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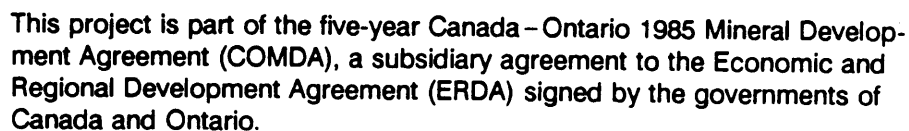


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FOREWORD

Outcrops of high purity gypsum are known from a number of localities in the James Bay Lowland. This report is the result of a detailed geological investigation of the gypsum deposits by staff of the Engineering and Terrain Geology Section (Ontario Geological Survey), with assistance from the Resident Geologist Office (Ministry of Northern Development and Mines) located at Timmins.

Although by no means conclusive, because of the limited data available, the results of this work have been most encouraging and confirm that the gypsum outcrops are of high chemical purity and suggest that the gypsum rich strata covers a large geographic area. This work was funded under the Canada-Ontario Mineral Development Agreement (C.O.M.D.A.) and complements a market assessment of these deposits being completed by the Mineral Development Section (Ministry of Northern Development and Mines). A synopsis of this geological report, combined with a market assessment of gypsum deposits in the James Bay Lowland will be released as Industrial Mineral Background Paper 12, entitled "Gypsum in Northern Ontario: Resources and Market Potential".

V.G. Milne
Director
Ontario Geological Survey

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ABSTRACT

Although the gypsum deposits in the James Bay Lowland were discovered over a century ago, and have been investigated sporadically ever since, these deposits have yet to be developed. Interest in these deposits is still strong with several companies presently funding exploration or market assessments of them. This is a geological evaluation of the deposits which is focussed on assessing the quality and quantity of the deposits and synthesizing what data is available. Results of this study indicate that the gypsum deposits are of high chemical purity and support the previous work which suggests that a considerable thickness is available for development at several localities. As the same geological section was encountered at each of the outcrop areas there is the implication that the gypsum may occur in the subsurface as an elongate belt which measures at least 70 kilometres in length and at least 10 kilometres in width. This study is complementary to an Industrial Mineral Background paper which is being released by the Mineral Development Section (Ministry of Northern Development and Mines) which will be focussed on the market potential of the gypsum.

GEOLOGY OF GYPSUM DEPOSITS IN THE JAMES BAY LOWLAND

OPEN FILE REPORT

by

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Manuscript approved for publication by O.L. White, Chief, Engineering and Terrain Geology Section, April 3, 1990.

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1.0 INTRODUCTION

Detailed mapping of the Middle Devonian Moose River Formation was undertaken in the James Bay Lowland in 1988 to re-evaluate the geology and resource potential of its gypsiferous horizons.

Prior to this work, the most recent study of the gypsum deposits was undertaken by Guillet (1964), who conducted general mapping in the area. Since that time, there has been sporadic interest in the geology and subsurface areal extent of these deposits. In the fall of 1987, reconnaissance field work and a preliminary market analysis was carried out on the gypsum deposits by the staff of the Mineral Development Section of the Ontario Ministry of Northern Development and Mines, Toronto. The results were sufficiently encouraging to suggest that additional mapping and sampling was deemed warranted. The objective of this James Bay Lowland gypsum study is to present detailed geological information on, and a resource map of, these gypsum deposits.

Gypsum is one of the most common naturally occurring sulphate minerals in the world and consists of hydrous calcium sulphate: $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. Gypsum can be associated with halite (NaCl) and anhydrite (CaSO_4) in evaporites or it can form thick, extensive beds interbedded with limestones, dolostones, and shales. Gypsum is very soft, and is white or colourless when pure, but can be tinted various colours when impurities are present. It can occur in a massive form (alabaster), fibrous

form (satin spar), or in monoclinic transparent selenite crystals (porphyroblastic).

In southern Ontario, gypsum deposits are mined from the Upper Silurian Salina Formation. These deposits are all located in the western Niagara Peninsula area and only known in the subsurface. Gypsum mining in southern Ontario commenced in the early 1800s and was confined to the Grand River Valley. Today, three deposits are actively being extracted: Domtar Construction Materials Limited at Caledonia; CGC Inc. at Hagersville; and Westroc Industries at Drumbo. Guillet (1964) and Haynes et al. (1988) provide detailed information on southern Ontario gypsum mining, past and present. Financial support for this project was provided by the Mineral Development Section (Ministry of Northern Development and Mines) using funds from the Canada-Ontario Mineral Development Agreement (COMDA).

1.1 Gypsum in the James Bay Lowland

In the James Bay Lowland physiographic region (Fig. 1 - in back pocket) a number of gypsum outcrops occur. These are found along the banks of several major rivers in the region, and at the topographic high Gypsum Mountain. For this project, the study area was defined to include all known outcrops of gypsum in the James Bay Lowland (see Fig. 1 - back pocket). This was augmented by drillhole data for areas between the outcrops where available. Due to the flat swampy terrain of the area; outcrops are restricted to the banks of rivers. The most significant of these river bank exposures are located along the Cheepash and Moose

Rivers (Fig. 1). The exposures of the Moose River were first mentioned by R. Bell (1877), with detailed geologic descriptions of the Moose River and Gypsum Mountain outcrops given by J.M. Bell (1904). Dyer (1929) gave an excellent report on the mineral resources of the James Bay Lowland which included a general description of the gypsum outcrops. The last detailed economic investigation of the James Bay Lowland gypsum deposits was carried out in 1963 by Guillet (1964). There has been no commercial production of these deposits to date.

1.2 Location

The area of study is approximately 60 km southwest of Moosonee and 270 km due north of Timmins (Figure 1). The area lies within the intracratonic, sedimentary Moose River Basin (Figure 2). The sites investigated for the gypsum study include: approximately 18 km of river bank exposure on the Cheepash River (both sides) in Roebuck and Maher Townships (Figure 1-3); about 9 km of exposure on the Moose River in Canfield, Carrol, and Ebbitt Townships (Figure 1-1); and approximately 1 km² of exposure at Gypsum Mountain (Stapells Township and the Kiasko River Area) (Figure 1-2).

1.3 Access and Field Work

The study area is low lying and poorly drained, with significant muskeg development despite the presence of numerous rivers. The area can be accessed in the summer by train (the

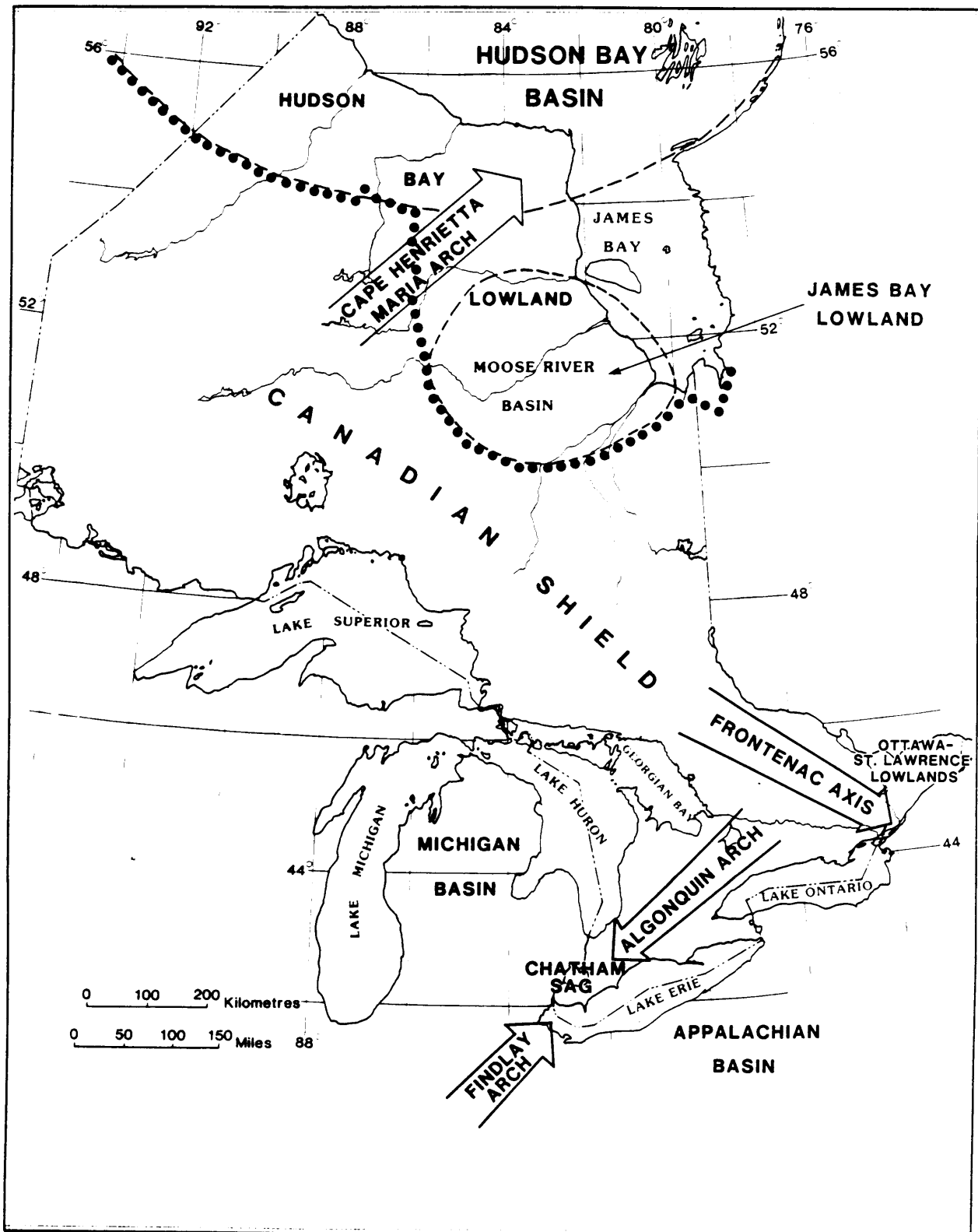


Figure 2: Sedimentary basins, physiographic elements, and structural features in northern Ontario. Basins are outlined with dashes and the lowlands are outlined with dots.

Ontario Northland Railway connects Cochrane to Moosonee), river (canoe or inflatable boat), or helicopter. In winter, access may be gained by winter roads, train, and helicopter.

For this field study, field equipment was transported by train to the community of Moose River Crossing (Figure 1). From Moose River Crossing, a helicopter was used to transport the field equipment to the first base camp on an island in the middle of the Moose River (2.5 km northeast of Moose River Crossing) (Figure 1-1). Halfway through the season, a camp move was made by helicopter to a second base camp on the Cheepash River, approximately 30 km north of Moose River Crossing (Figure 1-3).

The Moose River Formation outcrops along the Moose River were accessed with an inflatable boat (ZODIAC) fitted with a 9.9 HP motor. The low water level (and numerous rapids) on the Cheepash River required the use of a 17-foot aluminum canoe. The outcrops at Gypsum Mountain were accessed with the ZODIAC, after being flown into the area by helicopter.

1.4 Acknowledgements

This study benefited from the assistance of the Ministry of Northern Development and Mines (MNDM), in Toronto (specifically Ted Muir and Peter Telford) and of the Resident Geologist Office (MNDM) in Timmins. Special thanks go to Mike Bradshaw of the Timmins Office for his able field assistance and his contribution on the property descriptions for this report. The author is also indebted to Andrea Henry and Joel Mejilla for their adept summer assistance and to Mike Johnson (OGS) for his supervision and

helpful comments on this manuscript. Thanks also go out to the staff of the Ontario Ministry of Natural Resources Timmins Fire Centre who arranged for helicopter support.

2.0 GENERAL GEOLOGY

2.1 Geology of the Moose River Basin

Two intracratonic sedimentary basins, the Hudson Bay Basin (approximately 800,000 km²) and the Moose River Basin (approximately 100,000 km²), separated by the Cape Henrietta Maria Arch, on land, constitute the physiographic region of the Hudson Bay Lowland (Figure 2). The James Bay Lowland refers to the lowland surrounding James Bay and forms part of the larger Hudson Bay Lowland. The Moose River Basin occupies the physiographic land area termed the James Bay Lowland in Ontario.

A total thickness of Paleozoic/Mesozoic strata of less than 1000 metres overlies Precambrian basement rocks in the Moose River Basin. The southern boundary of the basin is marked by a distinct east-west trending, fault-controlled escarpment which separates the Precambrian uplands to the south from the swampy lowlands of the basin. Paleozoic units are predominant in the basin with only minor occurrences of Jurassic and Cretaceous sedimentary rocks. Quaternary and Recent deposits blanket the entire area. A summary of the Paleozoic geology of the Moose River Basin, details of the Devonian Moose River Formation, and a review of the basin's structural geology follows.

2.1.1 Paleozoic Stratigraphy

Paleozoic rocks in the Moose River Basin range in age from Upper Ordovician to Upper Devonian, and are succeeded by Mesozoic rocks in the southern portion of the basin. The entire sequence

is blanketed by Quaternary and Recent deposits. Paleozoic rock exposures tend to be sparse and widely separated, and are confined to the coast and along rivers that flow through the area and into James Bay.

The oldest Paleozoic rocks present in the Moose River Basin are those of the Upper Ordovician Churchill River Group and the Red Head Rapids Formation (Figure 3). In places, sandy basal clastic rocks directly overlie Precambrian granitic rocks, but the distribution and thickness of these clastics is not well defined and thus ages have not been assigned.

These units are present in outcrop in the Moose River Basin in the northern, western, and southeastern basin margins, but are poorly exposed. Units of probable Ordovician age have also been inferred from subsurface records in the eastern margin of the basin (Sanford et al. 1968). The Churchill River Group consists of calcareous quartz sandstone, very fine-crystalline dolostone, bioclastic limestone, and cherty dolomitic limestone. The overlying Red Head Rapids Formation consists typically of dolomitic limestone, iron-rich dolostone and microcrystalline dolostone with thin beds of anhydrite. These lithologies probably represent a minor transgression from the northwest over the Cape Henrietta Maria Arch (see Figure 2). A maximum thickness of approximately 80 metres has been recorded for these units. Silurian outcrops are present in the northern, western, and southeastern margins of the Moose River Basin. Silurian units include the Severn River, Ekwan River and the Attawapiskat Formations, and the lower and middle members of the Kenogami

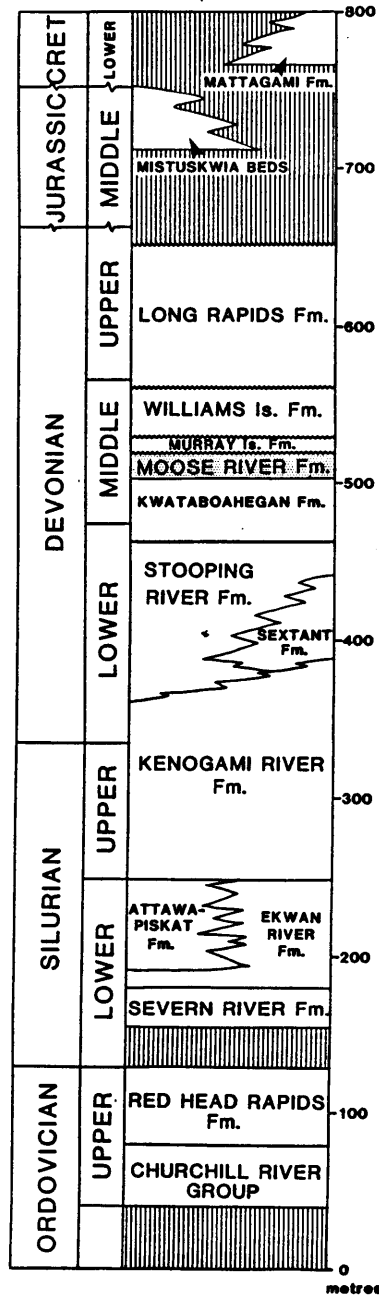


Figure 3: Stratigraphy of the Paleozoic and Mesozoic units in the Moose River Basin. The Moose River Formation is highlighted.

River Formation. The Severn River Formation consists of a mixture of lithologies including limestones, dolomitic limestones, and dolostones. The Ekwon River Formation consists of a well-bedded, skeletal and pelletoidal limestone and dolostone, whereas the Attawapiskat Formation consists of reefal carbonates. The combined thickness of these units can reach approximately 250 metres.

The Kenogami River Formation (which straddles the Silurian-Devonian boundary) consists of three informal members as follows:

- upper member: microcrystalline, brown and tan dolostone, with dolostone breccia (11-33 metres in thickness);
- middle member: red and green, gypsiferous mudstone, and dolostone (145-168 metres in thickness);
- lower member: fine-crystalline to microcrystalline dolostone with minor anhydrite (23-53 metres in thickness).

Contacts between the members are gradational. The Kenogami River Formation (the lower and middle members) is the only Silurian unit that is reasonably widespread in occurrence in the basin, and seen in outcrops along the Kenogami, Pivabiska, and Coal Rivers.

Devonian age rocks constitute most of the Paleozoic stratigraphic sequence in the Moose River Basin (approximately 400 metres) and are represented by the following units (in ascending stratigraphic order): the upper member of the Kenogami Formation, the Sextant, Stooping River, Kwataboahegan, Moose

River, Murray Island, Williams Island, and the Long Rapids Formations. All but the Sextant and Long Rapids Formations are marine carbonate units. Significant evaporites are only identified in the Moose River Formation.

The Sextant Formation consists mainly of reddish arkosic sandstone, but it also includes varicoloured conglomerates, siltstones, shales and clays, and has a maximum thickness of approximately 90 metres. It is present along the southern margin of the Moose River Basin and laterally wedges northward into and is overlain by marine carbonate beds of the Stooping River Formation. The Sextant Formation sediments are usually considered to be continental clastic beds (Sanford and Norris 1975), although Stoakes (1975, 1978) argues that the Sextant Formation consists of reworked coastal sediments.

The Stooping River Formation, correlative with the Schoharie, Bois Blanc and lower Onondaga Formations in the Appalachian Basin, consists of nodular to thin-bedded cherty limestone with minor dolomitic limestone and dolostone. It varies from 50 to 140 metres in thickness and is disconformably overlain by the Kwataboahegan Formation.

The Kwataboahegan Formation consists of massive to thick-bedded biohermal and biostromal limestones. The name, Kwataboahegan Formation, was introduced and defined by Sanford et al. (1968) to replace Martison's (1953) Upper Abitibi River Formation (see Figure 4 for terminology). The biohermal- biostromal nature of the Kwataboahegan Formation appears to be associated with topographic highs on the underlying Precambrian basement rocks.

Away from these topographic highs, the unit is thinner bedded and bituminous. Typically, the Kwataboahegan Formation is a very fossiliferous limestone with corals, stromatoporoids, and brachiopods most abundant.

For the Moose River Basin Gypsum Study, outcrops of the Kwataboahegan Formation were found at Stations 47, 48, 49, 60 and 61 on the Moose River (Figure 1-1). The limestones are bituminous, laminated, and dark brown to tan in colour. Outcrop thicknesses average approximately 2-3 m. Fossils are very abundant at Stations 60 and 61 (Figure 1-1).

The fossil assemblages in the Kwataboahegan Formation collected by Sanford and Norris (1975) are similar to those found in the Schoharie, Bois Blanc, Onondaga Formations faunas of the Appalachian Basin and similar to those of the Michigan Basin Detroit River Group. The maximum thickness of the Kwataboahegan is approximately 30 metres.

The Moose River Formation consists of a non-fossiliferous brecciated limestone and dolostone, with gypsum beds and minor anhydrite. The name Moose River Formation was originally introduced by Dyer (1928) but removed by Martison (1953) in favour of the term Middle Abitibi River Formation. Sanford et al., (1968) and Sanford and Norris (1975) eliminated the term Middle Abitibi River Formation and resurrected the term Moose River Formation (see Figure 4). A detailed description of the Moose River Formation follows this section.

The Moose River Formation is disconformably overlain by the Murray Island Formation, a banded sequence of calcareous

dolostone, limestone, and argillaceous limestone. The brachiopod assemblage found in this formation suggests it is stratigraphically equivalent to the Onondaga Formation in the Appalachian Basin and the Dundee Formation in the Michigan Basin (Telford 1988). The term Murray Island Formation was first introduced for these rocks by Sanford et al. (1968). Previous workers had assigned these strata to either the Moose River Formation or Martison's Abitibi River Formation. The maximum thickness of this unit is approximately 15 metres.

The Murray Island Formation is disconformably overlain by the Williams Island Formation which Kindle (1924) described as a sequence of shales and carbonates exposed around Williams Island on the Abitibi River. The unit was divided into two informal members by Sanford and Norris (1975): a lower and an upper member. The lower member is dominated by grey shale with soft sandstone, gypsiferous shale, siltstone, sandstone, soft limestone and brecciated limestone (35-50 metres in thickness). The upper member is a thin-bedded, argillaceous limestone and calcareous shale, dolomitic limestone, oolitic limestone, brecciated, vuggy limestone, and dolostone (30-45 metres in thickness). The fossil assemblage found in the Williams Island Formation is very similar to the assemblages found in the Traverse and Hamilton Groups of the Appalachian Basin (New York State) and Michigan Basin (southwestern Ontario). They have been dated as Upper-Middle Devonian (Givetian) (Norris 1986).

The upper contact of the Williams Island Formation with the Long Rapids Formation is observed on the east bank of the Abitibi

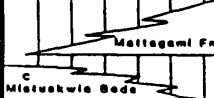
Savage & Van Tyul
(1919)

Kindie (1924)

Dyer (1928, 1930)

Martinson (1953)

Sanford et al. (1968)
Sanford & Norris (1975)
Norris (1986)

CRET. JUR.	LOWER										Mattagami Fm (Keele, 1920)	Mattagami Fm							
	MIDDLE																		
DEVONIAN	UPPER	Long Rapids Shale								Long Rapids Shale		Long Rapids Fm	Long Rapids Fm			Long Rapids Fm			U
		Abitibi River Limestone									Williams Island Lmat. Abitibi River Lmat.								Williams Island Fm
	MIDDLE	Sextant Sandstone and Shale								Sextant Beds		Abitibi River Fm	Williams Island Fm			Williams Island Fm			U
												Moose River Fm ^a	Abitibi River Fm	U ^b M ^b L	Murray Island Fm Moose River Fm Kwataboahagan Fm			L	
SILURIAN	LOWER											Sextant Fm	Sextant Fm						U
	UPPER											Kenogami River Fm	Kenogami River Fm	5	Kenogami River Fm			M	
		Attawapiskat Coral Reef										4							
		Ekwan River Limestone										3							
	LOWER	Severn River Limestone										Pagwa River Fm		2					Attawapiskat Fm Ekwan River Fm Severn River Fm
		Port Nelson Limestone											1						
ORDOVICIAN	UPPER	Shamattawa Limestone																	
	MIDDLE	Nelson River Limestone																	

- ^a originally included by Savage & Van Tyul as part of the Abitibi River Fm.
^b equivalent to the Moose River Fm.
^c defined by Telford (1982)
^d defined by Nelson (1984)

Figure 4: Stratigraphic Terminology of the Moose River Basin

River at Williams Island. The contact is sharp and disconformable. The Long Rapids Formation is the youngest Devonian unit present in the Moose River Basin and consists of interbedded brown-black shales, green-grey mudstones and shales, and carbonate nodules and beds. This formation appears to be correlative to the Kettle Point Formation in southern Ontario (see Russell 1985) and other Upper Devonian black shale units in eastern North America (i.e. the New Albany and Chattanooga) (see Cluff 1980; Kepferle and Roen 1981; Broadhead et al. 1982).

The Long Rapids Formation was first introduced as the Long Rapids Shale by Savage and Van Tuyl (1919) for a sequence of Upper Devonian shales exposed along the Abitibi River near Long Rapids and Williams Island. The average thickness of the unit is approximately 30 metres (Sanford and Norris 1975), but toward the eastern margin of the Moose River Basin, thicknesses of approximately 80 metres have been reported (from the Onakawana A & B Drillholes, Martison 1953; Bezys 1989). Dyer and Crozier (1933) subdivided the unit into three informal members when logging the Onakawana A drillcore (lower, middle and upper members). The lower member (up to 37 metres thick) consists of green-grey mudstone and shale, alternating with fissile black shale and frequent concretionary carbonate layers. The middle member (up to 30 metres thick) is a black fissile shale whereas the upper member (up to 20 metres thick) is a poorly consolidated green-grey clay and grey shale. The upper contact to the overlying Mesozoic rocks is not sharp and is difficult to discern.

Recent reviews of the stratigraphy of the Moose River Basin are outlined by Norris (1986), Sanford (1987), and Telford (1988).

Moose River Formation

The Middle Devonian Moose River Formation consists of an unfossiliferous sequence of limestone, dolomitic limestone, dolostone, brecciated carbonates, gypsum, with minor amounts of anhydrite, shale, and secondary selenite. The location and logs of eight regional drillholes that penetrate the Moose River Formation (in whole or in part) are shown in Figure 5 (in back pocket). Appendix 1 displays the geologic well logs of these holes. Six of the eight holes are located along or near the Mattagami, Abitibi, and Moose Rivers (within the southeastern part of the Moose River Basin). The other two holes, Jaab Lake (#38) and Schlievert Lake (#74), are located in the central portion of the Moose River Basin, to the west of the main group of holes. Shown in Figure 6 (in back pocket) are the drill logs for 18 holes drilled in 1963 for resource testing of the gypsum outcrops along the Cheepash River. These holes were drilled along a 5 km stretch of the Cheepash River by the Moosonee Gypsum and Exploration Company to delineate the gypsum present in the subsurface. The location of the Cheepash gypsum outcrops and drillholes is indicated in Figure 1-3.

The lower contact of the Moose River Formation with the Kwataboahegan Formation is not exposed in outcrop in the Hudson Bay Lowland. The contact has been penetrated by a number of

drillholes (Figure 5) and variety of rock types are identified within the lowest portion of the Moose River Formation. These basal beds consist of medium brown, sucrosic, extremely vuggy porous dolostone. Some of the vugs are infilled with calcite, and contain pseudomorphs of selenite. Below the contact, within the Kwataboahegan Formation, the rock becomes a fine to medium crystalline, slightly dolomitic limestone with bituminous laminae, and can contain abundant echinoderm columnals and fragmental solitary corals.

The contact of the Moose River Formation with the overlying Murray Island Formation is exposed at several localities along the Abitibi, Moose, and North French Rivers. Along the Abitibi River, the upper contact is sharp and undulating with up to 0.5 m of relief evident in the upper beds of the Moose River Formation. On Murray Island (Moose River), the contact also appears to be an erosional surface with limestone pebbles of the Moose River Formation contained in the basal, notably argillaceous dolostone beds of the overlying Murray Island Formation (See Photo 1a). This site is also the type locality for the Murray Island Formation.

The complete thickness of the Moose River Formation is nowhere exposed. The thickest, nearly continuous outcrop sequence is on the southern end of an unnamed island in the Abitibi River near the upstream (south) end of Long Rapids. At that locality, about 17.4 m of the upper part of the formation can be measured, consisting of brown to tan, fine to medium crystalline, laminated to thin bedded limestone. Rare

pseudomorphs of selenite can be found. Outcrop sequences of Moose River Formation gypsum and breccia, up to 9 m thick, occur along the banks of the Moose River for several kilometres downstream (northeasterly) from Moose River Crossing. Outcrops of gypsum and gypsum breccia occur along the banks of the Cheepash River, up to 12 m thick. Moose River Formation lithologies are also found on the Kiasko River up to 2.1 m thick, and up to 2.7 m thick on the Wakwayowkastic River.

In the subsurface, the thickest known sequence of the Moose River Formation is penetrated by drillhole #67 located on the southwest end of Mike Island on the Moose River where it is 80.2 m thick (Figure 5). The formation appears to thin rapidly in all directions from this drillhole. Significantly, the Moose River Formation is not brecciated in this hole, suggesting that none of the formation has been removed by dissolution. In another drillhole, hole #68 which is located 2.9 km downstream (northeast) from hole #67 on the south-western end of Murray Island, the formation thins to 48.5 m. The formation also appears to have been unaffected by dissolution and brecciation at this point.

In the opposite, southwesterly direction from Mike Island, two drillholes, the Ontario Geological Survey's Onakawana B drillhole (#77) (Bezys 1989) and Dewson Mines drillhole (#64.1) (Satterly 1953; Sanford and Norris 1975) show thicknesses of 41.4 and 41.8 m of the formation, respectively. Moose River Formation lithologies in both wells show extensive brecciation of the carbonates which suggests significant removal of the material by dissolution. In the central part of the Moose River Basin, in

the Ontario Department of Mines (ODM) Jaab Lake drill hole (#38) (Hogg et al. 1953; Sanford and Norris 1975; Stoakes 1975) and the Ontario Geological Survey (OGS) Schlievert Lake drillhole (#74), (Russell et al. 1985), the formation is 32.9 and 29.2 m thick, respectively. In the Jaab Lake hole, evaporites form only a very minor constituent of the Moose River Formation. Whereas in the Schlievert Lake hole, the formation is extensively brecciated, suggesting the presence of evaporites or carbonates which were subsequently removed by dissolution.

On the basis of its stratigraphic position between the underlying Kwataboahagan Formation and the overlying Murray Island Formation, the Moose River Formation in the Moose River Basin is dated as early Middle Devonian (mid - Eifelian). Lithologically, the Moose River Formation is comparable to the evaporitic and dolomitic phases of the Lucas Formation of southwestern Ontario and northern Michigan. Although widely separated by the Canadian Shield, the two formations appear to be very similar and are approximately of the same age (Sanford and Norris 1975).

The presence of evaporite minerals in strata of the Moose River Formation indicate a marked change in the depositional environment of the basin (see Section 5). Whereas the carbonates of the underlying and overlying units reflect normal marine circulation, the evaporites indicate restricted circulation. The presence of brecciation in several of the cores and much of the outcrop suggests that the evaporite deposits were originally much more extensive than they are now; post depositional dissolution

removing much of the material. Field study suggests that the dissolution occurred on a local opposed to regional basis as often the same outcrop area would have both brecciated and unbrecciated portions.

The unbrecciated carbonates of the Moose River Formation seen in this study were typically unfossiliferous, fine to medium crystalline, laminated to thin bedded, tan to dark brown coloured limestones. The beds were usually 2 to 3 m thick (see Photo 1b). In some outcrops, it appears that two or more cycles of brecciation are evident. Areas of possible karstification and sinkhole development are indicated in Figure 1 and are based on air photo interpretation and aerial reconnaissance.

2.1.2 Mesozoic Stratigraphy

Mesozoic strata are represented by two units in the Moose River Basin; the Middle Jurassic Mistuskwia Beds and the Lower Cretaceous Mattagami Formation. The Mistuskwia Beds consist of unconsolidated calcareous clays and sands with minor gravel beds. They appear to be restricted to the south-central portion of the basin. This unit has only been identified in drill core samples by palynologic analyses (see Telford et al. 1975; Telford and Verma 1982) and thus has not been given formal designation.

The Mattagami Formation consists of unconsolidated clays, sands, gravels, and lignite. A considerable amount of exploration has been associated with the lignite horizons in this formation in the central portion of the Moose River Basin. The Mattagami Formation is interpreted to be the product of rapid deposition

from a segment of a major river system which drained an extensive tract of the Canadian Shield (Try et al. 1984; Telford and Long 1986).

2.1.3 Quaternary Geology

A sequence of Quaternary glacial and glaciolacustrine deposits, as well as Recent marine clays, peat, and muskeg blanket the Paleozoic and Mesozoic units in the Moose River Basin. The thickness of this Quaternary material is variable but can reach 200 metres. Identification of the Quaternary/Cretaceous contact can be difficult because of the unconsolidated nature of the Cretaceous and Quaternary sediments.

The Quaternary geology of the Moose River Basin is poorly known with the more recent publications on the area presented by Skinner (1973) and Shilts (1986). Skinner reported the presence of at least five distinct till sheets separated by non-glacial and interglacial sediments as follows (from youngest to oldest):

- late- and post-glacial glaciolacustrine, marine, and terrestrial units
- Cochrane (Kipling) Till
- Friday Creek non-glacial sediments
- Adam (Matheson) Till
- interglacial Missinaibi Formation
- Till III
- intertill sediments II-III
- Till II
- Intertill sediments I-II

- Till I

The three pre-Missinaibi Formation tills (Till, II and III) which recorded oscillations of a restricted ice margin, were deposited by ice advancing from the northeast. Separating the tills are glaciolacustrine sediments with south trending paleocurrents indicating blockage of the natural drainage to the north.

Till III is overlain by the Missinaibi Formation, an interglacial sequence of marine, fluvial and organic sediments. This formation is overlain by the Adam (Matheson) Till, the Friday Creek non-glacial sediments, and the Cochrane (Kipling) Till. These units are, in turn, overlain by Recent glaciolacustrine and marine sediments (deposited in Lake Barlow-Ojibway and the Tyrrell Sea, respectively). Isostatic rebound of the land in the Moose River Basin and the subsequent regression halted marine sedimentation. Also, due to isostatic rebound, an extensive series of stranded beach ridges formed parallel to the Hudson Bay shoreline. Extensive peat bogs and spruce forests near river banks have developed since then.

In the Gypsum Study, some Quaternary sediments were encountered in the course of mapping the riverbanks for gypsum. At Station 7 on the Moose River, a very dark green, carbonaceous claystone was discovered on the riverbank where gypsum or gypsum breccia was expected. This claystone probably represents the Missinaibi Formation and is stratigraphically lower than expected relative to the gypsum deposits because of slump activity along the bank or possible sinkhole development within the gypsum.

2.2 Structural Geology of the Moose River Basin

Generally, Paleozoic units in the Moose River Basin are flat-lying, except along the basin's marginal areas where tectonic activity has disturbed the strata with faults and small-scale folding. The southern boundary of the basin (Figure 7) is truncated by an east-west en-echelon fault escarpment system, the Kapuskasing-Moosonee trend (Bennett et al. 1967). Definite evidence that this escarpment is fault controlled is found along the Missinaibi and Mattagami Rivers, with evidence to suggest multiple episodes of reactivation.

Several episodes of tectonic activity in the Hudson Platform area affected the deposition and subsequent burial history of the Paleozoic rocks in the Moose River Basin and are probably associated with horizontal plate movements along margins of the North American plate (Sanford 1987). Tectonic activity appears to have occurred during the Early to Middle Ordovician, Late Ordovician, Early Silurian, Early Devonian and Late Devonian. Further tectonism during the Middle to Late Jurassic included the emplacement of lamprophyric and kimberlitic intrusives in the Devonian strata in the southeastern corner of the Moose River Basin.

Three basement structural highs are presently known in the Moose River Basin: the Grand Rapids High, the Moose River High, and the Pivabiska Ridge. They are located toward the southern margin of the basin (Figure 7). The Grand Rapids High influenced sedimentation patterns in the Long Rapids Formation and the

overlying Cretaceous sediments, as indicated by their thickness and distribution patterns. The absence of Paleozoic or Mesozoic sediments on the Pivabiska Ridge indicates its influence as a Precambrian high, whereas the influence on sediments by the Moose River High is not fully understood. The axis of the main gypsum outcrop belt is roughly parallel to that of the Moose River High, suggesting its probable control during Middle Devonian evaporite deposition, but subsurface evidence is lacking to fully support this theory.

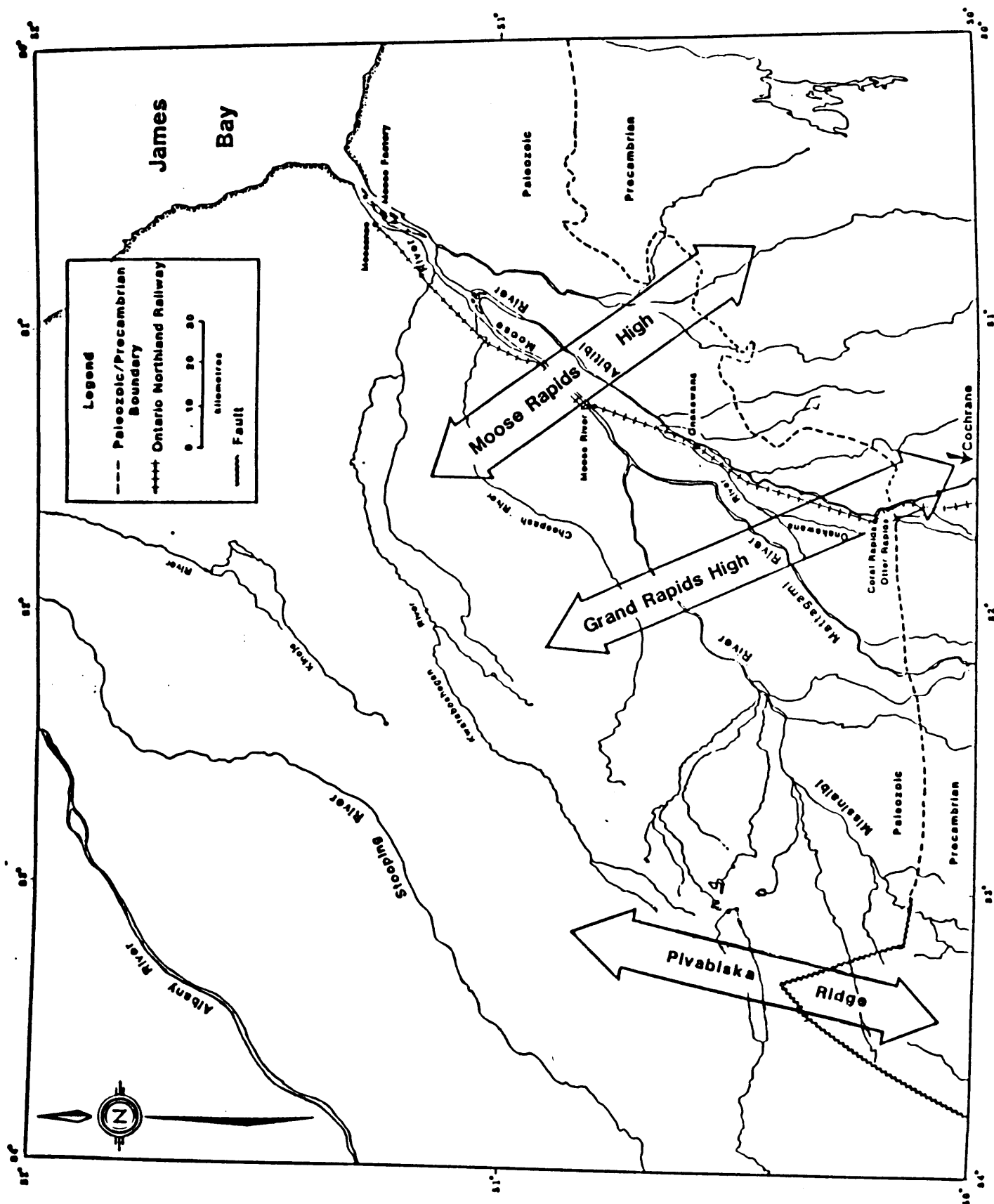


Figure 7: Structural map of the southern portion of the Moose River Basin indicating the Moose River and Grand Rapids Highs and the Pivabla Ridge

3.0 HISTORY OF PRIVATE SECTOR GYPSUM EXPLORATION IN THE MOOSE RIVER BASIN

The gypsum deposits of the Moose River Basin have been the focus of intermittent interest since they were first described by Robert Bell in 1875. In the early 1900's, exploration and evaluation of the gypsum outcrops was hampered by the inaccessibility of the area. Prior to the completion of the Ontario Northland Railway to Moosonee in 1933, only one company had managed to complete any work on the gypsum deposits. In 1911 Mr. W. Tees Curran and a group of engineers staked claims along the Moose River deposit en route from Montreal to carry out assessment duties on the islands of Hudson Bay (Dyer 1929). The claims were then allowed to lapse. Curran re-staked the property, but failed to perform the required assessment work and the claims were cancelled. A third attempt was made in 1923 and all assessment work was completed on twelve claims staked on the banks of the Moose River. Nine claims, S.5306 to S.5314, inclusively, covered the gypsum outcrops on the north side of the river with three claims, T.19449 to T.19451, located on the south shore. According to J. Lanning 91926, p.1173) four holes were drilled to depths of 7.6 m (25 ft.) to 14.3 m (47 ft.)

In May 1923, boring permits were issued to Curran covering a group of islands upstream from the gypsum outcrops. In 1926, the 12 claims were surveyed and a patent was granted in 1928. No further work was reported on the property. In 1974 the mining rights on the property were forfeited to the Crown because of

delinquent taxes. The surface rights are presently owned by J.W. Haley of Fredonia, Wisconsin.

In 1929, the Curran Company was reorganized and operated under the name of James Bay Basin Oil Company Limited. That same year, three holes were drilled on Murray, Mike and Grey Goose Islands. Hole No. 1 drilled in October 1929, was collared at the southwestern end of Mike Island, three kilometres above the bridge at Moose River Crossing. The vertical hole intersected 53.7 m of mottled gypsum interbedded with shale and limestone starting at a depth of 73.2 m. Hole No. 2 was drilled at the head of Murray Island at the upstream end of the Moose River exposures and intersected 19.6 m of gypsum interbedded with shale and limestone at a depth of 22 m. The Grey Goose Island hole did not intersect gypsum from the Moose River Formation.

In 1955, R.E. Parkes of Montreal staked 32 claims in Carroll and Canfield Townships. Fourteen claims were staked on the north shore of the Moose River between the Ontario Northland Railway (ONR) and the north boundary of the Curran claims. Eighteen claims were staked to the south of the Curran claims covering parts of Murray Island and the banks of the Moose River.

A total of 19 km of linecutting was carried out over the two properties, along which a geological survey was completed. The claims were subsequently transferred to Atlas Gypsum corporation Limited in November, 1956. No further work was reported and the claims were cancelled in December, 1957. The property was re-staked by the Atlas Gypsum Corporation, but no work was carried out and the claims were cancelled on January 13th, 1960.

A series of recurring Exploratory Licences of Occupation (ELO) were granted to the Moosonee Gypsum and Exploration Company beginning in April, 1960. The area included both the Moose River and Cheepash River gypsum deposits. No work was carried out until the fall of 1963 when the company completed an eighteen hole, 528 metre drill program over a 5 km distance along the south shore of the Cheepash River. The drilling proved the continuation of the gypsum to a depth of about 40 m with the best, continuous intersections of gypsum encountered in the centre of the outcrop area. The Exploratory Licence of Occupation covering the outcrop on the Moose River expired on May 3rd, 1963. No further work was reported by the company although the ELO covering the outcrops on the Cheepash River was held until May 1st, 1970.

In 1978, Kerr Addison Mines Limited, as part of its exploration program of evaluating continental clastic sedimentary formations for the presence of uranium, reviewed all available data on the Lower Devonian Sextant Formation. From this research and from exploratory drilling carried out in 1929, a 6.7 m to 10 m bed of "conglomerate breccia" was found to lie on the Precambrian basement near Moose River Crossing.

An Exploratory Licence of Occupation was obtained by Kerr Addison to cover the Moose River Crossing area. One 157 m hole was drilled on the east side of the ONR tracks at approximately mile 154.8 (248 km) in Ebbitt Township. A 17.5 m thick bed of sugary to crystalline gypsum was intersected starting at 40.3 m. The literature references to "conglomerate breccia" were found to

apply to detrital quartz beds or fossiliferous limestone debris at the base of the Kwataboahegan Formation and not continental clastic sediments (Resident Geologist Assessment Files - Timmins). The ELO lapsed in 1978.

The area encompassing the gypsum deposits remained dormant until November, 1985, when Edward Jerome of Sudbury staked 16 claims in Carroll and Canfield Townships on the northshore of the Moose River. The claims were transferred to Ed Ivall in December of 1985. No work was ever reported and the claims were cancelled in June of 1986.

During the fall of 1988, James Bay Travel Limited (Moosonee) and other associates made notice of their intent with the Ontario Ministry of Northern Development and Mines (Timmins) to procure Licences of Occupation for the Cheepash and Moose River gypsum outcrops. The consortium has since hired a consultant to prepare and implement a detailed evaluation of the deposits. Preliminary work, including geological data acquisition and a transportation feasibility study have been completed. A more thorough examination of the sites is expected to commence in the summer of 1989 (personal communications-James Bay Travel 1989).

In December, 1988, an aerial and ground inspection of the outcrops on the Moose and Cheepash Rivers was attempted by a company looking at the potential of exploiting the gypsum deposits for use in the high purity gypsum market. The excessive snowfall and poor ice conditions made observations of gypsum exposures difficult. The company plans to re-examine the area during the summer of 1989.

A third company, in the spring of 1989, began tests on the Moose River gypsum to determine its possible use as a substitute for cement in mine backfill.

4.0 GYPSUM IN THE MOOSE RIVER BASIN

4.1 Introduction

The maximum development of Moose River Formation gypsum occurs along the Moose River High, a broad anticlinal northwest-trending basement high (Figure 7). This area of gypsum outcrops occurs in a belt 70 km long and about 10 km wide if an ellipse is drawn around the outcrops from the Wakwayowkastic River in the southeast to the Cheepash River in the northwest. In holes drilled to the southwest and northeast of this outcrop belt, only minor amounts of gypsum have been intersected.

4.2 Gypsum in the Subsurface

An interval of 80.2 m of the Moose River Formation is encountered in drillhole #67 (see Figure 5 and Appendix 1) on Mike Island, with 53.7 m of the interval consisting of interbedded gypsum, shale and limestone. The remainder of the Moose River section in this core is carbonate. Drillhole #68, adjacent to hole #67 on nearby Murray Island, encountered 48.5 m of the formation, with 19.6 m consisting of massive gypsum. Both of these drillholes are located only a few kilometres southwest of the main gypsum outcrop belt.

An interval of approximately 5 m of gypsum occurs in the Ontario Department of Mines (ODM) Campbell Lake drillhole (#39) (Hogg et al. (1953); Sanford and Norris 1975). This hole is located near the southern margin of the Moose River Basin where it appears that part of the formation has been removed by

erosion. A total of 29.2 m of the Moose River Formation is present in this hole. In the OGS Onakawana B drillhole (#77), only 0.45 m of massive gypsum was encountered in the Moose River Formation interval, although to 17.8 m of gypsum breccia was intersected.

Drillholes containing no gypsum, but some gypsum breccia, include the OGS Schlievert Lake hole (#74) and Dewson Mines 1A (#64.1). The remaining two holes, ODM Jaab Lake (#38) and Hydro-Electric Power Commission of Ontario Drillhole R-1 (#42) (Sanford and Norris 1975), are devoid of either gypsum or gypsum breccia.

Drilling on the Cheepash River (Figure 6) demonstrated the continuation of gypsum to a depth of 40 m. It also demonstrated a very irregular bedrock surface caused presumably by sinkhole development and deep glacial scouring. The best and most continuous intersections of gypsum were made near the middle of the Cheepash River outcrop area (Figure 1-3), where 22 to 33 m of very pure gypsum was encountered in several adjacent holes.

4.3 Gypsum in Outcrop

Typically, gypsum outcrop along the Moose and Cheepash Rivers and at Gypsum Mountain is of a massive to banded, white variety (Photo 2). Other lithologies, including gypsum breccia, banded/impure gypsum and limestone are also present in outcrop. The following is a list of the lithofacies present in the three main study areas:

- 1a: massive gypsum
- 1b: banded/impure gypsum
- 2: gypsum breccia

- 3a: interbedded limestone with gypsum
- 3b: interbedded gypsum with limestone
- 4a: limestone
- 4b: limestone breccia

The three most common lithofacies are: massive gypsum (1a); banded/impure gypsum (1b); and gypsum breccia (2). The limestone and interbedded units are usually of minor occurrences. The banding present in the gypsum facies is usually caused by limy zones or coarsely crystalline selenite (Photos 3 and 4). Limestone beds, where present, consist of dark brown to tan, very fine to fine crystalline, laminated to massive limestone. Outcrop exposures range in thickness from less than 0.5 m to about 12 m, with an average thickness of approximately 2.5-3.0 m. Figure 1 indicates the facies present at each station.

The massive gypsum facies (1a), in its finest form, is a pure white, finely crystalline, alabaster-like gypsum. Snow-white varieties of this type of gypsum can be found at both the Cheepash and Moose River sites. When impurities (facies 1b) are present, they occur either as laminations (as in Photo 2) or as mottles which are referred to as chickenwire mosaic texture (Photo 5). Impurities consist of dark- coloured, coarsely crystalline selenite, limestone or organics such as bitumen. Nodular, enterolithic, and hassock gypsum textures were not identified in the Moose River gypsum outcrops, although nodular-like anhydrite appears to be present in the Schlievert Lake (#74) drillhole.

Gypsum outcrops in the Moose River Basin are usually white in colour, but can also be light grey, amber, salmon-pink, and orange. In the massive gypsum unit, these colours become more

pronounced towards the top of the unit, at the contact with the overlying breccia unit. Crystallinity and banding abundance also increase towards the top of the gypsum unit. It appears that where colour variations occur within an otherwise white gypsum, crystallinity will also increase. At this contact, brown to transparent, medium to coarse crystalline selenite is also very abundant and typically occurs as bands, 2-10 cm thick, or as mottles (Photo 6). Clear, colourless selenite is common as large crystals in veins and fractures (Photo 7).

In the Moose River outcrop sites, a thin (< 1 cm) laminae of green, glauconitic gypsum consistently appears at the top of the gypsum unit, 3-10 cm beneath the breccia unit. It is quite a persistent marker bed and can be traced for considerable distances along the outcrops. It was not identified at the Cheepash River or Gypsum Mountain study sites.

Limestone, and/or limestone breccia (4a and b) is a common component in the Cheepash River and Moose River sites (see Photo 1b). It is typically brown, very fine crystalline (aphanitic), and is sometimes laminated. It occurs as thin beds or laminae, or as clots and warped clusters within the gypsum unit. The limestone breccia unit is usually clast-supported with clasts ranging in size from < 1 cm to 5 cm. The matrix can consist of white to grey gypsum, but is usually devoid of visible gypsum. These limestone units are barren of fossils. At Gypsum Mountain, limestone units are a very minor component.

The interbedded facies (3a and b) are unique to the Cheepash River study area. These facies appear to occur where the massive

gypsum facies (1a) should usually occur, and they can also overlie the gypsum breccia facies (2). The banding or bedding in these facies can be quite persistent along the length of the outcrop, and can also grade into the massive white gypsum facies. The banding and laminations can be quite warped and deformed (as shown in Photo 2) and some outcrops have cross-cutting dikes of gypsum and limestone breccia. These interbedded facies do not appear well developed at the Moose River and Gypsum Mountain study sites.

The gypsum breccia facies (2) is a conspicuous unit at all three outcrop sites. It is most spectacularly developed on the Moose River where very large blocks of gypsum, limestone, and selenite (up to 6 m in diameter - average 0.5 m) are present in a matrix of fine to medium grained aggregates of gypsum, carbonate and argillaceous material (Photo 8). It is possible that two cycles of brecciation are present. The lower 1 m of the unit consists of matrix-supported breccia with clasts ranging from 5 to 30 cm in diameter. The upper portion of the breccia is clast-supported, with very large, exotic fragments. Many of these clasts do not appear to be related to any of the facies present in the outcrop belt. One typical example is a clast that contained abundant selenite eyes in a banded gypsum. Although the clast is quite large (3 x 6 m), the same lithology has not been identified in outcrop or drill core.

4.4 Cheepash River Gypsum Study Site

Exposures of gypsum occur over a distance of approximately 9 km on the Cheepash River, commencing about 16 km upstream (northwesterly) from the Ontario Northland Railway bridge (Figure 1-3 and 8). Outcrops of gypsum are discontinuous on both sides of the river, with section thicknesses ranging from 0.5 to 12 m (average 3 m). The dominant lithology in these exposures is a massive snow-white gypsum with a chickenwire mosaic texture. It is typically, medium to fine crystalline, with banding prominent in some sections. The bands consist of alternating massive gypsum and dark brown to clear, coarsely crystalline selenite. Limestone clasts and impurities are also common. Where the massive white gypsum dominates the section, the surface can be very smooth and scalloped, or rounded. The face of the outcrop can be undercut by dissolution (Photo 10a and b).

The massive gypsum unit is overlain by a gypsum breccia in some areas of the outcrops which consists of grey, fine- to medium-grained clasts of gypsum and limestone in a matrix of dark green-grey argillaceous material. The breccia unit is not as well developed on the Cheepash River as it is on the Moose River. The breccia unit is overlain by an impure white to brown massive gypsum at some outcrops along the Cheepash River. It consists of medium to finely crystalline gypsum with abundant limy clots and bands of argillaceous and laminated limestone (Photo 11a and b).

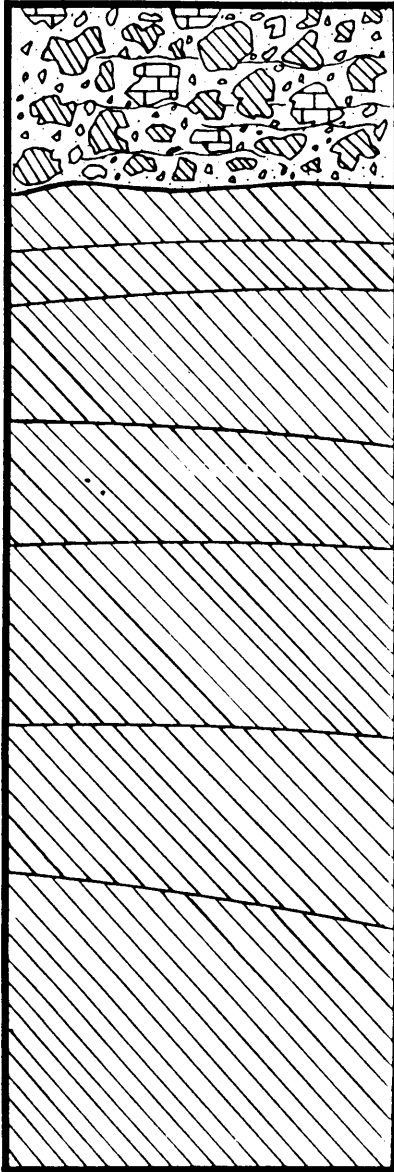
Along the south side of the Cheepash River, an 18 hole drilling program was carried out in 1963 (Figure 6). This program proved the existence of the gypsum to approximately 40 m

OUTCROP SECTION (# 106) OF CHEEPASH RIVER GYPSUM

6.0

METRES

0.0



GYPSUM BRECCIA:

- Clasts of gypsum, limestone and selenite (1.0 cm to 0.5 m in diameter)
- Some bedding present

MASSIVE GYPSUM with SELENITIC BANDS:

- Massive, white - brown gypsum at base, fine crystalline
- Selenitic gypsum towards the top (coarse crystalline)

**FIGURE 8: A typical lithologic section from
the Cheepash River.**

below the surface. As previously mentioned, the upper surface of the Moose River Formation in this area is very scalloped and eroded, probably due to a combination of karstification and glacial scouring.

4.5 Moose River Gypsum Study Site

Exposures of gypsum occur along the banks of the Moose River, northeast of the Ontario Northland Railway bridge at the community of Moose River Crossing (Figure 1-1). The north bank outcrops extend east for approximately 4 km, and the south bank exposures extend east for approximately 3.5 km. A second outcrop of gypsum, approximately 1 km in length, occurs 11 km east of the railway bridge on the south bank of the Moose River.

The Moose River gypsum exposures consist predominantly of two units: 1) massive to banded pure gypsum; overlain by 2) gypsum breccia (Photo 8; Figure 9). Outcrop exposures of both units range in thickness from less than 0.5 to 9 m, with an average thickness of 2.5 m. The lower gypsiferous unit typically consists of medium to finely crystalline, massive, white gypsum, with a chickenwire mosaic texture. The colour of the gypsum varies through white, orange, pink, brown, and grey. The massive gypsum unit in some exposures grades into an interbanded unit of dark brown selenite and white gypsum. Some outcrops of massive white gypsum have abundant, medium to finely crystalline, dark brown selenite eyes, which gives them a distinctive appearance.

The massive gypsum unit has a sharp contact with the overlying gypsum breccia unit. The breccia is a conspicuous rock

OUTCROP SECTION (#32) OF MOOSE RIVER GYPSUM

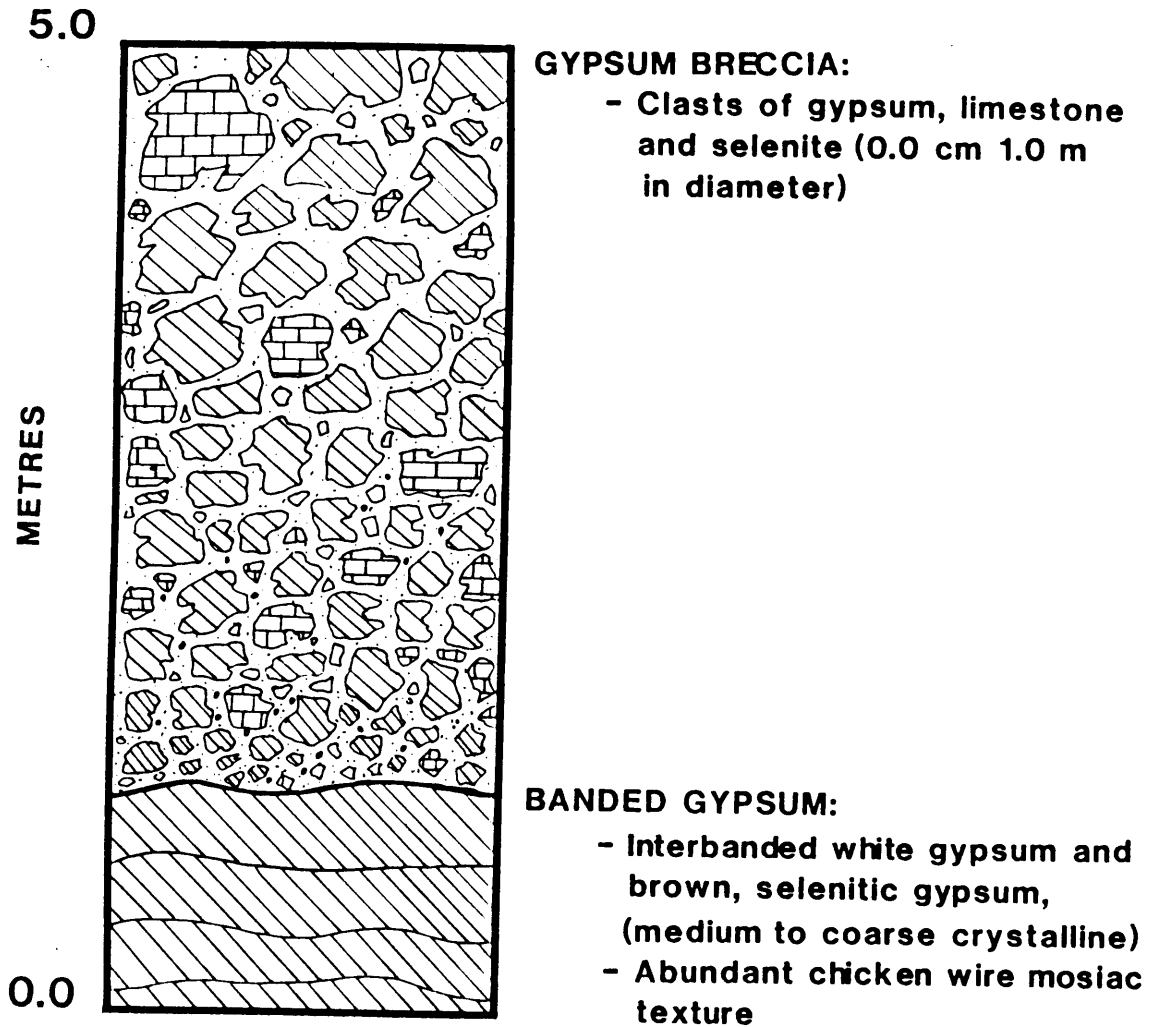


FIGURE 9: A typical lithologic section from
the Moose River.

type on the Moose River, with the lower 0.5 m usually matrix supported (Photo 6). It grades upward into a clast-supported breccia with large (up to 3 m in diameter) clasts of gypsum, selenite, and limestone contained in a grey matrix. The matrix consists of fine-grained aggregates of gypsum and breccia. The lower contact with the massive gypsum unit is usually very undulatory (up to 0.5 m).

On the Moose River, gypsum appears to extend several metres below the surface of the water, as indicated by the presence of deep pools beneath some outcrops at the shoreline. Large overhangs of gypsum are present where river water has dissolved the outcrop. Large solution cavities have developed along joint sets at the water level. These solution cavities are up to 1 m deep, and extend 3 to 4 m back into the outcrop, and nearly always vertical. The development of caverns appears to be more advanced on the Moose River exposures, since jointing is not as well developed at the Cheepash River and Gypsum Mountain outcrops.

4.6 Gypsum Mountain Study Site

Southeast of the Moose River gypsum exposures there is an area called Gypsum Mountain (Figure 1-2), which lies between the Abitibi and North French Rivers. The area is less than 8 m above the level of the surrounding muskeg, but due to improved drainage in the area, a varied and substantial growth of trees has developed, giving the area the appearance of considerable relief (Photo 12a and b). Gypsum Mountain was first discovered by

Alexander Niven in 1898 while surveying the Algoma-Nipissing boundary. Today the site is identified as an Area of Natural and Scientific Interest (ANSI) by the Ontario Ministry of Natural Resources because of its unique karst topography and the natural gypsum bridges which span the small streams and ponds at the site.

The area covers approximately 5 km², and can be most easily accessed by helicopter. For this study, an area of approximately 1 km² was mapped. The gypsum at Gypsum Mountain is predominantly massive, white, and medium to finely crystalline, with thin beds and laminae of brown limestone present in some sections. These outcrop exposures are difficult to examine because of the weathered nature of the outcrop surface. The outcrops are not as water-scoured as they are at the Moose and Cheepash Rivers sites. This study confirmed the presence of the gypsum breccia unit at Gypsum Mountain, specifically at the southern end of the mapped outcrop exposures. Photo 13 shows the contact between the massive gypsum unit and the gypsum breccia at Gypsum Mountain.

4.7 Wakwayowkastic River Exposures

Several low outcrops of gypsum occur over a one kilometre stretch of the Wakwayowkastic River - about 10 km above the junction with the North French River and about 32 km southeast of Moose River Crossing. Outcrops are restricted to the east bank of the river and form low, smooth exposures. A thickness of approximately 2 m of gypsum is exposed in the sections, and consists of white, finely granular, massive gypsum with traces of

dark impurities in the form of crenulated laminae. No limestone or gypsum breccia was observed.

4.8 Geochemistry

A total of 115 samples were submitted for chemical analysis. The analyses are presented in the appendices listed under their laboratory identification numbers. To identify specific sites from which the samples were taken, refer to Appendix 5 which correlates the laboratory number with site numbers. The raw chemical data is given in Appendix 3. To avoid bias the samples were sent to the laboratory in a random order. Major elements SiO_2 , Al_2O_3 , Fe_2O_3 , MgO , CaO , Na_2O , K_2O , TiO_2 , P_2O_5 , MnO , and loss on ignition are shown in Appendix 3.1. The samples were further analyzed for U, Cl, F, S, CO_2 , C(T), and free moisture. The results of these analyses are shown in Appendix 3.2. Semi-quantitative tests for a variety of major, minor and trace elements were also made. Elements detected in these analyses include Ca, Mg, Si, Fe, Al, Mn, Cu, Na, K, Cr, Pb, Ni, Ti and As. These results are on file with the Engineering and Terrain Geology Section, Ontario Geological Survey and the Mineral Development Section, Ministry of Northern Development and Mines. The chemical analyses were carried out by Lakefield Research, in Lakefield, Ontario. Appendix 5 lists the percentage gypsum, anhydrite, and carbonate calculated from the whole rock analyses. The method of calculation is given in Appendix 4.

Data from the three main study areas are listed separately in Appendix 5. The Moose River samples have an average gypsum

content of 96.44%, with a range of 92.35 to 98.57%. Anhydrite values for this study site range from 0.0 to 4.29%, with an average of 0.51%. The carbonate values range from 0.22 to 7.05% and have an average of 2.87%.

The Cheepash River site has samples with a gypsum content of 84.31 to 100.42%, with an average of 96.57%. Anhydrite values range from 0.0 to 7.68% with an average of 1.20%, and carbonate values range from 0.11 to 15.72% (average 2.81%). Samples from Gypsum Mountain range from 95.03 to 97.95% in gypsum content, with an average of 96.30%. Anhydrite values range from 0.0 to 2.05% (average 0.59%) and carbonate values range from 0.75 to 4.18% (average 2.55%). Values for NaCl (not shown on Appendix 5) from all study sites range from 0.0016 to 0.056%.

These gypsum values support and confirm the apparent high purity of the Moose River Basin gypsum deposits and suggest approximately equal purity across all sites sampled.

4.9 Thin Section Analysis

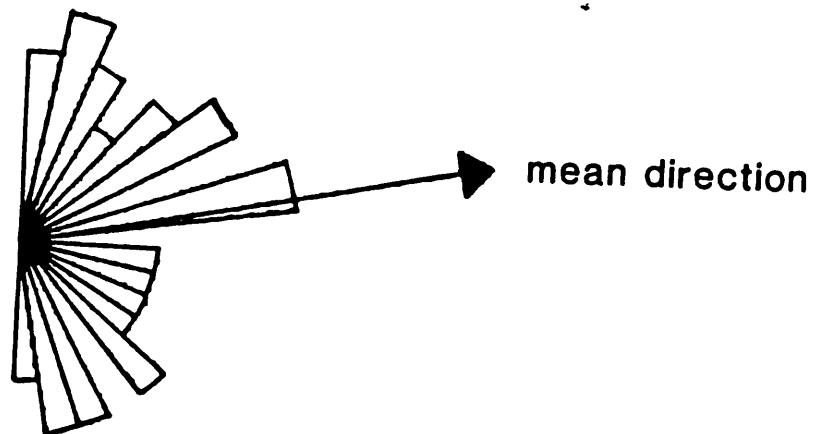
A total of ten thin sections were made from the three study areas (Appendix 2). From examination of these thin sections of the gypsum units, bitumen and carbonate particles were identified. In outcrop they were usually too small in size to positively identify. Anhydrite was not identified in any of the thin sections or in outcrop, although thin seams were identified in the Schlievert Lake (#74), Campbell Lake (#39), Jaab Lake (#38), and James Bay Basin Oil (#67) drillholes.

From visual analysis of the individual sections and from the corresponding hand samples, an impure sample could easily be distinguished from a pure sample. When the percent gypsum versus impurities averages are considered, the visual assessment correlates quite well with the analytical values (Appendix 2 and Appendix 5). In thin sections from all the study sites, gypsum crystals are mostly very fine- to fine-grained and occur in clusters or aggregates around larger crystals. Some of these "core" crystals are as large as 1 to 2 mm in diameter and probably represent the selenitic form of gypsum. Impurities (carbonates and insolubles) occur either in clusters within the fine-grained gypsum aggregates, or along grain boundaries. Impurities also occur along small fractures. Dolomite crystals (rhombohedrons) appear quite common (1-2 microns in diameter) and are sometimes seen as inclusions within the larger selenite crystals.

4.10 Joints Patterns in Outcrop

An interesting feature of the gypsum outcrops in the Moose River Basin, is the consistent joint pattern that emerges at the Moose and Cheepash River study sites (Photo 14a and b). Figures 10 and 11 are rose diagrams (joints vs. frequency) of joints measured from the Cheepash River and Moose River sites, respectively. All joints measured at the outcrop sites were

Cheepash River Joints

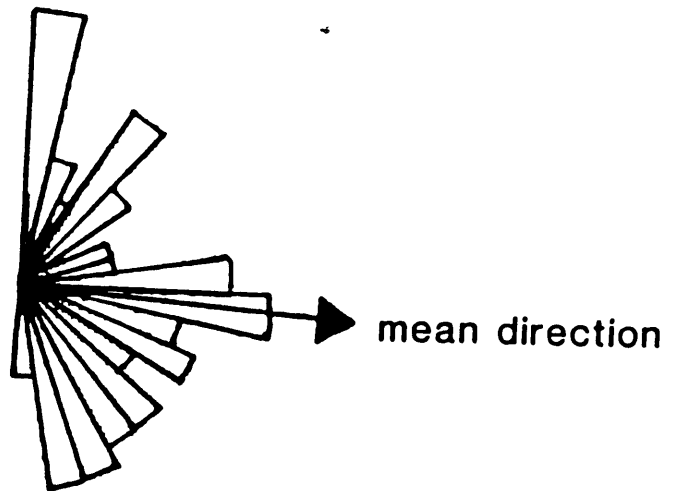


Number of observations: 28

Vector mean: 78.5

Figure 10: Joint patterns from the Cheepash River site and the mean vector direction.

Moose River Joints



Number of observations: 62

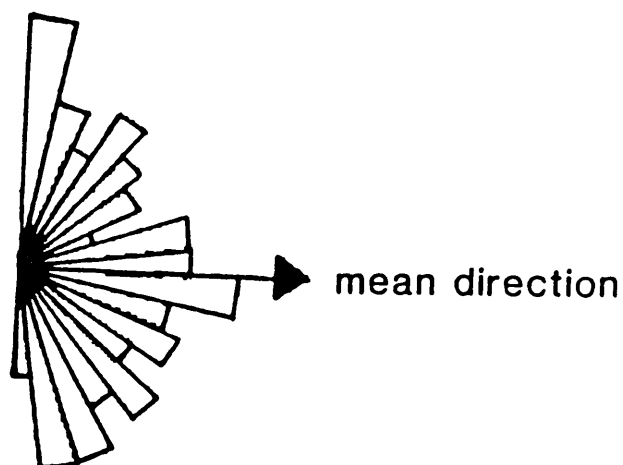
Vector mean: 94.1

Figure 11: Joint patterns from the Moose River site and the mean vector direction.

nearly vertical and spaced approximately 0.5 to 2 m apart. The representative rose diagrams are subdivided into 10 degree sectors (to equal 180 degrees). See Appendix 6 for joint measurements of each site.

The Cheepash River joints have a vector mean of 78.5 degrees, whereas at the Moose River site joint have a vector mean of 94.1 degrees. Figure 12 shows the average of both study areas to be 89.2 degrees, from a total of 90 observations. Jointing is better developed on the Moose River than the Cheepash River outcrops, attesting to the number of observations: 62 and 28, 10 respectively. The similarity of joint directions at the two sites suggest that joint patterns probably reflect a regional trend in this part of the Moose River Basin and not a localized orientation.

Gypsum Study Joints (cumulative)



Number of observations: 90

Vector mean: 89.2

Figure 12: Cumulative joint patterns from the Cheepash and Moose River sites and their mean vector direction.

5.0 DISCUSSION OF THE DEPOSITIONAL ENVIRONMENT AND DIAGENESIS OF THE DEPOSITS

Depositional Environment

The precise depositional environment of the gypsum is not clearly identifiable as a result of both poor preservation of the primary depositional structures and sparse outcrop exposure. However, the following statements can be made which suggest the deposition occurred in a quiet water hypersaline environment. The Moose River Formation strata, other than the gypsum beds are devoid of continental lithologies. So are the under and overlying formations (Kwataboahegan and Murray Island) which makes the sudden transition to continental deposition within the Moose River Formation relatively unlikely. The location of the exposures, well into the depositional basin, also supports a subaqueous setting. The apparent total size of the deposit, assuming that all the outcrops represent a single depositional event, is further evidence of modern day analogues and examples from the geological record suggest continental deposits (i.e. playas and playa lakes) to be relatively thin, laminated and are limited in geographic extent relative to subaqueous deposits (Kendall 1981). Continental deposits often display drying features (i.e. crusts etc.) and mineral zonation, which is not evident in the Moose River deposits.

Subaqueous gypsum deposits are assumed to result from the evaporation of very large water bodies or the desiccation of seas. They can be very large and very thick (e.g. Salina Formation of the Michigan Basin). Studies suggest that

subaqueous gypsum deposits can occur in both shallow and deep water (Kendall 1981). In both situations evaporation occurs at the water surface of a restricted basin and evaporite crystals rain down through the hypersaline water column and collect on the substrate (see Figure 13). Identified as supportive evidence for deeper water deposition is the presence of evenly laminated gypsum beds (rhythmites), turbidites, and the absence of shallow water depositional features (Schreiber et al 1976).

Anhydritisation and subsequently gypsification (see below) has destroyed most of the finer depositional features within the Moose River Formation gypsum deposits making identification of these features inconclusive. Limestone beds within the gypsum are finely crystalline and often thinly laminated suggesting quiet water deposition.

Several conditions are required for evaporite deposition to occur: restricted circulation, a high rate of evaporation and very low atmospheric humidity. Continuous input of normal marine water into a restricted basin is also required. Barriers to restrict circulation could be in the form of sand bars or reefs, or tectonic uplift.

The role of the Moose River High (Figure 7) during deposition of the gypsum is not clear. Although the gypsum is presently located on the flank of the high there is no evidence to indicate that the position of the high has not moved since deposition. Research by Stoakes (1978) suggests that the high was influential during the Middle Devonian and may have been the

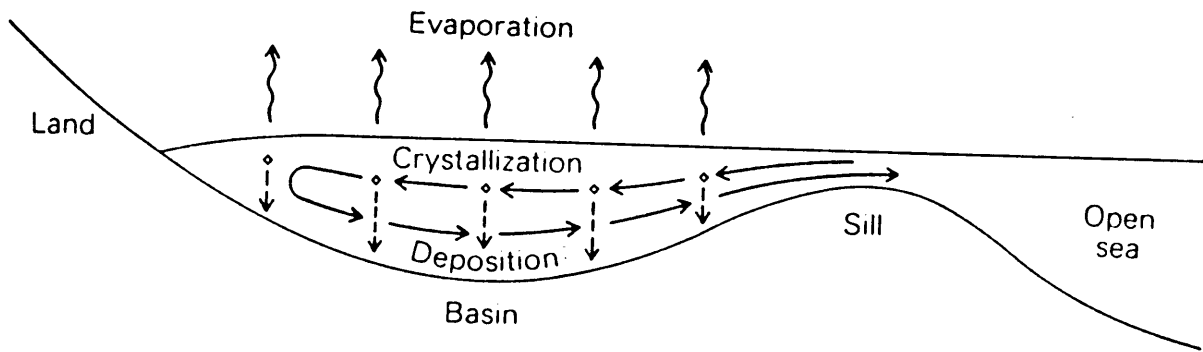


Figure 13: Simplified open system model of an evaporite basin with flow directions indicated by solid arrows (from Berner 1971, fig. 5-4).

ridge which caused the basin restriction and resulted in the gypsum being deposited.

Diagenesis of the Deposits

Anhydrite could not be visually identified in the outcrop exposures of the Moose River Formation in this study although the results of the geochemical analyses (Appendix 3) suggest that small quantities are present. During evaporation gypsum will precipitate rather than anhydrite, even when anhydrite is more stable (Berner 1971) and anhydrite seeds are present which would favor anhydrite deposition. Anhydrite can be identified in drill cores which intersect the Moose River Formation away from the main outcrop trend (Figure 5).

This suggests that at least a portion of the gypsum has undergone anhydritisation (i.e. the change from gypsum to anhydrite) and stayed in this form. This process is generally attributed the effects of overburden pressure and geothermal gradient. The return of anhydrite to gypsum (gypsification) requires the introduction of waters which are undersaturated with respect to sulphates (Sonnenfeld 1984). As surface waters are usually of this type, surface deposits are almost invariably altered to gypsum. The presence of traces of anhydrite in the geochemical data (Appendix 5) taken from outcrop samples suggests that the anhydrite which is present consists of relict grains surrounded by gypsum (Stoaks 1975, Sonnenfeld 1984).

Gypsification produces up to 61% increase in volume depending on the confining pressure (60 to 150 Kpa are required

to overcome this expansion). At high pressures a porphyblastic texture is produced in the gypsum where as at low pressures an alabastine texture results. Most of the Moose River Basin deposits have an alabastine texture suggesting low pressure gypsification has taken place. Further evidence of gypsification of the deposits exists in the form of warped and deformed beds of claystone and limestone within the gypsum, as a result of swelling (Photo 3).

In this study the common evaporite mineral halite (NaCl) was found to occur in only trace amounts in the deposits (Appendix 3). Hudson Bay Basin drillhole information suggests that halite was present in beds up to 11 metres thick (Sanford and Norris 1975). If present, this material was subsequently removed by subsurface dissolution. Scattered inclusions of gypsum and anhydrite are also evident in the Hudson Bay Basin core. Deposition and subsequent dissolution of halite from within the Moose River Basin gypsum is a possible mechanism for the formation of the gypsum breccia. At each of the study sites this lithology is found overlying the massive gypsum units. With the removal of the halite by dissolution, the upper massive gypsum unit would collapse on to the lower producing the gypsum breccia which is the pattern observed at each study sites.

6.0 SUMMARY OF RESULTS

1) Gypsum outcrops occur in a belt which appears to extend approximately 70 km from the Cheepash River in the northwest to the Wakwayowkastic River in the southeast, assuming an ellipse is drawn around the known deposits. This belt of outcrops has a maximum width of at least 10 km. and appears to parallel the axis of the Moose River High, a Precambrian basement high. No outcrops of gypsum have yet been discovered away from this belt. In the subsurface, minor gypsum is present in holes to the west and southwest of the belt.

2) The geology of the gypsum is very similar at all three of the main study sites: the Cheepash River, the Moose River, and Gypsum Mountain. The lithologies typically consist of a massive to banded white gypsum, overlain by a gypsum breccia. The presence of limestone and interbedded limestone and gypsum is of minor occurrence. This suggests an inter-relationship exists between the deposits and supports the suggestion that the outcrops form part of an elongate band of gypsiferous rocks, or at least all the outcrops represent remnants from the same depositional event.

3) Along the Moose River, outcrop thicknesses of massive to banded gypsum range from <1.0 to approximately 4 m. Subsurface thicknesses of 19.6 and 53.7 m of massive gypsum were measured in the nearby Murray and Mike Island drillholes, respectively. The deposits along the Moose River appear to have the best accessibility from a development viewpoint, since they lie

adjacent to the Ontario Northland Railway line near the community of Moose River Crossing.

4) The Cheepash River deposits display the greatest thickness of massive gypsum and present spectacular outcrop exposures. The outcrop thicknesses of gypsum range from <1.0 to approximately 7 m, whereas diamond drilling carried out near the river has intersected thicknesses of massive white gypsum ranging from 22 to 33 m, extending approximately 40 m below the surface. The outcrops are about 16 km northwest from the junction of the Cheepash River and the Ontario Northland Railway line.

5) At the Gypsum Mountain site, outcrops offer excellent exposures of natural gypsum bridges and examples of karst topography. Thicknesses of the gypsum are variable, averaging 2 to 4 m. The site is a considerable distance from the Ontario Northland Railway and is also identified as an Area of Natural and Scientific Interest (ANSI).

6) The Wakwayowkastic River outcrops are too limited in extent to provide much information on the gypsum at this locality. Outcrop thicknesses of gypsum are approximately 2 m, although subsurface drilling could prove the gypsum beds to be much thicker.

7) Geochemical results indicate the gypsum is of high purity, with gypsum values averaging 96.44, 96.57, and 96.30 % for the Moose River, Cheepash River and Gypsum Mountain sites, respectively. For the entire study area, anhydrite values range from 0.00 to 7.68 %.

8) This study has demonstrated that the three main study areas and the Wakwayowkastic River outcrops each contain the same type of gypsum deposit. Correlation to nearby drillholes containing gypsum is difficult because of the lack of consistent marker beds or horizons. Subsurface investigation for gypsum in the areas between the outcrops could delineate additional deposits of the gypsum belt.

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8.0 PHOTOGRAPHS

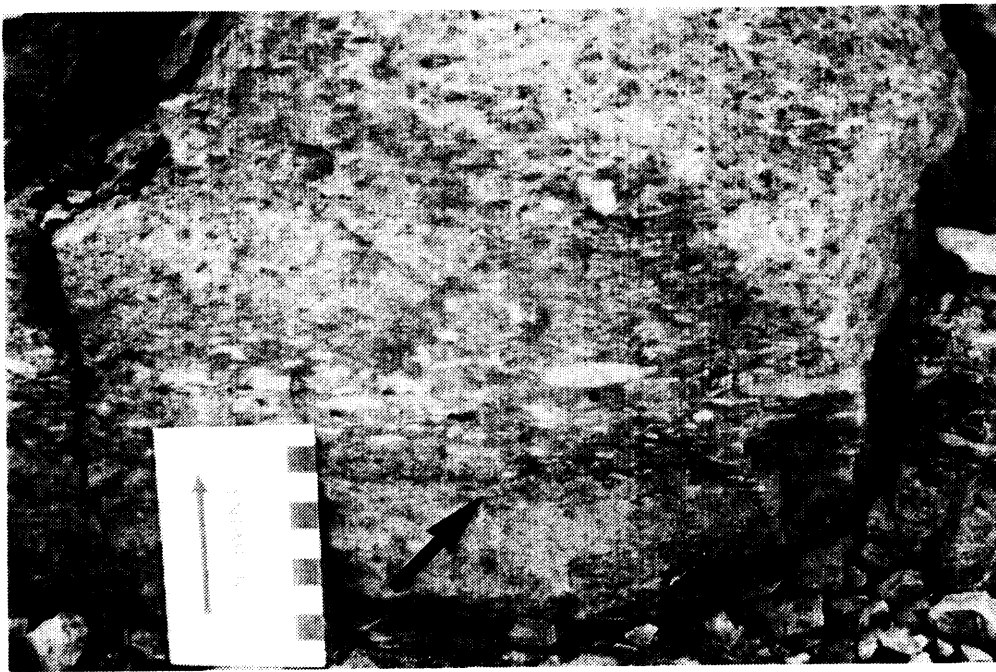


Photo 1a: Contact between the Moose River Formation (bottom) and Murray Island Formation (top). Arrow points to contact.



Photo 1b: Moose River Formation limestone at station 75 on the Cheepash River. Note the slight warping of the beds.



Photo 2: Massive to banded white gypsum (facies 1a and 1b) in outcrop. Cheepash River station 82.



Photo 3: Alternating bands of argillaceous limestone and white (facies 1b). Cheepash River station 77.

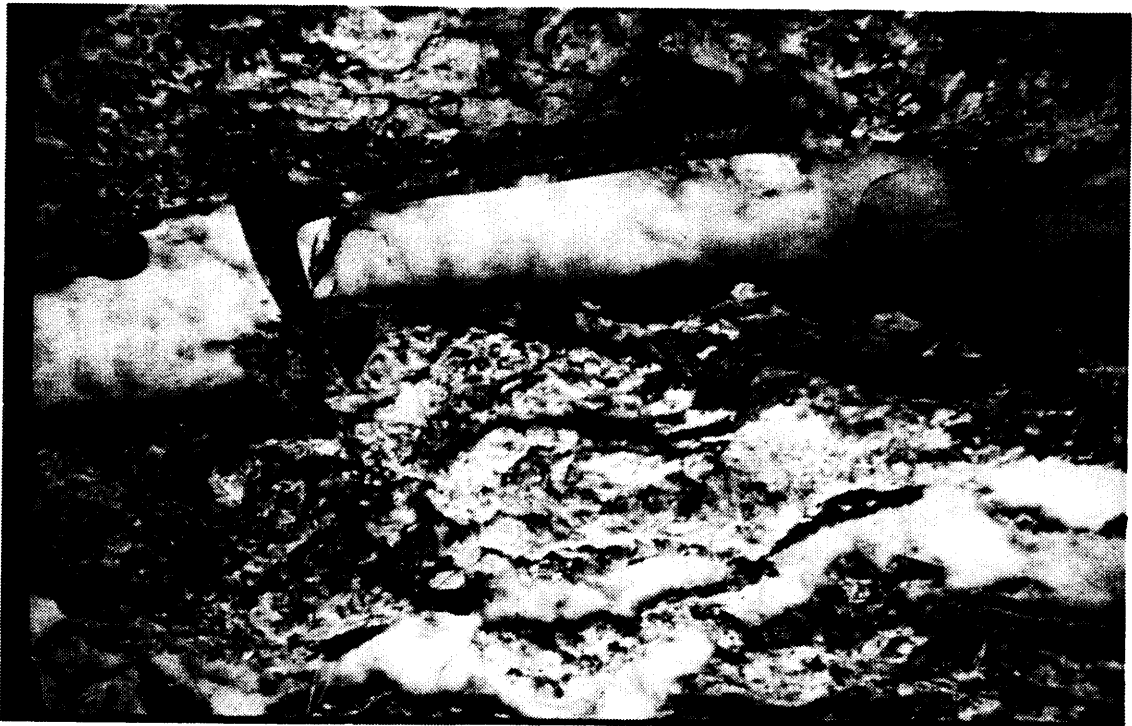


Photo 4: Banded white gypsum and fine crystalline limestone (facies 1b). Cheepash River station 101.



Photo 5: Massive, impure gypsum with chickenwire mosaic texture (facies 1b). Note the very coarse crystalline "eyes" of clear selenite. Cheepash River station 82.



Photo 6: Contact between the massive gypsum facies (1a) (bottom) and the gypsum breccia facies (2) (top). The gypsum facies is typically mottled with brown to salmon-pink selenite at this contact. Note the very argillaceous character of the breccia matrix and clast size increase upward. Moose River station 16.



Photo 7: Large selenite crystals in gypsum. Cheepash River station 72.

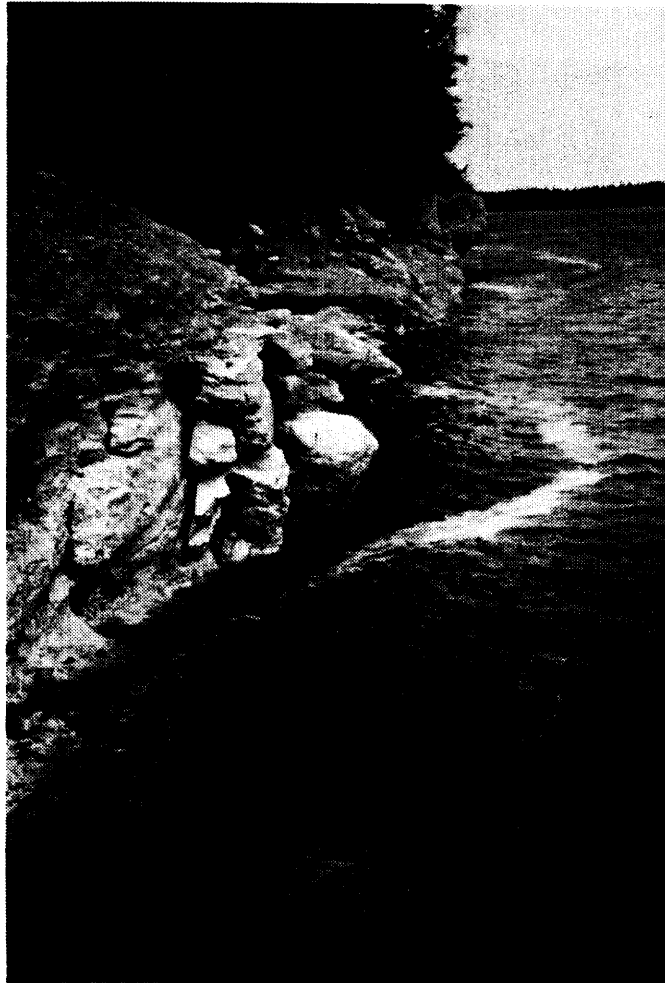


Photo 8: River bank exposure of the massive to mottled gypsum facies (bottom) overlain by gypsum breccia unit (top). Moose River station 21.



Photo 9: Large clast of white gypsum in gypsum breccia unit.
Moose River station 19.



Photo 10a: Prominent colouring banding in gypsum unit. Cheepash River station 101.

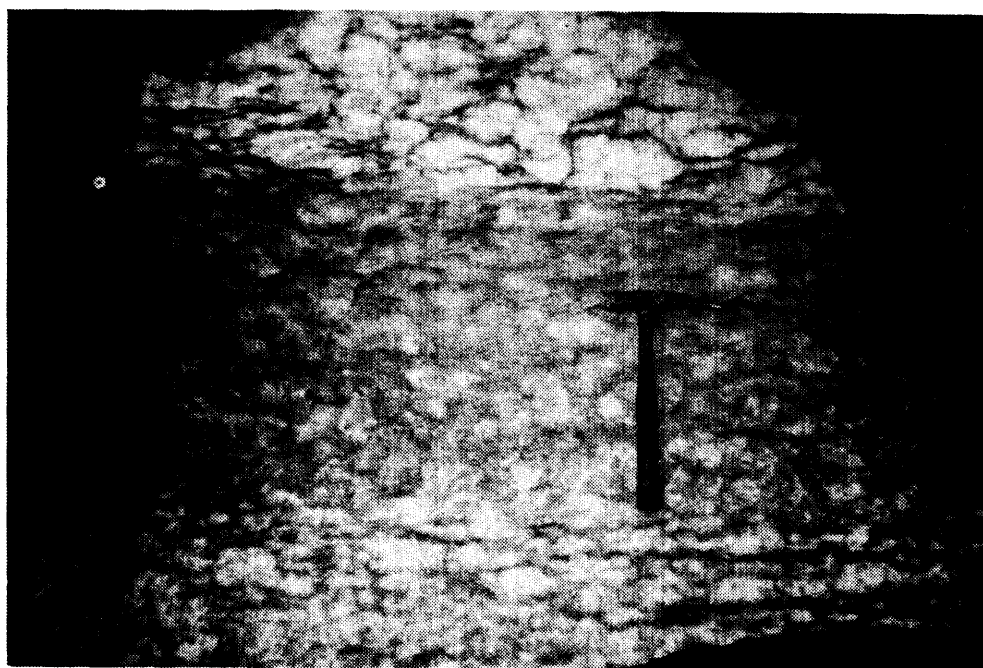


Photo 10b: Banding and chickenwire texture mosaic in gypsum unit. Cheepash River station 107.

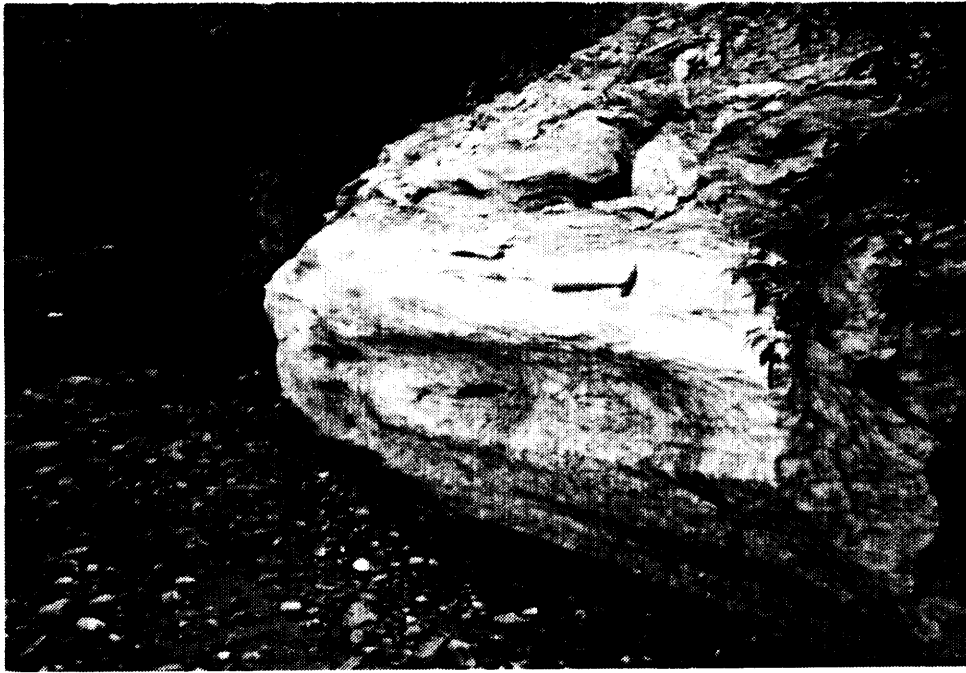


Photo 11a: Massive gypsum unit overlain by breccia unit. Note how water dissolution has undercut the gypsum outcrop. Cheepash River station 70.



Photo 11b: Massive gypsum unit with chickenwire mosaic texture overlain by gypsum breccia unit (top). Note calcareous clay intercalations in gypsum below contact. Cheepash River station 77.

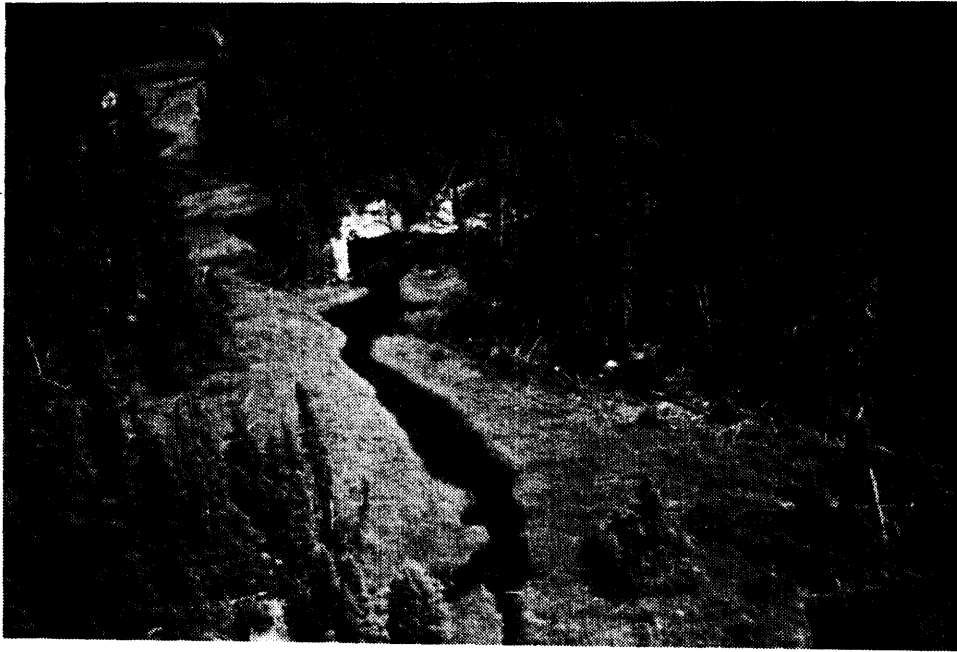


Photo 12a: Aerial view of the Gypsum Mountain area with a natural gypsum bridge in the background (Station RB-4).

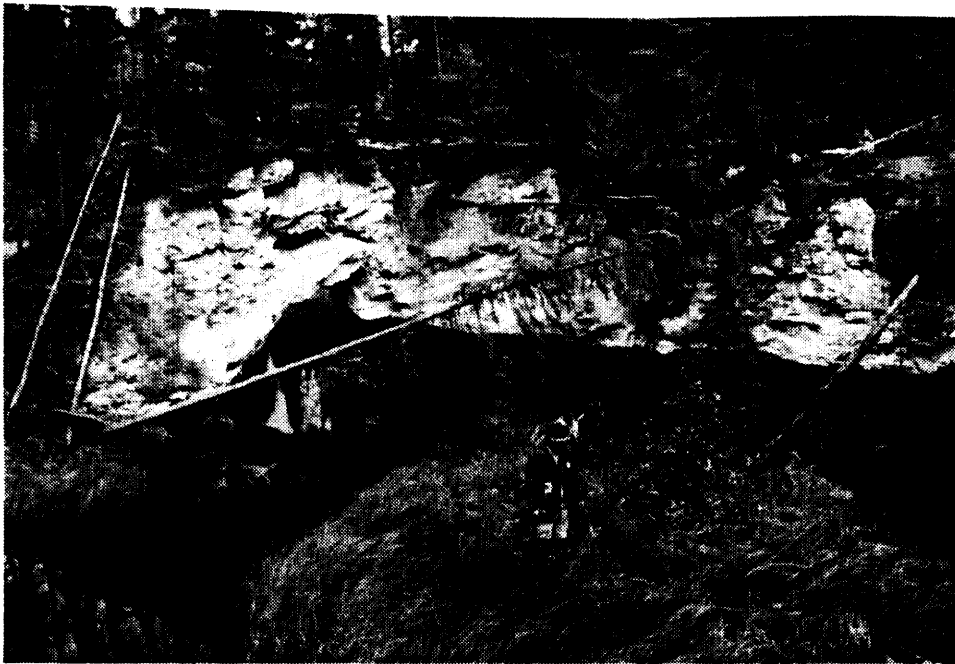


Photo 12b: Close-up of natural gypsum bridge. Gypsum Mountain station RB-4.

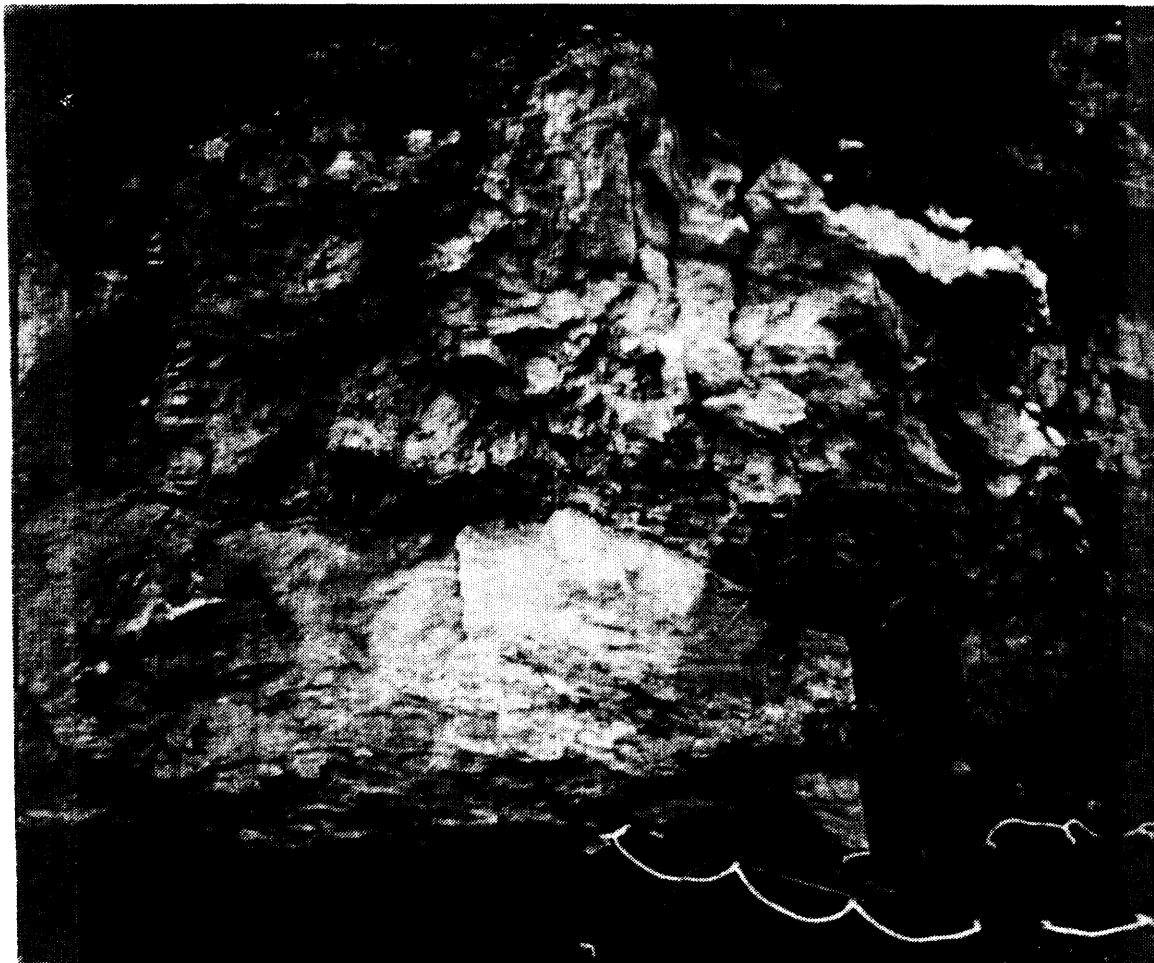


Photo 13: Contact between massive gypsum unit (facies 1a) (top) and gypsum breccia (facies 2). Gypsum Mountain station RB-5.

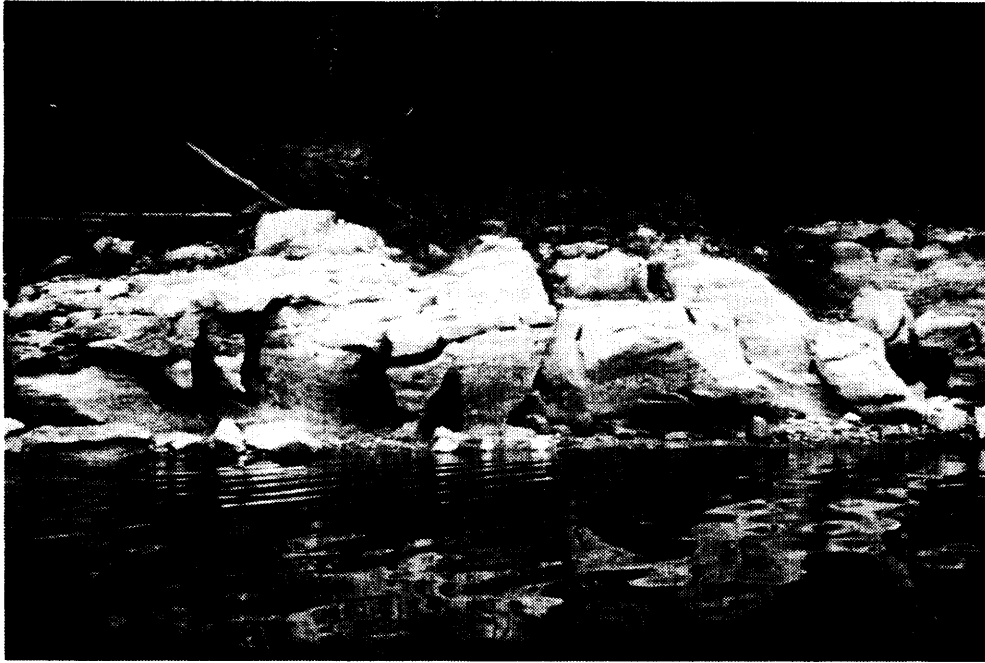


Photo 14a: Joints in a massive to banded gypsum unit. Moose River station RB-6.



Photo 14b: Joints in massive white gypsum. Cheepash River station 106.

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APPENDIX 1

DRILL LOGS FOR MOOSE THE RIVER BASIN GYPSUM STUDY
 (Moose River Formation Interval)
 (see also Figure 5)

#39: Ontario Department of Mines Campbell Lake Drillhole

Location: East side of Campbell Lake at approximately
 50°14'30"N, and 80°09'30"W.

References: Hogg et al. (1953), Sanford and Norris (1975)

DEPTH (m)	DESCRIPTION
0-213.4	Overburden Moose River Formation
213.4-214.7	Gypsum: vitreous, light grey to pale amber.
214.7-218.9	Limestone breccia: alternating with shale, limestone, gypsum, anhydrite; fragments are angular, shale fills cavities.
218.9-219.5	Limestone: light grey-brown, finely crystalline.
219.5-225.7	Gypsum: white to pink, to pale amber and grey.
225.7-226.3	Dolostone: argillaceous, light to medium grey, finely crystalline, grading to pale brown, microcrystalline, numerous fine fractures filled with anhydrite.
226.3-226.5	Limestone: light to medium brown, microcrystalline.
226.5-228.3	missing.
228.5-228.6	Limestone: argillaceous, medium grey-brown, poor recovery.
228.6-230.4	missing.
230.4-230.7	Dolostone: light tan, microcrystalline, contains grey argillaceous blebs and streaks.
230.7-231.0	missing.

- 231.0-233.5 Limestone: light to medium brown, microcrystalline, alternating with calcareous shale.
- 233.5-235.3 missing.
- 235.3-235.6 Dolostone: light cream, contains numerous honeycomb-like vugs, some filled with anhydrite.
- 235.6-239.6 missing.
- 239.6-242.6 Limestone: light to medium brown, finely crystalline to microgranular texture, scattered bituminous streaks, slightly pelletoidal.
- Kwataboahegan Formation
- 242.6-244.6 Limestone: light brown, fine to medium granular texture, slightly calcarenitic, contains numerous bulbous stromatoporoids; *Coenites?* sp., *Syringopora?* sp., and ostracodes from this interval.

Kwataboahegan and Stopping River Formation and Precambrian strata continue to 312.6 m (end of hole).

#74: Ontario Geological Survey Schlievert Lake Drillhole 83-8D

Location: North side of Schlievert Lakes at approximately
50°33'17"N, and 82°58'20"W.

References: Russell et al. (1985)

DEPTH (m)	DESCRIPTION
0-152.2	Recent and Quaternary sediments.
152.2-154	Cretaceous Mattagami Formation?
154-235.2	Devonian Williams Island Formation.
	Moose River Formation
235.2-241.2	Brecciated limestone: slightly calcareous in parts, fine to medium grained, grey, buff in colour, unit is characterized by very high porosity formed by vugs and brecciation caused by dissolution of anhydrite.
241.2-247.4	Brecciated limestone and mudstone: similar to 230.7-235.2 m (above), but with significantly higher mudstone content.
247.4-258.4	Brecciated limestone: top part is light-grey to white, very finely crystalline to sublithographic, with some fine grains and quartz sand grains; non-porous, but disturbed laminae; grades down into heavily leached, rubbly zone of the same lithology and with many vugs; grain size is slightly coarser at base.
258.4-264.4	Dolomitic limestone: tan, light grey becoming browner at base, very finely crystalline; texture ranges from nodular to bioturbated (toward the base) and faint colour laminations. Base is sharp, but conformable.
	Kwataboahegan Formation
264.4-317	Fossiliferous limestone and blue dolostone.
Kwataboahegan, Stooping River, and Kenogami River Formations and Precambrian strata continue to 624.5 m (end of hole).	

#42: Hydro-Electric Power Commission of Ontario, Renison Site,
Drillhole R-1

Location: Immediately east northeast of the Renison flag stop
on Ontario Northland Railway at approximately
50°58'36"N, and 81°07'18"W.

References: Sanford and Norris (1975)

DEPTH (m)	DESCRIPTION
0-9.1	Overburden
9.1-9.8	No recovery
9.8-10.2	Limestone: light brown to light yellow-brown, finely crystalline, microsucrosic texture, considerable intercrystalline and some vuggy porosity
10.2-10.4	Dolostone: light brown, sucrosic, extremely porous, vugs up to 0.5 cm in diameter
10.4-10.9	Limestone: slightly dolomitic, light brown, microsucrosic, some intercrystalline porosity and a few small vugs, in lower 0.3 m - mottled sucrosic dolostone interbeds which appear to be secondary dolostone.
10.9-13.4	Dolostone, and minor relict limestone mottling: medium grey-brown, micro-sucrosic, considerable intergranular porosity, vuggy with some vugs filled with white calcite, some pseudomorphs of gypsum.
13.4-14.1	Limestone: bituminous laminae, medium brown, finely crystalline, non-porous.
14.1-14.6	Dolostone: medium brown, sucrosic, highly porous, contains numerous vugs filled with calcite, some pseudomorphs of selenite.
	Kwataboahegan Formation
14.6-15.2	Limestone: slightly dolomitic, considerable bituminous laminae, finely to medium crystalline, contains abundant echinoderm ossicles, some fragmentary solitary corals

Kwataboahegan and Stopping River Formations continue to
74.7 m (end of hole).

#67: The James Bay Basin Oil Company Limited, Well No.1

Location: On Mike Island (Moose River) at approximately
50°47'48"N, and 81°20'00"W.

References: Satterly (1953)

DEPTH (m)	DESCRIPTION
0-11.3	Overburden
11.3-47.5	Devonian: Williams Island Formation; shale and limestone
47.5-53.6	Murray Island Formation: fossiliferous limestone
	Moose River Formation
53.6-53.9	Gypsum and selenite
53.9-56.7	Limestone: buff coloured, soft
56.7-59.7	Blue shale
59.7-65.2	Dolomitic limestone: gas?
65.2-72.8	Shale and brown dolostone: salt water and gas?
72.8-78.9	Mottled gypsum
78.9-80.8	Light blue anhydrite and gypsum
80.8-82.0	Interbedded gypsum and shale
82.0-84.4	Gypsum and selenite
84.4-85.0	Interbedded gypsum and shale
85.0-85.6	Dolostone: with anhydrite and selenite
85.6-89.0	Limestone: with anhydrite and selenite
89.0-89.6	Grey limestone and selenite
89.6-95.1	Gypsum and selenite
95.1-96.9	Limestone and selenite
96.9-101.2	Mottled gypsum
101.2-119.2	Gypsum, selenite, and limestone

119.2-133.8	Mottled limestone and selenite Kwataboahegan Formation
133.8-142.3	Mottled limestone
142.3-175.6	Brown limestone and shale (showing oil)
175.6-182.3	Conglomerate breccia; showing fossil in lower horizon
182.3-185.9	Granite (Precambrian)

End of Hole.

#68: The James Bay Basin Oil Company Limited, Well No.2

Location: On Mike Island (Moose River) at approximately
50°47'48"N, and 81°20'00"W.

References: Satterly (1953)

DEPTH (m)	DESCRIPTION
0-12.2	Overburden: Clay and boulders
12.2-18.6	Devonian Murray Island Formation: brown dolomitic limestone and grey shale Moose River Formation
18.6-21.9	Grey shale
21.9-34.1	Gypsum: good grade, some mottled
34.1-35.7	Gypsum and grey shale
35.7-38.7	Grey shale
38.7-39.9	Gypsum
39.9-48.8	Gypsum: bedded, with grey shale and selenite
48.8-51.2	Interbedded gypsum and limestone Kwataboahegan Formation
51.2-104.9	Limestone: light buff to dark brown and grey mottled.
104.9-114.9	Conglomerate Breccia: fossilized

End of hole

#38: Ontario Department of Mines Jaab Lake Drillhole

Location: North shore of Jaab Lake at approximately
51°11'54"N, and 82°56'00"W.

References: Hogg et al. (1953), Sanford and Norris (1975)

DEPTH (m)	DESCRIPTION
0-44.8	Overburden
	Williams Island Formation
44.8-58.2	Limestone: light brown to tan, fine to coarse crystalline, fossiliferous, some shale
	Murray Island Formation
58.2-64.6	Limestone: tan to light tan, fine crystalline, vuggy, fossiliferous
	Moose River Formation
64.6-67.1	Dolomitic limestone: light brown, fine crystalline, vitreous lustre, slightly bituminous
67.1-71.3	Dolostone: cream to light brown, fine crystalline to microcrystalline, vitreous
71.3-75.3	Limestone: blue-grey to medium grey, subaphanitic to medium crystalline, strongly argillaceous, strongly bituminous in places, contains minor anhydrite, crinoidal?
75.3-77.4	Shale: light grey, friable
77.4-79.9	Limestone: light brown, coarse crystalline
79.9-80.8	Dolostone: light tan, microcrystalline, good pinpoint porosity, a few scattered quartz grains
80.8-82.3	Shale: medium to dark grey, friable
82.3-97.5	Limestone (various forms): light tan to medium brown, fine crystalline, slightly bituminous, pelletal in places, vitreous lustre, slightly dolomitic at base, fragmentary crinoidal material at top,

numerous ostracodes at 88.4 m, fossils present include;

Amphipora cf. *nattressi* (Grabau) and cf.

Diplophyllum sp. from 86.4 m.

Diplophyllum? sp., *Amphipora* cf. *nattressi* (Grabau), and cf. *Microdema* sp. (=Ple

urotrochus sp) from 88.6 m.

Leiorhynchus? sp. from 86.8 m.

cf. *Diplophyllum* sp. from 87.6 m.

Spirifer sp., small young form, from 88.5 m.

Amphipora cf. *nattressi* (Grabau) and *Platyceras* sp. from 88.8 m.

97.5-174.0

Kwataboahegan Formation: limestones

Kwataboahegan, Stopping River, Kenogami River Formations continue to 354.2 m (end of hole).

#77: Ontario Geological Survey Onakawana B Drillhole

Location: Southwest of the Onakawana siding on the Ontario
Northland Railway at approximately 50°34'24"N, and
81°21'10"W.

References: Bezys (1989)

DEPTH (m)	DESCRIPTION
0-21.9	Quaternary and Recent Deposits
21.9-76.8	Cretaceous Mattagami Formation
76.8-151.6	Devonian Long Rapids Formation
151.6-259.2	Devonian Williams Island Formation
259.2-266.1	Devonian Murray Island Formation
	Moose River Formation
266.1-283.5	Brecciated limestone with some mudstone: limestone: grey brown, medium crystalline, irregularly bedded, limestone clasts occur at 266.5 m; mudstone: green-grey, containing angular limestone clasts of various sizes and compositions, becoming laminated by 268.1 m with silty horizons.
283.5-285.4	Mudstone: light and dark grey at top, red at base, calcareous, mottled, thin carbonate bands with wavy bedding in red mudstones.
285.4-287.4	Dolostone: gypsiferous, very fine crystalline, with some light grey argillaceous dolostone beds, gypsum occurs as smokey blebs.
287.4-288.6	Mudstone: grey, massive, noncalcareous, contains satin spar gypsum lenses.
288.6-302.1	Dolomitic limestone: gypsiferous, light grey to brown, very fine crystalline, coarse crystalline smokey gypsum mineralization throughout, satin spar lenses occur at 301.8 m, scattered pinpoint porosity and wispy black laminae.
302.1-302.7	Gypsum: cream-grey, coarse crystalline, satin spar lenses.

302.7-307.5

Dolomitic limestone: tan to grey-green, very fine to fine crystalline, thin bedded, disseminated pyrite crystals and wispy black laminae randomly oriented throughout, first appearance of rose gypsum blebs at 303.6 m, becoming more arenaceous by 307.5 m.

Basal sediments and Precambrian gneiss continue to end of hole (320.9 m).

#64.1: Dewson Mines Drillhole #1-A

Location: On east bank of Mattagami River at approximately
50°21'05"N, and 81°55'47"W.

References: Satterly (1953), Sanford and Norris (1975)

DEPTH (m)	DESCRIPTION
0-14.3	Recent and Quaternary deposits
14.3-26.2	Devonian Long Rapids Formation
26.2-99.1	Devonian Williams Island Formation
99.1-115.8	Devonian Murray Island Formation
	Moose River Formation
115.8-118.4	Shale: dark brown with some limestone breccia
118.4-121.9	Limestone: fine crystalline, some crinoid stems, some irregular bedding at base (15 degrees).
121.9-124.4	Limestone breccia: fine grained, large limestone fragments in clay matrix, bedding in limestone at 20 degrees.
124.4-125.9	Limestone: buff, fine crystalline, bedding at 20 degrees.
125.9-128.5	Limestone breccia: fragments of bedded brown-grey limestone, some "loose" clay and "limestone sand", vuggy in places, clay matrix, cavernous in places, dip of 60 degrees in one limestone fragment.
128.5-129.5	Limestone: brown, granular.
129.5-154.4	Limestone breccia: brown to pale buff limestone fragments in clay matrix, fine crystalline, some bedding evident in limestone, argillaceous in places, vuggy.
154.4-157.6	Limestone: grey to buff, containing aggregate of corals debris.

Kwataboahegan Formation sediments and Precambrian schists to 214.9 m (end of hole).

APPENDIX 2THIN SECTION DESCRIPTIONS FOR THE MOOSE RIVER BASIN GYPSUM
STUDY

Cheepash River Samples:

- 76-1: Fine- to medium-crystalline gypsum crystals - very consistent crystal size; large crystals of gypsum are rare; some alignment of crystals is evident; rare carbonate material (< 0.5 %); rare bituminous material along sutures and crystal contacts.

Percentage of gypsum from thin section analysis:

99-100%
impurities: <1.0%

Percentages determined from geochemistry:

Gypsum: 99.86%
Anhydr: 0.0%
Carbs: 0.28%

- 98-1: Very impure gypsum sample; very fine- to medium-crystalline gypsum crystal aggregates, with abundant impure material along finer crystalline zones and along contacts; impurities consist of very fine- grained bituminous and carbonate material (calcite and dolomite); dolomite rhombs are abundant (2-5 microns in diameter).

Percentage of gypsum from thin section analysis:

90-93%
impurities: 7-10%

Percentages determined from geochemistry:

Gypsum: 97.09%
Anhydr: 0.60%
Carbs: 1.79%

- 106-2: Very fine- to coarsely-crystalline aggregates of gypsum crystals (selenite); contacts to crystals are sharp; crystal shapes are predominantly anhedral; some crystals as large as 1-2 mm in diameter with inclusions of carbonates; very fine-crystalline dolomite rhombs and calcite crystals are present within and along sutures of gypsum crystals; rare bituminous material.

Percentage of gypsum from thin section analysis:

96-98%
impurities: 3-5 %

Percentages determined from geochemistry:

Gypsum:	95.89%
Anhydr:	0.31%
Carbs:	4.29%

107-13: Very fine- to coarse-crystalline aggregates of gypsum crystals; crystal contacts are not as sharp as other thin sections - more irregular; many crystals have halo structures; abundant calcareous material in stringers and clusters (very fine-crystalline).

Percentage of gypsum from thin section analysis:

	94-97%
impurities:	3-6 %

Percentages determined from geochemistry:

Gypsum:	96.61%
Anhydr:	0.98%
Carbs:	2.73%

113-1: Very fine- to medium crystalline gypsum crystals; large crystal forms are rare; crystals are very aggregated and interlocking; good alabaster form; rare carbonate and bituminous material - some dolomite rhombs.

Percentage of gypsum from thin section analysis:

	98-100%
impurities:	<1.0%

Percentages determined from geochemistry:

Gypsum:	97.71%
Anhydr:	0.11%
Carbs:	1.87%

Moose River Samples:

- 17-1: Very coarse-crystalline gypsum (selenite) crystals and aggregates of fine- to medium-crystalline gypsum crystals; crystals can be as large as 1-2 mm in diameter with inclusions of dolomite and calcite crystals (1-2 microns); streaks of insoluble bituminous material (resinous amber colour) present along gypsum crystal contacts.

Percentage of gypsum from thin section analysis:

96-98%
impurities: 2-4 %

Percentages determined from geochemistry:

Gypsum: 95.75%
Anhydr: 0.0 %
Carbs: 2.96%

- 21-2: Very fine- to very coarse-crystalline gypsum crystals; ranging from small gypsum aggregates to very large selenite crystals (1 mm in diameter); carbonate and bituminous material appear to collect within the fine-crystalline aggregates of gypsum; bitumen occurs as small (< 1 micron) flecks; dolomite rhombs are abundant as inclusions.

Percentage of gypsum from thin section analysis:

94-96%
impurities: 5-6 %

Percentages determined from geochemistry:

Gypsum: 92.35%
Anhydr: 0.0 %
Carbs: 7.05%

- 33-1c: Medium- to very coarse-crystalline gypsum (selenite) crystals; minor amounts of fine-crystalline gypsum aggregates; contacts are sharp and irregular; dolomite rhombs, calcite, and bituminous material tend to be associated with fine-crystalline aggregates of gypsum.

Percentage of gypsum from thin section analysis:

98-100%
impurities: 1-2 %

Percentages determined from geochemistry:

Gypsum: 98.24%
 Anhydr: 1.82%
 Carbs: 1.63%

- 44-1: Very fine- to very coarse-crystalline aggregates of gypsum (and selenite) crystals; crystals are very interlocking and anhedral; rare bituminous and carbonate material (very fine-crystalline) occurring as stringers - some dolomite rhombs 1-2 microns in diameter.

Percentage of gypsum from thin section analysis:

97-100%
 impurities: 1.0%

Percentages determined from geochemistry:

Gypsum: 96.85%
 Anhydr: 2.92%
 Carbs: 2.47%

Gypsum Mountain Sample:

- RB-1: Very fine- to fine-crystalline gypsum crystals (<1 micron in diameter); good alabaster fabric with interlocking contacts; many crystals with euhedral texture - many are elongated; large crystals (selenite) are rare (1-1.5 microns) and where present occur in aggregates; rare clusters of carbonate material (very fine-crystalline), tending to occur along fractures and sutures.

Percentage of gypsum from thin section analysis:

97-100%
 impurities: 0-3%

Percentages determined from geochemistry:

Gypsum: 97.95%
 Anhydr: 2.05%
 Carbs: 0.75%

APPENDIX 3

RAW GEOCHEMICAL DATA - 3.1

Sample No.*	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MgO%	CaO%	Na ₂ O%	K ₂ O%	TiO ₂ %	P ₂ O ₅ %	MnO%	LOI%
1	0.08	0.01	0.14	0.20	33.4	<0.01	0.01	<0.01	0.01	<0.01	21.1
2	0.07	0.03	0.09	0.30	35.5	<0.01	<0.01	0.01	<0.01	<0.01	21.1
3	0.14	<0.01	0.09	0.26	33.0	<0.01	0.01	<0.01	0.01	<0.01	21.2
4	0.12	<0.01	0.09	0.70	33.6	<0.01	<0.01	<0.01	0.01	<0.01	22.0
5	0.14	0.03	0.08	0.01	31.6	<0.01	0.01	<0.01	<0.01	<0.01	21.0
6	0.19	0.02	0.08	0.31	32.7	<0.01	0.01	<0.01	0.01	<0.01	21.3
7	0.32	0.07	0.08	0.46	34.0	<0.01	0.03	<0.01	0.01	<0.01	21.5
8	0.23	0.02	0.08	0.16	34.5	<0.01	0.01	<0.01	0.01	<0.01	21.1
9	0.13	<0.01	0.08	0.88	35.2	<0.01	0.01	0.01	0.01	<0.01	22.0
10	0.26	0.25	0.11	0.46	33.5	<0.01	0.03	<0.01	0.02	<0.01	21.4
11	0.15	<0.01	0.10	1.13	37.0	<0.01	0.01	0.01	0.01	<0.01	22.3
12	0.63	0.31	0.09	0.72	34.8	<0.01	0.04	<0.01	0.01	<0.01	21.7
13	0.15	<0.01	0.08	0.49	33.1	<0.01	0.01	<0.01	<0.01	<0.01	21.4
14	0.18	<0.01	0.08	0.53	34.2	<0.01	0.01	<0.01	<0.01	<0.01	21.7
15	0.14	<0.01	0.09	0.66	33.5	<0.01	<0.01	<0.01	<0.01	<0.01	21.7
16	0.18	<0.01	0.08	0.02	33.9	<0.01	0.01	<0.01	0.01	<0.01	21.1
17	0.15	<0.01	0.09	1.10	34.1	<0.01	<0.01	<0.01	0.01	<0.01	22.6
18	0.45	<0.01	0.11	0.12	34.2	<0.01	0.04	0.01	0.01	<0.01	21.0
19	0.14	<0.01	0.09	0.41	32.6	<0.01	0.01	<0.01	0.01	<0.01	21.5
20	0.16	<0.01	0.09	1.19	32.7	<0.01	0.01	<0.01	0.01	<0.01	22.2
21	0.30	<0.01	0.09	0.42	34.4	<0.01	0.01	<0.01	0.01	<0.01	21.5
22	0.12	<0.01	0.08	0.42	35.6	<0.01	<0.01	<0.01	0.01	<0.01	21.5
23	0.17	<0.01	0.08	0.22	36.3	<0.01	0.01	<0.01	<0.01	<0.01	21.2
24	0.12	<0.01	0.08	0.64	32.4	<0.01	0.01	<0.01	0.01	<0.01	21.7
25	0.31	<0.01	0.12	0.61	34.4	<0.01	0.01	0.01	<0.01	<0.01	21.6
26	0.16	<0.01	0.10	1.10	35.8	<0.01	0.01	<0.01	0.01	<0.01	22.2
27	0.16	<0.01	0.08	0.33	31.2	<0.01	0.01	<0.01	<0.01	<0.01	21.1
28	0.19	<0.01	0.08	0.29	32.5	<0.01	0.01	<0.01	<0.01	<0.01	21.1
29	0.71	0.10	0.08	0.26	31.6	<0.01	0.05	<0.01	<0.01	<0.01	21.2
30	0.28	<0.01	0.09	0.91	31.8	<0.01	0.01	<0.01	0.01	<0.01	21.8
31	0.16	<0.01	0.08	0.41	31.4	<0.01	<0.01	<0.01	0.01	<0.01	21.4
32	0.11	<0.01	0.07	0.34	32.0	<0.01	0.01	<0.01	0.01	<0.01	21.3
33	0.14	<0.01	0.08	0.40	31.4	<0.01	<0.01	<0.01	0.01	<0.01	21.4
34	0.11	<0.01	0.08	0.37	33.2	<0.01	<0.01	<0.01	0.01	<0.01	21.2
35	0.38	<0.01	0.10	0.35	32.2	<0.01	0.03	<0.01	<0.01	<0.01	21.1
36	0.19	<0.01	0.08	0.38	31.9	<0.01	0.01	<0.01	<0.01	<0.01	21.3
37	0.10	<0.01	0.07	0.03	30.7	<0.01	0.01	<0.01	0.01	<0.01	21.0
38	0.82	<0.01	0.24	0.10	30.8	<0.01	0.03	0.01	0.01	<0.01	21.0
39	0.07	<0.01	0.08	0.01	33.5	<0.01	0.01	<0.01	<0.01	<0.01	21.0
40	0.10	<0.01	0.08	0.59	34.0	<0.01	0.01	<0.01	0.01	<0.01	21.5
41	0.11	0.09	0.08	1.16	32.5	<0.01	<0.01	<0.01	0.01	<0.01	22.4
42	0.16	<0.01	0.08	1.05	31.0	<0.01	0.01	<0.01	<0.01	<0.01	22.2
43	0.15	<0.01	0.08	1.13	33.2	<0.01	0.01	<0.01	0.01	<0.01	22.4

* Sample numbers for Appendix 5 are the same as lab numbers in Appendix 3 which can be used to determine sample site locations in Figure 1.

Sample No.	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MgO%	CaO%	Na ₂ O%	K ₂ O%	TiO ₂ %	P ₂ O ₅ %	MnO%	LOI%
44	0.11	<0.01	0.07	0.54	32.2	<0.01	<0.01	<0.01	0.01	<0.01	21.6
45	0.10	0.05	0.07	0.30	32.6	<0.01	0.01	<0.01	0.01	<0.01	21.3
46	0.43	0.10	0.08	0.12	33.3	<0.01	0.01	<0.01	0.01	<0.01	20.8
47	1.08	0.43	0.08	0.01	33.2	<0.01	0.09	<0.01	<0.01	<0.01	21.1
48	0.24	<0.01	0.09	0.12	35.0	<0.01	0.02	0.01	0.02	<0.01	20.9
49	0.18	<0.01	0.08	0.73	33.2	<0.01	0.01	<0.01	<0.01	<0.01	21.9
50	0.16	<0.01	0.08	0.05	33.5	<0.01	0.01	<0.01	<0.01	<0.01	21.0
51	0.12	<0.01	0.08	0.54	33.7	<0.01	0.01	<0.01	0.01	<0.01	21.6
52	0.08	<0.01	0.07	0.06	33.2	<0.01	<0.01	<0.01	0.01	<0.01	20.9
53	0.18	<0.01	0.08	0.54	32.8	<0.01	0.01	<0.01	<0.01	<0.01	21.4
54	0.10	<0.01	0.08	0.22	33.9	<0.01	0.01	<0.01	<0.01	<0.01	21.0
55	0.33	<0.01	0.08	0.26	34.8	<0.01	0.02	<0.01	0.01	<0.01	21.1
56	0.11	<0.01	0.08	0.84	34.1	<0.01	<0.01	<0.01	0.01	<0.01	22.0
57	0.30	<0.01	0.08	0.47	33.0	<0.01	0.01	<0.01	<0.01	<0.01	21.4
58	0.18	0.01	0.08	<0.01	34.1	<0.01	0.01	<0.01	0.01	<0.01	20.8
59	0.13	0.01	0.08	0.13	34.4	<0.01	0.01	<0.01	0.01	<0.01	21.1
60	0.12	0.01	0.08	0.31	34.3	<0.01	0.01	<0.01	0.01	<0.01	21.3
61	0.13	<0.01	0.08	<0.01	33.0	<0.01	0.01	0.01	<0.01	<0.01	21.0
62	0.04	<0.01	0.08	0.06	34.1	<0.01	0.01	0.01	0.01	<0.01	21.2
63	0.08	<0.01	0.08	0.06	32.3	<0.01	0.01	<0.01	0.01	<0.01	21.1
64	1.00	0.15	0.21	0.27	32.6	0.05	0.04	0.01	0.01	<0.01	20.8
65	0.12	<0.01	0.08	0.84	32.3	<0.01	0.01	0.01	<0.01	<0.01	22.1
66	0.10	0.04	0.08	0.02	31.0	<0.01	0.01	<0.01	0.01	<0.01	20.9
67	0.06	<0.01	0.08	0.28	32.9	<0.01	0.01	0.01	<0.01	<0.01	21.2
68	0.08	<0.01	0.08	<0.01	33.7	<0.01	0.01	<0.01	0.01	<0.01	20.8
69	0.14	<0.01	0.08	0.18	34.2	<0.01	0.01	0.01	0.01	<0.01	21.2
70	0.17	<0.01	0.08	0.23	34.4	<0.01	0.01	0.01	0.01	<0.01	21.1
71	0.08	<0.01	0.08	0.41	35.1	<0.01	0.01	0.01	<0.01	<0.01	21.9
72	0.09	<0.01	0.08	0.01	34.7	<0.01	0.01	0.01	<0.01	<0.01	20.7
73	0.14	<0.01	0.08	0.28	32.7	0.08	0.01	<0.01	<0.01	<0.01	21.4
74	0.08	<0.01	0.08	0.14	33.5	<0.01	0.01	0.01	0.02	<0.01	21.3
75	0.14	<0.01	0.08	0.13	32.7	<0.01	0.01	0.03	<0.01	<0.01	21.1
76	0.10	<0.01	0.08	0.34	32.6	0.01	0.01	<0.01	<0.01	<0.01	21.5
77	0.07	<0.01	0.07	0.17	32.4	<0.01	0.01	<0.01	0.01	<0.01	21.1
78	0.06	<0.01	0.07	0.25	32.9	<0.01	<0.01	<0.01	0.01	<0.01	21.2
79	0.10	<0.01	0.08	0.10	33.3	<0.01	0.01	<0.01	<0.01	<0.01	21.0
80	0.20	<0.01	0.09	0.31	33.7	<0.01	0.01	0.01	<0.01	<0.01	21.3
81	0.15	<0.01	0.08	0.01	33.8	<0.01	0.01	<0.01	0.01	<0.01	20.7
82	0.11	<0.01	0.08	0.14	32.9	<0.01	0.01	<0.01	0.01	<0.01	21.1
83	0.11	<0.01	0.08	0.48	34.8	<0.01	0.01	0.01	0.01	<0.01	21.5
84	0.20	0.07	0.08	0.73	32.7	0.07	0.01	<0.01	<0.01	<0.01	21.6
85	0.10	<0.01	0.08	0.32	32.4	<0.01	0.01	<0.01	0.01	<0.01	21.1
86	0.08	<0.01	0.07	0.18	31.5	<0.01	<0.01	<0.01	<0.01	<0.01	21.1
87	0.09	<0.01	0.08	0.37	31.8	0.04	0.01	<0.01	<0.01	<0.01	21.5

Sample No.	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MgO%	CaO%	Na ₂ O%	K ₂ O%	TiO ₂ %	P ₂ O ₅ %	MnO%	LOI%
88	0.15	<0.01	0.08	0.50	32.4	<0.01	0.01	<0.01	<0.01	<0.01	21.4
89	0.12	<0.01	0.08	0.50	32.9	0.01	0.01	<0.01	<0.01	<0.01	21.4
90	0.10	<0.01	0.08	0.68	33.9	<0.01	0.01	<0.01	<0.01	<0.01	21.7
91	0.12	<0.01	0.08	1.30	33.4	<0.01	0.01	<0.01	<0.01	<0.01	22.8
92	0.08	<0.01	0.08	0.50	33.6	<0.01	0.01	<0.01	<0.01	<0.01	21.5
93	0.10	<0.01	0.08	0.33	33.6	<0.01	0.01	0.01	<0.01	<0.01	21.3
94	0.10	<0.01	0.08	0.62	38.7	<0.01	0.01	<0.01	<0.01	<0.01	21.5
95	0.48	<0.01	0.08	0.94	33.0	<0.01	0.04	<0.01	<0.01	<0.01	22.1
96	0.07	<0.01	0.08	1.00	34.4	<0.01	0.01	<0.01	<0.01	<0.01	22.2
97	0.09	<0.01	0.08	0.52	33.6	<0.01	0.01	<0.01	<0.01	<0.01	21.5
98	0.15	<0.01	0.08	0.96	33.5	<0.01	0.01	<0.01	<0.01	<0.01	22.2
99	0.10	<0.01	0.08	0.44	31.8	<0.01	0.01	<0.01	<0.01	<0.01	21.5
100	0.09	<0.01	0.08	0.20	32.8	<0.01	0.01	<0.01	<0.01	<0.01	21.2
101	0.16	<0.01	0.08	1.30	32.3	<0.01	0.01	<0.01	<0.01	<0.01	22.6
102	0.08	<0.01	0.08	0.54	32.6	<0.01	<0.01	<0.01	<0.01	<0.01	21.5
103	0.09	<0.01	0.08	0.15	33.2	<0.01	0.01	<0.01	<0.01	<0.01	21.1
104	0.28	<0.01	0.09	0.20	33.2	<0.01	0.02	0.01	<0.01	<0.01	21.1
105	0.14	0.03	0.08	0.26	31.3	<0.01	0.01	<0.01	<0.01	<0.01	18.9
106	0.25	<0.01	0.09	0.57	32.6	<0.01	0.01	<0.01	<0.01	<0.01	21.5
107	0.10	<0.01	0.07	0.25	31.7	<0.01	0.01	<0.01	<0.01	<0.01	21.3
108	0.08	<0.01	0.08	0.33	32.4	<0.01	0.01	<0.01	<0.01	<0.01	21.3
109	0.26	0.13	0.09	1.71	31.8	<0.01	0.01	<0.01	<0.01	<0.01	24.7
110	0.22	0.08	0.10	3.16	33.7	<0.01	0.01	0.01	<0.01	<0.01	25.1
111	0.14	<0.01	0.08	0.26	32.7	<0.01	0.01	<0.01	<0.01	<0.01	21.2
112	0.10	<0.01	0.07	<0.01	31.9	<0.01	0.01	<0.01	<0.01	<0.01	20.9
113	0.12	<0.01	0.07	0.60	31.2	<0.01	0.01	<0.01	<0.01	<0.01	21.6
114	0.11	<0.01	0.08	0.60	32.4	<0.01	0.01	<0.01	<0.01	<0.01	21.5
115	0.13	<0.01	0.07	0.35	31.6	0.03	0.01	<0.01	<0.01	<0.01	21.3

RAW GEOCHEMICAL DATA - 3.2

*** % Moisture - dash means Nil

Sample No *	U %	Cl %	F %	S %	CO2 %	C(T) %	Moisture %
1	<0.001	0.008	0.027	17.9	0.65	0.19	0.50
2	<0.001	0.008	0.023	17.1	0.59	0.17	0.56
3	<0.001	0.005	0.017	17.0	0.77	0.21	1.92
4	<0.001	0.008	0.10	17.7	2.04	0.57	0.66
5	<0.001	0.004	0.015	18.1	<0.05	0.016	0.69
6	<0.001	<0.001	<0.01	17.5	0.81	0.24	0.66
7	<0.001	0.006	<0.01	17.1	1.10	0.31	0.89
8	<0.001	0.002	0.013	17.7	0.37	0.10	0.41
9	<0.001	0.005	<0.01	17.2	2.15	0.60	2.29
10	<0.001	0.002	0.016	17.2	1.02	0.29	-
11	<0.001	0.005	0.015	16.8	2.46	0.69	1.08
12	<0.001	0.003	0.030	17.3	1.76	0.49	0.68
13	<0.001	0.006	0.015	17.4	1.39	0.38	1.02
14	<0.001	0.008	0.017	17.5	1.53	0.43	0.59
15	<0.001	<0.001	0.020	17.6	1.49	0.42	0.64
16	<0.001	0.001	0.015	17.9	1.10	0.30	1.32
17	<0.001	0.012	<0.01	17.0	3.30	0.92	0.63
18	<0.001	0.001	<0.01	17.6	0.40	0.12	0.81
19	<0.001	<0.001	0.014	17.6	1.03	0.29	1.08
20	<0.001	0.003	0.013	16.8	2.59	0.72	0.88
21	<0.001	0.005	0.015	17.6	1.28	0.35	0.96
22	<0.001	0.004	0.015	17.4	1.17	0.32	0.97
23	<0.001	<0.001	0.015	17.9	0.81	0.22	0.32
24	<0.001	0.003	<0.01	17.8	1.57	0.44	0.49
25	<0.001	0.006	0.027	16.8	1.72	0.50	3.47
26	<0.001	0.003	<0.01	17.2	2.86	0.80	1.10
27	<0.001	0.002	0.012	16.2	0.88	0.25	2.38
28	<0.001	0.002	<0.01	18.0	0.92	0.26	0.83
29	<0.001	0.006	<0.01	17.3	0.95	0.26	0.90
30	<0.001	0.003	<0.01	17.2	2.24	0.63	1.41
31	<0.001	0.004	<0.01	16.5	1.14	0.32	1.96
32	<0.001	0.007	<0.01	16.6	1.28	0.36	0.86
33	<0.001	0.003	0.018	18.7	1.16	0.33	0.74
34	<0.001	0.004	<0.01	17.2	1.06	0.30	0.61
35	<0.001	0.006	<0.01	18.1	0.84	0.23	1.09
36	<0.001	0.002	<0.01	17.2	1.21	0.34	0.98
37	0.001	<0.001	<0.01	18.5	0.23	0.062	0.92
38	<0.001	<0.001	<0.01	18.6	0.95	0.26	0.99
39	<0.001	0.002	<0.01	19.5	0.10	0.029	0.92

* Sample numbers for Appendix 5 are the same as lab numbers in Appendix 3 which can be used to determine sample site locations in Figure 1.

Sample No	U %	Cl %	F %	S %	CO ₂ %	C(T) %	Moisture %
40	<0.001	0.006	<0.01	17.6	1.64	0.46	2.56
41	<0.001	0.012	<0.01	17.5	2.86	0.80	0.61
42	<0.001	0.003	<0.01	17.2	3.12	0.87	1.90
43	<0.001	0.003	0.020	16.9	2.93	0.82	1.52
44	<0.001	0.007	0.015	17.2	1.53	0.43	1.41
45	<0.001	0.004	0.020	18.1	0.88	0.24	0.60
46	<0.001	0.001	0.019	17.7	0.51	0.14	0.71
47	<0.001	0.001	0.018	17.1	0.08	0.021	0.94
48	<0.001	0.002	0.015	18.1	0.20	0.054	0.71
49	<0.004	0.006	0.020	17.4	1.97	0.55	2.80
50	<0.001	0.002	0.020	17.9	0.13	0.035	0.65
51	<0.001	0.005	0.018	17.3	1.46	0.41	0.39
52	<0.001	0.004	0.015	17.7	0.19	0.053	2.11
53	<0.001	0.005	0.016	16.9	1.28	0.36	1.35
54	<0.001	<0.001	0.012	18.8	0.59	0.17	0.62
55	<0.001	<0.001	0.022	18.2	0.61	0.18	0.75
56	<0.001	0.004	0.030	18.0	2.09	0.59	6.74
57	<0.001	0.002	0.014	17.6	1.16	0.33	0.51
58	<0.001	<0.001	0.017	18.7	0.33	0.089	2.35
59	<0.001	<0.001	<0.01	18.4	0.35	0.096	0.97
60	<0.001	<0.001	0.028	18.7	0.77	0.22	2.70
61	<0.001	<0.001	0.016	17.6	0.18	0.050	0.72
62	<0.001	0.003	0.015	18.2	1.13	0.32	1.31
63	<0.001	<0.001	0.012	19.3	0.55	0.16	1.40
64	<0.001	0.003	0.016	18.2	1.67	0.47	6.82
65	<0.001	0.001	0.022	17.5	2.57	0.72	0.87
66	<0.001	0.001	0.021	18.9	0.51	0.15	0.84
67	<0.001	<0.001	0.015	18.8	0.87	0.25	0.89
68	<0.001	0.007	0.013	18.8	0.44	0.12	0.72
69	<0.001	0.003	0.015	18.8	0.77	0.22	1.20
70	<0.001	0.004	0.014	18.0	0.81	0.24	0.91
71	<0.001	0.002	0.019	18.7	2.05	0.58	1.63
72	<0.001	<0.001	0.020	19.0	0.27	0.073	1.11
73	<0.001	0.003	0.017	18.4	1.13	0.32	0.94
74	<0.001	<0.001	0.013	18.8	1.31	0.37	0.69
75	<0.001	0.006	<0.01	18.2	0.81	0.23	12.3
76	<0.001	0.006	0.013	17.9	1.57	0.44	0.65
77	<0.001	0.003	0.014	18.5	0.77	0.22	2.36
78	<0.001	0.003	0.013	18.6	1.02	0.29	0.59
79	<0.001	0.002	<0.01	18.6	0.55	0.15	1.79

Sample No	U %	Cl %	F %	S %	CO ₂ %	C(T) %	Moisture %
80	<0.001	0.004	<0.01	18.7	1.20	0.34	0.99
81	<0.001	0.002	<0.01	18.6	0.22	0.061	0.97
82	<0.001	<0.001	0.014	18.2	0.62	0.18	1.06
83	<0.001	0.003	0.012	18.1	1.49	0.42	1.01
84	<0.001	0.007	<0.01	17.5	2.02	0.57	-
85	<0.001	0.008	<0.01	18.5	0.92	0.26	0.47
86	<0.001	0.002	0.018	18.4	0.77	0.22	-
87	0.001	0.003	0.027	18.1	1.27	0.36	0.88
88	<0.001	0.004	<0.01	17.3	1.28	0.36	1.0
89	<0.001	0.011	0.013	18.2	1.14	0.32	1.88
90	<0.001	0.004	0.014	17.7	1.72	0.48	1.02
91	<0.001	0.011	0.014	17.1	3.54	0.99	1.41
92	<0.001	0.034	0.021	18.4	1.24	0.35	0.36
93	<0.001	<0.001	0.019	18.6	0.99	0.28	0.88
94	<0.001	0.005	<0.01	18.2	1.31	0.37	0.59
95	<0.001	0.006	<0.01	16.8	2.42	0.68	0.92
96	<0.001	0.008	0.013	17.4	2.53	0.71	1.64
97	<0.001	0.005	0.011	18.4	1.13	0.32	-
98	<0.001	0.008	<0.01	17.4	2.74	0.76	-
99	<0.001	0.004	<0.01	18.1	1.17	0.33	0.78
100	<0.001	0.003	<0.01	18.2	0.59	0.16	1.53
101	0.001	0.011	0.011	17.8	2.75	0.77	0.80
102	<0.001	0.003	<0.01	18.4	1.21	0.34	0.83
103	<0.001	0.002	<0.01	18.1	0.37	0.10	0.93
104	<0.001	<0.001	0.015	18.8	0.40	0.11	0.42
105	<0.001	0.004	<0.01	18.2	0.48	0.14	1.15
106	<0.001	0.007	<0.01	18.2	1.38	0.39	0.67
107	<0.001	0.008	<0.01	19.0	0.73	0.21	-
108	<0.001	0.008	<0.01	18.2	0.88	0.24	1.79
109	<0.001	0.017	0.01	15.9	4.07	1.14	2.27
110	<0.001	0.006	0.015	15.0	7.48	2.07	0.94
111	<0.001	0.002	<0.01	18.0	0.70	0.20	1.90
112	<0.001	<0.001	<0.01	18.8	0.08	0.022	1.30
113	<0.001	<0.001	<0.01	18.0	1.38	0.39	0.90
114	<0.001	0.006	<0.01	19.0	1.46	0.40	1.64
115	<0.001	0.005	<0.01	18.1	0.73	0.21	0.90

APPENDIX 4METHOD OF CALCULATION FOR GYPSUM AND ANHYDRITE PERCENTAGES
FROM RAW GEOCHEMICAL DATA

Steps:

- 1) $\% \text{MgCO}_3 = \% \text{MgO} \times 2.1$
- 2) $\% \text{CO}_2 \text{ in } \text{MgCO}_3 = \% \text{MgCO}_3 \times 0.524$
- 3) $\% \text{CO}_2 \text{ in } \text{CaCO}_3 = \% \text{CO}_2 - \% \text{CO}_2 \text{ in } \text{MgCO}_3$
- 4) $\% \text{CaCO}_3 = \% \text{CO}_2 \text{ in } \text{CaCO}_3 \times 2.27$
- 5) $\% \text{CaO in } \text{CaCO}_3 = \% \text{CaCO}_3 \times 0.56$
- 6) $\% \text{CaO in gypsum and anhydrite} = \% \text{CaO} - \% \text{CaO in } \text{CaCO}_3$
- 7) $\% \text{H}_2\text{O} = \text{Loss on Ignition (LOI)} - \% \text{CO}_2$
- 8) $\text{moles CaO} = \% \text{CaO in gypsum and anhydrite} / 56$
- 9) $\text{moles SO}_3 = (\% \text{S} \times 2.5) / 80$
- 10) $\text{moles } 2\text{H}_2\text{O} = \% \text{H}_2\text{O (from 7)} / 36$
- 11) IF $\text{moles } 2\text{H}_2\text{O} > (\text{or equal}) \text{ moles SO}_3$ then $\% \text{gypsum} = (\text{LOI} - \text{CO}_2) \times 4.785$ and $\text{anhydrite} = 0 \%$
- 12) $\text{excess H}_2\text{O} = \% \text{H}_2\text{O (from 7)} - (\% \text{gypsum} \times 0.209)$
- 13) $\text{excess CaO} = \% \text{CaO} - \% \text{CaO in } \text{CaCO}_3 - (\% \text{gypsum} \times 0.326)$
- 14) IF $\text{moles } 2\text{H}_2\text{O} < \text{moles SO}_3$ then $\% \text{gypsum} = \% \text{H}_2\text{O (from 7)} \times 4.785$ and $\% \text{anhydrite} = [(\% \text{S} \times 2.5) - (\% \text{gypsum} \times 0.465)] \times 1.7$
- 15) $\text{excess CaO} = \% \text{CaO} - \% \text{CaO in } \text{CaCO}_3 - (\% \text{gypsum} \times 0.326) - (\% \text{anhydrite} \times 0.412)$
- 16) $\text{Wt } \% \text{NaCl} = \% \text{Cl} \times 1.647$

Source: T. Muir (Mineral Development Section - MNM)

APPENDIX 5

CALCULATED MINERALOGY FOR MOOSE RIVER BASIN GYPSUM STUDY

LEGEND:

SITE #: Outcrop station number (see Figure 1)

LAB #: Laboratory number (refer to Appendix 2)

% GYP: Percent gypsum

% ANY: Percent anhydrite

% CARB: Percent carbonate

% AV. STAT: Average station percent for gypsum

D: Duplicate

FACIES: Samples consisted of the following facies 1a
(massive gypsum) and 1b (impure/banded gypsum)NOTE: All samples were removed from the outcrop as "grab
or chip" samples, with an attempt to avoid the
weathered rind of the outcrop.

MOOSE RIVER OUTCROP STATIONS:

SITE #	LAB #	FACIES	% GYP	% ANY	% CARB	% AV. STAT
4	18	1a	98.57	0.0	0.86	98.57
10	8	1a	99.19	0.0	0.78	99.19
12	10	1a	97.52	0.0	2.13	97.52
16	4	1a	95.51	0.0	4.35	
16	12	1a	95.41	0.0	3.71	95.46
17	13	1a	95.75	0.0	2.96	95.75
18	14	1a	96.51	0.0	3.26	96.51
20	16	1a	95.70	0.42	2.49	95.70
21	17	1b	92.35	0.0	7.05	92.35
22	22	1a	97.28	0.0	2.49	97.28
24	19	1a	97.95	0.0	2.18	97.95
25	15	1a	96.70	0.0	3.12	96.70
28	20	1b	93.83	0.0	5.41	93.83
29	21	1b	96.75	0.0	2.74	96.75
30	43	1b	93.16	0.0	6.20	93.16

SITE #	LAB #	FACIES	% GYP	% ANY	% CARB	% AV. STAT
31	23	1b	97.57	0.0	1.75	97.57
33	60	1b	98.24	1.82	1.63	98.24
34	25	1b	95.13	0.0	3.66	95.13
35	26	1a	92.54	0.0	6.05	92.54
36	27	1a	96.75	0.0	1.87	
36	28	1a	96.56	0.17	1.97	96.66
37	29	1a	96.90	0.0	2.05	
37	6	1b	98.05	0.0	1.72	
37	30	1a	93.59	0.0	4.72	96.18
38	24	1b	96.32	0.0	3.31	96.32
39	31	1b	96.94	0.0	2.42	96.94
40	11	1a	94.93	0.0	5.13	94.93
44	33	1a	96.85	2.92	2.47	96.85
46	34	1a	96.37	0.0	2.26	96.37
51	37	1b	99.38	0.06	0.51	
51	63	1b	98.33	4.29	1.22	
51	38	1b	95.94	3.21	2.12	
51	39	1b	100.01	3.82	0.22	98.42

TOTAL AVERAGE GYPSUM % FOR MOOSE RIVER OUTCROPS: 96.44

CHEEPASH RIVER OUTCROP SITES:

SITE #	LAB #	FACIES	% GYP	% ANY	% CARB	% AV. STAT
70	45	1a	97.71	0.0	1.88	97.71
71	52	1a	99.10	0.0	0.41	99.10
72	46	1a	97.09	0.0	1.11	97.09
73	5	1a	100.25	0.0	0.11	

SITE #	LAB #	FACIES	% GYP	% ANY	% CARB	% AV. STAT
73	47	1a	100.58	0.0	0.18	100.42
74	48	1a	99.05	0.0	0.41	99.05
76	50	1b	99.86	0.0	0.28	99.86
77	51	1b	96.37	0.0	3.10	
77	9	1b	94.98	0.0	4.53	95.68
78	44	1a	96.04	0.0	3.26	96.04
80	7	1a	97.61	0.0	2.31	
80	53	1a	96.27	0.0	2.69	96.94
81	54	1a	97.66	2.70	1.25	97.66
82	55	1a	98.04	0.0	1.28	
82	56	1a	95.27	1.19	4.41	
82	57	1a	96.85	0.0	2.45	96.72
83	59	1a	99.29	0.0	0.74	99.29
84	61	1a	99.62	0.0	0.41	99.62
85	62	1a	96.03	1.43	2.54	96.03
87	64	1a	91.54	4.99	3.68	91.54
88	65	1a	93.45	0.50	5.50	93.45
89	66	1a	97.57	3.20	1.15	97.57
90	67	1b	97.28	3.00	1.86	97.28
91	68	1b	97.42	2.89	0.99	
91	69	1b	97.76	2.62	1.68	
91	70	1b	97.09	0.0	1.75	97.42
93	71	1b	94.98	4.39	4.49	94.98
94	72	1b	97.76	3.47	0.61	97.76
95	73	1b	96.99	1.53	2.45	96.99
96	74	1b	95.65	4.29	2.92	95.65

SITE #	LAB #	FACIES	% GYP	% ANY	% CARB	% AV. STAT
97	77	1b	97.28	1.73	1.68	97.28
98	75	1a	97.09	0.60	1.79	
98	76	1b	95.37	0.69	3.43	96.23
101	78	1a	96.56	2.72	2.22	
101	79	1a	97.85	1.70	1.21	
101	80	1a	96.18	3.45	2.60	96.86
103	1	1a	97.85	0.0	1.40	
103	82	1a	98.00	0.0	1.35	97.93
104	81	1a	98.00	1.58	0.50	98.00
106	83	1b	95.75	1.24	3.19	
106	114	1b	95.89	4.95	3.08	
106	84	1b	93.69	0.31	4.29	
106	85	1b	96.56	2.29	1.96	
106	115	1b	98.43	0.0	1.52	
106	2	1b	98.14	0.0	1.22	
106	86	1b	97.28	1.30	1.68	
106	87	1b	96.80	0.40	2.74	96.57
107	88	1a	96.27	0.0	2.71	
107	89	1a	96.94	0.72	2.39	
107	32	1a	95.80	0.0	2.77	
107	90	1b	95.60	0.0	3.63	
107	91	1b	92.16	0.0	7.52	
107	92	1b	96.94	1.57	2.62	
107	93	1a	97.18	2.23	2.12	
107	94	1b	96.61	0.98	2.73	
107	36	1b	96.13	0.0	2.60	

SITE #	LAB #	FACIES	% GYP	% ANY	% CARB	% AV. STAT
107	3	1a	98.62	0.0	1.24	
107	95	1a	94.17	0.0	5.12	
107	96	1b	94.12	0.0	5.35	95.88
108	97	1a	97.47	1.15	2.36	
108	41	1a	93.50	0.46	6.03	
108	98	1b	93.12	0.34	5.84	
108	99	1b	97.28	2.59	2.48	
108	100	1b	98.62	0.0	1.26	96.00
109	101	1a	94.98	0.57	5.73	94.98
110	102	1a	97.09	1.45	2.53	
110	103	1b	99.19	0.0	0.78	
110	104	1b	99.05	1.60	0.83	
110	105	1b	88.14	7.68	0.99	
110	112	1a	99.62	1.15	0.18	
110	42	1a	91.30	0.93	6.66	
110	113	1b	96.75	1.70	2.89	96.31
111	106	1b	96.27	1.25	2.91	96.27
112	107	1b	98.43	2.94	1.56	98.43
113	108	1a	97.71	0.11	1.87	
113	109	1a	98.72	0.0	8.56	98.22
114	110	1a	84.31	0.0	15.72	84.31
115	111	1a	98.09	0.0	1.49	98.09

TOTAL AVERAGE GYPSUM % FOR CHEEPASH RIVER OUTCROPS: 96.57
 GYPSUM MOUNTAIN OUTCROP SITES:

SITE #	LAB #	FACIES	% GYP	% ANY	% CARB	% AV. STAT
RB-1	58	1a	97.95	2.05	0.75	97.95

SITE #	LAB #	FACIES	% GYP	% ANY	% CARB	% AV. STAT
RB-2	40	1b	95.03	0.0	3.49	95.03
RB-5	35	1a	96.94	0.29	1.77	96.94
RB-6	49	1a	95.37	0.0	4.18	95.37

TOTAL AVERAGE GYPSUM % FOR GYPSUM MOUNTAIN OUTCROPS: 96.30

APPENDIX 6

JOINT MEASUREMENTS FROM OUTCROP, MOOSE RIVER BASIN GYPSUM STUDY

Moose River Study Area Joints

Number of Observations: 62

Observed Directions in Degrees

160	160	82	30	140	148	120	5	156	34
0	100	35	40	160	135	157	50	82	135
6	144	100	110	75	110	100	10	140	125
163	8	85	95	153	100	120	38	148	19
35	20	114	10	5	108	90	170	10	95
18	63	125	100	162	166	120	45	172	88
10	145								

Vector Mean: 94.1
 Vector Length: 36.891
 Consistency Ratio: 59.501
 Variance: 3100.20
 F Ratio 34.83

Percentage of Joints in each 10° Section

Sector 1	(350 to 0 degrees)	contains 1.6 percent
Sector 2	(0 to 10 degrees)	contains 14.5 percent
Sector 3	(10 to 20 degrees)	contains 3.2 percent
Sector 4	(20 to 30 degrees)	contains 1.6 percent
Sector 5	(30 to 40 degrees)	contains 8.1 percent
Sector 6	(40 to 50 degrees)	contains 3.2 percent
Sector 7	(50 to 60 degrees)	contains 0.0 percent
Sector 8	(60 to 70 degrees)	contains 1.6 percent
Sector 9	(70 to 80 degrees)	contains 1.6 percent
Sector 10	(80 to 90 degrees)	contains 8.1 percent
Sector 11	(90 to 100 degrees)	contains 11.3 percent
Sector 12	(100 to 110 degrees)	contains 4.8 percent
Sector 13	(110 to 120 degrees)	contains 6.5 percent
Sector 14	(120 to 130 degrees)	contains 3.2 percent
Sector 15	(130 to 140 degrees)	contains 6.5 percent
Sector 16	(140 to 150 degrees)	contains 6.5 percent
Sector 17	(150 to 160 degrees)	contains 8.1 percent
Sector 18	(160 to 170 degrees)	contains 8.1 percent
Sector 19	(170 to 180 degrees)	contains 1.6 percent
Sector 20	(180 to 190 degrees)	contains 0.0 percent
Sector 21	(190 to 200 degrees)	contains 0.0 percent
Sector 22	(200 to 210 degrees)	contains 0.0 percent
Sector 23	(210 to 220 degrees)	contains 0.0 percent
Sector 24	(220 to 230 degrees)	contains 0.0 percent
Sector 25	(230 to 240 degrees)	contains 0.0 percent
Sector 26	(240 to 250 degrees)	contains 0.0 percent

Sector 27	(250 to 260 degrees)	contains	0.0 percent
Sector 28	(260 to 270 degrees)	contains	0.0 percent
Sector 29	(270 to 280 degrees)	contains	0.0 percent
Sector 30	(280 to 290 degrees)	contains	0.0 percent
Sector 31	(290 to 300 degrees)	contains	0.0 percent
Sector 32	(300 to 310 degrees)	contains	0.0 percent
Sector 33	(310 to 320 degrees)	contains	0.0 percent
Sector 34	(320 to 330 degrees)	contains	0.0 percent
Sector 35	(330 to 340 degrees)	contains	0.0 percent
Sector 36	(340 to 350 degrees)	contains	0.0 percent

Cheepash River Study Area Joints

Number of Observations: 28

Observed Directions in Degrees:

132	160	35	60	177	130	15	15	154	77
165	60	80	135	60	45	130	50	80	102
8	168	80	10	14	98	120	22		

Vector Mean: 78.5
 Vector Length: 17.218
 Consistency Ratio: 61.491
 Variance 3007.26
 F Ratio: 35.91

Percentage of Joints in each 10° Sector

Sector 1	(350 to 0 degrees)	contains	0.0 percent
Sector 2	(0 to 10 degrees)	contains	7.1 percent
Sector 3	(10 to 20 degrees)	contains	10.7 percent
Sector 4	(20 to 30 degrees)	contains	7.1 percent
Sector 5	(30 to 40 degrees)	contains	3.6 percent
Sector 6	(40 to 50 degrees)	contains	7.1 percent
Sector 7	(50 to 60 degrees)	contains	10.7 percent
Sector 8	(60 to 70 degrees)	contains	0.0 percent
Sector 9	(70 to 80 degrees)	contains	14.3 percent
Sector 10	(80 to 90 degrees)	contains	0.0 percent
Sector 11	(90 to 100 degrees)	contains	3.6 percent
Sector 12	(100 to 110 degrees)	contains	3.6 percent
Sector 13	(110 to 120 degrees)	contains	3.6 percent
Sector 14	(120 to 130 degrees)	contains	3.6 percent
Sector 15	(130 to 140 degrees)	contains	7.1 percent
Sector 16	(140 to 150 degrees)	contains	0.0 percent
Sector 17	(150 to 160 degrees)	contains	7.1 percent
Sector 18	(160 to 170 degrees)	contains	7.1 percent
Sector 19	(170 to 180 degrees)	contains	3.6 percent
Sector 20	(180 to 190 degrees)	contains	0.0 percent
Sector 21	(190 to 200 degrees)	contains	0.0 percent
Sector 22	(200 to 210 degrees)	contains	0.0 percent
Sector 23	(210 to 220 degrees)	contains	0.0 percent
Sector 24	(220 to 230 degrees)	contains	0.0 percent
Sector 25	(230 to 240 degrees)	contains	0.0 percent
Sector 26	(240 to 250 degrees)	contains	0.0 percent

Sector 27 (250 to 260 degrees) contains 0.0 percent
 Sector 28 (260 to 270 degrees) contains 0.0 percent
 Sector 29 (270 to 280 degrees) contains 0.0 percent
 Sector 30 (280 to 290 degrees) contains 0.0 percent
 Sector 31 (290 to 300 degrees) contains 0.0 percent
 Sector 32 (300 to 310 degrees) contains 0.0 percent
 Sector 33 (310 to 320 degrees) contains 0.0 percent
 Sector 34 (320 to 330 degrees) contains 0.0 percent
 Sector 35 (330 to 340 degrees) contains 0.0 percent
 Sector 36 (340 to 350 degrees) contains 0.0 percent

Total Joints from both the Moose and Cheepash River Study areas

Number of Observations: 90

Observed Direction in degrees:

160	160	82	30	140	148	120	5	156	34
0	100	35	40	160	135	167	50	82	135
6	144	100	110	75	110	100	10	140	125
163	8	85	95	153	100	120	38	148	10
35	20	114	10	5	108	90	170	10	95
18	63	125	100	162	166	120	45	172	88
10	145	132	160	35	60	177	130	15	15
154	77	165	60	80	135	60	45	120	50
80	102	8	168	80	10	14	98	30	22

Vector Mean: 89.2

Vector Length: 53.670

Consistency Ratio: 59.634

Variance: 3049.15

F Ratio: 35.42

Percentage of Joints in each 10° sector

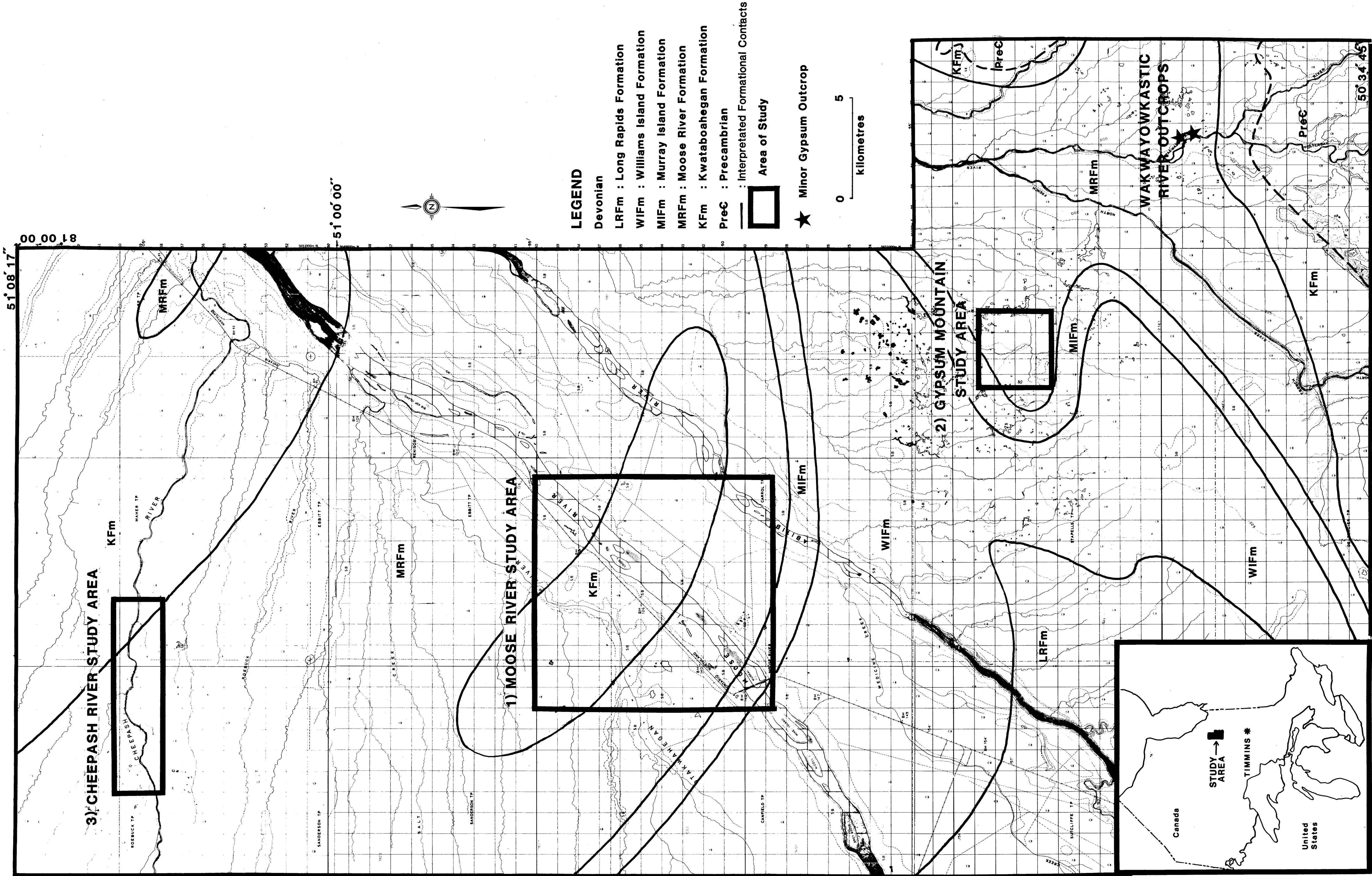
Sector 1 (350 to 0 degrees) contains 1.1 percent
 Sector 2 (0 to 10 degrees) contains 12.2 percent
 Sector 3 (10 to 20 degrees) contains 5.6 percent
 Sector 4 (20 to 30 degrees) contains 3.3 percent
 Sector 5 (30 to 40 degrees) contains 6.7 percent
 Sector 6 (40 to 50 degrees) contains 4.4 percent
 Sector 7 (50 to 60 degrees) contains 3.3 percent
 Sector 8 (60 to 70 degrees) contains 1.1 percent
 Sector 9 (70 to 80 degrees) contains 5.6 percent
 Sector 10 (80 to 90 degrees) contains 5.6 percent
 Sector 11 (90 to 100 degrees) contains 8.9 percent
 Sector 12 (100 to 110 degrees) contains 4.4 percent
 Sector 13 (110 to 120 degrees) contains 5.6 percent
 Sector 14 (120 to 130 degrees) contains 3.3 percent
 Sector 15 (130 to 140 degrees) contains 6.7 percent
 Sector 16 (140 to 150 degrees) contains 4.4 percent
 Sector 17 (150 to 160 degrees) contains 7.8 percent
 Sector 18 (160 to 170 degrees) contains 7.8 percent
 Sector 19 (170 to 180 degrees) contains 2.2 percent
 Sector 20 (180 to 190 degrees) contains 0.0 percent
 Sector 21 (190 to 200 degrees) contains 0.0 percent

Sector 22	(200 to 210 degrees)	contains	0.0 percent
Sector 23	(210 to 220 degrees)	contains	0.0 percent
Sector 24	(220 to 230 degrees)	contains	0.0 percent
Sector 25	(230 to 240 degrees)	contains	0.0 percent
Sector 26	(240 to 250 degrees)	contains	0.0 percent
Sector 27	(250 to 260 degrees)	contains	0.0 percent
Sector 28	(260 to 270 degrees)	contains	0.0 percent

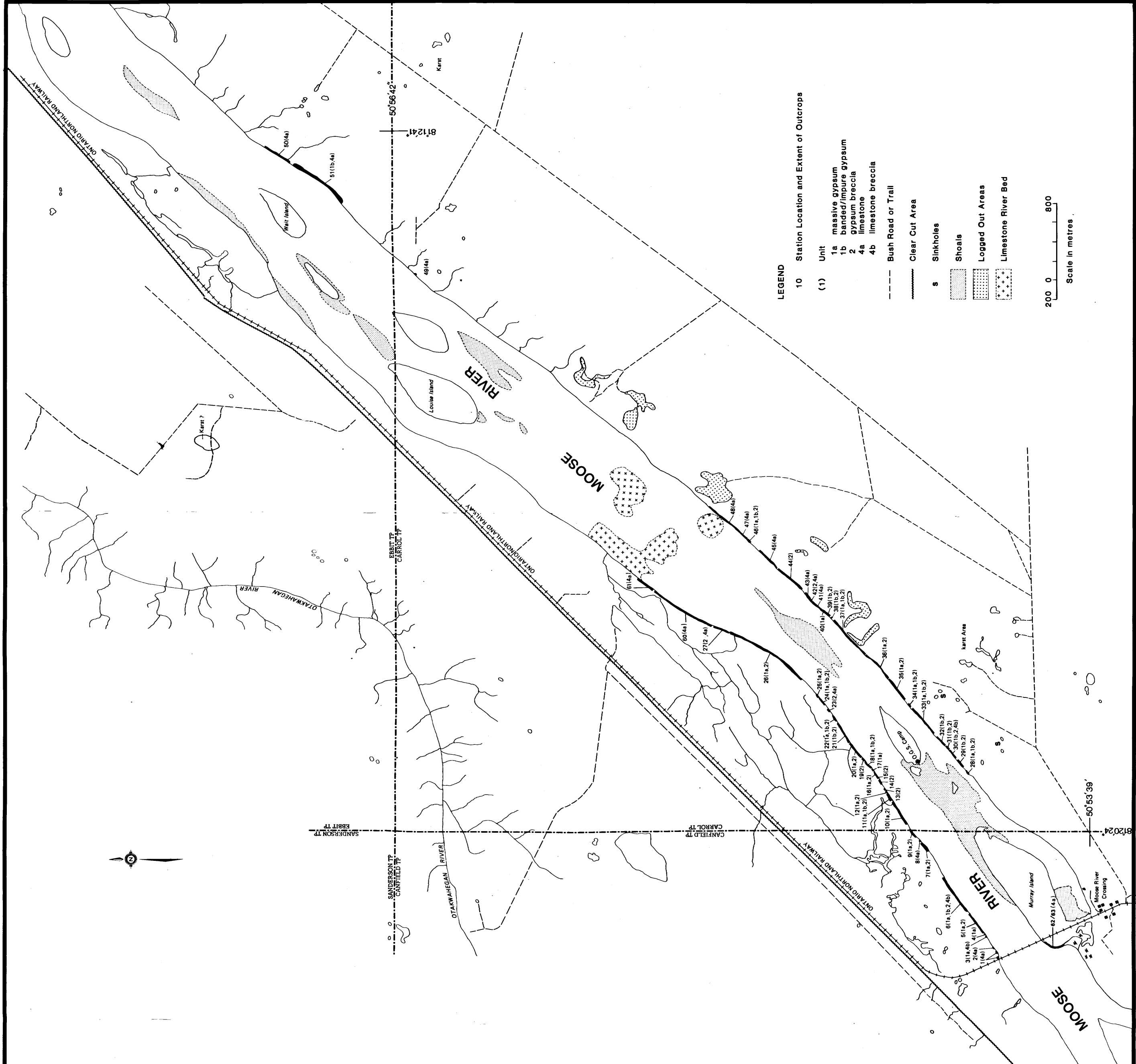
Percentage of Joints in each 10° Sector

Sector 29	(270 to 280 degrees)	contains	0.0 percent
Sector 30	(280 to 290 degrees)	contains	0.0 percent
Sector 31	(290 to 300 degrees)	contains	0.0 percent
Sector 32	(300 to 310 degrees)	contains	0.0 percent
Sector 33	(310 to 320 degrees)	contains	0.0 percent
Sector 34	(320 to 330 degrees)	contains	0.0 percent
Sector 35	(330 to 340 degrees)	contains	0.0 percent
Sector 36	(330 to 350 degrees)	contains	0.0 percent

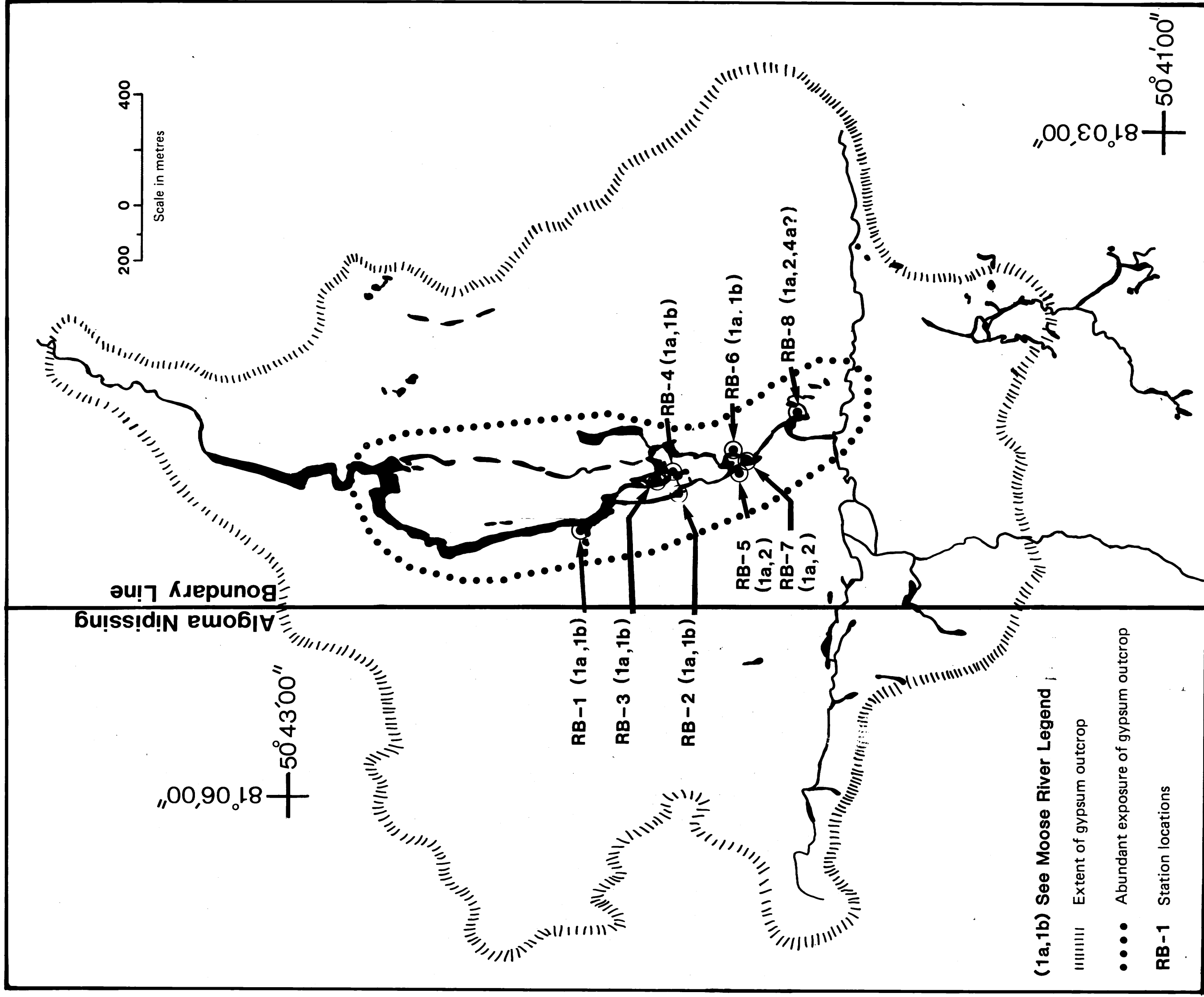
FIGURE 1: GYPSUM IN THE MOOSE RIVER BASIN, JAMES BAY LOWLAND



1) MOOSE RIVER STUDY AREA



2) GYPSUM MOUNTAIN STUDY AREA



3) CHEEPASH RIVER STUDY AREA

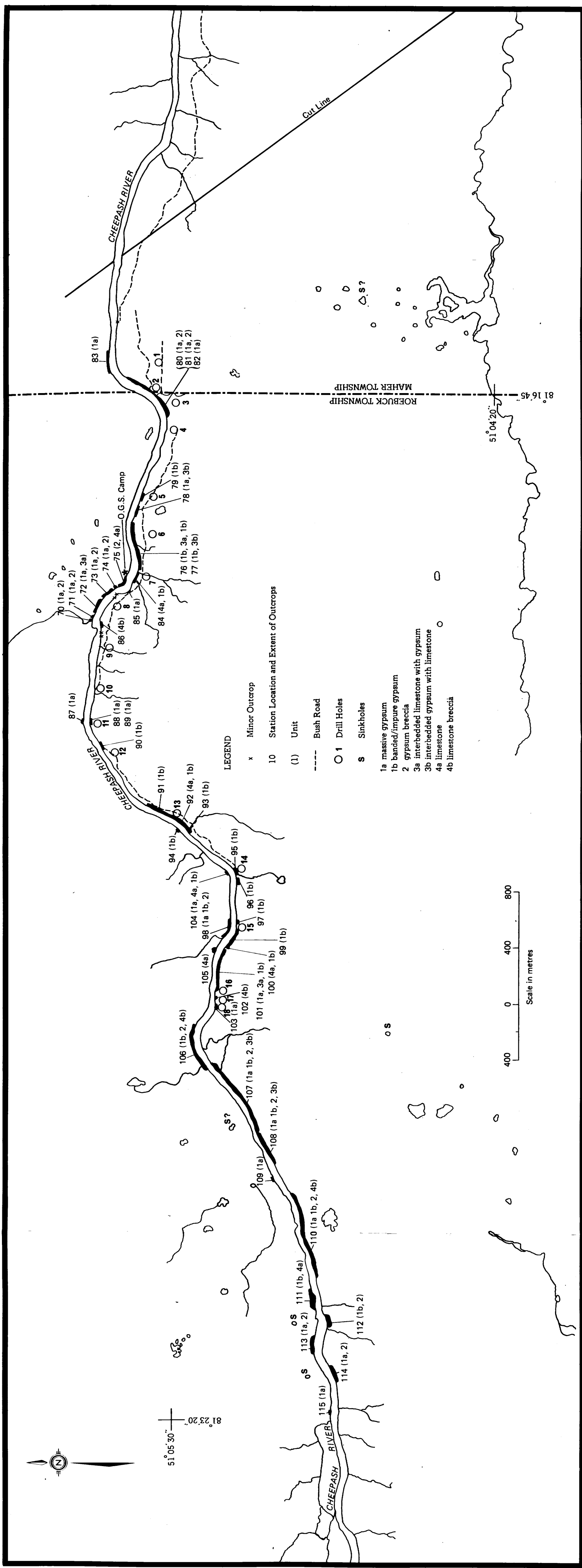


FIGURE 5: SUBSURFACE GEOLOGY OF THE MOOSE RIVER FORMATION
MOOSE RIVER BASIN

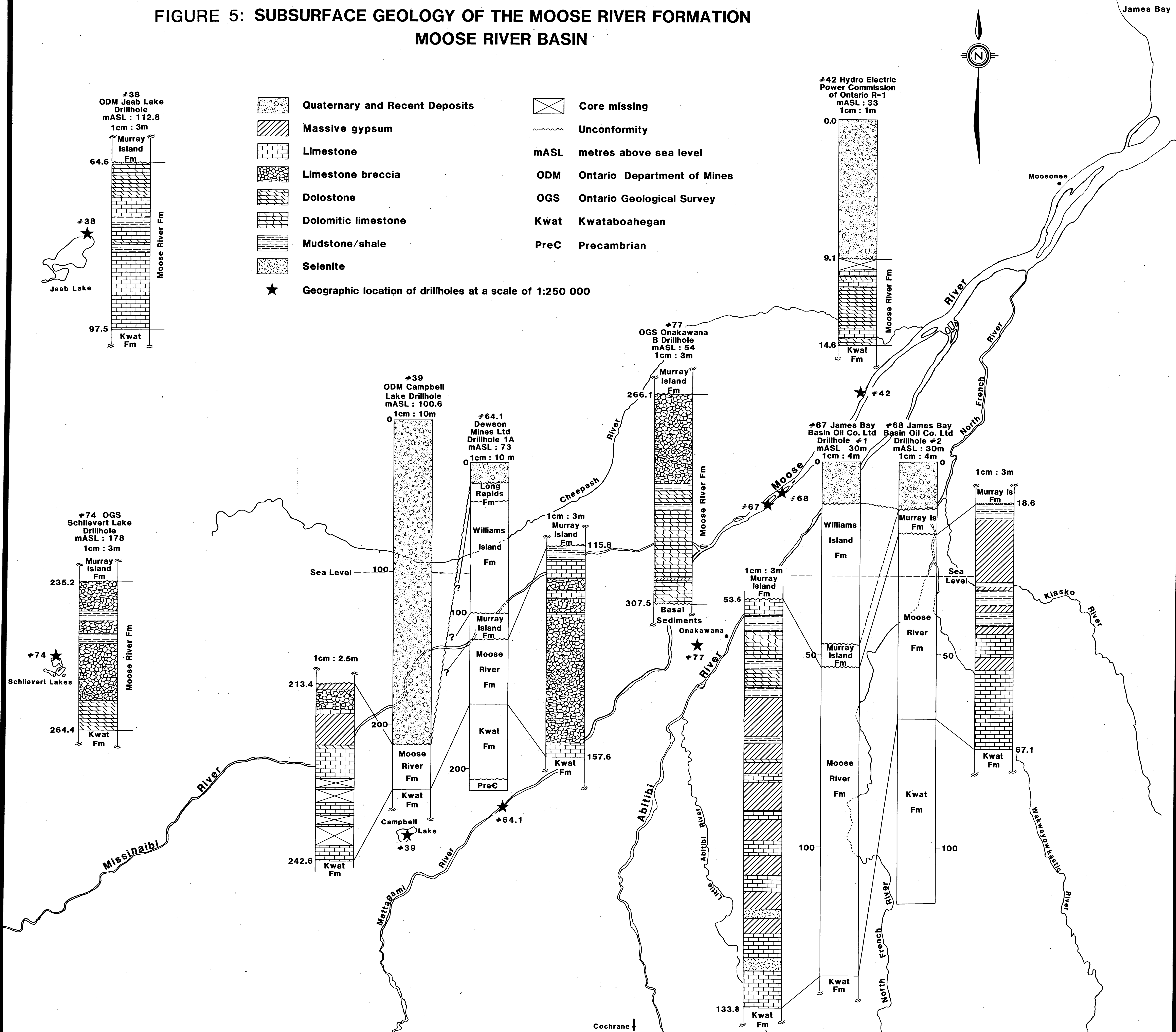
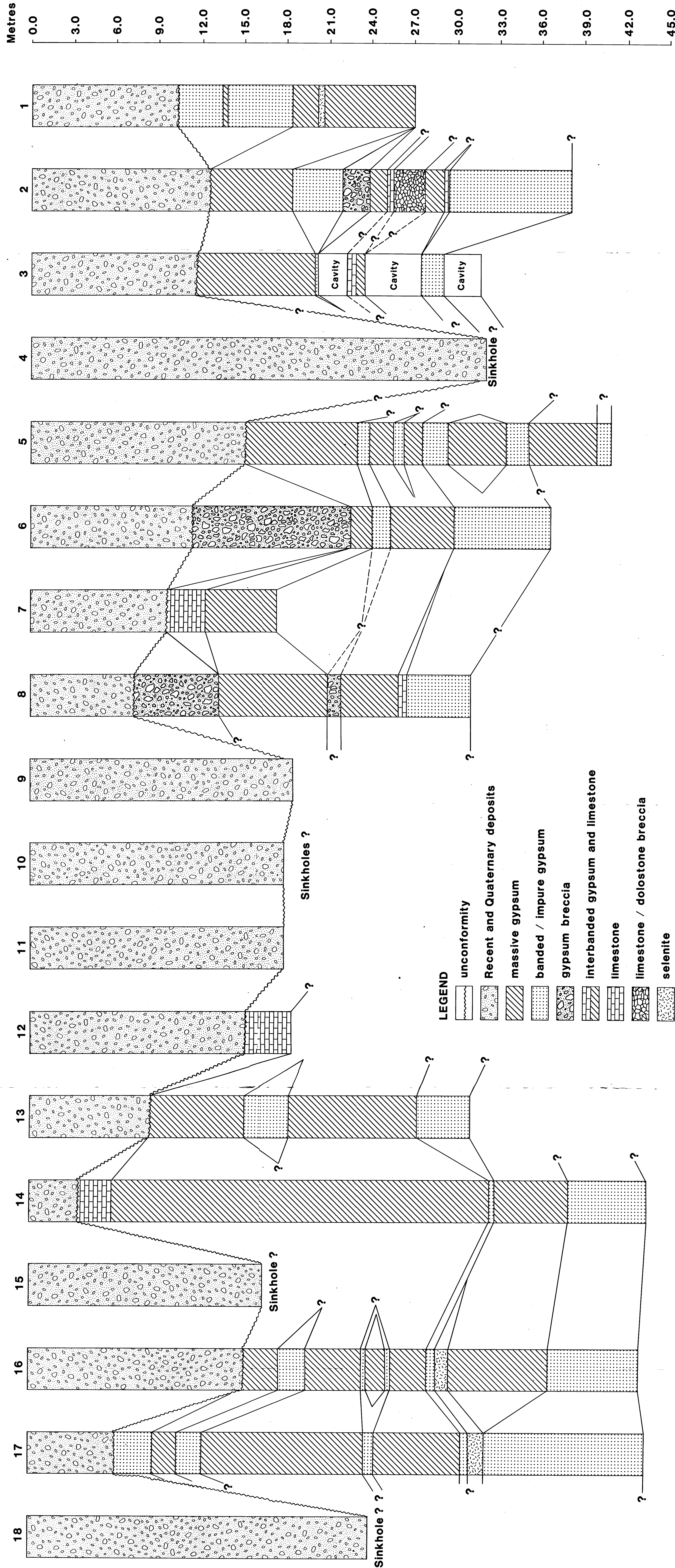


FIGURE 6: 1963 GYPSUM DRILLING PROGRAM, CHEEPASH RIVER, JAMES BAY LOWLAND



Note: Not to horizontal scale - see Cheepash River Map for drillhole locations modified after Guillet (1964)

Elevation above sea level approximately equals 30.5m

See Figure 1 for locations of drillholes









