

Speculations on the Creation of Accommodation Space in the Aptian McMurray Formation – Possible Mechanisms

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Most of the reservoirs of the Aptian McMurray Formation in northeastern Alberta are a complex amalgam of incised valleys and the tidally-influenced fill of those valleys. Initial regional mapping indicated at least 3 major complex and regionally mappable incised valley systems. More recent mapping suggests that in addition to these 3 major incision events, there may be as many more, less extensive, higher frequency erosional events within the McMurray Formation.

What created the accommodation space, multiple cut and fill events, multiple erosion surfaces within the McMurray Formation? In this presentation, we speculate on the complex interplay of evaporite dissolution, glacial eustacy and migration of a flexural wave associated with foreland basin tectonics.

The McMurray Formation sandstones are underlain by three Devonian aged evaporite sequences. In ascending order these are the Lotsberg, Cold Lake and Prairie Evaporite. These carbonate successions outcrop to the north-east and dip to the south-west under the McMurray depositional area. Dissolution by meteoric waters at the outcrop and in the shallow subsurface has taken place when these sequences were uplifted. Major dissolution occurred prior to and during McMurray deposition. The result of this dissolution was to provide additional local accommodation space for the deposition and preservation of McMurray aged sandstones. This accommodation space is evidenced by a marked increase in gross McMurray thickness in areas of maximum pre-McMurray dissolution.

A recent study from Oman (Maurer et al., 2012) suggests that a Late Aptian lowstand was responsible for cutting of a 50 m deep incised valley system. The valley was cut into carbonates of the Bab Basin and subsequently infilled with fluvial passing upwards to transgressive estuarine and then to shallow-marine sediments. At the latest Aptian to earliest Albian the basin was marked by sea-level rise, highstand and condensation. As many as eight higher-frequency sea-level perturbations were associated with sea-level fall. Detailed stratigraphy, biostratigraphy, oxygen isotope analyses and global literature review led Maurer et al. to propose that the lowstand was glacially induced. By way of comparison, the McMurray Formation consists of a lower fluvial succession, multiple cut and fill events of Late Aptian age and a latest Aptian to earliest Albian sea-level rise associated with the basin-wide Wabiskaw transgression overlain by shales of the Clearwater Formation. Regional mapping on several properties indicates a many as 3 major erosional events within the middle McMurray to possibly as many as 10. The question that arises is “could glacially-induced eustacy have caused the multiple cut and fill events that characterize the McMurray Formation?”

The surface associated with the Sub-Cretaceous unconformity at the base of the McMurray Formation contains morphological aspects of entrenched meandering rivers laterally migrating and cutting into the Devonian carbonates. Well-preserved incised channel and scroll patterns indicate channel widths of 140 -165 m wide, depths of about 14 m and a sinuosity index of 2.3. The lateral migration and entrenchment of the meanders suggest an episode of likely subtle uplift of the landscape. The age of lowermost McMurray sediments on the unconformity is Aptian. What mechanism may have caused the uplift? One possible mechanism is the passage of a flexural wave associated with movement of the forebulge as it migrated east or west, depending on tectonic loading in the Cordillera.