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Incorporating multiple sedimentological trends into a realistic geomodel: using the modern Mississippi False River point bar as a proxy for the ancient McMurray

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Abstract

The False River point bar on the Mississippi, immediately upstream from Baton Rouge, is of interest to those studying SAGD in the McMurray Formation as it is approximately the same horizontal scale as large features observed in the subsurface of Alberta (Figure 1).

Figure 1. False River point bar in Louisiana

Modelling this modern 3D point bar architecture combined with lithology data from 10 boreholes with well logs (Letchnowskyj, 2015) provided insight into sand on mud contact architecture and permeability distributions. This model can be used to predict steam pathways and by association better predict steam chamber morphology in McMurray SAGD projects.

In this case, a LiDAR survey of the area was used as a starting point to build a detailed 3D geomodel. Analysis of the LiDAR dataset allowed the point bar to be separated into 19 distinct bars, each representing the environment and fluvial dynamics at that time (Figure 2).

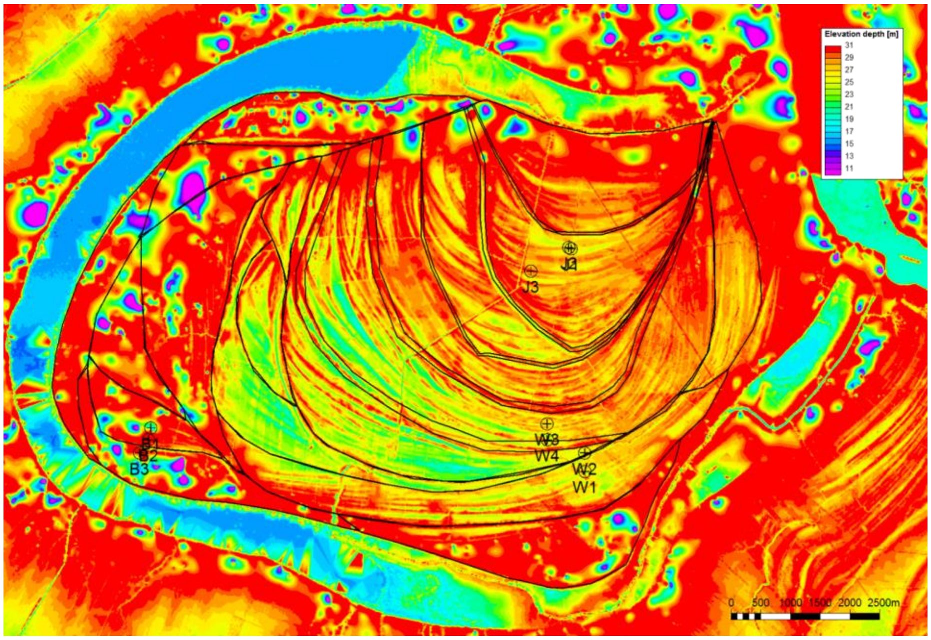

Figure 2. False River point bar composed of 19 individual bars

Ninteen depositionally appropriate dip surfaces were built to layer each separate bar by combining the scroll patterns observed in LiDAR with outcrop analogue data (Figure 2). The dip surfaces also provided the orientation of facies anisotropy, with lateral extents following the measurements of Nardin et al 2013. This model was intended to honour both the fining up vertical trend characteristic of point bar deposition, and the downstream fining observed in modern and ancient environments (Durkin et al 2015, Dashtgard and La Croix 2015). To honour these observations, a geomodel property was constructed honouring the vertical probability trends; this was then multiplied by the scaled dip azimuth of the layering surface for each zone (Figure 3).

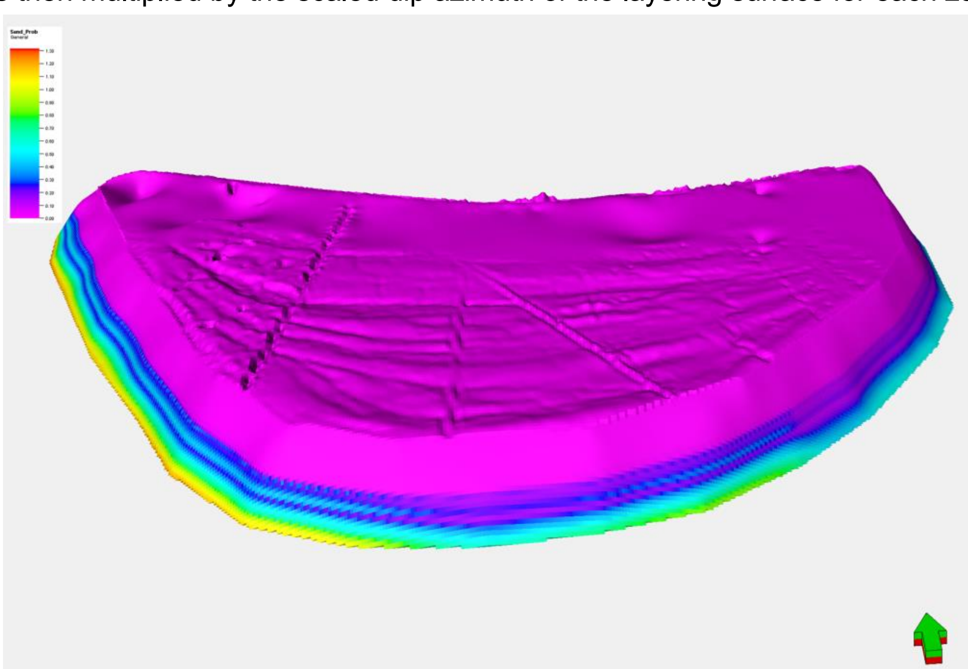

Figure 3. Combining horizontal and vertical sand probabilities for one bar, hot colours equal higher probability

For example, the azimuth of the dip surface might vary between 10 and 100 degrees for an individual north east facing bar. These dip azimuths may be normalised to be used as a scaling factor, in this case the 10 degrees north-northeast facing, upstream portion would become 1.5, and the west-southwest facing 100 degrees downstream portion becoming 0.5, varying smoothly between these values. Multiplying this scaled dip azimuth property by the vertical sand probabilities increases the distribution of sand upstream while lowering the proportion of sand downstream. In this way, the probability of sand can be changed laterally while maintaining the vertical trend (Figure 3). Using these probabilities to guide the facies modelling yields geologically appropriate facies distributions for each individual bar (Figure 4).

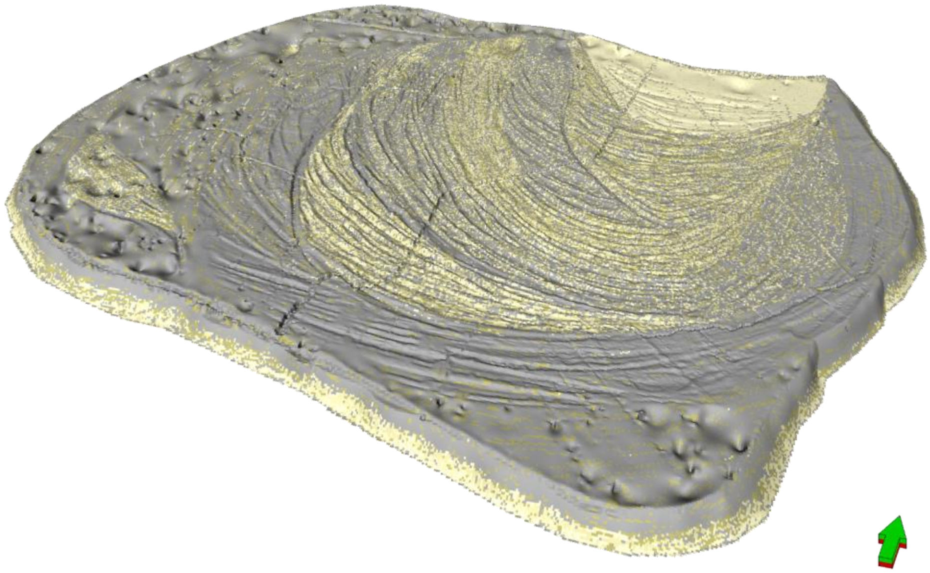

Figure 4. Geomodel for the entire point bar combining vertical and horizontal trends with separate trends for each of the 19 bars

As each bar has its own trends and facies probabilistic distributions, the interface of facies where bars intersect can be sharp. The combination of IHS deposited via lateral accretion juxtaposed with bars exhibiting varying sand probabilities and differing lateral accretion directions has implications for steamed reservoirs. This model suggests that the top of steam surface and the morphology of the steam chamber is complex (Figure 5).

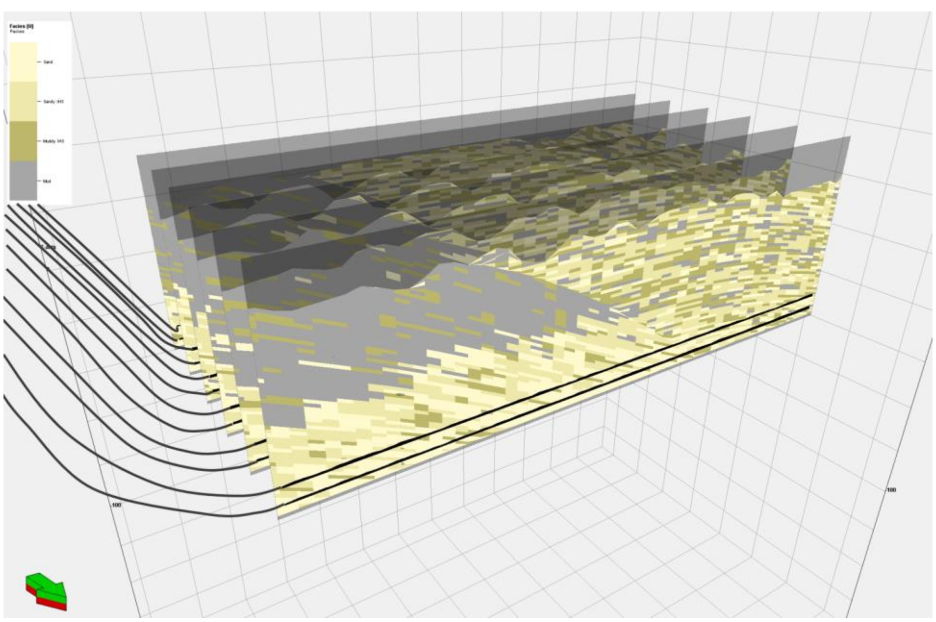

Figure 5. Hypothetical SAGD pad crossing a bar boundary. Steam would behave differently in each bar

The orientation of SAGD well-pairs will also affect the development of a steam chamber. Orienting wells to cut as many high permeability zones as possible should maximise access to high quality resource. However, as the orientation of bedding varies bar to bar, these contacts should be considered when planning wells.

Acknowledgements

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References

Dashtgard, S.E. and La Croix, A.D. 2015. Chapter 3: Sedimentological trends across the tidal-fluvial transition, Fraser River, Canada: a review and some broader implications. In: Fluvial-Tidal Sedimentology, (Ashworth, P.A., Best, J.J., and Parsons, D.P. (eds)). Elsevier, Amsterdam. Developments in Sedimentology No. 68, p. 111-126.

Durkin et al 2015, Stratigraphic Expression of Intra-Point-Bar Erosion and Rotation. Journal of Sedimentary Research. 85. 1238-1257. 10.2110/jsr.2015.78.

Lechnowskyj, A. 2015. The stratal architecture of the False River point bar (Lower Mississippi River, LA), MSc Thesis, 138 p.

Nardin, T.R., Feldman, H.R., and Carter, B.J., 2013, Stratigraphic Architecture of a Large-Scale Point Bar Complex in the McMurray Formation: Syncrude's Mildred Lake Mine, Alberta, Canada: in F.J Hein, D. Leckie, S. Larter, and J.R. Sutter eds., Heavy-oil and oil-sand petroleum systems in Alberta and beyond: American Assoc. Petroleum Geologists Studies in Geology 64, p. 273-311.