geoconvention
Calgary • Canada • May 15-19 2017

Distribution and characterisation of a large-scale McMurray Formation sand fairway, Athabasca Oil Sands Region, Alberta

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Summary

A large-scale, north-trending valley form is delineated in the McMurray Formation at the southeast-through-central portions of the Athabasca Oil Sands Region (AOSR), and contains a significant proportion of the region's high-quality bitumen resource. Its distribution is mapped based on the presence or absense of regional stratigraphic markers (commonly referred to as the 'upper' McMurray Fm): the regional markers were presumably erosionally removed during valley incision ("A-Valley" of Hein and Cotterill, 2006). In this study, the composite valley fill is examined from T70-8W4 to T87-12W4, where it is of variable width (10s of km) and thickness (10s to >100 m). Maps of its distribution and character, including sedimentological, ichnological, and component sedimentary body parameters, are presented from the ~170 km long north-south oriented transect.

Introduction

The AOSR is located in northeastern Alberta and northwestern Saskatchewan, Canada. The Early-Cretaceous McMurray Formation is the region's primary hydrocarbon-bearing unit. While the McMurray Formation was first comprehensively described by Carrigy in 1970, a robust, regional-scale model of the region's depositional history and framework has not been compiled in many years. While some workers (e.g., Flach and Mossop, 1985; Hubbard et al., 2011) have proposed a dominantly fluvial interpretation for the main bitumen-bearing units, subsequent investigators (e.g., Ranger and Pemberton, 1988; Gingras et al., 2016) have favoured a brackish water environment interpretation such as an embayment or estuary. Recent efforts have pursued a unified model for McMurray Formation stratigraphy, however, efforts are complicated by the fact that different parts of the McMurray Fm. appear to be controlled by different processes in varying proportions (e.g., rivers, tides, waves). This considerable complexity means that many of the depositional environments within the McMurray Formation have yet to be successfully mapped on a regional scale. Without a regional stratigraphic framework, the hydrocarbon resources of the McMurray Formation cannot be properly characterised. This study presents a perspective of a large-scale valley feature that is resolvable in well and seismic datasets and represents a basis for comparing various previously defined depositional models developed from across this portion of the AOSR.

Methods

The study integrates well log data and core descriptions for an area that covers >10,000km^2 in northeastern Alberta. It is bounded to the east by the 'bitumen edge', where much of the McMurray Formation dips below the regional oil-water contact. Within the study area, several major bitumen-producing projects are present (e.g., Foster Creek, Kirby, Surmont, Kinosis, Long Lake). As such, more than 20,000 publically available well log files are available in addition to ample recovered core. This core is analyzed at the AER Core Research Centre in Calgary, AB. Previous studies of smaller regions contained within the larger study area have variously interpreted McMurray Fomation sediments as tidally influenced fluvial to fluvial (Hubbard et al., 2011; Labrecque et al., 2011; Fustic et al., 2012; Musial et al., 2012; Durkin, 2016) to marginal marine (Dolby et al., 2013); however, these studies have not specifically focussed on the larger paleogeographic context within the regionally mapped valley system, nor deposit context within a regional stratigraphic framework.

Results

A series of east-west trending cross sections establish the paleogeographic limits of the mapped valley system. In localities where 3D seismic data is available, the edges of the valley are also corroborated with evidence for truncatation of regional 'Upper McMurray' stratigraphic markers. The regional stratigraphic framework constructed indicates that this valley formed near the end of McMurray time, just prior to transgression of the Boreal Sea into the Athabasca subbasin. Core, wireline log, and 3D seismic data reveal a complex and highly variable depositional setting. Morphologic interpretation suggests a meanderbelt dominated by mobile channels, with numerous attributes analogous to characteristics consistent with fluvial processes (e.g., evidence for down-valley translation of point bars, counter point bars, large scale upwards-fining point bar deposits, etc). Evidence suggests that the valley fill comprises one or more stacked channel successions, depending on paleogeographic position. Ichnologic interpretation is consistent with brackish water conditions in much of the valley fill (e.g., impoverished trace fossil suite including trace fossils such as *Cylindrichnus, Planolites, Paleophycus* and *Gyrolithes*). The overprinting of a brackish water signal on deposits with a fluvial meanderbelt architecture is not easily explained with existing sedimentary facies models. Future work will emphasize the stratigraphic and paleogeographic context of McMurray Formation deposits over the vast study area to better constrain these apparently disparate observations.

Acknowledgements

The authors would like to acknowlege the McMurray Geology Consortium sponsors (BP Canada, Cenovus Energy, Husky Energy, Nexen CNOOC, and Woodside Energy) for their funding contributions towards this project.

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