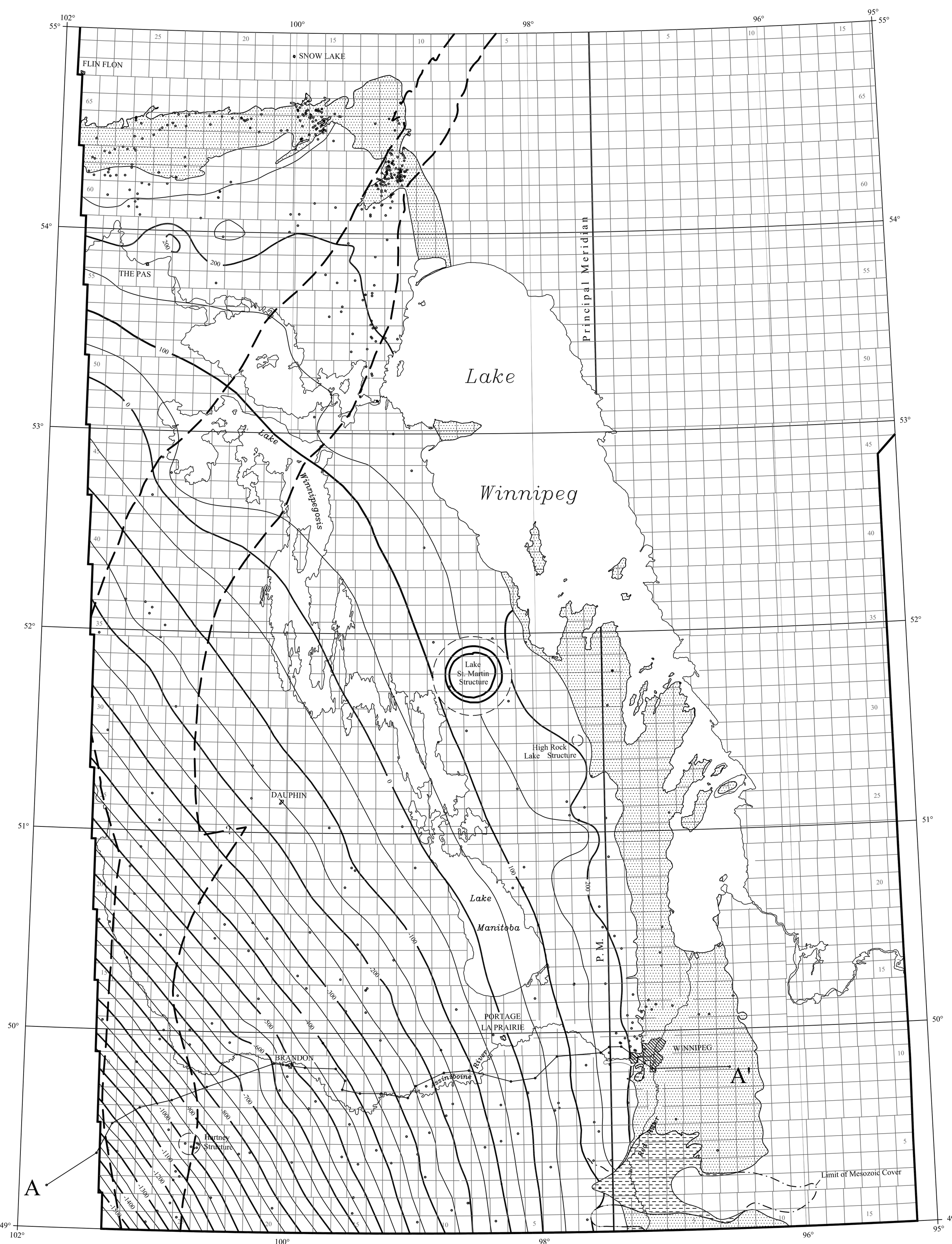
Manitoba
Energy and Mines
Geological Services Branch

GEOLOGY OF THE ORDOVICIAN RED RIVER FORMATION IN MANITOBA

Stratigraphic Map Series ORR-1



Structure Contour Map
1 : 2 000 000

0 25 50 75 100 km

RED RIVER FORMATION

Geological Framework

Ordovician carbonates were part of a large depositional province that extended from the Hudson Platform to the east and northeast, to New Mexico to the south (Norford *et al*., 1994). The Lower Ordovician shelf craton was emergent at that time. In mid-Upper Ordovician time, a major transgression inundated the entire continental area. The Red River Formation consists predominantly of carbonates (dolomites, dolomitic limestones, and minor limestones), although thin anhydrite units can occur in the subsurface within the upper Red River Formation (Fort Garry Member). Minor terrigenous material may be present locally in the basal Red River Formation (Dog Head Member - Hecla Beds). The Upper Ordovician transgression allowed for the deposition of burrow-mottled carbonates (lower Red River). The upper Red River is represented by three carbonate-evaporite cycles consisting of a basal, thin, argillaceous dolomite, overlain by fossiliferous mudstones/wackestones (commonly burrowed and dolomitized), laminated dolomite, and a capping anhydrite (Kendall, 1976). These evaporites are restricted to the central parts of the Williston Basin and can be present in south-western Manitoba. The regional isopach pattern of the Red River Formation reflect basin subsidence and is generally concentric to the Williston Basin. However, in Manitoba, the isopachs of the Red River Formation are east trending probably as a result of a higher rate of subsidence in the Manitoba portion of the Williston Basin.

The Red River Formation outcrop belt extends from the International Boundary, north through the Interlake area, north of Lake Winnipeg and swings west to the Manitoba-Saskatchewan border. Type outcrop sections occur along the outcrop belt, especially north of the City of Winnipeg and along the west shore and islands of Lake Winnipeg. Other exposures of the Red River Formation occur in building stone and aggregate quarries in Manitoba's Interlake area and areas east of the City of Winnipeg. The remainder of the unit is in the subsurface.

Stratigraphy

In Manitoba, the Red River Formation is divided into four members, where discernible. They are, in ascending stratigraphic sequence: the Dog Head, Cat Head, Selkirk (informally grouped as the lower Red River = Yeoman Formation in Saskatchewan), and Fort Garry (informally termed the upper Red River = Herald Formation in Saskatchewan) members. Red River Formation strata sharply overlie sandstones and shales of the Winnipeg Formation with apparent conformity. To the north, the formation oversteps the Winnipeg Formation and lies unconformably on the Precambrian. Generally, the basal Red River Formation contains argillaceous interbeds of Winnipeg-type lithology, termed Hecla Beds by Fuller (1961), and represents a transitional zone between the two formations (McCabe, 1978). The Red River Formation is overlain sharply and with possible slight disconformity, by shaly or carbonate beds of the Stony Mountain Formation.

Lower Red River strata consist of a light grey to yellowish-and-brownish-buff, mottled, fossiliferous, dolomitic limestones. The darker brownish mottles consist of almost pure, finely crystalline, granular dolomite, whereas the lighter grey to buff patches are fossiliferous limestone (wackestone). Prominent fossils within the lower Red River include Receptaculites and Maclurites, although crinoids, corals and brachiopods occur as debris.

In the outcrop belt, the lower half of the Fort Garry Member consists of crypto-crystalline, dense, sublithographic dolomite and the upper half consists of fine crystalline, sparsely fossiliferous, cherty dolomite. These two units are separated by beds of argillaceous dolomite breccias, which may be evaporite solution beds. High-calcium limestone beds occur sporadically at the top of the member to the south. The uppermost high-calcium limestone bed probably represents the Hartaven Member (Stony Mountain Formation) in Saskatchewan and southwest Manitoba. To the north the member becomes more argillaceous.

The transition between the lower Red River and Fort Garry Member is subtle and, therefore, difficult to ascertain in drill core. Kendall (1976) implies that there was no break in sedimentation.

The maximum thickness of the Red River Formation (ca. 178.9 m) occurs near the International Boundary and thins to approximately 40 m in the north (about 13 %/100 km) (Bezys and McCabe, 1996). The thinning is accompanied by a lithological change from dolomitic limestone in the south to dolomite in the north. It is not clear if the lithologic change in the lower Red River carbonates is due to primary lithofacies variation related to basin differentiation, or if it results entirely from secondary diagenetic effects.

The regional depositional (isopach) trends for Ordovician strata in southwestern Manitoba are approximately east-west to slightly northeast. This trend is markedly discordant to the present structural trend, and to the overall Williston Basin depositional trends. This may be the result of a higher rate of subsidence in the Manitoba portion of the basin. There are slight structure contour deviations along the trend of the Churchill Superior Boundary Zone (Birdtail-Waskada Axis in southwestern Manitoba).

Economics

The Red River Formation carbonates show considerable variation in porosity from good to non-porous. Oil staining in the formation has been reported in 4 wells: 16-33-4-13W (Dome *et al* Greenway), 8-36-8-14W (CEGO Glenboro Prov.), 8-20-9-6W (B.A. Morisseau, 1-27-17-26W (Imperial Birtle). Production from the formation is obtained in North Dakota, Montana and Saskatchewan wells. Four porosity zones exist in the formation that can be traced over much of Manitoba and are referred to as the upper zone and units "A", "B", "C" (Sproule *et al* , 1964). These zones are not continuously porous, but are persistent zones in which porosity may be developed and should be considered as prospective.

The best prospects for oil production in the Red River Formation in Manitoba occur along the trend of the Birdtail-Waskada Axis. It provides the structural relief that may be associated with coincident stratigraphic traps. A strong gravity high along the Birdtail-Waskada Axis, with a coincident magnetic high, may also provide possible structural discontinuity within Paleozoic strata (McCabe, 1967). Recent re-interpretation of seismic data from southwestern Manitoba indicate that the Devonian Prairie Evaporite dissolution edge is coincident with faulting emanating from the Precambrian (along the trend of the Birdtail-Waskada Axis), which could result in the local development of a porous dolomitized zone (such as the Minton pool in Saskatchewan (Dietrich *et al*., 1997)). Source rocks in the Red River Formation in Saskatchewan come from kukersites, a lime mudrock composed predominantly of Gloecapsomorpha prisca alginite (Osadetz and Snowden, 1995). These beds have limited distribution and thickness, but they persist across a large area. Some beds are bioturbated and where bioturbation is complete, it destroys the kukersite and the rock is identical to "Tyndall Stone" (Selkirk Member).

In Manitoba, carbonate outcrops have been used extensively as a source of crushed stone, although Red River Formation quarry operations have been few. A few operations have developed to the north of the City of Winnipeg, east of Selkirk, but as suitable Stony Mountain Formation rock exists in the towns of Stonewall and Stony Mountain. The Red River may be utilized in the future as these other sources are diminished.

For nearly a hundred years, portions of the upper part of the Selkirk Member have been used as an ornamental building stone (Tyndall Stone). The stone graces several provincial legislatures, (including Manitoba's), the Parliament Buildings in Ottawa, the Museum of Civilization in Hull, and many other buildings. The source of this stone is the Gillis Quarry at Garson (40 km northeast of Winnipeg).

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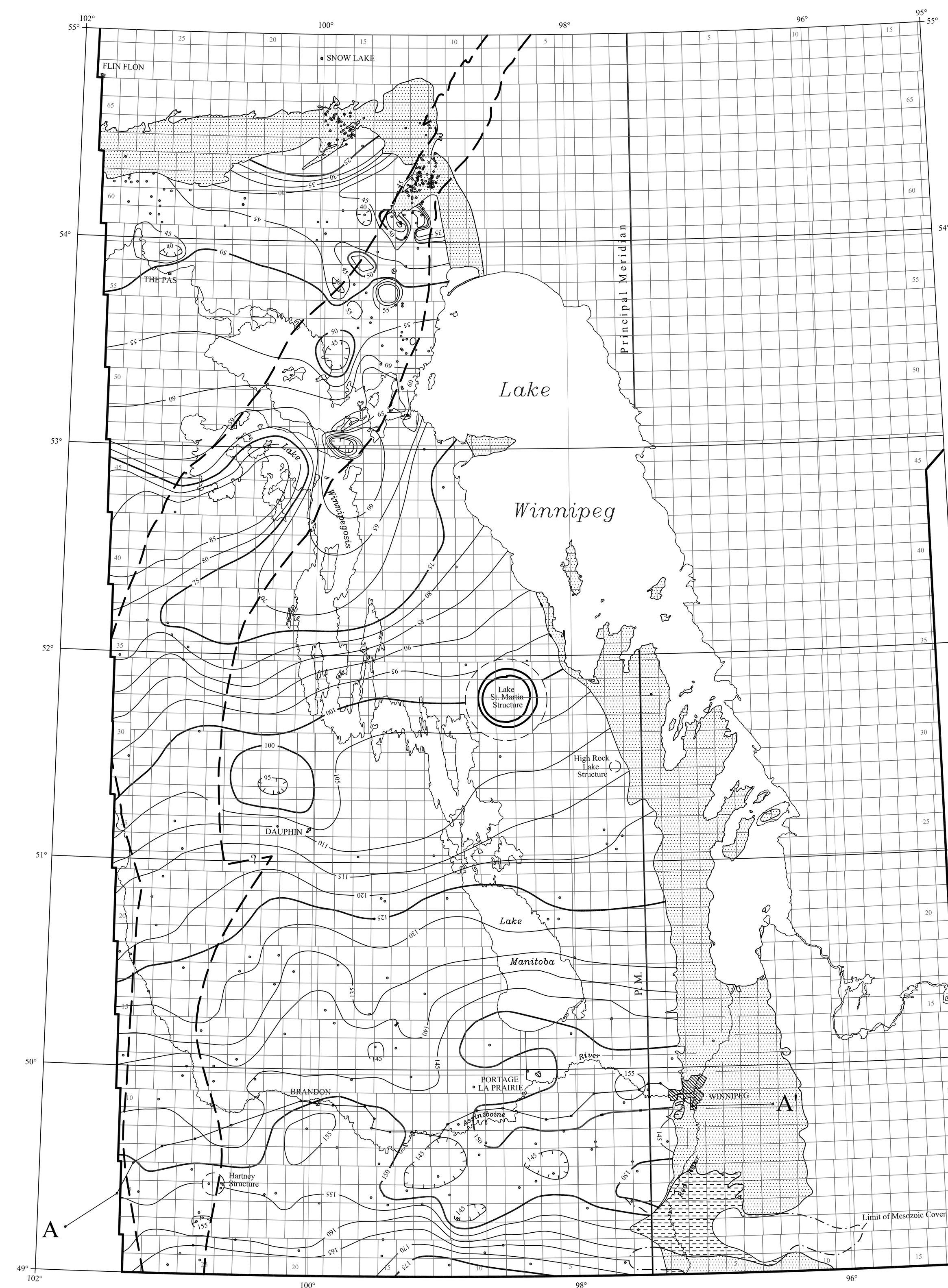


Isopach Map
1 : 2 000 000

0 25 50 75 100 km

LEGEND (1 : 2 000 000 maps)

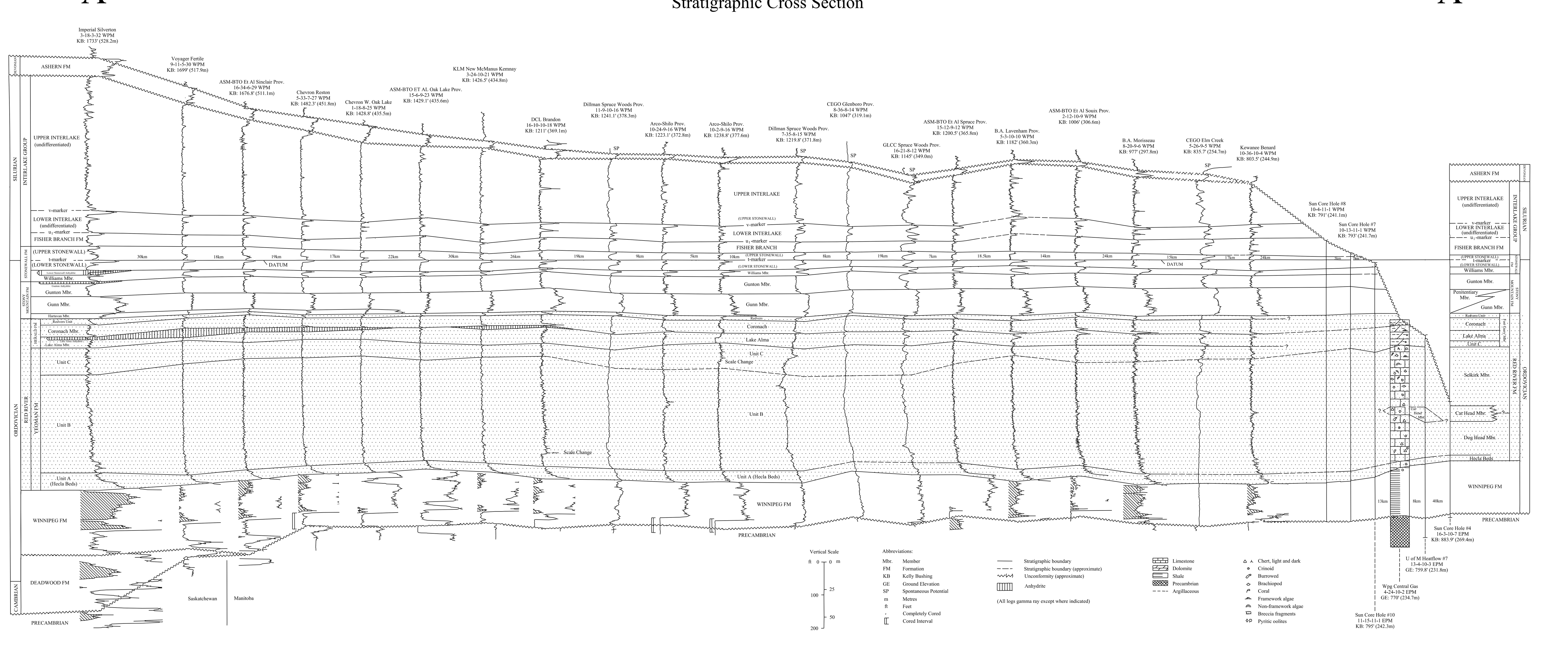
- Red River outcrop belt
- Red River subcrop belt
- Control well *
- Isopach Map contour interval (5 m)
- Structure Map contour interval (50 m) (sea-level datum)
- A A' Stratigraphic cross section
- Churchill Superior Boundary Zone

* Both confidential and non-confidential wells were used in the construction of these maps; only non-confidential wells are depicted.

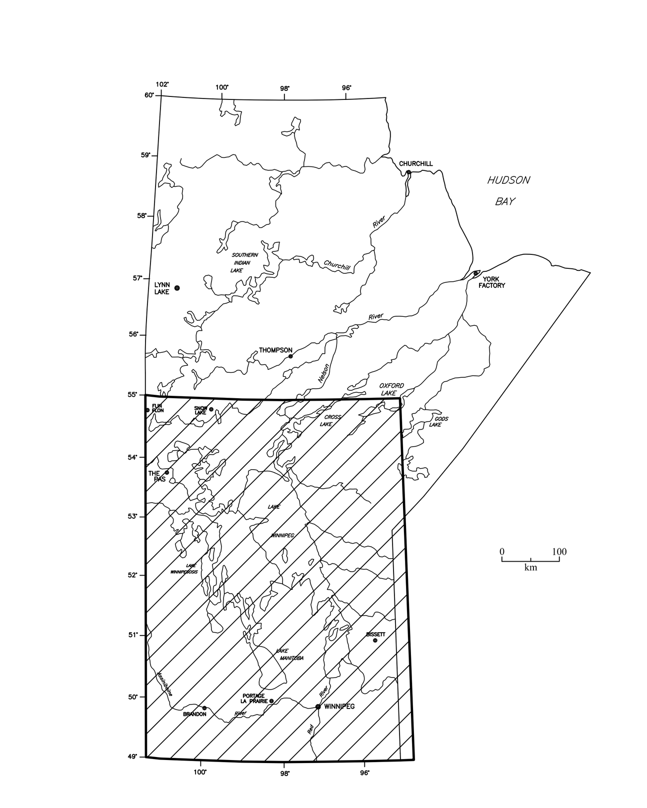
A

Stratigraphic Cross Section

A'



Location Map



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Compilation by: R.K. Bezys and G.G. Conley
Cartography by: M.E. McFarlane

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