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MIDDLE DEVONIAN FACIES BELTS, MACKENZIE CORRIDOR

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Preamble

Sediments illustrated on this map range from Lower to Upper Devonian, however, the emphasis is on the Middle Devonian section, hence the title.

The older literature of Devonian rocks of this northern area appeared to reflect an almost incredible stratigraphic complexity. This was especially so in the Norman Wells and Pine Point areas prior to the publications by Bassett (1961) and Skall (1975). Northern Devonian strata can all be fit into an elegantly simple depositional model. Because a conceptual model inevitably influences how markers are picked, how nomenclature is applied, and maps are drawn, that model must be explained. Once that is done, whether or not the reader agrees with all aspects of the model, the pictorial material should be self-evident.

This map is an adjunct to two other Open File reports: No. 761, the barrier complex and No. 1228, the Kee Scarp play (Williams, 1981, 1985).

Depositional model

Late Eifelian to Early Frasnian rocks of western Canada record a major transgression, a major regression, and the beginning of another major transgression. These terms 'transgression' and 'regression' are here used as shorthand for speed-up and slow-down, respectively, of the rate of apparent sea level rise (or apparent subsidence). It is assumed that these major events were related primarily to changes in the rate of cratonic subsidence and that eustatic effects were of secondary importance. Although no proof is available, the transgressions are believed to be brief events compared with the regressive interlude.

In areas dominated by carbonate deposition, which is what we are concerned with here, a transgression could result in one of two possible effects: 1) drowning or 2) keep-up sedimentation (after Schlager, 1981; for present purposes, I include 'catch-up' with 'keep-up'). The terms 'drowning' and 'keep-up' mean just what they say. In

certain areas, for reasons unknown, carbonate production could not keep up with accelerating sea level rise; the result - a drowned blanket of carbonate below an ever-deepening column of water with little or no sedimentation. In other areas carbonate production did keep up, maintaining the sediment/water interface at or near sea level. Such keep-up areas, if large, became carbonate banks or barriers, if small, became pinnacle reefs or small banks.

During a regression or times of slow subsidence, carbonate keep-up areas may show little change in the nature of accumulating sediments, perhaps a higher proportion of inter- or supratidal strata. Of course, over or on the flanks of active arches, the net result of arching plus slow cratonic subsidence might be uplift, erosion, or nonmarine deposition. During regressions, by and large, the action shifts to the drowned areas. Carbonate banks, lacking much room to grow vertically, grow laterally, creeping seaward over their own talus. Or, in areas near the source of terrigenous clastics, shallowing-upward, seaward prograding clastic banks will spread into the drowned area. Where such clastic banks reach a thickness which puts their tops within the euphotic zone, carbonate deposition may become reestablished.

The three major events, named after well known formations in Alberta were, oldest to youngest: the Keg River transgression (Keg River barrier and reefs), the Watt Mountain regression (widespread karsting, erosion, the Gilwood nonmarine sandstone), and the Swan Hills transgression (Swan Hills reefs). The Swan Hills transgression continued well into Frasnian time, its end being marked by the regressive Cooking Lake carbonate.

THE MODEL APPLIED TO GIVETIAN ROCKS NORTH OF 60°N

Keg River transgression

The onset of the Keg River transgression resulted in the drowning of the Hume-Nahanni-Lonely Bay platform carbonate over most of the map area. Much of this vast

platform eventually sank out of sight, below the photic zone, and remained virtually starved of sediment through the entire Givetian and much of the Frasnian Stages.

The main keep-up area is in the south - the great Keg River barrier complex. The preserved extent of this barrier is some 800 km from Great Slave Lake to the Rocky Mountains in British Columbia. About half of the barrier lies north of 60°. Smaller keep-up areas were the Deep Bay bank and the ten known Horn Plateau reefs; these all occur within a ±150 km wide belt seaward of the main barrier. Two other such reefs are known: the Root River reef (63°, 125°) and the Manitou reef (66°20', 129°). No doubt there are others.

Watt Mountain regression

The sedimentary response to the Watt Mountain regression varied greatly over the map area. As the regression began most of the area was an open sea, several tens of metres to a hundred or more metres deep, over the drowned Hume-Nahanni platform. The western part of this sea remained starved of sediments; Givetian strata, if present, are within the basal beds of the bituminous shales known as Western Canol or Horn River fondofacies.

The northeastern part of this sea was invaded by fine terrigenous clastics. By Givetian time the delta front of the great Devonian clastic wedge of the Franklinian Trough had prograded westward to a point near Banks Island (see Fig. 15 of Embry and Klovan, 1976, specifically the Weatherall/Hecla transition belt). The Hare Indian mud bank (clinofacies) was a prodeltaic lobe, the advance party, so to speak, of this clastic invasion. Only the western part of this lobe remains, the eastern part has been destroyed by erosion. The southern tip of another lobe is preserved southwest of the McConnell Range (64°, 124°). Very little terrigenous material reached farther south.

There is no evidence that the Hare Indian mud bank ever stood above sea level, however it did reach the intertidal zone. Wave action produced the sorted fine sands of the Charrue sandstone and other Charrue-like lenses of uppermost Hare Indian

strata. Over part of the mud bank carbonates formed, the basal non-reefal part of the Kee Scarp limestone.

The southern part of the map area, including most of the area covered by the Keg River barrier, was mildly positive through lower and mid-Paleozoic time; this is the Tathlina Arch. Probably all of the main transgressive seas of Paleozoic time inundated the entire arch, only to have their sediments stripped away during the succeeding regressions. This certainly happened in Givetian time (see Williams, 1984, Question 3).

Over the Givetian apex of the arch (a gentle arc between Tathlina and Trout Lakes) uplift was in the vicinity of 100 m and the seaward edge of the Keg River barrier was eroded off during the Watt Mountain regression (section DD'). Uplift on the flanks was much less, but the entire barrier and back-barrier belts were exposed and extensively karsted (section CC').

Concurrent with the erosion and karsting of the barrier, sedimentation continued along its seaward margin, including the Cordova Embayment. Being remote from the source area of terrigenous clastics, most of the detrital material was derived locally; the Slave Point/Sulphur Point carbonate tongue (sections CC' and DD') prograded seaward over their own talus mixed with what little terrigenous material was available. The basal part of this Slave Point/Sulphur Point carbonate tongue is the same age, and is analogous to the basal part of the Kee Scarp limestone (section BB').

The tops of some, perhaps all, of the Horn Plateau reefs must have been exposed, eroded and probably corroded by fresh water during the Watt Mountain regression [see Fuller and Pollock (1972), for a review of the evidence for deep weathering].

Swan Hills transgression

The most dramatic sedimentary response of this transgression was the development of the Kee Scarp reefs in the Norman Wells area. The foundation for the reefs, which had developed during the Watt Mountain regression, was the Hare Indian

mud bank with its capping of Kee Scarp platform limestone. After growing to heights of up to 260 m the reefs were drowned. Debris from the reefs, mixed with the deep-water shales of the Eastern Canol Formation, yield fossils that span the Givetian/Frasnian boundary (see Figure 5, Johnson et al., 1985).

Over most of the map area west and south of the Hare Indian mud bank the transgression left no detectable sedimentary record. The area remained drowned and starved of sediment.

In the southern part of the map area the Swan Hills transgression resulted in the deposition of, then the drowning of, the Slave Point Formation. No large reefs comparable with the Swan Hills or Kee Scarp reefs are known, however there may have been some incipient reef growth along the seaward rim of the Slave Point/Sulphur Point carbonate bank. This is shown diagrammatically on section CC'.

Nomenclature

Readers familiar with the literature will notice that several well known formation names are not used. Without going into historical details, certain names have evolved in a way to render them useless or misleading. The list includes:

Pine Point Formation or Group - has been applied to several different time-slices of both barrier and fore-barrier sediments.

Presqui'ile Formation - now known to be a metasomatic dolomite of no particular age or facies significance (Skall, 1975).

Ramparts Formation - as recently redefined by Pugh (1983) this term now includes the Kee Scarp (as used herein), most of the Hare Indian clastics, as well as the post-Hume reef in the Fort Good Hope area.

Some formation names require a modifier to make their meanings clear:

Sulphur Point Formation - this name is so firmly established in Alberta that its use will continue even though, as shown by Skall (1975) it is older than, and unrelated to the Sulphur Point type section. The former can be designated

Alberta Sulphur Point (or Bistcho Member of the Muskeg Formation), the latter is included in the expression Slave Point/Sulphur Point, as shown on sections CC' and DD'. There is no regionally mappable break within the carbonate unit.

Horn River Formation - the terms, fondo facies or clinofacies define two units of different thickness, lithology and age. The fondo facies is thin, bituminous shale, largely of Frasnian age; the clinofacies is thick, contains limestone beds, and is largely of Givetian age (Williams, 1983).

Canol Formation - Given the depositional model outlined previously the Canol shales are a deep water fondofacies with diachronous upper and lower boundaries. Being a starved basin deposit, either local or widespread hiatuses are to be expected, both below and within the unit. The age of the basal Canol beds could be as old as Eifelian over parts of the western map area, where they directly overlie the Hume Formation. However, to many geologists the term 'Canol' implies a post-Kee Scarp age, in accordance with the original definition (Bassett, 1961). To try to avoid ambiguity the terms 'eastern' or 'western' have been appended. As used on the cross-sections, the term 'Eastern Canol' means the black shale overlying the Kee Scarp or Hare Indian formations. The term 'Western Canol' is used beyond the limit of recognizable Hare Indian shale; the Western Canol is analogous to the Horn River fondofacies. The term 'Canol-like shale' (Lenz, 1972) is useful in those areas where a black bituminous shale, commonly quite thick, is known or suspected to include strata that are older than the Hume Formation.

Significance of the isopachs

From isopachs of some formations one may deduce the pattern of syn-depositional tectonic warping; 'thicks' were basins, 'thins' were arches. Given the depositional model previously expounded, with the phenomena of lateral accretion of the clinofacies, and the fondothem origin of the thin bituminous facies, one cannot make such simplistic deductions in the case of this map. Clastic mudbanks (clinofacies) may

have been localized by a number of factors, including proximity to the source, wind and water currents and the presence or absence of sediment traps, which may, or may not be of tectonic origin. The thickness of fondoform muds settling in deep quiet water could be largely independent of bottom topography.

In my opinion, based more on intuition than evidence, the following factors contributed to the isopach pattern:

1) Proximity to clastic source. This factor exerted the dominant influence on the location of the Hare Indian mudbank. A secondary influence may have been the Keele Arch (Cook, 1975) whose eastern flank approximately coincides with the eroded eastern limit of the Hare Indian Formation north of 66°N.

2) Sediment traps created by reentrants along the Keg River bank. This was the dominant factor in the case of the Utahn Embayment in British Columbia and the Cordova Embayment (~60°N, 120°W). The Great Slave Lake area was probably an embayment; however, the northeastern part of this carbonate rim has been destroyed by erosion (see Fig. 3B of Williams, 1984). Each of these physiographic sediment traps were slightly negative through Middle Devonian time; there probably was a cause and effect relationship here, the carbonate bank tended to fringe the sub-basins, creating the reentrants.

3) Tectonic traps. The Mackenzie Plain is a graben-like depression between the Franklin and Mackenzie Mountains. A study of Lower Paleozoic sediments suggests that this has been a long-lasting negative belt probably containing a network of grabens or half-grabens (report in preparation). The lobe of thick Hare Indian shale in this area (centered ~60°20'N, 124°W) may be in part a result of tectonism. The unusually thick Horn River

fondofacies in the Pointed Mountain area (~60°20'N, 124°W) remains unexplained; a local downwarp is one tenable explanation, time is another.

4) Time. The Canol-like shales of the western part of the map area represent a time span from Eifelian, possibly Emsian, until well into Late Devonian (Lenz, 1972, p. 351). In contrast, the western and eastern Canol represent a much shorter time span.

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