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Belly River Channel Architecture Reservoir Analog – Ghost Dam, Cochrane, Alberta.

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Summary

The Belly River Formation forms a clastic wedge deposited in the Late Cretaceous adjacent to the Canadian Cordillera. The Belly River Formation is a continental succession of clastic sediments shed from the rising cordillera. The formation is interpreted as an alluvial plain with varying fluvial styles (Putnam, 1993). This research focuses on an outcrop located at the Ghost Dam, Cochrane, Alberta to study the channel geometries as well as the fluvial architecture of the Belly River Formation. High resolution GPS data from the outcrop was used to create a 3D facies model within Petrel which can later be used to model fluid flow in Belly River fluvial reservoirs. The widths and thicknesses of the channels seen in outcrop were compared to the predicted channel geometries seen in the subsurface east of Calgary, approximately 100km east of the outcrop, Figure 1.

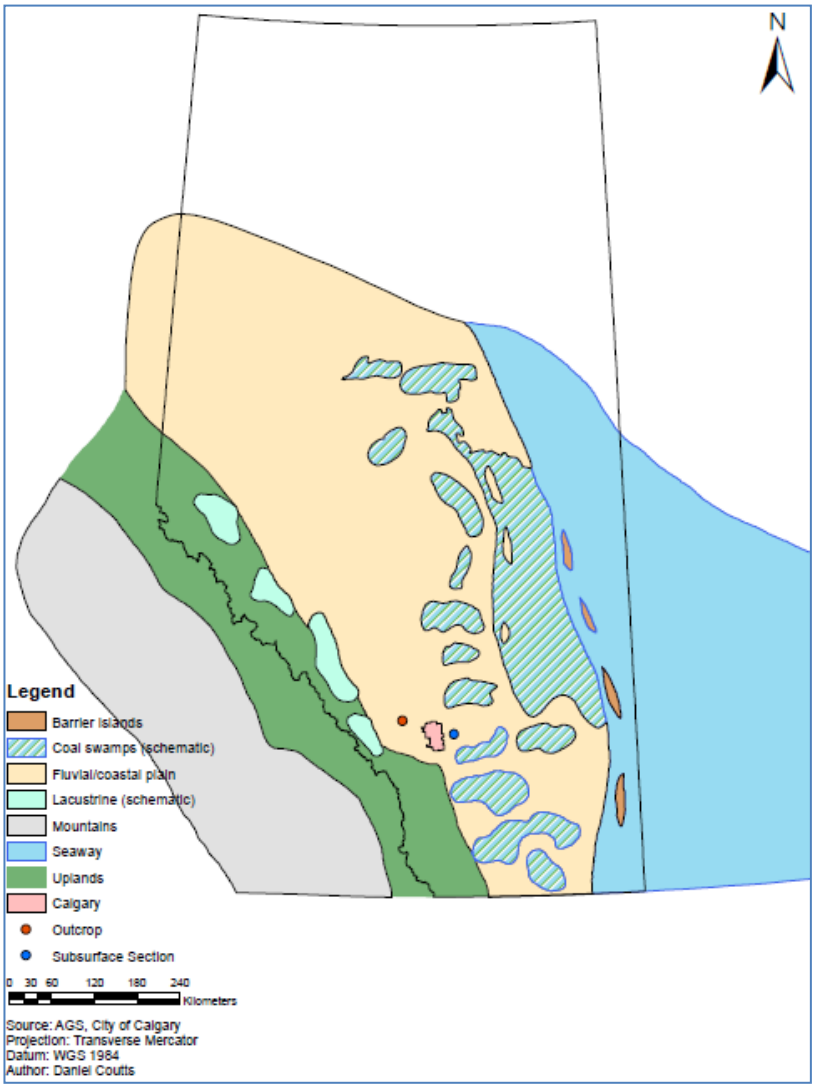

Figure 1 - Paleogeographic map of the Upper Cretaceous Belly River Formation. The location of the outcrop is marked in red and the location of the subsurface section is marked in blue. Modified from AGS, 2008.

Introduction

During late stages of the cordilleran orogeny sediments shed from the rising cordillera were deposited in the inland sea during the Late Cretaceous, Campanian. The basal contact of the Belly River Formation lies conformably on the Lea Park shale. The upper boundary of the Belly River is a transgressive boundary with the Bearpaw shale. The formation is interpreted to be deposited in a low lying alluvial plain. Proximal to the sediment source the fluvial system is interpreted to be an anastomosing system where more distal to the

sediment source the fluvial style transitions to a meandering system (Putnam, 1993). Both channel and shoreline sandstone deposits in the Belly River Formation are conventional reservoir targets for both oil and gas across Alberta.

Discussion

Lithofacies

Three lithofacies were identified in the Ghost Dam outcrop. They consist of channel deposits, proximal over bank deposits, and distal over bank deposits. Channel deposits are characterized by fine grain sand, cm sized clay rip up clasts and large pebbles, as well as 10cm sized woody debris lodged within the channel deposits. Channel deposits had little organic debris compared to the over bank deposits. Channel deposits are very well cemented and exhibited cross trough bedding and tabular cross bedding. Four channels were studied in detail at the outcrop. Proximal over bank deposits are characterized by grain sizes in the very fine sand grain size to silt range, however silt composes the majority. Proximal over bank deposits show high abundance of organic material. Single over bank deposits are 10-30cm thick, however thicker over bank complexes are seen, constructed of multiple single sheets interbedded with distal over bank deposits. These complexes are up to 10m in thickness. Proximal over bank deposits exhibit cm-scale parallel laminations as well as climbing ripples. The distal over bank deposits are characterized by a grain sizes in clay-silt range. They consist of largest abundances of organic materials, cm scale coal lenses and root traces. These deposits are not well cemented. Figure 2 shows the location of stratigraphic sections as well as coloured lithofacies.

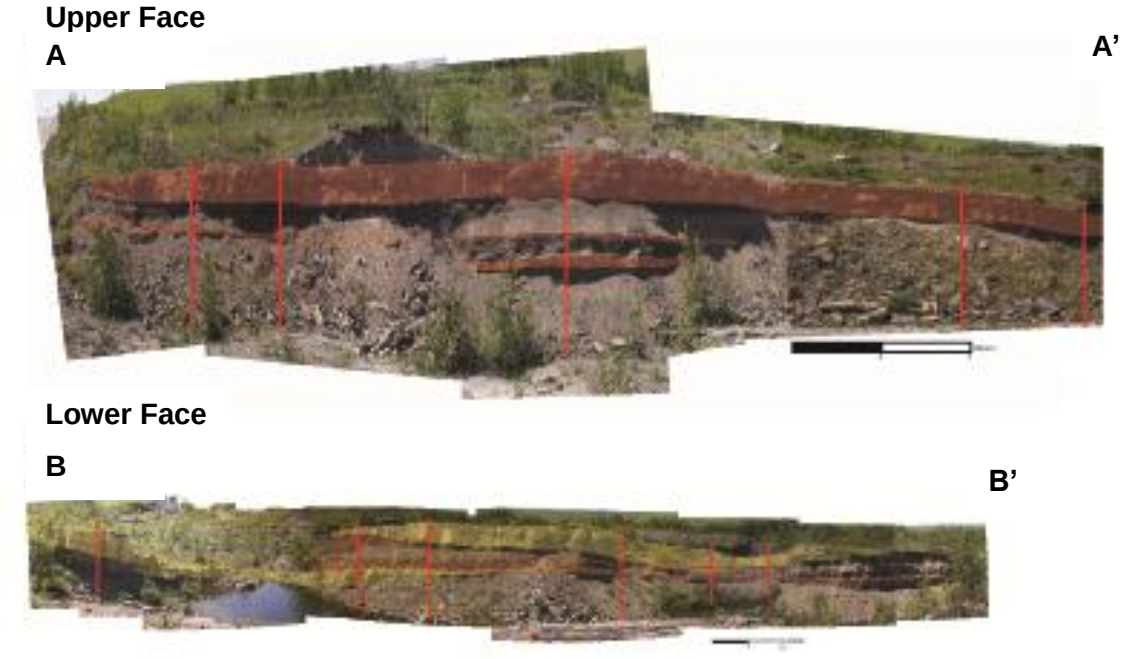

Figure 2 -Panoramic photos of the Ghost Dam outcrop. Channels are shaded in yellow, proximal over bank deposits are shaded in orange, and distal over bank deposits are not coloured. Channels 1 and 3 are not shown.

Channel Dimensions and Connectivity

Channels at the Ghost Dam outcrop are non-amalgamated showing very little multi-story incision. Channels 3 and 4 are partially overlapping due to flow direction however they do not seem to be formed as a single channel. Single channels offer a single gas reservoir within the channel boundaries. A channel which has partially incised into another channel offers the possibility to produce hydrocarbons from both channels. The true widths of the channels, channel width taken perpendicular to paleoflow,

were 32m, 88m, and 174m, for channel 2, channel 3 and channel 4 respectively. The south channel margin of channel 1 is not exposed in outcrop so a true width could not be obtained.

Splay dimensions

Proximal over bank deposits were observed to be spatially continuous at the Ghost Dam outcrop. Many splays continued into covered areas where they could not be measured. As mentioned above single splay sheets were measured up to 30cm in thickness, however multiple splays interbedded with thin (less than 10cm thick) distal over bank deposits which ranged from 2m to 10m in thickness. Splays offer a fluid migration pathway which is spatially continuous across the width of the outcrop,300m. Splays are bounded by a channel on one side however if the splay is incised later they can act as a low permeability migration pathways for hydrocarbons between two channels. The effectiveness of the splays as a migration pathway has yet to be determined by the Petrel model created through this research. This migration process can offer a reason as to why some channels can produce at high rates initially but then at low rates for a long length of time thereafter, where as others produce rapidly with no extended low production rate period.

Depositional Setting

The Belly River Formation is interpreted as an anastomosing river system proximal to the cordillera and a meandering fluvial system distally, towards the inland sea (Putnam, 1993). The anastomosing river system interpretation is supporting the study area location (proximal to the cordillera). High abundance of organics as well as root traces and lenses of coals in the distal over bank deposits indicate vegetated channel banks. The channels show no inclined heterolithic strata. This is most likely due to a less sinuous channel, which agrees with the anastomosing model. Palynology conducted on the distal over bank deposits show a distinct marine influence. This indicates a depositional environment of a wet coastal plain which is proximal to the inland sea where the waters are more brackish. The waters occupying the area outside the channels would be considered more brackish and have marine influence.

Facies Model

The facies model was constructed in Petrel through use of high resolution GPS data points taken at the outcrop. Points were taken across the top and bottom surfaces of channels and splays seen in the outcrop. Fluvial channels were extended up to 200m along the channel axis in the direction of paleoflow. The channels were extended in a straight line due to the low sinuosity of anastomosing rivers (Makaske, 2001). The true widths of the channels were measured perpendicular to the paleoflow seen at the outcrop. Proximal over bank deposits were extended to the boundaries of the model due to laterally extensive nature seen in outcrop. This model will be used to evaluate how over bank splay deposits can be used as migration pathways for hydrocarbons between channels. The addition of petrophysical data as well as the programming and completion of this model is outside the scope of this project.

Subsurface Correlation

The outcrop at the Ghost Dam is compared to a subsurface section located east of Calgary. Channel thickness and depths found at the outcrop are comparable in thicknesses, and channel connectivity based various well spacing found in the subsurface area. This study area has well spacings of in the range of 215-300m.

Conclusions

This research compares the channel morphology and overall architecture of the system of an outcrop at the Ghost Dam, Cochrane, Alberta to the morphology seen in a subsurface section seen east of

Calgary, approximately 100km from the outcrop. The use of high resolution GPS allowed for better visualization of the architecture and interconnectivity of channel and over bank deposits. This allows for better understanding of fluid flow in costal deposits.

Acknowledgements

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References

Dawson, F.M., Evans, C.G., Marsh, R., Richardson, R., 1994, Uppermost Cretaceous and Tertiary Strata of the Western Canada Sedimentary Basin, G.D. Mossop and I. Shetsen (comp.), Canadian Society of Petroleum Geologists and Alberta Research Council, URL <http://www.ags.gov.ab.ca/publications/wcsb_atlas/atlas.html>, [December 26, 2012].

Dawson, F.M., Evans, C.G., Marsh, R., Richardson, R., 2008, Schematic Lower Belly River (Foremost) Paleogeography (GIS data, polygon features), Alberta Geological Survey, Digital Data 2008-0284.

Haywick, D.W., 1982, Sedimentology of the Wapiabi-Belly River Transition and the Belly River Formation (Upper Cretaceous) Near Ghost Dam, Alberta, McMaster University – Department of Geology.

Makaske, B., 2001, Anastomosing rivers: a review of their classification, origin and sedimentary products: Earth-Science Reviews, 54(2-3),149-196.

Putnam, P.E., 1993, A multidisciplinary analysis of Belly River-Brazeau (Campanian) fluvial channel reservoirs in west-central Alberta, Canada: Bulletin of Canadian Petroleum Geology, 41(2), 186-217.