Highstand Stacked Tidal Flat / Standing Water Evaporite Cycles of the Midale Evaporite in Southeast Saskatchewan, Mississippian Williston Basin*

J. H. Lake[1] and D. M. Kent[2]

Search and Discovery Article #10715 (2015)**
Posted February 16, 2015

*Adapted from extended abstract prepared in conjunction with a presentation given at CSPG/CSEG 2007 GeoConvention, Calgary, AB, Canada, May 14-17, 2007,

[1]Lake Geological Services Inc., Swift Current, Saskatchewan, Canada
[2]D.M. Kent Consulting Geologist Ltd., Regina, Saskatchewan, Canada

Abstract

The Midale Marly and Midale Evaporite were recognized early in studies of the Williston Basin as a major marine transgression in predominantly regressive cycles (Harris, 1966; Hendricks, 1988). The cycles of the Mississippian in the Willsiton Basin reflect an aerially shrinking basin with time (Figure 1 and Figure 3). The Harris model suggests that hydrocarbons are trapped laterally by facies changes, and successive evaporates overriding the carbonates act as a top seal. The Midale Marly and Midale Evaporite reverse this trend. These units are interpreted to represent deposition within a Highstand Systems Tract Sequence Stratigraphic setting (Figure 2). The Marly dolomite reservoirs were deposited in shallow ponds along the shoreline according to the topographic relief of the underlying strata. The marine transgression on this Highstand package accounts for the variability in degree of dolomitization and reservoir thickness. A brief hiatus in deposition between Marly and the Evaporites is often marked by a thin organic lens. This core display will demonstrate the depositional environment and assess the regional significance of the Midale Evaporite. Is there important information to be learned from studying evaporites and does it have any economic significance?

Stratigraphy

The Midale Evaporite is composed of numerous stacked deepening-upwards metre-scale cycles which are characterized by basal laminated dolomite muds, rootlets, burrow-mottled dolomite muds, and in some instances are capped by laminated evaporites. The laminated muds are interpreted as representing a tidal flat environment. They are often organic-rich in nature. The plant rootlets and burrowed muds represent a transition into slightly deeper waters. Often the Midale Evaporite cycles are composed of these features, as in the Weyburn oil pool. However, a complete cycle (Figure 4 and Figure 5) includes the laminated evaporates at the top of the cycle as well. It is only at the very top of the Midale Evaporite package that we see Sabkha evaporites and evidence of extended exposure.

Shark Bay in Western Australia is an ideal modern analogue for the Midale Evaporite. Studies by Logan et al. (1970), and Harris and Kowalik (1994) suggest that sea grasses are capable of developing carbonate shoal complexes and isolating localized hypersaline basins, as we see in the Midale Evaporite rock record. Kent (2003) suggests the majority of Paleozoic evaporites accumulated by pelagic settling of gypsum crystals in water depths of greater than 10 metres in the Williston Basin. The sequences which include the laminates-rootlets-burrowed cycles (such as those seen at Weyburn) may in fact represent the barriers required to deposit the cycles which include the laminated evaporites. Harris and Kowalik (1994) suggest that bays such as Hamelin and Lharidon Basins in Western Australia may, in fact, be sufficiently large to represent those of ancient epeiric seas. The Faure Sill creates restricted circulation for these basins and is a few feet below sea level with small fans built at channel openings (Logan et al., 1970), similar conditions existed during Midale Evaporite deposition. The important point in studying the Midale Evaporite is that there were no significant lateral facies changes, but rather the cycles accumulated vertically according to available accommodation space. This would suggest that the Highstand was very stable in terms of sea level fluctuations and that it is witness to a major interglacial event at this time. The Midale Evaporite may have lateral time equivalent higher energy facies in a basinward direction which would have reservoir potential (basinward of the sea grass barrier).

Facies Distribution

And what does the Midale Evaporite facies distribution look like? In general, the topographic relief on the Midale Vuggy and Marly controls the accommodation space available for Midale Evaporite distribution. The underlying Frobisher Beds shoreline trends north-south through Steelman, then heads west above Midale and Weyburn pools. However, the Midale Evaporite flooded beyond the shoreline of the underlying Frobisher Beds.

We would expect to encounter aeolian facies in the hinterland to the north. If the predominant wind direction was from the northeast (as interpreted from plate migration by Scotese), then we should see the effects of aeolian transport of sediments into the Midale Evaporite Highstand. The barrier which creates the conditions necessary for standing water evaporates would also be close to normal marine salinity waters beyond the barrier, creating a stratigraphic facies trap in the transition from carbonates to evaporites.

The sabkha evaporites at the top of the Midale Evaporite section provide the necessary top seal for hydrocarbon trapping in the final marine regression. The barrier was probably controlled by a basement feature (A. Marsh, personal communication, 2007). The ultimate control on Midale Evaporite deposition is attributed to Highstand Systems Tract interglacial conditions.

Selected References

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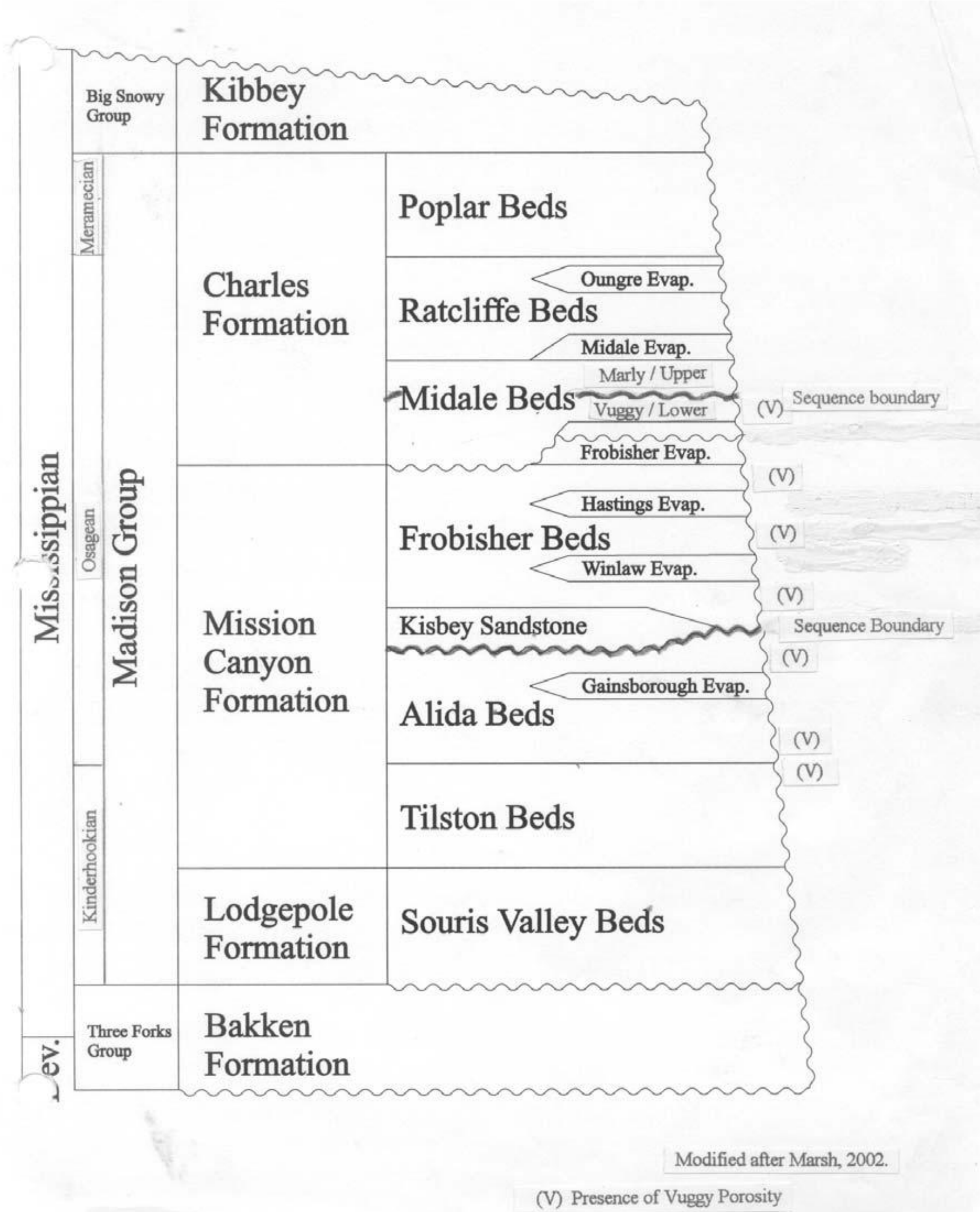

Figure 1. Stratigraphic column of the Williston Basin showing the position of the Midale Evaporite within the Mississippian Charles Formation (after Marsh, 2002).

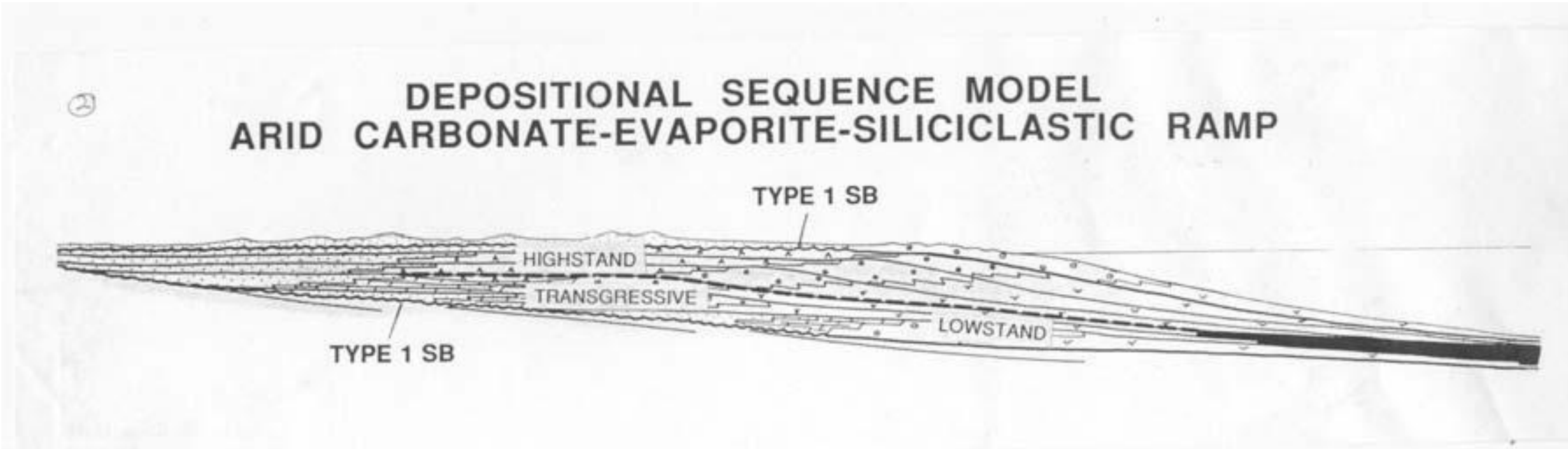

Figure 2. Sequence stratigraphic setting of depositional arid carbonate-evaporite-siliciclastic ramp. The Midale Evaporites were deposited within a terminal Highstand Systems Tract (Shallow Platform Environment with stable sea level conditions for extended period of time).

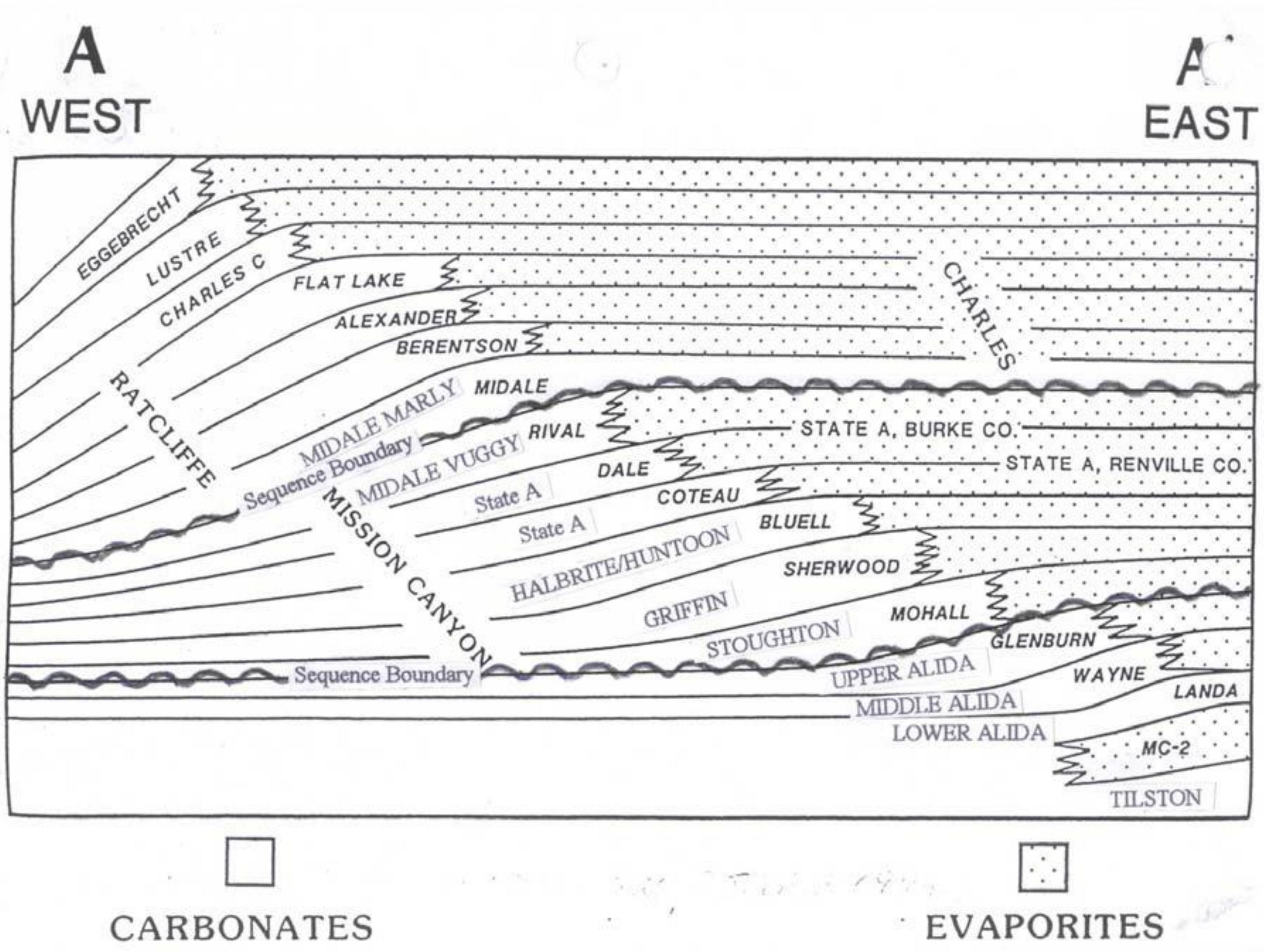

Figure 3. Williston Basin Model of sedimentation in a shrinking basin with time. Note the exception to the shrinking trend in the Midale/Midale Marly sequence. The model suggests that fluids are trapped laterally by facies change from carbonates to evaporates and vertically by transgression of evaporates basinward over previous carbonate cycle. The Midale Evaporites are the exception and stacked vertically in response to accommodation space and stable sea level conditions (maximum Highstand Flooding conditions associated with interglacial climate).

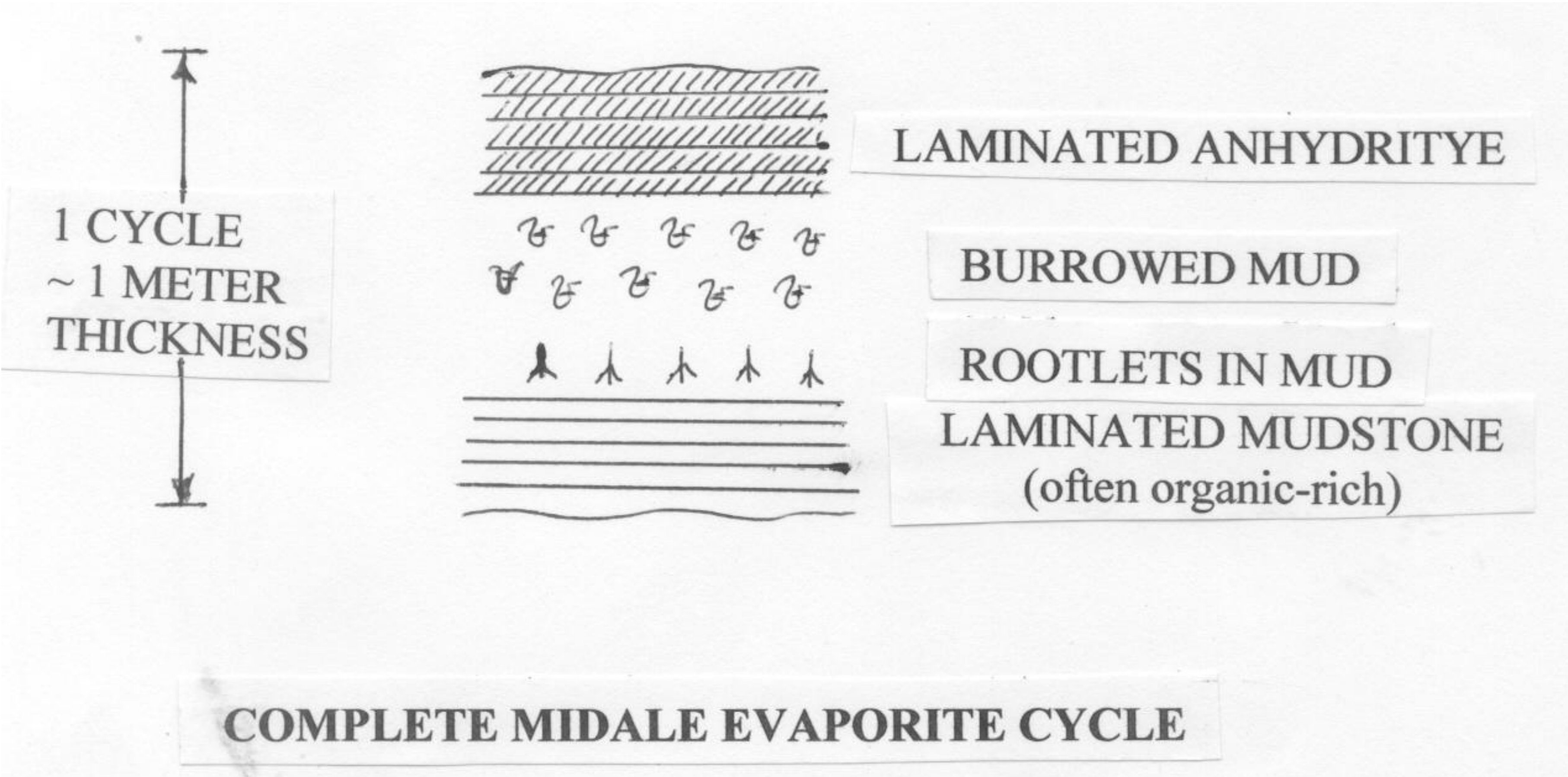

Figure 4. Idealized model of a complete Midale Evaporite cycle. The stacked cycles commonly include the basal portion including laminated (often organic-rich) muds, roots and burrowed dolomitized muds. Occasionally the cycles are capped by laminated standing water anhydrites. The modern analogue is the Hamelin Basin in Shark Bay, Western Australia (see Logan et al., 1970).

Figure 5. Core photo of an individual cycle from the Midale Evaporite. Note the laminated muds and rooted and burrowed strata (laminated anhydrites not deposited/ preserved here). Cycle averages 1 meter in thickness (7-5-5-4W2M Steelman core).