Palynology and geochemistry of channel-margin sediments in the tidally influenced lower Fraser River, British Columbia, Canada: Implications for recognizing brackish water and tidal influence across the tidal-fluvial transition

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Summary

Palynology and geochemistry, when combined with sedimentological and ichnological characteristics, can aid in facies recognition and in paleoenvironmental interpretations. In mixed-influence, marginal-marine settings, the delivery of allochthonous organic material *via* fluvial or tidal flow produces distinctive palynological and geochemical signatures in sediments across the tidal-fluvial transition. These signatures can be employed to determine the provenance of organic matter and give insights into the relative control of fluvial and tidal processes on sediment deposition. In the rock record, differentiating marine and continental (non-marine) deposits is relatively straightforward using sedimentological, ichnological, and/or palynological data. However, recognizing varying degrees of tidal deposition or brackish-water incursion in marginal-marine settings is significantly more challenging. To determine whether brackish-water and tidal controls can be recognized across the tidal-fluvial transition, the palynology and geochemistry ($\delta^{13}C$) of sediments in the tide-influenced, lower Fraser River, B.C. are studied. These data provide baseline data from comparison to equivalent rock-record deposits, including those of the bitumen-hosting middle McMurray Fm.

In the lower Fraser River, B.C., the palynology and geochemistry of channel-margin sediments in the freshwater-tidal and brackish-water-tidal reaches are measured. Results from the river samples are compared to control samples collected from the delta front (62 m water depth). In all samples, the key palynomorphs (pollen, spores, dinoflagellate cysts), their provenance (marine, brackish-water or terrestrial), and their abundances are recorded. For comparison to the palynological data, Carbon-13 isotope enrichment (C^{12}/C^{13}) values are also measured.

Palynological assemblages are dominated by terrestrially derived bisaccate pollen (*Pinus, Abies, Picea*) and alder (*Alnus*) grains. Dinocysts typically comprise less than 3% of each assemblage, although suites show a marked trend of increasing dinocyst abundance down the depositional profile (in the seaward direction). Cysts of marine dinoflagellates, mainly *Alexandrium* spp. and *Operculodinium centrocarpum*, generally occur in higher concentrations with increasing tidal and

brackish-water influence, as well as with decreasing grain size. Fine-grained sediments (< 0.177 mm in diameter), transported as washload, show higher concentrations of dinocysts than do coarser-grained, bedload-dominated sediment. While the forcing function that leads to saltwater incursion up the channel is tidal magnitude, the majority of sediment and organic matter is delivered from the river. This is the main reason why dinoflagellate numbers are low throughout the tidal- and brackish-water-influenced distributaries of the lower Fraser River. As expected, geochemical signatures generally show increasing $\delta^{13}C$ enrichment in the seaward direction. $\delta^{13}C$ values range from approximately -26.41$^{0}/_{00}$ in the freshwater-tidal zone to approximately -23.3$^{0}/_{00}$ in the delta-front control samples.

In the Fraser River, where abundant hydrodynamic and water chemistry data are available, it is relatively easy to relate palynological and geochemical characteristics of the sediments to the depositional conditions under which they were deposited. In the subsurface, however, the paleo-position of sediments across the tidal-fluvial transition must be interpreted using only physical characteristics, including palynology and geochemistry. This study provides an example of the magnitude and rate of change that can be expected in palynological and geochemical characteristics with changing tidal and fluvial influence, and with changing salinity conditions. In particular, the Fraser dataset suggests that it is possible to determine relative position within the tidal-fluvial transition and along a paleo-depositional trend by measuring the percentage and types of dinocysts and the geochemical signature of sediments along that trend. Determining paleo-depositional position is particularly important in hydrocarbon reservoirs that are composed of inclined heterolithic stratification (e.g., reservoirs of the middle McMurray Formation), because the lateral extents, and volume, of mud beds in IHS-dominated reservoirs appears to vary with position in the tidal-fluvial transition.