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PRELIMINARY GEOLOGICAL INVESTIGATIONS INTO REPORTED MARL DEPOSITS ON THE SADDLE LAKE RESERVE, ALBERTA

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1. Introduction

1.1 Background

In September 1981, Mr. Jim Razzel, an Economic Development Co-ordinator for the Saddle Lake Reserve, contacted the Alberta Geological Survey and Alberta Agriculture regarding possible marl deposits on the Saddle Lake Reserve.

In October of the same year, Mr. Adolf Gettel and the author made a preliminary geological investigation into these deposits, the results of which are presented in this report.

1.2 Location and Access

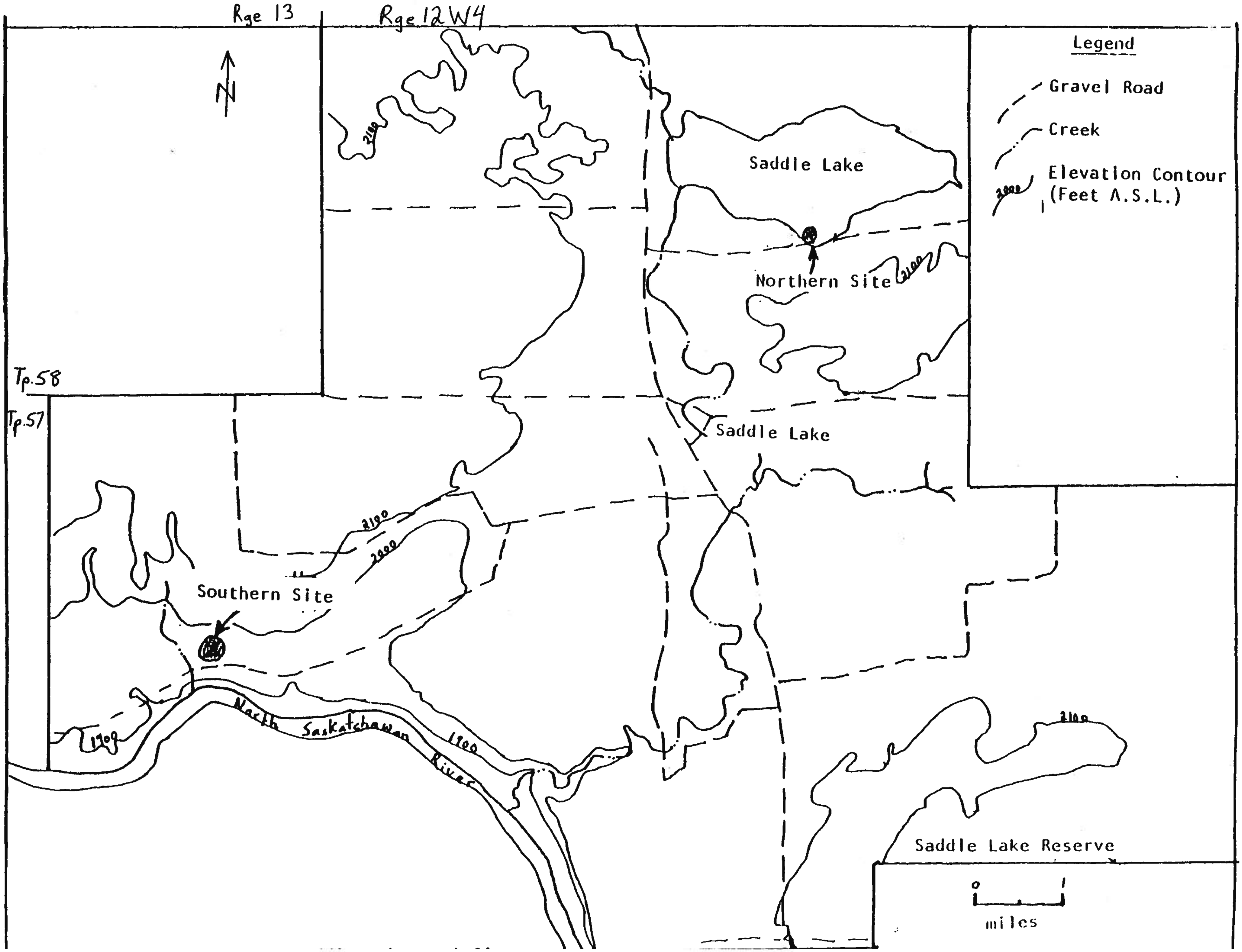
The two alleged marl deposits on the Saddle Lake Reserve are shown on figure 1 and are hereafter referred to as: Northern and Southern sites.

The Northern site is located 5 km south of Saddle Lake (L.S.D. 13, Sec. 12, Twp. 58, Rge. 12 W4th - approximately). Access into this site is good via a local gravel based road (Fig. 1).

The Southern site is located in the extreme southwestern end of the Reserve, about 1 km north of the North Saskatchewan River (L.S.D.'s 3, 4, 5, 6, 7, 8; Sec. 24, Twp. 57 Rge. 13, W4th - approximately). Access into this site is fair, via a partially improved gravel based road. This road passes immediately by the southern end of the site (Fig. 2).

1.3 Previous Work

No previous recorded work on either site is known, aside from a consultant's report (authors unknown) to the Tribe that made mention of marl deposits. Local people claim that approximately 10 years(?) ago a drilling program was undertaken at the Southern site, no record of this is available.



Rge 13
Rge 12 W4
Tp. 58
Tp. 57
N
Saddle Lake
Northern Site
Saddle Lake
Southern Site
North Saskatchewan River
Saddle Lake Reserve
2100
2000
1900
Legend
Gravel Road
Creek
Elevation Contour (Feet A.S.L.)
0
1
miles

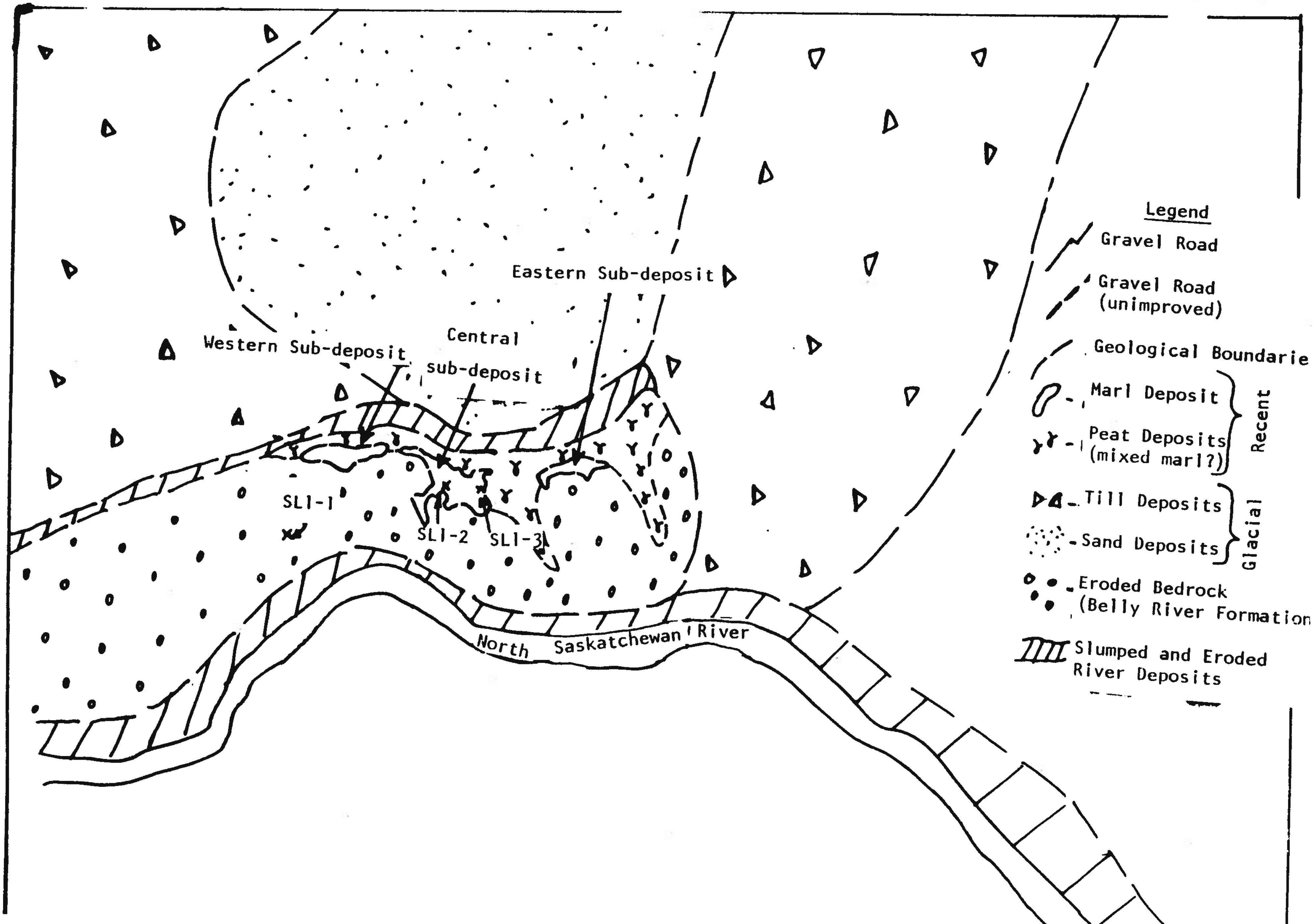
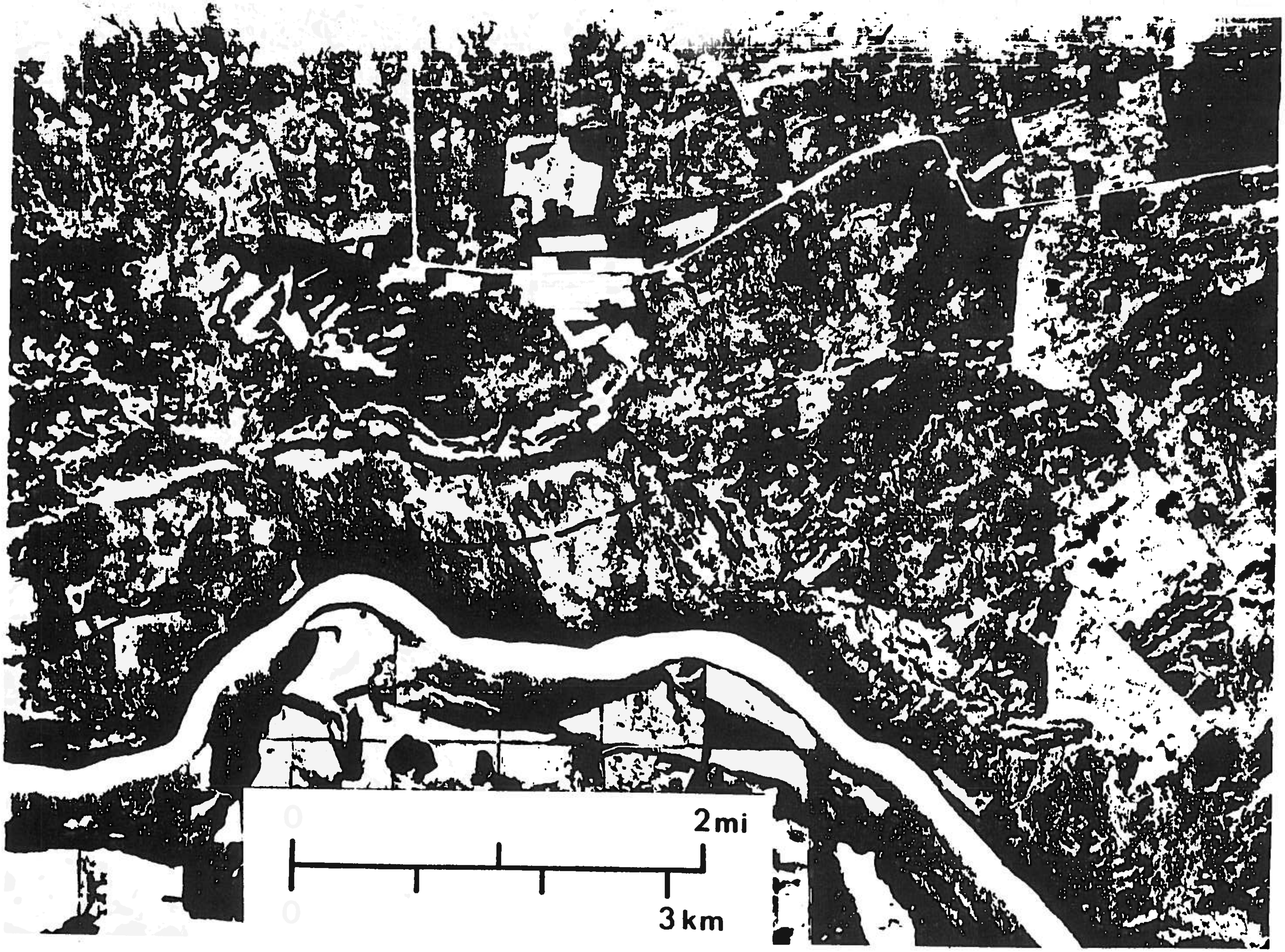


Figure 2. Location, Access, Surficial Geology and Sample Sites - Southern Deposit, Saddle Lake


0
2mi
0
3km

1.4 Method of Study

Both sites were examined on foot and surface samples (only) were collected. An attempt was made to trace the aerial extent of the sites both in the field and by air photo interpretation.

Samples were submitted to the Alberta Research Council's chemical laboratory for determination of CaO, SiO_2 and H_2O content. The samples were also examined with a binocular microscope.

2.0 General Geology

The surficial geological setting of the Southern and Central Saddle Lake Reserve area is shown in figure 2. It consists primarily of undulating to steeply rolling glacial till deposits (many of which have been ice thrusted), a small amount of glacio-fluvial sand and gravel deposits and mixed deposits associated with the North Saskatchewan River (i.e. terrace, alluvial and eroded slope deposits - Ellwood, 1961 and unpublished A.R.C. data). The detailed surficial geology of the Southern site is shown on figure 3.

The bedrock geology underlying the Saddle Lake Reserve consists of the Cretaceous age, Belly River Formation. This formation consists of interbedded sandstones, siltstones, mudstones, ironstone beds and coal seams (Green, 1972).

3.0 Deposit Descriptions

3.1 Northern Site

A detailed examination was made at this site and one surface sample was collected (Fig. 1). Although a 1 cm thick crust of white crystals was oberved at the Northern site, it was the author's opinion that this is not a marl deposit. Mr. Gettel supported this view, and suggested that the white precipitated crystals are sodium, potassium and minor calcium carbonate salts deposited from groundwater discharging at the site during summer evaporation. This phenomena is well known and widespread in east-central Alberta. These salts are drawn to the surface in midsummer and are generally flushed back into the soil horizon the following spring. The net result is that no thick accumulation of salts (or marl) occur.

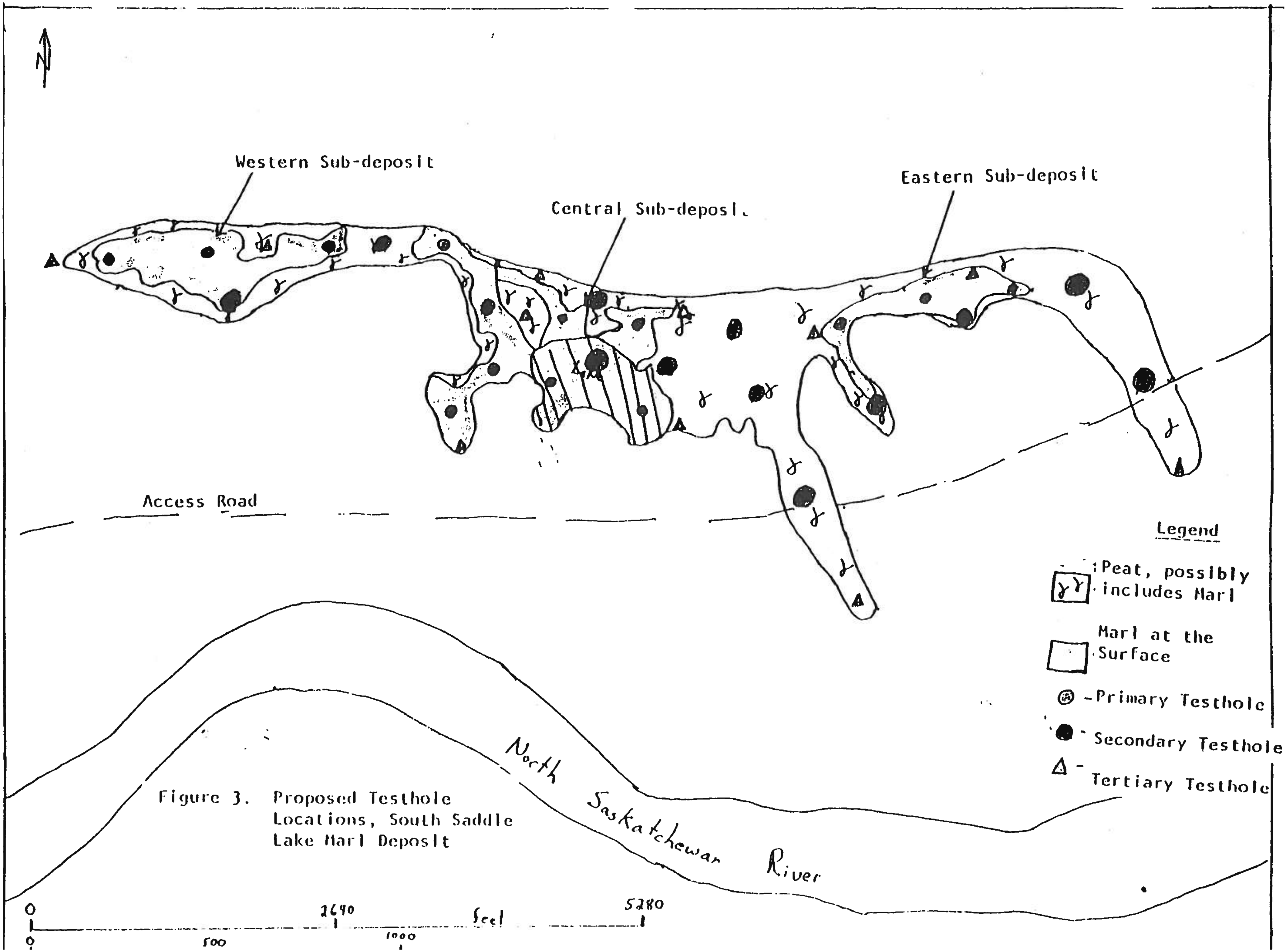


Figure 3. Proposed Testhole Locations, South Saddle Lake Marl Deposit

This sample yielded a CaO value of 8.4 percent (or 15.0% $CaCO_3$). In a previous work (Macdonald, in press) this author has defined marl to have a $CaCO_3$ value of 50 percent or greater. This grade cutoff was chosen for geologic and economic reasons. Any material with less than 50 percent $CaCO_3$ has little economic value.

In summary, the chemical analysis supports Mr. Gettle's and the author's opinion that the Northern site is not a marl deposit.

3.2 Southern Site

3.21 Geological Setting of the Deposit

The marl deposit is located on a terrace of the North Saskatchewan River, eroded primarily into the Belly River Formation sandstone. Immediately to the north of the deposit outwash sand and gravel overlies an upland region (Fig. 2). This deposit of sand and gravel directly overlies the Belly River Formation .5 km north of the marl deposit, and overlies a sandy-silty calcareous till 7 km farther to the north. A sample of the Belly River Formation sandstone yielded 37.5 percent $CaCO_3$ (21% CaO) suggesting that it is calcite cemented.

Groundwater seepages and springs eminate from the base of this upland and flow onto the terrace.

3.22 Sampling

This site was examined in some detail and two surface samples were collected. Sampling sites are shown on figure 2. One sample of Belly River Formation sandstone was also collected.

3.23 Analytical Results

The results of chemical analytical work are summarized in Table 1.

Sample Species	SL1-1 Bedrock	SL1-2 Marl	SL1-3 Marl
CaO%	21.0	42.5	32.8
$CaCO_3$%[1]	37.5	75.9	58.5
H_2O	--	64.4	79.3
SiO_2	38.2	5.1	9.8

Table 1. Summary of Analytical Results

[1] $CaCO_3$ is calculated from CaO determination, by multiplying CaO by a factor of 1.785.

The results show that although both samples are marl, the grade of marl shows a wide variation. In particular, sample SL1-3 is a low grade material. Both marl samples are highly water saturated (%H_2O is by weight).

Microscopic examination of the two marl samples showed that the major contaminating material is vegetative organic remains. SiO_2 as detrital quartz, is the other minor contaminant (5-10% - Table 1).

Sample SL1-2 (Central Deposit - 75.9% $CaCO_3$) showed: abundant plant remains, Chara sp. "stalks" and seeds"[2], pelecypods, ostracodes and a small percentage (5.1%) of silt size quartz.

Sample SL1-3 (Central Deposit - 58.5% $CaCO_3$) showed: much more plant remains than in SL1-2, a lot more silt size quartz than SL1-2 (9.8% - Table 1) pelecypods and gastropods.

3.24 Origin of Deposit

The origin of the Southern Deposit is believed to be related to the discharge of groundwater from the northern upland region which is a groundwater recharge area. Rainwater entering this recharge area is quickly passed downward through the highly permeable outwash sand and gravel and enters into the Belly River Formation sandstone aquifers. Acidic groundwaters leach out calcium carbonate cement from the bedrock and dissolve Ca^{+2} and $HCO_3^{=}$ ions into solution. These ions are carried through the aquifer in groundwater which discharges at the base of the uplands, onto the terrace. During discharge, $CaCO_3$ (as marl) is reprecipitated by physico-chemical processes and/or by the green algae Chara sp. (see Macdonald, in press for a more complete discussion).

This process of groundwater discharge and precipitation of marl, began in post-glacial time (< 10,000 years B.P.) sometime after the river terrace was cut and abandoned.

3.25 Extent of Deposit

Mapping the aerial extent of this deposit was attempted, based on field observations and air photo interpretation. Figures 2 and 3 shows that the Southern Deposit can be subdivided into an eastern, western, and central sub-deposits.

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[2] Chara sp. is a variety of green algae that commonly inhabits calcareous lakes. This group of algae is often cited as being instrumental in precipitating marl.

The western sub-deposit has an aerial extent of about 51,200 m[3]. No surface samples or drillhole data were collected.

The central sub-deposit is by far the largest of the three sub-deposits with an estimated aerial extent of 153,600 m[4]. A sample from both ends (east and west) of the lake at this sub-deposit were collected (SL1-2 and SL1-3; Table 1). The thickness of the deposit is unknown.

The eastern sub-deposit has an estimated aerial extent of 25,600 m[5]. No surface samples or drillhole samples were collected.

3.26 Quarriability

All three sub-deposits are within 1 km (or less) of an improved gravel road (Fig. 3). Since the deposits are all highly water saturated, quarrying could best be done by a draglaine type operation when the ground is frozen. Over most parts of the deposits overburden is absent, however unuseable low grade marl may overlie certain areas and would have to be considered as overburden.

3.27 Reserves

Reserve estimates are impossible to determine at this time, because the deposit thickness and quality variations are unknown. The three sub-deposits have a combined aerial extent of 230,400 m^2. By way of example only; if the average thickness of greater than 50 percent $CaCO_3$ marl was found to be 1 m over all three deposits - then 230,400 m^3 of in situ material would be present. If the thickness of greater than 50 percent $CaCO_3$ marl was found to be 2 m in all three sub-deposits - the volume of in situ material would be 460,800 m^3.

Because these deposits are highly water saturated the amount of dry marl available from the wet crude (or in situ) material must be calculated. Figure 4 shows a graph for estimating tonnage dry marl available per cubic metre of the wet crude. As an example the average moisture content for the central deposit (Table 1) is about 72 percent. Figure 4 shows that 72 percent moisture in the crude marl yields about .29 tonnes of dry marl per cubic metre of crude (in situ) marl.

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[3]Based on a rectangle with dimensions of 640 m x 80 m.

[4]Based on a rectangle, centered around the lake with dimensions of 480 m x 320 m.

[5]Based on a rectangle with dimensions of 320 m x 80 m.

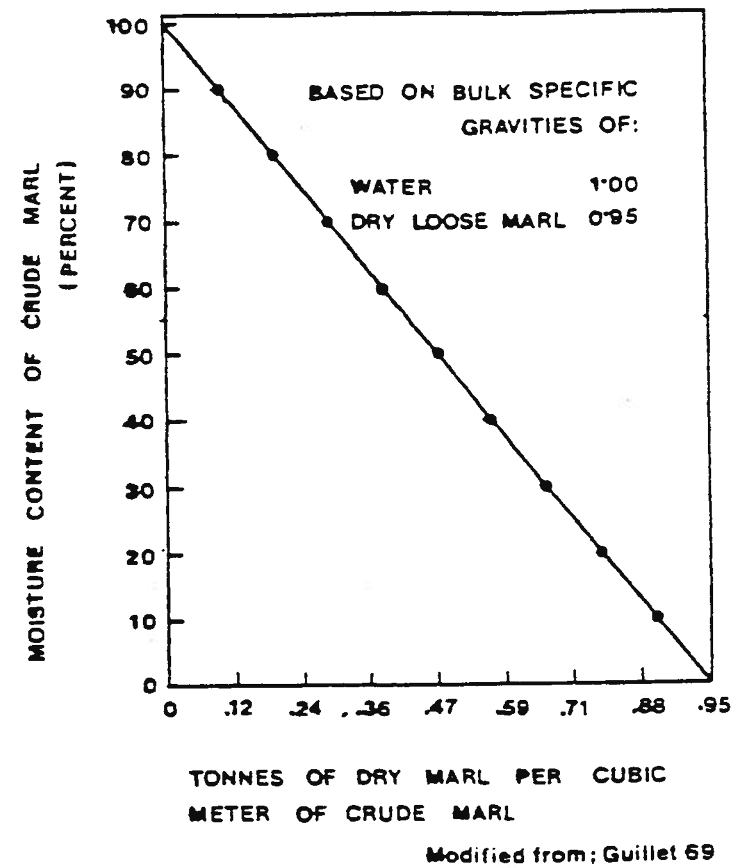

Figure 4. Tonnes of Dry Marl Available per Cubic Metre of Crude Marl - based on Moisture Content

To calculate the tonneage reserve estimates for this deposit it is necessary to obtain a volumetric estimate based on testhole data, obtain the average moisture content for the deposit (or for a given resource block), determine the tonnes of dry marl per cubic metre of wet curde (as per Fig. 4), and then multiply this factor by the true volumetric wet crude value[6].

It can be seen from these calculations that high moisture contents can seriously reduce the apparent reserves at a given deposit. The necessity of obtaining accurate moisture contents can not be stressed enough.

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[6] By way of example if the three deposits do have an aerial extent 230,400 m^2 and if a 1 m average thickness (of 50% or greater $CaCO_3$) is present the volume of wet crude is 230,400 m3. If the average moisture content for all three deposits is found to be 72 percent - the .29 value previously mentioned can be applied. This then yields 66,816 tonnes of dried marl, in this example.

The high percentage of organic matter observed in two collected samples would further reduce reserved estimates if a high grade end product was desired (i.e. high $CaCO_3$ value). The marl grade could be beneficiated by removing the organics (commonly done by burning them). Removal of the detrital quartz would be more of a problem. The net result is that the marl grade increases while the reserve estimates decrease. If the marl is to be used without beneficiation, no further reduction of the reserves need be accounted for.

3.28 Intended Use

It is of utmost importance that the intended use and user be clearly established before any further development of the marl deposit proceed. The specifications for raw material, with respect to their finished product, vary considerably. These specifications will have an influence on the next stage of development of the deposit with respect to the detail and analytical work that must be performed.

If the marl is to be used to produce an agriculture liming product the following should be considered:

1) Specifications for $CaCO_3$ content is usually set at 70% or greater
2) Organic and other contaminants are generally not important, as long as the 70% grade cutoff is present
3) It is usually sufficient to stock pile the marl on a dry location in order to dewater it for sale, i.e. the moisture content of the product need not be zero.
4) Size specifications of the raw material will accept anything up to sand size (i.e. ≃ 1 mm).
5) Small deposits, in terms of the reserves, can be exploited profitably with a minimal amount of capital investiment (basically a backhoe/dragline and a dump truck).
6) The market demand for "agriculture lime" is minimal at the present, however Alberta Agriculture officials are predicting an increased and steady demand in the future.

On the other hand, if the marl is to be used for cement production, these factors should be considered:

1) $CaCO_3$ content required in the raw material is very high, i.e. 90% or greater, and this high grade must be maintained.
2) Contaminants must be removed by some beneficiating process.
3) The raw material must have a moisture content of nearly zero before it can be used. Therefore the marl would have to be both stockpile dried <u>and</u> heater dried.
4) All of the raw material must be ground to a size of usually 0.0625 mm. In this respect marl often has an advantage over limestone in that often this is the grain size when mined.
5) Deposit reserves must be very large and well defined to support an "on site" cement plant. Grade variations within the deposit must also be well defined. The initial capital investment is very large.
6) The market demand for cement is generally very good in Alberta.

4.0 Conclusions

Marl is not present at the Northern Site near Saddle Lake and therefore this site has no economic potential.

The Southern Site contains three sub-deposits of marl. The combined aerial extent of these three is about 230,000 m^2 of <u>in situ wet crude</u> marl. The thickness and volume of the marl is unknown. Two surface samples collected yield an average of 67.2 percent $CaCO_3$ and 71.9 percent water for the Central Southern Deposit. Most of the contaminating material in the marl is thought to be vegetative organic materials, which can be removed to veneficiate the marl grade. These deposits have reasonably close road access and would best be quarried in the winter by a drag line type operation. Reserve estimates are not available, however based on the very large surface exposures this could be a very economical deposit, i.e. if the thicknesses are great and quality high.

The intended use of the marl should be decided as soon as possible, because the cost and method of future developments will depend on this.

5.0 Recommendations

5.1 Southern Deposit

The Southern Deposit may have considerable potential for large tonneages of marl, based on the large aerial extent. The two samples collected indicate a low grade marl with wide variation in $CaCO_3$ content. This, however, may not be true for all three sub-deposits.

It is recommended that an exploratory testhole drilling/sampling program be undertaken once the area is frozen (mid-winter). This can be done with hand tools or with a truck or tracked vehicle mounted auger unit. Using hand tools may be cheaper, but would take longer than a truck mounted auger program, and labour costs may end up being more expensive.

5.11 Proposed Auger Drilling Program

It is proposed that a two to three day auger drilling program be undertaken at the Southern Deposit. The first day should be spent drilling thirteen "primary" holes (Fig. 3). This would provide a minimal amount of information on the three sub-deposits. Day two should be spent drilling the "secondary" holes (Fig. 3). These holes are designed to test the lateral extent of the sub-deposits and explore the areas mapped as "peat" on figure 3. Marl may underlie these peat deposits at some depth. "Tertiary" testholes could be done on the third day, or at the end of the first or second days if time permits. The Tertiary testholes should only be drilled if nearby primary and/or secondary testholes support the drilling, i.e. if marl is encountered. These Tertiary testholes would give maximum information on the aerial extent of the Southern deposit as a whole. Any testhole encountering sand, bedrock or glacial till deposits in the first one metre should be abandoned as marl is almost never found below these sediments. Channel or chip samples of the sediment should be collected every 0.5 to 1.0 metre interval, depending on the uniformity of the material. Drilling should stop when sands, bedrock or till is encountered. If all proposed testholes are drilled, a good geological reconaissance of all three sub-deposits plus the potential for other deposits in the immediate area can be made. Preliminary reserve estimates can also be made.

This program is only a rough guide and may be modified by field conditions or the capabilities of the personnel on the job site.

If this deposit is to be used to manufacture cement, it is strongly recommended that all proposed testholes be drilled. Detailed drilling on a grid pattern would also be necessary at a later stage.

Costs estimates for this program will depend on: company employed, type of rig employed (i.e. truck or track mounted), transportation of rig to the site, overnight crew lodgings, equipment breakage, job time completion, and geologist's and sampling assistant's time. Other additional costs will be sample analyses ($CaCO_3$ and H_2O content) and a geologist's time for compiling and preparing a report.

A crude estimate of the toal costs for this next stage of development of this marl deposit is as follows;

				Expected Maximum
A.	Rig Costs: $67 to $125/hour (truck versus track mounted)			
	1.	$536 to $1000/day x 3 days		$3000
B.	Mobilization Costs			
	1.	Truck Mounted - 4 hours (there and back)	one or the other	$ 270
	2.	Track Mounted - 4 hours		$500-600
	3.	Crew lodging - 2 nights; 2 drillers, 2 geologists @ $60/man/night		$480
	4.	Miscellaneous		$500
C.	1.	Geologist and Assistant - 3 to 4 days in field $50/hour geologist, $15/hour assistant		$3000
	2.	Write and prepare report - difficult to estimate; minimum of		$2000 +
D.	Analytical Costs			
	1.	CaO and H_2O content/smaple = $12 estimate 100 to 200 samples = $1200 to $2400		$2400
		Total Estimated Cost		$11,980 +

It should be stressed that this cost estimate is only to be used as a guideline - actual costs may vary considerably. This is not an actual job estimate.

5.12 Undertaking the Drilling Program

It is further recommended that a reliable geological consultant and drilling company be contracted to do this work. Some geological consulting firms have their own drilling rigs, and this may then reduce the total cost. Some geological consultants and drilling companies capable of undertaking this work are:

Geological Consultants

1. Halferdahl & Associates Ltd.
   Edmonton
   439-9789
2. Trigg Woollett Consulting Ltd.
   Edmonton
   425-8905
3. Geoscience Consulting Ltd.
   Edmonton
   955-7151
4. Mr. Bob St. Louis[8]
   Graduate Student
   Dept. of Geology General Office
   University of Alberta
   Edmonton

Drilling Companies

1. Garrity & Baker Drilling Co.
   Edmonton
   477-6518
2. Canadian Geological Drilling
   Edmonton
   454-5725
3. Adder Drilling
4. Mobil Auger and Research
   Edmonton
   436-3960

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[8]Mr. St. Louis is not a practicing geological consultant, however has indicated an interest in doing this job. His work would be supervised by a professional geologist (A.P.E.G.G.A. member).

References

Ellwood, R.B. (1961): Surficial Geology of the Vermillion area, Unpublished thesis, University of Illinois.

Green, R. (1972): Geological Map of Alberta, Alberta Research Council, Map 35.

Macdonald, D.E. (in press): Marl and Tufa deposits in the Central and Peace River districts of Alberta, Alberta Research Council.