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Reservoir Characterization of a Mississippian Carbonate – Example from the Lodgepole Formation, Daly Oil Pool, Williston Basin, Southwestern Manitoba

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Summary

Daly Unit 3 is located on the carbonate slope of the Lodgepole Formation, on the eastern edge of the Williston basin. It has produced oil on waterflood since 1953. The re-development and optimization of this field requires a validated reservoir flow (dynamic) model that can be used in evaluating technical uncertainties and reducing risks. Towards this objective, the first step would be to build a geologic model that is constructed on consistent reservoir characterization across the reservoir.

The Lodgepole at Daly is comprised of six correlatable depositional cycles, each containing several shallowing upward cycles, starting at the base with the Cruickshank Crinoidal, Cruickshank Shale, Lower Daly, Middle Daly, Upper Daly and the Unnamed (Young and Rosenthal, 1991). These cycles have been sampled in twelve wells for thin section petrography, core analyses and in three wells for capillary pressure data. This core display will present examples of the depositional facies and the diagenetic alteration that has occurred, concomitant with which are variations in porosity, permeability and capillary pressure data. The methodology and approach that will be used to integrate geology with engineering will also be addressed.

Four main fabrics have been identified, each characterized by differences in mineralogy, permeability, and pore throat size and distribution:

Fabric A is comprised of a partially to completely dolomitized pelletoidal mudstone to packstone. Increasing dolomitization is often associated with a higher level of dissolution between the dolomite rhombs. This, combined with the large irregular shapes of the intercrystalline pores relative to the size of the dolomite rhombs, clearly indicates extensive post-dolomite dissolution of the calcite matrix. Porosity and permeability vary from 12 to 33% (average of 18%) and 3 to 85 mD (average 18 mD), respectively. Pore throat size varies from 0.7 to 2 um (average of 1.5 um). Fabric A occurs in the Unnamed and Upper Daly, and is commonly associated with dolomitization.

Fabric B is a mudstone to pelletoidal packstone-grainstone with poor porosity due to high argillaceous content and/or cementation. It’s considered a non-reservoir rock. Porosity ranges from 6 to 15% (average of 10%), permeability between 0.02 and 3 mD (average of 0.9 mD) and pore throats between 0.3 and 1.9 um (average of 1 um). This fabric can be found in all six cycles.

Fabric C is a crinoidal-pelletoidal packstone with fair to good inter and intra particle porosity. Porosity ranges from 7 to 16% (average of 12%), permeability varies from 3 to 6 mD (average of 5 mD), and pore throats are 1 to 3 um (average 2 um). This fabric can occur anywhere from the Middle Daly down to the Cruickshank Crinoidal.

Fabric D is very similar to C, but the crinoids are typically larger, leaving larger pore throats between the grains. The porosity range is narrow (8-12%, average of 10%), but the permeability ranger is higher (10 to 168 mD, average of 35 mD). Pore throats are larger as well, with capillary pressure data indicating 2 to 14 um in size, with an average of 4 um. This Fabric is most common in the Cruickshank Crinoidal, but can also occur in the overlying cycles up to the Middle Daly.

Although porosity ranges vary for some fabrics (e.g. compare Fabric A and D), the key reservoir attribute that will most likely impact fluid flow is permeability which in turn is controlled by pore throat size and distribution. In addition to depositional facies, diagenesis has played an important role in preserving and destroying reservoir quality. Dolomitization, cementation and replacement by anhydrite and silica are some of the examples that will be shown in this core display.

With the identification of Fabrics A to D, this information will be used to define the reservoir properties for the different “flow units” that will comprise the reservoir model for this pool. From this geocellular (static) model, an upscaled flow simulation (dynamic) model will be created. An iterative approach using history matching and reservoir modelling will help create a validated model that will assist with business decisions.

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References

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