Controls on facies distributions in the Charlie Lake Formation, Peace River Arch, Alberta

E.L. Percy¹², C. Frostad², A. Juska², C. Schmidt², C. Sitzler², and J.P. Zonneveld³
University of Calgary, Tourmaline Oil Corp, University of Alberta

Summary

The Triassic marks a transition from a passive margin to a foreland basin setting in Western Canada, resulting in the transition from carbonate-dominated deposits of the Paleozoic to clastic-dominated successions in the Mesozoic (e.g., Ferri and Zonneveld, 2008; Beranek and Mortensen, 2007; 2011; Zonneveld and Moslow, in press). The sediments of the Upper Triassic Charlie Lake Formation record a portion of this important structural and paleogeographic transition, and host significant volumes of hydrocarbons. Despite the geologic and economic importance of this formation, it is underrepresented in the geologic literature and is arguably one of the least understood intervals in Western Canadian Sedimentary Basin. This study aims to describe and map the distributions of lithofacies in the Charlie Lake Formation in the Peace River Arch area to understand how this succession was accumulated.

Introduction and Study Area

The Upper Triassic Charlie Lake Formation is a complex heterolithic succession dominated by sabkha-style deposits (Arnold, 1994) deposited during an interval of global aridity, resulting in an unusual mixture of siliciclastic, carbonate and evaporite rocks (Zonneveld et al., 2001). The Charlie Lake Formation was deposited along the western margin of the North American craton, with the thickest accumulation occurring in the vicinity of the collapsed Peace River Arch (Davies, 1997). The Peace River Arch area is characterized by southwest and northeast striking normal faults that formed during the Precambrian to Carboniferous and were reactivated during Triassic sedimentation (Davies, 1997). Recent research suggests that the Western Canadian Foreland Basin started to form during the Triassic, rather than in the Early Jurassic (Unterschutz et al., 2002; Ferri and Zonneveld, 2008; Beranek and Mortensen, 2011; Golding et al., 2016a; Golding et al., 2016b; Rohais et al., 2016). The onset of compression in the fold and thrust belt resulted in significant angular unconformities (such as the Coplin Unconformity), as well as syn- and post-depositional controls on facies and pay distributions within the strata of the Charlie Lake Formation in the Peace River Arch area.
The study area for the present project covers the Peace River Arch (PRA) area within Alberta. In this study well logs, 3D seismic, and core descriptions were integrated to understand the stratigraphic architecture and depositional model of the Charlie Lake for the study area.

**Results and Interpretations**

The Charlie Lake in the study area is divided into an upper unit, a Middle Boundary Lake unit, and a lower unit for this study. The top of the lower unit is marked by the Coplin unconformity. This angular unconformity overlies strata that dips significantly westward due to post depositional uplift of the North American craton. The lower unit is composed of three members dominated by sabkha style deposits of dolomitic algal mats, red beds, and anhydrite. Significant vertical and lateral facies heterogeneity occur within the lower unit. The Middle Unit (the Boundary Lake Member) occurs between the Coplin and Boundary Lake unconformities; however, this unit was outside the scope of the present study and is not further discussed. The upper unit overlies the Boundary Lake unconformity and consists of alternating clastic-dominated members and members composed of sabkha deposits (Figure 1). The top of the upper unit is truncated by the Worsley unconformity, or by the base of the Baldonnel Formation in some areas. The clastic members are composed of relatively uniform distributions of dolomitic silt- and sandstone beds deposited in tidal flat/tidal channel environments. The members dominated by sabkha deposits are composed of similar facies as the lower unit. Members within the upper unit are erosionally truncated by unconformities towards the eastern erosional edge of the Charlie Lake Formation.

Controls on the distribution of reservoir-quality lithologies (i.e. pay distribution) are dominated by two factors: the lateral distribution and thicknesses of reservoir facies within syn-depositional fault-basins; and secondary dissolution caused by post-depositional erosion. The control on reservoir facies distribution differs for members dominated by sabkha deposits versus those dominated by clastic lithologies. The distribution of dolomitic stromatolites and anhydrite within the sabkha deposits correlate with reactivated Mississippian aged faults identified through seismic and residual maps. During deposition of the sabkha lithologies subtle topographic relief, caused by the uplift and down-dropping of basement blocks, resulted in syn-depositional control on the distribution of pay and non-pay lithologies. For the clastic members, pay coincides with the updip erosional edge of each member indicating post-depositional porosity enhancement due to secondary dissolution.

**Conclusions**

The onset of compressional tectonics during the Upper Triassic had a significant influence on facies distributions, as well as on syn-depositional and post-depositional erosion of the various members of the Charlie Lake Formation. Controls on reservoir distribution within the Charlie Lake Formation depend on the lithology of each member. Clastic members are more homogenous allowing for post-depositional porosity enhancement due to groundwater dissolution where they are overlain by subaerial unconformities whereas syn-depositional structural control dominated reservoir distribution in sabkha-style units.
References


Rohais, S., V. Crombez, T. Euzen, and F. Baudin, 2016, The Lower and Middle Triassic of Western Canada: passive margin, back-arc, or fore-arc geodynamic setting?, Geoconvention abstract, Calgary CA, March 7-11.


Figure 1: Described core and corresponding logs for part of the upper Charlie Lake Formation. The lithology alternates between dolomitic and anhydrite-bearing stromatolite shallow subtidal/sabkha facies, and siliciclastic intertidal facies.