Factors Affecting Petroleum Fluid Compartmentalization in the Upper Cretaceous Chinook Formation, West-Central Alberta

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The Chinook Formation is late Cretaceous in age (83 Mya), and is a northwest- to southeast-trending, siliciclastic shoreface deposit located in west-central Alberta within T60-66, R05-11 W6. The Puskwaskau Formation is stratigraphically above the Chinook, while the Colorado Formation is stratigraphically below, both of which are marine shale. Although geologically coeval with the Chungo and Milk River Formations, the Chinook is a prolific producer of both oil and gas, while the Chungo to the southeast is barren and the Milk River's production occurs much farther south.

Chinook wells are relatively shallow (about 1500 – 2000 m below surface). Production exhibits as a linear trend, which splits about midway along its length into a main trend and a smaller, secondary trend separated by a streak of low or no production. Cumulative production in the Chinook is about 150 bcf and 3.5 mmbbl; initial production of a Chinook well is up to 3 mmcf/d, and a well may produce 3 bcf or more in its lifetime. The dilemma of why Chinook production occurs in 'pockets' along its trend is satisfied via a detailed geological investigation of the parameters influencing petroleum fluid segregation in the reservoir. The primary goal of this study is to determine the factors that control petroleum fluid compartmentalization in the Chinook, while secondary goals included determination of the reservoir's lithological and petrophysical trends, and structural attitude of the formation.

The study area includes 632 wells, 498 of which have well logs available for study and 232 of which are currently producing from the Chinook. Petrophysical data collected from these logs include subsea top of the Chinook, Puskwaskau and Colorado Formations, total metres of sand at 75 and 90 API on the gamma log, and total metres of pay at 9% and 12% on the density log. In the absence of a density log, a sonic log was used with cutoffs of 240 and 260 microseconds per metre, respectively. These data were used to create contour maps at 1:100 000 scale, including structural attitude of the Chinook subsea top (at a 20 m interval), gross sand and net porous sand (both at a 5 m interval). Correlation of production trends with the sand and pay maps determined that 75 API on the gamma log and 9% on the density log were appropriate reservoir-specific cutoff values for the Chinook.

Ten wells evenly spaced along the Chinook trend with various production capabilities were chosen for core analysis, and were measured, photographed and logged. Samples were taken from three of the cores for thin section analysis to determine lithological character, and cross sections along the main and secondary trends were prepared from the logs of the analyzed cores as well as a section perpendicular to trend strike, to determine depositional variation across the reservoir and confirm paleoenvironmental interpretation. Through correlation of the porosity and permeability data available from Accumap together with the core investigation, the location and lithological character of the reservoir was determined. Plotting of this data on a production basemap revealed that the reservoir location varied considerably along the trend.

Porosity and permeability data from the core analyses were also utilized in the calculation of petrophysical parameters of the Chinook, including pore throat size, Sw_{irr}, effective porosity, hydrocarbon concentration, reservoir quality index and free fluid index. These data were then statistically analyzed to determine the range, mode, mean and standard deviation, and relevant values were correlated with each well's geographical location to determine variance along trend. Data from oil-dominant wells were also compared to data from gas-dominant wells, to establish parameters responsible for fluid partiality.

The findings of these investigations were then utilized in an analysis of the depositional environment, diagenetic and deformational histories, which together led to the conclusions that petroleum fluid segregation in the Chinook reservoir is attributable to a combination of factors working in concert, including:

<u>Petrophysical Factors:</u>

- The most important parameter influencing petroleum fluid segregation in the Chinook reservoir is permeability. The range and distribution of permeability is a direct result of depositional, deformational and diagenetic factors that have affected the reservoir.

<u>Depositional Factors:</u>

- The reservoir occurs in the massive sand sequence near the top of the Chinook. As the sequence is not laid down over the region as a sheet, but rather in parcels, this naturally isolates the packages of sand (and therefore the reservoir).
- Northeast transport of coarse fluvial sediments from the Chungo/Brazeau south of the Chinook, together with fines removal and reworking by longshore drift, have resulted in porous, permeable packages of sand in the Chinook shorefaces.

<u>Diagenetic Ffactors:</u>

- Timing and mineralogical character of cementation agents have played a very important role in permeability distribution and resulting segregation of Chinook production. Semi-isolated parcels of sand (as described in Depositional factors) subjected to porosity-obliterating poikilotopic calcite or sideritic cementation, now act more as caprocks than as reservoirs.

<u>Deformational Factors:</u>

- Uneven folding has created increased permeability in some zones, while decreasing permeability in other zones. Compression has also resulted in episodic zones of very poor permeability, resulting in poor communication between reservoirs.