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Characterization and Evaluation of Deltaic Sandstone Reservoirs of the Dunvegan Formation, Kaybob South

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Summary

Sandstones of the Cretaceous Dunvegan Formation within and around the Kaybob South Field are part of a legacy gas pool producing from a complex delta lobe. It is important to note that recently, oil production has also picked up in this area mainly with the implementation of horizontal wells. This presentation will investigate the complexities and variations of the Dunvegan from a geological perspective. Further, investigation will be undertaken on recent developments on a potential light oil play using horizontal drilling in the fine-grained deltaic sandstones of the Dunvegan.

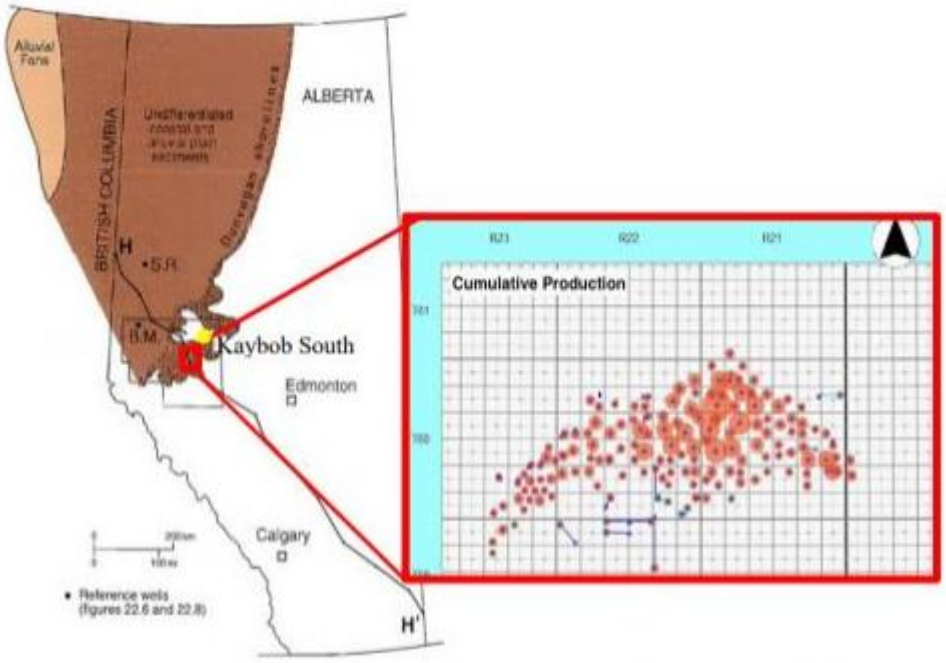

Figure 1. Adapted from Bhattacharya., 1994 – Kaybob gas pool is marked by the yellow dot. The pool of study is within the red box where a map of cumulative production is shown. Red production bubbles indicate this is a gas dominated pool.

Introduction

The Dunvegan Formation is a prolific gas producing unit in west-central Alberta. It was discovered in the 1950's and has recently received attention for its oil production in horizontal wells within and near the Kaybob South (Figure 1). The area of focus in this study is the southwest of the Kaybob South region (Figure 1). This region also exhibits oil production on the peripheries of the pool where horizontal wells are located. The Dunvegan is stratigraphically trapped with deltaic sands acting as reservoir. The Dunvegan delta itself contains highly river dominated deltas and transgressive sheet sands (Bhattacharya and Walker, 1991). Overall the Dunvegan can be described as an extensive, southeasterly thinning sandy clastic wedge of middle Cenomanian (lowermost Upper Cretaceous age) (Bhattacharya, 1994). The formation consists of interbedded mudstones, hummocky cross stratified sandstones and laminated mudstones. The Dunvegan Formation is overlain be shales of the Kaskapau Formation and underlain by shales from the Shaftesbury Formation.

Theory and/or Method

To gain knowledge of the Dunvegan Formation in the study area a variety of geologic tools were employed. This included the use of well cores to identify and observe potential reservoirs as well as calibrate API sand cut offs. Well logs in the study area were correlated using formation top picks on flooding surfaces. This was completed alongside examining production data from intervals of interest in the Dunvegan Formation.

In total, six cores were logged in the study consisting of 4 facies. This included a heavily bioturbated laminated mudstone, a fine to medium grained sandstone, a fine to very fine-grained sandstone and interbedded very fine-grained sandstone and claystone. The facies vary from well to well, with the described facies within the core then being correlated with gamma ray (GR), neutron/density and resistivity logs. Using the core analysis for each of the facies, cross plots of porosity and permeability were created. Using these cross plots, trends of each individual facies were analyzed to asses reservoir potential.

Several maps were created of facies, surfaces, reservoir properties were created. Further, a cut off of 90 and 75 API were used in this study. Isopach, structural, net reservoir, and net pay maps based on the surfaces were produced and contoured allowing a visual representation of the Dunvegan reservoir. Cross sections were also created to examine pool architecture. Maps created were then overlain with the cumulative and first 36-month production data of the study area to integrate the reservoir architecture and production trends to aid in our interpretation.

Examples

The Dunvegan succession is effectively shown by well 100/07-33-059-22W5M. There are three gas-saturated upward coarsening successions in-between the Shaftsbury Shale below and the Kaskapau Shale above. A gamma ray cut off of 75 API shown in Figure 1 highlights the most productive facies within the Dunvegan. Figure 2 shows a core taken from the lower coarsening upwards sequence, with the start of the middle coarsening upwards sequence near the top.

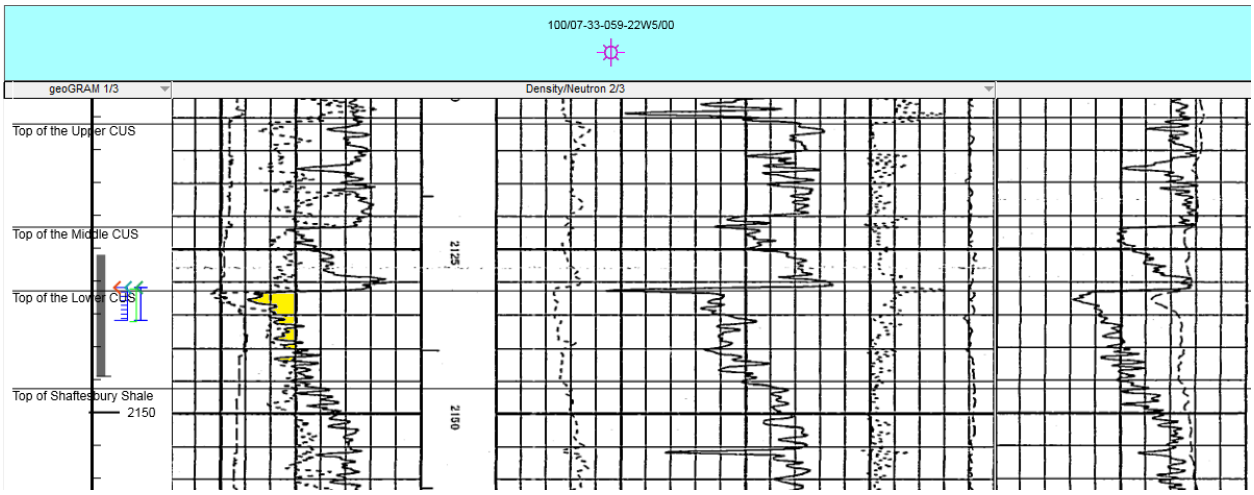

Figure 1: Core log taken from GeoScout highlighting the reservoir sand of the Dunvegan, lining up with the core seen in Figure 2.

The core is located and was studied at the Alberta Core Research Centre. The core was broken down into four observable facies, based on lithological characteristics. Facies 1 is the base of the Dunvegan 2 Coarsening Upwards Sequence and consists of heavily bioturbated laminated mudstone. Facies 2 is composed of fine to medium-grained sandstone, with a consistent presence of organic matter and rare clay interbeds. Facies 3 is a very fine to fine-grained sandstone with a greater abundance of organic matter and clay interbeds. Facies 4 is near the base of the lower Coarsening Upwards Sequence and composed primarily of very fine sand regularly interbedded with clay.

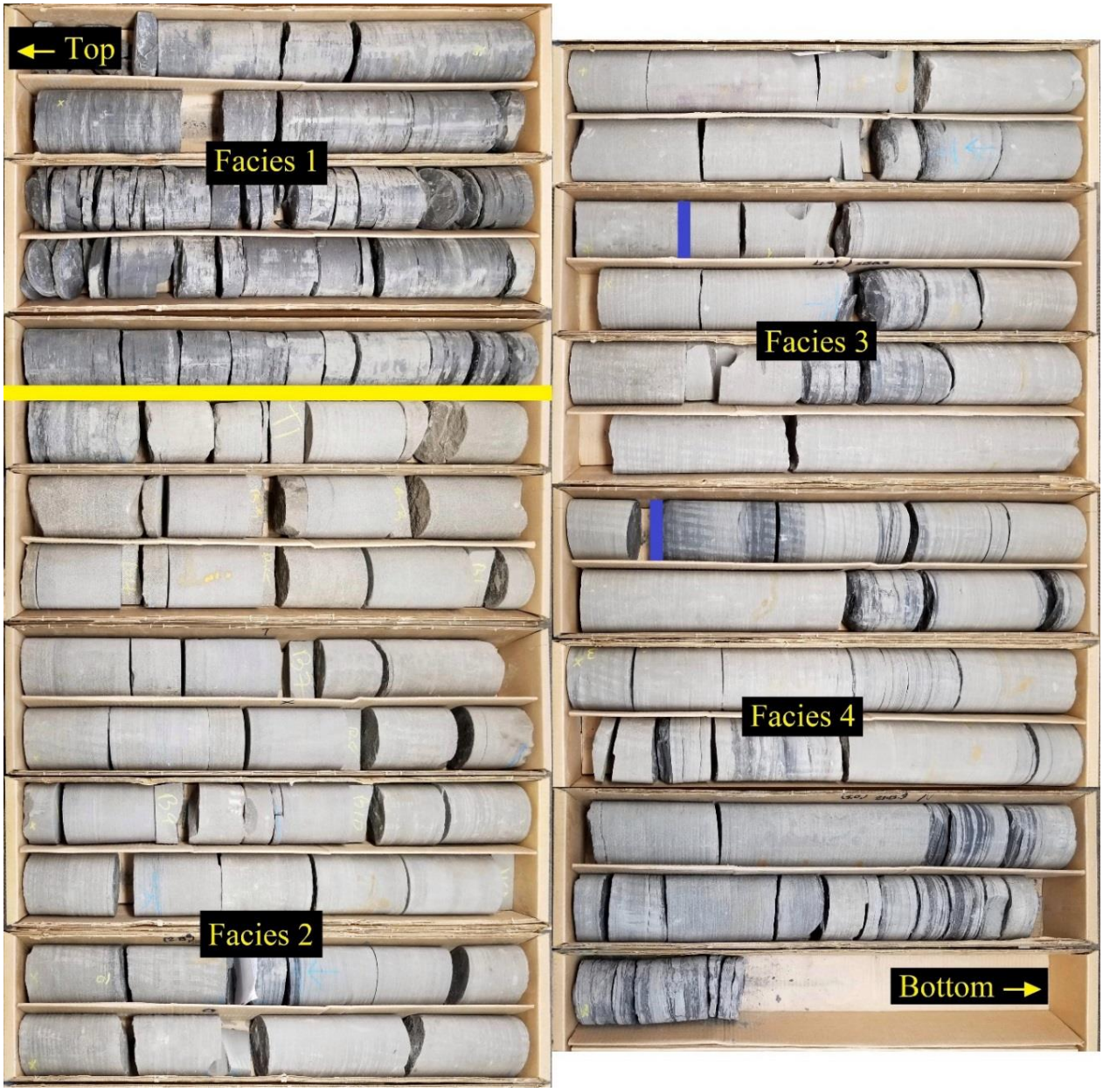

Figure 2: Core taken from 100/07-33-059-22W5/00 highlighting the clean sands of the lower Upper Coarsening Sequence of the Dunvegan. The boundary between Dunvegan 2 and Dunvegan 3 marked by a yellow line. Identified facies divided by blue lines.

Conclusions

Reservoir characterization and resource evaluation were completed in the Dunvegan Formation located in the Kaybob South Field which is located in township 60 and ranges 21-23.Through examination of the core, the Dunvegan Formation can be subdivided into 4 facies consisting of a heavily bioturbated laminated mudstone, a relatively clean fine to medium-grained sand with organic matter and rare clay, a very fine to fine-grained sandstone with a greater abundance of organic matter and clay interbeds and a very fine-grained sand with regular interbeds of clay. The depositional setting of this area is thought to be a deltaic system with the coarsening upward facies succession occurring as a result of prograding marginal marine and shallow marine depositional systems (Bhattacharya and Walker., 1991).

From the porosity and permeability cross plots there appears to be two main producing intervals which were the fine to medium grained sandstone (Facies 2) and the very fine to fine grained sandstone (Facies 3). Facies 2 consists of a clean sand which corresponds to a low gamma ray with this interval having an overall thickness of 7.4 meters. Facies 3 consists of a more clay and organic rich sand which is also more cemented which corresponds to a slightly higher response on the gamma ray with an overall thickness of 2.3 meters. Core analysis data was analyzed to determine the porosity and permeability of each reservoir unit. Facies 2 has a porosity of 14 to 20% and a permeability of about 10 mD. Facies 3 has a porosity of 8 to 12% and a permeability of about 5 mD. The petroleum system is capped by a mudstone unit which has low porosity and permeability thus preventing the migration of petroleum from the system perhaps acting as a seal.

Further investigation using production data is needed to estimate the original oil in place (OOIP) and determine the efficiency of enhanced oil recovery techniques such as horizontal multi-stage hydraulic fractured wells.

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