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**CHARACTERIZATION OF FACIES AND PERMEABILITY PATTERNS IN
CARBONATE RESERVOIRS BASED ON OUTCROP ANALOGS**

**Quarterly Report for the Period
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**By
C. Kerans**

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**Robert E. Lemmon, Project Manager
Bartlesville Project Office
P. O. Box 1398
Bartlesville, OK 74005**

**Prepared by
University of Texas
Bureau of Economic Geology**

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Objectives

The primary objective of this research is to develop methods for better describing the three-dimensional geometry of carbonate reservoir flow units as related to conventional or enhanced recovery of oil. Detailed characterization of geologic facies and rock permeability in reservoir-scale outcrops of the Permian San Andres Formation in the Guadalupe Mountains of New Mexico will provide the key data base.

To this end detailed sampling on grids using a portable core-plugging device was undertaken within a previously established detailed geologic framework. Petrophysical and rock-fabric data from these sampling grids has been obtained and analyzed. The next step is to relate the petrophysical data to the geologic framework, prepare a simulation grid, and perform experimental computer flow simulations. Progress during this quarter focused on (1) relationships between rock-fabric and petrophysical data and (2) development of a geostatistical model of permeability distribution in preparation for quantifying the simulation grid.

Summary of Results

Examination of thin sections from the fusulinid facies in the core from well Algerita 3 and from Irbarne Tank outcrop-grids A and B show that these San Andres clinolform deposits are dominated by packstones and wackestones composed of very large grains. The sediments have been completely altered to dolostone characterized by 50 micron dolomite crystals. There is ample suggestion that the rocks once contained anhydrite which has been completely dissolved. In some samples, fusulinids have been selectively dissolved.

Analysis of the porosity and permeability data from the plug and whole-core samples indicates that permeability is a function of sorting as well as porosity in samples with less than 3 percent

separate-vug porosity (fig. 1). Poorly sorted packstones would normally plot in the class 3 field of figure 1 but the replacement of mud-size particles with 50 micron dolomite crystals reduces the negative effect of sorting on permeability. Well sorted packstones would normally plot in the class 2 field of figure 1 but the very-large grain size (1000 microns) increases the positive effect of grain size on permeability. Samples with greater than 3 percent separate-vug porosity tend to have higher porosity but similar permeability values compared with low vuggy porosity samples. The average porosity for the samples with low vuggy porosity is 11 percent while for high vuggy porosity, the average is 18 percent. Comparable permeabilities are 7 md and 6 md.

Examination of the vuggy samples suggests that dissolution of the fusulinids and associated anhydrite produced a touching-vug pore system resulting in outcrop samples with unrealistically high permeability values. In order to obtain realistic permeability values for the vuggy intervals, a 60 foot interval of fusulinid rock in the core from well Algerita 3, taken 1000 feet back from the outcrop, was studied. Permeability measurements were taken every 2 inches of the 60 foot interval using a mechanical field permeameter (MFP) resulting in 360 measurements. Variogram analysis was done on the MFP data to characterize the spatial distribution of permeability. The vertical variogram indicates a correlation range of 1.6 ft, a nugget of 0.045 md², and a sill of 0.089 md² based on a spherical variogram model. The variogram results are similar to those from outcrop measurements in the upper San Andres parasequence at Lawyer Canyon. Permeability is characterized by local random heterogeneity and relatively small correlation range of permeability in the vertical direction.

Geological analysis of these San Andres over ramp clinoform strata indicate a well layered structure on the 500-1,000 ft lateral scale and 5-30 ft vertical scale. This layered geologic structure will be integrated with the above defined highly variable permeability structure to constrain fluid flow experiments.

Figure Captions

Figure 1. Permeability/porosity cross-plot for Irabarne Tank and Algerita #3 outer ramp clinoform facies.

Figure 2. Vertical variogram of permeability structure from a 60 ft interval of outer ramp cyclic fusulinid-peloid wackestone/packstone facies.

Irabarne Tank and Algerita 3 Data **Very Large Grain Fusulinid Facies**

Vertical Variogram, Algerita No. 3 Well

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