Open File Report OF98-6

Observations on Selenite Distribution within the Lake Agassiz Clay Plain

Manitoba Energy and Mines

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Observations on Selenite Distribution within the Lake Agassiz Clay Plain

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- iceberg scouring
- rockhounding

TABLE OF CONTENTS

FIGURES

INTRODUCTION

Selenite or hydrated calcium-sulphate ($CaSO_4 \cdot 2H_2O$) is the crystallized form of gypsum. In Manitoba, selenite crystals are commonly observed as secondary mineral growths in outcrops of Cretaceous shale in the southwestern part of the province, where they are sometimes referred to as "Manitoba diamonds". Small selenite crystals are also frequently found at shallow depths in glacial tills developed overlying the Cretaceous shale. They are not reported, however, in the tills of the Interlake or southeastern Manitoba that have developed over Precambrian or Paleozoic bedrock terrain. The most notable occurrence of secondary selenite crystals, however, is in the Winnipeg region where selenite rosettes, occasionally more than 10 cm in diameter, have been found within the thick deposits of glacial Lake Agassiz clay.

Selenite crystals have been reported in the Winnipeg region since work began on the Winnipeg floodway in 1959. Selenite crystals were intersected in numerous test holes drilled east of Winnipeg to determine the geotechnical properties of the Lake Agassiz clays (Mishtak, 1961). During the actual construction of the floodway, selenite crystals were unearthed in significant numbers and have been collected by rockhounds ever since. In the Winnipeg area, selenite crystals occur as "rosettes" -many crystals radiating from a common centre. They are transparent, contain few inclusions and range in color from clear, or very pale yellow, to rich amber. The crystals have been commercially exploited for at least the past six years.

The purpose of this open file is to provide a brief discussion on the possible origin of selenite crystals in the Lake Agassiz clays, and provide information on the locations where selenite crystals have been observed during various mapping projects carried out by Manitoba Energy and Mines and the Geological Survey of Canada under Canada's National Geoscience Mapping Program (NATMAP). It should be noted that most of these locations are on private land or along the public road allowance adjacent to private land, and for this reason the appropriate authorizations must be obtained before any exploration is considered. Although the Mining Recording Branch (Manitoba Energy and Mines) considers selenite collecting to be "rockhounding" and, as such, no permits are required, access to private land and permission to work along the road allowance would have to be authorized by the land owner or the regional Department of Highways office. In addition, road allowances often contain buried cables, generally telephone and/or Hydro lines, that have to be located before any digging is done.

DISTRIBUTION

To date, exploration for selenite crystals has generally taken place in the vicinity of known occurrences along the Winnipeg floodway, due primarily to a lack of information on their distribution (G. Hasler, pers. comm., 1998) and the ease of access to this area. In the summer of 1980, the City of Winnipeg Geotechnical Drillhole Database (Reid, Crowther and Partners Limited, 1972) was reviewed, specifically for references to gypsum. Many references to gypsum were found, but no obvious distribution pattern emerged. In addition, the presence of gypsum does not necessarily indicate the presence of commercially viable selenite crystal deposits.

In the summer of 1980 two backhoe pits were dug along the Garvin Road allowance in Birds Hill, 2.0 and 2.4 km east of PR # 207, and large selenite crystals were encountered. In the first hole (UTM zone 14, 650300 east/5537600 north) dug early in the summer, crystals were found at a depth of 2.7 to 5.7 m. The crystals were very pale yellow and generally increased in size with depth. The crystals were pristine, and up to 10 cm in diameter. The second hole (UTM zone 14, 650600 east/5537600 north) was dug in the fall, and was similar to the first hole except that the crystals were deeply etched due to dissolution, possibly indicating some seasonal alteration of the crystals.

In the summer of 1997, 1533 one metre-deep hand-auger holes were drilled in NTS sheet 62H. These auger holes were generally drilled at a one mile (1.6 km) spacing, and the sediments described in detail. At 56 sites, selenite crystals up to 3 mm in length were observed, generally at a depth approaching one metre (Fig. 1). These sites were clustered in a non-random distribution. At an additional 9 sites in the SW quarter of NTS sheet 62I, tiny selenite crystals were observed (Fig. 1). It should be noted that the presence of tiny selenite crystals within one metre of surface does not mean that there will be commercially viable crystals at depth.

ORIGIN OF SELENITE

Studies by Day (1977) and Pach (1994) and numerous local investigations have shown that shallow groundwater in many parts of the clay plain is oversaturated in gypsum, providing conditions suitable for the precipitation of selenite crystals. While numerous studies have noted the widespread distribution of carbonates within the shallow clays, providing a readily soluble source of calcium, the origin of the sulphate is less certain.

Upwelling saline groundwater may form the major source of sulphate to shallow groundwater in some parts of the Lake Agassiz clay plain, however, it is the opinion

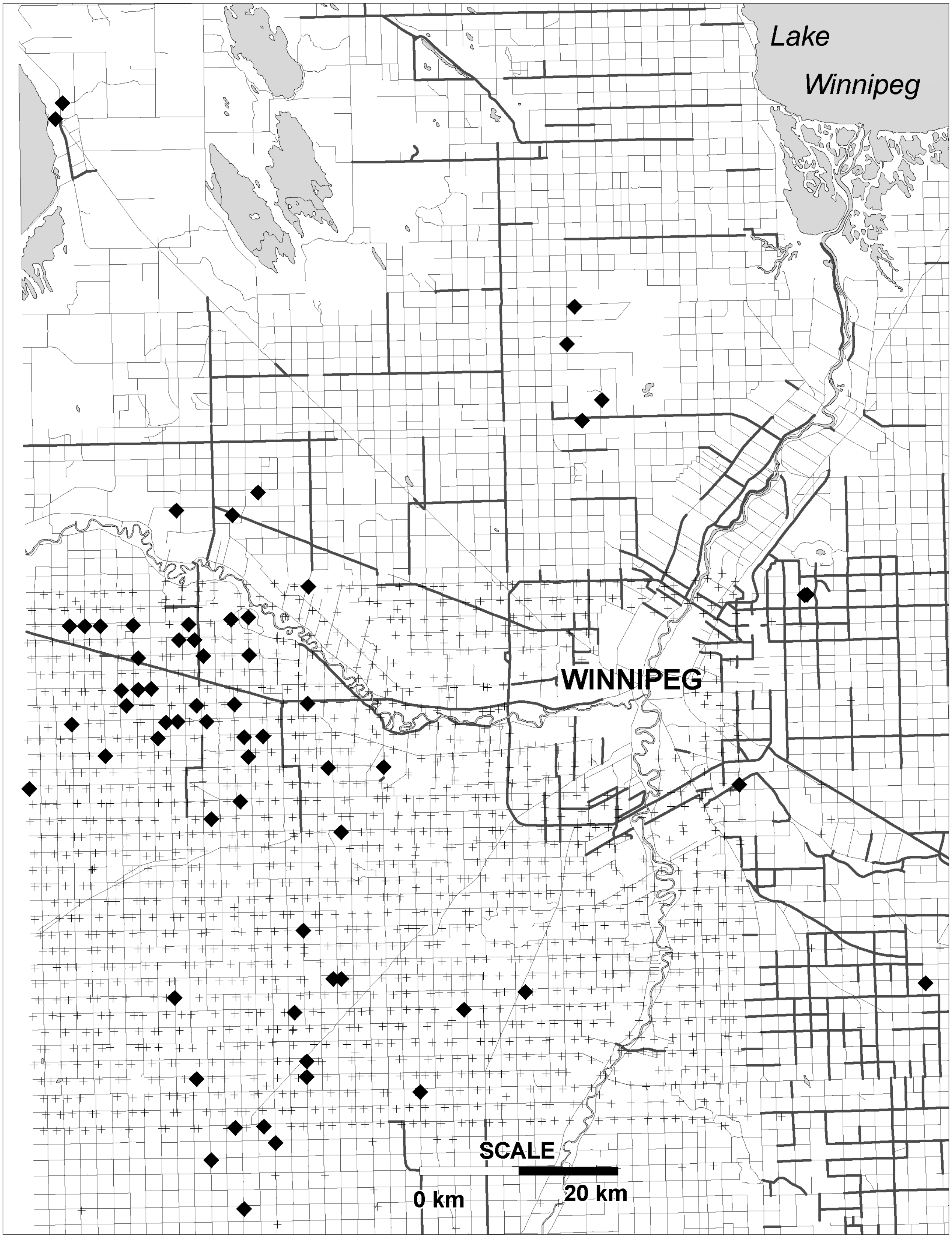

Figure 1: Selenite distribution; large diamonds represent sites where selenite was observed, small crosses represent sites where no selenite was observed.

of the authors that oxidation of organic sulphur in the unsaturated zone, near or above the water table, provides the main source of sulphate throughout most of the area. This argument is supported by the occurrence of selenite crystals at shallow depths in parts of the clay plain that are believed to have been underlain by fresh groundwater since the end of the last glaciation, and by the very high ratio of sulphate to chloride concentration in shallow groundwater in most areas of the basin. Evaporative concentration of sulphate from a saline groundwater source would result in a high chloride to sulphate ratio, the reverse of what is generally found.

The clay itself may provide the alternate source of sulphate (SO_4^{-2}) ions. The clay was deposited into the deep water of Lake Agassiz 10-11 000 years ago (Fenton et al., 1983), while glacial spillways above the Manitoba escarpment were actively eroding Cretaceous shale, which is believed to be the primary source for the Lake Agassiz clay in this area (Wicks, 1965). Subsequent analysis of isotopic ratios on the clay verifies a Cretaceous source and consequently an abundant source of organic sulphur (Mkumba, 1983).

Clay is generally considered an aquitard (water moves very slowly through it), however, fractures provide conduits for the relatively rapid migration of water and oxygen. Pach (1994) estimated vertical groundwater velocities of up to 12 cm/year within fractured clays in the Winnipeg region. The fractures are a result of iceberg scouring on the floor of Lake Agassiz (Woodworth-Lynas and Guigne, 1990) and post-Lake Agassiz desiccation. The fractures can penetrate tens of metres into the clay, providing conduits to transport water and oxygen, allowing evaporative concentration of the soil water to occur.

If oxidation does play a significant role in the formation of selenite crystals, then much of the crystal forming process must occur above the water table. Data presented by Mishtak (1961) suggests that the present-day water table is approximately 3.5 m below surface. The water table adjacent to the Winnipeg floodway is drawn down to the bottom of the trench and, as a result, is deeper than the surrounding area. Below the present-day water table are remnants of pre-existing water tables. At an average of 5.5 m below surface, there is a dramatic colour change from dark brown to dark gray (Mishtak, 1961). This transition represents a change from oxidizing (brown) to reducing (gray) conditions, and reflects the position of an old, stable water table. Below the brown/gray transition, zones of brown clay extend along fractures into the underlying gray clay. The base of these prongs of brown clay probably represents another remnant water table. These two remnant water tables are indications of a warmer, drier climate, which was prevalent in southern Manitoba between 8 000 and 2 500 years ago (Ritchie, 1969). Although crystals have been found below the brown/gray transition, there is some indication that these crystals are associated with the prongs of brown (oxidized) clay below (G. Hasler, per. comm., 1998).

The conditions required to produce selenite crystals can be found throughout the Lake Agassiz clay plain, although the absence of crystals over much of the area suggests that conditions on their formation are poorly understood. A study that will hopefully resolve some of these issues has been initiated at the University of Manitoba (N. Chow, per. comm., 1997).

CONCLUSIONS

If oxygen is required for the development of selenite crystals, then the large well formed crystals described from the Birds Hill backhoe pits and the floodway are probably thousands of years old. They probably precipitated from solution when the water table was at or below the brown/gray transition. The slow rate at which sulphate and calcium enriched groundwater travels through the clay, would indicate a long growth period. In contrast, the crystals observed in shallow holes augered across the Lake Agassiz clay plain, shown in figure 1, are very small and above the present day water table. For this reason they are thought to be much younger and are possibly forming as a result of the present day groundwater conditions.

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Appendix 1
Locations where selenite crystals were observed within the upper metre of sediment.

Site	Easting	Northing	UTM Zone	NTS Map	Sheet	Projection	Township	Range	Meridian	Section	Quarter	Comments
60	628550	5430450	14	62H	3	NAD27	1	2	e	2	NW	Abundant selenite flakes, 80-100cm.
75	614200	5433400	14	62H	3	NAD27	1	1	e	20	SW	Abundant selenite flakes at bottom.
85	596900	5482350	14	62H	5	NAD27	6	2	w	15	NW	Abundant selenite flakes near base.
163	584300	5528200	14	62H	13	NAD27	11	3	w	9	SW	Selenite crystals.
164	583000	5528100	14	62H	13	NAD27	11	3	w	9	SW	Selenite crystals.
165	581300	5528000	14	62H	13	NAD27	11	3	w	6	NW	Selenite crystals.
172	662500	5498500	14	62H	10	NAD83	7	6	e	31	SE	Selenite crystals.
214	600200	5538500	14	62H	13	NAD27	12	2	w	12	SE	Selenite crystals at base.
284	593300	5516800	14	62H	13	NAD27	10	2	w	5	SE	Selenite crystals at base.
326	603500	5513700	14	62H	13	NAD27	9	1	w	29	SW	Selenite crystals at 1 metre.
368	627050	5566750	14	62I	3	NAD27	14	2	e	35	NW	Clusters of selenite crystals at 0.9m
382	594100	5535400	14	62H	13	NAD27	11	2	w	33	SW	Selenite crystals.
384	626300	5563000	14	62I	3	NAD27	14	2	e	23	NW	Clusters of selenite crystals at 0.8 to 1.0m
386	588100	5534700	14	62H	13	NAD27	11	3	w	35	SW	Selenite crystals.
389	582500	5534600	14	62H	13	NAD27	11	3	w	32	SW	At 1.1 m selenite balls (in seams) up to 4 mm diameter.
390	629800	5557350	14	62I	3	NAD27	14	3	e	6	SW	Clusters of selenite crystals 90 - 100m.
391	579200	5534500	14	62H	13	NAD27	11	4	w	35	SE	Selenite seams throughout bottom 70 cm.
392	577600	5534500	14	62H	13	NAD27	11	4	w	34	SE	Selenite crystals.
393	576100	5534500	14	62H	13	NAD27	11	4	w	34	SW	Selenite crystals.
402	594200	5531600	14	62H	13	NAD27	11	2	w	16	NE	Selenite crystals.
404	592400	5535200	14	62H	13	NAD27	11	2	w	32	SW	Selenite crystals at base.
437	627800	5555250	14	62I	3	NAD27	13	2	e	35	SE	Clusters of selenite crystals.
519	643700	5518500	14	62H	14	NAD27	10	4	e	4	SW	Selenite crystals below 50 cm; up to 3 mm in size.
520	643700	5518500	14	62H	14	NAD27	10	4	e	4	SW	Selenite crystals.
555	594100	5521300	14	62H	13	NAD27	10	2	w	20	SE	Selenite crystals.
564	579700	5521400	14	62H	13	NAD27	10	4	w	13	NE	Selenite crystals.
587	607800	5520300	14	62H	13	NAD27	10	1	w	11	SW	Selenite crystals.
611	572000	5518100	14	62H	13	NAD27	10	4	w	7	SW	Selenite crystals.
614	602200	5520200	14	62H	13	NAD27	10	1	w	7	NE	Selenite crystals.
637	590400	5515050	14	62H	13	NAD27	9	3	w	29	NW	Selenite crystals.
655	595600	5523400	14	62H	13	NAD27	10	2	w	21	NE	Selenite crystals.
656	593700	5523300	14	62H	13	NAD27	10	2	w	20	NE	Selenite crystals.
661	585000	5523200	14	62H	13	NAD27	10	3	w	28	SW	Selenite crystals near base.
669	576300	5524600	14	62H	13	NAD27	10	4	w	27	NW	Selenite crystals.
676	585800	5524800	14	62H	13	NAD27	10	3	w	28	NW	Selenite crystals.
677	587000	5524900	14	62H	13	NAD27	10	3	w	27	NW	Selenite crystals.
679	589900	5524900	14	62H	13	NAD27	10	3	w	26	SW	Selenite crystals.
818	599700	5503800	14	62H	12	NAD27	8	2	w	24	SE	Selenite crystals.
999	603500	5498900	14	62H	12	NAD27	8	1	w	8	SW	Tiny selenite crystals at base.
1000	602700	5498900	14	62H	12	NAD27	8	1	w	7	SE	Selenite crystals at base.
1024	622100	5497600	14	62H	11	NAD27	7	2	e	31	NE	Selenite crystals.
1045	586700	5497000	14	62H	12	NAD27	7	3	w	34	NW	Selenite crystals.
1182	611500	5487500	14	62H	11	NAD27	7	1	w	1	SW	Selenite crystals at base.
1218	600000	5489000	14	62H	12	NAD27	7	2	w	12	SE	Selenite crystals at 50 cm.
1225	588900	5488800	14	62H	12	NAD27	7	3	w	11	SW	Selenite crystals.
1254	600000	5490600	14	62H	12	NAD27	7	2	w	14	SE	Selenite crystals at base.
1259	575350	5587300	14	62I	5	NAD83	17	4	w	3	NW	Abundant selenite crystals from 0.7 to 1m.

Appendix 1 Continued
Locations where selenite crystals were observed within the upper metre of sediment.

Site	Easting	Northing	UTM Zone	NTS Map	Sheet	Projection	Township	Range	Meridian	Section	Quarter	Comments
1271	574650	5585700	14	62I	5	NAD83	16	4	w	33	NE	Selenite crystals 0.8 - 1m.
1280	592800	5483900	14	62H	12	NAD27	6	2	w	19	NW	Selenite crystals (best in awhile).
1282	595700	5484000	14	62H	12	NAD27	6	2	w	21	NW	Selenite crystals.
1302	615900	5495800	14	62H	11	NAD27	7	1	e	28	NE	Selenite crystals at base.
1312	598800	5495500	14	62H	12	NAD27	7	2	w	35	SW	Selenite crystals.
1394	586850	5546200	14	62I	4	NAD27	12	3	w	34	NE	Selenite crystals.
1402	592500	5545700	14	62I	4	NAD27	12	2	w	32	NW	Selenite crystals.
1409	600100	5526700	14	62H	13	NAD27	10	2	w	36	NE	Selenite crystals.
1416	588700	5533100	14	62H	13	NAD27	11	3	w	26	SE	Selenite crystals.
1423	587100	5533100	14	62H	13	NAD27	11	3	w	27	SE	Pockets of tiny selenite crystals.
1430	595100	5548000	14	62I	4	NAD27	13	2	w	4	NE	Selenite crystals.
1440	583000	5531300	14	62H	13	NAD27	11	3	w	20	SW	Selenite crystals.
1444	589600	5531500	14	62H	13	NAD27	11	3	w	13	NW	Selenite crystals.
1455	592700	5526600	14	62H	13	NAD27	10	2	w	32	NW	Selenite crystals.
1458	588900	5526500	14	62H	13	NAD27	11	3	w	2	SE	Selenite crystals (hot spot).
1462	581800	5526500	14	62H	13	NAD27	10	3	w	31	NW	Selenite crystals (hot spot).
1503	593700	5475700	14	62H	5	NAD27	5	2	w	31	SE	Selenite crystals.
1505	590400	5480600	14	62H	5	NAD27	6	3	w	12	NW	Selenite crystals (individual crystals up to 3 mm).