

Coarsening-Upward Cycles in the Upper McMurray Formation: Regional Gas/Bitumen Reservoir Seals

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At least two coarsening-upward (C/U) cycles have been recognised in the upper McMurray Formation of the south Athabasca area. The base of each cycle is a distinctive shale interval resting upon a flooding surface. The C/U cycles appear regional in extent, but may be incised by younger channels. Their preservation potential increases upward within the McMurray Formation, the uppermost cycle being the most laterally extensive.

Within a C/U cycle, the upward increase in grain-size, decrease in shale content, and progressive change in sedimentary structures represent the superposition of shallow/proximal upon deeper/distal environments suggesting progradation of a sand body. Ichnofossil evidence indicates that the system prograded into a marine to brackish water body below fairweather wave base. Ichnofossils become progressively rare and lower in diversity upwards in a cycle, indicating increasingly stressful conditions for both epifauna and infauna. We interpret this stress to be the development of freshwater conditions of a highstand bayhead delta system.

A gas leg may be trapped immediately beneath the basal shale units. Where there are multiple cycles of gas overlying bitumen, the reservoir fluids are obviously sealed by the basal shale of each C/U cycle. The presence of a seal between gas and bitumen is a key factor in determining whether gas production would affect *in situ* recovery of deeper bitumen reserves.

The C/U cycles may be mapped using their gamma ray signature, but should always be backed up by core observation. Sometimes the upper part of a C/U cycle has been eroded, yet the basal sealing shale is preserved. Because the coarsening-up gamma ray signature is missing in such cases, the presence of the regional sealing shale can only be reliably confirmed from core evidence.