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CORDIERITE-ANTHOPHYLLITE ROCKS AT RAT LAKE, MANITOBA; A METAMORPHOSED ALTERATION ZONE

By

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TABLE OF CONTENTS

INTRODUCTION

Cordierite-anthophyllite rocks containing disseminated sulphides of iron and copper, and traces of molybdnite outcrop on the south shore of a small bay at Rat Lake, Manitoba (Location "S", Fig. 1). These rocks are similar to those that occur in association with massive sulphide ore bodies at the Sherridon Mine, Manitoba, and the Coronation Mine, Saskatchewan.

The outcrops are found in an amphibolitic unit within cordierite-sillimanite-anthophyllite-biotite gneisses of "unknown affinity" (Schledewitz, 1972). The amphibolite mineralogy is plagioclase, amphibole, biotite and minor quartz. Small patches of hypersthene bearing amphibolite have also been reported (Schledewitz, 1972). The amphibolite is therefore mineralogically quite different from the cordierite-anthophyllite rocks. However, it is concluded from field relationships that they grade into each other laterally along strike.

Baldwin and Turnock (1974) suggest that the cordierite-anthophyllite rocks at Rat Lake may represent a metamorphosed regolith. Further consideration and a re-evaluation of the data indicate that the cordierite-anthophyllite rocks at Rat Lake may be interpreted to have been a chloritic alteration zone, possibly associated with a massive sulphide deposit, that was subsequently subjected to high grade regional metamorphism.

Although geophysical investigations to date have not been encouraging, they have not been extensive enough to cover the area with massive sulphide potential.

It is the purpose of this report to establish the geological data base for the interpretation of these rare cordierite-anthophyllite rocks and to outline an area of potential mineralization.

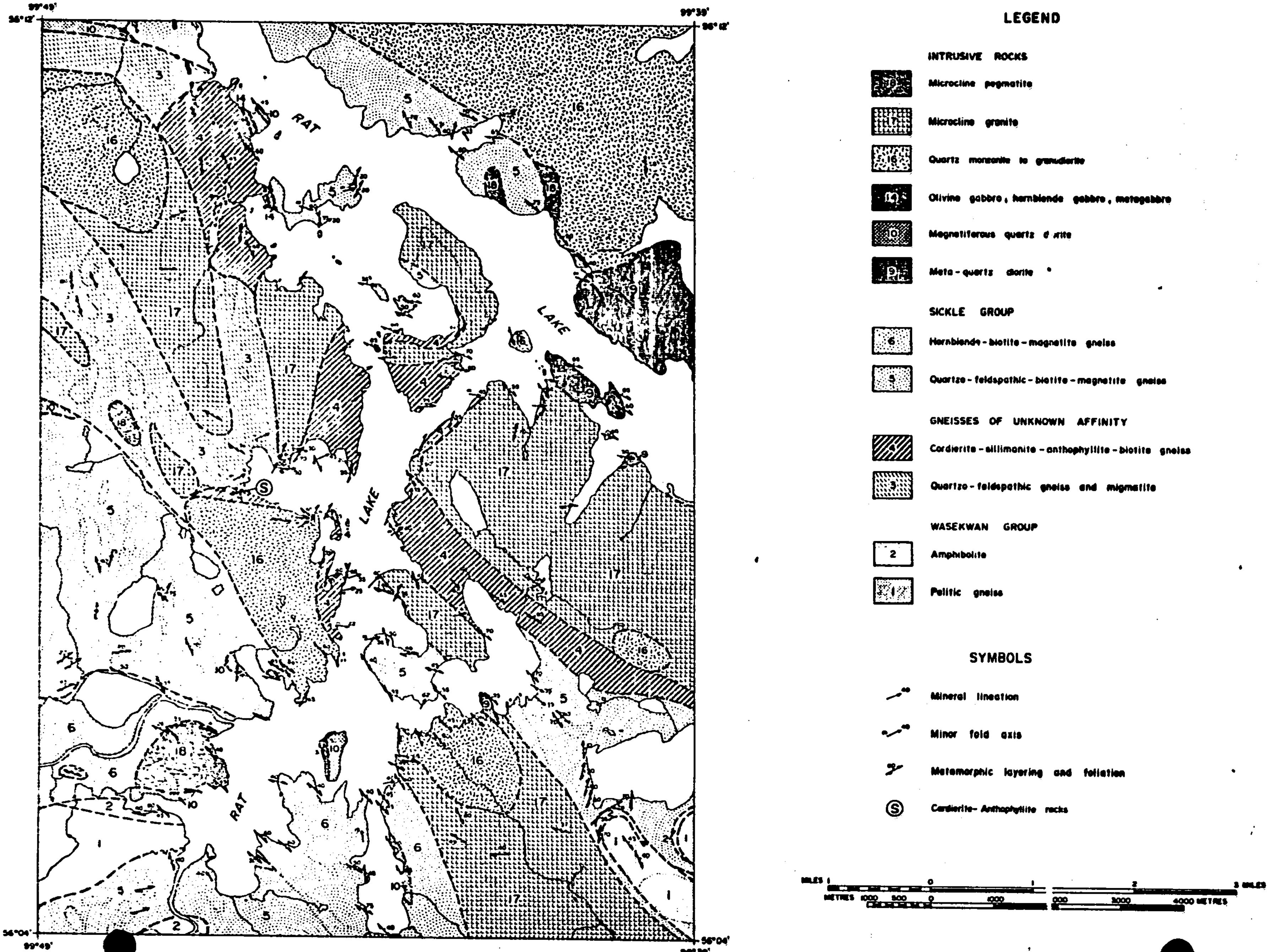

Figure 1 **Geological map of the western part of the Rat Lake area.**

GENERAL GEOLOGY

In the Rat Lake area pelitic, semi-pelitic and psammitic gneisses comprise the lithologies that represent the Wasekwan Group. Magnetiferous quartzo-feldspathic gneisses with variable amounts of hornblende and/or biotite represent the Sickle Group. Amphibolites of unknown origin occupy the stratigraphic position which separates the Wasekwan and Sickle Groups. Gneisses of unknown affinity underlie much of the area to the west and northwest of Rat Lake (Fig. 1, units 3 and 4).

The rocks in the area have been subjected to polyphase regional metamorphism in the upper amphibolite facies. The paragneisses were intruded by large batholithic masses of granitic rocks, minor stock-like bodies of quartz-diorite and minor basic to ultrabasic intrusions (Fig. 1, units 9, 10, 14, 16, 17, 18).

Initial folding about E-W fold axes resulted in tight isoclinal folds that were inclined to the south resulting in the apparent overturning of the Sickle/Wasekwan sequence. Subsequent folding was synchronous with batholithic emplacement and was followed by shearing and a final phase of open folding (Schledewitz,1972).

GNEISSES OF UNKNOWN AFFINITY (3, 4)

The gneisses of unknown affinity comprise a belt of highly granitized paragneisses intruded by quartz monzonite and granite. Because of the absence of the marker amphibolite (unit 2) in the west and northwest part of the Rat Lake area, and the high degree of migmatization, recrystallization and potash metasomatism, these rocks cannot be readily placed in the Sickle/Wasekwan lithologic sequence.

Units (3) and (4) may represent granitised and highly altered pelitic gneiss, (unit 1) of the Wasekwan Group, in contact with an arkose-derived gneiss of the Sickle Group (unit 5), (Schledewitz, 1972). The structural positioning of these units requires only that isoclinal folding be inclined to the south. Therefore, on the south limb of folds it appears that the stratigraphic section is overturned.

An alternative interpretation is that units (3) and (4) represent a group of rocks transitional from the Wasekwan Group to the Sickle Group. In this case (3) and (4) are older than (5) and again inclined isoclinal folding is the only deformation necessary to produce the distribution of the rocks.

A third possibility exists. Unit (4) may belong to the Wasekwan Group and unit (3) to the Sickle Group. Inclined isoclinal folding can also accommodate such an interpretation of the rock types.

In the above three possible interpretations of the stratigraphic positions of the gneisses of unknown affinity, inclined isoclinal folding with Sickle Group rocks occupying synclinal troughs and Wasekwan Group rocks anticlinal crests results in the distribution of the rock types as seen on the geological map (Fig. 1).

Schledewitz (1972) and Elphick (1972) subscribe to overturning of the Sickle/Wasekwan stratigraphy to explain some of the geological structures in the eastern part of Rat Lake and in the Mynarski-Notigi Lakes area. If the overturning of the stratigraphy took place in the western part of Rat Lake, then Sickle Group rocks occupy antiformal synclines and the Wasekwan Group rocks synformal anticlines. There is however, no sound geological basis for applying the overturned sequence hypothesis to the western part of the Rat Lake area.

CORDIERITE-ANTHOPHYLLITE ROCKS

Various cordierite-anthophyllite schists, porphyroblastites and granoblastites comprise the rock types found at Location "S" (Fig. 1). Although Baldwin (1971) divided the rocks, on the basis of mineralogy and texture, into fourteen units, they can be broadly separated into two main groups: (1) a quartz bearing group (units 1 to 4), and (2) a quartz free, hercynite bearing group (units 5 to 14), (Fig. 2).

(a) Quartz bearing rocks

The quartz bearing rocks are quartzites and schists. The quartzites contain 60 to 85 modal percent quartz. Biotite, anthophyllite, sillimanite occur as short prismatic crystals enclosed in quartz grains. Cordierite which can occur in quantities up to 10 modal percent forms a granoblastic mosaic with the quartz grains. In the schists, quartz and cordierite account for 50 to 65 modal percent of the rock, biotite 25 to 30 percent, sillimanite and/or anthophyllite 10 to 20 percent, garnet 5 percent. Magnetite is present as finely disseminated anhedral grains. A schistose fabric is imparted to the rocks by the alignment of biotite and anthophyllite. Quartz and cordierite form a medium grained mosaic. Garnet is porphyroblastic and inclusion free. Sillimanite occurs as short prismatic crystals and as fibrolite. Alternation of light coloured and dark coloured layers in the rocks may reflect primary layering.

(b) Quartz free rocks

Cordierite-anthophyllite schists, porphyroblastites and granoblastites are the most abundant rocks at Location "S" (Fig. 2). The

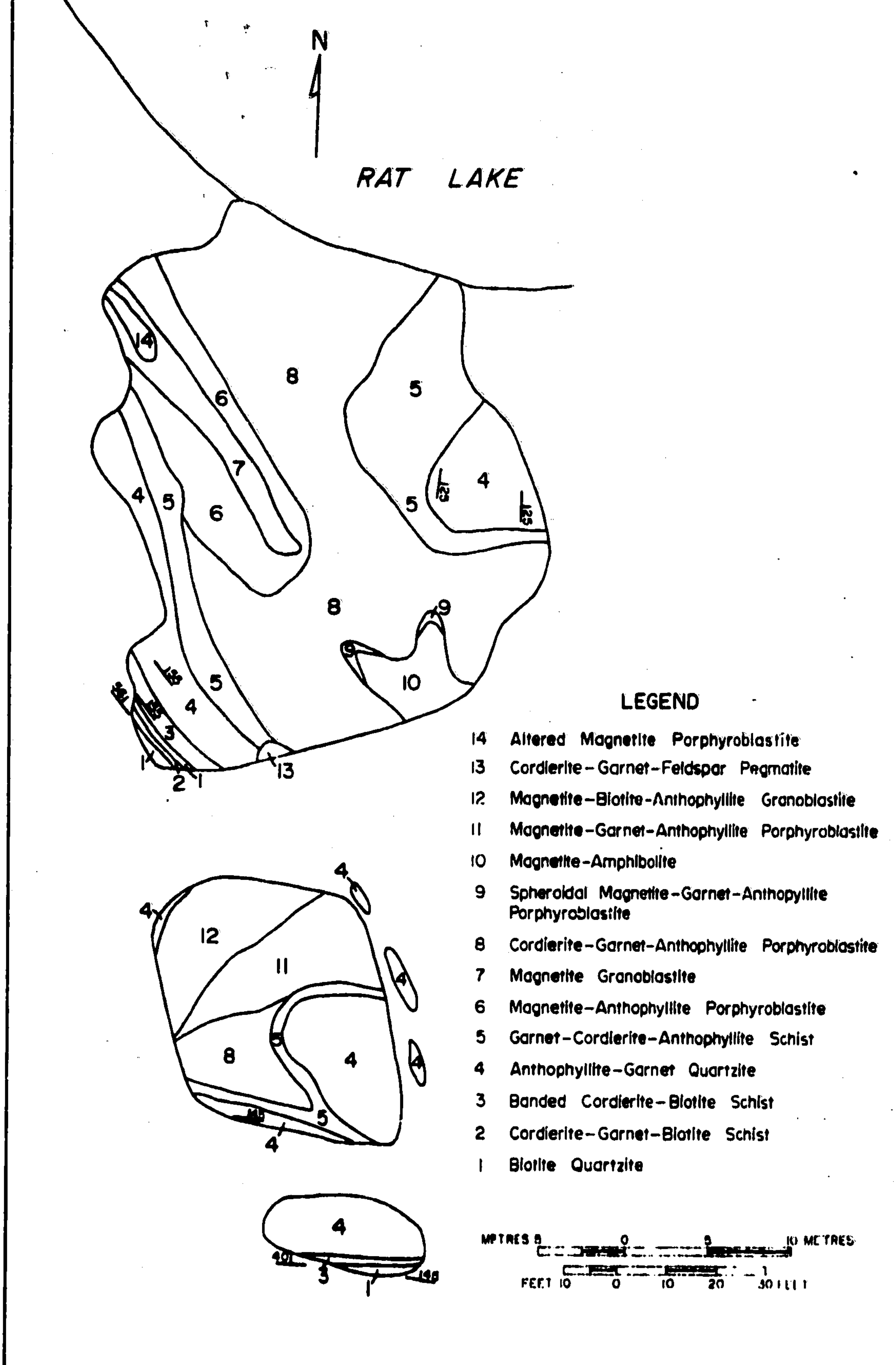

Figure 2 Geological map of cordierite-anthophyllite rock outcrops.

presence or absence of garnet, cordierite and magnetite porphyroblasts define mineralogical layering that may reflect original layering. The mineralogy within a layer is homogeneous. Cordierite, anthophyllite, garnet, biotite and magnetite are the dominant minerals. Sillimanite, hypersthene and staurolite occur as relict minerals.

Anthophyllite occurs as short, well formed prismatic crystals, commonly in a parallel orientation (nematoblastic). More rarely it occurs as radiating clusters that have a hypersthene nucleus core. Anthophyllite and hercynite are never found in contact with one another and are always separated by a thin rim of cordierite completely surrounding the hercynite. The composition of the anthophyllite as determined optically is approximately 70 percent Mg end-member (Baldwin, 1971) in the anthophyllite-gedrite system.

The cordierite is a very Mg rich variety having an $MgO/FeO = 3.4$ (Baldwin, 1971), and with a $\Delta = 0.25^{\circ}$ is in the low cordierite field. Unit cell determinations on cordierite (Baldwin, 1971) show that the iron end-member makes up 20 percent or less of the cordierite. Cordierite occurs as porphyroblasts, as rims around hercynite and as individual grains or clusters of grains interstitial to anthophyllite.

The cordierite porphyroblasts are formed by replacement of garnet through the reaction:

$$\text{garnet} + \text{sillimanite} \longrightarrow \text{cordierite} + \text{hercynite}$$

In these porphyroblasts the hercynite occurs as wormy trails radiating out from the terminations of sillimanite crystals. Garnet relicts are highly corroded and embayed. The sillimanite, garnet and hercynite are completely enclosed by cordierite. In a few porphyroblasts the reaction has gone to completion leaving euhedral hercynite crystals completely enclosed in a granoblastic mosaic of cordierite.

Cordierite occurs interstitially between anthophyllite and hercynite. This occurrence of cordierite indicates that hercynite and anthophyllite are not mutually compatible and react to form cordierite.

The incompatibility of cordierite and anthophyllite is shown by the reaction:

$$\text{Anthophyllite} + \text{hercynite} \longrightarrow \text{cordierite}$$

and by the ubiquitous occurrence of indivudual hercynite grains and clusters of hercynite grains interstitial to anthophyllite.

Most garnets are porphyroblastic and idioblastic. Some xenoblastic crystals have an inclusion free core and an outer rim that has abundant inclusions of anthophyllite, biotite and cordierite with or without inclusions of sillimanite. The garnets are strongly fractured. A few garnet crystals contain corroded relict staurolite. The garnets are pyralspite (Baldwin, 1971), having the composition of almandine 52 percent, pyrope 32 percent and spessartite 10 percent in terms of mole percent end-members. Only in the presence of sillimanite does garnet show any sign of reaction or alteration.

Biotite is present with all mineral assemblages. It occurs as euhedral crystals studded with abundant zircon inclusions surrounded by pleochroic haloes.

Magnetite is ubiquitous and occurs as subhedral to anhedral grains disseminated throughout the rock. In the spheroidal magnetite-garnet-anthophyllite porphyroblastite (unit 9, Fig. 2), the magnetite occurs as spheroidal porphyroblasts comprised of a granoblastic mosaic of equigranular euhedral crystals. The magnetite granoblastite (unit 7, Fig. 2) is a 5 metre thick layer of massive equigranular euhedral magnetite with less than 2 modal percent equigranular euhedral hercynite. The magnetite-biotite-anthophyllite granoblastite (unit 12, Fig. 2) is similar to spheroidal magnetite-garnet-anthophyllite porphyroblastite (unit 9, Fig. 2) except that garnet rims have formed around the magnetite porphyroblasts.

Orthopyroxene (hypersthene) occurs as relict crystals forming the nucleii of radial anthophyllite growth. Only rare, corroded bits of hypersthene have escaped alteration to anthophyllite.

Hercynite is present in all rocks except units (1-4). The amount of hercynite present is dependent upon the extent of the reaction between garnet and sillimanite and/or anthophyllite and hercynite.

Very minor amounts of hematite and siderite are present. Hematite has probably formed from a late stage oxidation of magnetite. Siderite occurs in fractures and appears to have been produced by late stage hydrothermally introduced carbonate that reacted with magnetite.

Mineral relationships and textures indicate that the rocks were progressively metamorphosed through the staurolite zone of the amphibolite facies and eventually to the assemblage garnet-cordierite-sillimanite-hypersthene indicative of a high temperature, moderately high pressure pyroxene granulite facies of metamorphism. Subsequently the granulite facies assemblage has been retrograded to upper amphibolite facies represented by the assemblage garnet-cordierite-anthophyllite-hercynite.

The wide spread presence of magnetite and the development of hercynite signify that pO_2 was low and constant during the metamorphism.

A more detailed account of the textures, microfabrics, mineral reactions, metamorphism and phase relationships is given by Baldwin (1971).

CHEMISTRY OF THE RAT LAKE CORDIERITE-ANTHOPHYLLITE ROCKS

It is evident from the mineralogy that the cordierite-anthophyllite rocks at Rat Lake have an unusual bulk rock chemistry. A comparison between the average of nine chemical analyses of the cordierite-anthophyllite rocks at Rat Lake, and of chlorite schists from the Killingdal Mine, Norway, is given in Table 1.

The cordierite-anthophyllite rocks at Rat Lake are characterized by enrichment of MgO and FeO and depletion of lime, alkalies, and silica in relation to the rocks in the surrounding area.

Anthophyllite, gedrite and cordierite can occur naturally over a wide range of conditions. These minerals are found in the albite-epidote-hornfels and hornblende hornfels facies of contact metamorphism. In regional metamorphism they are found in the almandine-amphibolite to hornblende granulite facies. However, these minerals are rare and their occurrence appears to be restricted to three important limiting factors (Lal and Moorhouse, 1969).

(1) K_2O must be very low resulting in the excess of FeO, MgO and Al_2O_3 not accommodated in biotite going to form anthophyllite or gedrite. CaO and Na_2O must be low, otherwise hornblende and sodic amphibole would take the place of anthophyllite and gedrite.

(2) $$\frac{FeO + MgO + MnO}{Al_2O_3 - (Na_2O + 2\,CaO)} > 1$$

(3) FeO/(MgO + FeO) must be such that the composition of the rock falls in the field gedrite (anthophyllite)-garnet-cordierite or on the joins cordierite-gedrite (anthophyllite) or garnet-gedrite (anthophyllite) in the AFM diagram.

From the chemical analyses and the AFM plot (Fig. 3) it is evident that the Rat Lake rocks fulfill the three requirements. The chemistry of the

TABLE I

	Rat Lake	Chlorite Schist*
SiO_2	40.51	46.70
TiO_2	0.26	2.23
Al_2O_3	20.39	15.47
Fe_2O_3	5.66	13.53
FeO	14.02	
MnO	0.09	0.28
MgO	14.98	14.99
CaO	0.31	3.68
Na_2O	1.15	1.54
K_2O	0.46	1.54
P_2O_5	—	0.25
Totals	98.73	99.57

* Average of eight chlorite schist analyses from Killingdal Mine, Norway (Rui, 1973).

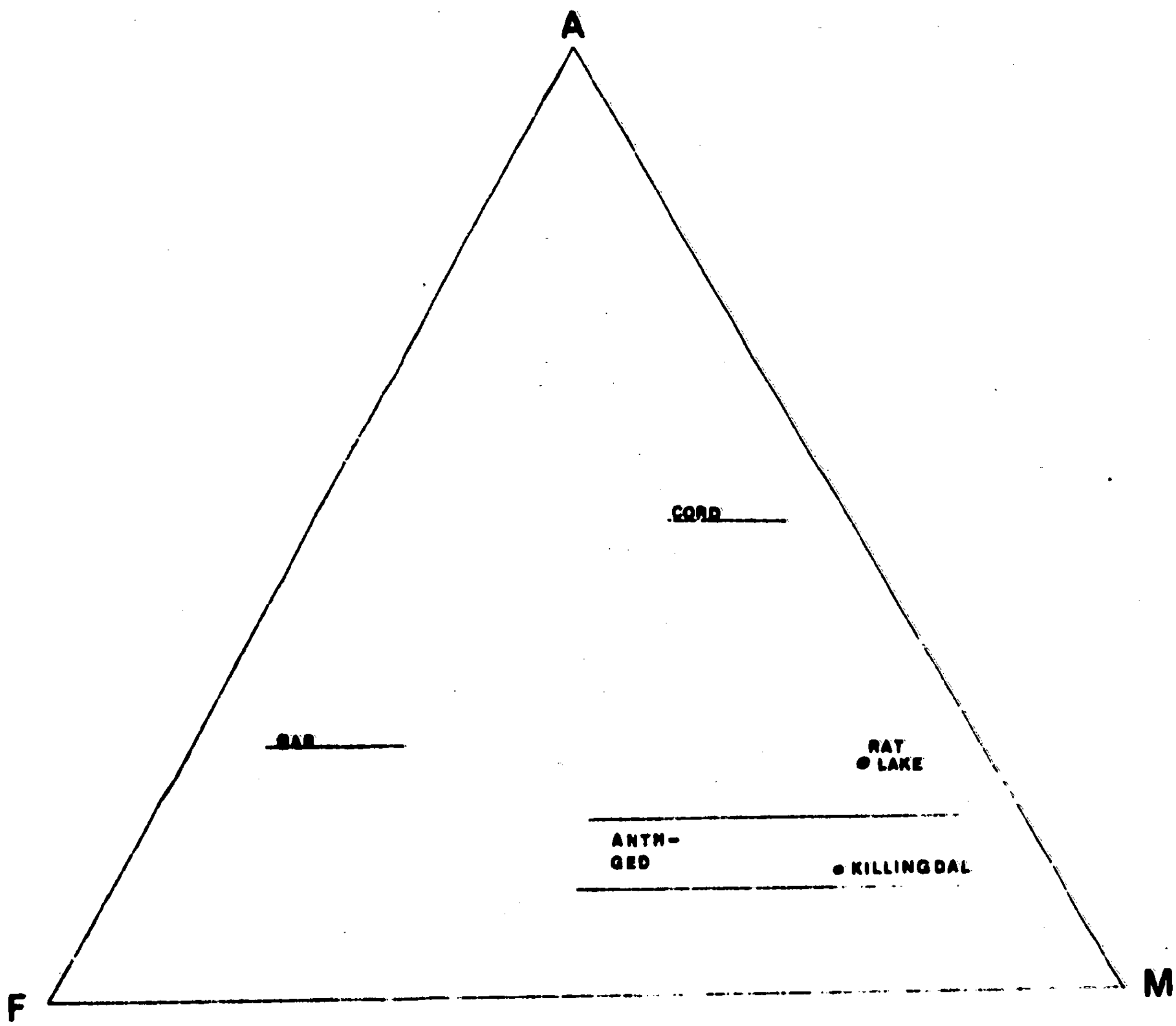

Figure 3. AFM plot of chemical analyses from Rat Lake and the Killingdal Mine, Norway. The positions of CORD and ANTH are taken from Winkler (1967). The position of anthophyllite was calculated from analyses given in Deer, Howie, Zussman (1962).

chlorite schists from the Killingdal Mine also falls into the gedrite (anthophyllite)-cordierite-garnet field and thus these rocks have the correct chemistry to produce cordierite-anthophyllite assemblages under conditions of high grade metamorphism.

ORIGIN OF CORDIERITE-ANTHOPHYLLITE ROCKS

Eskola (1914) pointed out that the composition of cordierite-anthophyllite rocks is such that they do not correspond to that of any sedimentary or igneous rock. He interpreted rocks of this kind as being a product of contact metamorphism with enrichment of iron and magnesium and depletion of calcium and alkalies.

Wegmann and Kranck (1931) suggested that granitization and regional metamorphism could give rise to local concentrations of basic material as counterparts to concentrations of acidic material in granitized rocks. Again the origin of these rocks was attributed to metasomatism but, in this case, related to regional metamorphism.

In contrast, Touminen and Mikkola (1950) suggested that isothermal metamorphism of quartz-chlorite rocks would result in cordierite-anthophyllite rocks. They attributed cordierite-anthophyllite rocks to recrystallization of chloritic zones produced by intense deformation prior to metamorphism.

Froese and Whitmore (1964) and Froese (1969) attribute the cordierite-anthophyllite rocks at the Coronation Mine to being regionally metamorphosed zones of chloritization that were presumably produced at the time of mineralization prior to metamorphism.

The association of cordierite-anthophyllite rock and massive sulphide deposits is well known. Cordierite-anthophyllite rocks occur in the Coronation Mine (Froese, 1969) in the Sherridon Mine (G. Gale, pers. comm.) at Gullbridge, Newfoundland (Upadhyay and Smitheringale, 1972) and in alteration zones below sulphide deposits in the Rouyn-Noranda area, Quebec (Rosen-Spence, 1969).

The geochemistry of chlorite schists from the Killingdal Mine, Norway, is similar to that of the cordierite-anthophyllite rocks at Rat Lake. The AFM plot (Fig. 3) shows that the assemblage cordierite-anthophyllite-garnet could be produced from the chemistry of these chlorite schists if metamorphic conditions similar to those at Rat Lake were attained at Killingdal.

Magnesium metasomatism produces alteration zones which in low grade metamorphism are represented by high Mg chlorite schists. Many such zones (i.e. Killingdal) are attributed to alteration during the emplacement of massive sulphide deposits. The chemistry of the cordierite-anthophyllite rocks at Rat Lake does not match that of any sedimentary or igneous rock. Therefore rock alteration must have taken place.

Alteration pipes associated with massive sulphide bodies have limited lateral extent and cross-cut lithologic boundaries. The cordierite-anthophyllite rocks at Rat Lake outcrop over an area 200 feet by 90 feet and the anomalous chemistry can be traced across lithologic layering.

Therefore, it is suggested that the cordierite-anthophyllite rocks at Rat Lake represent a chloritic alteration zone that has suffered subsequent high grade regional metamorphism.

Pyrrhotite is the dominant sulphide in the quartz free rocks. Minor pyrite, chalcopyrite and trace amounts of molybdenite occur as fine disseminations in the rocks, along fractures in the rock and along cleavage cracks in amphiboles. Sulphide in cleavage cracks in the amphiboles is particularly notable in the radiating anthophyllite. In contract, the quartz bearing rocks contain pyrite as the most abundant sulphide mineral.

Froese (1969) reports that in the alteration zone at the Coronation Mine, pyrrhotite and pyrite occupy small fractures in the rocks and cleavage cracks in the amphiboles. In general pyrrhotite is the common iron sulphide developed in the cordierite-anthophyllite rocks, and pyrite in the gangue minerals.

Magnetite, as previously mentioned, is present throughout the cordierite-anthophyllite rocks at Rat Lake. Froese (1969) observes in the Coronation Mine that magnetite is particularly abundant in cordierite-anthophyllite rocks; the crystals are relatively large and subhedral to anhedral.

Therefore, because of similarities that exist between the cordierite-anthophyllite rocks at Rat Lake and metasomatic alteration zones associated with massive sulphide deposits, it is further suggested that not only are the cordierite-anthophyllite rocks at Rat Lake a metamorphosed chloritic alteration zone, but, one that is possibly associated with a massive sulphide deposit.

GEOPHYSICAL SURVEYS

To date, two independent geophysical surveys have been conducted over the area. During the Southern Indian Lake Project of the Manitoba Mines Branch, an airborne INPUT survey, including EM and Mag, was carried out. On April 2, 1975 an EM-16 ground survey was carried out by the Geological Survey Section, Manitoba Mines Branch. The results of the two surveys are not encouraging.

(a) Airborne INPUT survey

It appears that low gain settings were used to eliminate high noise levels thus lowering the sensitivity of the instrumentation (Burton, 1975). A large number of EM anomalies lie outside the specific area of the cordierite-anthophyllite rocks (Fig. 4). Weak anomalies located in the areas around the cordierite-anthophyllite rocks are attributed to resistivity contrasts and lake bottom sediments or overburden sources (Burton, 1975). Magnetic intensities in the area are high, making delineation and interpretation difficult. Several magnetic anomalies occur within the vicinity of the cordierite-anthophyllite rocks. One of these anomalies is of medium strength and may have some significance since it has a lower magnetic susceptibility than the others in the area that are due to magnetite (Burton, 1975). A report by G. Burton, Mineral Evaluation Section, on the geophysical aspects of the INPUT survey in the vicinity of the cordierite-anthophyllite rocks is attached as Appendix "A".

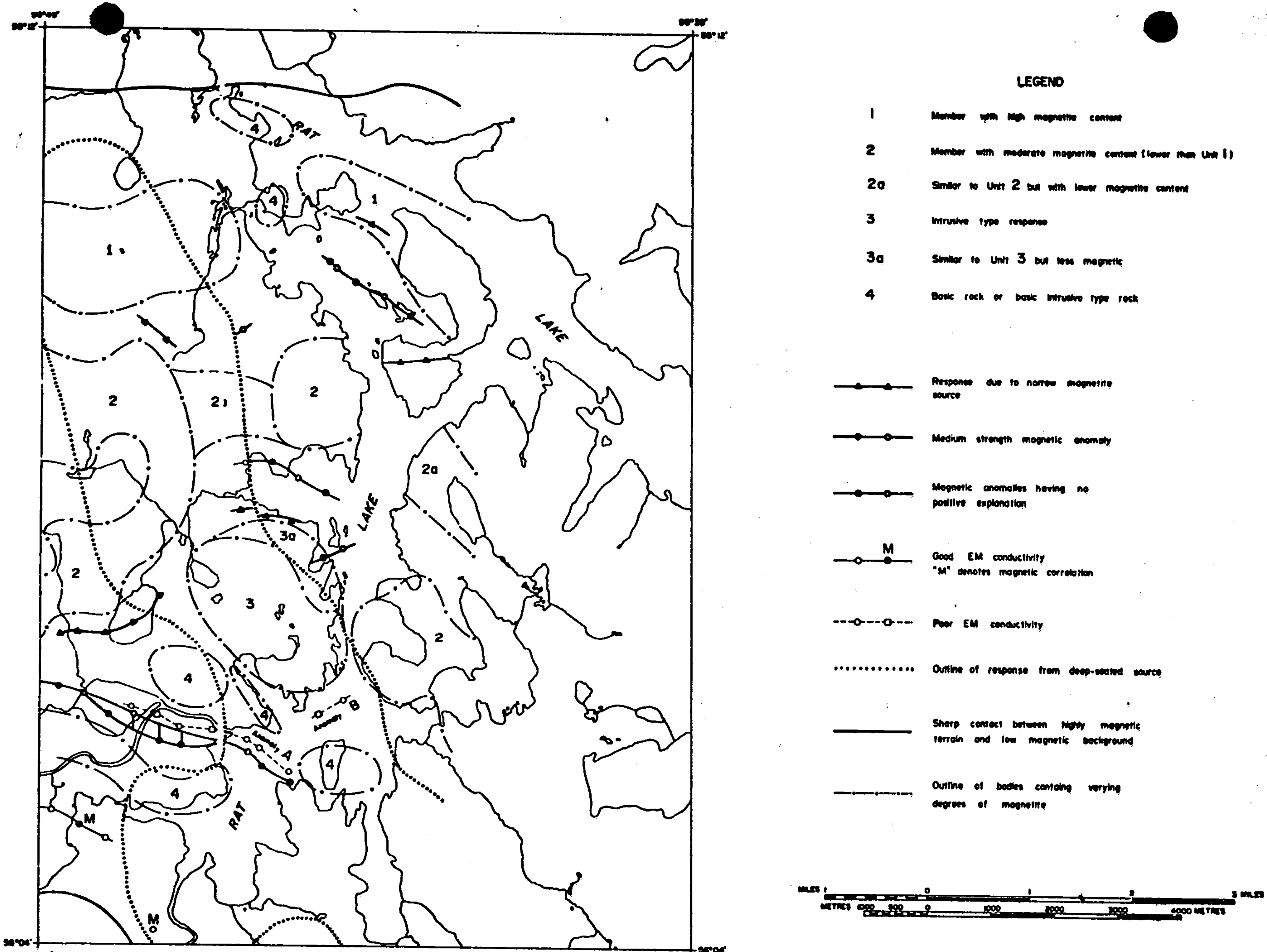

Figure 4 Interpretation map of INPUT survey results over the western part of the Rat Lake area.

(b) EM-16 survey

Heavy concentrations of magnetite in the cordierite-anthophyllite rocks rendered precise measurements impossible due to local warping of the VLF magnetic field. Magnetic inphase angles varied widely over the outcrops and subsided once the magnetite horizons had been crossed. The quadrature responses were highly positive until the magnetite horizons had been crossed and they then fluctuated around zero.

Because of the abundance of magnetite in the cordierite-anthophyllite and limited depth penetration of this instrument, this survey did not yield any useful data.

A report with geophysical profiles across the outcrops was prepared by Roger Haskins (Exploration Operations Branch, Manitoba Mineral Resources Division) and is submitted in Appendix "B".

CONCLUSIONS AND RECOMMENDATIONS

The Rat Lake cordierite-anthophyllite rocks are interpreted as a metamorphosed chloritic alteration pipe of the type in association with some massive sulphide deposits.

Due to lack of exposure in the area, additional geological mapping and a bedrock geochemical survey would yield very little additional information.

It is therefore recommended that an EM-17 horizontal loop survey with accompanying proton magnetometer survey be conducted over the area. A base line (E-W) should be laid out over the lake with survey lines at 200 foot spacing running N-S from the base line. Stations at 100 foot spacing should be adequate with tightening up to 50 feet if an anomaly is encountered.

The area to be covered is outlined in Figure 5. Base line and survey lines should be laid out as shown on Figure 5.

The magnetite layer in the cordierite-anthophyllite rock will have some effect on an EM-17 survey. The magnetite layer is thin and therefore its effect will probably be confined to approximately two hundred feet on either side of the layer (G. Burton, pers. comm.). Also, if the magnetite has high magnetic susceptibility the response will be strongly negative in contrast to positive responses over sulphide bodies. Resolution could be improved by using short cable lengths.

Self-potential surveys have been used with some success in exploring for massive sulphide deposits. The best results have been obtained in summer months when the probes can be put directly into the ground. Self-potential must be used in areas of fairly dry ground. The amount of swamp and lake in the area to be surveyed at Rat Lake make a self-potential survey of little value in the Rat Lake area (G. Burton, pers. comm.).

If this survey indicates the presence of electromagnetic conductors, a drilling programme should be initiated.

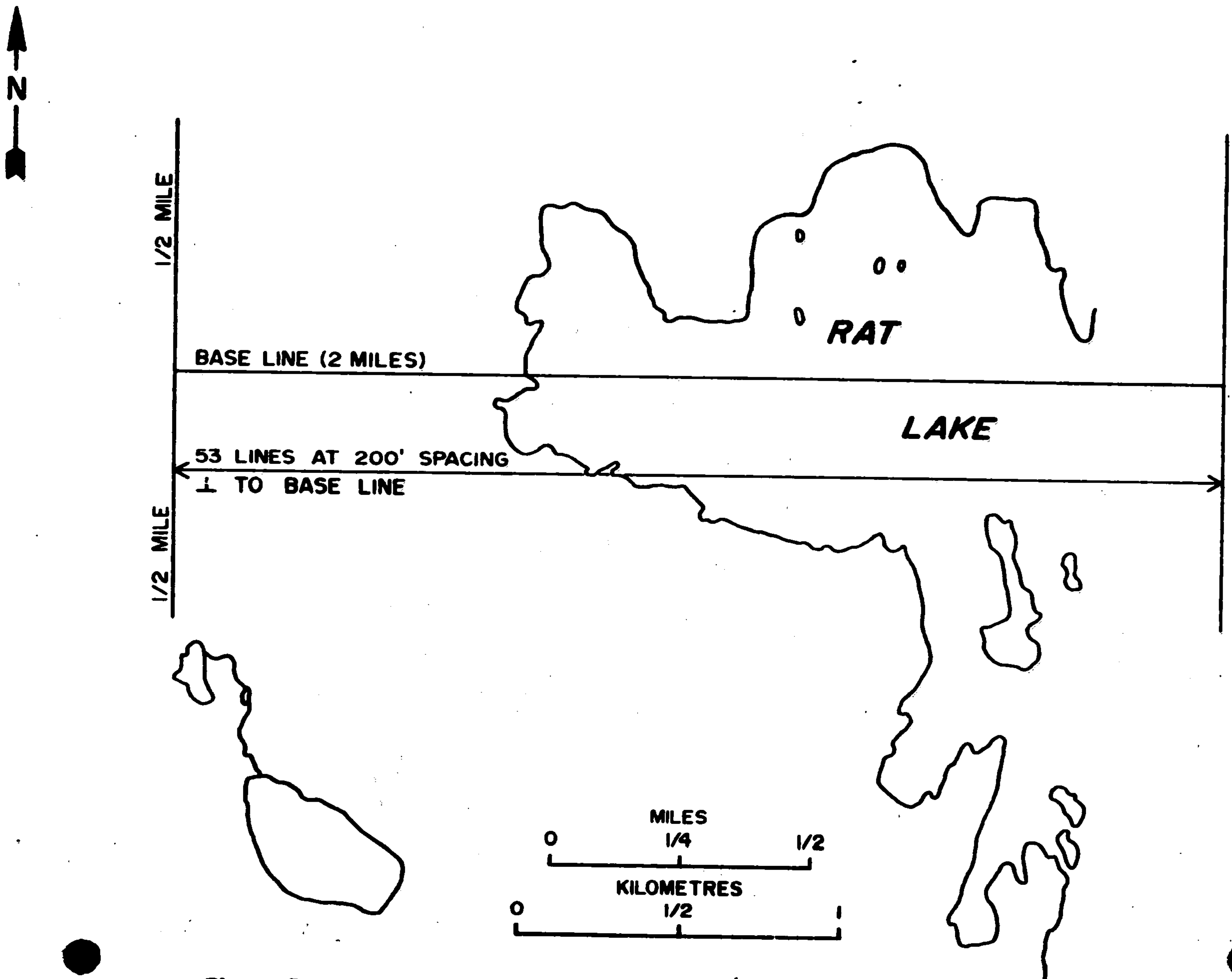

Figure 5 Proposed geophysical grid over part of the Rat Lake area.

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Appendix "A"

GEOPHYSICAL NOTES FOR RAT LAKE

The following discussion is a synopsis of the interpretations made on the INPUT Survey results in the region of the Rat Lake Alteration Zone. The Airborne Survey, including both EM and Mag readings, was carried out during 1968 under the Southern Indian Lake Project. Results of the Analysis are shown on an interpretation map presented as an overlay to the geology (Fig. 4). An area of 5 x 10 miles has been interpreted.

Electromagnetic Results

Conductivities illustrated by the INPUT Surveys in the area are very poor. It appears that low gain settings have been used to eliminate high noise levels, thus lowering the sensitivity of the instrument. A large number of EM anomalies occur in a region just south of Rat Lake. These lie outside the area of interest.

Within the area two anomalies of import were recognized. Anomaly A has a long strike length with varying conductivities. A medium strength magnetic anomaly parallels this anomalous zone and may have some association with the EM response. Anomaly B is a weak EM response having fair conductivity occurring on two lines in the lake. The west anomaly is slightly magnetic. This anomaly may be of interest.

No EM anomalies of significance occur in the vicinity of the alteration zone. Other weaker anomalies located in other parts of the study area are attributed to resistivity contrasts and lake bottom sediments or overburden sources.

Magnetic Results

Magnetic intensities in the area of interest are very high, making delineation and interpretation difficult. A zone of high, erratic magnetic responses occurs in a belt about 12 km (7 miles) wide, stretching the length of Rat Lake, as shown on the accompanying map. This belt contains units with high magnetite content (units 1 and 2). Also zones of high magnetic intensities demark the north and south extremes of the belt which are in contact with the less magnetic terrains to the north and south. These areas to the north and south of the main belt are distinguished by their magnetically flat character and lower background values.

An intrusive type response (unit 3) occurs just south of the alteration zone. This appears to be caused by a deep-seated granitic-type source. Responses indicative of basic rock types or basic intrusive rocks are exemplified by unit 4.

Several magnetic anomalies occur within the vicinity of the Rat Lake Alteration Zone. One anomaly appears to be confined to the contact of the intrusive rock (unit 3, Fig. 4; unit 16, Fig. 1). One single anomaly with a strong magnetic response appears to be due to a narrow magnetite source. The third magnetic anomaly is of medium strength. It occurs along the shore and partly out into the bay, north of the alteration zone. This anomaly may have significance since it has a lower magnetic susceptibility than the other anomalies in the area that are due to magnetite.

Magnetic anomalies due to narrow magnetite sources are shown in blue on the accompanying map. Other magnetic anomalies occurring in the survey area for which no explanation can be given are shown in green. These have the form of narrow dike-like responses and medium strength intensities.

A zone containing a high magnetic background indicative of a response from deep-seated source traverses the area in a north-south direction.

Appendix "B"

RESULTS OF RAT LAKE GEOPHYSICAL SURVEY

On April 2, 1975, an EM-16 survey was conducted over the Rat Lake cordierite-anthophyllite horizon by Roger Haskins and Dave Baldwin of the Geological Survey Section. The results of the survey are negative.

Heavy concentration of magnetite in the host rocks surrounding the horizon rendered precise measurements impossible, due to local warping of the VLF magnetic field. Magnetic inphase angles varied widely over the outcrop and subsided once the magnetite horizons had been crossed. The quadrature responses were highly positive until the magnetite horizons had been crossed. They then fluctuated around zero.

A twenty foot station interval was maintained on all readings. Station NAA, which is parallel to the local strike, was used as the transmitter. Two profiles were done (see Fig. 6). Line #1(L_1) was placed over the cordierite-anthophyllite horizon, at right angles to strike. Line #2(L_2) was placed 400 feet to the east of L_1, over a known gossan zone for comparative purposes.

Line #1 was run from the Wasekwan type rocks on the north, into the Sickle type rocks to the south. The first peak (Fig. 7) occurs at about the contact between the "Sickle" and "Wasekwan" rocks (P_1). The second occurs over a four foot thick bed of magnetite (P_2). At (P_3) the limit of magnetite was reached and readings became more constant, centering around zero.

Line #2 (Fig. 8) was entirely in "Wasekwan" rocks and no significant variation was recorded in the EM properties of the rocks.

It is concluded that there are no massive sulphides present at this locality.

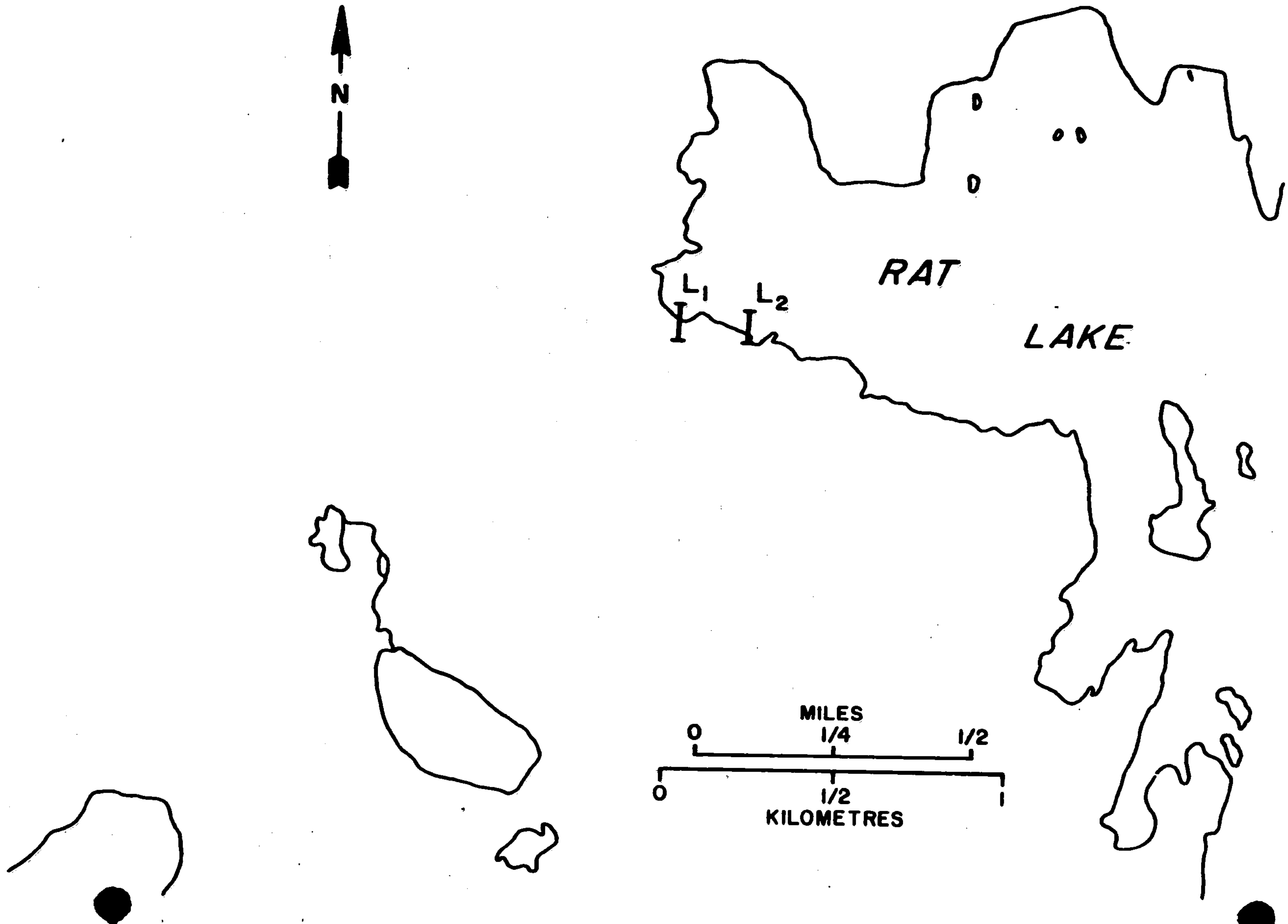

Figure 6 Location of geophysical profiles.

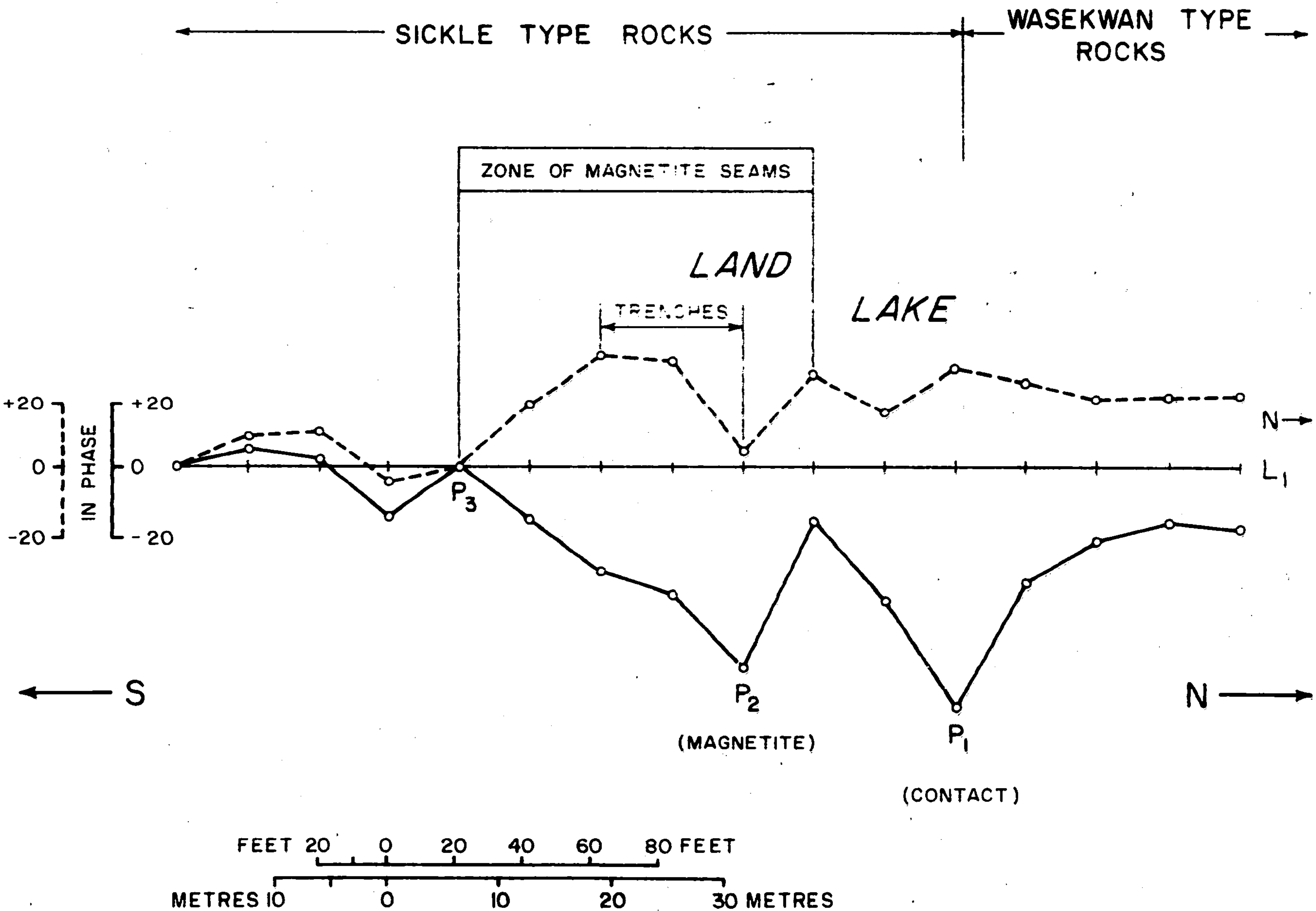

Figure 7 Geophysical survey results on Line 1 (Fig. 6).

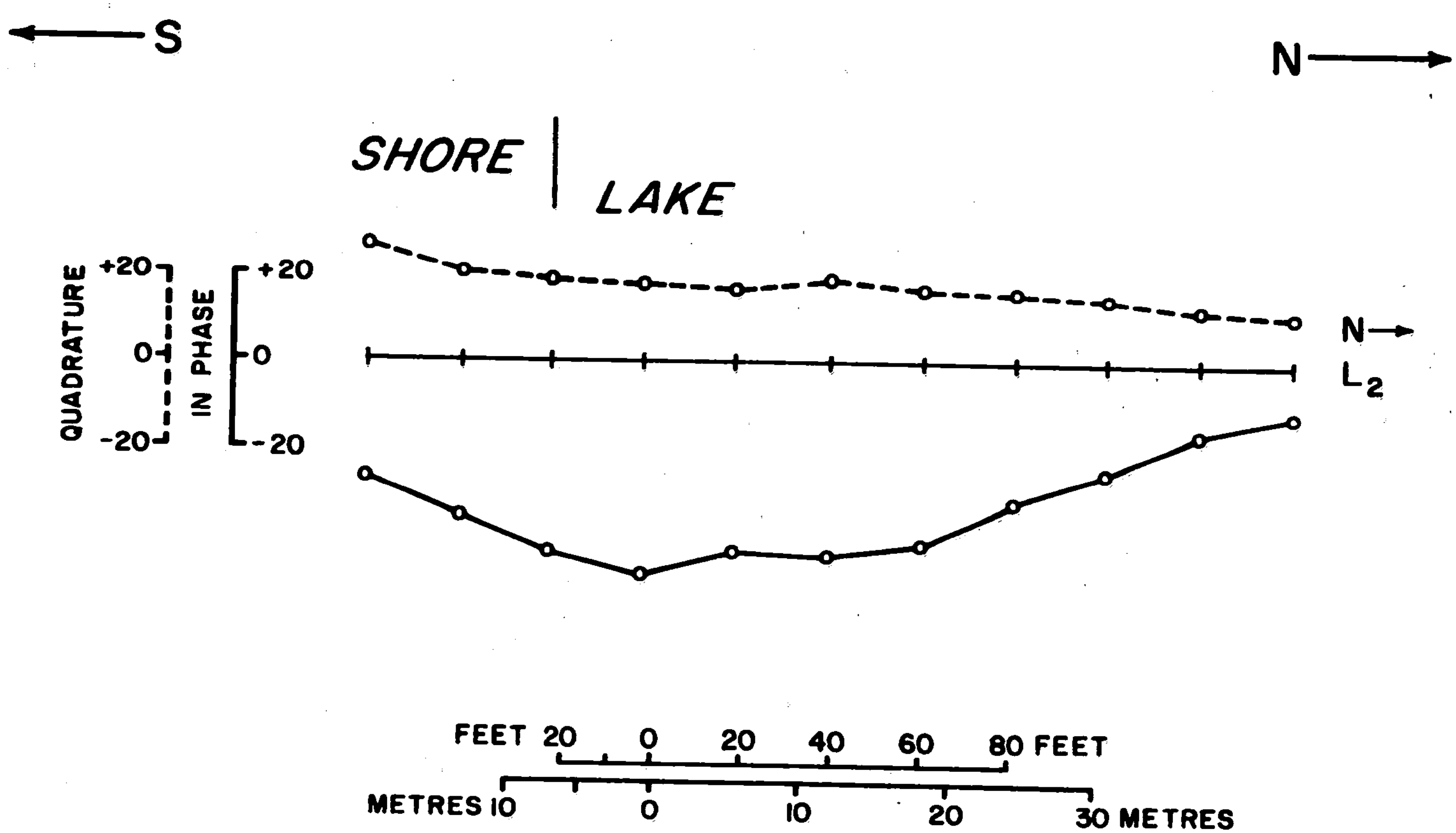

Figure 8 Geophysical survey results on Line 2 (Fig. 6).