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Role of Nomenclature in Pay Zone Definitions, Bakken - Three Forks Formations, North Dakota

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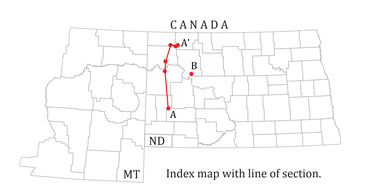

Figure 1 - The wireline log of the EOG Resources - #2-11 Liberty well is displayed with core analyses, fluid saturations, nomenclature, and a representative core section. In comparison to the wells in the cross-section, the Liberty well shows high oil saturations throughout the lower portion of the Three Forks section suggesting potential. Location of the well is indicated by "B" on the index map.

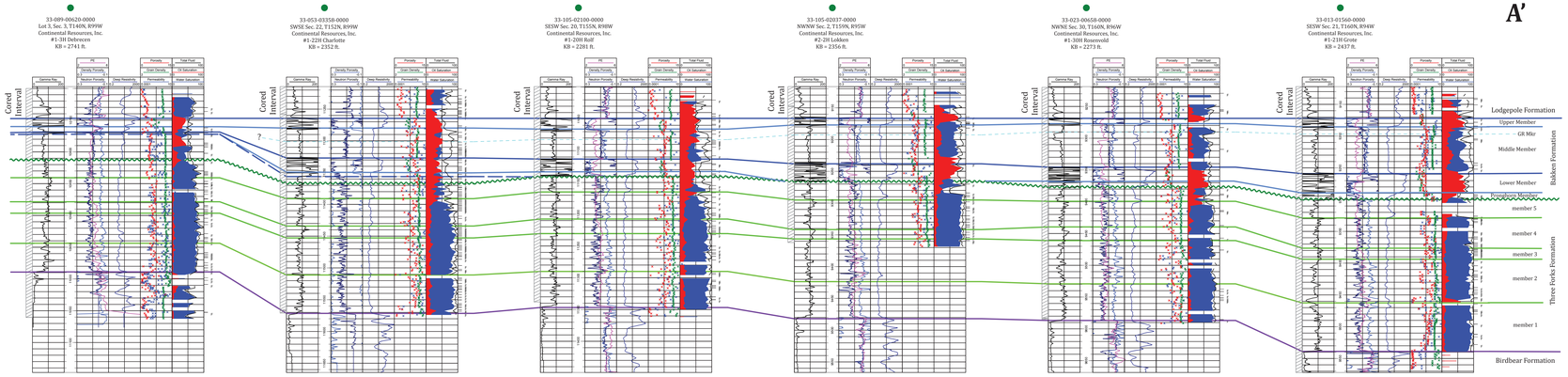

Figure 2 - Isopach maps of the individual members, in descending order, of the Three Forks Formation in North Dakota and Montana. A. - Three Forks member 5 reaches maximum thickness of 85 ft. B. - Three Forks member 4 reaches a maximum thickness of 67 ft. C. - Three Forks member 2 reaches a maximum thickness of 67 ft. D. Three Forks member 1 reaches a maximum thickness of 77 ft. All maps have a contour interval of 5 ft.

	MBKU	MBKM	MBKL	MBK-P	DTF6	DTF5	DTF4
Average Oil Saturation (%)	39.1	28.7	36.5	26.4	30.4	12.1	13.8
Average Water Saturation (%)	15.5	39.9	21.7	49.7	40.2	67.7	68.0
Average Empty (%)	45.4	31.5	42.5	23.9	29.6	20.2	18.1
Number of Wells	14	40	19	15	37	30	23
Number of Analyses	68	1332	174	69	1017	226	281

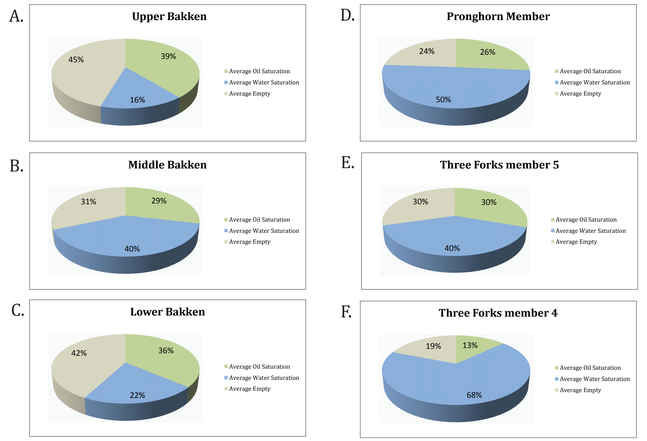

Figure 3 - Data table and pie diagrams comparing the average fluid saturations for all of the members of the Bakken Formation (A-D) and for the upper two members of the Three Forks (E and F) based on available core analyses. Saturations are similar for the Bakken shales with the Middle Member displaying a slight increase in water. Limited core data for the Pronghorn suggests that saturations are similar to that of the underlying member 5 of the Three Forks Formation. A significant increase in water saturations occur in member 4 of the Three Forks.

Summary

The Three Forks Formation has been a focus of interest with the drilling and completion of wells in the "first and second bench." Recognition of the production potential of this formation requires a re-examination of the stratigraphy and its position relative to the newly defined Pronghorn Member of the Bakken Formation.

The Three Forks Formation overlies the anhydrites of the Birdbear Formation and underlies the Bakken Formation. Recent cores provide a view of the entire stratigraphic succession (Fig. 1). Isopach maps of each of the members are shown in Figure 2. Member 1 is a redbed sequence consisting of a tan to grey-green to red interbedded mudstones mixed with siltstones and sandstones. Anhydrite is present as nodules and layers. The member is representative of a sabkha environment of deposition. Member 2 is an interbedded sequence of grey-green and dark red mudstones with occasional anhydrite nodules and beds. Member 2 represents environments ranging from sabkha to tidal mudflat. Member 3 is a red to grey-green slightly dolomitic mudstone mixed with poorly sorted clasts representing a mudflat. Basal member 4 consists of grey-green, tan and orange-red interbedded mudstone to sandy dolostone that is brecciated probably due to dewatering. This is overlain by an interbedded sequence of apple-green dolomitic mudstone and tan dolostone with desiccation breccia at the base and structures that include ripples, flaser beds, syneresis cracks, and mudcracks. Capping the sequence is a massive dark brown to dark red dolomitic mudstone. Member 4 represents a fining-upward sequence indicative of tidal mudflat to intertidal to shallow offshore environments. Member 5 repeats the sequence with basal tan dolomitic, brecciated dolostone that is overlain by the apple-green claystone and tan dolostone with ripples, flaser beds, syneresis cracks, and mudcracks. This also represents a progression from tidal mudflat to intertidal to supratidal environments. At the top of the Three Forks is a significant unconformity.

The rock that lies between the unconformity and the Lower Bakken shale has been named the Pronghorn Member of the Bakken Formation. In an ascending order, a "complete" Pronghorn Member has a transgressive "Skolithos" burrowed basal sandstone, a medium brown dolomitic mudstone with HCS beds, a brachiopod bearing lime mudstone, and an dark grey limestone representing environments from shoreface to nearshore to open marine. In the northern portion of the basin, the Pronghorn is predominantly a shale facies deposited in a marine environment.

Log signatures can be used to differentiate between the Three Forks Formation and Pronghorn Member of the Bakken (Cross-section A-A'). Current industry terminology refers to the member 5, 4, 2, and 1 as benches (i.e. member 5 is referred to as the "First Bench"). Careful attention to the stratigraphy is necessary when discussing producing intervals. The cross-section also plots the fluid saturations. It is interesting to compare the oil saturations (red) against the water saturations (blue). Oil saturations are consistent through the Bakken, but tend to taper off below member 5. Correlations become especially important in the Continental Resources, Inc – #1-3H Debrecen well where the highest oil saturations are in the Pronghorn Member not the upper Three Forks. In contrast to the cross-section wells, the EOG Resources, Inc. – #2-11H Liberty has oil saturations throughout the Three Forks section. Also plotted on the section are fractures (F) indicated on the core analyses in an attempt to determine the controlling factor. An abundance of fractures appear to coincide with higher water saturations in the Three Forks. The opposite is reflected by fractures in the Bakken.

The pie diagrams in Figure 3 illustrate the average saturations for each member using currently available core analyses. Data is summarized in the overlying table.

Bottjer et al. (2011) presented XRD data for the various members of the Bakken and Three Forks formations (Fig. 4). It is interesting to note the high occurrence of silicates and dolomite throughout the sections especially in the marker bed that denotes the top of member 4 of the Three Forks Formation. The absence of significant amounts of clay suggests that the marker bed may not confine a fracture stimulation treatment as previously thought.

A preliminary examination of the Three Forks Formation raises some interesting questions as to how extensive is the resource, what are the controlling factors, and what constitutes the reservoir. Additional examination of new cores may answer some of the questions.

Reference

Bottjer, R.J., Sterling, R., Grau, A., and P. Dea, 2011, Stratigraphic Relationships and Reservoir Quality at the Three Forks-Bakken Unconformity, Williston Basin, North Dakota, *in*, Robinson, J.W., LeFever, J.A., and S.B. Gaswirth, eds., The Bakken-Three Forks Petroleum System in the Williston Basin: Rocky Mountain Association of Petroleum Geologists, 546p.

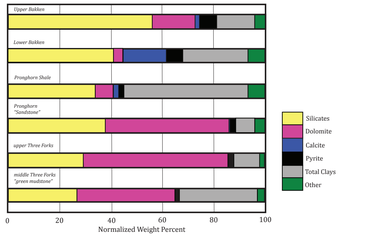

Figure 4 - Average X-ray diffraction mineralogy weight percentages for the Upper Bakken, Lower Bakken, Pronghorn shale, Pronghorn sandstone, member 5 of the Three Forks, and marker that comprises the top of member 4. Percentages for each zone are averages from multiple samples and multiple wells and have been normalized to 100 percent. Note the high clay content of the Pronghorn shale, which explains its low resistivity on wireline logs and unstable nature of this interval as observed in cores. Note the high degree of dolomite and silicates in the "green mudstone" of member 4 that suggests that the interval may not be a barrier to fracture stimulation (modified from Bottjer et al., 2011).