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The use of dipmeter logs and core observations to characterize estuarine point bars of the Lower Cretaceous McMurray Formation, Christina River, AB, Canada

Qi Chen, Murray Gingras

Earth and Atmosphere Science, University of Alberta

Summary

Study area/Method

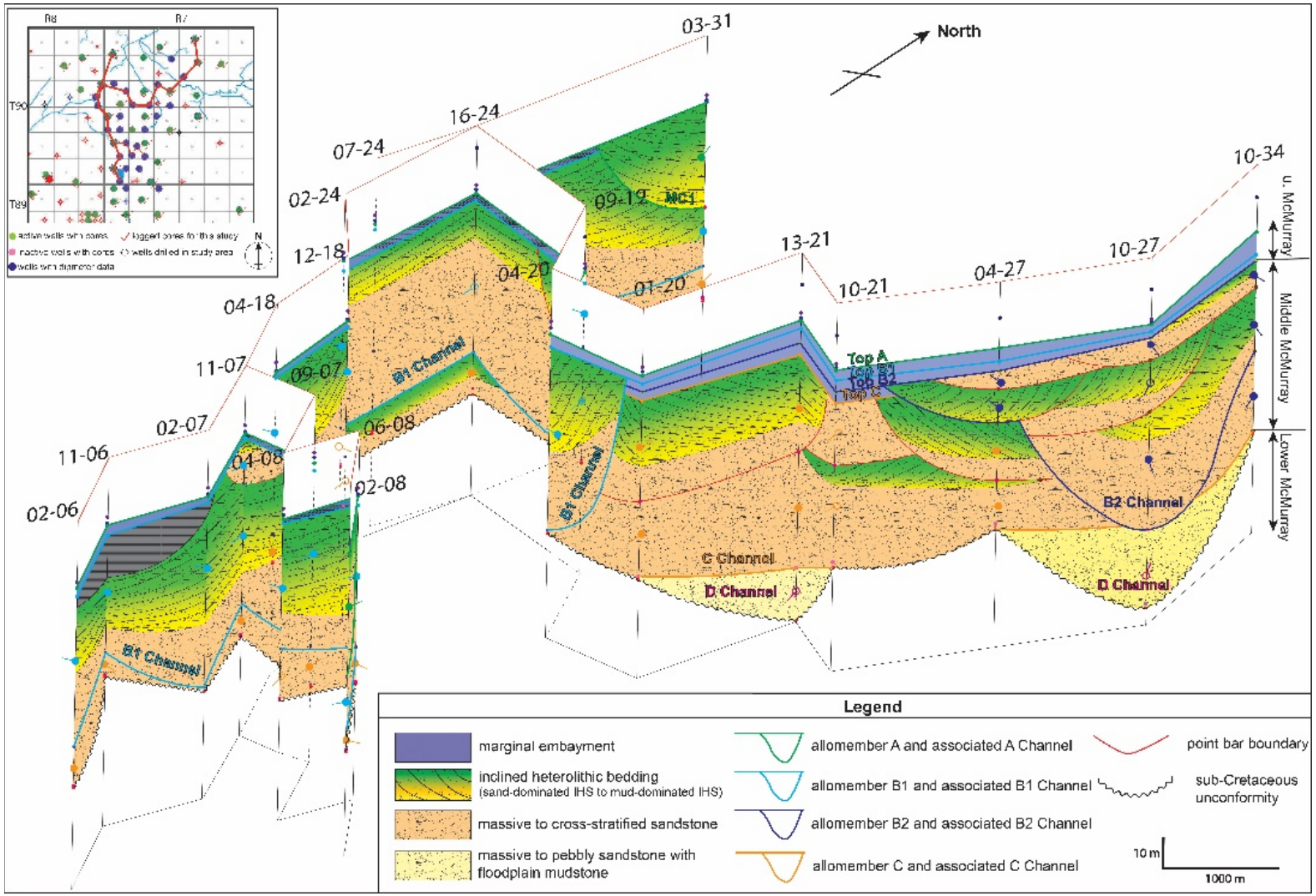
The study area is located 30 km east of the town of Fort McMurray and covers ~2500 km2, coincides with the main fairway paleovalley. It extends between ranges 7-8W4M and townships 89-90. A dataset consists of petrophysical logs from 84 wells, 35 of which posses dipmeter data. 49 logged cores are used to support log interpretations. Wells with both core and dipmeter data are studied for facies assignation, and petrophysical logs were used in combination with core data to establish well-to-well stratigraphic correlation across the study area. Of particular note is the use of dipmeter data to differentiate between distinct estuarine point-bar deposits within the amalgamated meandering belts of the middle McMurray member (Brekke and Couch, 2011; Brekke et al., 2017). The resulting tadpole characteristics were compared to core observations to establish a detailed point-bar facies classification scheme.

Results

Eight sedimentary facies are identified within the McMurray Formation in the study area, comprising various parts of a tidally and fluvially influenced, estuary channel point-bar complex (Facies Association 1) and storm- and wave-influenced marginal marine deposit (Facies Association 2). FA1 is the predominant component of the lower to middle members of McMurray Formation, core and dipmeter data are interpreted as estuarine point bars. The point bar comprises 1) a lower section represented by cross-stratified sandstone with local mud clasts and disorganized, low- to high-angle dipmeter readings, signifying the basal section of fluviotidal to inner estuarine point bars; 2) a middle section represented by sandstone- and mudstone-dominated inclined heterolithic stratified (IHS) lateral accretionary deposits with consistent low-angle dips (4-20º), subtle shallow-to-steep-to-shallow dipmeter pattern, and counterclockwise or clockwise rotation of the bed dips; and 3) an upper section constituent of abandoned channel, laminated, and lenticular mudstone showing low-angle (<4º) dipmeter readings.

Well-to-well correlation within the study area and emphasizing dipmeter log coverage shows distinct point-bar stacking patterns and various stratigraphic units (A/A Channel, B1/B1 Channel, B2/B2 Channel, and C/C Channel) (Figure. 1). Differences are observed between stratigraphic units. As indicated in Figure. 1, the older stratigraphic units (B2 and C Channel) are characterized by stacked amalgamated point bars and sand channel dunes with variable directions of lateral accretion. On the contrary, the younger stratigraphic units (A and B1 channel) are characterized by well preserved, large-scale single-story point bar deposits with greater lateral and vertical continuities, and generally displaying consistently dipping lateral accretion. The dominant sedimentary facies observed within each unit are similar, but the sediment fill of the channels shows an overall increase of IHS facies over cross-stratified sandstone facies sequentially from C Channel to A Channel. This is related to a corresponding increasing abundance of brackish water trace fossil assemblages upwards.

Figure. 1 Fence diagram with major facies distribution and stacking patterns of point bars. The dominant direction of point bar lateral accretion deposit is indicated with tadpole symbols.



Observations/Discussion

The difference in point-bar stacking patterns between various stratigraphic intervals provides additional evidence for the ongoing discussion on the mainstream McMurray Formation depositional models: incised valley fill (IVF) *versus* distributary channel and associated delta-plain model. The IVF model is supported by this study, because: 1) the increasing thickness/scale of individual point bars in younger stratigraphic units imply a gradual increase in the rate of accommodation space creation during the overall transgression; 2) the extensive brackish water trace fossil assemblage throughout the McMurray interval is contrary to fluvial-dominated deltaic systems; and, 3) the increasing dominance of brackish water influenced facies in younger units indicate gradual transformation from fluvially-dominated inner estuarine to mixed-energy tidal-fluvial estuarine channel system.

Conclusions

In addition to traditional stratigraphic interpretation using petrophysical logs, and facies analysis using sedimentological and ichnological analysis, this study follows on efforts of Brekke and Couch (2014) and Brekke et al. (2017), adds more details on dipmeter characteristics of various parts of estuarine point bars in the McMurray Formation. It emphasizes the importance of using dipmeter with cores to discriminate different facies of estuarine point bars, the resulting stacking patterns within various stratigraphic intervals provide the basis for the reconstruction of the paleodepositional history and relative sea-level changes.

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