# Reservoir Characterization of the Cardium Formation in the Carrot Creek Area

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The Cardium Formation in the Carrot Creek area (off the NW tip of the Pembina Pool) has been the subject of increasing interest in the last few years as horizontal drilling and completion technology continues to improve. The lower permeability sandstone reservoir facies, which until recently has been bypassed, has become more economically viable due to new horizontal drilling and hydraulic fracturing techniques. This study focuses on Township 52, Range 13 west of the 5$^{th}$ meridian. Here, the Cardium Formation is composed of conglomerates, sandstones, interbedded sandstones and shales, and mudstones/shales. The well-described Carrot Creek conglomerate lobes are the focus of almost all prior research in the area, including the work by Bergman and Walker (1986 and 1987). Characterization of the lower sandstone part of the reservoir is incomplete, as it was formerly not of economic interest.

This research explores the relationships between and the geometry of the non-conglomeratic reservoir facies in the Carrot Creek area. Facies of particular interest include the bioturbated shales, tabular-bedded sandstones, and interbedded shales and sandstones. Incorporating detailed facies descriptions with sequence stratigraphic correlations has allowed for a better understanding of facies distributions within the study area and, in turn, a better three-dimensional construction of a reservoir model.

Through analysis of lithology, bedforms and grain size, as well as bioturbation intensity and diversity, six distinct facies have been determined. These facies were then used to correlate well logs throughout the area via cross sections and the use of sequence stratigraphic principles. Mapping using geophysical well logs, detailed core logging and petrographic analysis assisted in the identification and delineation of the stratigraphic framework of the stacked shoreface facies and facies associations.

There are varying degrees of bioturbation in the different facies of this shallow marine sequence. Within intensely bioturbated sections it is sometimes difficult to identify basic sedimentological features such as bedforms and facies contacts. Facies 1 is an intensely bioturbated, black to dark grey shale and siltstone. It commonly has a sand content of less than 10%, with certain areas in the upper section of the facies ranging between 20% and 30%. In areas of higher sand content, the silty/sandy lenses have sharp erosive bases and varying types of internal lamination. Facies 2 consists of interbedded bioturbated shales and very fine-grained sandstones. This facies has greater than 30% shale content and is heavily bioturbated. The bioturbation seen in Facies 2 is similar to that in Facies 1. There are

multiple preserved sedimentary structures within the sandstones in this facies. Facies 3 is comprised of interbedded shale and fine-grained sandstone. The degree of bioturbation in this facies is low compared to Facies 2. The bioturbation that is present is concentrated in and around the shale lenses. The primary bedding structures are well preserved. Facies 4 has the highest sand content and is the main reservoir target for horizontal wells adjacent to the Carrot Creek oil pools. This facies has little bioturbation and well-preserved bedding structures. Facies 5 is a transgressive lag deposit that overlies an erosional surface on top of Facies 4. It is composed mainly of pebble-sized chert grains and ranges in thickness from a thin veneer to 19 m. Facies 6 is a black, organic-rich, massive, laminated, fissile shale. It is interpreted to be a transgressive marine shale.

The typical stratigraphic profile is coarsening upwards from mud/shale facies to interbedded mud and sand to sandier facies at the top of the sequence. There is a localized conglomerate overlying the transgressive erosive surface above the upper sand body. Cross sections reveal that there are multiple inter-fingerings of facies as the Cardium shoreline progrades into the Cretaceous Western Interior Seaway. Understanding these stratigraphic sequences is key to determining proper horizontal well placement, as lateral variation of the facies will affect both hydrocarbon storage and drainage. The results of this study suggest that more accurate predictions of lateral facies occurrences are possible and that delineation of prospective unconventional reservoir fairways can be a reality.

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#### References

Bergman, K.M. and Walker, R.G. 1986. Cardium Formation conglomerates at Carrot Creek Field: offshore linear ridges or shoreface deposits. Modern and Ancient Shelf Clastics, v. 9, p. 217-268.

Bergman, K.M. and Walker, R.G. 1987. The importance of sea-level fluctuations in the formation of linear conglomerate bodies; Carrot Creek Member of Cardium Formation, Cretaceous Western Interior Seaway, Alberta, Canada. Journal of Sedimentary Petrology, v. 57, p. 651-665.