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Application of Automated Quantitative Sequence Stratigraphy – Triassic Montney Formation, Fort St. John Graben Area, Canada

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Introduction

Sequence stratigraphy is a powerful method to assist in the understanding of sedimentary record. It provides a picture of a basins' sedimentary architecture within the geological timelines at different scale. Sequence stratigraphic model is based on relative sea level, accomodation space and sedimentary influx variations.

We have developed a multi-scale automated sequence stratigraphy workflow for interpreting well log data. This workflow automatically identifies sequence stratigraphic surfaces, including sequence boundaries and maximum flooding surfaces, for large datasets. By using this automated approach, the evaluation and creation of sequence stratigraphic frameworks can be accomplished without manually interpreting each well. This not only speeds up the process and improves accuracy but also facilitates the handling and understanding of big data. The workflow has been successfully tested on the Triassic Montney deposition in the Fort St. John Graben area of Western Canada Sedimentary Basin (WCSB).

Methodology

Implementation of the automatic sequence stratigraphic workflow requires several steps. We start with the creation of a digital well log database. Next, all logs are re-sampled, normalized, and volume of shale (Vsh) curves are generated automatically. Then, reference wells, which are representative of a large number of wells, are identified. The chronostratigraphic tops are picked for these reference wells. Using the reference wells, chronostratigraphic tops are picked automatically for the rest of the wells using a combination of multi-window autocorrelation, and neural networks. Following the method introduced by Ainsworth (2018), called the "QSS method," sequence stratigraphic surfaces are automatically identified and added to each well, and automated sequence stratigraphic cross-sections are built. The automation produces 5th-order parasequence sequence stratigraphic boundaries, which can be automatically upgraded to the 4th and 3rd orders through mathematical interpretation of cyclic changes. All stages of the automatic sequence stratigraphic workflow are explained through its application to the Montney Formation.

Results

The Montney Fm. of WCSB is one of the leading gas-condensate resource play in North America and has been one of the most productive unconventional reservoirs in western Canada since 2010. It spans a large continuous area of the WSCB and is characterized by varied stratigraphic and structural frameworks, depositional processes, and hydrocarbon fluid generation and migration. Numerous publications dealing with the sequence stratigraphy are available to compare with our results.

We have used 280 vertical wells in this study covering 800 sq km (20 x 40 km) of area. The well log database was created, resampled, smoothed and converted to Vsh logs automatically. One reference well is chosen for each 100 sq km representing nearly 50 wells in its vicinity. The tops, with ages assigned, are picked through the automation process. Also, sequence stratigraphic surfaces (sequence boundaries and maximum flooding surfaces) were identified automatically on all wells with the identification of ranking of sequence stratigraphic surfaces (from 5th order to 3rd order).

The Montney Fm. records deposition from the latest Permian to the Mid-Triassic. It consists of two global stages (Induan and Olenekian) which may be subdivided into four regional substages Griesbachian, Dienerian, Smithian and Spathian. Basinwide unconformities occur roughly synchronous with the boundaries between the Dienerian and Smithian and between the Smithian and Spathian providing the basis for the three-fold subdivision of the Montney Formation into basinwide Lower (Griesbachian-Dienerian), Middle (Smithian) and Upper (Spathian) members (Zonneveld, 2018).

These listed sequences stratigraphic division can be seen to coincide with interfaces derived from QSS technique automatically. The sequence stratigraphic surfaces obtained through the QSS technique coincide well with the ones described by researchers. The figure above shows reference well, from left to right, assigned age, calculated Vsh curve, picked tops, T-R sequences (triangles) and QSS curves (5th, 4th and 3rd order sequences), all are automatically identified and assigned. Maximum value of QSS curve shows flooding surfaces and minimum shows sequence boundaries of different orders.

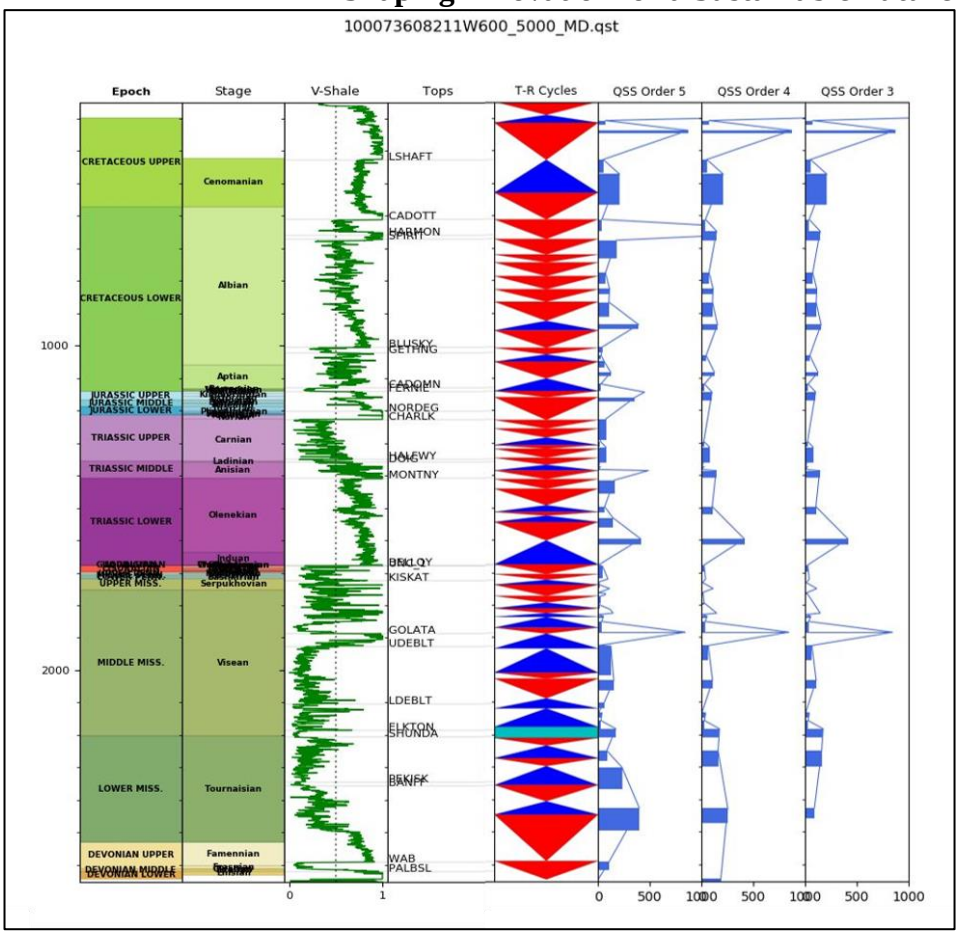

Fig. 1 Processed reference well from let to right: automatically assigned age scaled by rate of deposition, tops, T-R triangles, sequence strat surfaces (Sb and MFS), ranking (from 5th order to 3rd order)

Conclusions

The stratigraphic architecture of the Montney Fm. in Fort St. John graben area is examined and interpreted within sequence stratigraphic context using an automatic method of identifying sequence stratigraphic surfaces and upgrading them from 5th order to the 3rd order. This allows for the fast and accurate identification of sequence stratigraphic surfaces for large datasets. By applying this method one can quickly map large area for the average Vsh trends within each parasequence and can separate the areas with high quartz containing siltstone trends as well as presence of turbidites.

KEYWORDS: automatic sequence stratigraphy.

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