Application of Structure-from-Motion photogrammetry for determining the depositional architecture of McMurray Formation outcrops

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In the lower Cretaceous McMurray Formation, the juxtaposition of trough cross-bedded sand underlying inclined heterolithic stratification (IHS) is commonly interpreted to represent the growth of a fluvial or estuarine point-bar. This paradigm has led to the development of a bias regarding the depositional architecture of McMurray Formation sediment, such that the majority of geobodies in the McMurray Formation are interpreted to represent inner estuary lateral accretion point-bars. This bias is addressed by using an Unmanned Aerial Vehicle and Structure-from-Motion photogrammetry to generate three-dimensional outcrop models from which bedding architecture can be analyzed.

Determining the depositional architecture of McMurray Formation outcrops is achieved by analyzing bed orientation trends from a dense dataset acquired from the 3D models. Bed orientation data, when compared to sediment transport directions at outcrops along the Steepbank and MacKay Rivers, suggest that two dominant barforms exist within the McMurray Formation. The outcrops along the Steepbank River conform to the normal view on McMurray bar elements, where four stacked lateral accretion point-bar elements are recognized. In contrast, sediments along the MacKay River are ascribed to a middle estuary forward-accreting compound dune complex that is uncomformably overlain by inner estuary IHS deposits.

The recognition of compound dune barforms in addition to lateral accretion point-bars in the McMurray Formation becomes important when applied to stratigraphic models. In subsurface studies, compound dune complexes are rarely recognized, despite their presence in outcrop exposures. Bed orientation data from outcrop models in this study suggest that there is more than one type of geobody in the McMurray Formation. These include: (1) the transition from cross-bedded sand to IHS, representing the growth of a laterally accreted point-bar; (2) sharp-based IHS units with no developed lower point-bar sand body; and (3) forward accreting compound dunes.

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