Preparation of Northern Mid-Continent Petroleum Atlas

**Quarterly Report
January 1 - March 31, 1998**

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TITLE: PREPARATION OF NORTHERN MID-CONTINENT PETROLEUM ATLAS

Cooperative Agreement No.: DE-FG22-97BC15008--03

Contractor Name and Address: The University of Kansas Center for Research Inc.

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OBJECTIVES

As proposed, the third year program will continue and expand upon the Kansas elements of the original program, and provide improved on-line access to the prototype atlas. The third year of the program will result in a digital atlas sufficient to provide a permanent improvement in data access to Kansas operators. The ultimate goal of providing an interactive history-matching interface with a regional database will be demonstrated as the program covers more geographic territory and the database expands. The atlas will expand to include significant reservoirs representing the major plays in Kansas, and North Dakota.

Primary products of the third year prototype atlas will be on-line accessible digital databases and technical publications covering two additional petroleum plays in

Kansas and one in North Dakota. Regional databases will be supplemented with geological field studies of selected fields in each play. Digital imagery, digital mapping, relational data queries, and geographical information systems will be integral to the field studies and regional data sets. Data sets will have relational links to provide opportunity for history-matching, feasibility, and risk analysis tests on contemplated exploration and development projects. The flexible "web-like" design of the atlas provides ready access to data, and technology at a variety of scales from regional, to field, to lease, and finally to the individual well bore. The digital structure of the atlas permits the operator to access comprehensive reservoir data and customize the interpretative products (e.g., maps and cross-sections) to their needs. The atlas will be accessible in digital form on-line using a World-Wide-Web browser as the graphical user interface.

Regional data sets and field studies will be freestanding entities that will be made available on-line through the Internet to users as they are completed. Technology transfer activities will be ongoing from the earliest part of this project, providing data information sets to operators prior to the full digital atlas compilation.

SUMMARY OF TECHNICAL PROGRESS

As part of the first two years of the project "Pages" and data schema for the atlas overview and field studies were developed and made accessible through the world-wide-web. The atlas structure includes access to geologic, geophysical and production information at levels from the national, to the regional, to the field to the individual well. Several approaches have been developed that provide efficient and flexible screening and search procedures. Database queries are now routed through a relational database management system that provides the individual access to production, well-log, core and other databases. In the third year, this flexible access will be expanded to include access to user-defined maps, cross-sections and other technical products. The continually evolving prototype of the digital atlas is accessible through the Kansas Geological Survey Petroleum Research Section (PRS) HomePage (The Universal Resource Locator [URL] is <http://www.kgs.ukans.edu/PRS/PRS.html>). The Digital Petroleum Atlas (DPA) HomePage is available directly at <http://www.kgs.ukans.edu/DPA/dpaHome.html>. Technology transfer is underway through presentations at national and regional meetings and through the use of monthly electronic updates and the on-line availability of the DPA products. Project information and Quarterly Progress Reports are linked to the Digital Petroleum Atlas HomePage.

Work has progressed on the Arbuckle field study. Robert O'Dell has reviewed a large part of the well data and we should have regional and field maps up on the DPA site within the next quarter. Regional work by Steinhauf and others (1998, Attachment 1) on the depositional facies and petrophysical properties is being integrated in the DPA.

TECHNOLOGY TRANSFER

Technology transfer is ongoing through presentations at national and regional meetings and through the use of electronic updates and the on-line availability of the

DPA products (See Attachment). Project information and Progress Reports are linked to the Digital Petroleum Atlas HomePage. The prototype Digital Petroleum Atlas remains one of the most visited pages on the Kansas Geological Survey web site (Current usage statistics can be accessed at the bottom of the Petroleum Research Section HomePage or at http://www.kgs.ukans.edu/PRS/usage/past_stats.html). Industry continues to access and use the digital data and technology from the DPA project.

REFERENCES CITED

D.M. Steinhauft, E.K. Franseen, A.P. Byrnes, 1998, Arbuckle Reservoirs in Central Kansas: Relative Importance of Depositional Facies, Early Diagenesis, and Unconformity Karst Processes on Reservoir Properties, Extended Abstract for AAPG Annual Meeting, Salt Lake City, Utah, 6p.

Attachment 1

Presentation and extended abstract for AAPG Annual Meeting in Salt Lake City, Utah.

Arbuckle Reservoirs in Central Kansas: Relative Importance of Depositional Facies, Early Diagenesis, and Unconformity Karst Processes on Reservoir Properties

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Arbuckle strata account for about 40% of the produced oil and known reserves in Kansas. Much of the past production has come from the upper 25 feet of the Arbuckle in areas of structural highs and regional uplifts, related to basement structural elements, that were enhanced by karstic processes related to the overlying unconformity. A detailed analysis of the facies and reservoir characteristics of the Arbuckle in Kansas has not been performed. Results from our initial study of six cores from several different regions in central Kansas suggest that Arbuckle reservoir characteristics are also strongly related to depositional facies, early diagenesis, and dolomitization. The development of brecciation, fracturing and dissolution related to the post-Arbuckle unconformity is variable and variously created or destroyed porosity.

Five main depositional facies, identified to date, account for more than 85% of the cored interval described in all 6 cores. Listed in approximate order of relative abundance, with the most abundant facies first, these include (1) clotted algal boundstone (2) laminite algal boundstones, (3) peloidal packstone-grainstone, (4) packstone-grainstone, and (5) wackestone-mudstone. Intraclastic conglomerate and breccia, cave fill shale, depositional shale, and chert account for the remaining 15% of the total rock. Petrophysical properties of the facies at the core plug scale are generally controlled by matrix grain size. All lithologies exhibit increasing permeability with increasing porosity and can be characterized as lying along the same general porosity-permeability trend. Clotted algal boundstones, peloidal packstone-grainstone, wackestones, mudstones, and shale generally exhibit porosities less than 10% and

absolute permeabilities below 0.1md and frequently below 0.01md. These facies also exhibit high to very high irreducible water saturations (S_{wi}) and effective hydrocarbon permeabilities at S_{wi} that are one to several orders of magnitude less than the absolute permeability values. In contrast, laminated algal boundstones with abundant grains exhibit porosities ranging from 10% to 30% and absolute permeabilities ranging generally from 0.1md to 1,500md. Irreducible water saturations within these facies are related to permeability but are generally low and effective hydrocarbon permeabilities range between approximately 30% and 100% of absolute permeabilities. Early chert replacement, early and late dolomitization, early to late brecciation and fracturing have variously created or destroyed porosity. These processes, in conjunction with depositional facies, have created a vertical heterogeneity and resulted in complex compartmentalization within the Arbuckle Group strata.

Our initial studies on the six cores and reconnaissance of others suggest that the facies and paragenetic sequence of events described in this paper are characteristic of most Arbuckle strata in Kansas. Our continuing regional stratigraphic and sedimentologic study is providing a framework for Arbuckle strata, and detailed information on the relative importance of depositional facies, diagenesis and unconformity-related karst processes for controlling reservoir architecture in various structural settings. Integration of depositional facies and diagenetic features with petrophysical properties (including porosity, permeability, capillary pressure, electrical resistivity, and relative permeability) is allowing evaluation of the role that the various facies play within the total reservoir system. It is also resulting in quantitative translation of geologic models into numerical reservoir properties models for reservoir simulation and as an aid in determining production strategies.