The Utility of Palynofloral Assemblages for the Interpretation of Depositional Paleoenvironments and Sequence Stratigraphic Systems Tracts in the McMurray Formation at Surmont, Alberta*

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Introduction

Palynofloral assemblages from the McMurray Formation are generally rich and diverse. They reveal insights into the depositional paleoenvironments and can be used to discern elements of sequence stratigraphic systems tracts, specifically candidate maximum-flooding surfaces. The character of the palynofloral assemblages and the identification of these candidate flooding surfaces allow subdivision of the McMurray Formation into palyno-chronostratigraphic units which can be identified locally in the Surmont area (Figure 1), and subsequently used for mapping purposes. Additional investigations suggest these palyno-chronostratigraphic units may have regional utility.

Palynofloral Assemblages

The palynofloral assemblages from the McMurray Formation are dominated by terrestrially-derived forms: gymnosperm pollen and pteridophyte spores are abundant. This domination and accompanying species richness suggest that the depositional paleoenvironments were fluvial-dominated draining a vegetationally diverse hinterland (Figure 2). Freshwater algae (e.g., *Schizosporis*, *Pediastrum*) are occasionally abundant, indicating short-lived freshwater lacustrine habitats were present. Importantly, dinoflagellates of brackish-water origin are prevalent throughout much of the strata of the McMurray Formation ,indicating varying and persistent marine influence on deposition. This is corroborated by sedimentary structures of tidal origin and varied ichnologic assemblages of brackish trace-makers. These brackish-water dinoflagellates include species of *Nyktericysta*, *Vesperopsis*, *Balmula*, and *Pseudoceratium*. Their abundance and diversity can be related to the extent of marine influence on deposition; the greater the abundance and diversity, the greater the marine influence (Figure 2). Peaks in abundance can be interpreted as candidate maximum-flooding surfaces.

Palyno-Chronostratigraphy

In the Surmont region, at least five distinct palyno-chronostratigraphic units can be identified based on unique palynofloral assemblages (Figure 3). In the local Surmont area these units undoubtedly reflect unique depositional paleoenvironments, the evolution of diverse paleohabitats, and the influence of marine waters on deposition on these strata. At least three candidate maximum-flooding surfaces can be interpreted, based on the abundances of dinoflagellates, calibrated to sedimentologic and seismic data.

- The lower two units are of very limited geographic extent, occurring in only a few wells, and represent local infill of topography on the Devonian unconformity. Palynofloral assemblages are dominantly of terrestrial origin with no dinoflagellates present.

- Unit 3 represents the Basal Shale, a locally thick argillaceous section present over part of the Surmont area. This shale has been described in the terms of pseudo- or muddy inclined heterolithic stratification (IHS). Where this shale is well-developed the dinoflagellate assemblages are abundant and diverse, indicating dominant brackish paleoenvironments. This is corroborated by an ichnofossil assemblage comprised of *Planolites*, *Arenicolites*, *Skolithos* and *Cylindrichnus*. In parts, freshwater algae (*Hurlandsia*) are present. A candidate maximum-flooding surface can be interpreted in the upper part of this shale where a peak of *Pseudoceratium* is identified.

- Unit 4 encompasses the dominant arenaceous strata which form the major reservoirs in the Surmont area. Palynofloral assemblages are not robust due to the lack of appropriate shale lithologies to be sampled. Where palynofloral data can be obtained, a diverse assemblage is recognized, containing brackish-water dinoflagellates indicative of some marine influence. At least one candidate maximum-flooding surface can be suggested.

- Unit 5 represents the Top Shale, another locally thick argillaceous section present over parts of the Surmont area. In contrast to the Basal Shale, much of the Top Shale contains minor abundances of brackish-water dinoflagellates. The exception is near the very top of this unit where a distinct peak of dinoflagellates indicates a candidate maximum-flooding surface.

- Unit 5 is unconformably overlain by shales of the Wabiskaw Formation. Palynofloral assemblages from the Wabiskaw are extremely diverse and abundant and contain cosmopolitan taxa correlatable to worldwide sequence chronostratigraphies. This distinct shift in the nature of the dinoflagellate assemblages serves as a unique manner in which to differentiate the overlying Wabiskaw Formation from strata of the older McMurray and could be a more reliable criterion than petrophysical characteristics.

Although the majority of palynoflora from the McMurray Formation are non-age-diagnostic, some tentative correlations can be made to worldwide chronostratigraphies. The McMurray Formation is interpreted as being primarily late Aptian in age, although the lowermost stratigraphy present at Surmont may be as old as early Aptian (Figure 4). No diagnostic Barremian or older palynofloras have been identified. The top of the McMurray Formation can be no younger than earliest Albian based on the presence of earliest

Albian dinoflagellates in the overlying Wabiskaw Formation. Simple correlation of candidate maximum-flooding surfaces to worldwide sequence chronostratigraphies for the Aptian indicate that the McMurray Formation at Surmont may have been deposited in approximately 6.0 Ma. The unconformity with the overlying Wabiskaw may represent as much as a 2.5-3.0 my. hiatus/time gap.

References

Barson, D., Bachu, and S., Esslinger, P., 2001, Flow systems in the Mannville Group in the east-central Athabasca area and implications for steam-assisted gravity drainage (SAGD) operations for in situ bitumen production: Bulletin of Canadian Petroleum Geology, v. 49, p. 376-392.

Michoux, D., 2002, Palynology of the Lower Cretaceous McMurray Formation, Alberta, Canada: Thirty-fifth annual meeting, American Association of Stratigraphic Palynologists, London, UK, September 11-13; also Palynology, v. 27, p. 237, 2003 (abstract).

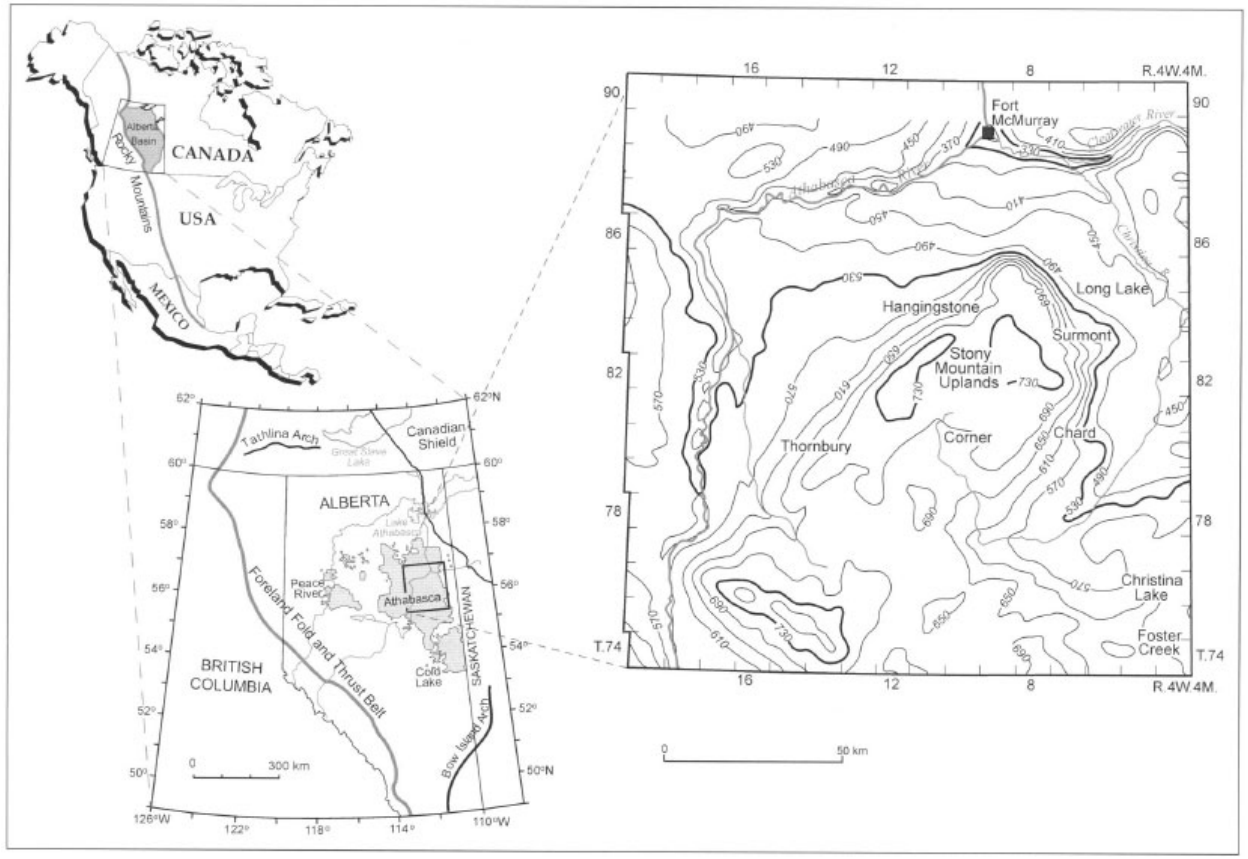

Figure 1. Location map for Surmont area in Athabasca Oil Sands Region, northeastern Alberta (from Barson et al., 2001).

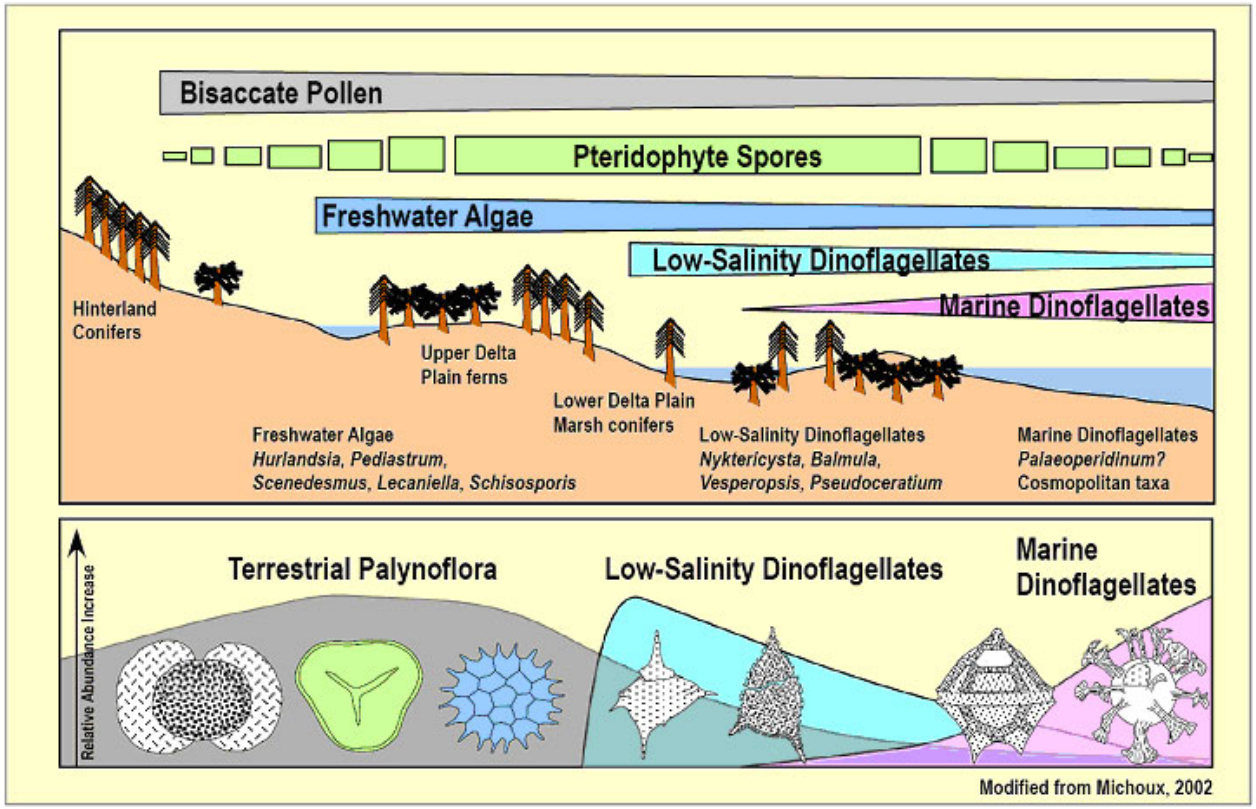

Figure 2. Idealized distribution of palynoflora from hinterland, through tranisitional and into marine paleoenvironments. Upland paleoenvironments are dominated by terrestrial palynoflora: bisaccate pollen, pteridophyte spores (e.g. trilete spores) and freshwater lacustrine algae (e.g. Pediastrum). Low-salinity dinoflagellates (e.g. Vesperopsis, Pseudoceratium) represent the landward encroachment of marine (tidal) waters, and marine dinoflagellates (e.g. Palaeoperidinium, and other cosmopolitan forms) are abundant in offshore, neritic paleoenvironments and deeper. Distribution and relative percentages of these palynofloral groups within these paleoenvironments may be altered by factors such as climate, increased fluvial activity, and changes in sea-level. Paleoenvironments with low-salinity dinoflagellates are those envisaged for much of the deposition of the McMurray Formation at Surmont. Diagram modified from Michoux (2002).

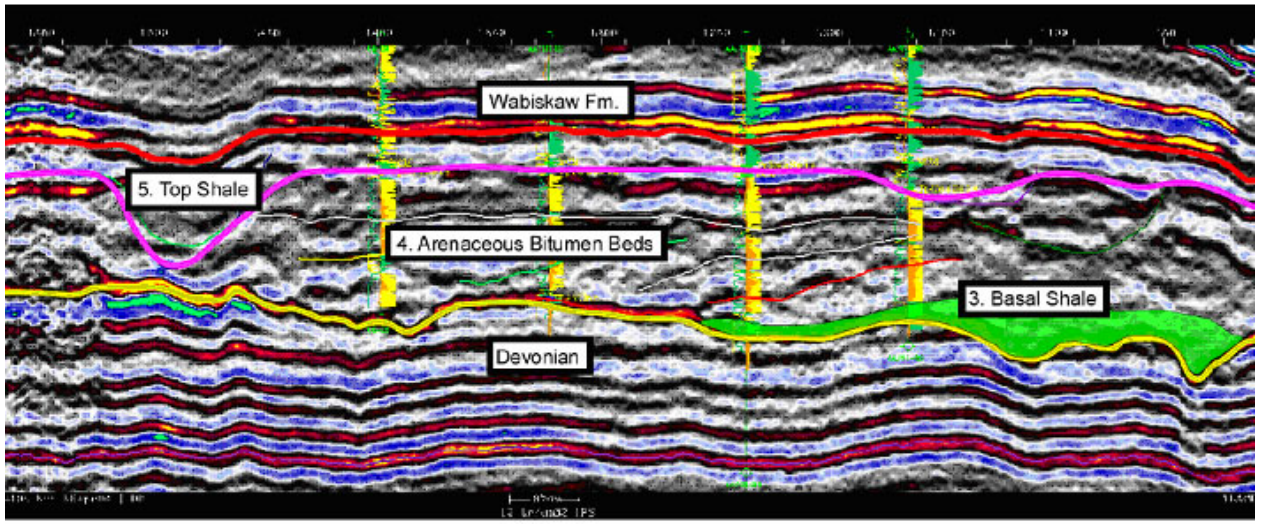

Figure 3. Random seismic line through the Surmont area, annotated with the identified palyno-chronostratigraphic units calibrated to seismic interpretations. Lowermost units 1 and 2 are not present. The Basal Shale (in shaded green) is locally present in low-lying topography immediately above the Devonian unconformity (in yellow). Thick bitumen-saturated arenaceous beds are predominant: note the interpretation of the inclined reflectors possibly representing tidal channels. Such a determination would be confirmed by the presence of low-salinity (brackish) dinoflagellates in the corresponding palynofloral assemblages. The Top Shale (in pink) is locally thick, cutting down almost to the Devonian unconformity. The entire region is then unconformably overlain by strata of the Wabiskaw Formation (in red).

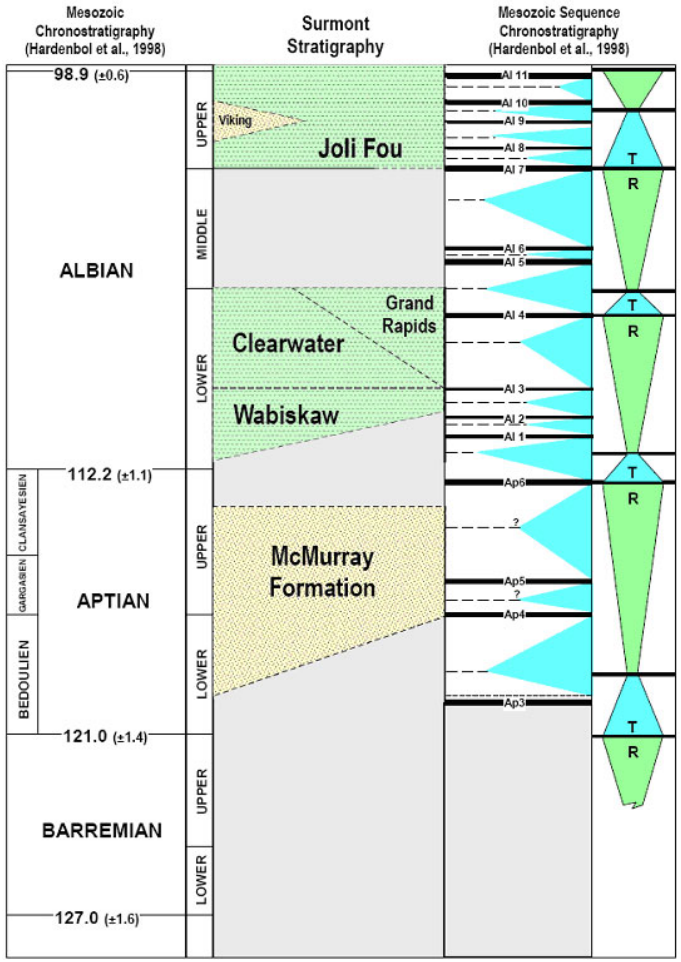

Figure 4. Schematic chronostratigraphy of the McMurray Formation at Surmont as derived from aspects of the palynostratigraphy. Ages are derived from rare diagnostic dinoflagellate species as well as calibration of candidate maximum-flooding surfaces to the sequence chronostratigraphy. Ages for stratigraphy overlying the Wabiskaw are derived from literature sources.