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CHARACTERIZATION OF SHORELINE BARRIER RESERVOIRS

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by

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INTRODUCTION

The objective of project BE1 is to develop a methodology for the effective characterization of shoreline barrier reservoirs. To accomplish this goal, it is necessary to address what reservoir and production characteristics are common among shoreline barrier island reservoirs. Our approach to the problem is to compare reservoir models from two different barrier island systems, the Muddy formation in Bell Creek field and the Almond formation in Patrick Draw field, and to determine the similarities and differences between two different types of shoreline barrier reservoirs.

The tasks for FY91 are to begin the construction of a quantitative geological and engineering reservoir model for the Patrick Draw field; to identify the similarities and differences among various shoreline barrier deposits; and to identify effective techniques for characterizing this class of reservoirs. The status of the work is described below.

GEOLOGIC AND ENGINEERING MODELS

The stratigraphic and structural framework of the reservoir in the Arch Unit has been determined through the generation of cross-sections. Preliminary facies correlations indicate that the thickest and highest reservoir quality sands are located in the southwest portion of the Arch Unit, and reservoir quality generally degrades northward. A number of areas with high potential for faults have been identified based on high structural gradient. The confirmation of fault locations and their effect on production will be pursued in FY92.

Grain size was measured for 300 grains per thin section in 75 thin sections from outcrop and reservoir rocks using NIPER's petrographic image analysis system. Analysis of grain size is important to this study in two ways: (1) in determining the degree of depositional similarity between the outcrop and subsurface rocks, and (2) in distinguishing reservoir rock types and their relationship to depositional and diagenetic facies. Subsequent correlations between grain size, pore size distributions, permeability, and other petrophysical properties will be an important component in defining the flow units within the reservoir.

Petrographic and X-ray diffraction (XRD) analyses have been performed to determine the mineralogy and diagenetic history of the rocks and provide another basis of comparison of outcrop and reservoir rocks.

Analysis of reservoir engineering data included determining the spatial distribution of the amounts and types of fluids produced during the initial production test. These data were normalized by the length of the perforated interval to allow meaningful comparison of wells. Analysis of primary production included the distribution of reservoir pressure at three times during primary production. The pattern of cumulative production correlates well with the sand thickness. Analysis of the ratio of initial oil production and primary cumulative oil production was performed to identify anomalous production areas within the field.

Major heterogeneities are indicated by the waterflood performance response in the Arch Unit. Waterflooding resulted in less than 10% incremental oil production, and less than half of the injected fluid was recovered. Analysis of secondary production using Hall plots to determine the water permeability and water relative permeability indicated a significant loss of permeability to water, which may partially explain the poor waterflood sweep efficiency. Poor reservoir connectivity was indicated in plots of water-oil ratio versus cumulative oil production where a double water breakthrough (dual peaks) was observed in wells located close to an identified permeability barrier. The low injected fluid recovery suggests a high degree of channeling, most likely caused by fractures; however, the fracture locations have not been positively identified.

Other fluid anomalies identified in the Arch Unit include variations in the types of fluids produced during initial production. Production of oil and gas within a primarily oil producing area suggests lateral compartmentalization of fluids and the possibility of vertical rather than horizontal hydrodynamic communication. A salinity anomaly was identified in the Monell Unit where higher salinities (TDS) occur in the updip (shallower) portion of the Monell Unit while lower salinities (6-7%) occur in the downdip (deeper) part of the reservoir. It was noted that this anomaly generally corresponds with the observed change in the pattern of initial hydrocarbon production and also indicates laterally restricted fluid movement in the reservoir.

SIMILARITIES AND DIFFERENCES AMONG SHORELINE BARRIER DEPOSITS

The similarities and differences of reservoir characteristics among shoreline barrier systems were examined to determine the common characteristics within shoreline barrier deposits. The comparison of characteristics of the Almond formation in Patrick Draw field, a mesotidal barrier system, with the Muddy formation in Bell Creek field, a microtidal system, indicates differences in the degree and scale of compartmentalization due to sedimentological features. These differences indicate that microtidal and mesotidal barrier systems comprise distinct subclasses of shoreline barrier deposits that must be accounted for when determining the degree of transferability of

properties from one reservoir to another. Grain size measurements from 79 thin sections taken from outcrop and subsurface Muddy formation have been compared to those of Patrick Draw field to determine the degree of similarity in pore-scale, sedimentological features.

Data on facies dimensions and geometry within mesotidal barrier systems were compiled from field measurements and literature sources to determine the degree of variability within mesotidal barrier systems. Those dimensions from the Almond formation facies fall within typical dimensional limits of the other formations considered.

Comparison of reservoir characteristics of Patrick Draw field and Bell Creek field indicate (1) that both reservoirs experienced early stage leaching which modified the pore systems; however, greater amounts of ductile sedimentary and igneous rock fragments in the framework composition of the Almond formation, along with greater amounts of diagenetic clay and other factors, reduced permeability and porosity; (2) the initial oil production was similar in both reservoirs even though the permeabilities in Bell Creek are 1 to 2 orders of magnitude higher than those in Patrick Draw field; and (3) secondary recovery in Bell Creek field produced 2.5 times more oil than Patrick Draw field. The implications of these differences for identifying what characteristics can be transferred among different reservoirs will be discussed in a topical report.

EVALUATION OF EFFECTIVE TECHNIQUES FOR CHARACTERIZING SHORELINE BARRIER RESERVOIRS

Evaluation of effective characterization techniques included: (1) geostatistical analysis of closely spaced minipermeameter measurements and comparison with CT density profiles and (2) wireline log analysis techniques of determining in situ stresses from density logs to determine propensity for fracturing and determining pore fluid pressure from sonic transit times.