HELICOPTER ELECTROMAGNETIC AND MAGNETIC SURVEY

KIMBERLY-CLARK CANADA LIMITED

SLATE ISLANDS AREA, ONTARIO.

December 1, 1960.

CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

TABLE OF CONTENTS

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I. INTRODUCTION

On November 2 and 3 a combined electromagnetic and magnetic survey was performed for Kimberly-Clark Canada Limited over the Slate Islands in northern Lake Superior. The geographical coordinates of the area are: 87°00'W, 48° 40'N.

A total of 77 line miles of survey were flown along traverses over the islands and the water between the islands with an average traverse spacing of 1/4 mile. Traverse direction was N 20° W, crossing the regional geological strike approximately at right angles.

The aircraft employed for the survey was a Sikorsky S-55 helicopter, registration CF-KQD. It was manned by: H. Weise, pilot; E.W. York, navigator; L. Hanna, instrument operator and was serviced by D. May, aircraft engineer.

The purpose of the survey was to use the combination of low-altitude EM and magnetics to explore for massive sulphide orebodies. Since a line spacing of 1/4 mile was used the survey can be considered reconnaissance in nature, in that bodies of appreciable length could be missed between the flight lines.

The present report provides an explanation of the symbolism and presentation employed, a description of the geophysical equipment and an interpretation of the EM data.

II. GEOPHYSICAL EQUIPMENT

Mounted on the Sikorsky-S-55 helicopter are: the Canadian Aero in-phase/out-of-phase, high sensitivity electromagnetic unit; a Gulf Model III total intensity magnetometer; a Measurement Engineering Ltd. 1903R Mark II scintillation counter; an APN-1 radio altimeter; an Aeropath 35 mm. continuous-strip camera.

The electromagnetic detector employs a co-axial coil arrangement with the transmitting coil mounted forward and the receiver on a "stinger" projected aft from the tail to provide a coil separation of 60 feet. Both in-phase and out-of-phase components of the secondary field are measured at a low frequency (390 cps) and the high sensitivity attained permits good depth penetration. (An anomaly of 20-30 ppm can usually be discerned.) Another important characteristic of this system is excellent resolution of conductors made possible by the small coil separation and by the low operational altitude attained.

The operation of a sensitive magnetometer in conjunction with the EM detector is considered essential in sulphide exploration. At the very low terrain clearances attained by the helicopter even small traces of pyrrhotite can be readily detected (15-25 gammas) and such detailed magnetic data can be extremely valuable in the interpretation and appraisal of the EM results. Needless to say it is also of great advantage to have the magnetics recorded simultaneously on the same tape at the same altitude as the EM data so that the exact positional and magnitude relationships between the two are immediately obvious.

The scintillation counter charts variations in the gamma radiation and may in some areas be useful in mapping rock types which can be distinguished by their inherent content of radioactive minerals. Soil-rock contrasts are also often apparent and swamps and lakes are immediately obvious because they absorb all radiation from below and show as flat lows on the scintillation record. This instrument is therefore carried as valuable auxiliary location equipment on all of our helicopter surveys.

A continuous record of terrain clearance is provided by the APN-1 radio altimeter. This data is essential in a proper appraisal of EM anomalies because the amplitude of EM response decays very rapidly with increasing altitude. In-phase anomalies appearing on our maps are normalized for variations in terrain clearance so that they can be compared on a more direct basis.

The data from all this electronic equipment is charted on a six-channel Brush recorder mounted in the S-55. Fiducial markers appear at regular time intervals on the Brush tape and permit synchronization of the geophysical data with the flight path film record provided by the Aeropath 35 mm. wide-angle continuous-strip camera.

The total magnetic intensity is also recorded on a 10-inch rectilinear recorder to provide greater facility in the compilation of isomagnetic contour maps.

III. PRESENTATION OF RESULTS

The EM anomalies are plotted on a transparent overlay to the 1320 feet per inch photo base map. The EM map also shows the picked fiducials, the flight path and the outlines of major planimetric features.

We believe that the most important characteristics of an electromagnetic anomaly are: 1. its position; 2. the ratio of in-phase component to quadrature component; 3. in-phase amplitude; 4. width; 5. line-to-line continuity; 6. relationship of magnetic anomaly to EM anomaly. Our map presentation is designed to show these features.

An individual anomaly as taken from the profile traces of the Brush tape is represented on the plan map by:

1. A symbol (hollow square, solid square, triangle, X, or small upright line) plotted on the flight line, which gives the position of the centre of the anomaly peak (when such can be determined). The symbol also serves to indicate the ratio of in-phase component to quadrature component. Each of the first four symbols mentioned above corresponds to a particular ratio range, (see the legend on the map), and since this ratio is chiefly a function of conductivity, each symbol in effect corresponds to a particular conductivity range. The small upright line is used instead of a ratio symbol only in cases where the

1. (cont'd)

ratio is indeterminate or where the anomaly consists solely of out-of-phase response.

2. A figure written above the symbol, giving the "normalized in-phase amplitude" (i.e. corrected for altitude variation). This figure may be considered to be on an arbitrary scale although it is in fact derived by comparing the recorded response with the response from a standard dyke model. This in-phase amplitude figure is a function of the depth and geometry of a body as well as of its conductivity, and it gives a measure of the relative strengths of response from various conductors.

If a purely out-of-phase anomaly is plotted then the letters "OP" appear instead of the amplitude figure.

3. A pair of marks (arrow-heads) straddling the symbol, giving the "half-peak width" of the anomaly. This quantity is useful for two reasons. In the first place an estimate of the true width can be calculated from the half-peak width (the latter actually defines the upper limit of the true width). Secondly, these half-peak width symbols can be joined up from line to line to show the interpreted continuity of individual conductors.

3. (cont'd)

Note that square brackets are also employed on certain anomalous zones and that they may also be joined up from line to line to show continuity of a conductive zone. These brackets are used to show the outside limits of any multiple conductive zone in which there is an uncertainty as to the number of individual conductors present or where it is not possible to determine the half-peak widths of one or more of the individual conductors.

4. A letter "M" plus a figure (both written beneath the ratio symbol) giving the amplitude in gammas of the coincident magnetic anomaly if one exists. If the magnetic anomaly is slightly offset but still close enough that it could be associated there is an arrow over the "M" pointing to the direction of offset of the magnetic high from the EM anomaly. We have adopted the procedure of showing pertinent magnetic information right on the EM map because experience shows that the existence of coincident or closely associated magnetics is often very important in the appraisal of electromagnetic anomalies, and this presentation simplifies the study of this relationship.

Elsewhere within the survey area, but mainly on Patterson Island, other low amplitude quadrature anomalies have been plotted. A perusal of the EM tapes will show that there is additional minor quadrature variation which we have not plotted. Most of the anomalies which appear on the map are only 20-40 ppm in amplitude; to pick anything smaller would be risky since we would be within the instrumental noise level of the system. Even on those anomalies which are presented the actual edges of conductive zones are in most cases quite indistinct.

These out-of-phase anomalies are mainly very broad (800 feet to 2800 feet) but there are a few which appear to be relatively narrow. Once again very small conductivity contrasts are responsible and as with the more extensive zone on Mortimer Island we conclude that the anomalies could be due either to small conductivity contrasts within the bedrock, or to weakly-conducting overburden.

The narrow out-of-phase anomalies were examined carefully for the possibility of related magnetic anomalies. A sharp out-of-phase anomaly with coincident magnetic peak would be important as it could be indicative of poorly-conducting sulphides (conductivity too low to appear on in-phase trace) or it could lead to something better between the present traverses. Unfortunately no such correlation of EM and magnetics exists. We are confident that the narrow anomalies result from the same type of minor conductivity contrast that gives rise to the broader anomalies.

On the in-phase EM trace of the six-channel Brush tape

Some of the stronger magnetic bodies gave rise to magnetic permeability anomalies on the EM records (almost entirely in-phase) but these have no significance as far as conductors or sulphides are concerned.

There is a marked degree of magnetic activity within the survey area with several very strong anomalies predominating.

Respectfully submitted,

A. R. Rattew, P. Eng.,
Geophysical Engineer.

December 1, 1960.

IV. INTERPRETATION

There are no in-phase conductivity anomalies on the entire survey and the quadrature anomalies which we have plotted are all of very low amplitude. It is also apparent that these quadrature anomalies are mainly very broad. There is no correspondence between EM and magnetic anomalies. It is therefore obvious that no prospects for sulphide orebodies have been revealed by the survey.

The largest zone of out-of-phase response is on Mortimer Island, the northernmost of the Slate Islands group. It extends the full length of the island and on most traverses it is seen to be almost as broad as the island. Since most of these anomalies are broad and of very low amplitude (20-40 p.p.m.) their edges are very poorly defined and the plotted width could therefore be in error. This uncertainty accounts for the irregular outline of the zone and for the apparent marked variations in width seen on certain traverses. Because of the uncertainty of the zone boundaries we have not joined up the brackets from line to line but the continuity of the conductive zone is obvious.

It takes only a very small conductivity contrast to account for such broad, low amplitude, out-of-phase anomalies. The most plausible explanation is that the island is of slightly higher conductivity than the surrounding water. The overburden may account for this higher conductivity or it could be due to the bedrock itself.

there are several "permeability" anomalies which have not been plotted on the EM map. These are of the opposite sign to conductivity anomalies and since they are due to magnetic permeability rather than conductivity they have no place on a conductivity map. It will be seen that they correspond with relatively strong magnetic anomalies and that there is little or no effect on the quadrature trace. The best examples of this phenomenon are seen on traverses 4, 10, 11 and A.

Note that the extra traverses, A and B, were flown to obtain more detail over a strong magnetic anomaly and not to detail a conductor. The extra traverses 3 and 4 were obtained because there was excessive instrumental noise on these traverses the first time they were flown.

V. CONCLUSIONS

No prospects for sulphide deposits are apparent on the combined electromagnetic and magnetic survey of the Slate Islands. Since the line spacing employed was 1/4 mile the survey can be considered reconnaissance in nature; a sulphide body of appreciable length could exist between the flight lines.

Minor changes in bedrock and/or overburden conductivity are deemed to be responsible for the low amplitude quadrature anomalies observed. Even the most weakly-conducting graphitic rocks normally give stronger, more clearly defined anomalies than these, so we can conclude furthermore that no appreciable quantities of graphitic material occur within the survey area.

CANADIAN AERO SERVICE LIMITED
OTTAWA, ONTARIO

GEOLOGY REPORT

plus

Summary of Aeromagnetic & Electromagnetic Survey

KIMBERLY-CLARK PULP & PAPER CO. LTD.

SLATE ISLANDS, LAKE SUPERIOR

January 1961

G. E. Parsons

CONTE

SUMMARY

Slate Islands consist of a circular group of islands approximately fifteen square miles in size and located seven miles south of Jackfish on the north shore of Lake Superior.

The geology of the islands is quite complex. Two periods of volcanism separated by a period of mountain-building and basic intrusion are indicated. The earlier period of volcanism is represented by trachytic to andesitic flows and agglomerates, while the latter period is mainly basaltic flows. The earlier rocks are highly folded and rather extensively altered to chloritic and sericitic schists.

In the latter part of the last century, considerable work was done on gold-bearing quartz veins. The present investigation, consisting of fifteen days' mapping and prospecting, was concentrated on the north and west parts of South Slate and adjacent islands. The presence of gold values on the islands was confirmed, but no showings of economic size or grade were noted. The rocks of the islands are of a type with which ore bodies of copper, nickel, silver and/or iron are associated, although the ground work to date has failed to locate evidence of these metals.

An airborne electromagnetic and magnetic survey was performed late in the fall by Canadian Aero Services Ltd. using a Sikorsky S-55 helicopter to determine if base metals and/or iron deposits existed. Since a line spacing of one-quarter mile was used, the survey was of a reconnaissance type in that bodies of ore could be missed between flight lines. No electromagnetic anomalies suggesting massive sulphides were recorded, but several strong magnetic anomalies (up to 7,000 gamma above base level) were revealed in South Slate Island. A ground investigation of the mineralization causing these anomalies is warranted. This investigation should take the form of geological prospecting of the anomalous area and, if indications warrant additional work, detail mapping, sampling and ground magnetic surveys; this would involve a time requirement of one to four weeks by a two or three-man crew.

INTRODUCTION

Location and Size

Slate Islands consist of a group of islands in Lake Superior, seven miles south of the north shore village of Jackfish. The group is mostly confined to a circular area five miles in diameter, and contains roughly fifteen square miles of land and inland lakes.

Purpose and Scope of Survey

Kimberly-Clark Pulp & Paper Company desired to determine if the islands warranted mineral exploration, and if the geological evidence justified the mineral rights being retained.

The only published report (reference 1) noted the presence of several volcanic necks and two periods of volcanism. These features, the circular outline of the island group, and their proximity to alkaline complexes on the mainland, suggested the possible existence of a ring-type volcanic structure favourable for mineral deposits. The above reference also noted several gold-bearing quartz veins. An investigation of these indications on the islands appeared advisable and prompted this survey.

The writer and a high-school student spent the period August 2-18, 1960, mapping and prospecting the islands. In addition to checking the features referred to in the above paragraph, it was originally hoped to obtain in this period sufficient data to build up a geological picture of the whole island group. It soon became apparent that the geology was too complex to do this in the time available, and our efforts were concentrated on the west part of the South Slate Island and on the islands between South Slate Island and Mortimer or North Slate Island.

High seas on frequent days confined the investigation to inland and sheltered parts of the islands. The rugged nature of a good deal of the shore line, as well as reefs, made landings difficult except on relatively quiet days. The rugged terrain inland did not lend itself to accurate traversing, although this was partially compensated by rather numerous topographical features visible on the air photographs.

The rocks are named strictly from features observed in field work and macroscopic identification of minerals. Except on one specimen, no microscopic or chemical analyses were made to confirm or deny the field deductions. If additional or a detail mapping survey becomes necessary, some microscopic thin section studies of the rocks may be desirable to assist in clarifying the geology.

All assays for gold were made by Swastika Laboratories in Swastika, Ontario.

Previous Geological Work

The only published report on the geology of the islands is by A.L.Parsons (ref.1) based on three weeks' field work in 1917. His work was prompted by reports of high grade gold ore on the islands. He reports that, - "so far as he is aware, no previous attempt was made to differentiate various rock types and this is less surprising when one sees the character of the rocks, for with few exceptions they are so decomposed and altered that it is extremely difficult to secure satisfactory specimens for study." The geological map accompanying A.L.Parsons' report appears to have been based on spot observations with the result his distribution of rock types cannot be confirmed on the ground in a good number of areas. The chief value in this report is his description of the veins on which work had been done prior to his examination.

Previous Mineral Exploration

Evidence of previous exploration is still visible in pits and three tunnels. This work pre-dates A.L.Parsons' report in 1917 because all of it was described by him (ref.1).

Two tunnels were located near the north tip of the west shore of South Slate Island. They are approximately 450 feet apart; the northerly one is roughly 200 feet long, and the southerly one is plugged with shore gravel so that its depth is not determinable. The third tunnel is on the west shore at the mouth of Lambton Cove (Copper Harbour), Mortimer Island. It is roughly 75 feet long. All three tunnels were collared at the high water mark of Lake Superior and are now partially filled at their mouths with shore gravel.

A number of pits were noted on the veins described by A.L.Parsons, and in all cases these were badly overgrown.

Residents, Habitation and Timber

The only regular resident on the island is the lighthouse-keeper on the south shore of South Slate Island. Tourists interested in lake trout fishing frequent the islands during the summer months. They occupy cabins of which there are three on McGreevy Harbour and one in the southwest corner of McColl Island. Several large pleasure cruisers anchored overnight in the shelter of the islands during the writer's stay there.

Caribou, beaver and rabbits are fairly abundant; these were the only animals, large or small, noted on the islands.

In the area traversed by the writer, the trees tend to be distinctly scrubby or stunted in appearance except in sheltered valleys. This is likely due both to climate and a poor mantle of soil.

TOPOGRAPHY

Mortimer and Delaute Islands are exceedingly rugged with rocky shores often rising as precipitous cliffs a hundred feet or more out of Lake Superior. These massive rocks on Mortimer Island have acted as a bulwark against Lake Superior for the other islands and probably saved them from complete destruction.

South Slate and the other islands present a variety of topography which is largely due to the variety of rock types and wave erosion. The shore lines are exceedingly irregular with jutting points, pinnacles, reefs, precipitous cliffs, frequent bays and sand and gravel beaches. In the northwest corner of South Island in particular, there are flat areas of sand and gravel with old beach lines up to several tens of feet above the present lake level. Projecting up through these sand and gravel areas are pinnacles of schist and ribs of rock that were previously subjected to wave erosion. Inland the surface varies from gently rolling to distinctly rugged. Areas underlain by massive rocks such as gabbro and diabase invariably stand up as topographical features.

The inland lakes are for the most part elongated parallel to the rock trends which are generally northeasterly. On the subject of lakes, A.L.Parsons states, - "Several of these lakes, possibly all of them, appear to be crater lakes, while the highest point on the island seems to be an old volcanic neck." While the possibility of volcanic craters or necks occurring on the islands cannot be denied, the writer failed to find any evidence to substantiate A. L. Parsons' statement.

Close to 40% of the portion of South Slate and adjacent islands covered by the writer is exposed rock or rock with little soil. A much higher percentage of Mortimer Island would fall into this category. The soil, although not examined in detail, appears to be largely derived from the rocks on the islands. The only pebbles noted foreign to the area were of flint. Similar flint pebbles are common to glacial deposits on the mainland to the north, hence we must conclude that some glacial debris has been dumped on the islands.

GEOLOGY

General

The geology of Slate Islands is complex. It will take a great deal of detail mapping to sort it out, and it is only possible to present a partial and tentative picture from the work to date.

In brief, two major periods of rock formation are in evidence. The older period consists of porphyritic and amygdaloidal lava flows and agglomerates of mainly a trachytic and andesitic composition. These rocks have been subjected to mountain-building forces, and consequently are highly folded, sheared and altered.

This older group of rocks was considered by A.L.Parsons to be Pre-Keweenawan, and regional geological maps classify them as Keewatin in age. The lack of any similarity with the Keewatin rocks on the mainland would cast doubt on the advisability of considering them Keewatin in age. The writer considers them more likely to be early Keweenawan in age.

These older rocks are cut by an abundance of gabbroic and diabasic dikes, sills and intrusive masses, and locally overlain by amygdaloidal basaltic lava.

The second group of rock formation strongly resembles other Keweenawan-age rocks in the Lake Superior area, and hence can safely be considered of this age. The writer has tentatively placed in this period the massive greenstones of Mortimer Island because of their indicated chemical similarity, and also because they are not cut by the abundance of diabase dikes as in the case of the early-formed rocks.

A. L. Parsons maps and describes tuffs of Keweenawan age. He gives them a peculiar distribution pattern scattered along the shores of South Slate Island, as well as noting that they overlie the older schists on some of the high hills. On checking the localities where he marks these tuffs on his map, agglomerates are generally present along with other types common to the present writer's early-formed rock group. The only evidence of overlying rocks was located in his tuff locality on the west shore of South Slate Island; here, good amygdaloidal basalt overlies the earlier schistose rocks and dips into Lake Superior. The only rock that might constitute his overlying tuff is a weakly developed reddish conglomeratic rock with abundant hematite lying between the basalt and earlier-formed schists. This formation resembles more a basal-type conglomerate representing a period of erosion between the two periods of rock formation than a tuff.

In the table of formations presented below, the rocks are listed according to their indicated age with the youngest rocks at the top of the list. Although two main periods of rock formation, separated by a period of mountain-building, are indicated, the relative age relation is far from certain for the early-formed volcanic rocks and also for the Mortimer Island greenstones.

Table of Formations

Younger Period (Middle Keweenawan Age) - a period of basic intrusions and surface lava flows.

Diabase dikes

Greenstones of Mortimer Island

Amygdaloidal basaltic lava

Gabbro and diabase dikes, sills and intrusive masses

Period of mountain-building creating areas of schists out of older rocks below.

Older Period (Early Keweenawan Age?) - a period of volcanism, - dominantly trachytic to andesitic in composition.

Agglomerate type Ag-2

Iron Formation or Jasper

Amygdaloidal andesitic lava type L-2

Agglomerate type Ag-1

Porphyritic and amygdaloidal lava type L-1

Description of Rock Types

Lavas Type L-1

This is a catch-all division for a group of trachytic volcanic rocks. Although they are considered to be primarily flows, no doubt some volcanic explosive-type rocks are also included. They are characterized by erratic variations in colour from mottled pinks, to green, to red, to reddish brown. Phenocrysts of hornblende (mostly chloritized), ragged pink and white felspar, and/or amygdules are normally present.

The porphyritic and amygdaloidal type L-1a is well exposed inland from the southeast shore of McGreevy Harbour, and inland to the south and east of the south end of Lawrence Bay. The distinctly porphyritic types consist of numerous small ragged red to white felspar phenocrysts in a dense green matrix. Occasionally the phenocrysts are chloritized hornblende crystals in a dense reddish or salmon-pink groundmass. Amygdaloidal types are scattered throughout the above areas, but are specifically well developed southeast of McGreevy Harbour where white quartz amygdules are up to an inch across. The outcrops with amygdules are usually also to some degree porphyritic; however, the reverse is not always true.

The McColl Island type L-1b is a very distinctive uniform and fine to dense, rather massive, dull chocolate-brown rock. It is generally flecked with small green chloritic spots. There is nothing to indicate it is a lava rather than an intrusive except its fine dense texture. It constitutes most of the inner part of McColl Island. Indefinite rock types on the peninsula between Lawrence and Camp Bays may be the same rock type. Here, the rocks are mottled greens, red and brown in colour, but generally with felspar, or hornblende phenocrysts or amygdules, indicating their lava origin.

Agglomerate Type Ag-1

This agglomerate is considered to be the explosive volcanic equivalent of the trachytic lavas just described. Typically it consists of light flesh-coloured fragments in a darker green chloritic matrix. Both the fragments and the matrix generally carry abundant phenocrysts of pink felspar and hornblende. The fragments may range up to several feet across, and their outline varies from angular to lenticular and bomb-like. The edges of some of the angular fragments are exceedingly ragged. The fragments are often oriented in a specific direction, but no evidence of sorting into beds was observed.

Good type localities of these rocks are:-

- in the northwest part of South Slate Island south of amygdaloidal lava type L-2
- south shore of Mortimer Island west of Lambton Cove
- inland from the southeast shore of Camp Bay, South Slate Island
- along the north shore of the peninsula north of McGreevy Harbour
- southwest corner of South Slate Island west of Horace Cove

Locally these rocks are highly altered to chloritic and sericitic schists, and in some such cases impossible to differentiate from other rocks also so altered. Occasionally as on the west shore of McColl Island, the fragments are still discernible in the agglomerates so altered.

Wave-eroded highly sheared agglomerate along the west shore of McColl Island.

A close-up of above agglomerate showing lenticular bomb-like volcanic fragments.

Amygdaloidal Green Andesitic Lavas Type L-2

This term has been applied to rather dense, green (usually light) rock with a consistent content of amygdules. The amygdules are generally the sizes of peas and almonds, but do reach up to over an inch in diameter; they are nearly all composed of white quartz although some calcite is also present. Some evidence of large pillows were noted in the reefs north of Amyg Island, but nowhere else.

These rocks are well exposed on Amyg Island and the adjacent northwest shore of South Slate Island, the west shore of Edmonds Island, the southeast shore of Camp Bay, and the east shore of Horace Cove. Although in all localities they are very similar and bordered on their south, southeast or east sides by the agglomerates just described, it is difficult to reconcile all the data and consider their occurrence in all areas as being part of the same flow. Southeast of Camp Bay along strike to the northeast they become also porphyritic, suggesting that here they may grade into the porphyritic amygdaloidal lava type.

They vary from quite massive to highly sheared and schistose. The more massive types are less dense, with only scattered amygdules, and at times not readily distinguishable from gabbro. The highly schistose varities cannot be distinguished from the chlorite-sericite schists unless the quartz amygdules are present.

Iron Formation

This term is applied to bright red banded jasper rock. This rock is highly contorted, brecciated and cut by quartz veins and stringers. The exposures are small and occur along the northwest shore of South Slate Island and the west shore of Edmonds Island. Pebbles of red jasper are also prevalent in the shore gravels in this area. It is generally associated with agglomerate type Ag-2, although it also occurs in proximity to amygdaloidal lava type L-2. It is probably a siliceous precipitate from volcanic hot springs, of little extent, and does not occupy any specific stratigraphic horizon.

Both tunnels on the northwest corner of Slate Island were collared in brecciated rocks containing this red jasper formation.

Agglomerate Type Ag-2

This agglomerate is similar to type Ag-1 except it contains fragments of bright red jasper. It generally contains a greater variety of fragments than Ag-1, and in one locality there was distinct evidence of bedding and an assortment of the pebbles or fragments according to size, suggesting it may be a volcanic conglomerate. All the fragments appear to be volcanic in origin and generally are quite angular. This rock is exposed on the northwest corner of South Slate Island and on Sea Gull Island and adjacent reefs. The bright red jasper fragments in the reefs stand out to make this rock a very distinctive type under the water.

Chloritic and Sericitic Schists

The early group of trachytic and andesitic flows have been variously subjected to shearing stresses. This has resulted locally in formations of highly altered schistose rocks that vary in colour from light green to yellow to buff. Locally, in these rocks it is possible to detect amygdules and fragments which disclose the rock type from which they were derived. In a number of localities these schistose rocks contain small bright green spots up to 2/10th of an inch in size. Due to the fact that certain copper minerals are green, a rock sample (Sl-19) was submitted to the Ontario Department of Mines for spectrographic and X-ray analysis. The latter identified the green spots as a mixture of quartz and mica. The spectrographic analysis of the rock specimen indicated traces (0.01 to 0.10%) of chromium, manganese, nickel, vanadium and zirconium, and no copper. The green colour is likely due to a chromium-bearing mica.

Good type localities of these rocks are along the north shore of Edmonds and Bowes Islands and the north shore of McGreevy Harbour.

Agglomerate type Ag-2 on a small island off northwest corner of South Slate Island; variously shaped fragments of volcanic rocks and red jasper.

Agglomerate type Ag-1 in cliff on west shore of South Slate Island; unsorted, thickly packed angular volcanic fragments.

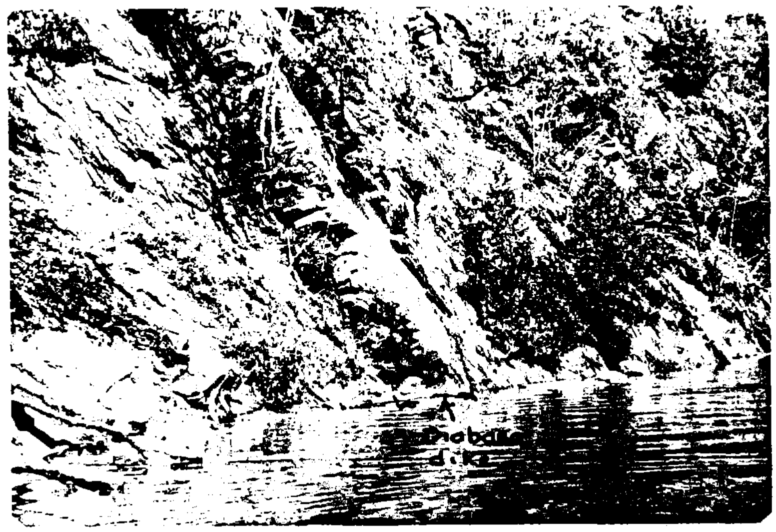
Syenite Dikes

On the southwest corner of Edmonds Island was found a 7-ft. wide syenite dike cutting amygdaloidal lava. It consists of small hornblende phenocrysts in a reddish-brown matrix. Similar dikes were noted along the northwest shore of a small bay on the east side of the mouth of Horace Cove.

Gabbro and Diabase

These basic rocks are liberally distributed throughout the area of the older volcanic rocks and cutting them as dikes, sills and intrusive masses. These rocks are massive and unsheared. They are dark green and vary in texture from fine-grained to quite coarse. They consist of plagioclase and pyroxene. Both magnetite and quartz were observed in some outcrops as accessory constituents.

Most outcrops of these rocks stand up above the general terrain and represent some of the higher ground on South Slate Island. The dikes trend and dip and strike in just about every direction. The outline and trends of the masses of gabbro are irregular and impossible to predict. The best evidence of a sill is the gabbro mass at the lumber camp opposite Jack Island in McGreevy Harbour.



A diabase dike cutting sericitic schists on north shore of McGreevy Harbour.

West shore of South Slate Island; a multi-fragment breccia cutting amygdaloidal lava type L-2.

Amygdaloidal Basaltic Lava

On the south west shore and the adjoining reefs are exposed very dark green and purplish-green amygdaloidal lavas overlying the older schists. The base of these lavas is generally marked by hematite-staining and/or by hematite-rich breccias and conglomeratic rocks. The amygdules are variously filled with chloritic minerals, calcite and quartz as agate. These rocks are quite massive and unsheared. Locally amygdules are absent and the rock has a diabasic texture. They dip out into Lake Superior at around a 50° angle. They are so similiar to other basaltic flows of Keweenawan age in the Lake Superior region that they must be considered of this age. In other locales, these rocks often carry copper in the amygdules, but a careful examination revealed none here.

Greenstones

The greater part of Mortimer Island consists of massive green rock of a dioritic or gabbroic composition. Locally there is weak evidence of pillows as well as amygdules; however, in general there is no concrete evidence of structures that would clearly indicate whether these rocks are intrusive or flow rocks. A. L. Parsons considers them Pre-Keweenawan in age due to their similarity to Keewatin greenstones. The writer considers that they are more likely Keweenawan in age, i.e. related in age to the amygdaloidal basaltic lavas that overlie the early schists, etc. on the west side of South Slate Island.

Structure

The structural pattern of the rocks on Slate Islands, in detail, is far from clear and likely will remain so until the whole island group is mapped and studied in great detail. The structure of the early-formed volcanic rocks is confused in part by the numerous dikes and masses of gabbro that cut these rocks in various directions and forms. Although the early-formed volcanics have been tightly folded so that they generally strike northwest-southeast, there are still a number of exceptions to this trend. It is highly probable that the volcanic series of rocks before folding consisted of a number of lava flows and fragmental and ash units with variable lateral continuity. On folding, the units responded differently to the mountain-building stresses imposed on them. The lava units would tend to resist shearing, while the fragmental-ash units would tend to shear and in some cases squeeze around islands or broken off units of massive lava. McColl Island is a possible example of this phenomenon; the more massive lava of the central part of the island appears to terminate at the north end of the island and be replaced by schistose rocks trending at right angles to that of the lava and island.

While the early-formed volcanic series usually shows some to extreme shearing, the gabbro, diabase and Mortimer Island greenstones are for the most part quite massive. Most of the shearing is steep-dipping, although locally it becomes quite flat.

The amygdaloidal basaltic lavas on the west shore of South Slate Island dip out into Lake Superior. The attitude of the massive greenstone rocks on Mortimer Island is not known, but it is possible that they also dip out into Lake Superior. These massive rocks are partly responsible for the continued existence of the Slate Island group, i.e. they protected the schistose rocks from the ravages of Lake Superior. On the other hand, the interlocking pattern of gabbro and diabase masses no doubt contributes to the stability of the island group and is a reason why it still exists as a land area. It possibly represents the centre of igneous intrusive action making it a unit distinct from the surrounding area now under Lake Superior.

Economic Geology

The rocks of Slate Islands are favourable types for a number of minerals. Copper mineralization is often associated with rocks of Keweenawan age. Silver, nickel and/or magnetite might be expected with the sills and masses of gabbro and diabase. The alteration and structural deformation of rocks have also made them potentially favourable host rocks for mineral deposits. On the other hand, no evidence has been located to suggest that a major mineral deposit exists.

Copper

A number of sulphide-bearing zones were found on the shores of Mortimer Island. The dominant sulphide mineral is marcasite (FeS_2) with no evidence of zinc, copper, nickel or gold accompanying it. The only sign of copper noted was some staining in a calcite vein in amygdaloidal lava on the west shore of South Slate Island. Reference (1) states that the tunnel on the west shore of Copper Cove was apparently driven on evidence of copper mineralization but that the author was unable to detect copper. The writer examined the tunnel and also could find no evidence of copper mineralization.

Keweenawan-age rocks are known for their frequent showings of copper, and it is surprising that there is so little evidence of it on Slate Islands. On the other hand, the specific series of Keweenawan rocks with which copper is generally associated, namely interbedded amygdaloidal basaltic lavas and sediments, are only locally present on the islands.

Gold

Reference (1) describes a number of quartz veins, some of which carried gold values. A number of these veins were re-located and examined by the writer. The letter-designation for the veins used in reference (1) have been retained in the notes below.

A. Veins - These occur in the northwest part of South Slate Island. They are described by A.L.Parsons as being eight inches and five inches wide, north-south striking veins which carried no values in gold and silver. In this area the writer located old trenches in a rusty siliceous carbonate zone with some quartz but no sulphide mineralization.

B. Veins - These are A.L.Parsons' designation for the two veins on which tunnels were driven in the northwest corner of South Slate Island. They are indefinite breccia zones of red jasper and white quartz in schists and schistose agglomerates. Only very minor evidence of any sulphides was noted. A.L.Parsons reports samples of vein material assayed nil in gold and silver though the brecciated rock yielded 0.40¢ ($20 gold) in gold per ton. There appears no justification for driving the tunnels on the evidence of mineralization.

D. Vein - This vein occurs on the west shore of Lawrence Bay near its mouth. It consists of a white quartz vein up to eight feet wide in a rather strong shear zone in gabbro. The shear strikes N 55° E magnetic and dips vertically. The quartz and sheared gabbro were void of sulphides. A.L.Parsons reports the assays for gold and silver returned no values.

E. Vein - This vein is also on the west shore of Lawrence Bay. The writer was unable to locate the vein in place, but found a rubble area of large blocks of bullish-white quartz. A.L.Parsons reported the vein was about eighteen feet wide and the assay results were negative.

F. Vein - This vein is described by A.L.Parsons as being on the west side of St.Mary's Bay, four to eight inches wide, consisting of white and milky quartz with some visible gold, and exposed in numerous pits over a 400-ft. length. He took three samples across the width of vein which yielded $15.40, $0.00 and $3.20 per ton ($20 gold). The writer and his assistant spent one-half day criss-crossing the area where the vein is supposed to be without finding any trace of old workings or the vein. It is probable that it is now overgrown and will have to be re-found. Another search of the area was planned but prevented by high seas during the last week we were on the islands.

G. Vein - This vein was not checked by the writer; it is described by A.L.Parsons as follows:- "At the point marked G are two veins about fifty feet apart, the easterly one being fifteen inches wide and the westerly two inches. These were exposed on the rocky shore, but were not traced inland. No traces of old workings were found, though there is a record of work having been done. The larger vein gave on assay $1.60 and $2.40 per ton, while the smaller one yielded $2.60 per ton." All values are at $20 gold.

<u>K. Vein</u> - This vein is exposed on the northeast point of South Slate Island that is closest to Mortimer Island. It is exposed in one pit and consists of a 4-ft. width of white barren quartz. The vein strikes N 30° E magnetic and dips vertically. The writer noted nothing that justified sampling, and A. L. Parsons reports no values from his assays.

<u>Lighthouse Veins</u> - These veins were not visited by the writer and are described by A. L. Parsons as follows:- "Probably the most striking exposure of quartz veins on the islands is on the face of the cliff just below the lighthouse. At this point the vein system appears to consist of at least six distinct veins, though at a point possibly 600 feet east there is only one visible. The greatest width measured is seven feet. Five samples were taken from various points for assay. One of these showed a trace of gold, the others nil."

<u>N. Vein</u> - This vein is south of the end of Lawrence Bay. A. L. Parsons reported a 12-ft. wide vein, samples from which yielded no gold. The writer located rusty, carbonated and chloritic rocks with quartz veins and stringers in this area but nothing worth sampling.

<u>Miscellaneous Veins</u> - The writer took four samples for gold assay, and these are listed in appendix No. 1. Samples SI-1 and SI-2 were of brecciated quartz with fine pyrite in iron formation, and similar to the type of mineralization on which the two tunnels were driven in this general locality. They indicated that gold is present but in rather insignificant quantities.

Sample SI-3, which assayed 0.15 oz. in gold, was from a 6-inch boulder on the north shore of the peninsula north of McGreevy Harbour. The mineralization looked good with both a white and a grey quartz being present plus cubical and massive pyrite. No more similar boulders were located, and the writer considers that this one likely came from the reefs which are rather abundant in front of this shore line. We were not able to examine the reefs after the boulder was found due to rough seas.

Trap Rock

The gabbro, diabase and possibly the greenstone of Slate Islands would fall in the category of trap rock. Trap rock is a term applied by the construction industry to a uniform, basic igneous rock; it is in demand for concrete and asphalt mixes for super-highways where heavy traffic exists. The production of trap rock in Ontario in 1958 totalled 550,362 tons valued at $1,265,996 (approximately $2.30/ton). Most of this came from quarries at Havelock and Marmora, 110 to 120 miles east of Toronto. Due to transportation costs, there is no hope of a Slate Island source competing with the present sources in the Toronto area; however, it might possibly do so in populated areas further west. The Slate Island occurrence is favourably located at water level and with good harbour possibilities. There is no shortage of trap rock occurrences, so that the value of a particular deposit depends on its proximity to a market.

A check was made with the Ontario Department of Mines and the Department of Mines & Technical Surveys, Ottawa, to find out if any enquiries had been received for trap rock. Ottawa reported an enquiry from Holmes Foundry Limited in Sarnia which was followed up, but from their reply the writer gathers that their requirements are small and would have little bearing on the economic potential of any trap rock source.

The Northern Miner, December 29, 1960, page 7, reports Tough-Rock Quarries Ltd. plan on having in operation trap rock quarries in Hotham and Frechette Islands on the north shore of Lake Huron by mid-year 1961. The first quarry is engineered to produce two million tons of trap rock annually. They report that the rock is of premium quality and tests have shown that all samples exceed specifications for highway and engineering construction. These quarries could eliminate the possibility of a quarry on Slate Islands ever competing for the markets east of Lake Superior.

AEROMAGNETIC & ELECTROMAGNETIC SURVEY

Canadian Aero Services Ltd. were commissioned in the late fall of 1960 to conduct a combined electromagnetic and magnetic survey over Slate Islands, with flight lines spaced at one-quarter mile interval. A Sikorsky S-55 helicopter was used, and seventy-seven miles of survey were flown. They prepared a report covering this survey entitled "Helicopter Electromagnetic and Magnetic Survey, Kimberly-Clark Canada Limited, Slate Islands Area, Ontario" dated December 1, 1960. In January 1961 they completed a detailed contour map of the magnetic data which is attached to this report.

Canadian Aero conclude, - "No prospects for sulphide deposits are apparent on the combined electromagnetic and magnetic survey of Slate Islands. Since the line spacing employed was one-quarter mile, the survey can be considered reconnaissance in nature; a sulphide body of appreciable length could exist between the flight lines." The survey does not deny that a disseminated sulphide deposit exists.

The contoured magnetic map shows an erratic magnetic pattern and magnetic intensities up to 7,000 gamma above base. This magnetic intensity can be safely considered as primarily due to magnetite but possibly also in part to pyrrhotite (FeS). A comparison of the magnetic intensity with the underlying rocks in the area mapped reveals the anomalies are not over the areas of gabbro and diabase, as might be expected, but over areas of volcanic rocks. The fact that the high anomalies tend to be local rather than linear suggests that they are due to mineralization rather than a continuous rock unit. Although as stated the mineral causing the anomalies must be mostly magnetite, the possibility exists that some base metal mineralization may accompany the magnetite. None of the anomalies is strong enough or of sufficient size to be considered as a possible iron ore body.

It is concluded advisable that the three magnetic anomalies of over 5,000 gamma be located on the ground and sufficient prospecting and mapping be completed over them to determine if their cause has any economic significance.

CONCLUSIONS AND RECOMMENDATIONS

The rocks of Slate Islands must be considered favourable for deposits of gold, silver, base metals and possibly iron. To date, only gold has been located but not in quantities suggesting economic concentrations. Further prospecting for gold alone is not justified; however, if exploration should be continued for other metals, then the possibility of locating a gold deposit should not be ignored.

The present ground investigation covered only a portion of the island group. The extent and quality of the previous exploration are unknown, although one reference reports two prospectors were engaged for two or three years on the islands.

The airborne electromagnetic survey failed to reveal any prospects for massive sulphides although such bodies could still exist between the one-quarter mile-spaced lines of the survey. However, without any evidence of sulphides of commercial metals being present in the rocks, one is not justified in conducting additional electromagnetic surveys.

The magnetic anomalies located by the airborne survey are no doubt primarily caused by the iron-mineral magnetite. They are not intense or extensive enough to be seriously considered as ore bodies of iron. However, other valuable minerals may accompany the magnetite. The fact that the higher intensity anomalies are local and do not occur as a continuous linear unit suggests they are due to mineralization rather than a rock unit.

It is recommended that the cause of the three magnetic anomalies of over 5,000 gamma in South Slate Island be investigated as to mineralogical character, and, where the indications justify it, that the anomalous areas be explored by mapping, prospecting and ground magnetic surveys. Such a ground evaluation would require a geologist, a magnetometer operator and possibly one labourer for a period of one to four weeks.

If the above investigation fails to reveal any significant mineralization, it is considered that the expense of further mineral exploration of Slate Islands is not justified and the mineral rights for the islands should be abandoned.

G. E. Parsons

G. E. PARSONS,
Consulting Geologist.

January 1961
Toronto, Ont.

Appendix No. 1

LIST OF ASSAY SAMPLES

Location	Sample No.	Ozs.	Gold per ton Value at $35.00	Description
Northwest shore of South Slate Is.	SI-1	0.005	$0.17	Boulder of brecciated grey quartz, jasper and pyrite
ditto	SI-2	0.03	$1.05	Brecciated grey quartz and fine pyrite in iron formation
North shore of peninsula north of McGreevy Harbour	SI-3	0.15	$5.25	6-inch boulder - grey and white quartz; 30% massive and cubical pyrite
West shore of Mortimer Is.	SI-4	Nil	-	Black quartz, graphite, minor sulphides in strong fault zone

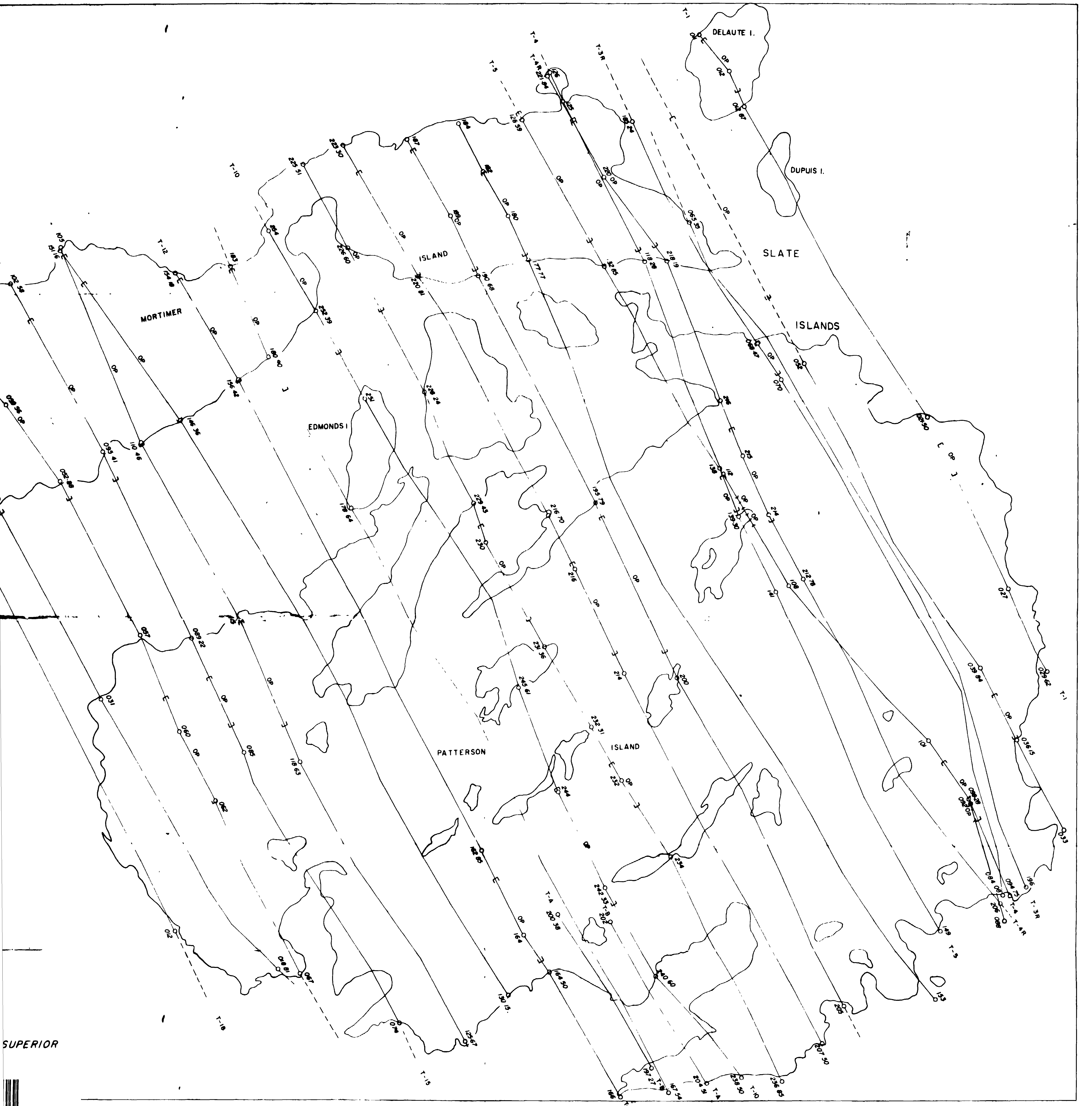
Appendix 2

REFERENCES

1. A. L. Parsons - Slate Islands, Lake Superior, 27th Annual Report of Ontario Bureau of Mines, 1918

2. Bureau of Mines, Ontario, 1901, p 87 & 88 - this reports the islands as belonging to "Lieutenant Governor J.C.Patterson of Manitoba . . . Two prospectors had been engaged for past two or three years and mining has been in progress since December 1899 . . . A number of test pits have also been sunk at points all over the islands. Thos. Davis is superintendent of work. The force consists of six including four miners." The geology of the tunnels in the northwest corner of South Slate Island is described but no values reported.

Note: There are a number of other references but these are chiefly a repetition of information noted in (1).



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