Integration geoConvention 2013 geoscience engineering partnership

Using Recent Point Bar Deposits in the Meander Belt of the Liard River, NWT to Aid in the Understanding of Reservoir Geometry in McMurray Formation Valley Fills in the Athabasca Basin

Jason M. Lavigne*, Canadian Natural Resources Limited, Suite 2500, 855 – 2nd Street SW, Calgary, AB, T2P 4J8
Email: jason.lavigne@cnrl.com

and

Derald G. Smith, 31064 Woodland Close NW, Calgary, AB, T3R 1G5, and Department of Geography, University of Calgary, Calgary, AB, T2N 1N4, Canada, Email: dgsmit@ucalgary.ca

Introduction

Traditional facies models for meandering river and tidally influenced estuarine channels consist of a fining-upwards succession of clean sand and gravel deposits (channel thalweg) that pass vertically though muddying-upwards lateral accretion deposits (point bar) that gradationally pass into low angle mudstone deposits (channel abandonment).

While this model has extensive applicability for individual channel bodies, caution must be exercised when applying the model to the fills of deep, narrow incised valleys. These fills are abundant in the McMurray Formation in the southern part of the Athabasca Basin and constitute hydrocarbon reservoirs actively being developed with SAGD recovery techniques.

Liard River, Northwest Territories

Many Recent river valley deposits, such as the Liard River in the Northwest Territories, contain fills that are comprised of coarser-grained, higher-gradient colluvium deposits at the base of the valley that are sharply (and locally, erosively) overlain by lower-gradient meander belt deposits comprised largely of Inclined Strata (IS) and Inclined Heterolithic Strata (IHS) of point bar origin.

When stacked vertically, these two facies belts, while appearing to conform to the archetypical fining upwards facies model, are completely unrelated and do not merely represent the gradual abandonment of a single channel. Rather, they are two sedimentologically distinct units that represent different phases and styles of valley fill deposition. Individual phases are separated by a mappable surface. The upper meander belt unit is characterized by numerous point bar and oxbow fill deposits.

IHS characterizes the point bar units. They form during waning seasonal flooding of the river and consist of a basal highly aggradational rippled unit (peak flood), which passes vertically into a ripple cross-laminated unit with abundant organic detritus (waning flow). The cycles are capped by dark mud beds with numerous silt laminae. This represents stagnant water in the post flood period. These three facies, corresponding to one years annual flood cycle, represents about 3 months of deposition. Thickness of individual mud laminae varies from several cm to several dm, with mud beds generally thickening upwards.

IHS sets often show a pronounced muddying upwards profile. The dips of the beds range from 8-12 degrees and show a decrease in dip upwards. These deposits conform to published models for abandoned channel fills. Muddy oxbow fills are on the order of 1/3 the thickness of the entire point bar succession.

McMurray Formation, NE Alberta

Ancient deposits of parts of the Lower Cretaceous McMurray Formation in the Athabasca Basin show a similar vertical succession of facies. In some Incised Valley fills that hang from within the Upper McMurray, clean sand deposits on the order of 25m thick are overlain by a meander belt unit on the order of 15m thick which is comprised of several distinct point bar units, occasionally separated by muddy abandonment fills.

While 40m thick channel-point bar units have been documented in the McMurray Formation, they occur in more northern parts of the basin in areas where channels and point bars are relatively unconfined by valley walls. To the South, many of these units are confined within very narrow “smaller” Incised Valleys that are on the order of 1.6km wide. Spatially, it is harder to place such large channel features into such narrow valleys.

The increasing use of micro-resistivity image logs in well bores has allowed for the differentiation of subsurface sedimentary bodies and allowed for the interpretation of paleoflow direction and depositional trajectories of point bar units. High well density, coupled with extensive core and supplemented with image logs allows for the detailed interpretation of the valley fill deposits.

In a typical valley fill the primary reservoir unit consists of 20-25m of high angle cross-bedded sandstones corresponding vertically aggraded 2D dunes (dips up to 25^0) that are oriented parallel to the valley. Above a sharp break, about 15m of lateral accretion beds (dips between 8-12^0) are oriented perpendicular to the valley walls. This break corresponds to the erosive base of the meander belt that constitutes a separate fill phase of the valley. Upper McMurray marine deposits transgressively overlie the meander belt.

IHS beds in the meander belt are characterized by light bioturbation, predominantly monospecific assemblages of *Cylindrichnus*. They display a muddying upwards character and mud-rich oxbow fills are present. Individual mud beds vary from dm to several dm in thickness.

Conclusions

Despite appearing to conform to idealized facies models for meandering rivers, incised valley fills in some McMurray Formation reservoirs appear to be comprised of a lower, high net to gross basal sand deposited in a high-gradient fluvial system. These deposits are sharply overlain by a variable net to gross lower gradient meandering fluvial system. Single “Mega Channels” do not appear to be responsible for the fill of these important reservoir units.