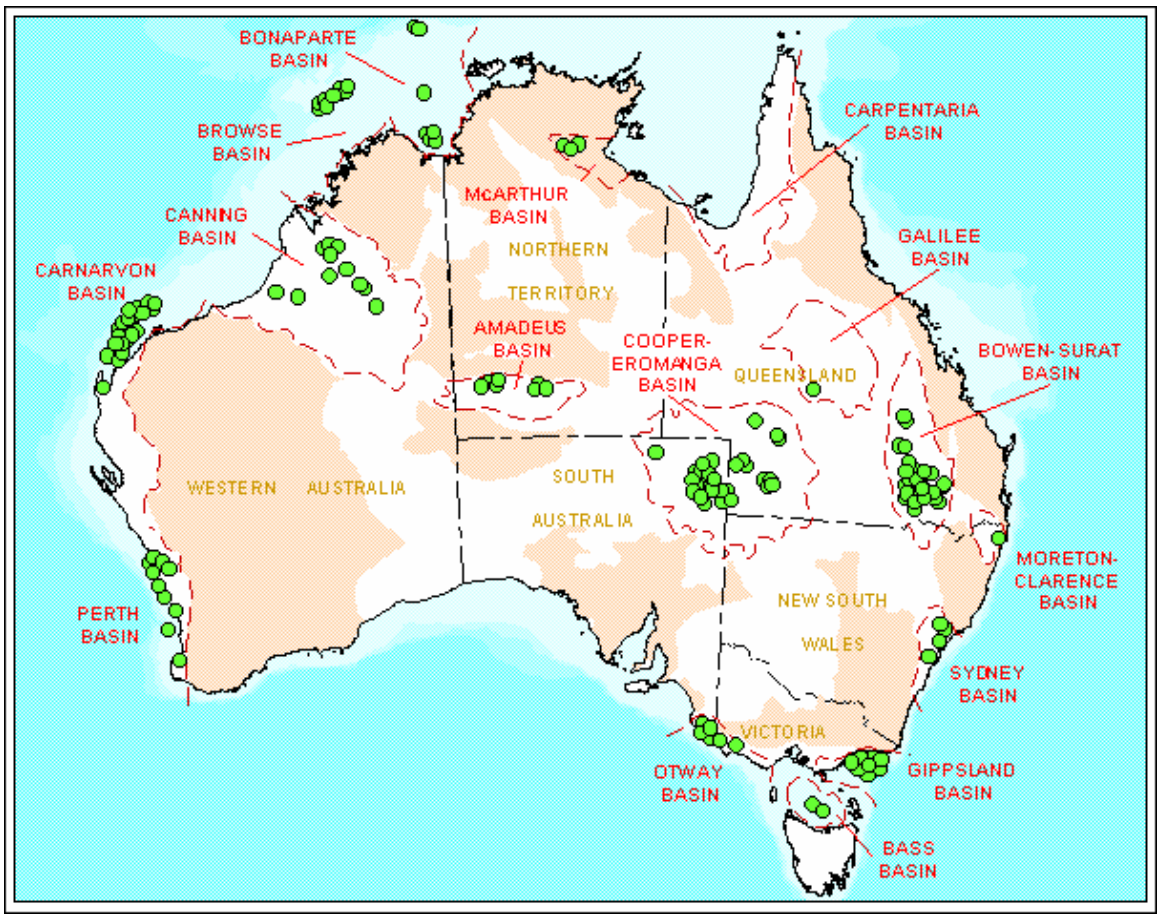

Figure 1. Location map showing samples analyzed for this study.

The relative potential of the petroleum systems in each basin (Bradshaw *et al*., 1994) were 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 were evaluated in an effort to identify areas where particular petroleum systems may exist but have been overlooked or poorly tested.

ANALYTICAL PROGRAM

- API gravity
- % Sulfur, %Nickel and %Vanadium
- Deasphalting (%Asph)
- Liquid chromatography (% Saturates, % Aromatics, and % NSO's)
- Molecular sieve to concentrate branched/cyclic fraction
- Detailed C_7 gas ghromatography
- Capillary GC 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 Australia fields, since these petroleums generally have low contents of conventional biomarkers. In the eastern Australia basins, the C7 tool should be useful for discriminating, and evaluating the effective sources of Permian, Jurassic and Late Cretaceous to Early Tertiary land-plant derived oils which, otherwise, show only subtle compositional differences (e.g. Alexander *et al.*, 1988, Boreham and Powell, 1993).

Compound-specific isotope analysis (CSIA) is another new corrrelation method that offers considerable potential as a source-specific tool applicable to light oil, condensate and gas. Its 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 $\delta^{13}C$ profiles for some selected oils will also be included in the study.

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 magnetic media.

Analytical data are presented within **Basin Data Volumes,** and 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 is presented in a comprehensive **Final Report**. For each of the basins studies, the **Final Report** 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 $52,500.

TIMING

The report is completed and available for immediate delivery.

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Appendix A
Samples Analyzed for this Study