

**GREATER ROCKY MOUNTAIN
PETROLEUM SYSTEM STUDY**

PHASE II

**Detailed Rocky Mountain Gas Analysis GIS
Database and Regional Interpretation**

GEOMARK RESEARCH, LTD.

A Proposal

2005

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PHASE II

Project Summary

GeoMark Research is initiating a series of regional gas studies for the Rocky Mountain region. These studies will provide a Phase II extension of the Regional Petroleum System Studies GeoMark conducted over the past several years, and concentrate on detailed analyses of both conventional and unconventional (shale gas, coal bed gas, and tight gas including basin centered gas) accumulations. The objectives of these studies are to a) identify the diverse gas sources, b) evaluate thermal maturity differences in commonly sourced gases, c) ascertain the magnitude of gas mixing, and d) evaluate and map gas quality. Compositional and isotopic data will be acquired from new gas samples collected from each basin; these will be combined with the Phase I gas dataset to provide an integrated petroleum fluids database for the greater Rocky Mountain region.

Introduction

GeoMark has completed a series of oil & gas geochemistry projects for basins in the Rocky Mountains. **Figure 1** shows the oil and gas samples evaluated in these studies. The studies conclusively resolved the oil-based petroleum systems of the region, and proved that important compositional differences are represented in the gases in the basins. However, it was also clear that a more comprehensive geochemical program (stable carbon and hydrogen isotope analyses) is needed to address the origin, maturity, and quality of gases in the basins. This is especially true for basin-centered gas accumulations that typically have not been the subject of detailed geochemical investigations. Therefore, GeoMark Research is launching a multi-basin program to obtain and analyze a new suite of gas samples, concentrating on isotope geochemistry.

The results of the effort will be presented as a digital database accompanied by maps and compositional plots. Data will be provided in Microsoft Excel™ and Access™ formats; ESRI's Arcview™ will be the GIS application for the map component of the projects.

The project will accomplish the following:

- Map the distribution of gas types (biogenic, thermogenic, mixed gases);
- Determine and map the number of families with distinct differences in gas composition and/or isotopic character, and associate the compositions with a source interval;
- Identify and map maturity differences of various sourced gases;
- Map the percentages of methane, wet gas, CO₂, and nitrogen throughout the basins;
- Compare the quality of natural gas (BTU content), and map heating values for related gases.

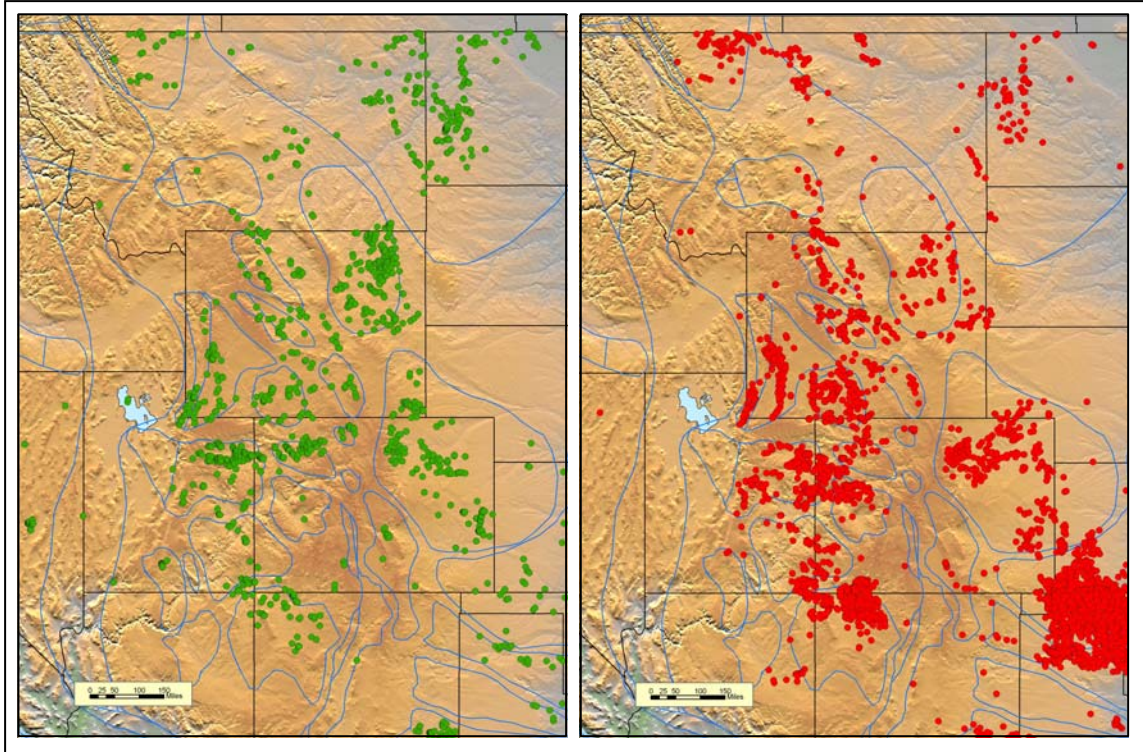


Figure 1. Oil and gas samples evaluated in the Phase I Studies.

Technical Discussion

Differences in the composition and isotope geochemistry of natural gases are increasingly important in the exploration and exploitation of conventional and unconventional resources. Geochemical data provide information useful for defining the origin and differences in gas quality and provenance. Multiple sources for gases occur in the Rocky Mountain basins; a number of these are also sources for oils, but some have no significant oil component. The use of stable carbon and hydrogen isotope geochemistry in conjunction with conventional compositional data provides an opportunity to identify gases derived from different sources, calibrate the maturity of gases from common sources, and create the possibility of recognizing basinal areas where gases from two or more sources are mixed. Mixing occurs where two or more petroleum systems overlap and can result in changes in gas quality.

The map in **Figure 1** shows gas data presently in GeoMark's database (RFDbase) for major Rocky Mountain basins. The majority of the gas samples do not have isotopic compositions available. Identification of individual gas sources and the ability to study the maturity of gases is facilitated by acquisition of a more extensive carbon and hydrogen isotope database for each basin.

The analysis of a sufficiently large collection of gases representing important producing areas in the basin are key to confidently achieving the project's objectives. The initial studies are planned to include the analyses of at least 200 gases from each of the basins, but in fact we expect to have many more than the 200 minimum number for each basin.

Presentation of Results

All analytical data from the Rocky Mountain Gas Study will be provided on a CD-ROM, and additionally will be posted to GeoMark's online web site (www.RFDbase.com). Provided with these data will be interpretative plots and maps used to classify and interpret the data. Interpretive commentary will be given in an Adobe PDF document. Participating companies will be provided access to RFDbase. Participants will need to be Microsoft Excel™, Access™, and ESRI Arcview™ users.

Analytical Program

GeoMark's standard gas analysis program involves gas chromatographic measurement of nitrogen, carbon dioxide, hydrogen sulfide, methane, ethane, propane, iso- and normal butane, iso- and normal pentane, hexane, and higher molecular weight components (up to C₁₂ if present).

A GV GC-IRMS is used to measure the $\delta^{13}\text{C}$ composition of methane, ethane, propane, and the butane gases, as well as CO₂. The procedure couples a gas chromatograph to a combustion interface and an isotope mass spectrometer (IRMS). The technique converts gas components to CO₂ and measures the ¹³C to ¹²C ratio of the individual gases. This provides a detailed "fingerprint" of the gas in the reservoir assuming higher molecular weight homologues are present in more than trace concentrations. Data for very dry gases will be limited to bulk composition, and deuterium and carbon isotopic composition of methane.

Rocky Mountain Database

Data from the *Rocky Mountain Basin Gas Study* will be integrated into GeoMark's RFDbase Database. RFDbase is an internet-enabled database for the storage, review, and manipulation of all petroleum fluid analyses. GeoMark will continue the *Rocky Mountain Basin Gas Database* in future years and continue to add new data. The Database will include interpretive codes as well as all graphic and tabular results.

Participation

Each participant will be required to make a financial and sample contribution to the study. The numbers for each will vary by basin, and the tally for all the basins is presented below. The dollar and sample contributions indicated are for each participating company.

Each individual basin project will remain open and active, receiving new samples as new members join or as existing members have new samples analyzed. The databases will expand in time with the addition of new samples. Participants will be charged an annual fee for continued participation in the growing database beyond the original term of the project. The original term of each project will end one year after the threshold sample number has been analyzed. Samples acquired and analyzed in the one year period after

sample threshold has been reached will be included in the original project. The annual fee for participation in an individual basin after the initial one year period will be 10% of the original price.

Project/Study Region	Financial Contribution	Minimum Gas Sample Contribution
<i>Year One</i>		
Uinta Basin	\$ 35,000	50
Piceance Basin	\$ 35,000	50
Greater Green River Basin	\$ 40,000	75
<i>Year Two</i>		
Big Horn Basin	\$ 30,000	50
Wind River Basin	\$ 30,000	50
Paradox Basin	\$ 30,000	50
<i>Year Three</i>		
Powder River Basin	\$ 35,000	50
Overthrust	\$ 25,000	25
San Juan Basin	\$ 30,000	25

Timing

The study will commence when three participants commit for one or all of the three basins. The order of completion may change depending on the interests of the participants. Data sets will be made available online as soon as they become available from the laboratory.

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