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High Resolution Sedimentology of the Upper Jurassic Nikanassin Formation, in the Grande Cache Area of Alberta

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Summary

Several excellent outcrops of the Upper Jurassic Nikanassin Formation can be examined along Highway 40, close to Grande Cache. Two outcrops exposed within the Stearn Anticline allow the chance to compare and contrast a dominantly braided portion of the Nikanassin with a clearly meandering portion of the same Formation. The close proximity of the outcrops allows the chance to compare two strikingly different fluvial depositional settings, and to draw conclusions on how and more importantly why these differences occur. The larger scale bedforms of the braided section are interpreted as downstream accreting macroforms, in contrast to the lateral accretion surfaces of the meandering system. The proportions of the fluvial channel and crevasse splay lithofacies components are also very different. Diagnostic criteria are developed for the two depositional settings, and interpretations are put forward to explain why these differences occur, and their potential impact on sand distribution.

Introduction

Sedimentological analysis of ancient fluvial deposits is hardly new. However the fieldwork undertaken during this study, close to Grande Cache, utilized high resolution logging and photo mosaic interpretation to build up a highly detailed picture of the sedimentary architecture of two contrasting fluvial depositional settings, in close stratigraphic proximity. The results could be used to investigate the net:gross; stacking patterns; the contrasting proportions of lithofacies; and diagnostic criteria of each setting. They could also be used to interpret the environments of deposition in minutiae, and to consider the impact on sand distribution laterally and vertically.

The two fluvial intervals form part of the Upper Jurassic Nikanassin Formation, which was sourced from the rising cordillera to the West. It conformably overlies the mainly marine Fernie Formation, and is capped

by a regional unconformity though to represent as much as 27 million years (Leckie and Smith 1992). The Nikanassin is dominated by flood plain deposits in the west grading to shoreline and estuarine sandstones near its eastern erosional limit.

Logging methodology

Two outcrops were logged at a high resolution during this study. It is clear that the two outcrops, despite their close proximity, are from different portions of the Nikanassin Formation, with the meandering portion almost certainly younger than the braided portion. Classic sedimentological logging at a centimeter scale was reinforced by high resolution photo mosaic interpretation. In the case of the subhorizontally dipping braided succession, five vertical sections were measured at 50 metre intervals along the outcrop.

A single high resolution section was measured along the steeply dipping meandering section, and a photo mosaic interpreted to highlight the gross depositional character of the beds. The high dip meant that it was not practical to measure more than one section along this outcrop.

Examples

The logged section through an interpreted braided portion of the Nikanassin is exposed in a flat, crestal portion of the anticlinal structure. It comprises thin, 50 to 150 cm thick, trough cross-bedded sandstone beds, interbedded with equivalent thicknesses of mudstones, often with thin but laterally extensive crevasse splay deposits. What is striking about this outcrop is the exceptional development and delineation of downstream accreting macroforms (DAMs), which are interpreted as bars migrating in a downstream direction. Detailed logging and photo mosaic interpretation have allowed these to be mapped out across 300 m of continuous outcrop. The crevasse splays, which rarely exceed a few centimetres in thickness, also feature small troughs, and are capped by current ripples.

In contrast the logged section through the interpreted meandering deposits, exposed in the forelimb of the same anticline, is dominated by crevasse splay deposits up to at least a metre in thickness. These beds are made up exclusively of climbing ripples. The meandering channel deposits, with well developed lateral accretion surfaces (LAS), make up less than 10% of the outcrop. Channel sandstone beds are typically 1 to 4 m in thickness. There are subsidiary lithofacies including coals and potential deltaic sandstone beds, indicating possible changes in relative sea level in a paralic setting. The coals appear to take up a significant proportion of the structural deformation, and are extensively cleaved.

Conclusions

It is clear that the two outcrops, despite their close proximity, are from different portions of the Nikanassin Formation. There is a striking contrast in depositional character, with the braided fluvial deposits comprising a relatively high net:gross system that can be characterized as thicker trough cross-bedded sandstone beds interbedded with thinner mudstones. Occasionally the mudstones are themselves thinly interbedded with very fine grained, low angle trough cross-bedded, sandstones beds with current rippled tops, interpreted as crevasse splays. In contrast the meandering deposits are a low net:gross system dominated by silty crevasse splay beds, which were deposited rapidly and may indicate significant changes in discharge. Channels make up less than 10% of the section, and are characterized by well developed

lateral accretion surfaces. Subsidiary lithofacies include coals, which may prove a significant source rock in the subsurface.

The very detailed logging of the two outcrops demonstrates an enormous contrast in depositional style and preservation, which is interpreted to relate primarily to the distance from the shoreline and consequent changes in gradient. The braided river deposits are extremely sheet-like in character, suggesting a wide, low relief, braid plain with high energy channels running across it. The gradient is thought to be relatively high, indicating a distal setting, at a considerable distance from the palaeo-shoreline. In contrast the meandering deposits are interpreted to have a much lower gradient, probably proximal to the coastline, with relatively few channels crossing a low relief, very low gradient floodplain. Frequent flooding, represented by abundant crevasse splays, suggests flashy discharge. Without doubt the amount of accommodation space also played a role in the preservation (meandering portion) or erosion (braided portion) of associated overbank deposits.

The proportion of sand is significantly higher in the braided fluvial deposits, although the thin mudstone beds are typically laterally persistent, acting as barriers to vertical flow. The sandstone beds are very laterally persistent over the span of the measured section. The channel deposits make up only a small proportion of the section of the meandering deposits, although there is potential for a least a portion of the siltstones to act as reservoirs in the presence of fractures.

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References

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