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Reservoir Characterization and Depositional Environment of the Cenonmanian Barons Sandstone – Penny Pool, SW Alberta

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Summary

The early Cenomanian Barons Sandstone, located within the Fish Scales Formation, is a proven oil and gas reserve in southwest Alberta. Despite production from several isolated sandstone and conglomerate bodies within the Barons Sandstone, a lack of published studies limits the understanding of geology of this reservoir. Net pay values are difficult to assign in this region due to high content of pyrite & bentonite beds affecting petrophysical data. To maximize production efficiency, a greater understanding of pool characteristics is necessary. This study focuses on the Southwest Alberta Penny Pool and surrounding area - spanning Townships 7 to 9 and Ranges 21 to 24 west of 4th meridian. Poor water flood results and new production opportunities in a potential halo-type tight oil play to the southwest of the Penny Pool would benefit from a more detailed reservoir characterization. This resource play will be better understood through the identification and analysis of facies and their distribution within the Penny Pool, and with further research on the depositional environment of the Barons Sandstone.

Introduction

The Barons Sandstone lies within the Alberta Colorado Group and was deposited in the Western Interior Seaway. The unit appears as isolated muddy sandstone and conglomerate bodies, irregularly-distributed at several orientations, throughout southwest Alberta within the Fish Scales Formation. Pools display a linear trend with widths ranging from 3-5km and lengths from 5-15km. Facies within the Barons Sandstone vary depending on the pool. The Penny Pool, discovered in 1995, lies at the southwest edge of Lethbridge, Alberta with a northwest-southeast trend. The Fish Scales Formation is thought to have sourced the estimated OOIP of 27827.07 MBbl and estimated OGIP of 12.56 Bcf to the Penny Pool (geoSCOUT). Average API gravity in Penny Pool oil is 27.5 and recoverable oil is estimated to be 7740.23 MBbl giving a 27.8% recovery factor (geoSCOUT). Some noteworthy features of the pool are the high contents of pyrite, bentonite and fish scales present throughout the entire succession.

Theory and/or Method

Five major Barons Sandstone facies have been identified. Three cored intervals in the Penny Pool and three in the surrounding area were used in conjunction with petrophysical wireline logs to map facies architecture. Cross section work throughout the pool was used to correlate chrono-stratigraphic bentonite marker beds and other horizons of interest. TOC analysis and petrographic thin-section analysis was performed to correlate facies and interpret reservoir hydrocarbon properties. Finally, using all available data sets, a depositional model will be proposed and discussed.

Reservoir Properties

Core analysis, TOC analysis and petrographic data were used to interpret Penny Pool reservoir properties. In mud draped very-fine sand facies, porosities range from ~3.0-6.0% with permeabilities ranging from ~0.09-0.18 mD. In medium to coarse sandstone facies, porosities range from ~10-15% and permeability ranges ~8.0- 54.0 mD. Sandstones in the Penny Pool have a high bulk grain density due to high concentrations of pyrite throughout the succession. This proves challenging for reservoir analysis because pyrite can lower petrophysical readings of porosity on density-porosity logs and alter readings on resistivity logs. The presence of bentonite in the region further complicates analysis due to the swelling nature of these clays upon contact with water. Log profiles where bentonite layers are present are generally quite characteristic.

Depositional Environment

The depositional environment as interpreted from core, core analysis data, petrophysical log correlation and petrological data indicates a marine shoreline setting prograding to the southwest or the landward location of a barrier island retrograding to the southwest. The succession displays an upward coarsening and upward sanding profile. Correlation of chrono-stratgraphic bentonite beds and gamma ray sand profiles show NW-SE trending sand bodies were deposited by clinoforms dipping to the southwest, oriented NE-SW. On the southwest side of Penny Pool, the Barons unit displays a gradual south-westward pinch out of the sandstones, where therein lies the potential for a tight oil halo-type play. On the north side, there is a sharp boundary where sandstones are unconformably replaced by a sandy mud facies containing abundant fish scales. Sandstones of the oldest Barons facies display very fine grain size with abundant mud draping and mainly rippled sedimentary structures, representing a current dominated marine setting. At the top of the succession, as the environment shallows, sand reaches a coarse-grained size and mud-draping is less abundant. Limited bioturbation, appearing only in confined packages, and abundant pyrite indicate a stressed and primarily anoxic to dysoxic environment.

Conclusions

A focused approach to reservoir characterization is conducted in this study through the analysis and mapping of five Barons Sandstone facies. A depositional model is proposed to aid in understanding of reservoir properties and facies distribution. Using the data and observations in this study, Penny Pool production and advanced hydrocarbon recovery techniques can be orchestrated efficiently.

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