RESERVOIR CHARACTERIZATION AND PETROLOGY OF THE BAKKEN FORMATION, ELM COULEE FIELD, RICHLAND COUNTY, MT

by

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ABSTRACT

Elm Coulee Field, discovered in 2000 in Richland County, Montana, is the largest oil field in the Williston Basin. This field produces from the middle member of the Devonian-Mississippian Bakken Formation and has an estimated ultimate recovery of 200-250 MMBO. The Bakken's diagenetic history in combination with horizontal drilling and hydrofracturing practices make it possible to get large recoveries from this low permeability and porosity field.

The Bakken Formation in Elm Coulee Field is composed of three main members with an average total thickness of 40 feet. The lower Bakken member consists of dark, laminated, organic-rich marine shale. This member pinches out toward the western and southern limits of the field. The middle Bakken member contains six shallow marine silty-dolostone facies. From bottom to top these include: a brachiopod-rich facies, a burrowed and bioturbated facies, two laminated facies, a laminated and burrowed facies, and finally a massive to brachiopod-rich facies. These were deposited in offshore marine and mid to distal shelf environments below normal wave base. Like the lower member, the upper Bakken member is laminated, dark, organic-rich marine shale, but it is continuous across the field. The upper Bakken member is the main source bed for the oil found within the middle Bakken reservoir at Elm Coulee.

The main types of porosity within the middle Bakken are secondary pores and intergranular pores. Secondary porosity is the result of dolomitization and subsequent dissolution. Within portions of the middle Bakken member containing the highest dolomite percentages (up to 60%) and lowest clay percentages,

some of the rhombohedral dolomites have 10 micron gaps along the edges of the crystals. These gaps form due to both the formation of the dolomite rhombs adjacent to the detrital grains and the later dissolution of the edges of those rhombs. If many of these "slot" pores exist, they can connect, thus acting like microfractures, and lead to preferential pathways that contribute to increased permeability and production.

Production at Elm Coulee would not be possible if the Bakken Formation had not undergone a variety of diagenetic stages that have resulted in a dolomite-rich reservoir rock with enhanced secondary porosity. The diagenetic sequence of the Bakken begins with mechanical compaction, early dolomitization related to shelfal seepage reflux, and pyrite formation. Next is a period of dedolomitization, deeper burial related dolomitization, the formation of sphalerite, anhydrite cement, quartz replacement, and quartz overgrowths. There are also two stages of fracturing at Elm Coulee. The first, mineralized vertical to subvertical fractures, is probably related to either Devonian salt dissolution, the reactivation of basement faults, or pressure release from dewatering of the sediments, and the second, open horizontal fractures, is related to pressure release from the hydrocarbon expulsion process. The beginnings of hydrocarbon generation in the shales also expelled acids into the middle Bakken which dissolved parts of the dolomite rhombs, thus increasing porosity and enhancing storage space for the following expelled oil.

The results of this study in conjunction with previous analyses of Elm Coulee Field indicate that the Bakken petroleum system within the Williston

Basin has huge potential for future discoveries. Understanding the distribution of facies, the types of porosity, and the diagenetic stages that have occurred within the middle Bakken reservoir member is the key to determining new drilling targets within Elm Coulee and also to the search for similar locations in this basin that may be good targets for future production.