GEOCHEMISTRY OF BASINS ON THE ATLANTIC CONTINENTAL MARGINS OF GREAT BRITAIN

AREA I

WEST OF SHETLANDS BASINS

GEOMARK
RESEARCH, INC.

PROSPECTUS

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INTRODUCTION

Project Objectives. GeoMark Research, Inc. has completed a review of aspects of petroleum systems existing in the Faeroe and West Shetland Basins located west of the Shetland Islands, north of the British mainland. The project area is approximately defined by 1°-5° west longitude and 59°-62° north latitude. Quads 202, 203, 204, 205, 206, 207, 208, and 214 are of particular interest in this project. Clair field and discoveries to the southwest of Clair are included in the area of interest (Stronsay, Foinaven, and Schiehallion). Figure 1 is an outline map of the general area of interest in the project.

Oil geochemistry, rock geochemistry, and contemporary 1D basin simulation techniques were used in evaluation of the petroleum systems in the project area.

Oil Geochemistry. Enormous insight into petroleum systems can be gained by the analysis and interpretation of even a few key oils. Analyses that initially have been performed on selected oils from west of the Shetlands indicate a complex history of oil accumulation (Figure 2). A selection of oils from basins outside the project area have been included in the study. These oils have been used to determine the degree of compositional relationship of the west of Shetlands oils to oils from the main producing areas of the United Kingdom. Table I provides a list of the oils that were included in this study. These oils are located on the map of the project area (Figure 1).

Each oil was characterized by a detailed analytical program that included bulk compositional data, quantitative biomarker analysis of terpanes and steranes, and determination of stable carbon isotope composition of saturate and aromatic hydrocarbon fractions. Rigorous comparison of the geochemical data was accomplished using cluster and principal component analyses with corresponding source rock depositional environment predictions (Moldowan et al., 1985 and Zumberge, 1987).

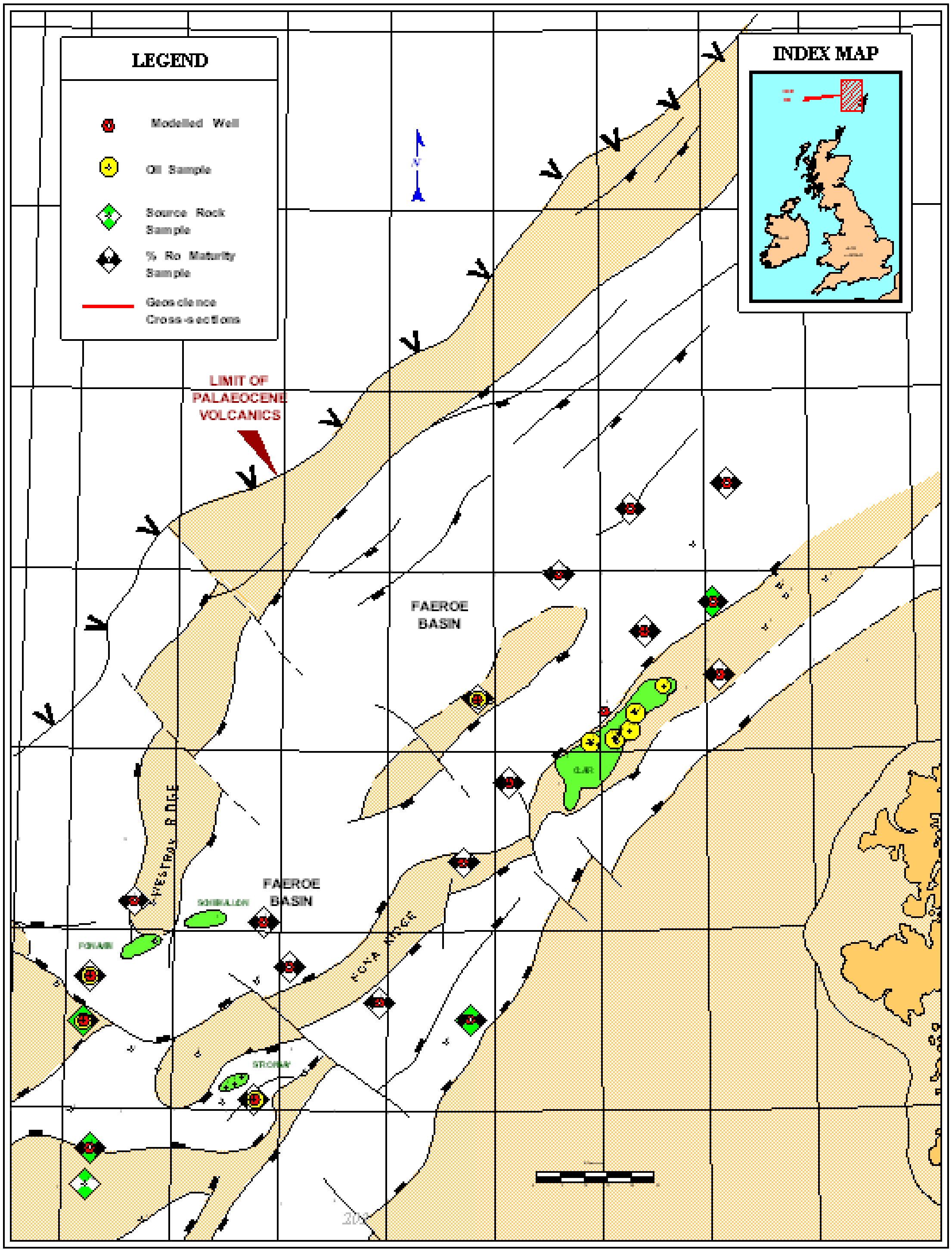

Figure 1. Location map showing distribution of analyzed samples.

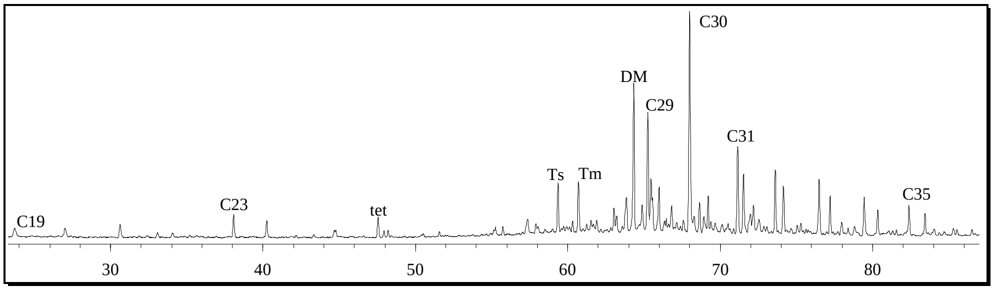

Figure 2. Clair Field oil terpanes indicating intense past biodegradation (DM Hopane). The presence of n-paraffins suggests subsequent charging with nondegraded oil.

Oil geochemistry was used to evaluate key exploration issues.

- The number of sources responsible for the oils.
- The number of depocenters ("kitchens") for oils derived from a common source.
- Identification of altered oils and assignment of these to their proper compositional families.
- Evaluate the possibility of oil mixing (oils from different source facies, fresh oils with altered oils, etc.)

Modeling. Oil and gas source facies are commonly separated from units that are reservoir facies in the Faeroe, Solan, and West Shetland Basins. Geochemical studies (Bailey et al., 1987) have demonstrated that few "effective" sources are present across crests of long standing highs that were sites for most of the wells. Stratigraphic units that might provide environments suitable for the development of hydrocarbon sources are either immature or too organically impoverished or oxidized to constitute significant source intervals. Sources for oil accumulations at Clair, Stronsay, Foinaven, and Schiehallion are considered to occur in structurally deeper, more basinal areas (Faeroe and possibly the West Shetland Basins). In the project, new rock geochemistry has been acquired and combined with existing data. These data were used to constrain 1D models for key wells on the margins of these west of Shetland basins. Modeling of the wells provided insight into the burial and thermal history of this important exploration frontier area.

Modeled wells on the Rona Ridge, Judd Platform West Shetland and Solan Basin were used to constrain models built from geoscience sections crossing into deeper parts of the basin (for example, Booth et al., 1993; Hitchen and Ritchie, 1987; Duindam and van Hoorn, 1987; Mudge and Rashid, 1987; and Ridd, 1981). Shale velocity plots were constructed for a large number of wells to refine estimates of missing section at important unconformities and to use the geological implications of the missing section to improve understanding of the flanking depocenter environments. Identification of late tectonic inversion was also made using these data.

Estimates of the present-day, "expected" hydrocarbon product from Jurassic, Cretaceous, and Tertiary strata were made from the models. These estimates were based on the assumption that organic facies suitable for the generation of hydrocarbons exists at some horizon in each of these major intervals basinally. The likelihood of the existence of these units are discussed using relevant literature and regional considerations.

Table II gives a list of wells that were modeled and for which geochemical data were obtained for the purpose of constraining models. The population of wells modeled is shown on Figure 1.

Thirteen wells were modeled in the original report. Modeling of these wells was undertaken to establish a basis for modeling undrilled locations in the area using hypothetical wells (pseudo-wells). Four hypothetical wells were constructed. These wells were located between the Rona Ridge and the Flett Ridge (Flett Subbasin), in the Faeroe Basin, on the flank of the Rona Ridge, and in the West Shetland Basin. Analysis of the results from the hypothetical wells permitted the construction of a "vector" map attempting to show the approximate time of oil and gas migration from the various depocenters.

Aspects of the late tectonic history (Cretaceous and Tertiary) of the West of Shetlands were interpreted using shale compaction data. Late uplift and erosion were inferred for Cretaceous and Tertiary sections interpreted to be too compact for the depths at which they presently occur. Using these data, the Rona Ridge was found to have remained relatively stable through a Mid Tertiary erosional event. Areas over and around the Flett Ridge were found to have experienced erosion not compensated for by later deposition.

2D fluid flow modeling was undertaken by GeoMark and the Staff of Platte River Associates, Inc. This modeling showed the potential importance of faults as conduits for the migration of oil to reservoir section.

Both the hypothetical 1D and 2D fluid flow modeling predicted initial generation of oil from those areas containing thick Lower Cretaceous section (for example, the Flett Subbasin). Later generation and migration from the Jurassic occur in the axial Faeroe Basin and on the flanks of the Rona and Westray ridges.

The general geology of the West of Shetlands area was interpreted from wells and cross sections provided by Duindam and van Hoorn (1987) and Mudge and Rashid (1987). Lithofacies and chronostratigraphic relationships were assigned to the units in the cross sections. A map estimating the amount of section lost at the Mid Tertiary unconformity was build from consideration of shale compaction data. Several hypothetical wells reflecting the stratigraphic hierarchy defined for the 3D simulation were modeled in 1D. Isopachs of several intervals were built. The 3D simulation was performed by Mobil Oil personnel using Mobil's 3D Sextant fluid flow simulation.

ANALYTIC PROGRAM FOR OILS

All of the oil samples were analyzed using the following technical program:

- API Gravity
- % Sulfur
- Ni/V Ratios
- C15+ vs. <C15+
- Deasphalting
- Liquid Chromatography (%Sat %Aro %NSO)
- Capillary GC of Whole Crude Oil
- Stable Carbon Isotopic Composition of the C15+ Saturate and Aromatic Hydrocarbons
- Quantitative GC/MS analysis of C15+ Saturate Hydrocarbons for Terpane/Sterane Distributions

ANALYTIC PROGRAM FOR ROCKS

Samples selected for thermal maturity were analyzed by vitrinite reflectance. All samples selected for source rock characterization were assessed by the following techniques:

- Total Organic Carbon (TOC)
- Rock-Eval Pyrolysis
- Kerogen Maceral Analysis (TAI)
- Vitrinite Reflectance (% Ro)
- Bitumen Analysis (This includes all the analytical procedures listed above for oils, with the exception of API gravity, Ni/V and %S)

PRESENTATION OF RESULTS

Results from this project are presented in both analytical and interpretative formats to insure that all findings are accessible to explorationists and research personnel. The analytic data from the oil work and the modeling are provided on personal computer disks and within a **Basin Data Volume** which includes the following**.**

Oil Data

- Physical property data
- Liquid chromatographic data
- Gas chromatographic data
- Stable carbon isotope data
- GC/MS mass chromatograms

Modeling

- Temperature and organic geochemical data used to constrain models
- Model parameters
- Stratigraphic, lithologic, and thermal input to models
- Depth vs present-day temperature and maturity plots for individual models
- Hydrocarbon generation versus depth and time for individual well models
- Burial history plots for individual well models
- Plots of sonic travel time of shales and silty shale for wells selected

A synthesis and interpretation of all information is presented in a comprehensive Final Report. The Final Report includes:

- Regional geology
- Differentiation of oil families by multivariate statistics
- Inferred oil/source correlations
- Interpretation of oil characteristics
- Maps of expected present-day product for various inferred horizons
- Interpretation of hydrocarbon generation and timing

PARTICIPATION

The complete study is available at a cost of US $32,500.

TIMING

This study is complete and available for immediate delivery.

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Table I. List of Oils

Oils included in GeoMark Research West of Shetlands Study

Location		*Depth*		*Unit*
Clair	206/8-1a	6365-6595’		Devonian
Clair	206/8-1a	5985-6211’		Carboniferous
Clair	206/7-1	5358-5807’		Carboniferous
Clair	206/9-2	5655-5830’		Carboniferous
Clair	206/8-2			
Clair	206/8-3a			
	205/10-2b	FIT-1	8218’	Early Paleocene
	204/23-1	DST-1	3848-70 meters	Basement
	204/28-1	DST-2	1899-1939 meters	Upper Jurassic
	205/26a-2	DST-1b	6840-70’	Early Cretaceous
	205/26a-2	Additional sample from independent source.		

Oils analyzed for comparison to West of Shetlands Samples

Moray Firth	Beatrice
East Shetland	Cormorant
East Shetland	Hutton
Central Graben	Argyll
Dutch North Sea	K-18-1
Orkney Islands Seep	Devonian
Orkney Islands Seep	Devonian
Hibernia	

Bazhenov three Upper Jurassic sourced oils (Volgian)

Table II. Wells Used For Modeling

Well	Total Depth	Deepest Formation Penetrated
Arco 205/26a-2	8101’	Jurassic/Triassic
BP 205/22-1a	10600’	Jurassic/Basement
Mobil 205/23-1	9008’	Jurassic/Triassic
Phillips 205/25-1	8531’	Jurassic/Triassic
Elf/Conoco 205/20-1	6709’	Jurassic/Basement
BP 204/23-1	12739’	Jurassic/Basement
BP 204/28-1	6476’	Jurassic/Basement
Britoil 204/19-1	15368’	Jurassic/Triassic/Devonian
BP 205/16-1	14170’	Cretaceous/Basement
Britoil 205/10-2b	18903’	Cretaceous
Elf 206/11-1	15157’	Cretaceous
BP/Chevron 206/8-6a	8989’	Cretaceous/Basement
Mobil 206/10a-1	9808’	Cretaceous/Carboniferous/Devonian
Shell 206/2-1a	14744’	Cretaceous
Amoco 206/3-1	16220’	Cretaceous
Shell 206/5-1	13608’	Jurassic
Esso 214/28-1	16812’	Cretaceous
British Gas 214/30-1	10933’	Cretaceous