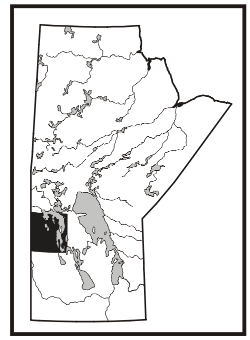
GS-34 SALINE SPRING GEOCHEMISTRY, WEST-CENTRAL MANITOBA

by S.E. Grasby[1]



Grasby, S.E. 2000: Saline spring geochemistry, west-central Manitoba; *in* Report of Activities 2000, Manitoba Industry, Trade and Mines, Manitoba Geological Survey, p. 214-216.

SUMMARY

Saline spring waters have been sampled along the west shore of Lake Winnipegosis. Preliminary results suggest Pleistocene glaciation had a significant impact on the regional flow system of the Paleozoic aquifers in the area.

INTRODUCTION

The carbonate rock aquifer constitutes the fresh water–bearing portion of the Paleozoic outcrop belt in southern Manitoba, and is a principal groundwater resource for Manitoba. Over the last three years, the Geological Survey of Canada, in co-operation with Manitoba Water Resources and the Manitoba Geological Survey, has conducted a regional assessment of the hydrogeology and hydrogeochemistry of the aquifer. The fresh water–bearing portion of the aquifer is bounded on the east by the erosional limits of the Paleozoic outcrop belt, and on the west by a hydrological divide defined by the Rat, Red and Assiniboine rivers, and lakes Manitoba and Winnipegosis. West of this divide, the salinity of waters rapidly increases to that of typical formation waters in the Williston Basin. Potential eastward migration of these saline brines would threaten the long-term stability and quality of the fresh water–bearing portions. The purpose of this study was to conduct a geochemical and stable-isotope analysis of brine waters in order to understand better their origin and how they relate to the regional flow system. The saline springs along the west shore of Lake Winnipegosis offer the easiest means of sampling these waters.

HISTORICAL PERSPECTIVE

The earliest reports of saline springs in Manitoba are from the journals of La Verendrye in the early 1700s. By the early 1800s, there are records of salt-production operations in the area. Although providing an important source of salt for early settlers, these operations had been abandoned by the 1880s due to competition from rock salt being shipped by rail from Ontario (Petch, 1990).

There is little previous work on the saline springs of Manitoba. The first chemical analyses were reported by Tyrrell (1892). Since then, they have been sampled by Stephenson (1973), van Everdingen (1971) and Wadien (1984). However, water chemistry and stable-isotope data from these studies is either not complete, inaccessible or limited to a minor number of springs. Geochemical sampling of precipitates from many of these sites has been conducted by Bezys et al. (1997).

REGIONAL DISTRIBUTION

The regional distribution of saline springs in Manitoba is depicted in Figure GS-34-1. Most sites have been found either through historical

[1] Geological Survey of Canada, 3303 33rd St. NW, Calgary, Alberta T2L 2A7

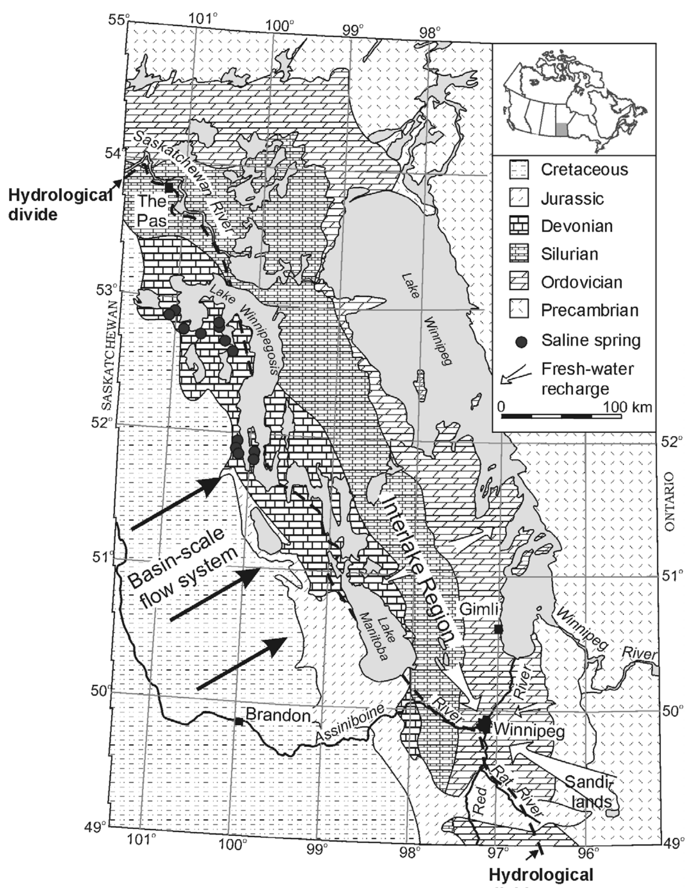


Figure GS-34-1: Regional map showing known locations of saline springs.

records or by use of airphotos. Spring sites are often readily apparent on airphotos because surrounding vegetation has been killed off by the saline water. To date, more than 65 sites have been identified that have currently flowing springs or show signs of recent activity. Forty-five sites have been sampled to date for water chemistry. It is interesting to note that people living in the Dawson Bay area tell stories of portions of Lake Winnipegosis that do not freeze during the winter and trucks falling through areas of weak ice. This suggests that saline waters may also discharge into the lake, thereby locally reducing the freezing temperature of the water.

There is a marked difference in character in discharge sites going from south to north. In the southern sites, springs are surrounded by grassy meadows or light brown to grey mud. In contrast, springs in the northern part tend to have large amounts of iron staining, forming red mounds around the spring outlet and over an extensive area surrounding it. As well, the northern sites typically have large growths of bacteria mats around the outlets; these are absent in the south.

SPRING CHEMISTRY

Stable-isotope data for the springs are plotted in Figure GS-34-2, along with the global meteoric water line (GMWL). Spring waters tend to plot along the line and are distinctly different from values typical of formation brines observed west of Manitoba (Rostron et al., 1998). This indicates that the saline springs originated as meteoric water. The total dissolved solids (TDS) load of the spring sites is variable and ranges from 2000 to 114 000 mg/l. Springs with the highest TDS are in the Pelican Bay area. Given the meteoric origin of the waters, the high TDS content must then be due to dissolution of evaporite beds. The piper plot in Figure GS-34-3 illustrates that spring waters are all Na-Cl in composition. Figure GS-34-4 shows a good linear correlation between Na and Cl, consistent with dissolution of halite. The variation in concentration is likely a complex relationship involving residence time in the subsurface (dictating the amount of dissolution and water/rock interaction that occurs) and the degree of mixing with shallow groundwaters.

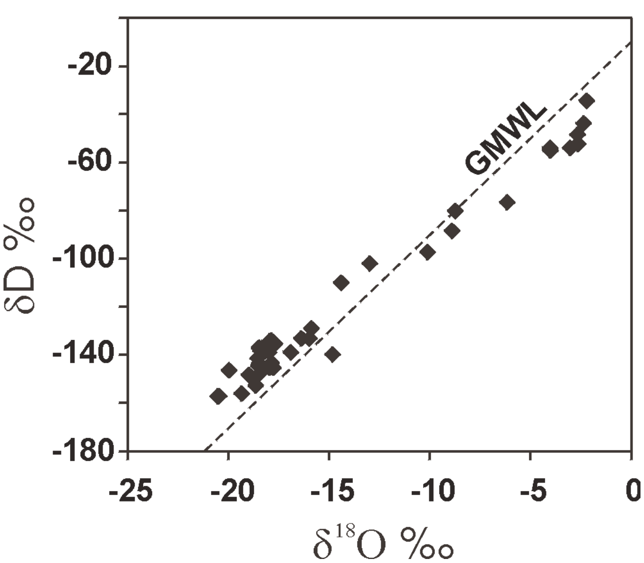


Figure GS-34-2: Plot of δD versus $\delta^{18}O$ for saline spring waters. GMWL, global meteoric water line.

DISCUSSION

An important characteristic of saline spring waters is that they have a stable-isotope signature consistent with meteoric water. This implies that there must have been a large flux of fresh water into the aquifer. Previous models have either interpreted this as local influx of groundwater (e.g. Hitchon, 1969), or basin-scale flow of meteoric waters, from recharge sites in South Dakota, around the edges of basin brines in the

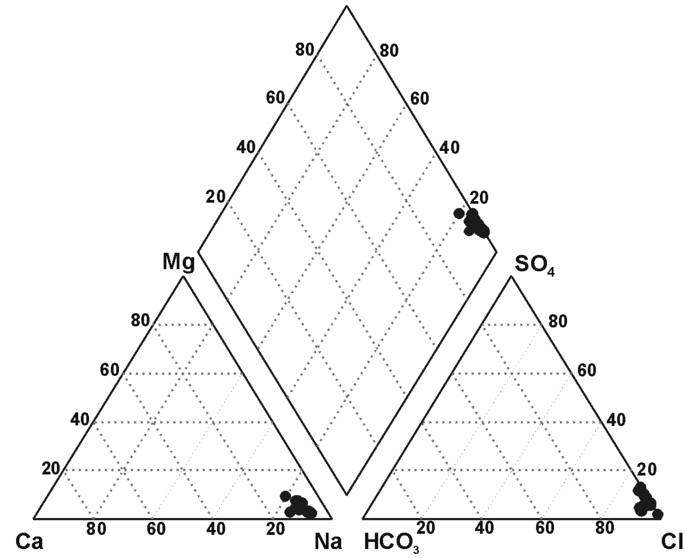


Figure GS-34-3: Piper diagram (in meq/l) showing major-ion composition of spring waters.

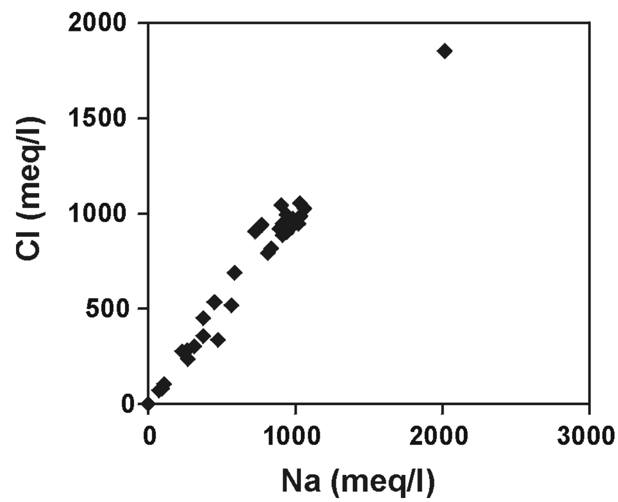


Figure GS-34-4: Plot of Na versus Cl, illustrating a strong linear correlation.

deepest portions of the Williston Basin to discharge sites in Manitoba (e.g. Bachu and Hitchon, 1996). The first model invokes crossformational flow, which tends to have inherently lower permeability than flow along bedding. The second model involves long-range transport of fluids with little or no mixing. As an alternative, Grasby et al. (2000) have suggested that these saline meteoric waters represent a significant influx of glacial meltwater during the Pleistocene. The hydrological head due to overlying ice sheets would have been large enough to drive basal meltwater into the Paleozoic successions that outcrop in southern Manitoba. Grasby et al. (2000) estimated that metlwaters may have reached as far as 300 km into the Williston Basin. Here, the fresh waters would readily dissolved evaporite beds. The retreat of ice sheets would allow the re-establishment of the present southwest to northeast flow system of the Williston Basin (Bachu and Hitchon, 1996), thus pushing the meltwaters back to surface, where they express themselves as the saline springs observed today.

Future work on modelling water-rock interaction and regional hydrodynamics will test this hypothesis.

ACKNOWLEDGMENTS

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