A Tide-Influenced River Delta in the Campanian Upper Eagle Member of Central Montana

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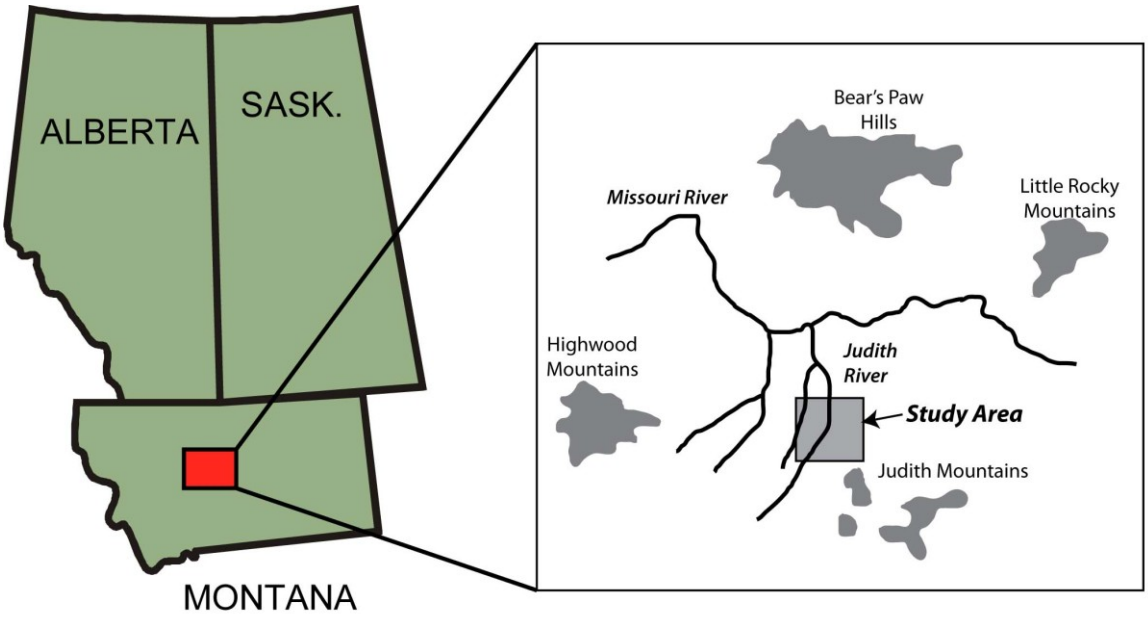
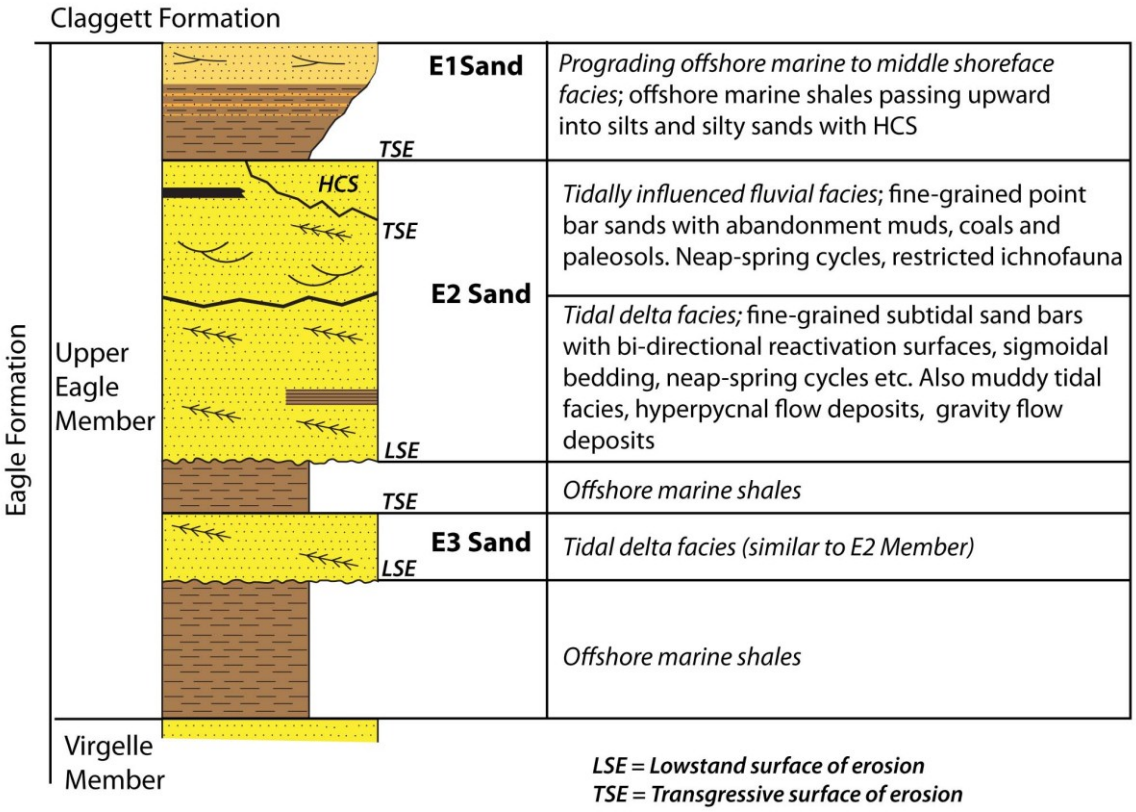
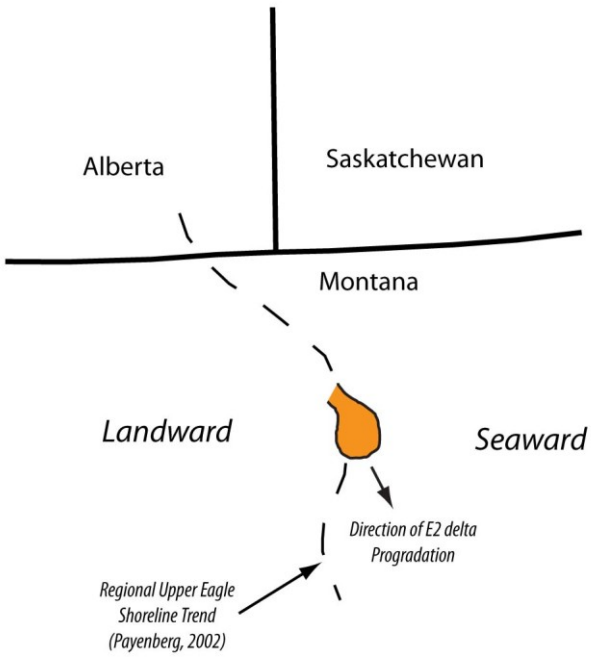
In central Montana there are a series of deeply incised river valleys in which the Upper Cretaceous Santonian-to-Campanian section is well exposed. Along the Judith River and its tributaries there are superb, flat-lying, continuous exposures of the Campanian Eagle Formation. The Upper Eagle Member in Montana is equivalent to the gas-bearing Alderson Member of the Milk River Formation in Western Canada which hosts giant, mature, low-permeability gas fields in Alberta and Saskatchewan.



The Upper Eagle member was deposited along a regional north-south trending shoreline in northern and central Montana (Payenberg, 2002). Exposures of the Upper Eagle member in the study area show that it contains three prominent sand bodies called, in ascending order, the E3, E2 and E1 sands. These units are described here for the first time.

The E1 is a regional, wave-dominated shoreline sand that progrades to the east. The E2 and E3 sands are locally developed units that are interpreted as southeasterly prograding lowstand tide-influenced river deltas. The E2 sand is the better exposed unit, allowing detailed examination of facies characteristics, distribution and architecture, and this is the unit that is described here.





The E2 sand forms a broad SE trending lobe approximately 12 km wide (parallel to shoreline) and 18 km in length (along depositional dip), although the dimensions have not yet been fully determined. The E2 sand in the central part of the lobe averages between 15m and 20m, generally evenly divided between the lower E2 tidal delta and the upper tidally-influenced fluvial deposits. The E2 sand thins laterally to zero edges in the NE and SW. The base of the E2 sand is in sharp erosional contact with underlying offshore marine shales.

The E2 sand body contains four main facies associations:

1) Subtidal sandstones and mudstones. This facies dominates the lower half of the E2 unit and averages 8m in thickness throughout an area some 10km wide and 12 km long. Steeply dipping southeasterly prograding clinoforms are present throughout the succession indicating that the delta platform prograded in that direction.

Tidally-influenced facies are recognized by the presence of:

- Mud drapes and mud couplets formed during daily ebb-flow cycles.
- Lateral bundle thickness variation resulting from spring-to-neap tidal rhythms. Many thousands of these neap-spring cycles are observed in the E2 with a wide variety of lithologic, geometric and ichnological characteristics.
- Various reactivation surfaces resulting from bidirectional flow. Foresets deposited by the dominant current are typically eroded by the subordinate current. The scale of the erosion indicates moderately asymmetric tide conditions. Other indicators of this tidal asymmetry are the presence of well-developed subordinate current ripples on foresets, and intersecting flasers known as 'flaserforks'.
- Features such as flaser bedding and herringbone cross-bedding are very common.

Mud-dominated intervals are relatively rare, but in several locations heterolithic mud/sand intervals up to 2m thick are present. These muddy sediments are dominated by wavy and lenticular bedding and contain thin, muddy neap-spring cycles.

Paleocurrents in the E2 subtidal sands indicate a strong flood-dominant signature on both the NE and SW flanks of the delta. In the central part of the delta lobe there is a balanced flood-ebb signature.

2) Sediment gravity flows. These are common throughout the lower half of the E2 sand and consist of 3 types of deposit.

Hyperpycnal flow deposits. These typically consist of alternating sets of massive to parallel-laminated sand beds succeeded by bi-directional current rippled sands. Bed thicknesses range from a few cm to a metre. These are present throughout the delta platform. At the NE and SW margins hyperpycnal flow deposits replace the subtidal sands and dominate the depositional facies.

Debris flow deposit. This consists of large, randomly-oriented, cobble-sized sandstone clasts set in an offshore marine mudstone matrix. A single layer containing what appears to be multiple debris flows is present at the NE edge of the delta. This layer is approximately 6m thick and extends over an area of about a kilometer.

Massive, chaotic sand beds. These consist of muddy, highly carbonaceous, fine- to medium-grained sand which are internally mixed and chaotic. Many thin chaotic beds are present in the lower half of the E2, but the thickest and most extensive bed is present in the E1 sand and is 1.5m thick and extends for 2.5km in length.

3) Tidally-influenced fluvial sands. The contact between the subaqueous tidally-deposited sands in the lower E2 unit and the overlying fluvial sands is highly erosive, and an extensive lag unit consisting of logs and other large pieces of wood is often present. Multiple channel cuts are seen and the contact appears to be diachronous. The thickest fluvial section is 16m, at the northwestern end of the depositional system. The lower part of the fluvial section typically contains large, metre-scale troughs. These pass upwards into broad channels with lateral accretion beds indicating point bar deposition, often with abandonment muds, coals and paleosols. There is extensive tidal influence particularly in the point bars, where flaser bedding, sigmoidal bedding and sandy neap-spring cycles are common.

4) Hummocky cross-bedded sands. At the seaward end of the E2 depositional system hummocky cross-bedded sands are present, up to 5m in thickness. These appear to be transgressive, wave-dominated shoreface sands that have partially truncated the underlying E2 delta and fluvial facies.

Continuing field work on these Upper Eagle Member outcrops will concentrate on the landward and seaward termination of the E3 and E2 fluvio-deltaic systems.

References

Payenberg, Tobias H.D. 2002

Litho-, chrono- and allostratigraphy of the Santonian to Campanian Milk River and Eagle Formations in southern Alberta and north-central Montana: implications for differential subsidence in the western interior foreland basin. University of Toronto Ph.D. Thesis.