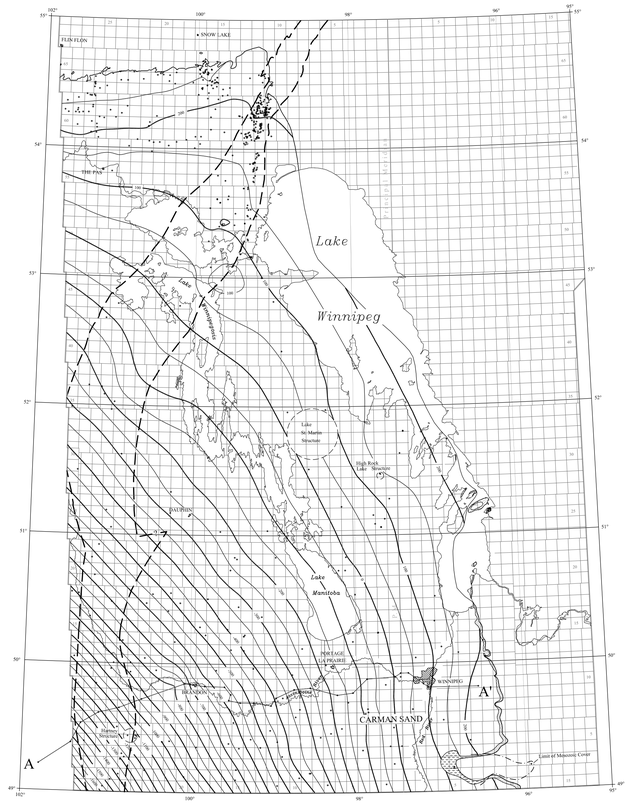
Manitoba
Energy and Mines
GEOLOGICAL SERVICES BRANCH

GEOLOGY OF THE ORDOVICIAN WINNIPEG FORMATION IN MANITOBA

Stratigraphic Map Series Ow-1

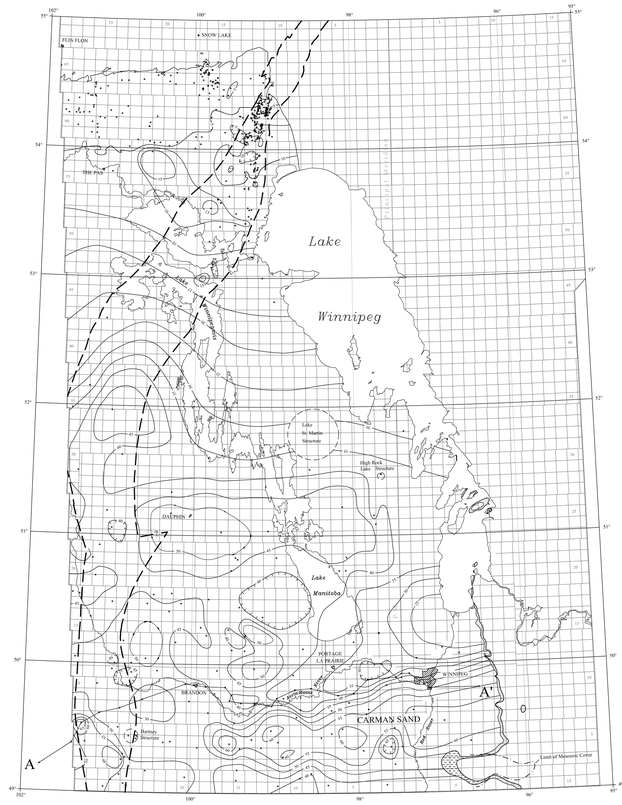
Structure Contour Map



0 25 50 75 100 km

1 : 2 000 000

Isopach Map



0 25 50 75 100 km

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WINNIPEG FORMATION

Geological Framework

The Winnipeg Formation consists of a complex sequence of interbedded sands and shales, ranging in composition from more than 90% shale to more than 90% sand. Deposition occurred in shallow marine seas during Middle Ordovician time and maximum deposition occurred in northwestern North Dakota.

The Winnipeg Formation is an erosionally isolated element of the eastern North America cratonic platform succession deposited across the Transcontinental Arch (Osadetz and Haidl, 1989). The lowermost Winnipeg Formation was deposited in a deltaic environment during a major transgressive event where the maximum amount of subsidence had taken place (LeFever *et al.*, 1987). Sea level continued to rise and the deltaic deposits were covered by shallow marine deposits and were eventually covered by marine shales and dolomitic limestone. The Winnipeg Formation outcrops on Hecla, Punk, Black, and Deer Islands and Grindstone and Big Bullhead points on Lake Winnipeg. The remainder of the unit is in the subsurface.

Stratigraphy

The Winnipeg Formation consists of a complex sequence of interbedded sands and shales. The sand is poorly consolidated, medium grained, mature, well rounded and quartzose; the shales commonly are light olive-grey, kaolinitic, with variable sand and silt content. The normal sequence consists of a thin basal sandstone overlain by interbedded sand and shales, with the shale content increasing upwards. Pyritic, phosphatic, and/or limonitic concretions and oolites are common in some zones (Binda and Simpson, 1989).

The Winnipeg Formation overlies, unconformably, the deeply weathered and eroded, peneplained Precambrian basement, except in the extreme southwest corner of the province where a thin wedge of Cambrian Deadwood Formation occurs unconformably below the Winnipeg Formation. It is overlain, conformably, by limestones and dolomites of the Red River Formation. The basal Red River strata contain argillaceous interbeds of Winnipeg-like lithology, and represent a transitional zone between the two formations (Hecla Beds).

The structureless nature of the lower sandstone unit suggests rapid deposition from suspension (Shum, 1990). Episodic sedimentation in calm water is represented by wavy and horizontal laminations. Likewise, fluctuating current conditions are represented by cross stratified sandstone beds. The presence of small brachiopods and limonite and pyrite oolites reflect a shallow marine depositional environment (Cowan, 1971). Three facies are interpreted for the Winnipeg Formation (from north to south): basin margin sand facies; transitional; and offshore mudstone (Vigrass, 1971; McCabe, 1978).

The sand source for the Winnipeg Formation is suggested to be truncated Cambrian clastics on the west and north shores of the transgressing seas (Andrichuk, 1959). The Athabasca sandstone in northern Saskatchewan and the Precambrian Sioux quartzite in the Sioux Arch (South Dakota) have also contributed to Winnipeg Formation sedimentation (Genik, 1954).

The maximum thickness of the Winnipeg Formation (ca. 68.6 m) occurs in southwestern Manitoba. The Winnipeg Formation has been divided into stratigraphic units by Baillie (1952), Genik (1954), and Vigrass (1971). The lowermost unit consists of a basal sandstone unit and one, or two, overlying shale and sandstone units. A formal subdivision of the Winnipeg Formation is not used in Manitoba.

The Carman Sand (see Isopach Map) is a single, continuous, relatively uniform sand body throughout its indicated extent. The maximum thickness of the Carman Sand is 63.4 m and the formation thins to the south and north of the sand body, largely due to the effects of differential compaction, which gives rise to a slight anticlinal flexure over the sand body. The body extends from the outcrop belt just west of the Sandilands Provincial Forest (Range 8 East) to Pelican Lake (Range 16 West) - a distance of 240 km. The width of the sand body ranges from less than 25 km to greater than 95 km. This sand body apparently occurs entirely within the basinal shale facies, although the eastward extent, and the possible relation to an eastern source area, are not known because of erosional truncation of the unit.

The regional depositional (isopach) trends for Ordovician strata in southwest 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. The Winnipeg Formation shows the highest degree of isopach and lithofacies differentiation. It thins irregularly from a maximum thickness of 68.6 m in southwestern Manitoba to zero at its northern limit occurrence, a thinning of at least 17%/100 km. The thinning is accompanied by an irregular lithofacies change from dominantly shale in the south to almost totally sandstone in the north. The isopach pattern is complicated by the effects of differential compaction associated with complex local lithofacies changes.

The regional isopach pattern of the Winnipeg Formation reflects basin subsidence and is generally concentric to the Williston Basin. However, in Manitoba, the isopachs of the Winnipeg Formation are east-trending, probably as a result of a higher rate of subsidence in the Manitoba portion of the Williston Basin.

Economics

Eight oil and gas shows in the Winnipeg Formation have been reported in Manitoba: 1-28-1-2W1 (CEGO Gretna), 5-13-5-22W1 (S.V. Warnez), 3-18-8-18W1 (Chevron Wawanesa), 15-18-10-27W1 (Calstan Daly), 3-17-12-24W1 (Imperial Blossom), 3-19-13-15W1 (Cdn-Sup Hockin Haliboro), 8-34-16-21W1 (Dome Strathclair), 16-18-18-29W1 (Imperial Madeline), (Andrichuk, 1959).

Available data indicate a relatively low value for source rock potential in Winnipeg strata in the Manitoba portion of the Williston Basin, but data from deeper areas of the Williston Basin indicate that the shales of the Winnipeg Formation are source rocks in some parts of the basin (McCabe, 1978). The sparsity of oil shows and lack of production from the Winnipeg Formation, on both a local and regional basis, is a negative factor. On a positive note, excellent reservoir beds are present along with complex facies changes, and several areas of possible stratigraphic entrapment can be delineated. Data are not sufficient to determine if stratigraphic closure does occur. No structural are known, but geophysical (magnetic and gravity) anomalies along the Birdtail-Waskada Axis (Churchill Superior Boundary Zone) offer potential structural/stratigraphic targets. 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 (Dietrich *et al.,* 1997). Only a few holes have been drilled specifically to test the Winnipeg Formation, and the sparcity of oil shows reflects, in part, this lack of selectivity in drilling targets.

Silica sand from the Winnipeg Formation was extracted at Black Island (Lake Winnipeg) and used as foundry sand. It has been used for glass manufacturing and has the potential to be a source for silicon metal.

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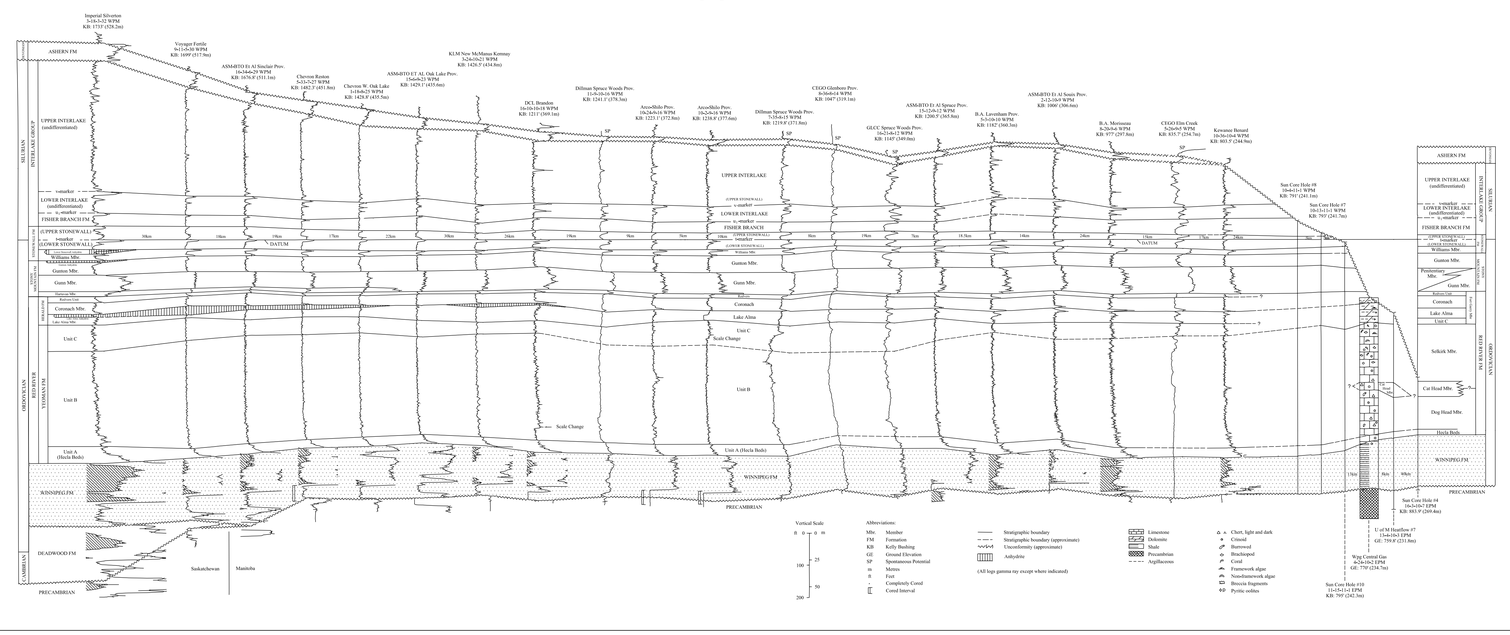
LEGEND (1 : 2 000 000 maps)

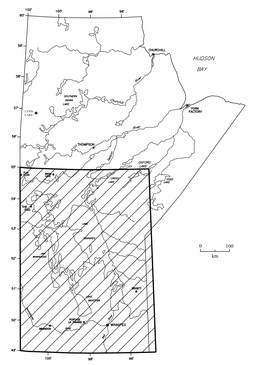
- Winnipeg outcrop belt
- Winnipeg subcrop belt
- Control well *
- Isopach Map contour interval (5 m)
- Structure Map contour interval (50 m) (sea-level datum)
- A A' Stratigraphic cross section
- Churchill Superior Boundary Zone

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

Stratigraphic Cross Section



Location Map



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

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