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GEOLOGY AND NICKEL SULFIDE DEPOSITS OF THE RAGLAN AREA

SOCIETE MINIERE RAGLAN DU QUEBEC LTEE

GEOLOGY AND NICKEL SULFIDE DEPOSITS OF THE RAGLAN AREA, UNGAVA, QUEBEC

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Aerial View of Donaldson Minesite, August 1982 (looking west)

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MAPS ACCOMPANYING REPORT

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6. Donaldson Surface drill hole location plan and projected ore zones. 1:1250

I. INTRODUCTION

a) HISTORICAL ASPECTS

The Cape Smith-Wakeham Bay belt of Proterozoic rocks in the Upper Ungava Peninsula were first prospected by Murray Watts in 1931 and 1932. The remoteness of the area, short summers and lack of communications discouraged any follow-up work until 1955 and 1956, when renewed prospecting confirmed the earlier indications of copper-nickel mineralization. During these years, good surface indications of sulfide mineralization were discovered, primarily over a length of 32 miles extending between Cross Lake and Raglan Lake. In 1956, an exploration permit covering this tract of ground was issued to Lemoyne Explorations Limited. Its successor company, Lemoyne Ungava Mines Ltd. received the same area in 1957. Exploration momentum increased dramatically during 1957 and over 30 mining companies received Mineral Exploration Licences which essentially covered the entire belt from Cape Smith on the Hudson Bay coast to Wakeham Bay on the coast of Ungava Bay.

It was also during 1957 that the outcrop of an asbestos orebody was discovered some 15 miles to the north of the general area being explored for nickel mineralization. In May 1959, Murray Mining Corporation Limited obtained a mineral exploration licence covering Asbestos Hill and the surrounding area. Diamond drilling investigations by Murray Mining continued over the following three field seasons at Asbestos Hill until the property was optioned to Hudson Strait Asbestos, a subsiduary of Asbestos Corporation in 1962. Ten years later, in September 1972 the first production of ungraded fibre from Asbestos Hill was shipped from Deception Bay.

Between 1957 and 1959 the Cross Lake - Raglan Lake portion of the belt was held under the original licences either directly or through subsiduaries by Lemoyne Ungava Mines Limited and Raglan Nickel Mines Limited. All work on the Lemoyne holdings during 1957 was carried out under the supervision of Asarco Exploration Company of Canada, a wholly-owned subsiduary of American Smelting and Refining Limited. Between 1957 and 1960 no further work was carried out by Asarco or Lemoyne, although the area was mapped by geologists of the Quebec Dept. of Mines in 1958. Work on the Raglan Lake property of Raglan Nickel Mines Limited continued during 1957, 1958 and 1963 and the area was geologically mapped by the Quebec Dept. of Mines in 1959.

In 1960, Raglan Nickel Mines applied for and obtained a new Mineral Exploration Licence (P.R.M.-160) which was held by subsiduary company Raglan Quebec Mines Limited and covered the showings found and examined in 1957 and 1958. Lemoyne Ungava Mines Limited allowed their concessions to lapse and these reverted to the Crown. On February 28, 1961, the Quebec Government passed Orders - in - Council authorizing the Minister of Mines to offer for sale by tender the rights to obtain Mineral Exploration Licences on the original Lemoyne Ungava holdings. These auctions took place in April, 1961 and Raglan Quebec Mines Limited was successful in acquiring block M-89 at Cross Lake under the terms of Licence 174. Falconbridge Nickel Mines was successful in acquiring Mineral Exploration Licences 175 and 176 covering tracts M-103 and M-104 respectively through its subsiduary company, Bilson Quebec Mines Limited.

Through a reorganization of Raglan Nickel Mines Limited, complete management was taken over by Falconbridge Nickel Mines Limited on January 1, 1966 and a new company, New Quebec Raglan Mines Limited formed to explore the four concessions. New Exploration Permits 533 and 534 covering essentially the four original concessions and comprising a total of approximately 300 square miles were obtained from the Quebec Government on June 7, 1972. During 1981 the name of New Quebec Raglan Mines Ltd. was changed to La Societe-Miniere Raglan du Quebec Ltee.

b) PRESENT CLAIM STATUS

Exploration permits PRM 533 and PRM 534 were reduced in size during the latter part of 1981 and again in April 1982 to allow the staking of 1162 claims (as per General Property Map - Figure 1). The remaining portions of 533 and 534 were allowed to lapse on June 7, 1982. A summary of claims groups and staking date are listed below in Table I.

TABLE I

Claim Group	Number of Claims		Staking Date
I	505	636 claims	Aug-Sept 1981
II	71		Aug-Sept 1981
III	60		Aug-Sept 1981
Donaldson	99	99 claims	December 1981
A-1	20	238 claims	June 1982
A-2	27		June 1982
A-3	48		June 1982
A-4	97		June 1982
A-5	28		June 1982
A-6	18		June 1982
B-1	12	189 claims	June 1982
B-2	20		June 1982
B-3	157		June 1982
Total	1162 claims for 18,592 hectares		

Microfilm

PAGES DE DIMENSION HORS STANDARD

MICROFILMÉE SUR 35 MM ET

POSITIONNÉES À LA SUITE DES

PRÉSENTES PAGES STANDARDS

Numérique

PAGES DE DIMENSION HORS STANDARD

NUMÉRISÉE ET POSITIONNÉE À LA

SUITE DES PRÉSENTES PAGES STANDARDS

For details of claim numbers, staking dates and UTM co-ordinates of survey control corners, the reader is referred to J.P. Cloutier - FNM Report, July 1982.

c) EXPLORATION GEOPHYSICS

A combined airborne electromagnetic and magnetic survey was flown between July 22 and August 16, 1970 by Spartan Aero Limited on behalf of New Quebec Raglan. (Stemp 1971). The survey by Canso aircraft based at Raglan, acquired 13,830 line miles of geophysical data over a large area of the Povungnituk River area. Due to in-flight problems on the magnetic data recovery and subsequent digitizing and data processing, the magnetic survey proved of little value.

A second airborne magnetic survey was flown during the period of July 29 to August 10, 1980 by Aerodat Ltd. of Toronto. This survey employed a radar-controlled helicopter, equipped with a Barringer AM-104 proton precession, total field magnetometer with a cycle time of 0.5 seconds and a sensitivity of one gamma. Radar positioning was by the Motorola Mini-Ranger III system. The survey acquired 4174 line kilometres of magnetic data over Permit areas 533, 534 and 660. Magnetic maps at a scale of 1:10,000 were produced in total field and enhanced filtered format. These data were also colour contoured at 1:20,000 by Data Plotting Services of Toronto. This magnetic survey was of prime importance to the subsequent geological survey and the resolution of location and structural controls to the ultramafic bodies of the area.

d) PHOTOGRAPHY AND CARTOGRAPHY

During the period July 27 to August 16, 1977, Northway-Gestalt

Corporation of Toronto completed a photographic survey of Permit areas 533 and 534. Forty-four survey triangulation stations throughout the Raglan Permit areas were targetted with white unbleached cotton crosses prior to the photography. Both colour and black and white photography was produced at a scale of 1:12,000.

Topographic mapping of the entire area at a scale of 1:5000 with 6m contours and 3m interpolations was prepared from the survey-controlled photography by Northway-Gestalt. Consecutively numbered maps from 1 to 86, each covering an area of 5 x 2.5 km (12.5 sq. km) were drawn in the UTM format. Although initially prepared specifically for geological and diamond drilling exploration work, the topographic mapping can be redrawn and recontoured at any scale or degree of accuracy for special purposes.

e) GEOLOGICAL MAPPING

Detailed geological mapping began in the 1981 summer season and was completed at the end of the 1982 season. The project utilized the services of senior geological students for the most part and was supervised and controlled in the field by the author. A total of 30 man/months of geological mapping is involved in the completed compilation map sheets at 1:25,000 attached to this report (Figure 2).

Mapping control utilized the 1:5000 topographic sheets, overlain by 1:5000 enhanced magnetic sheets and coloured airphotographs. In the treeless area of Raglan where weathering has produced subtle colour changes in rocks of different composition, colour air photographs proved to be a major asset. Except for minor changes, a legend prepared from all available information in advance was adhered to throughout the survey. A standard 1:5000 sheet is

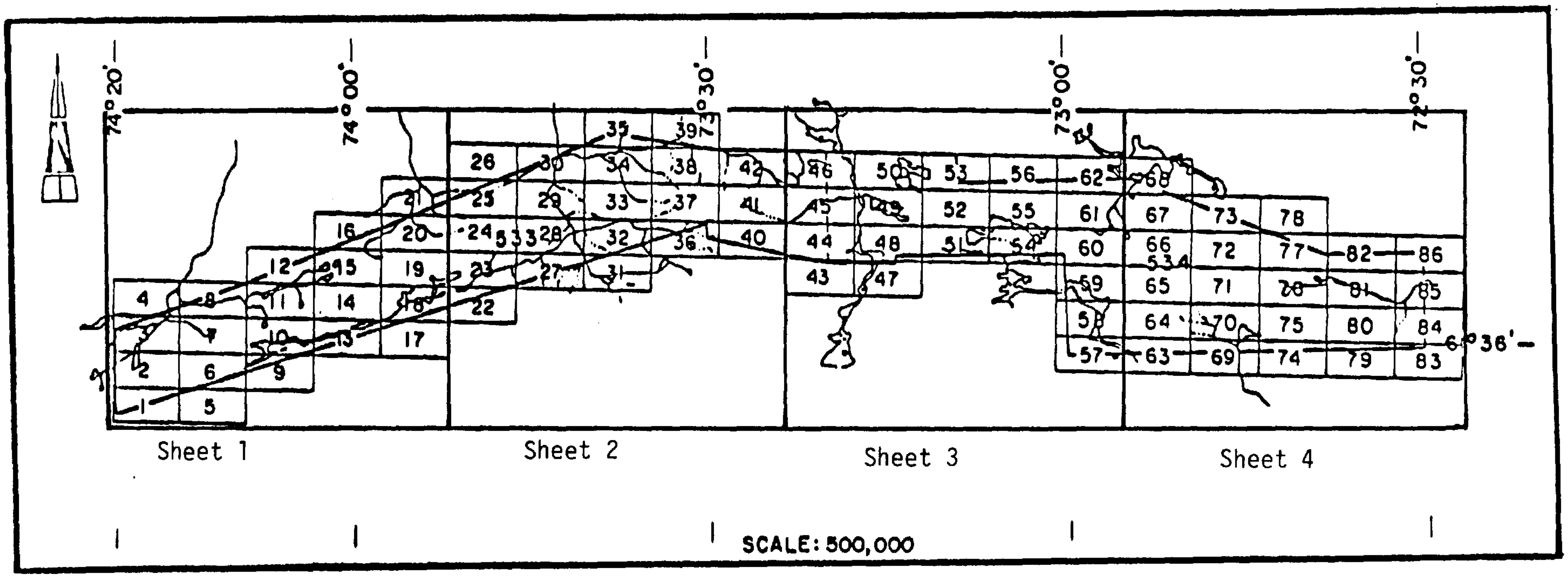


Figure 2a) Location plan of numbered 1:5000 geological mapping sheets and 1:25,000 geological compilation sheets.

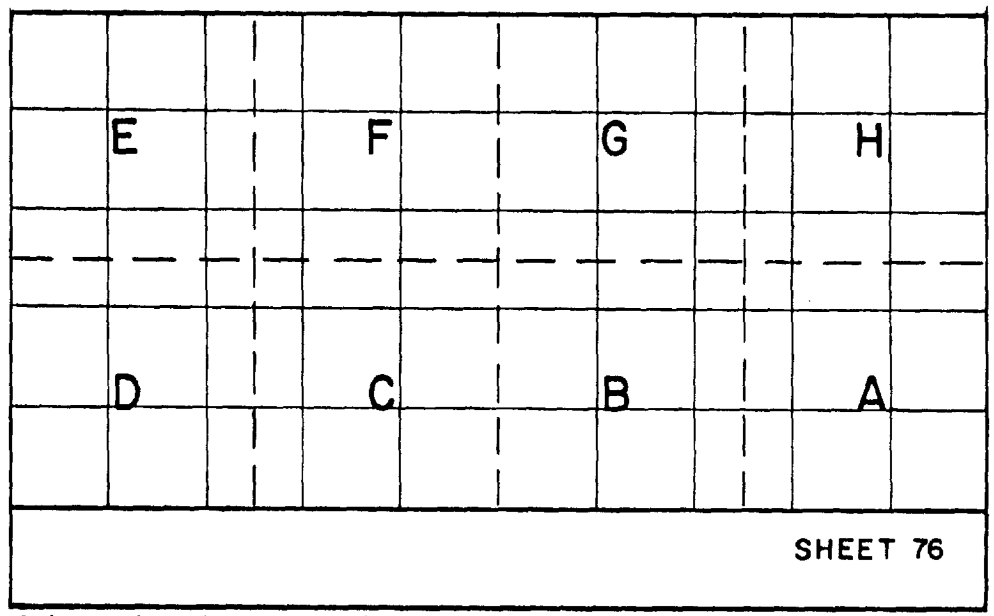
divisible into 8 blocks with dimensions of 1250 x 1250m. These block areas are exactly the size of a coloured photo overlay and so were numbered A through H as illustrated in Figure 3. All mapping information and collected samples are referenced to the sheet number and the lettered block. Thus sample number 76-A-1 would be number 1 sample in block A of sheet 76.

Each geologist worked either independently or with an associate in the completion of each sheet. Basing the entire program out of Raglan Camp proved advantageous in aspects of quality control, intercommunication on sheet boundary problems and general understanding of the regional picture. Combined group field trips to selected areas increased the overall understanding of the geology and aided the maintenance of interest and morale.

Daily helicopter travel in Ungava is often plagued with weather problems. Apart from the necessity of an experienced pilot for the program, each geologist carried survival equipment, a signal flag and a Genave Alpha 6 walkie-talkie set-up on 122.8 MHz for helicopter communication.

f) DIAMOND DRILLING

A list of total diamond drill footage carried out in the Raglan area is given in Table 2. The 1982 diamond drill program by Longyear Canada Inc. involved 33 holes with a combined footage of 13,641 feet. This program involved 2 Longyear 38 machines working for the period June 1 - July 12, 1982. One machine and all necessary support equipment and supplies were prepositioned west of the Deception River in April 1982 to alleviate the problems of overland travel during the breakup and run-off period. Holes



Schematic diagram of 1:5000 sheet showing sample number blocks 1250 x 1250 m in size.

Figure 2b

TABLE 2

SUMMARY OF DIAMOND DRILLING

RAGLAN AREA*

Area	Year	No. of holes	Footage	Remarks
Donaldson	1966	31	34,651	Surface
	1967	23	22,182	"
	1968	66	30,912	"
	1969	2	2,703	"
	1970	115	43,647	Underground
	1981	78	48,634	Surface
	1981	3	1,926	Metallurgical
Total surface		203	141,008	
Total underground		115	43,647	
Combined Total		318	184,655	
Katiniq	1964	16	7,640	Surface
	1965	14	5,453	"
	1966	29	14,890	"
	1967	42	19,030	"
	1968	45	22,364	"
	1969	49	29,042	"
Total		195	98,419	
No.2 & No.3 Showings	1962	9	8,719	Surface
	1963	?	?	"
	1964	-	-	-
	1965	4	2,007	"
	1966	2	1,745	"
Total		15	12,471	
Boundary	1966	9	4,959	Surface
	1968	17	6,825	"
Total		26	11,784	
Regional	1982	33	13,641	Assessment
GRAND TOTAL			320,970	

* Does not include pre-1962 drilling by Asarco and Raglan Nickel Mines.

lengths were restricted to 400 feet and locations selected to give complete assessment credits to the 973 claims presently held between Donaldson and Cross Lake. Although many of the holes provided important geological information on untested ultramafic bodies, the restraints necessary imposed on the program somewhat limited the value of the data obtained. Results of the assessment drill program are discussed in later parts of this report.

It is recommended that future drill programs, whether they be regional assessment drilling projects or detailed testing of potential areas, be started on July 1st. This would remove the problem of finding adequate supplies of water and also allow time during the early part of any program for a surveyor to establish UTM co-ordinates when most of the snow has melted.

II. GEOLOGY

REGIONAL GEOLOGY - CAPE SMITH FOLDBELT

The Cape Smith foldbelt of Northern Quebec constitutes a segment of the discontinuous band of Proterozoic rocks distributed around the Archean Superior Province. It forms the boundary zone between the Churchill and Superior structural provinces of the Shield, striking east-west for 375 km across the Ungava Peninsula between Cape Smith on Hudson Bay and Wakeham Bay on the shores of Hudson Strait (Figure 3). In the central part, it has a maximum width of 80 km and tapers to 30-50 km in width at the extremities. The foldbelt is located at approximately 62°N latitude, about 480 km north of the treeline and a similar distance south of the Arctic Circle. It is a typical arctic environment in the region of permafrost, which in this area extends to at least 540m below surface.

Volcanic rocks predominate in the stratigraphy of the Cape Smith belt, which can be broadly subdivided into a lower sedimentary unit, a central division of tholeiitic basalts and sediments (Povungnituk Group) and an upper division of komatiitic basalts (Chukotat Group). Steep north-dipping thrust faults disrupt the entire sequence and subdivide it into a number of separate blocks. Mafic to ultramafic sills are abundant in the east-central part of the belt. The entire assemblage is in unconformable contact with Archean rocks in the south and with increasing metamorphism grades into gneissic rocks affected by the Hudsonian orogeny in the hinterland to the north. The belt is early Proterozoic (Aphebian) in age and is stratigraphically and geochronologically

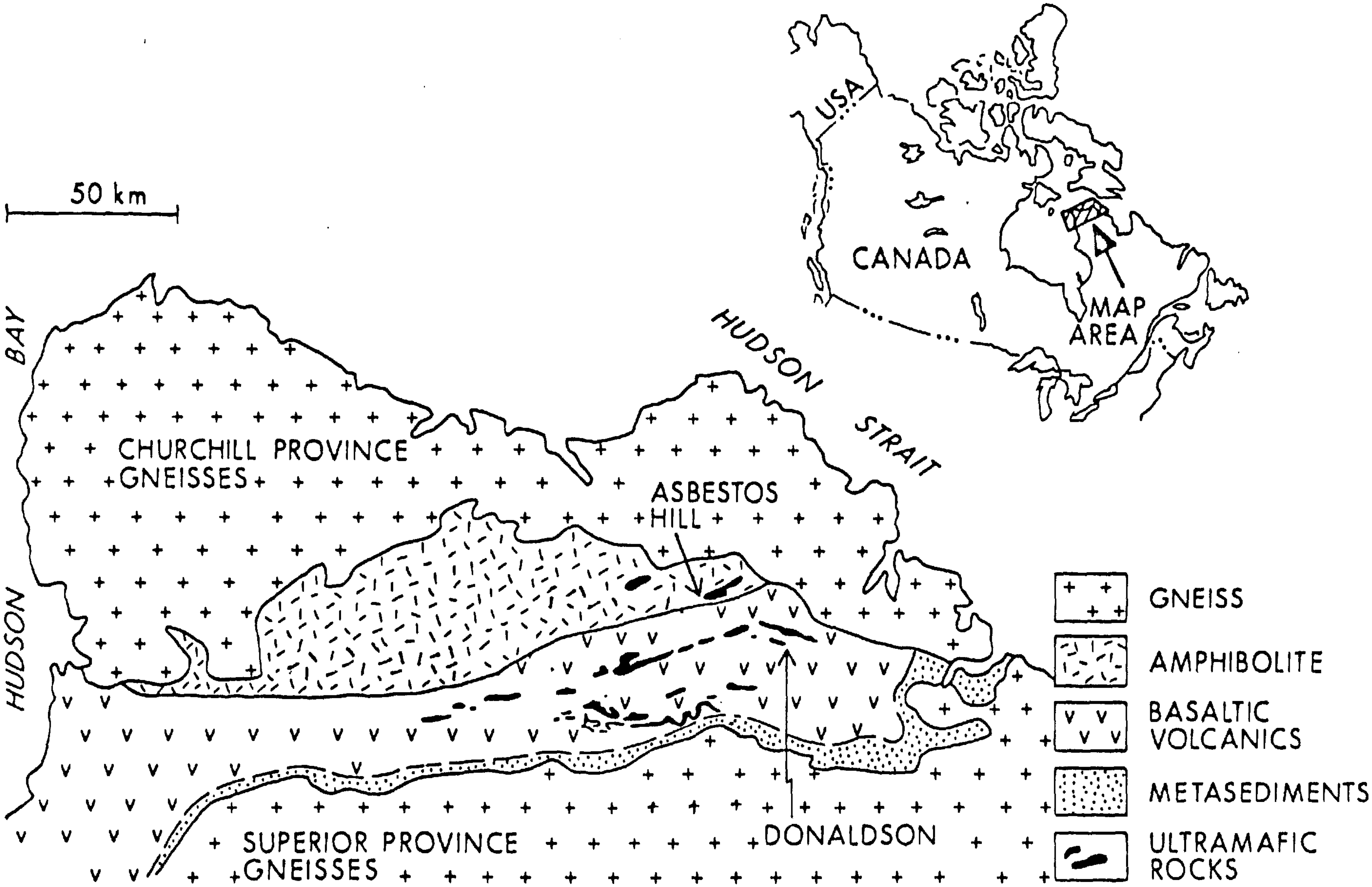


Figure 3 : Geological sketchmap of the Cape Smith - Wakeham Bay fold belt.

correlatable with the rocks of the Labrador Trough and the Belcher Basin.

GEOLOGY OF THE RAGLAN AREA

The Raglan area refers to the belt of rocks up to 8km across and 100km long, extending from Cross Lake in the west to Mont Lune in the east, and which essentially conforms to the area contained within the boundary of the original Raglan PRM's 533 and 534. The geology of this area is presented as four compilation sheets at a scale of 1:25,000, at the back of this report.

Major Geological Units

i) Povungnituk Group

The Povungnituk Group consists of a mixed succession of sediments and mafic, iron and titanuim-rich tholeiitic volcanics, which constitute the lowermost or older volcanic group in the supracrustal succession. Within the Raglan belt, Povungnituk volcanics are exposed along the entire southern edge of the area and are lithologically distinctive from the volcanic rocks of the Chukotat Group. They range from thick differentiated flows with a basal layer of medium to coarse grained gabbro overlain by a pillowed top, to thinner flows composed entirely of pillows. The massive gabbroic layers in differentiated flows are more erosionally resistant and can be traced as narrow linear ridges in the field. Large and prominent basalgabbros are mappable units extending in some cases for many hundred of metres. In general the volcanics are medium to dark green in colour and weather a dark greyish-green. Morphologically the pillows are large and slabby with poor weathering characteristics. They are ubiquitously vesicular and amygdaloidal with quartz and carbonate-filled drainage cavities. Glassy interpillow material also accompanied by quartz and rusty carbonate is abundant. Disseminated sulfides, pyrrhotite and chalcopyrite are extremely common throughout the Povungnituk volcanic assemblage as they are in the bands of interbedded argillaceous sediments.

Along the entire exposed band in the Raglan area, the Povungnituk tholeiites form a north-facing, north-dipping homoclinal sequence. Although dips in varying segments are highly variable, an average north dip of about 50° can be assumed. The sedimentary rocks overlying the volcanics form part of the Povungnituk Group. As this group has many interbedded sedimentary units throughout its entire thickness across the Cape Smith belt, and inasmuch as the overlying Chukotat is essentially devoid of sediments, the Povungnituk-Chukotat Group boundary is placed at the upper interface of the sedimentary band with the overlying Chukotat volcanics.

The sedimentary band overlying the Povungnituk tholeiites is of major geological significance in that it is the preferred locus of major MgO-rich subvolcanic sills and intrusions and perhaps more important, has been instrumental in the subsequent structural development of the Raglan belt. The contact between them is sheared for a major proportion of the observed length. Between Lac Long (Sheet 1) and the 5-8 Area (Sheet 2), shear effects are not restricted to the contact and it is evident that volcanics and sediments interdigitate in a complex manner.

Sedimentary rocks are the least resistant to erosion with resultant poor exposure in low lying valleys. Width of the sedimentary band in the Cross Lake to Donaldson section varies between 1000-2000m but this reduces to about 500m in the area east of Donaldson.

Principal component of the sedimentary group is an argillaceous sequence comprised of black graphitic slate, sulfidic slate, grey finely laminated argillite, siliceous argillite and argillaceous quartzite. Of lessor importance is an arenaceous sequence composed of arkose, arkosic quartzite to pure white quartzite with coarse flaggy bedding. A single occurrence of coarse conglomerate is present in one of the northern, thrust-repeated sedimentary exposures.

The graphite and sulfide-bearing argillaceous sediments are highly conductive and the airborne electromagnetic survey of Spartan Aero (1971) outlined highly anomalous regional conductors which clearly define sedimentary horizons. As conductive sediments underlie all the principal mineralized ultramafic bodies and in addition overlie at least two of them (Donaldson, 2-3 Area), electromagnetic methods of exploration are of limited value. The slates are variable in composition and display micro folding, recrystallization and brecciation textures. Fine grained laminae of feldspathic quartzite with disseminated pyrrhotite can alternate with laminae of argillite. With increasing sulfide content (pyrrhotite with lessor chalcopyrite), the rock may be classified as a sulfide iron formation. Massive sulfide zones of pyrrhotite and pyrite form part of sedimetary sequence at Mont Lune (Sheet 4), resulting in spectacular gossans which can be traced for thousands of metres. Other minerals identified in the metamorphosed fine grained sediments are quartz, feldspar, biotite, sericite, sphene, chlorite, epidote axinite and graphite. Slate breccias are present at Donaldson, Katiniq and 2-3 where available drill core gives a greater appreciation of the changing lithologies. Breccias range from black slate fragments in sulfide to more complex types consisting of a variety of arenaceous and sulfide fragments in a fine grained black graphitic matrix.

Highly siliceous rocks are present in the sedimentary sequence at some localities. Where exposed in the field there is little doubt of their clastic origin. In drill core at Donaldson and elsewhere, hard siliceous fine grained rocks with little indication of primary structures have been intersected at a number of places in the sedimentary sequence close to ultramafic sills. These units are light coloured and cherty in appearance and in earlier logs have been termed "jasperoid". Although there is still some doubt, which will require elucidation by additional work, the "jasperoid" zones are considered to be fine grained clastic quartzites.

ii) Chukotat Group

The transition from the Povungnituk Group, the upper part of which is the sedimentary sequence, to the Chukotat Group, characterized by high-MgO volcanic rocks, appears to be conformable. The contact in many places however, is occupied by intrusive sills of ultramafic and gabbroic composition. Chukotat volcanics are present along the entire length of the Raglan belt in a series of repeated thrust slices, with the best exposures visible at Cross Lake and Mont Lune. A variety of easily recognizable, megascopic and petrologic features distinguishes the MgO-rich Chukotat flows from the Povungnituk tholeiites.

The Chukotat succession consists of a series of pillowed flows and thicker more lenzoid differentiated flows. They are light to grey-green in colour, after variolitic but seldom amygdoloidal. Pillows are thin-rimmed, extremely variable in size and shape and rarely have interpillow material. The more magnesian lavas have undulatory ropy surfaces and are characterized by extensive polyhedral jointing. When flows are more than a few metres thick they are well layered with red-weathering basal olivine and pyroxene cumulate zones. Some pillows have readily recognizable microspinifex texture along the inside faces of the chilled margin. Visible phenocrysts are either olivine or pyroxene and the lavas are distinguished as olivine-phyric or pyroxene-phyric depending on the phenocryst phases.

In thin-section, the more magnesian flows show well developed microspinifex texture and narrow cumulate zones. Elongate blades of amphibole pseudomorphing quenched-crystals of olivine and pyroxene occur in a matrix of chlorite, feldspar and sericite. Fresh skeletal clinopyroxene in blocky and acicular grains may occur with chlorite-amphibole pseudomorphs after cumulate olivine grains in a fine-grained matrix of platy amphibole and glass. Even where more extensively altered, the microspinifex texture is preserved by straight lines of dusty opaque granules between areas of fine amphibole and chlorite exhibiting plumose and dendritic patterns.

From external studies on volcanic rocks from Cross Lake and Katiniq it is evident that there is good correlation of magnesia content with phenocryst type. Olivine-phyric rocks have MgO contents ranging from 12-18 wt. percent, which places them in the group of komatiitic basalts recognized in Archean terrains. Pyroxene-phyric volcanics contain between 7-12 wt. percent MgO.

In summary, the Chukotat volcanic succession differs radically from the older Povungnituk flows, in having well developed pillows, a high MgO content reflected by microspinifex texture, olivine and pyroxene cumulate zones in layered flows, little if any interflow sediments and a lack of contained sulfides.

iii) Amphibolites and Metasediments

As the belt of Chukotat volcanic rocks narrows to the east on Sheets 3 and 4, it becomes juxaposed by faulting against a broad band of amphibolites and underlying metasediments which rest unconformably on Archean gneisses at the north edge of the Cape Smith basin. These supracrustal rocks are remnants of the oldest units deposited in the basin and undoubtedly have their stratigraphic equivalents above the unconformity on the south side.

Basement rock is coarse grained, pinkish-white migmatized gneissic granodiorite composed of quartz, feldspar and variable amounts of muscovite. Foliation in the gneisses is preferentially developed at the basement-sediment contact indicating that the unconformity is probably sheared.

A thick horizon of metasediments overlies the gneissic basement. The lowermost unit is micaceous quartzite, but at some localities a thin band of bright red-weathering quartz-amphibole-pyrrhotite schist is present above the unconformity. The greater proportion of the metasedimentary band is a metapelitic rock, classified as biotite-muscovite-quartz schist. Large garnets and amphiboles are locally abundant. Narrow bands of amphibolite are interbedded with the sediments at some localities.

The amphibolite band varies in width from 200m on Sheet 3 to over 2000m in the Mont Lune area of Sheet 4. Although there is a considerable range in mineral composition, from chlorite-actinolite schists to coarse grained amphibole-plagioclase schists, the amphibolite unit is considered to represent highly metamorphosed volcanics of Povungnituk age. Interlayering with micaceous and siliceous metasediments is a common feature throughout the unit. Near the southern margin, schistosity and shearing is less intense and primary volcanic features are recognizable. Crude pillow shapes and patches of white quartz and carbonate with coarse amphibole laths suggestive of original interpillow material, are preserved.

iv) Mafic and Ultramafic Intrusions

Large volumes of mafic to ultramafic magmatic liquids have been involved in the evolutionary development of the Raglan area and Cape Smith belt in general. Widespread intrusion of MgO-rich Chukotat magmas into the upper parts of the Povungnituk succession was presumably concomitant with the extrusion of the Chukotat komatiitic basalts. The sedimentary group of the Upper Povungnituk was the preferred locus of intrusion, and perhaps because of its general structural incompetence allowed extensive sill development. For a similar reason, the sediments readily sheared along north-dipping reverse faults during the subsequent folding episode. As will be discussed in the next section, faulting has structurally repeated the sediment-sill assemblage as a series of thin slices. Intrusive rocks can be readily classified into two distinct groups: layered composite sills and intrusive dunitic peridotites.

Layered Composite Sills

This group comprises the largest volume of intrusive rocks in the Raglan area. All attitudes of mineralogical stratification, banding or internal gabbro-peridotite contacts are essentially parallel to the attitudes of enclosing volcanic or sedimentary rocks. This indicates that the latter were horizontal at the time of sill intrusion. The mafic and ultramafic rocks are undoubtedly pre-folding in age.

Layered composite sills are up to 10,000m in length and can have individual thicknesses of over 500m. Multiple intrusions, representing separate magma pulses have built up a series of stacked layered bodies 1500m in thickness, with little or no sedimentary material between them. All sills have hornfelsed adjacent sediments in a contact thermal aureole 1-2m wide.

The principal components of the layered differentiated intrusions are a basal zone of ultramafic rock and an upper overlying capping of gabbro. Proportions of these two rock types are highly variable and no two sills appear to be exactly identical. They range in composition from essentially gabbroic sills with a narrow basal zone of pyroxenite to thick ultramafic bodies with a thin upper gabbro layer. Some of the larger sills have approximately equal proportions of the two rock types. This extreme range in bulk composition indicates derivation from a continually differentiating source over a long period of time. An analogy would be the Chukotat komatiitic basalts, which show cyclic changes in composition from olivine-phyric to pyroxene-phyric to plagioclase-phyric. There is a consistent but steady trend from komatiitic to tholeiitic compositions in the Chukotat towards the north and in the younger formations.

Ultramafic portions of composite sills are grossly phase layered from a narrow basal unit of pyroxenite to olivine-pyroxenite and peridotite. The proportion of coarse, poikilitic or oikocrystic clinopyroxene can be readily estimated in the field on account of its high weathering characteristic. This produces a reddish-weathering knobby surface. Finer scale mineralogical layering is present in some sills, but is not a universally recognized feature. Diffuse and irregular layering is present in the main sill of sheet 75 (compilation sheet #4) where peridotite layers alternate with layers of pyroxenite. At this locality, irregular shaped blocks of pyroxenite are enclosed in chilled peridotite, testifying to static differentiation, followed by renewed pulses of peridotite, which broke up and incorporated portions of earlier formed layers.

Overlying gabbroic units of the composite sills consist of a variety of textural and mineralogical types, ranging from quartz-bearing leucogabbro to dark leucoxene-bearing mafic gabbro. A minor sulfide content may be present in some of these gabbroic rocks.

Significant features of the layered composite sills can be summarized as follows:

a) Great lateral continuity in sedimentary host rocks.

b) Bulk composition variable from sill to sill, with gabbro and peridotite the differentiation end members.

c) Differentiation by crystal fractionation in a static environment, resulting in a sharp demarcation of upper and lower layers and a coarse grained oikocrystic texture to the peridotite.

d) Negligible sulfide content.

Intrusive Dunitic Peridotites

The second group of intrusions are referred to as dunitic peridotites to reflect their high olivine content and ultrabasicity. They are the ore-bearing ultramafic bodies of the Raglan belt and show a number of unique features which distinguishes them from the layered composite sills. From west to east, the dunitic peridotites are named, East Lake, 2-3, Katiniq, 5-8, 13-14, West Boundary, Boundary and Donaldson. Each of these will be discussed is detail in a later section of this report. For the present, features common to them all and relating to aspects of petrogenesis will be examined.

The group of eight intrusions are more or less equally spaced along a single stratigraphic horizon for a distance of 37 km. The distribution of these bodies is centred on the apex of a regional flexture, where strikes change from WSW to ESE on compilation sheet 2. They are contained within structural block 2 (cf Structure and Metamorphism) at the contact of the Povungnituk sediments and overlying Chukotat volcanics. The linear distribution over a considerable strike length, points to some fundamental structural control.

Significant features of the intrusions can be summarized as follows:

a) Highly irregular shape

b) All are apparently part of a late magmatic event, crosscutting earlier gabbro intrusions (2-3, Katiniq, 5-8), and partially intruding and including blocks of Chukotat volcanics (East Lake, 2-3, Katiniq, 5-8)

c) They are undifferentiated, lacking an associated gabbro phase, but may be zoned. Dunitic cores partially enclosed by peridotite, olivine-pyroxenite and pyroxenite border phases are recognized at East Lake and Katiniq.

d) Although the intrusions are sill-like in overall attitude, drilling has established the presence of deep, cross-cutting "root zones" at 2-3 and 5-8.

e) Alteration of primary silicates is extensive; petrologically the intrusions are rich in original olivine as well formed grains accompanied by small equant to skeletal crystals of clinopyroxene and approximately 10 percent matrix. The latter is a fibrous mixture of pyroxene and feldspar altered to amphibole and chlorite and a proportion of devitrified dark glass. This texture results from increasingly rapid cooling of a liquid containing a high proportion of cumulate olivine.

f) Ubiquitous development of spectacular columnar jointing is evidence of high level emplacement and rapid cooling.

g) Consistent presence of a sulfide phase in all intrusions. Where the sulfide content is high, the intercumulous matrix is absent and the rock is an olivine-sulfide assemblage.

The above features contrast significantly with those described for the layered composite sills. They will be addressed in determining the chronological sequence of events for the Raglan area.

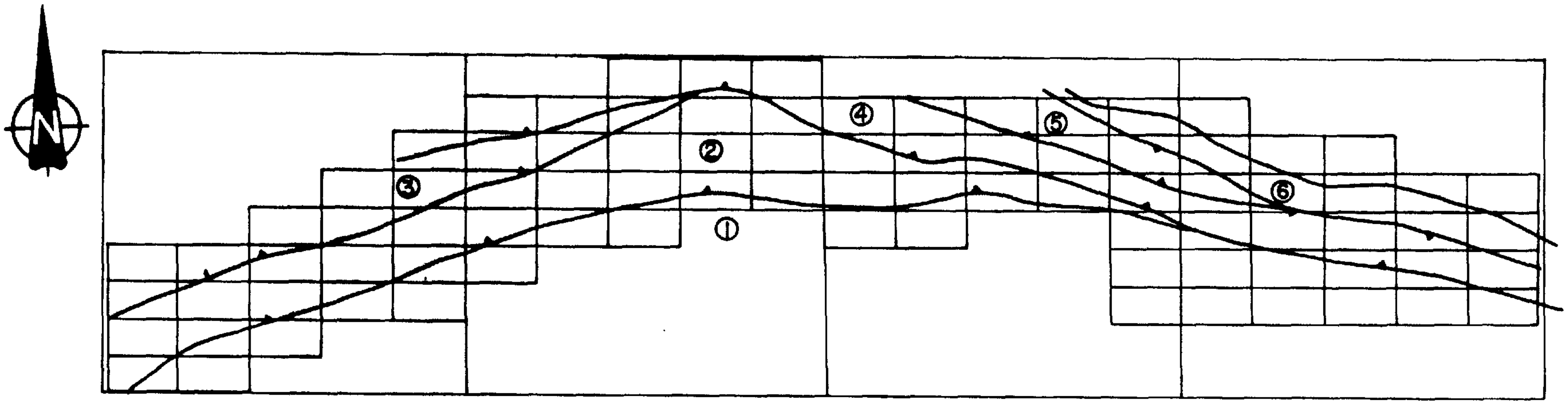
STRUCTURE AND METAMORPHISM

Three phases of deformation, D_1-D_3, are recognized in the structural evolution of the Cape Smith belt. Within the Raglan area, all three phases are readily apparent and the chronological sequence of events determined for this area could presumably be extrapolated to the belt as a whole.

The earliest detectable deformation D_1 produced a strong schistosity parallel to bedding. S_1 is observed in the argillaceous sediments on the east shore of Cross Lake, and is the prevalent schistosity in the metasediments and amphibolites overlying the basement gneisses in the eastern part of the area.

The second phase of deformation D_2 produced major folds parallel to the trend of the belt. F_2 folds are well developed in the Chukotat volcanics along the entire length of the Raglan belt. Preferential preservation of F_2 synclines as fault-bounded blocks is the principal structural feature of the area. F_2 axial planes are upright or overturned and steeply north-dipping. The post D_1 age of these structures is indicated by the folding of S_1 with the bedding. This feature is especially well exposed at the fold closure of the Cross Lake syncline where axial plane F_2 cleavage cuts the S_1 schistosity and bedding in the sediments. F_2 folds are variably plunging due to rotation during deformation D_3. This produced gentle cross folds with upright axial surfaces trending northwest to north-south and gentle 10-15° plunges to the east and west. F_3 fold axes are mapped in the Mont Lune and Cross Lake areas.

Steep, north dipping, reverse faults have subdivided the area into a number of thrust slices or blocks. Latest movement on these faults appears to be post F_2. For convenience the individual blocks are numbered 1-6 as illustrated in Figure 4. Strike faults are recognized in the field by intense zones of shearing, usually accompanied by reddish-orange weathering carbonatization. As



Scale - 1:500,000

Thrust faults identified in the Raglan area subdividing the stratigraphy into block slices numbered 1-6, from south to north

FIGURE:

the preferred locii for faulting is sediment-volcanic contacts or entirely within poorly exposed sedimentary bands, fault exposures are not continuous. On the compilation sheets, only those portions of faults which can be traced in the field are recorded. Figure 4 includes some fault extrapolations and interpolations to produce a structural picture compatible with all observed evidence.

Block 1 comprises the north dipping, north-facing Povungnituk volcanics and some of the overlying sedimentary band. Between Cross Lake and Donaldson, its north-bounding fault in part follows the volcanic-sediment contact and in part cross-cuts the stratigraphy. From Donaldson eastwards, the fault appears to be restricted to the volcanic-sediment contact zone, with both rock types being severely affected by shearing.

Block 2 is of major economic significance in that it encloses all the ultramafic bodies containing nickel sulfide mineralization. Block 2 includes upper Povungnituk sediments and a large syncline of Chukotat pillowed volcanics, the north limb of which is truncated by the fault with Block 3. The synclinal axial plane is upright for 25 km from Cross Lake to the northeast, at which point it becomes overturned to the north. Subsiduary sub-parallel anticlinal and synclinal axes behave in a similar manner. From a point north of Katiniq the syncline becomes distinctly asymmetric, with a broadening southern limb and increasing truncation of the northern limb by the fault to the north. At the south end of Lac Rinfret, this fault appears to truncate the fold axis, leaving the remaining portion of the block as a north-facing homoclinal sequence. East of Donaldson, block 2 pinches out in a complex area of multiple layered sills to the north of Lac Wakeham. The complete disappearance of block 2 results from the convergence of its upper and lower bounding faults.

The fault truncating the north limb of the Cross Lake syncline, reverses the facing direction of rocks within the overlying block 3. This block comprises a similar sequence of sediments with layered composite sills and north-facing Chukotat volcanics. It is recognizable as a unit from Cross Lake to the apex of the major strike change in the belt, north of 5-8 area. Convergence of its lower fault with the basal fault of block 4, pinches it out at this point.

Block 4 extends from the Deception River near the northern limit of mapping, through Lac Rinfret, Mont Lune and to the eastern limit of mapping. It is bounded on the north by a wide north-dipping shear zone and maintains a uniform width of about 2500m. For the greater portion of its length, its essential component is a north-dipping, north-facing homoclinal sequence of Chukotat volcanics. At Mont Lune however, it is a well-preserved syncline with reverse plunges on either side of the Mont Lune F_3 cross fold. A well preserved syncline of Chukotat rocks on its north side has been designated block 5 (compilation sheet 3) which appears to be faulted out against the amphibolites along the north edge of the basin. The metasediments and metavolcanics (amphibolites) overlying the Archean gneisses in this area are a south-facing, south-dipping assemblage, which although designated as block 6 on Figure 4, may represent high grade metamorphic equivalents of Povungnituk rocks. The synclinal block 4 assemblage at Mont Lune is therefore bounded by a south-dipping shear on the north side and north-dipping reverse fault on its south side.

Cross faults constitute a conspicuous structural element along the entire Raglan belt. They trend in varying directions, but predominantly within the quadrant from northwest to northeast. They affect all rock units in the area, offset F_2 fold axes and in some cases appear to offset the reserve strike faults. Apparent lateral displacement can be considerable on some faults, but this may reduce to zero when traced along strike. As apparent displacement across a fault is a function of its attitude and the dip of formations affected, in addition to direction and amount of net movement, it is difficult to fully access the nature of the cross faults. They appear in general to be tensional adjustments, with normal and perhaps some rotational movement and to have formed during the late D_3 deformation event, which produced N-S F_3 cross folds.

Metamorphic assemblages throughout most of the Raglan belt are in the low greenschist facies. Mineral assemblages in the ultramafic rocks are lizardite/antigorite-diopside-tremolite, compatible with this grade. Although antigorite is considered to have a higher thermal stability than lizardite, it is never accompanied by regenerated metamorphic olivine, which could be correlated with upper greenschist facies conditions. Across the south dipping fault closest to the Archean unconformity, garnet and amphibole indicate amphibolite facies conditions. The sharp transition across the fault appears to imply pre-fault metamorphism, which in this area probably relates to the D_1 event.

SUMMARY OF GEOLOGIC HISTORY - RAGLAN AREA

Progressive stages in the geologic development of the area are portrayed diagrammatically in sections 1-5, Figure 5. The end of Povungnituk tholeiitic submarine volcanism saw the deposition of a thick sequence of black siltstones, siliceous argillites and related clastic sediments (Section 1). Renewed magmatic activity was initiated as thick layered sills intrusive into the sediments (Section 2). These sills have peridotitic bases reflecting MgO-rich initial compositions and are related to the Chukotat Group. Within the initially flat-lying sedimentary basin, the sills occupied many horizons, were laterally extensive and slowly differentiated by fractional crystallization in a static environment. Their source was presumably a magma chamber undergoing differentiation, to account for the varying bulk compositions involved. Repeated intrusions in some areas built up a succession of composite as well as wholly gabbroic sills.

During or perhaps immediately following sill intrusion, surface volcanism renewed with a succession of MgO-rich pillowed volcanics and associated layered flows assigned to the Chukotat Group (Section 3). The transition from the Povungnituk, the upper part of which is siltstone, to the Chukotat Group is probably conformable and determined by the first appearance of these high MgO volcanic rocks.

The subsequent deformational events are not well understood and what follows is regarded as highly speculative. D_1, the first deformational event probably involved a limited amount

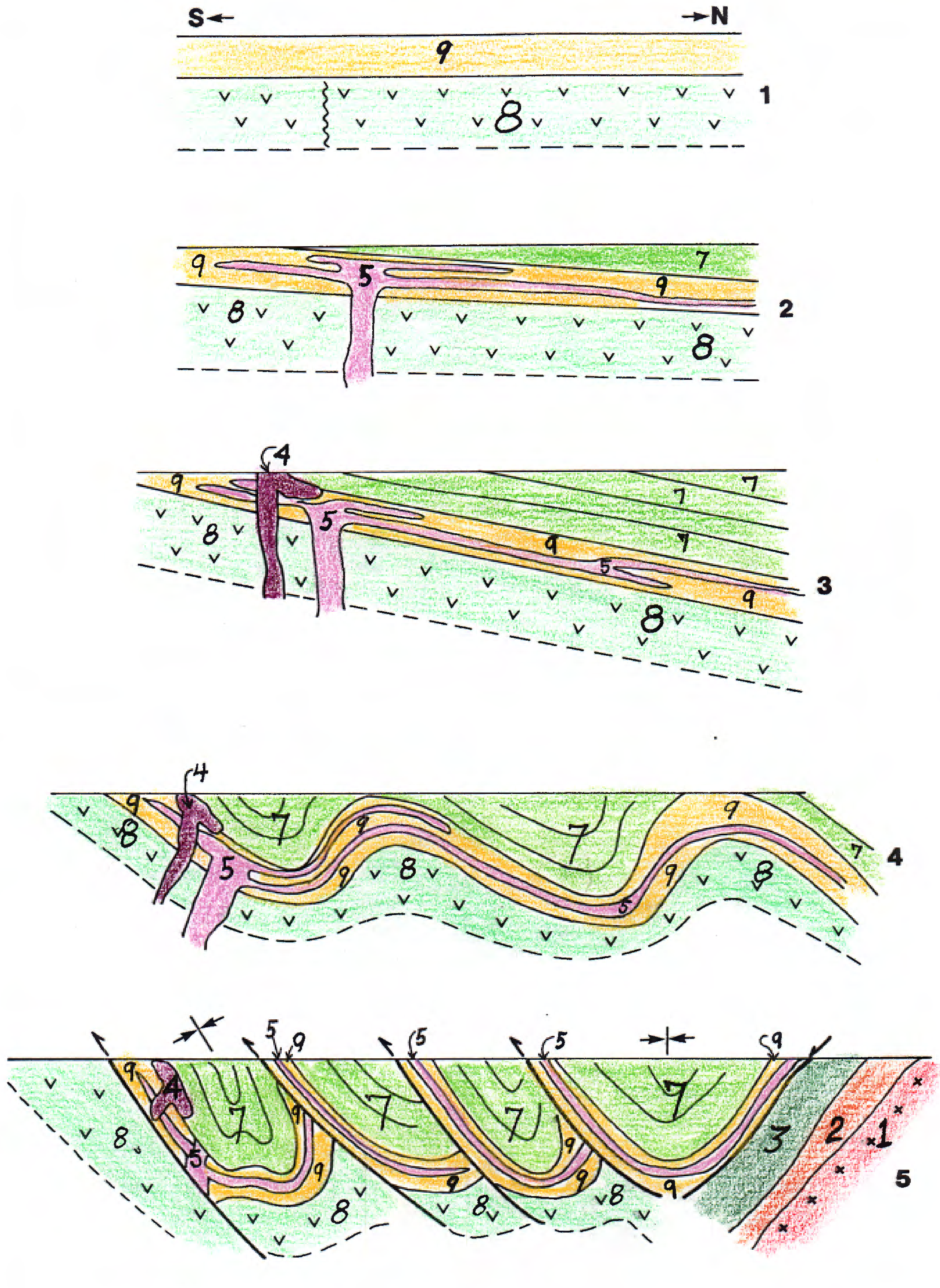


Figure 5

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of tight folding and limited thrusting. Metamorphic grade rose to the amphibolite facies in the northeast portion of the area adjacent to the hinterland gneisses. South-dipping underthrusting (compilation plans 3 and 4) in this area may account for the broad arching of the belt in this region.

The timing of intrusion of dunitic peridotite bodies is not certain. They are clearly related to the Chukotat komatiitic volcanism, but appear to represent a late pulse of primitive sulfide-bearing magma, perhaps from the same source, but subsequent to the expulsion of large volumes of less primitive, more fractional magma. This scenario may explain some features of the Raglan ores, such as high nickel in sulfide ratios and high platinum group element contents, which are indicative of sulfide-equilibration with large volumes of magma. The intrusions occurred subsequent to the main Chukotat volcanism in a lower temperature regime prior to the D_2 event (Section 3). The evidence of quenched matrix and columnar jointing indicate a quick cooling, high level envrionment. The linear distribution of the intrusions at the lower margin of the Chukotat komatiitic basalts and their emplacement about the apex of the arch, suggests some structural control, which could have been initiated during the D_1 event.

D_2 and the development of major reverse faults produced the principal folding and structural division of the belt rocks into tectonic slices (Section 4,5). D_3, with its associated doming and cross faulting adjustments completed the geological picture as presently observed. All secondary, post magmatic features in the ultramafic host rocks and sulfide ore zones such as silicate replacement and sulfide mobilization, result from greenschist facies metamorphism coeval with the D_2 and D_3 events.

III. NICKEL MINERALIZATION AND ULTRAMAFIC HOST ROCKS

The foregoing section summarized the results of the Raglan geological mapping program and attempted to place the sequence of events in their chronological order. It has shown that the sulfide-bearing intrusive dunitic peridotites are structurally, petrologically and chemically distinctive from the bulk of the layered differentiated sills in the area. In this section, each of the mineralized intrusions will be examined separately with emphasis on new data acquired during the 1982 drill program, but also incorporating prior information and drilling results where these have been readily available. The mineralized Cross Lake sill is included in this group, although it has certain features which appear to place it in a separate category, transitional between the two groups. The bodies examined will be Cross Lake, East Lake, 2-3 Zone, Katiniq, 5-8 Zone, 13-14 Zone, West Boundary, Boundary and Donaldson.

a) CROSS LAKE SILL

(Sheets 2 and 6. Compilation sheet 1)

The ultramafic-mafic body which dramatically outlines the synclinal fold at Cross Lake is designated the Cross Lake sill. It is the most economically important sill at Cross Lake and has had extensive exploration for Cu-Ni sulfide mineralization. Stratigraphy, the sill occurs at or close to the Povungnituk-Chukotat contact and is therefore the lowermost MgO-rich intrusion in the Chukotat system.

The sill has continuous exposed outcrop around the fold closure for a total distance of 10,000m. Widths vary considerably along the attenuated limbs, but greatest widths are evident at the nose of the fold, attesting to the 30-35° NE plunge of the fold axis. The south-facing north limb dips south between 50-75°, while the north-facing south limb has a 55-65° dip to the north. Along the entire segment of the north limb and for intermittent portions on the south limb, the sill is composite in structure, with an upper gabbro facies overlying the peridotite. A significant portion of the composite sill is separated from the overlying volcanic rocks by a thin septum of argillaceous sediments. Contacts between the sill and sediments are relatively straight and regular. At both the Main Cross Lake mineralized area on the fold nose and the C1-C2 area of the south limb, the gabbro and overlying sedimentary units are absent. These localities are characterized by highly irregular intrusive contacts, with lobes of peridotite extending up into the overlying volcanics. A large block of volcanics is enclosed in peridotite close to C2 area, suggestive of violent stoping action.

Petrology

Petrographic examinations were made on 7 equally spaced samples from a 200m traverse across the sill on claim 309235-4. Results are tabulated below.

C2-5	Hangingwall Chukotat volcanics	
C2-4	Peridotite:	Fresh to partially serpentinized olivine poikilitically enclosed in large plates of amphibolitized clinopyroxene. Matrix is fine grained serpentine.
C2-3	Peridotite:	Similar to C2-4. Greater degree of alteration with remnants of clinopyroxene in secondary amphibole. Olivine altered to serpentine and amphibole. Matrix chlorite and serpentine.

C2-2	Peridotite:	Intercumulate equant clinopyroxene 20% olivine altered to serpentine and amphibole. Sulfide 10%.
C2-1	Peridotite:	Poikilitic clinopyroxene 30-40% with some equant grains. Olivine 100% serpentinized. Matrix of chlorite and late cross-cutting amphibole. Sulfides 10%.
C2-6	Peridotite:	Extensively altered. Large clinopyroxene altered to amphibole. Matrix of serpentine, chlorite and amphibole. No primary textures.
C2-7	Peridotite:	Approx. 10% altered clinopyroxene. Serpentine and abundant secondary amphibole. Minor sulfide.
C2-8	Olivine Pyroxenite:	Clinopyroxene-rich, altered to amphibole. Serpentine and amphibole pseudomorphs after olivine.

Base of sill.

With the exception of an olivine-enriched basal zone and an adjacent marginal zone of pyroxenite, there is little evidence of significant compositional changes in the C2 section of the sill. Alteration of all phases increases downwards, but it would appear that the bulk composition of the rock is that of a peridotite with a clinopyroxene content ranging between 10-40 percent. This is a higher content than is present in most of the intrusive dunitic peridotites which host Cu-Ni sulfide mineralization.

Mineralization

Previously reported, drill indicated tonnage from the Cross Lake, C_1 and C_2 areas is as follows:

Locality	Tonnage (ST)	% Ni	% Cu
Cross Lake	4,388,500	1.63	0.73
C_1	1,140,500	1.80	1.02
C_2	2,419,400	1.75	1.04
Combined Total	7,982,300	1.70	0.87

Cross Lake sulfide mineralization has an average Cu/Cu+Ni ratio of 0.34 and a relatively low Ni/Sul ratio. The tendency towards lower Cu/Cu+Ni ratios in more magnesian bodies and vice versa is well documented and the 0.34 value for Cross Lake is compatible with its inferred low magnesia bulk composition. Similarly, the low Ni/Sul ratio infers the equilibration of abundant magmatic sulfide with a liquid of less than ultramafic composition.

Diamond drilling for assessment purposes in 1982, involved three short holes at the eastern end of the sill.

DDH W-13 (90°) Claim 409236-4

3.66- 11.42 Slates
11.42- 35.66 Volcanics
35.66- 75.92 Slates
75.92-119.58 Gabbro
119.58-154.53 Serpentinite. Minor sulfides.

This hole was designed to intersect the previously untested eastern extension of the Cross Lake sill. The hole was stopped in serpentinite and should be deepened at a later date.

DDH W-14 (90°) Claim 405666-4

6.70-132.30 Volcanics
132.30-154.53 Serpentinite. Minor sulfides.

DDH W-15 (90°) Claim 405665-4

6.46- 39.52 Volcanics
39.52- 58.83 Serpentinite

58.83-154.53 Volcanics

This hole did not reach the main sill and should be deepened at a later date.

Conclusions

Mapping of the sill suggests that the Main zone and C_1-C_2 zone were intrusive vent areas characterized by turbulent flow of olivine-bearing liquid, which penetrated as irregular lobes into the volcanic roof rocks. This feature is enhanced by folding in the Main zone area at Cross Lake. Lateral to the vent areas, sill material intruded the sediments close to the volcanic contact in more quiescent conditions. Magmatic sulfides carried in with the magma settled out quickly in footwall embayments within the vent areas and were not carried beyond the influence of the intruding turbulent flow.

Bulk composition of the sill cannot be calculated. From the differentiated gabbro layer overlying the greater proportion of the sill, it can be inferred that the bulk liquid was much less MgO-rich than that represented by the peridotite presently exposed in the C_2 vent area. The latter contains 60-90% cumulate olivine in a pyroxene matrix. This composition is distinctly less olivine-rich than present in the host of the Katiniq and Donaldson ore zones.

b) EAST LAKE SILLS

(Sheets 14 and 18. Compilation sheet 1).

Prior to geological mapping, no information was available on the nature and extent of the East Lake sills. They were readily apparent from the airborne magnetic survey where the main sill has a maximum magnetic expression of 65,000 gammas. The four mineralized sills collectively grouped as the East Lake sills are termed the South, West, Main and East sills for the purposes of this report.

The Main and East sills lie at the Povungnituk sediment-Chukotat volcanic contact. The South sill is located for the most part within a band of Povungnituk volcanics and the West sill occurs wholly within the sedimentary band. Sedimentary rocks are poorly exposed at East Lake, as they are throughout most of the belt and are limited to small areas of frost-heave in close proximity to the ultramafic sills. Sediments consist of two bands of argillaceous slates in the area and a unit of white, thinly bedded feldspathic quartzite in immediate contact with the Main, South and West sills. Frost heave material indicates the presence of an included block of quartzite in the central part of the Main sill.

South Sill

This body strikes NE across sheets 14A and 18D for 1400m and has maximum width in plan view of about 350m. Attitudes from columnar jointing and flaggy jointing in the dunitic core indicates a 20° dip to the north. In plan, the sill is comprised of a dunitic core, underlain and concentrically surrounded by peridotite (10b), olivine pyroxenite (10c) and a border zone of pyroxenite (10d). The outcrop pattern is the result of the flat dip, topography and local warping of the sill. The sill is in contact, along its base with gabbro, pillowed Povungnituk tholeiites and feldspathic quartzites. As such the lower contact appears cross cutting although the nature of the contact, whether intrusive or faulted, is not known. Disseminated sulfides (5-10% Po, Pn) occur near the base of the sill throughout the olivine pyroxenite and peridotite phases. In addition, two significant gossans occur at or near the footwall contact. Both gossans comprise areas of scattered frost-heave each approximately 10m. wide with 80-100m of strike length. Up to 70% net and reverse net-textured sulfides (Po, Pn, Cpy) occur in each of these zones. In addition, disseminated pyrrhotite and chalcopyrite (locally up to 10% sulfides) occur in the underlying country rock along the southeast margin of the sill.

Structurally, it is possible that the South Sill represents a fault-bounded sheet which has been thrust to the south over Povungnituk Group rocks (gabbro, pillow and massive basalt, sedimentary rocks). In this case the plane of detachment would be coincident with, or immediately below the pyroxenite border phase of the sill. The South Sill may thus represent the marginal phases which are absent from the south part of the Main Sill. In this regard, it is noteworthy that the dunitic phases of both sills are megascopically similar; both are light grey on fresh surface and devoid of sulfides.

West Sill

The West Sill is an ESE-trending, steep-dipping (60-70°N) linear body which crops out in 14A, B and continues to the southwest into Sheet 13. Mineralization is confined to the northeast end of the sill in sheets 13G and 14A, B. Sulfides are concentrated near the footwall contact with up to 25% Po, Pn, Cpy in 14A. Mineralization decreases to the southwest, ending in Sheet 13F. The mineralized part of the sill, in sheets 13 and 14 consists of a pyroxenite base (10d) overlain by olivine peridotite (10b) and locally capped by gabbro (9a,c). The sill is both underlain and overlain by sedimentary rocks with feldspathic quartzites on the north and slates on the south side.

Main Sill

The Main sill of the East Lake Group outcrops along the Chukotat-Povungnituk boundary in Sheets 14A, H and 18D, E, F. The sill trends ENE, dips to the north at 60° (from columnar jointing, basal jointing in dunite), has an exposed strike length of 2400m and is approx. 425m thick (corrected for 60° dip). An aeromag anomaly extends to the ENE for an additional 1000m and may represent the down plunge extension of the sill. The Main Sill is comprised of two large dunitic pods (10a) partially enclosed by pyroxenite (10d), olivine pyroxenite (10c) and peridotite (10b) border phases. The north margin of the sill is pyroxenite, which is locally capped by medium-grained, equigranular gabbro (9a). The sill appears to be in contact with an aphyric Chukotat massive flow along this margin. The southern margin, however, appears to be missing as border rocks (ie. pyroxenite) are absent. Steeply-dipping shearing and strong serpentinization (with the development of asbestos) characterize much of this southern margin. Feldspathic quartzite and argillaceous slates are in contact with the southern margin of the sill.

The Main Sill exhibits bilateral symmetry about a NNW-trending axis through its centre. The symmetry is expressed in the two dunite pods and the feldspathic quartzite re-entrants at the west and east ends.

Sulfide mineralization is concentrated near the northern margin of the sill. In addition to the three gossans, disseminated sulfides

(Po, Pn, Cpy) occur in dunite in the northern half of the sill (1-2%, locally 5-8%). The three gossans occur in dunite, peridotite and olivine pyroxenite with a sulfide content (Po, Pn) of up to 25%. Some of the feldspathic quartzites within and adjacent to the sill are mineralized with pyrrhotite. The apparent restriction of sulfides to the northern half of the sill, the lobate outline of the ultramafic and the occurrence of sedimentary rocks within the sill indicate that the Main Sill may have undergone a multiple intrusion history.

The possibility that the South Sill may represent the marginal (southern) phases of the Main Sill has important implications regarding mineralization along the footwall of the Main Sill.

East Sill

The East Sill outcrops as frost-heave material in 18G and 19B. The sill is outlined by a 600m long aeromag anomaly (approx. 62,000γ), separate from the linear extension of the anomaly associated with the Main Sill. Three lithogies are present; basaltic flow-breccia (6e) (Chukotat), dunite (10a) and pyroxene peridotite (10b). The volcanic rocks may represent a raft within the sill.

Mineralization is confined to the ultramafic units and includes a 30 x 100m gossan along the north side of the frost heave area. The dunite contains 2-3% Po, Pn (locally to 10%). The gossan area exhibits angular blocks with 15-80% sulfides (Po, Pn); the highest sulfide contents occurring as reverse net texture sulfides in a pyroxene peridotite at the SE edge of the gossan, near the gossan-dunite contact. No structural attitudes could be obtained on this sill.

The location of the gossan along its north side may indicate that this sill is overturned with the sulfides concentrated near the footwall. Alternatively, the sulfides may simply be located well above the footwall contact.

Petrology

To fully document the ultramafic rocks of the sills, the samples listed below were studies in polished thin-section. In each case, the number represents the (DDH-metres down hole) for samples selected from the 1982 drill program.

W9-116.7 (PTS 7022) East Lake (Main Sill) - Peridotite-Dunite

Euhedral to subhedral lizardite pseudomorphs after olivine, with 10% remnant fresh olivine. Clinopyroxene in interstitial equant grains. Remaining matrix is a dark fibrous mixture of radiating amphibole (?) in serpentine and chlorite suggestive of a quench texture. Euhedral opaque chromite. Intercumulus sulfide blebs of Po, Pn and magnetite. (Figure 11, App. III)

W9-92 (PTS 7033) East Lake (Main sill) Dunite-peridotite

Lizardite serpentine with hour-glass texture, pseudomorphic after olivine and 5-10% interstitial equant clinopyroxene. Remaining matrix fibrous texture. Chromites rimmed with magnetite occur in pseudomorphs and matrix. Absence of any silicate inclusions in Po, Pn sulfide phase.

W9-43.8 (PTS 7024) East Lake (Main Sill) Peridotite

Large poikilitic clinopyroxenes with pseudomorphs of lizardite and later antigorite and amphibole. Matrix chloritic. Sulfides minor and redistributed.

<u>W9-116.5</u> (PTS 7028) East Lake (Main sill) Dunite + sulfide

Well preserved texture of lizardite pseudomorphs after olivine and interstitial clinopyroxene altering to amphibole. Matrix of fibrous amphibole and chlorite. Sulfides Po, Pn rimmed by magnetite as intercumulus blebs.

<u>W10-49.2</u> (PTS 7030) East Lake (Main sill) Dunite + sulfide

Essentially 95% olivine partially serpentinized to lizardite and 5% clinopyroxene. (Freshest olivine noted in Raglan area.) Sulfides 5-10% disseminated intercumulate with magnetite rims to Po and invades cleavages of Pn. (Figure 12. App. III)

<u>W10-70</u> (PTS 7031) East Lake (Main sill) Dunite-peridotite

Antigorite pseudomorphs after olivine plus 10% intercumulate and poikilitic fresh clinopyroxene. Euhedral opaque chromite. Sulfides 5-10 percent with sulfide-silicate margins sharp Po:Pn - 4:1.

<u>W10-120</u> (PTS 7033) East Lake (Main Sill) Dunite

Dark and highly altered dunite.

<u>W11-35</u> (PTS 7034) East Lake (South sill) Olivine pyroxenite.

Highly altered olivine pyroxenite with large poikilitic clinopyroxene containing olivine pseudomorphs altering to amphibole. Surrounding matrix of chlorite and amphibole. Euhedral chromite rimmed by magnetite. Minor sulfide.

<u>W11-67</u> (PTS 7035) East Lake (South Sill) Peridotite

Well preserved magmatic texture of lizardite pseudomorphs after olivine and 5-10% clinopyroxene partially altered to amphibole. Magnetite rims olivine pseudomorphs. No sulfide.

These samples verify the nomenclature of ultramafic types within the East Lake sills. Of enigmatic interest is the variation in degree of silicate alteration from the presence of lizardite, antigorite and amphibole in some samples to fresh olivine with intercumulate sulfides in others. The lessor degree of alteration in the dunitic phases indicates a reduced regime of metamorphism in this area in comparison to those further east. As a consequence, sulfide ore zones within the sills should have less sulfide-silicate intergrowth and hence the possibility of a higher grade and recovery of concentrates.

Mineralization

Assays of surface samples collected during the geological mapping program are listed on Table 3. Values over 3 percent Ni were obtained in samples from both the South and East Sills. Lower grade disseminated mineralization is exposed on the Main and West sills. An unusually wide range of nickel in sulfide ratios is evident from the Table but arithmetic averages range between 8.1-14.6. For samples containing over 2.0 percent Ni, the average Ni/sul ratio is 7.7 which is lower than values from the Donaldson and Katiniq ore deposits.

Diamond drilling for assessment purposes in 1982 involved two short holes on each of the Main and South sills. Location of water sources and ease of access were of prime concern during this regional drilling program and these contraints negated the possibility of any systematic approach to sill evaluation.

Main Sill

DDH W-9 (90°) Claim 405354-3

5.18- 18.89 Serpentinite, pyroxenitic marginal phase

18.89- 34.38 Gabbro

34.38-124.05 Serpentinite, peridotite. Minor dissem. sulfides.

TABLE 3

SURFACE ASSAY SAMPLES - EAST LAKE SILLS

(Sheets 14 & 18. Compilation Sheet 1)

Sample	Field No.	Ni %	Cu %	Co %	S %	Ni/Sul	Cu/Cu+Ni
a) Main Sill							
2420	14A27	0.24	0.03	0.01	0.57	13.1	0.12
2422	18EJ1	0.55	0.14	0.02	2.70	6.8	0.20
2423	18EJ2	0.48	0.08	0.02	1.87	8.4	0.14
2435	18E25	0.21	0.08	0.02	1.60	4.5	0.28
2436	18E27	0.25	0.12	0.02	1.79	4.7	0.32
2442	18F5	0.73	0.20	0.02	1.66	13.3	0.22
					Aver.	8.5	
b) South Sill							
2426	14A36	0.37	0.23	0.01	1.07	10.5	0.38
2427	14A37	2.38	0.41	0.05	7.84	9.8	0.15
2428	14A38	1.33	0.32	0.03	4.36	9.8	0.12
2438	18D1	0.34	0.32	0.01	0.76	12.4	0.49
2441	18D2	0.61	0.24	0.02	1.14	15.3	0.28
2446	18D3	0.54	0.19	0.02	1.15	13.9	0.26
2415	18D4	0.17	0.02	0.01	0.15	-	0.11
2421	18D5	0.44	0.08	0.02	1.97	7.4	0.15
2444	18D6	0.41	0.18	0.02	1.20	10.6	0.31
2443	18D7	0.50	0.27	0.02	1.44	10.6	0.35
2445	18D10	0.40	0.17	0.01	0.84	13.9	0.29
2429	18D18	3.08	0.52	0.06	12.3	8.3	0.14
2430	18D19	2.53	0.39	0.05	10.7	7.8	0.13
2431	18D20	1.98	0.40	0.04	6.41	9.9	0.17
					Aver.	9.9	
c) East Sill							
2452	18G1	2.10	0.48	0.06	11.5	6.2	0.19
2450	18G2	0.48	0.14	0.02	1.63	9.4	0.23
2451	18G3	0.83	0.18	0.03	3.09	8.8	0.18
2449	18G4	2.83	0.77	0.07	12.9	7.3	0.21
2458	18G5	0.53	0.17	0.02	1.73	9.7	0.24
2456	18G6	0.85	0.26	0.02	3.13	8.8	0.23
2457	18G7	3.00	0.78	0.07	15.0	6.7	0.21
					Aver.	8.1	
d) West Sill							
2411	14A6	0.27	0.12	0.01	0.67	12.1	0.31
2412	14A8	0.50	0.07	0.02	0.70	20.1	0.12
2413	14A9	0.48	0.16	0.02	0.50	24.0	0.25
2414	14A10	0.58	0.21	0.02	0.63	23.0	0.27
2416	14A16	0.28	0.04	0.01	0.52	16.0	0.13
2417	14A17	0.47	0.19	0.02	5.14	3.2	0.29
2418	14A18	0.23	0.09	0.01	1.41	5.5	0.28
2419	14A19	0.15	0.04	0.01	0.36	12.7	0.21
					Aver.	14.6	

DDH W10 (90°) Claim 405354-4

3.35 - 124.05 Serpentinite. Dunitic with minor dissem. sulfides throughout.

South Sill

DDH W-11 (90°) Claim 405354-5

3.35 - 123.14 Serpentinite. Dunitic, minor disseminated sulfides.

DDH W-12 (90°) Claim 405356-5

3.87- 78.78 Volcanics

78.78-100.92 Serpentinite, olivine pyroxenite. Minor sulfides.

100.92-124.05 Volcanics

Conclusions

The East Lake sills have considerable potential for the discovery of significant nickel sulfide deposits. The favourable geological setting, presence of dunitic ultramafic rocks, persistance of a disseminated sulfide phase and the occurrence of sulfide-rich gossans warrants thorough evaluation.

c) 2-3 AREA SILL

(Sheets 23, 27 and 28. Compilation sheet 2)

The 2-3 ultramafic sill is an irregularly shaped elongate body, 3000m long and up to 200m in true thickness. It has intruded the contact zone between the Povungnituk black slates and the younger komatiitic basalts of the Chukotat. For the greater part of its length the footwall is composed of gabbro, part of an earlier extensive intrusion. Drilling has indicated a northerly dip of about 45-50° for the body in the area of the No. 2 and No. 3 sulfide zones. At other localities footwall structural contours indicate steep dips in the area that have been termed "root zones" (Figure 6).

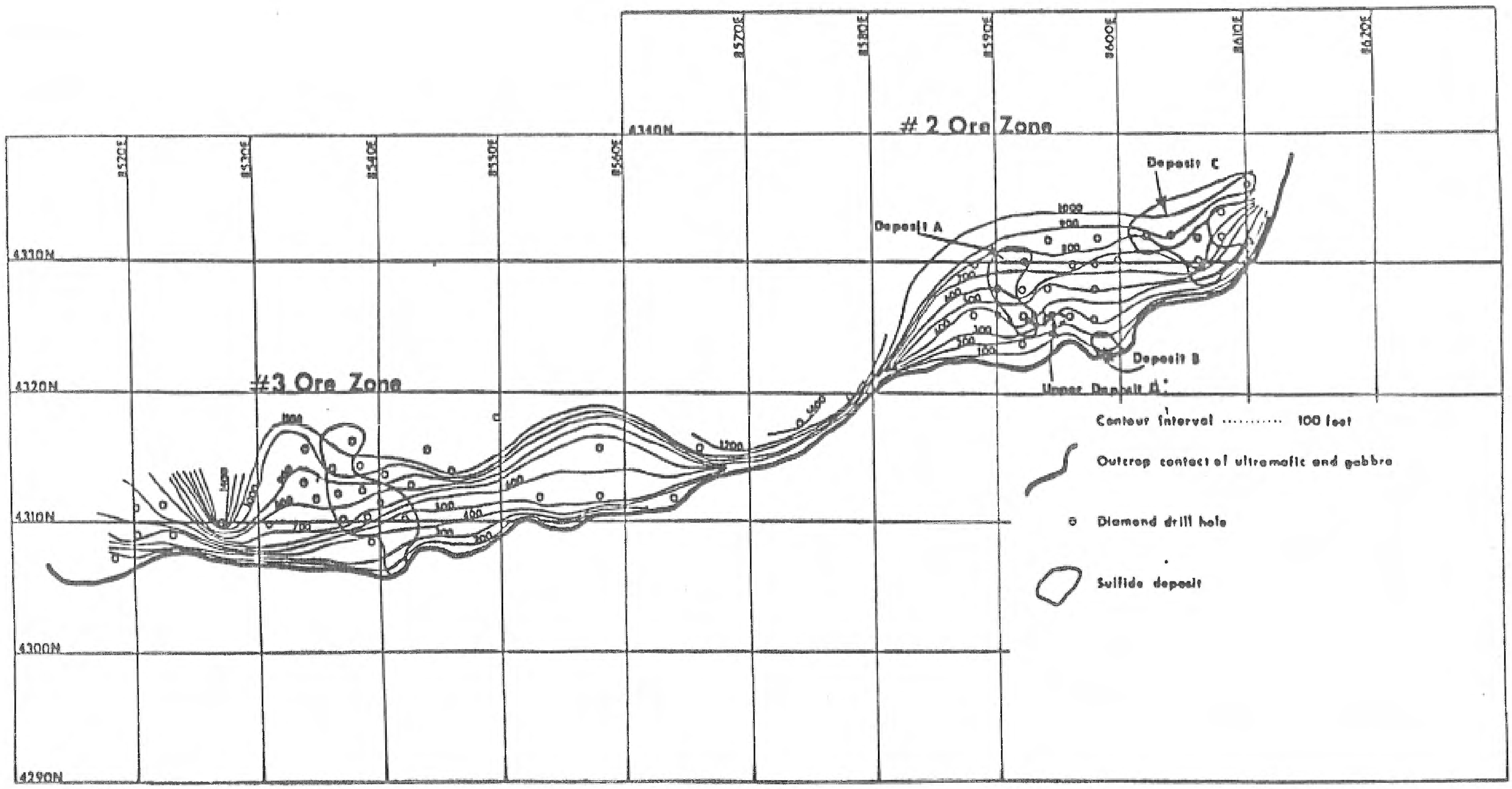


Figure 6 Structure contour of the basal contact of the 2-3 ultramafic sill with the 2-3 gabbroic sill or Mg-basalt volcanic rocks.

Throughout the intensively drilled parts of the 2-3 ultramafic unit xenoliths of volcanic and hornfelsed sedimentary rocks are present in the central and lower segments.

In spite of pervasive serpentinization, relict mineralogy texture and grain morphologies are still preserved. The serpentinite is subdivided into a wehrlitic-dunitic central core zone and marginal upper and lower clinopyroxenitic border zones. The central zone mineralogy consists of serpentine, clinopyroxene, chromium spinels, magnetite, chlorite, tremolite and carbonate. Clinopyroxenitic border zones vary in width and along the basal contact may be absent or diminish in thickness adjacent to sulfide accumulations. They are highly altered to tremolite chlorite and carbonate.

Petrology

The samples listed below were examined in polished thin section to verify field terminology. In each case the number represents the (DDH-metres down hole) for samples selected from the 1982 assessment drill program.

W1-123 (PTS 6967) 2-3 Area Peridotite

Fine grained completely amphibolitized ultramafic, with flaky, colourless amphibole (no preferred orientation), serpentine and chlorite. Rare outlines visible for pseudomorphed olivine.

W1-11.5 (PTS 6970) 2-3 Area Volcanic

Basalt with microspinifex texture. Altered to colourless fuzzy amphibole, but retaining outlines of probable olivine and pyroxene spinifex with a variety of acicular and plumose textures. Patches of chlorite, small euhedral zoisites and minor carbonate.

W1-11.7 (PTS 6973) 2-3 Area Volcanic

Acicular spinifex (olivine and pyroxene), altered to amphibole. Plagioclase interstitial to amphibole. Veinlets of chlorite and carbonate and lessor plagioclase and zoisite. (Figure 10, App. III)

W2-20.5 (PTS 6984) 2-3 Area Slate

Rounded patches of coarse grained feldspar (Orthoclase + Na-plagioclase), quartz and sulfide in a matrix of biotite quartz, feldspar and graphite.

W2-45.1 (PTS 6985) 2-3 Area Diorite

Coarse grained orthoclase and sodic plagioclase mantled by a micrographic intergrowth of quartz and feldspar. Dark interstitial patches of chlorite, muscovite, carbonate and epidote.

W3-79.3 (PTS 6990) 2-3 Area Altered ultramafic

Talc carbonate replacement of serpentinized peridotite. Interstitial patches of chlorite with rhombic dolomite euhedral.

W4-63 (PTS 6992) 2-3 Area Dunite

Lizardite pseudomorphs after olivine, altering to fibrous amphibole. Minor fresh clinopyroxene. Secondary vein of magnetite and sulfide in coarse antigorite serpentine.

In general the 2-3 ultramafic is highly altered to secondary silicates and sulfides display an intergrowth with fine acicular antigorite.

Mineralization

Disseminated sulfide is common throughout the entire thickness of the 2-3 sill. Sulfide accumulations at or near the base of the sill constitute greater than 85% of the sulfides by volume, and are intimately related to the basal topography of the sill.

Structure contours of the basal contact of the 2-3 ultramafic sill, clinopyroxenite-gabbro and clinopyroxenite-magnesium basalt show that the contact is highly irregular along and across strike. From west to east along the strike, the floor of the intrusion undulates between zones of very steep contours termed "deep zones" and zones of rolling gentle contours termed "flat zones".

The flat zones are characterized by north-west trending depressions immediately to the east of the deep zones. The depressions are concave both along and across strike. These depressions resemble deep canoe-like troughs in the basal contact. Only within these canoe-like troughs adjacent to the deep zones are massive and net-textured sulfide deposits located.

Sulfide zones may occur above or below the basal clinopyroxenitic border zone. In the No. 3 ore zone, net-textured sulfide in dunite grades downwards into a barren or weakly mineralized border zone. Alternatively, a weakly mineralized border zone may overlie net-textured or massive sulfide in contact with footwall gabbro.

Local redistribution of sulfides resulting from serpentinization, tremolitization and carbonatization is a common feature of the 2-3 ores. The remobilization of sulfide involves the growth of serpentine blades at the expense of interstitial and net-textured sulfide, and the growth of tremolite into and around disseminated sulfide patches. Locally, sulfides replace olivine pseudomorphs in net-textured ore, a feature which is common to most of the Raglan mineralized zones.

Present mineral inventory, calculated to include probable and possible ore categories is as follows: (LAW 1982).

	D.S. Tons	% Ni	% Cu
No. 2 Area	1,261,500	3.09	0.89
No. 3 Area	1,997,600	3.82	0.90
Total	3,259,100	3.54	0.90

Analyses of two samples of 2-3 ore are given in Table 4. The low total for the net-textured ore sample reflects the lack of a determination for MgO. Ni/Sul ratios for massive and net-textured ores are 14.6 and 9.7 respectively. Average grades for the two zones indicate a Cu/Cu+Ni ratio of 0.2. PGE contents will be considered in a later section of this report.

1982 Assessment Drilling

Five short assessment diamond drill holes were completed in the 2-3 Area during 1982.

DDH W-1 (90°) Claim 405733-3

3.65- 71.62 Volcanics

71.62-124.05 Serpentinite, peridotite. Minor sulfides.

DDH W-2 (90°) Claim 405735-4

4.12- 7.01 Volcanics

7.01- 32.61 Gabbro

32.61- 41.27 Volcanic

41.27-119.18 Gabbro-diorite.

This hole failed to intersect the ultramafic sill and remained in hangingwall rocks north of the steeply dipping "root zone".

DDH W-3 (90°) Claim 405636-5

5.18-122.84 Serpentinite. Minor sulfides.

DDH W-4 (90°) Claim 405371-3

4.87- 30.15 Gabbro

30.15-124.05 Serpentinite. Minor sulfides.

TABLE 4

ANALYSES OF THE 2-3 SULFIDE ORES

	23-53-723 (Massive sulfides)	23-46-493 (Net-textured ore)
Fe	48.0	23.7
Ni	15.8	3.07
Cu	2.0	1.51
Co	0.26	0.08
S	32.9	9.9
Si	0.88	23.9
Total	99.84	62.16
Pt (Toz/ST)	.059	.027
Pd	.018	.037
Rh	.032	.008
Au	.003	.004
Ag	.075	.214
Ni/Sul	14.6	9.7
Cu/Cu+Ni	0.11	0.33

Assays indicate an increasing nickel and sulfur content towards the bottom of the hole (0.51% Ni, 1.39% S).

DDH W-5 (90°) Claim 405374-1

4.36- 54.58	Volcanic
54.58- 90.45	Serpentinite. Dunitic, minor sulfides.
90.45-114.35	Volcanic
114.35-124.05	Gabbro

Conclusion

The 2-3 ultramafic sill is structurally complex and its geometry not well understood. Ore zones are restricted to paleotopographic footwall depressions. Ore grades and nickel in sulfide ratios are high. There would appear to be considerable potential for additional ore zone discoveries in this body. A compilation of all prior data on UTM 1:1250 sections is recommended.

d) KATINIQ SILL

(Sheets 28 and 32. Compilation sheet 2.)

The Katiniq sill is a lenticular body up to 150m in thickness and about 2500m long, intruded with a slight discordance along the contact between overlying Chukotat volcanic rocks and an underlying differentiated gabbro sill. At the west end, near the Deception River, the sill dips north at about 50° but this reduces to 30-35° at the eastern end.

The sill is composed of olivine-rich rocks showing a characteristic concentric zonation, with the olivine concentration increasing from a few percent at the pyroxenitic margins to 90 percent in the dunitic centre of the intrusion. Matrix to the olivines is fine grained, composed of finely intergrown tremolite and chlorite.

It has derived from the alteration of a pyroxene-plagioclase intrafasciculate texture, produced by quenching. The presence of this fine grained groundmass phase throughout the sill, the occurrence of small hollow and skeletal pyroxene crystals and the spectacular development of hexagonal columnar jointing just above the base, provides evidence for high-level emplacement and rapid cooling.(Figs 13,14)

Mineralization

Nickel sulfide mineralization at Katiniq occurs dominantly at or close to the footwall contact. Massive ore occurs at the base resting either directly on the footwall contact of the sill or underlain by a zone of marginal pyroxenite. Massive ore is overlain at a sharp contact by net-textured ore, which itself has a fairly sharp upper contact with disseminated sulfides. There is a tendency for major sulfide zones to be spacially related to topographic lows in the footwall of the sill. This is a feature common to most of the Raglan deposits and supports an origin by gravitational settling of immiscible sulfide liquid.

Katiniq mineralization consists of hexagonal pyrrhotite, pentlandite, chalcopyrite, magnetite, minor pyrite, trace sphalerite and local concentrations of ferrochromite. The mean bulk ratio of Cu/Cu+Ni is 0.2 and Ni/sul values range between 8-12 percent with a mean around 10 percent. Common to most sulfide occurrences in the Raglan area, Katiniq mineralization shows a widespread secondary modification of primary sulfide-silicate textures. It involves the systematic replacement of primary net-textures with complex silicate-sulfide intergrowths. Serpentinized olivine is partially replaced by sulfide and fibrous serpentine (antigorite) is intergrown with original sulfide. (Figs. 15-16. App. III)

Mineral inventory estimates for the Katiniq ore zones are listed in Table 5 (LAW 1982).

Conclusions

The Katiniq sill has not yet been fully evaluated and the potential for additional ore zones is high. Future drilling recommendations must await full documentation of all data on 1:1250 sections.

e) 5-8 AREA SILL

(Sheets 32, 33, 36 and 37. Compilation sheet 2.)

The 5-8 ultramafic intrusion is a highly irregular shaped body located mid-way between the Katiniq and 13-14 zones. It extends 2700m in an E-W direction and ranges in exposed width from 100m in the narrow central zone to about 700m on its west limb. Footwall rocks are sediments and gabbro and the northern extremities of the east and west limbs are in contact with Chukotat volcanics. For the most part the 5-8 body crosscuts the stratigraphy and is intrusive into an earlier gabbro exhibiting gross phase layering, from a fine grained melanogabbro, a medium grained melanogabbro and a course amphibole gabbro.

The basal east-west segment of the 5-8 ultramafic consists of a coarse grained pyroxenite overlain by olivine pyroxenite or oikocrystic peridotite with pods of fine grained peridotite-dunite. These in turn are overlain by oikocrystic olivine-pyroxenite and pyroxenite. The pyroxenite-gabbro contact appears gradational, suggesting that the gabbro may have been partially assimilated during emplacement. Extending north from the basal section, the "wings" of the 5-8 body consist of serpentinized oikocrystic peridotite

TABLE 5

NEW QUEBEC RAGLAN MINES LIMITED

PRELIMINARY MINERAL INVENTORY ESTIMATES

KATINIQ AREA

	Probable			Possible			Total		
Zone	d.s. Tons	% Ni	% Cu	d.s. Tons	% Ni	% Cu	d.s. Tons	% Ni	% Cu
A	97,000	4.63	0.74	40,000	4.63	0.74	137,000	4.63	0.74
B	458,300	3.66	0.91	26,600	3.52	0.81	484,900	3.65	0.91
C	32,500	1.87	0.46	-	-	-	32,500	1.87	0.46
D-1	581,900	2.85	0.75	31,500	1.96	0.52	613,400	2.80	0.74
D-2	106,375	4.49	1.89	8,500	4.04	2.62	114,875	4.45	1.94
E	564,425	3.41	0.87	21,500	4.28	0.97	585,925	3.44	0.88
F	32,000	2.46	0.54	10,250	2.46	0.54	42,250	2.46	0.54
G	653,850	2.72	0.75	59,000	2.40	0.64	712,850	2.69	0.74
H	70,500	2.92	0.53	29,000	2.92	0.53	99,500	2.92	0.53
I	42,000	2.47	0.43	19,250	2.47	0.43	61,250	2.47	0.43
J	1,078,350	3.46	0.90	116,750	2.93	0.62	1,195,100	3.42	0.87
K	20,400	4.70	2.60	10,750	4.70	2.60	31,150	4.70	2.60
L-1	24,600	2.54	0.78	10,875	2.54	0.78	35,475	2.54	0.78
L-2	22,600	2.38	2.55	10,375	2.38	2.55	32,975	2.38	2.55
M	99,500	2.89	0.78	37,100	2.93	0.85	136,600	2.90	0.80
N-1	40,000	2.07	0.85	18,625	2.07	0.85	58,625	2.07	0.85
N-2	10,000	2.81	0.34	-	-	-	10,000	2.81	0.34
O	46,000	3.57	1.38	22,750	3.57	1.38	68,750	3.57	1.38
P	130,000	1.96	0.49	70,575	1.88	0.48	200,575	1.93	0.48
Q-1	210,000	4.81	1.22	76,950	4.81	1.22	286,950	4.81	1.22
Q-2	68,000	4.99	2.36	25,000	4.99	2.36	93,000	4.99	2.36
R	17,000	4.09	0.63	5,500	4.09	0.63	22,500	4.09	0.63
S	36,200	6.22	1.66	4,100	7.35	1.97	40,300	6.33	1.70
T	161,700	3.41	1.00	70,925	3.41	1.00	232,625	3.41	1.00
U	51,600	5.80	1.79	25,800	5.80	1.79	77,400	5.80	1.79
V	49,200	2.76	0.72	34,650	2.91	0.74	83,850	2.82	0.73
W	18,950	2.85	3.91	10,250	2.92	3.59	29,200	2.87	3.80
TOTALS	4,722,950	3.358	0.929	796,575	3.316	0.966	5,519,525	3.352	0.935
With 15% Dilution	5,431,392	2.92	0.81	916,061	2.88	0.84	6,347,453	2.91	0.81

and marginal zones of pyroxenite. Lateral projections of pyroxenite form narrow zones at the gabbro-sediment contact on both the east and west sides. These presumably represent injections of pyroxenitic liquid from the marginal phase during intrusion of the main ultramafic body.

Petrology

The samples listed below were examined in polished thin-section. In eash case the number represents the (DDH-metres down hole) for samples selected from the 1982 drill program.

E13-19.7 (PTS 7038) 5-8 East Limb. Peridotite

Completely altered peridotite. Lizardite pseudomorphs after olivine, and lessor amphibolitized clinopyroxene. Lizardite altering to fine grained amphibole needles.

E13-47.5 (PTS 7039) 5-8 East Limb. Olivine pyroxenite.

Large poikilitic plates of clinopyroxene. Olivine-rich areas altered to textureless mixture of lizardite, antigorite and amphibole. Magnetite and chromite grains.

E13-90 (PTS 7042) 5-8 East Limb. Mineralized peridotite.

Remnant clinopyroxene crystals and patches of serpentine in sulfide-rich rock. Sulfide mobilization textures predominate. Sulfides Po, minor "flame" Pn and Cpy.

E13-90.1 (PTS 7043) 5-8 East Limb. Mineralized peridotite.

Sulfide replacement of olivine pseudomorphs in clinopyroxene- evidence of sulfide mobilization. Dark reddish-brown spinels.

E14-29 (PTS 7046) 5-8 East Limb. Volcanics.

Highly altered volcanic rock with skeletal crystal forms altered to amphibole and patches chlorite.

E14-32.2 (PTS 7047) 5-8 East Limb. Volcanics

Amphibolitized fine grained volcanic rock with a micro spinifex texture preserved by straight lines of opaque granules. These presumably were skeletal olivines.

E14-34.6 (PTS 7048) 5-8 East Limb. Spinifex volcanics.

Better preserved microspinifex texture than 7047 above. Amphibole after pyroxene in plumose textures between original olivine spinifex blades. No evidence of cumulate phase.

E17-116.6 (PTS 7050) 5-8 West Limb. Dunite-peridotite.

Lizardite pseudomorphs after olivine and minor clinopyroxene. Minor sulfide phase.

Petrological observations on 5-8 samples can be summarized as follows:

i) Overlying Chukotat volcanics are MgO-rich microspinifex-textured komatiitic basalts, similar to those overlying Donaldson, Boundary, Katiniq, 2-3, East Lake, and Cross Lake bodies.

ii) Peridotite, with a significant clinopyroxene content is the dominant rock type.

iii) Alteration of primary silicate phases is intense and includes lizardite, antigorite, amphibole and chlorite.

iv) Sulfide phase observed to be pyrrhotite-rich and should therefore have a lower Ni/sul ratio.

v) Sulfide-silicate relationship inextricably mixed, with extensive sulfide replacement of and movement into original cumulate olivines.

Mineralization

Four areas of surface mineralization, designated showings 5, 6, 7 and 8 are exposed in the 5-8 ultramafic sill. Showing 5 occurs in a fine grained peridotite immediately above the basal pyroxenite and consists of 10-30 percent disseminated to net-textured sulfides. Previously quoted intersections have grades ranging between 1.5 - 8.7% Ni. Showing 6 occurs as an area of frost-heaved olivine pyroxenite to peridotite containing about 10 percent sulfides in a central portion of the west limb. Showing 7 is a series of small gossans in footwall enbayments consisting of 10 percent sulfide in basal pyroxenite. Showing 8 is a series of sulfide gossans in peridotite at the northern extremity of the east limb. Ore intersection of 4.7 feet assayed 6.45% Ni in this area. Results of 1981 chip sampling in showing 8 area are listed in Table 6. The best grade material averaged 2.15% Ni, 0.7% Cu with a Ni/sul ratio of 9.5. Arithmetic average of 6 samples areas however, gave a low Ni/sul ratio of 7.7.

Five short assessment diamond drill holes were collared in 1982 at various locations along the northern edge of the 5-8 body.

DDH E-13 (90°) Claim 405714-2

4.35-121.92 Serpentinite. Minor sulfides throughout.

91.85-98.45 (6.6m) Massive fine grained sulfides.

This massive sulfide zone is fine grained, pyrrhotite-rich and considered to be remobilized. Average grade is 0.83% Ni, 0.28% Cu, 0.11% Co and Ni/sul ratio 0.8

TABLE 6

SURFACE ASSAY SAMPLES - 5-8 AREA

(Sheet 37. Compilation sheet 2)

Sample	Field No.	Ni %	Cu %	Co %	S %	Ni/Sul	Cu/Cu+Ni
2312	Chip	0.37	0.30	0.02	1.81	6.6	0.45
2313	Chip	0.43	0.11	0.02	2.23	6.5	0.20
2314	Chip	2.15	0.70	0.04	7.24	9.5	0.25
2315	Chip	0.36	0.11	0.01	1.19	9.6	0.23
2316	Chip	0.84	0.24	0.03	4.69	6.0	0.22
2317	Chip	0.66	0.16	0.03	2.75	7.9	0.20
					Aver	7.7	

DDH E-14 (90°) Claim 405715-2

Collared 350m west of E-13 and north of the mapped ultramafic contact.

3.35- 40.81	Volcanics. Microspinifex and flow top breccia.
40.81- 46.46	Black slates, sulfidic.
46.46-121.21	Serpentinite (dunite-peridotite). Minor sulfides.
121.21-124.05	Black slates, sulfidic.

DDH E-15 (90°) Claim 405717-4

Collared close to the north contact of the east limb immediately north of No. 7 showing.

6.13-124.05 Gabbro

Gabbro throughout this hole indicates a very steep peridotite-gabbro contact, not incompatible with a late intrusion history for the peridotite.

DDH E-16 (90°) Claim 405718-4

Collared in gabbro close to the northeast corner of the west limb to verify the possibility of a northeast plunge direction. This possibility was suggested by the northeast strike elongation exhibited by the east limb.

4.26-123.14 Gabbro

No northeast plunge is possible in this area.

DDH E-17 (90°) Claim 405720-4

Collared at the northwest corner of the west limb.

2.74-124.05 Serpentinite. Marginal pyroxenite, peridotite with an inclusion of sulfide-rich black slate between 26.83-33.73.

Narrow zone of remobilized sulfide contained minor Ni.

Conclusions

The entire 5-8 ultramafic body has a visible sulfide content of 1-2 percent, but the abundant poikilitic clinopyroxene phase suggests its bulk composition is less MgO-rich than the Donaldson body. Although some narrow high grade sulfide intersections have been reported in prior drilling, nickel in sulfide ratios for most sulfides appear to be low. This feature could have resulted from large scale incorporation of sulfide-rich sedimentary material (DDH E-17) and the subsequent remobilization of nickel-poor, massive sulfide veins (DDH E-13). Sulfide remobilization and sulfide-silicate textural changes are extensive and comparable to the observed features in the 13-14 ultramafic body. 5-8 zone is structurally complex and its attitude and geometry not well understood. A compilation of all prior data on UTM 1:1250 sections is required before recommendations can be made.

f) 13-14 AREA SILL

(Sheet 37. Compilation sheet 2)

The 13-14 Area derives its name from two patches of mineralized frost heave, which were initially designated as showings 13 and 14. The area lies at the apex of a pronounced strike change in the rocks of the belt, where the ENE trend of the Cross Lake-Katiniq segment changes to the ESE trend of the West Boundary - Donaldson segment.

Magnetically, the 13-14 ultramafic body has a circular expression in total field with a maximum intensity of 61,500 gammas. Enhanced magnetics suggest a flattened C-shape to the body and this is somewhat confined by the sparse outcrops. There is no evidence to indicate that the structure is a minor F_2 fold closure, but this remains a possibility. As a whole, the unit has an E-W dimension of 1500m and a maximum N-S dimension of 700m. Columnar jointing in peridotite at two localities indicate a northerly dip of between 25-50°. Footwall rocks are graphitic slates and the body appears to have a northern contact with Chukotat volcanics. Two areas of gabbro and argillaceous slates underlie the central area between the north and south limbs. Air photo lineaments, suggestive of cross faults intersect the ultramafic at two localities, but as outcrop density is low and of poor quality, structural observations are limited.

Petrology

The samples listed below were examined in thin section. In each case, the number represents the (DDH-metres down hole) for samples selected from the 1982 drill program.

E11-54.5 (PTS 7025) 14 Area. Peridotite.

Olivine pseudomorphs visible but obscured by extensive later antigorite development. Remnant equant clinopyroxene and amphibole. Zoned opaque chromites. Sulfides mostly Po with minor Pn and Cpy intimately intermixed with magnetite. Extensive sulfide redistribution.

E11-47 (PTS 7026) 14 Area. Mineralized peridotite.

Similar to 7025 above with large poikilitic plates of clinopyroxene and extensive redistribution of sulfide to olivine pseudomorphs. Deep reddish-brown transluscent spinels.

E11-51 (PTS 7027) 14 Area. Mineralized peridotite.

Similar to above. Lizardite and antigorite pseudomorphs after olivine, but texture poorly preserved. Equant clinopyroxene altering to amphibole. Sulfide redistribution to olivine pseudomorphs with antigorite development in intercumulus phase.

E12-59.5 (PTS 7036) 13 Area. Altered dunite.

Pseudomorphs of talc-carbonate after olivine in chlorite matrix. Minor sulfides with abundant secondary serpentine laths.

Some general observations can be made regarding the petrology of the 13-14 ultramafic body.

i) There is a higher clinopyroxene content than Donaldson and West Boundary.

ii) Original magmatic textures are largely obscured by alteration.

iii) Sulfide phase is pyrrhotite-rich.

iv) There is extensive sulfide redistribution due to the development of secondary alteration minerals.

Mineralization

Assay results of chip sampling across patches of rubbly gossan are listed in Table 7. The distribution of frost heave surface material in this area creates some doubt as to exact source of the mineralization. For portions of the segmented south limb, it would appear to be basal or footwall mineralization. Nickel grades of most samples are less than 1 percent and the average Ni/Sul ratio for all 11 samples is 7.6.

Assessment diamond drill holes E11 and E12 were collared at the east and west ends of the ultramafic body respectively.

DDH E11 (90°) Claim 405635-5

4.67-122.53 Serpentinized peridotite. Disseminated sulfides throughout. Minor remobilized sulfide stringers.

DDH E12 (90°) Claim 405688-5

3.66- 72.04 Serpentinite. Minor sulfides throughout.

72.04-124.05 Arenaceous and graphitic slate.

Mineralization in E11 averages 0.43% Ni, 0.10% Cu, 0.03% Co

TABLE 7

SURFACE ASSAY SAMPLES - 13-14 AREA

(Sheet 37. Compilation sheet 2.)

Sample	Field No.	Ni %	Cu %	Co %	S %	Ni/Sul	Ni/Cu+Ni
2301	Chip	1.13	0.38	0.03	4.67	7.9	0.25
2302	Chip (200')	0.66	0.28	0.02	2.90	7.4	0.30
2303	Chip	0.53	0.23	0.02	3.44	5.2	0.30
2304	Grab	0.47	0.24	0.02	2.93	5.4	0.34
2305	Chip	0.37	0.09	0.02	1.61	7.6	0.20
2306	Chip	0.46	0.15	0.02	1.15	12.2	0.25
2307	Chip	0.59	0.21	0.02	2.16	8.8	0.26
2308	Chip	0.41	0.09	0.02	1.49	8.9	0.18
2309	Chip	0.40	0.15	0.02	1.66	7.8	0.27
2310	Float	1.10	0.36	0.04	5.61	6.5	0.25
2311	Float	0.93	0.21	0.03	5.03	6.2	0.18
					Aver.	7.6	

and 1.47% S for a intersection length of 111.25m. This mineralization has a calculated Ni/Sul ratio of 9.4 which is close to that for Katiniq deposits. Although maximum nickel grade within this continuous intersection is 0.88% Ni, the hole should be deepened to the footwall contact. The consistent presence of a sulfide phase is regarded as positive indicator for footwall ore zones. Although the 13-14 body may be structurally complex and therefore difficult to evaluate, it does warrant thorough investigation.

g) WEST BOUNDARY SILL

(Sheets 40 and 41. Compilation sheet 2.)

Originally designated as the 15-16 Showing area, the West Boundary sill is the largest discrete ultramafic body occurring between Cross Lake and Donaldson. It strikes WNW for 3500m and has a maximum outcrop width of 550m. A large percentage of the surface exposure consists of rubbly frost-heaved material and the western end is covered with overburden. Road construction and gravel dumps have disturbed some portions along the northern edge of the sill. Best exposures for geological examination occur along the southern edge.

The sill occupies the interface between the southern sedimentary belt and the overlying Chukotat volcanics. Both the sediments and the underlying Povungnituk pillowed volcanics dip and face to the north in a normal sequence. Columnar joints in peridotite at the southern margin of the sill indicate a northerly dip of 15-30°. At a second locality on the north side, columnar joints indicate a dip of 40° to the north. There is a general primary layering evident in the sill, with compositions changing from a basal zone of peridotite, upward through olivine pyroxenite to a upper zone of pyroxenite. Magnetite layering is present in the basal peridotite. Comparison with the orientation of cooling joints in the same outcrops suggests that the magnetite layering may lie parallel to the primary layering of the ultramafic and the sill must therefore dip north at about 40°.

Megascopic observations on the rocks of the West Boundary sill indicate the presence of a fine grained, columnar-jointed basal peridotite containing 60-70 percent olivine and 1-4 percent sulfide. It weathers a dark tan colour, but fresh surface are blue-green and glassy due to serpentinization. Overlying the peridotite, the ultramafic is an oikocrystic peridotite on olivine pyroxenite (10 b,c) containing 40-60 percent olivine and rough weathering pyroxene oikocrysts up to 1-2 cm. in size. This unit grades in some localities to a grey-weathering, bluish-green pyroxenite consisting essentially of amphibole and talc. Minor sulfides are present in all units. A small body of gabbro near the base of the sill appears to be a late intrusion.

Petrology

To fully document the ultramafic rocks of the sill, the samples listed below were studied in polished thin-section. In each case, number represents the (DDH-metres down hole) for samples selected from the 1982 drill program.

E7-72.5 (PTS 6995) West Boundary. Dunite/Peridotite.

Colourless amphibole is extensively developed in serpentine pseudomorphs after olivine and within interstitial patches of chlorite. 1% sulfides + magnetite. (Fig. 19. App. III)

E7-77 (PTS 6996) West Boundary. Olivine pyroxenite.

Poikilitic porphyroblasts of pyroxene altered to amphibole enclosed amphibole/chlorite pseudomorphs after olivine. Original magmatic texture destoyed by extensive fine amphibole development.

E8-109.8 (PTS 6997) West Boundary. Dunite.

Euhedral antigorite pseudomorphs after olivine in net-texture sulfides (Po, Pn). No magnetite. Sulfides unaffected by antigorite growth. Well preserved primary texture. (Fig. 17, 18. App. III)

E8-106.6 (PTS 7007) West Boundary. Peridotite.

Lizardite pseudomorphs after olivine often ringed by magnetite and sulfide (Po, Pn, Cpy), with silicate overgrowth initiating penetration of intercumulus sulfide.

E10-96 (PTS 7008) West Boundary. Dunite.

Antigorite pseudomorphs after olivine (plus minor amphibole) with net sulfides and various sulfide replacement textures.

E9-110.1 (PTS 7020) West Boundary. Peridotite-Dunite.

Lizardite pseudomorphs after olivine, altering to antigorite and fibrous amphibole in some cases. Matrix antigorite.

E9-96 (PTS 7021) West Boundary. Peridotite-Dunite.

Serpentinite. Fine grained matrix serpentine with suggestion of fibrous texture enclosing olivine pseudomorphs outlined by magnetite and extensively replaced by fibrous amphibole. Euhedral zoned chromites common.

These samples confirm the layered nature of the West Boundary sill, ranging from olivine pyroxenite to dunite. The extensive alteration of all primary phases is similar to the Donaldson and Boundary peridotites and the presence of lizardite, antigorite and amphibole suggests a grade of metamorphism in the mid-greenschist facies. An intercumulus fibrous texture is evident in some samples but for the most part, this has been destroyed by late antigorite growth. Sulfide-silicate intergrowth is less prevalent than occurs at Donaldson, which may have implications of better sulfide concentrate grade.

Mineralization

Sulfides are present throughout the West Boundary sill in the range of 1-5 percent, indicating complete sulfur saturation. Sulfide content increases to the 30-40 percent range in gossans, which have been mapped at intervals over a strike length of 800m in the western part of the body. Gossans occur close to the base of the sill for part of this length and between the basal peridotite and oikocrystic olivine-pyroxenite for the remainder. Assays for gossan samples are listed on Table 8. Of considerable interest is the value of 4.96% Ni and 0.59% Cu present in sample 40-18.

Four short drill holes were completed for assessment purposes in 1982. Significant results are tabulated on Table 8. Holes E8 and E10 intersected low grade disseminated mineralization with nickel values ranging up to 1.15% Ni. Calculated nickel in sulfide ratios range from 10.9 to 16.0. These are high values and are comparable to those present in Donaldson mineralization.

Conclusion

West Boundary sill has had no prior exploration expenditures other than described in this report. Its high olivine content, stratigraphic location, sulfide content and nickel in sulfide ratios combine to place it high on the priority list as a potential host for nickel sulfide ore zones.

TABLE 8

SURFACE ASSAY SAMPLES - WEST BOUNDARY SILL

(Sheets 40 & 41)

Sample	Field No.	Ni %	Cu %	Co %	S %	Ni/Sul	Cu/Cu+Ni
2401	40-16	1.59	0.46	0.05	7.87	6.7	0.22
2402	40-18	4.96	0.59	0.07	14.7	10.8	0.11
2403	40-23	1.00	0.23	0.03	3.91	8.4	0.19
2407	41-CJ2	1.67	0.62	0.03	4.48	11.5	0.27
2408	41-CJ3	1.80	0.37	0.03	3.36	15.8	0.17
					Aver.	11.6	

1982 ASSESSMENT DRILL RESULTS

DH	From-To (m)	Ni %	Cu %	Co%	S %	Ni/Sul	Cu/Cu+Ni
E8	92.28-115.66 (23.38)	0.72	0.23	0.03	2.07	10.9	0.24
E8	108.62-110.62 (2)	1.01	0.16	0.04	2.32	13.4	0.14
E10	84.88- 98.15 (13.27)	0.61	0.12	0.03	1.12	16.0	0.16
E10	95.10- 96.62 (1.52)	1.15	0.23	0.04	2.50	13.9	0.17

h) BOUNDARY SILL

(Sheet 44. Compilation Sheet 3.)

The Boundary ultramafic body, so named because it straddles the west boundary of the original PRM. 160 concession block, lies at the contact of Povungnituk tholeiitic basalts and komatiitic basalts of the Chukotat Group. It is intrusive into the thick sequence of argillites and siltstones at the top of the Povungnituk, locally lying in contact with an older gabbroic sill. The body has an east-west strike length of about 3000m and a 15° northerly dip. Prior to erosion it is highly likely that the Boundary ultramafic was continuous with West Boundary and possibly Donaldson sills, forming a single large mineralized complex.

The Boundary intrusion has a strike length very much greater than its dip length and so has a general flattened "cigar" shape. Drill data from the eastern area indicates that the ultramafic interfingers with sediments and volcanics and decreases rapidly in thickness down dip to the north. Surface mapping and magnetic data suggest a thinning of the ultramafic in the central part of sheet 44 at about 586750E. This provides a natural division of the sill into east and west parts, which seems to coincide with changes in the geometry of the sill. The east end hosts most of the presently known sulfide mineralization. It is geologically complex and occurs as a single 100m thick unit or four thinner units separated by intervening sediments and volcanics. The western part of the ultramafic is at least 300m thick.

Petrology

The following samples were studied in polished thin section to more fully describe the Boundary ultramafic. In each case the number represents the (DDH-metres down hole) for samples selected from the 1982 drill program.

E6-82.6 (PTS 6968) Boundary. Mineralized serpentinite.

Rock is a partially carbonatized antigorite serpentinite. Minor clinopyroxene. Olivine pseudomorphs partially replaced by sulfide. Abundant antigorite growth in sulfides.

E4-113.6 (PTS 6969) Boundary. Mineralized peridotite.

Remnant clinopyroxene. Well defined olivine pseudomorphs in antigorite matrix. Pseudomorphed olivines varied in size and clouded with secondary amphibole needles. Sulfide mobilization apparent. Abundant magnetite.

E4-54.6 (PTS 6983) Boundary. Dunite.

Lizardite pseudomorphs after olivine, partially carbonatized. Intercumulus sulfide-magnetite mixture (from serpentinization, minor magnetite remaining around olivines). Incipient antigorite growth in intercumulus sulfide phase. (Fig. 20. App. III)

E6-86 (PTS 6986) Boundary. Dunite-peridotite.

Olivine pseudomorphed to lizardite and incipient amphibole needles. Minor fresh clinopyroxene. Sulfide patches remobilized around olivine pseudomorphs. Some antigorite in matrix.

E6-106 (PTS 6988) Boundary. Dunite-peridotite.

Olivine pseudomorphs appear to be lizardite, and well preserved. Minor fresh clinopyroxene. Some sulfide rimming pseudomorphs due to remobilization.

The entire area examined has been metamorphosed to (lower) greenschist facies, characterized by antigorite-chlorite ± diopside ± tremolite ± dolomite in the ultramfic rocks and zoisite-chlorite-tremolite in the mafic rocks. Biotite is entirely lacking in the metasediments, except immediately adjacent to the ultramafic body.

Within the ultramafic, the sequence of alteration appears to be as follows:

a) Lizardite and/or antigorite pseudomorphing olivine.

b) Tremolitic alteration of serpentine and clinopyroxene (common in the mineralized zones).

c) Dolomitic alteration of serpentine.

d) Late antigorite veinlets.

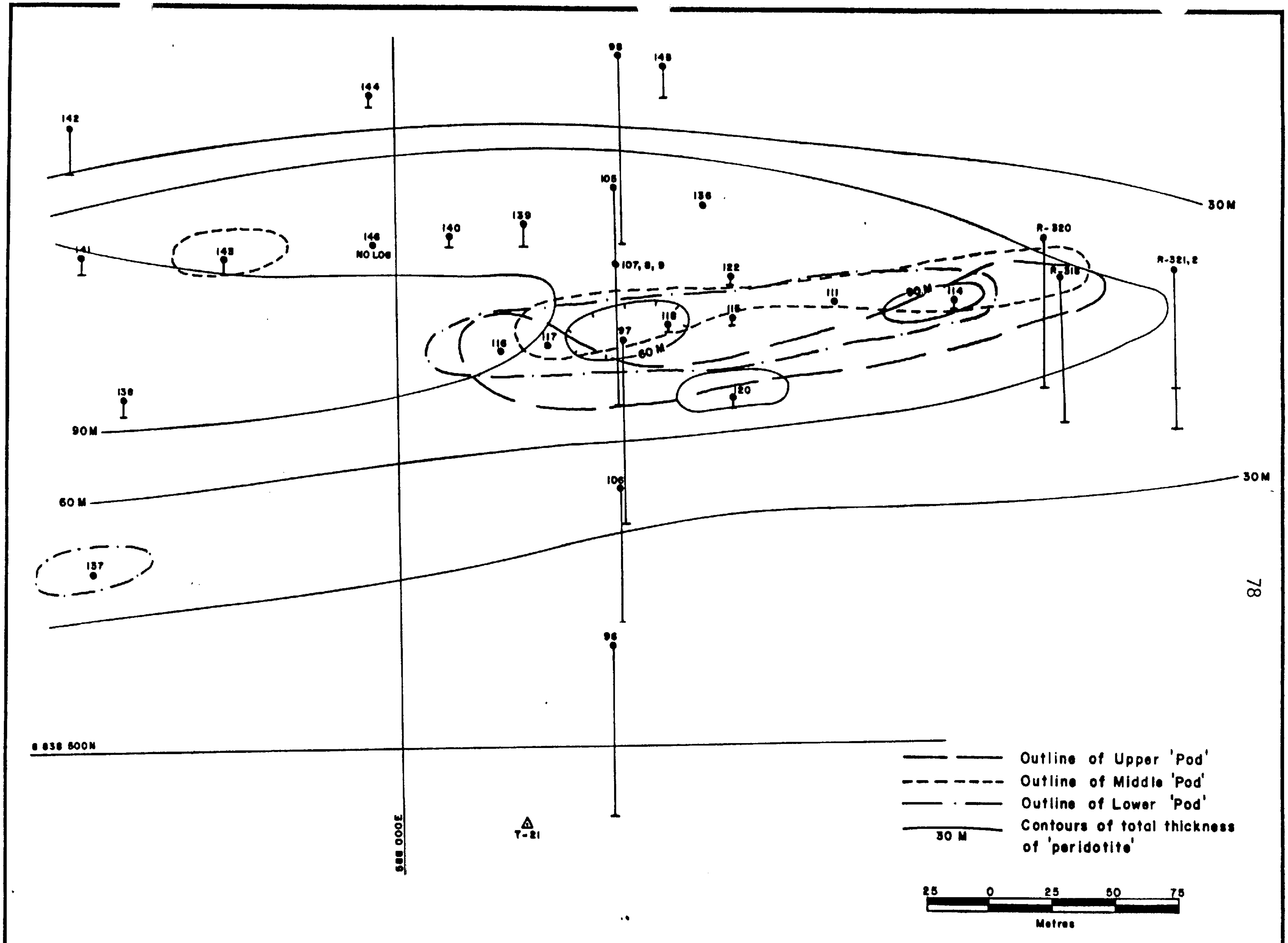
Pyroxenites are present in the marginal areas of the Boundary sill. They are fine-grained and consist of prismatic to skeletal augite with cores of chloritized pigeonite in a fine altered matrix.

Peridotites in the areas of mineralization are essentially cumulate rocks with a fine grained groundmass and well developed columnar jointing.

Mineralization

Sulfide mineralization at Boundary occurs at the basal ultramafic-metasediment contact, at the base of higher ultramafic units overlying bands of sediments or volcanics, or entirely enclosed with ultramafic rocks, perhaps at internal intrusion contacts. There is no apparent control by footwall topography, but all significant sulfides occur in the thicker, central part of the flattened "cigar-shaped" body (Figure 7).

Ore mineralogy consists of the simple assemblage of pyrrhotite, pentlandite, chalcopyrite and magnetite. Except for massive sulfide, textural modification is severe and ubiquitous. Common sulfide textures include veinlet filling and fracture coatings, reverse


142
144
141
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146
NO LOG
140
139
105
136
107, 8, 9
122
R-320
R-321, 2
111
114
90 M
97
116
117
60 M
120
138
90 M
60 M
30 M
106
30 M
137
6 838 500N
588 000E
T-21
Outline of Upper 'Pod'
Outline of Middle 'Pod'
Outline of Lower 'Pod'
Contours of total thickness of 'peridotite'
30 M
25
0
25
50
75
Metres

Figure 7

net texture involving sulfide replacement of serpentinized cumulate olivine, and random complex intergrowths of sulfide with antigorite and tremolite. Copper rich veinlets cut massive and disseminated sulfide sections and are also present in footwall metasediments.

Drilling has shown that mineralization in the eastern end of the Boundary ultramafic body occurs in 3 east-west trending pods stacked on top of each other to a depth of 100m. The ore pods are all extremely elongate with strike length of about 350m and down-dip extensions of 50m. Thicknesses vary from thin seams to nearly 10m of high grade ore. The three main ore pods have possible speculative reserves of:

Upper zone	190,000 tons	2.5% Ni
Middle Zone	110,000 "	1.8% Ni
Lower Zone	250,000 "	4.1% Ni

(Based on 1.5% Ni cut-off for Lower and Middle Zones, 1% Ni cutoff for Upper Zone. Minimum 15 Ni-ft.)

Assessment diamond drill holes E4, E5 and E6 during the 1982 program, were collared in a north-south fence pattern in the approximate centre of the western part of the body.

E4 (90°) Claim 405674-4 (Central)

4.17-121.92 Serpentinized peridotite-dunite. Sulfides throughout (87m 0.43% Ni) Bottomed in mineralization 1.71% Ni.

E5 (90°) Claim 405675-4 (South)

3.08- 17.19 Serpentinite

17.19- 51.86 Volcanic

51.86-124.05 Serpentinite. Minor sulfides.

<u>E6</u> (90°) Claim 405671-5 (North)

6.83- 16.30 Volcanic

16.30- 27.12 Slate

27.12- 41.76 Volcanic

41.76-122.96 Serpentinite. Disseminated sulfides throughout. Low grade mineralization.

<u>Conclusions</u>

The thin nature of the hosting ultramafics at the east end of the Boundary sill, mitigates the possibility of large tonnage potential. En echelon lenses to the exposed sill may occur down-dip to the north as is indicated by the presence of unexplained magnetic anomalies. The shallow dip of the Boundary sill and enclosing rocks suggests that any such lenses would be a relatively shallow depth.

The thick, well mineralized western part of the sill has the potential for major nickel ore zones. Initially, the assessment drill holes E4, E5 and E6 should be deepened to the footwall contact to establish sill geometry in this area.

From available data, grades of massive sulfide sections at Boundary contain 12-13% Ni, somewhat higher an average than those at Donaldson. Complex textural modifications due to metamorphic recrystallization with resulting silicate-sulfide intergrowth will undoubtedly reduce nickel recoveries at acceptable concentrate grades.

i) <u>DONALDSON SILL</u>

(Sheet 48. Compilation sheet 3.)

The Donaldson ultramafic sill is the most easterly of the mineralized intrusive dunitic bodies and it is the one which has received the greatest amount of exploration and development. The ultramafic is intrusive into Povungnituk sediments close to the contact with Chukotat MgO-rich volcanics. Interlayering of volcanics and sediments is evident close to the contact, indicating that in this area at least, Chukotat volcanism had begun in a sporadic fashion prior to the cessation of active sedimentation. Although the immediate area of Donaldson is low-lying and drift-covered, the ultramafic is exposed on surface for a strike length of about 1400m. Magnetic signature indicates lateral extensions for a total strike length of about 2800m. Enhanced magnetics show the anomaly to be in two parts separated by a magnetic low, which correlates with the east and west ultramafic exposures separated by a central area of gabbro.

Host rocks to the ultramafic body consist of a variety of fine grained argillaceous sediments, amphibole-rich volcanics and a range of earlier gabbro sills and intrusions. Sediments include fine grained quartzites, quartz-feldspar-biotite siliceous argillites, laminated argillites, black graphitic slates and pyrrhotite-rich sulfidic slates. They exhibit a complete range of sedimentary features together with micro-folding and faulting textures. Volcanic rocks are light to dark green and tremolite-rich. Only in thin-section is it evident that they can possess a microspinifex texture completely replaced by fibrous amphibole. Gabbroic rocks are considered as a single group, but include a wide range of compositions from porphyritic granophyre, and altered diorite to dark green gabbro. Some of the gabbros had an originally high titanium content, evident from a "wormy" texture due to elongate, irregular grains of sphene which formed at the expense of ilmenite.

Donaldson ultramafic rocks range in composition from marginal zones of pyroxenite to olivine-rich dunites. Although secondary alteration of all primary silicate minerals is practically complete, original textures are preserved. Pyroxenites alter to colourless amphibole and serpentinization with lessor talc-carbonate alteration is pervasive in the olivine-rich cumulate rocks. The matrix quench texture observed in all the mineralized intrusive dunitic peridotites of the Raglan area is also present at Donaldson. Olivine cumulate rocks consist of euhedral grains of pseudomorphed olivine and a fine grained serpentine matrix in approximately equal proportions. Talc-serpentine-amphibole pseudomorphs after olivine vary in shape from equant to elongate with maximum c/a axes dimension of about 6:1. The matrix exhibits radial growths and quench textures and may be heavily disseminated with minute particles of ilmenite. The quench texture is comparable to the clinopyroxene-chlorite intergrowths visible in the Katiniq ultramafic and is typically developed in quickly-cooled MgO-rich, layered extrusive rocks in other parts of the world. (Fig. 21. App. III)

Structure

The ultramafics hosting the Donaldson ore zones are irregular in shape both along strike and down-dip to the north. Adding to this complexity are four NE trending, late cross faults which interrupt stratigraphic continuity in an E-W direction. For reference these are termed the NE, Esker, Pov and West faults. Two NW trending faults, termed the NW and Innuit faults appear to be important only in the eastern half of the area. As discussed in an earlier section of this report, the cross faults are tensional elements related to the D_3 deformation event and presumably have normal or rotational movements. The variation and irregularity of dip of the stratigraphy intersected by the faults has produced considerable apparent offsets across the faults. For the following analysis of Donaldson structure, the reader is referred to the coloured 1:1250 cross-sections on file and to the diamond drill hole and section location plan of Figure 8.

The division of the Donaldson area into two distinct structural domains appears to take place along the Pov. fault. An apparent rotational or scissors movement is suggested for this fault as it cannot be readily extended beyond the mine buildings to the south. It separates the thick, flat lying sill with its irregular footwall topography, which hosts the west Donaldson ore zone, from a series of thinner north-dipping sills on the east side. The principal West Donaldson sill is truncated by an interpreted fault termed West fault, located subparallel to and 300m west of the Pov fault. Sedimentary rocks underlie the overburden-covered area west of the West fault as indicated by drill holes E2 and E3, completed during the 1982 assessment program. Hole E3 intersected 15m of serpentinite which represents the magnetically indicated western extension of the Donaldson sill beyond the fault. Its magnetic expression is 600m long, but down dip attitude and thickness are not known (Area A, Figure 8).

West Donaldson

The structure of the West Donaldson area is most easily reviewed by an examination of N-S cross-sections 590242E, 304, 366, 402 and 430. Two flat-lying to gently N-dipping ultramafic sills are present, separated by a narrow septum of sediments and volcanics. This intervening assemblage is not visible on surface but appears

Microfilm

PAGES DE DIMENSION HORS STANDARD

MICROFILMÉE SUR 35 MM ET

POSITIONNÉES À LA SUITE DES

PRÉSENTES PAGES STANDARDS

Numérique

PAGES DE DIMENSION HORS STANDARD

NUMÉRISÉE ET POSITIONNÉE À LA

SUITE DES PRÉSENTES PAGES STANDARDS

to extend in an E-W direction immediately to the south of the Donaldson Surface deposit. The upper sill of the pair hosts both the Surface and West Donaldson ore deposits. It has a maximum thickness of 250m overlying the West ore zone, which occurs in a pronounced footwall embayment, but not necessary in direct contact with footwall rocks. The exposed Surface deposit, close to the outcrop edge of the upper sill occurs in a subsiduary footwall embayment with a maximum depth of about 35m.

The lower sill has not been drill tested to any great extent, but appears to have a maximum indicated thickness of about 200m. Disseminated sulfide mineralization is recorded in those holes which have intersected this body and narrow zones of high grade ore are present (DDH 160-54, 0.39m, 5.40% Ni, 1.80% Cu). Although detailed information on the lower sill is minimal, it represents a substantial potential target, perhaps best evaluated by underground drilling from the 702E and 703N drives (Area B, Figure 8).

The West Donaldson upper sill pinches off in a bulbous termination down-dip on some sections, but continues as a mineralized unit to the east until it is truncated by the NE trending Pov fault. This is illustrated on section 590550E, where the downdip extension is open to the north of the fault. No diamond drilling has been undertaken north of the fault on any section east of 550E, and so this remains a deep area of untested, but considerable potential (Area C, Figure 8).

East Donaldson

On a structural and sill geometry basis, the area east of the Pov fault is referred to as East Donaldson. Two additional faults, the Esker and NE faults trend northeast subparallel to the Pov fault at approximate intervals of 200m. Between the Pov and Esker faults, two ultramafic sills dip approximately 30°N. The upper sill is 80m thick and has a basal zone of mineralization. (DDH 160-88, 7.1m, 3.03% Ni, 0.57% Cu; Section 590612E). The up-dip extension of this zone is intersected in DDH 160-190 with a narrow high grade zone of 0.37m, 14.3% Ni, 5.6% Cu, 0.22% Co in an overall sill thickness of 37m. High grade stringers are also present in DDH 160-130, but because of the presence of the Povungnituk River, there is a paucity of drilling in this area and the structure is not well understood. Nevertheless, the downdip region north of the Esker fault does have some potential, but perhaps of lower priority (Area D, Figure 8).

South and east of the Esker fault, the overall structure is more simple and lithologies can be correlated from section to section. Continuity of lithologies is disrupted somewhat by the NE fault and the northwest trending NW and Innuit faults. Three ultramafic sills in this area dip about 35°N and vary in thickness from a minimum of 10m to over 100m. Black graphitic slates, siliceous argillites and interbedded volcanics comprise the intervening rock types. A gabbro sill up to 70m thick displaying chilled contacts with enclosing sediments is present between the upper and central ultramafic sills. The lowermost sill of the group is mineralized and hosts the important East Donaldson deposit. This mineralized zone is unique in its location close to the upper of hangingwall surface of the sill, and overlying an enclosed thin septum of volcanics and sediments. It is not certain whether this represents a large included block within the sill or whether the sill is composed of two distinct intrusions, one of which is highly mineralized.

The East Zone maintains continuity for a considerable distance, but is disrupted by the NW and Innuit faults at its western end (Section 590657E). In this area a high grade intersection of remobilized massive sulfide is present in DDH 160-233 (Section 690705E, 5.24m, 11.34% Ni, 3.66% Cu). These sulfides are enclosed in volcanics and sediments and as a remobilized gash vein-filling, may not have a great deal of continuity. Hole deflection negates the possibility of determining its exact location with reference to the East zone and further drilling from the 702E drive is required.

The upper sill at East Donaldson is sporadically mineralized and three small ore zones termed the 104, 206 and 47 Zones have been outlined. The 47 zone has formed close to a footwall topographic depression in the sill but this relationship is not apparent in the other two zones. Exploration drilling in this eastern part of the Donaldson complex has concentrated on the investigation of the upper sill. The lower sill, which hosts the East Donaldson deposit is an obvious drill target in its down dip extension. (Area E, Figure 8.)

The magnetic expression of the East Donaldson sills extends east to slightly beyond the Povungnituk River. A short assessment drill hole (E-1) collared east of the river during the 1982 program, intersected sediments and Chukotat volcanics but failed to reach the horizon of the ultramafic sills. This area, where the sill complex is thinning and pinching out is regarded as having low potential (Area F, Figure 8).

Summary of Donaldson Areas for Additional Potential

With reference to Figure 8, the following locations have potential for adding tonnage to presenting known ore zones or for the discovery of new zones within the extensions of documented mineralized environments.

A. Downdip on the west extension sill to the west of West fault. This sill is thin near surface but no information is available at depth.

B. The lower sill underlying the mineralized West Donaldson sill.

C. The Donaldson sill down dip and north of the Pov fault.

D. Downdip on the mineralized sill between the Pov and Esker faults.

E. East Donaldson lower mineralized sill (host to East zone) on downdip extension.

F. East extension to Povungnituk River of East Donaldson sills.

Mineralization and Mineralogy of Donaldson Ores

Mineral inventory estimates for Donaldson are listed in Table 9 (LAW 1982). Quoted grades indicate a Ni:Cu ratio 4.3=1 and a Cu/Cu+Ni value of 0.19 for these ores, compatible with a magmatic origin from a magnesia-rich source. In this section, a brief review of the sulfide mineralogy will be made, with emphasis on sulfide-silicate relationships and the conditions under which these developed. A complete list of research reports conducted by Falconbridge Metallurgical Laboratories on Raglan ores is appended to this report. The greater proportion of more recent investigations has been undertaken by R. Buchan at FML and in the following section, liberal use is made of that material. (Appendix II)

TABLE 9

NEW QUEBEC RAGLAN MINES LIMITED

PRELIMINARY MINERAL INVENTORY ESTIMATES

Donaldson Area

		Metric			Imperial		
Area	Category	Tonnes	% Ni	% Cu	d.s.Tons	% Ni	% Cu
West	Proven	2,010,238	3.47	0.85	2,215,907	3.47	0.85
East	Proven	664,169	3.41	0.68	732,122	3.41	0.68
Open Pit	Proven	173,057	3.27	0.82	190,763	3.27	0.82
TOTALS	Proven	2,847,464	3.44	0.81	3,138,792	3.44	0.81
East	Probable	515,884	4.08	0.87	568,664	4.08	0.87
Upper	Probable	471,824	2.72	0.68	520,096	2.72	0.69
TOTALS	Probable	987,708	3.43	0.78	1,088,760	3.43	0.78
TOTALS	Proven & Probable	3,835,172	3.44	0.80	4,227,552	3.44	0.80

With few exceptions, the sulfide mineralogy consists of pyrrhotite, pentlandite and chalcopyrite and occasionally minor pyrite. Available electron-probe analyses of these minerals are listed in Table 10. Of note is the unusually high nickel content in some pentlandite (*) associated with a substantial cobalt content. Associated pyrrhotite (**) has an exceptionally high nickel content of 1.39 percent. A single analysis of pyrite from Donaldson shows a significant Co content of 0.51 percent.

Pentlandite is fresh and unaltered in most samples examined with only some slight alteration to violarite noted in the Donaldson Surface deposit. It occurs as blocky grains for the most part with only 2-3 percent occurring as exsolution "flames" in pyrrhotite. The latter mineral is present as a mixture of both monoclinic and hexagonal types. Chalcopyrite content in individual samples is highly variable and may constitute up to 30 percent of the total sulfides. It is prominent as late veinlets accompanied by pyrrhotite or pyrite. Pyrite-chalcopyrite veinlets in some samples contain trace amounts of rare minerals such as galena, gersdorflite and native gold. Calculated pyrrhotite/pentlandite ratios for the ore zones intersected by the 1981 metallurgical test holes are as follows.

DDH	Metres	Po:Pn
160-224	193-237	0.9 (West
	239-274	1.2
160-225	7-26	2.3 (Surface)
160-228	237-248	1.5 (East)

TABLE 10

ELECTRON-PROBE ANALYSES OF ORE MINERALS

RAGLAN AREA (wt %)

	Ni	Cu	Co	Fe	S	Area
Pentlandite	35.0	0.17	0.80	29.4	32.6	Donaldson
"	36.3	0.04	0.03	30.9	33.6	"
" (*)	38.1	-	0.71	28.3	33.1	"
"	37.8	-	0.53	29.4	34.0	Boundary
"	35.4	-	1.10	29.7	33.2	2-3 Area
Pyrrhotite	0.29	0.07	0.14	60.9	39.4	Donaldson
"	0.39	0.03	0.05	59.7	40.3	"
" (**)	1.39	-	-	58.4	39.9	"
"	1.06	-	0.08	59.4	40.1	Boundary
"	0.68	-	-	60.0	39.5	2-3 Area
Chalcopyrite	0.05	34.8	-	29.9	34.9	Donaldson
"	-	34.4	-	30.5	34.8	2-3 Area
Pyrite	0.08	0.03	0.51	46.1	53.0	Donaldson

Oxides present in the sulfide ores consist of euhedral, opaque and zoned Fe-rich chromites, trace amounts of anhedral ilmenite grains throughout matrix silicates and abundant secondary magnetite derived from the serpentinization of olivine. Magnetite generated during this process, depending on its mobility state, either remains as discrete particles in the serpentine, forms rims around the serpentine pseudomorphs or where an intercumulate sulfide phase is present, becomes incorporated with the sulfides. In the latter environment magnetite exhibits a tendency to form rims around pyrrhotite grains and to preferentially invade pentlandite grains along cleavages and fractures. This serves to demonstrate that the sulfides were present as an interstitial phase prior to the serpentinization of olivine on cooling from magmatic temperatures.

The subsequent sequence of geological events documented for the Raglan area, involved prograde metamorphism to at least the grade of mid greenschist facies, which produced severe modifications to the ultramafic rocks and their contained sulfides. The modifications have important economic connotations. On the positive side, ore values are upgraded in the formation of nickel-rich mobilized veins and the possible amalgamation of disseminated sulfide to a coarser 'droplet' form. Of greater significance is perhaps the negative side, where induced silicate growth in net-textured sulfides surrounding serpentinized olivine grains, has produced a fine intermixture and sulfide grain division, such as to seriously affect concentrate recoveries and grades.

Silicates formed in the sulfide phase during metamorphism are euhedral, sharp-terminated grains of tremolite and fine acicular crystals of antigorite serpentine. The latter is predominant in most ore samples and can be observed at many stages of development. Increasing content of acicular antigorite in the sulfides is accompanied by sulfide transferral to alternate sites, in most cases to the cumulate olivine pseudomorphs. Demonstrable evidence for this movement of sulfide includes the presence of increasing proportion of sulfide within the preserved outline of olivine grains, interconnecting network of fine stringer sulfides and sulfide zonation in the cumulate olivine grains. In the latter case, central cores are pyrrhotite surrounded by overgrowths of pentlandite. Increasing antigorite growth at the site of the original intercumulate sulfide phase eventually results in a fine mesh intergrowth, with the remaining sulfide occupying minute triangular interstices between matted grains of acicular antigorite. The process results finally in what is termed a "reverse-net" texture. Sulfides surrounded or enclosed by carbonate appear to be shielded from secondary antigorite development.

The preferential development of euhedral amphibole crystals in the sulfide phase, accompanied by only incipient amphibole development in the serpentine pseudomorphs and the preferential first development of acicular antigorite in the sulfide phase rather than in the pseudomorphs, relates to sulfur loss or sulfide mobilization under the prevailing metamorphic conditions. Porphyroblastic silicate growth in the sulfide phase does not reflect "force of crystallization", but to the availability of growth sites, perhaps under constant pressure in an essentially closed chemical system.

IV. PLATINUM GROUP ELEMENT (PGE) CONTENT OF RAGLAN ORES

Recent analytical work on Donaldson ores show them to be rich in platinum and palladium with about 2.2 and 4.4 ppm respectively. These determinations, weighted in proportion to tonnages for the West, East and Surface deposits were obtained from the core intersections of the 1981 metallurgical test hole program. Additional data from Donaldson, Katiniq and 2-3 Area is available from special studies on selected individual samples. The recalculated figures representing metals in 100 percent sulfides are listed in Table 11.

Mineralogical work by G. Spinger at FML has identified and analysed the palladium minerals, kotulskite Pd (Te, Sb, Bi), merenskyite Pd $(Te, Bi\ Sb)_2$, sudburyite Pd Sb, testibiopallidite Pd Te Sb and an unnamed mineral with the approximate composition $(Pd, Ni)_2(Te,Sb)_3$. Platinum occurs as sperrylite $PtAs_2$ and possibly elemental Pt. Some platinum-bearing phases are closely associated with galena. In addition, gold is present as electrum with a silver content of 20 percent. Overall gold content of the ores is very low, with the exception of two samples with anomalously high values of 2.0 and 2.4 g/tonne respectively.

Many of the platinum group minerals occur as inclusions in pyrite and pyrrhotite rather than chalcopyrite and pentlandite. Further research on platinum group element chemistry and distribution in the Raglan ores is being done at Carleton University by H. Dillon-Leitch under the supervision of D. Watkinson.

TABLE 11

PGE CONTENT OF RAGLAN ORES METALS IN 100% SULPHIDES

	Ni	Cu	Co	Pt	Pd	Rh	Ru	Ir	Os	Au
		%		ppm = g/tonne						
Donaldson W (1)	12.99	3.11	0.2	3.5	12.0	(0.7)	(1.7)	(0.3)	(0.3)	(0.4)
Donaldson (4) West (160-224)	12.43	3.98	0.18	7.7	12.1	-	-	-	-	-
East (160-228)	11.53	2.04	0.17	5.4	10.4	-	-	-	-	-
Surface (160-225)	10.79	2.15	0.18	5.2	12.7	-	-	-	-	-
Katiniq (2)										
(K64)	9.03	3.56	0.18	3.3	6.3	0.5	1.5	0.2	0.3	0.3
(K88)	9.21	0.93	0.17	1.9	5.4	0.7	1.3	0.2	0.2	0.1
(B4AG)	8.7	1.51	0.18	2.7	5.0	0.4	0.8	0.2	0.2	0.1
2-3 Area (3) (23-53-723)	14.6	1.85	0.24	2.0	0.6	1.1	-	-	-	-
(23-46-493)	9.7	4.76	0.25	1.0	1.3	0.3	-	-	-	-

(1) Naldrett (2) Barnes (3) Miller (4) FNM-Sudbury Assay Lab.

V. RAGLAN AREA - EXPLORATION PRIORITIES AND RECOMMENDATIONS

This report has documented the geological setting, structural environment and composition features of a group of eight intrusive dunitic peridotite bodies which make them unique and distinct targets for nickel sulfide mineralization in the Raglan belt. They can be considered as late stage intrusions or feeder vents through which cumulate olivine in a pyroxenitic liquid accompanied by sulfide, rose to near-surface levels and quickly cooled. Their location is structurally controlled at the margin of a basin in which a thick sequence of MgO-rich komatiitic volcanic rocks was accumulating. Because of late structural disturbances and the convergence of high angle reverse faults, no additional equivalent bodies are present east of Donaldson mine. To the West of Cross Lake, the geology is not well known and its consideration is beyond the scope of this report.

Each of the dunitic peridotite bodies varies in size, shape and other structural details but within each, sulfide mineralization rich in nickel and platinum group elements occurs in zones towards the structural base of the host body, in areas of paleotopographic lows. These features are consistent with an interpreted magmatic origin for the sulfide mineralization. In light of this, the thickest and largest bodies, or those areas closest to deep feeder vents have the highest potential for the presence of large orebodies. West Donaldson is the largest single ore zone presently known, but there is no valid reason to assume that it is the largest that may be found in the Raglan area.

The present established infrastructure at Donaldson and the

Katiniq-Donaldson road must be considered in recommending exploration priorities. With this in mind, future exploration targets for drill intensive exploration can be listed as follows.

1) Donaldson: The remaining areas of potential listed for Donaldson would be in reach of a mine development system (A-F, Figure 8) and as such have high priority.

2) Boundary: Because of its thickness and known sulfide content, the western half of Boundary ultramafic body has a high priority and a high potential for large ore zones. The eastern half is more complex and consists of a number of thinner sills similar to East Donaldson. The pod-like zones presently known in the eastern part are near surface, but have limited tonnage potential.

3) West Boundary: Little is presently known about the West Boundary ultramafic, but it has the size, sulfide content and composition to anticipate the possibility of large ore zones.

4) Katiniq: Established reserves of ore grade material at Katiniq could almost certainly be doubled by fill-in and additional down-dip exploration drilling.

5) East Lake: Although located about 15 km beyond the end of the Katiniq access road, East Lake is given high priority because of its size, composition and sulfide content. This represents a major unexplored target of high potential. Lessor apparent silicate development in the sulfide phase would enhance concentrate grades.

6) 2-3 Area: This body is relatively thin and steeply-dipping. It has an established tonnage reserve in canoe-shaped troughs

in the basal contact. Deeper drilling would be difficult and expensive but as a whole, the body has additional potential of lower priority.

7) 5-8 Area: 13-14 Area: Although within reach of the Katiniq-Donaldson road, these zones are listed as low priority for the reason discussed in their individual sections.

VI. RAGLAN NICKEL IN GLOBAL PERSPECTIVE

Table 12 lists all significant world nickel deposits which are known to have pre-mining reserves of more than 100 x 10^3 tonnes nickel metal and/or average grades of more than 1.0% Ni. For comparison purposes, the deposits are grouped in the broad divisions of intrusive dunite, volcanic peridotite and gabbroic associations, representing the principal host rocks to these magmatic ores. There are obviously many differences in detail between deposits within each association, but as a whole they have fundamental similar characteristics. Because of the generally accepted magmatic origin for sulfide nickel deposits, whereby an immisible sulfide phase separates from a crystallizing silicate melt, some features are common to all deposits. Later deformation, metamorphism and alteration may often obscure the initial magmatic character.

Tonnage and grade are the most important features of any deposit. Factors influencing tonnage would include

1. Size of the host igneous body. As the size of the host increases, the potential for larger tonnage deposits also increases.
2. Nickel and sulfur content of the magma.
3. Size of the confining trap in which the sulfides accumulate.
4. History of magma intrusion and circulation.
5. Post ore deformation.

Factors influencing grade are more difficult to define, but must be controlled principally by the crystallization history of the magma and the magma's primary sulfur and metal content. Sulfur saturation of the magma before significant silicate crystallization would permit the existence of a high grade sulfide phase. Silicate

TABLE 12

COMPARISON OF WORLD NICKEL SULFIDE DEPOSITS

(Selection based on reserves > 100 x 10^3 Ni tonnes and/or > 1% Ni grade)

(Listed by decreasing Ni grade in each association)

Deposit	Country	Orig Reserves Ni x 10^3 tonnes	% Ni	TGF*	Ni:Cu	AGE	Geol Environment
		A. INTRUSIVE DUNITE ASSOCIATION					
Flying Fox	Aust	24.4	6.1	0.7	-	Archean	Greenstone Belt
Ungava (4)	Can	402.9	3.11	6.3	4	Low. Proter.	Mobile Belt
Cosmic Bay	Aust	77.7	2.89	1.1	-	Archean	Greenstone Belt
Digger Rocks	Aust	47.6	2.39	0.6	-	"	"
Manibridge	Can	17.0	2.17	0.2	13	" (?)	Mobile Belt
Agnew	Aust	922.0	2.05	9.4	20	"	Greenstone Belt
Bucko Lake	Can	85.1	1.85	0.8	14	" (?)	Mobile Belt
Thompson Area	Can	2420.0	1.80	21.8	15	" (?)	Mobile Belt
Digger Rocks	Aust	53.6	1.39	0.4	-	"	Greenstone Belt
Amax No. 34	Can	88.1	1.33	0.6	17	" (?)	Mobile Belt
Honeymoon Well	Aust	720.0	0.9	3.2	-	"	Greenstone Belt
Moak Lake	Can	750.0	0.75	2.8	-	" (?)	Mobile Belt
Mount Keith	Aust	1740.0	0.6	5.2	60	"	Greenstone Belt
Six Mile	Aust	475.0	0.5	1.2	60	"	"
		B. VOLCANIC PERIDOTITE ASSOCIATION					
Carnilya East	Aust	14.7	3.78	0.3	19	Archean	Greenstone Belt
Nepean	Aust	7.2	3.6	0.1	15	"	"
Redross	Aust	34.3	3.43	0.6	14	"	"
Kambalda	Aust	708.5(?)	3.28	11.6	13	"	"
Rankin	Can	16.3	3.2	0.3	-	"	"
Marbridge	Can	17.6	2.53	0.2	-	"	"
Selukwe	Zimb	25.0	2.5	0.3	-	"	"
Spargoville (3)	Aust	15.5	2.46	0.2	11	"	"
" (1)	"	8.5	2.35	0.1	12	"	"
" (2)	"	2.8	2.32	0.0	12	"	"
Langmuir (2)	Can	30.8	2.2	0.3	27	"	"
Scotia	Aust	17.6	2.14	0.2	16	"	"
Munda	Aust	4.2	1.65	0.0	16	"	"
Mt. Windarra	Aust	102.6	1.53	0.8	-	"	"
Shebandowan	Can	225.0	1.50	1.7	1.5	"	"
Langmuir (1)	"	2.6	1.3	0.0	-	"	"
Dordie Rocks (N)	Aust	12.3	1.23	0.1	19	"	"
Widgiemooltha	"	12.3	1.23	0.1	12	"	"
Wannaway	"	54.9	1.22	0.3	12	"	"
Sotham	Can	6.3	1.05	0.0	-	"	"
Texmont	"	38.0	1.0	0.2	50	"	"
Damba	Zimb	75.0	1.0	0.4	-	"	"
Shangani	"	147.2	0.92	0.7	-	"	"
Trojan	"	109.0	0.78	0.4	-	"	"
Hunters Rd	"	210.0	0.7	0.7	-	"	"
		C. GABBROIC ASSOCIATION					
October	USSR	2200.0	3.65	40.1	0.77	Phan.	Fold Belt
Tamyr	"	1000.0	2.5	12.5	-	"	"
Lainijaur	Swed	2.6	2.22	0.0	2.5	Low. Prot.	Mobile Belt
Phoenix	Bots.	94.5	2.1	1.0	2.6	Archean	"
Gordon L	Can	17.3	1.62	0.1	2.4	"	Greenstone Belt
Sudbury	Can	12500.0	1.60	100	1.2	Low. Prot.	-
Talnakh (2)	USSR	1068.0	1.5	8.0	0.5	Phan	Fold Belt
Carr Boyd	Aust	11.5	1.49	0.1	0.3	Archean	Greenstone Belt
Montcalm	Can	63.4	1.41	0.4	2.1	Archean	Greenstone Belt
Giant Mascot	Can	28.7	1.4	0.2	2.8	Phan	Fold Belt
Pikwe	Bots	423.0	1.36	2.9	2.6	Archean	Mobile Belt
Kenbridge	Can	37.1	1.06	0.2	1.9	"	Greenstone Belt
Dumbarton	"	16.3	1.06	0.1	3.1	"	"
Jinchuan	China	5450.0	1.06	28.9	1.58	Low. Prot.	Mobile Belt
Maskwa	Can	11.2	1.05	0.1	5.8	Archean	Greenstone Belt
Madziwa	Zimb	30.0	1.04	0.2	-	"	"
Pechenga	USSR	360.0	1.0	1.8	2.3	Mid Prot	Mobile Belt
Lynn L.	Can	182.9	1.0	0.9	1.9	Archean	Greenstone Belt
Empress	Zimb	110	0.8	0.4	1.3	"	"
Monchegorsk	USSR	331.4	0.7	1.1	1.75	Mid. Prot.	Mobile Belt
Kotalahti	Finl	162.5	0.7	0.6	2.5	Low Prot.	"
Norisl'sk	USSR	831.4	0.5	2.1	0.66	Phan	Fold Belt
Bruvann	Norw	141.9	0.33	0.2	2.3	Mid Prot	Mobile Belt

*TGF - Tonnage Grade Function - See text.

TABLE 13

TONNAGE GRADE FUNCTIONS BY DEPOSIT AND COUNTRY

Country	Deposit	TGF	Normalized TGF by Country	Normalized TGF by World
Canada	Sudbury	100	72.9	36.1
	Thompson	21.8	15.9	7.9
	Raglan	6.3	4.6	2.3
	Moak Lake	2.8	2.0	1.0
	Shebandowan	1.7	1.2	0.6
	Others	4.6	3.4	1.7
			100	
USSR	October	40.1	61.1	14.5
	Tamyr	12.5	19.1	4.5
	Talnakh	8.0	12.2	2.9
	Norilsk	2.1	3.2	0.8
	Pechenga	1.8	2.7	0.7
	Monchegorsk	1.1	1.7	0.4
			100	
Australia	Kambalda	11.6	32.0	4.2
	Agnew	9.4	25.9	3.4
	Mt. Keith	5.2	14.3	1.9
	Honeymoon Well	3.2	8.8	1.1
	Six Mile	1.2	3.3	0.4
	Others	5.7	15.7	2.0
			100	
China	Jinchuan	28.9	100	10.4
Africa	Pikwe	2.9	32.9	1.0
	Phoenix	1.0	11.4	0.4
	Others	4.9	55.7	1.8
			100	100

crystallization prior to sulfur saturation removes nickel from the system resulting in lower grade deposits and lower Ni/sul ratios. The sulfide phase may also be locked into a large surrounding volume of silicate minerals resulting in low grade disseminated deposits. Post-ore deformation and sulfide mobilization may have an upgrading effect in some instances. In general it would appear that factors influencing tonnage and grade are essentially independent of each other.

A Tonnage Grade Function (TGF) has been calculated to quickly compare the different deposits in terms of these two most important economic features. It is recognized that in some cases the listed tonnages are averages for a number of deposits in a district eg. Sudbury, Kambalda, Thompson, Raglan, etc, rather than individual ore zones, but in these cases the geological environment is a distinct controlling unit. As Sudbury is the world's largest resource of nickel sulfide mineralization, the TGF for Sudbury is 100. This is derived by the formula Ni x 10^3 metric tonnes resource x %Ni ore grade/200. All deposits or areas of deposits are therefore related to the TGF=100 for Sudbury and can be considered to be percentages of the total Sudbury resource. TGF's are listed in decreasing order for the world's nickel sulfide deposits arranged by country, on Table 13.

Raglan ranks ninth in terms of the world's principal sulfide nickel resource with 2.3 percent of the total. With its present quoted reserves, Raglan represents 4.6 percent of Canada's nickel resource. The data presented in this report would suggest that this is a minimum figure, which can be substantially increased by additional exploration.

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APPENDIX I

DETERMINATION OF TONNAGE FACTORS RAGLAN ORES

The variation in specific gravity (SG) and tonnage factor (TF) for individual ore zones at Raglan is not determined solely by the nickel content, but by the varying proportions of total sulfide and silicate phases. As the proportions of pentlandite and pyrrhotite vary locally and can usually not be determined megascopically with any degree of accuracy in fine grained ores, the proportion of total sulfide occurring in the low density serpentinite host rock must be determined. It can be assumed that the pyrrhotite/ pentlandite ratio is relatively constant for a single discrete ore zone, but that this may be radically different from other zones within the same host on to zones in other ultramafic bodies. For tonnage calculations, it is necessary to predetermine the sulfur content of a variety of samples and relate this to assayed nickel content and measured SG. This information can be obtained in the field at an early stage in the exploration of an ore zone.

The attached curves illustrate the procedure using samples selected from DDH 160-224 (West Donaldson). Sulfur and nickel assays are obtained on samples containing as wide a range of visible sulfide content as possible. Plotting percent sulfur against SG for all samples determines the principal curve (Figure 2). The average value for all samples will lie on this curve and define its angle (Figure 3). The Ni and S values for the average can be used to construct a new curve which obviates the difficulty of selecting a best-fit curve through a more scattered group of points (Figure 4). This curve is required because in normal practice it is probable that only nickel assays would be available. For any drill hole intersection within an ore zone, the average nickel value can be equated to an appropriate S content, which in turn can be used to determine the most accurate SG for that intersection or ore block.

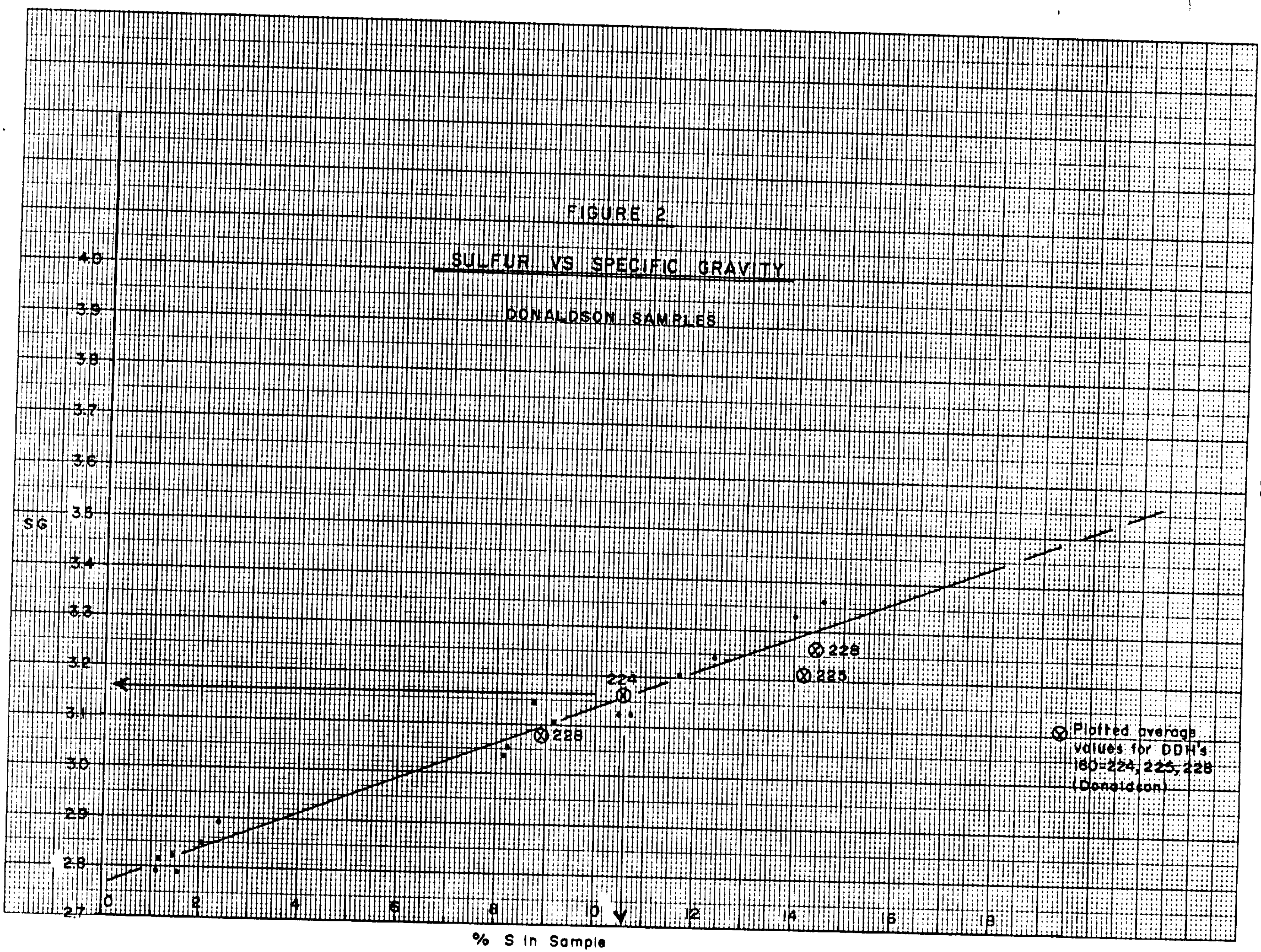
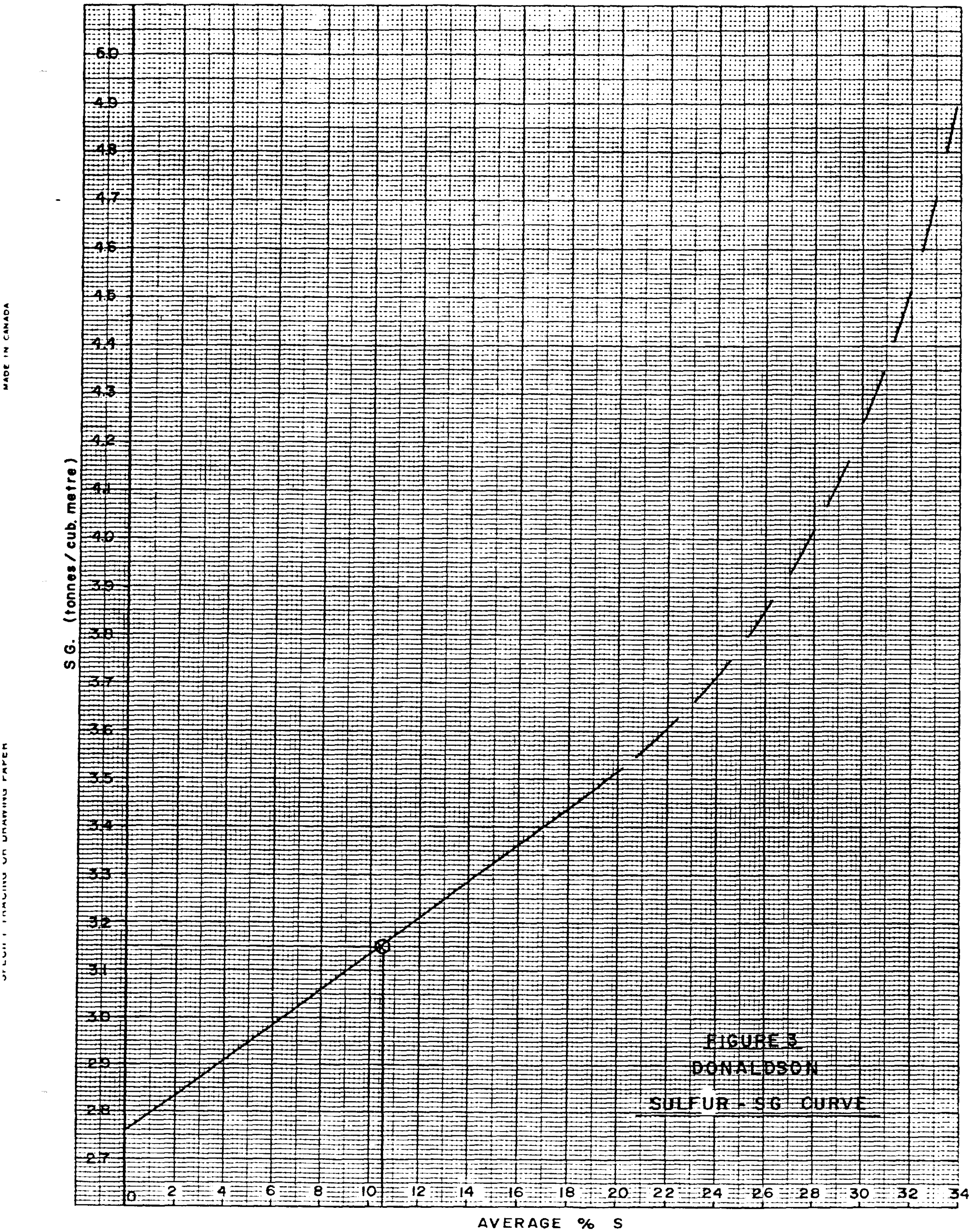
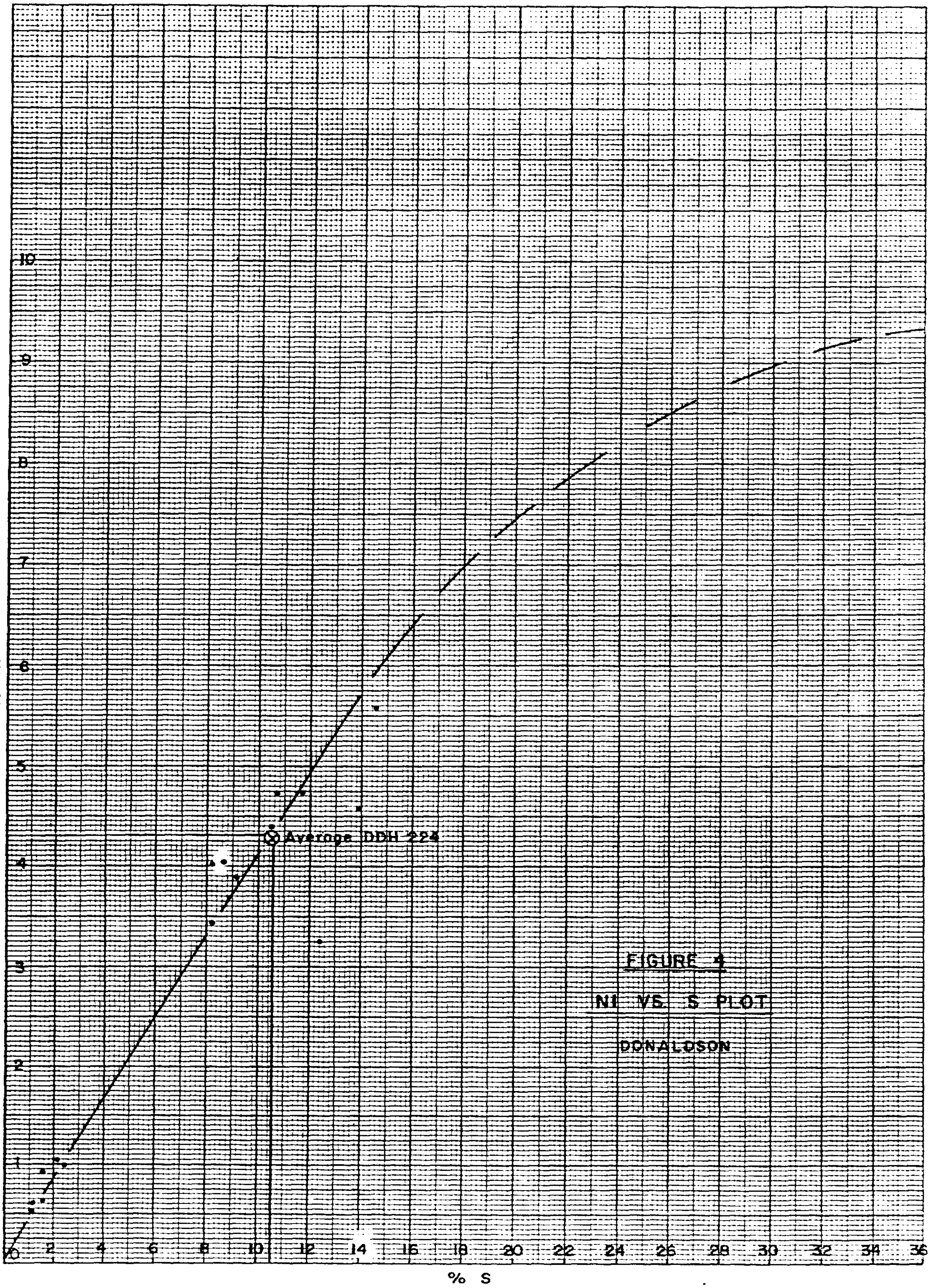


FIGURE 2
SULFUR VS SPECIFIC GRAVITY
DONALDSON SAMPLES
SG
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
0
2
4
6
8
10
12
14
16
18
% S in Sample
224
228
225
228
Plotted average values for DDH's 160-224, 225, 228 (Donaldson)


5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
S G. (tonnes / cub. metre)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
AVERAGE % S
FIGURE 3
DONALDSON
SULFUR - SG CURVE


% Ni
% S
10
9
8
7
6
5
4
3
2
1
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
Average DDH 224
FIGURE 4
NI VS. S PLOT
DONALDSON

APPENDIX II

Reports on Raglan Samples on Hand at FML

(Does not include metallurgical reports from Lakefield or FML)

1961

MR-184 Mineralogical Study of 12 Samples from Ungava.

Petrographic descriptions of samples taken from a traverse across an alternating gabbro-ultramafic sequence by J. Shepherd.

MR-187 Mineralogical Study of 3 Miscellaneous Samples from Ungava and one from Manitoba.

Miscellaneous samples collected by J. Shepherd and S. Staunton.

1962

MR-231 Mineralogical Study of 2 Samples from Ungava (OE A 2178, 2179)

Drill core samples from DDH B3-E, Con. 103, @ 310' and 606'.

1963

Whole Rock Analyses of 181 Samples from Traverses by A.J. Naldrett.

Ni, Cu, Co, Fe, S Analyses of 34 samples from DDH's B-2-C and B-3-B (A.J. Naldrett)

1964

Mercury Determinations on Ungava Samples (J. Boldy)

18 Samples submitted by D.S. Kerby - labelled AN 63-58 to AN 63-215; thin sections made but no report issued.

1965

Raglan Lake - Miscellaneous drill logs.

1966

Lakefield Report (D.W. Deane) Microscopic Examination of 3 ore samples from 4A Showing.

Lakefield Report (R.W. Deane) Microscopic Examination of Composite Head Samples fron Ungava (6 Head Samples from Raglan 160 Project)

Properties of N.Q.R. Rocks affecting Geophysical Measurements (A.R. Graham)

MR-475 Reconnaissance Examination of Core Specimens from Raglan 160 Project.

This is the most comprehensive report written at FML on mineralized samples from the Raglan 160 project. Pages 23 to 25 attached give extracts from the report dealing with ore mineral characteristics, relationships and factors affecting metallurgical treatment.

Of the samples submitted by A.D. Mutch in December 1965, only 25 were described in this report. About 40 others are in storage at FML and of these, about half have been thin-sectioned.

Weighting of Ore Grades for Densities and Metallurgical Recoveries in Peridotitic-related Ni Ores (A.R. Graham)

Precious Metal Values in Raglan 160 Ore - memo J.M. Mortimer to A.D. Mutch.

1967

MR-532 Mineralogical Examination of Sample from New Quebec Raglan.

Description of casual mineralized DDH sample for R.C. Mott.

Report on Ungava Nickel Geology (H.D.B. Wilson)

1968

Report on the Origin of the Ungava Ni Sulphide Ore (A.D. Mutch)

1970

MR-693 Mineralogical Examination of Sample from Donaldson Mine, New Quebec Raglan.

Description of a casual sample from 704E Drift, 700 Level, Donaldson Mine for A.M. Clarke.

1971

Analysis of the 1970 N.Q.R. Reassay Program (H. Squair) (Evaluation of Sampling and Analytical Errors during the 1970 Program)

1972

320 Drill Core Samples from 5-8 Area (H. Squair). Study not undertaken at FML after H.S. left company. Samples still in storage - 54 polished-thin sections made.

1975

Whole Rock Analyses of 7 samples for A. Miller Thesis.

1976

MR-965 Reconnaissance Petrographic Examination of 37 Samples from Ungava.

Very brief petrographic notes on samples from Povungnituk Gp., Perkins Lake Gp., Timmins Lake and Mequillon Lake Gps., and Katiniq.

PGM and Trace Element Analysis of 23 Samples (A.J. Naldrett).

13 Pol-thin Sections of Cross Lake Samples Prepared for C.J.A. Coats (no report requested).

Report on Ultramafic Sills of the Labrador Trough (C.J.A. Coats).

Electron-probe Analysis of Sulphides from Donaldson Mine (internal memo, GS).

1977

Review of Geological Mapping and Geophysical Coverage (C.J.A. Coats)

1978

PGM and Trace Element Analysis of Selected Drill Core Samples Stored at Lakefield (Hoffman, U. of T. per A. J. Naldrett).

1979

Analysis of Donaldson Mine Composite Sample (W.L. Ott)

1980

Colour Photomicrography of N.Q.R. Ore Textures (RB to C.J.A. Coats)

1981

MR-1215 New Quebec Raglan Drill Cores: Metallurgical Assessment.

Report on 66 drill core samples from Metallurgical test holes 160-224, 160-225 and 160-228 (RB to CJAC)

1982

MR-1232 Progress Report: Mineralogy of N.Q. Raglan ores (RB)

TABLE 14

ASSAY VALUES FOR MISCELLANEOUS MINERALIZED HORIZONS

Sample	Field No.	Au (oz)	Ag (oz)	Cu %	Zn %	Description
2619	54G5	Nil	Nil	Nil	0.02	Volcanics-mineralized
2620	84A1	Nil	Nil	0.05	0.64	Brecciated sulfidic slate
2621	54F6	Nil	Nil	0.01	0.07	1-3% sulfides in volcanics
2623	54D1	Nil	Nil	0.03	0.02	Pov. volcanics 1% sulf.
2624	54F1	Nil	Nil	0.04	0.09	Massive sulfide
2625	54G2	Nil	Nil	0.01	0.02	Dissem. sulf-volcanics
2626	54G1	Nil	Nil	0.05	0.02	Massive sulfide
2627	80A1	Nil	Nil	Tr	0.02	1-3% py, po in seds.
2628	84E1	Nil	Nil	Nil	0.02	3% sulf. in volcanics
2629	84H1	Nil	Nil	0.01	0.01	3% sulf. in volcanics
2630	54G7	0.007	Nil	0.01	0.03	Gossan 3% sulf. volcanics
2631	54A2	Nil	Nil	Tr	0.03	2% sulf. in sediments
2632	61A1	Nil	Nil	0.14	0.49	Mass. sulf-volcanics
2633	61C1	0.001	Nil	0.05	0.28	Mass. sulf-volcanics
2634	61C2	0.005	Nil	0.58	0.06	Hornfelsed sediments
2635	61E6	0.001	Tr	0.08	0.11	Mass. sulf.-sediments
2636	61E7	0.002	Nil	0.07	0.06	Mass. sulf.-sediments
2637	61G2	Nil	Tr	0.11	0.89	" " "
2638	61G3	Nil	Nil	0.02	1.97	" " "
2640	62D1	Nil	Nil	0.07	0.47	" " "
2641	67E1	Nil	Tr	0.01	0.04	1-3% sulf.-hornfels
2642	67E2	Nil	Nil	0.05	0.09	Mass. sulf-schist
2643	67E3	Nil	Nil	0.03	0.02	" " "
2644	30C-D	Nil	Nil	0.03	0.01	Green carb. + pyrite
2645	30C-D	Nil	Nil	0.03	0.01	" " "
2646	30C-D	Nil	Nil	Tr	Tr	" " "
3647	30C-D	Tr	Nil	0.05	0.01	" " "
2648	30C-D	Nil	Nil	0.01	0.01	" " "
2649	3C2	Tr	Nil	0.09	0.32	Mass. Po-sediments
2650	3C1	Tr	Nil	0.01	0.01	Carb. + py-volcanics
2656	60H-2	0.029	Tr	0.01	0.01	Carb. + py-sediments
2657	60H-5	0.001	Nil	0.09	0.01	Carb. + py-fault zone
2659	60H7	0.006	Nil	0.06	0.01	Shear + pyrite
2660	60H8	Nil	Nil	Nil	Tr	Graphitic slate + sulfides
2661	60H9	Tr	Tr	0.06	Tr	Mass. sulfides-sediment
2663	75D1	0.001	Tr	0.05	0.02	Dissem. sulf.-gabbro
2664	75E1	Nil	Tr	0.06	0.08	Mass. sulf-sediments
2665	75H1	Nil	Nil	Nil	0.01	Dissem. sulf-quartzite
2666	77E1	Nil	Nil	0.02	0.01	Sulfides-sediments
2667	77F1	Nil	Tr	0.01	0.01	Sulfides-sediments
2668	77F3	Nil	Tr	0.02	Tr	" "
2669	79A1	Nil	Nil	0.01	Tr	Dissem. Po - slates
2671	81C1	Nil	Nil	0.01	0.02	Dissem. Po - volcanics
2672	81E2	Nil	Nil	Nil	0.01	Altered ultramafic
2673	81E3	Nil	Tr	0.01	0.18	Mass. sulf.-sediments
2674	81E4	Nil	Nil	0.01	0.17	" " "
2675	81E5	Nil	Nil	0.01	0.03	Dissem. sulf-volcanic
2677	4A2	Nil	Nil	0.01	0.02	Sulfides-sediments
2688	8K14	0.001	Nil	0.02	0.01	" "
2689	8K2	Nil	Tr	0.01	0.03	Sulfides-volcanics
1520	160-54	0.001	-	-	-	1.5 m. QV in argillite
2318	29-1	0.002	-	-	-	QV
2319	29-2	0.005	-	-	-	Green carb + quartz
2320	29-3	0.002	-	-	-	QV
2462	29-4	0.007	-	-	-	Massive pyrite breccia

APPENDIX III

PHOTOMICROGRAPHS ILLUSTRATING SIGNIFICANT FEATURES OF RAGLAN ROCK TYPES

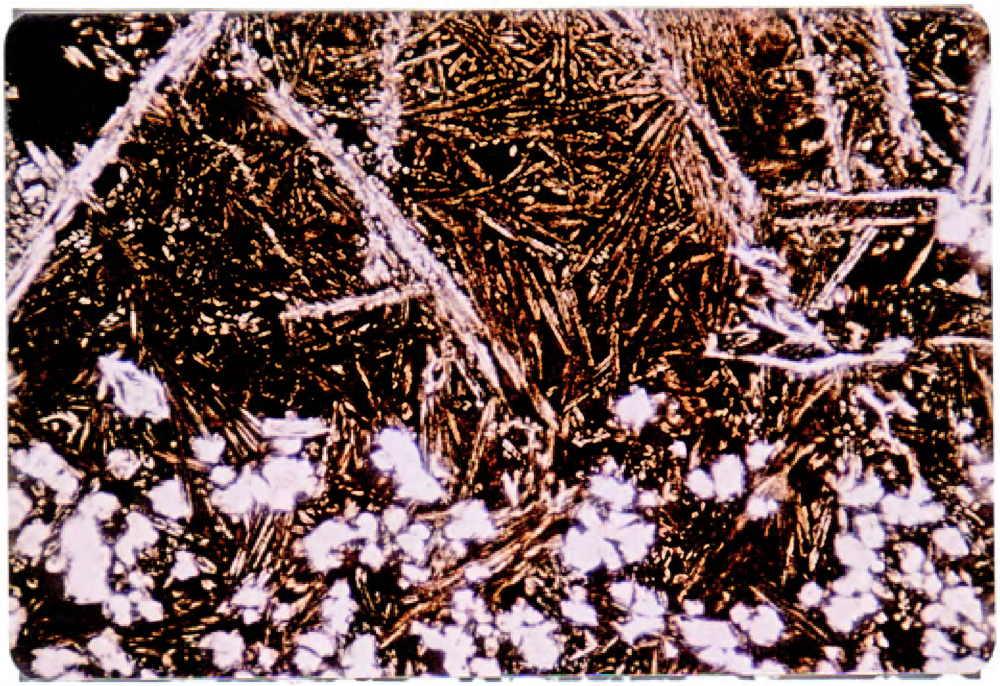


Figure 9 - CROSS LAKE (C1-1). Chukotat volcanic rock with fresh clinopyroxene spinifex and pseudomorphs of chlorite and amphibole after cumulate olivine. Large blades also olivine. (PL.)

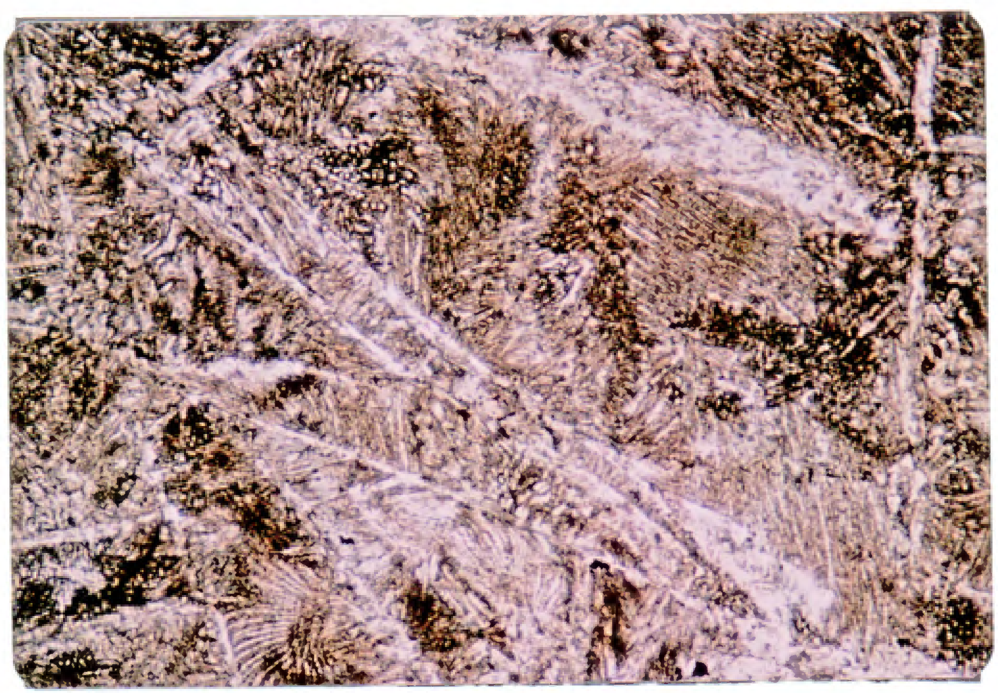


Figure 10 - 2-3 AREA (W1-11.7). Chukotat volcanic rock with acicular spinifex of olivine and pyroxene, now altered to amphibole. Insterstitial plagioclase in matrix (PL).

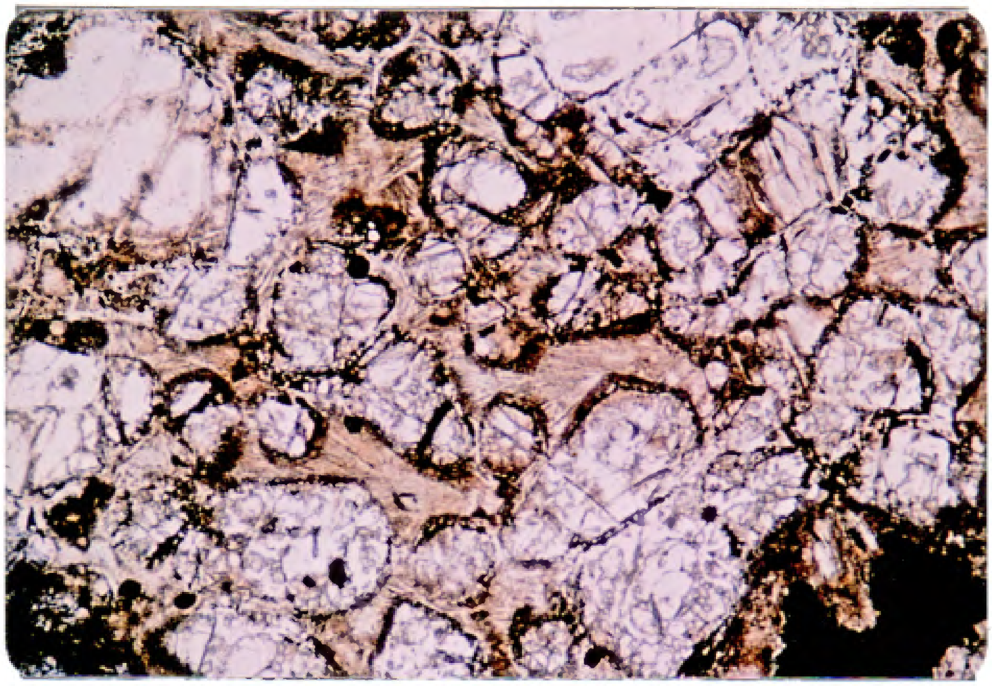


Figure 11 - EAST LAKE (W9-116.7). Lizardite pseudomorphs after subhedral olivine with small equant clinopyroxene in "quenched" fibrous matrix of radiating amphibole, serpentine and chlorite (PL).

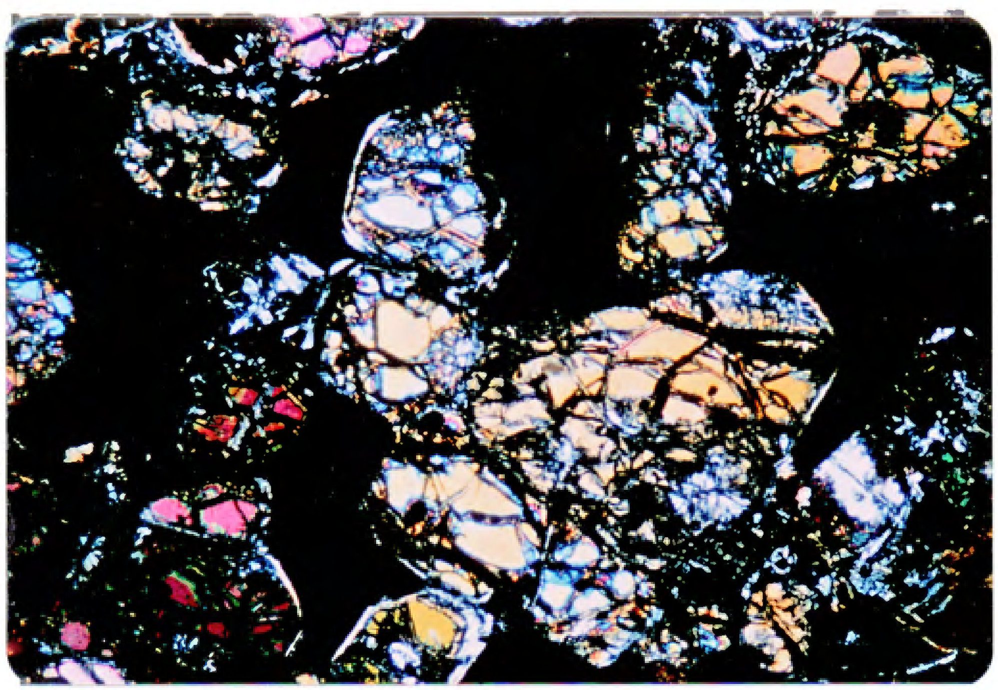


Figure 12 - EAST LAKE (W10-49.2). Partially serpentinized olivine and 5% equant clinopyroxene with intercumulate sulfides (black). Sulfides includes pyrrhotite, pentlandite and magnetite (XN).

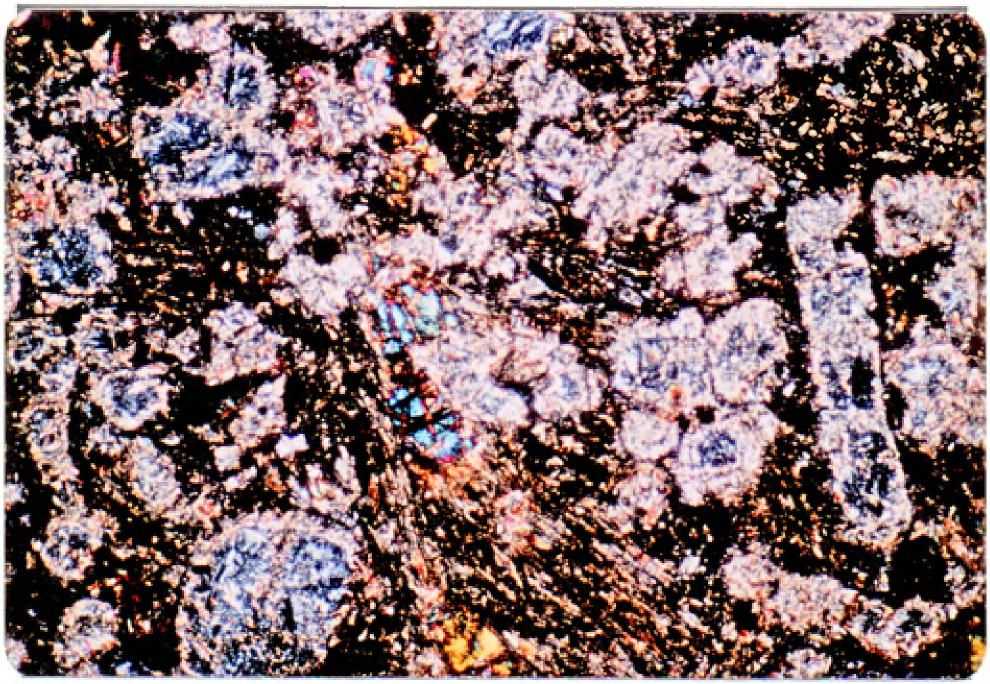


Figure 13 - KATINIQ (K-2, Surface). Serpentine pseudomorphs after olivine, marginally altered to amphibole, with equant clinopyroxenes in fine bladed "quenched" matrix (XN).

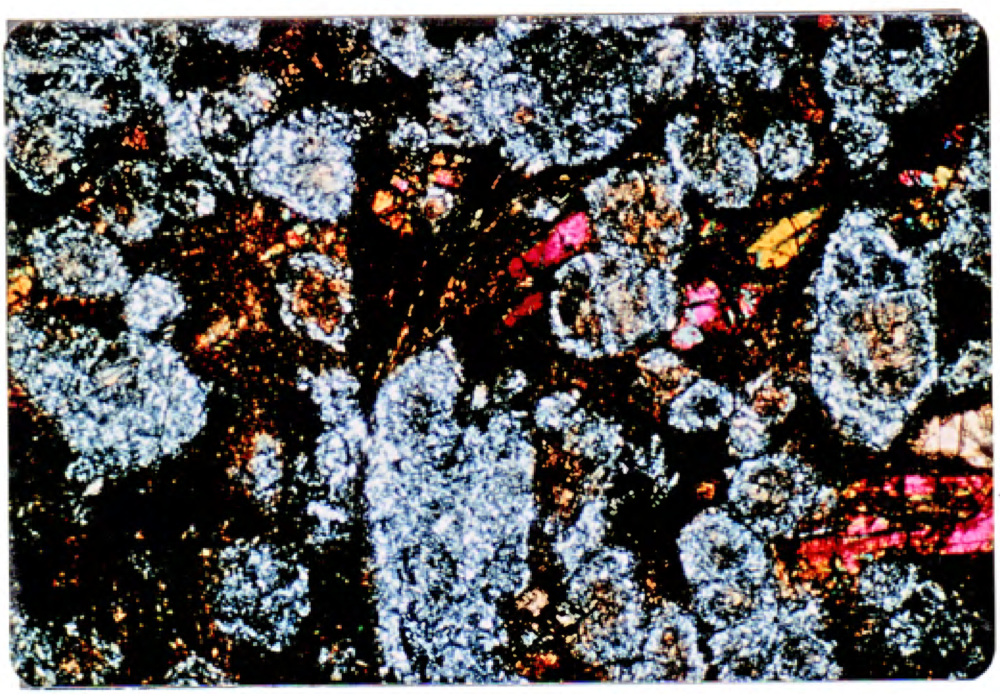


Figure 14 - KATINIQ (K41-211). Serpentine pseudomorphs after olivine with equant and skeletal clinopyroxene in bladed "quenched" matrix (XN).

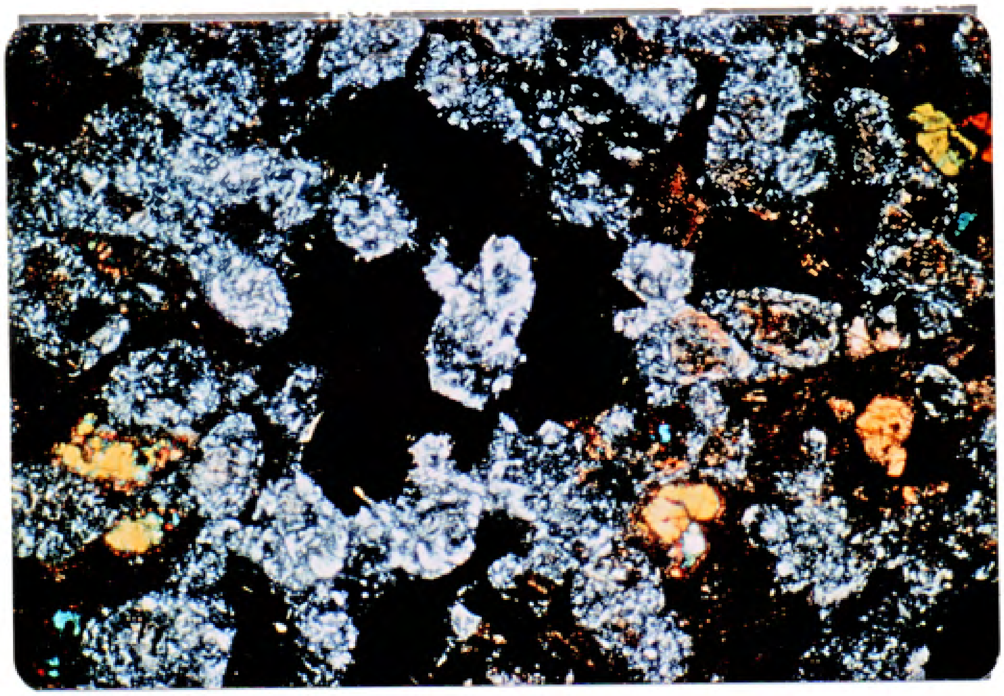


Figure 15 - KATINIQ (K41-220). Serpentine pseudomorphs after olivine with small skeletal clinopyroxenes. Disseminated sulfides (black) show incipient antigorite development (XN).

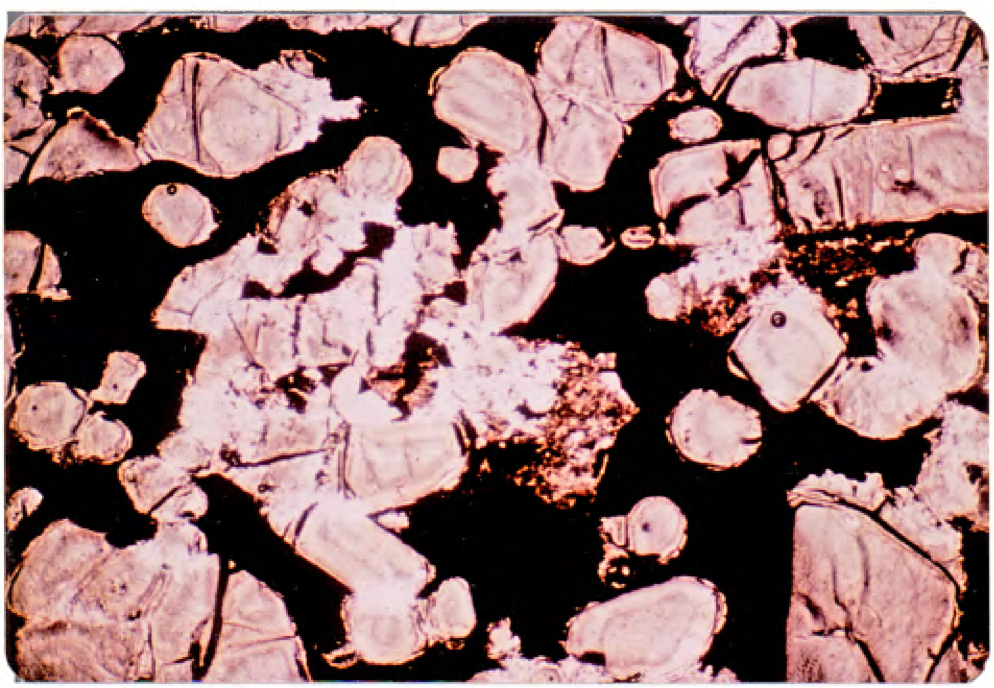


Figure 16 - KATINIQ (K138-571). Euhedral pseudomorphs of serpentine after olivine in unmodified net-textured sulfides (PL).

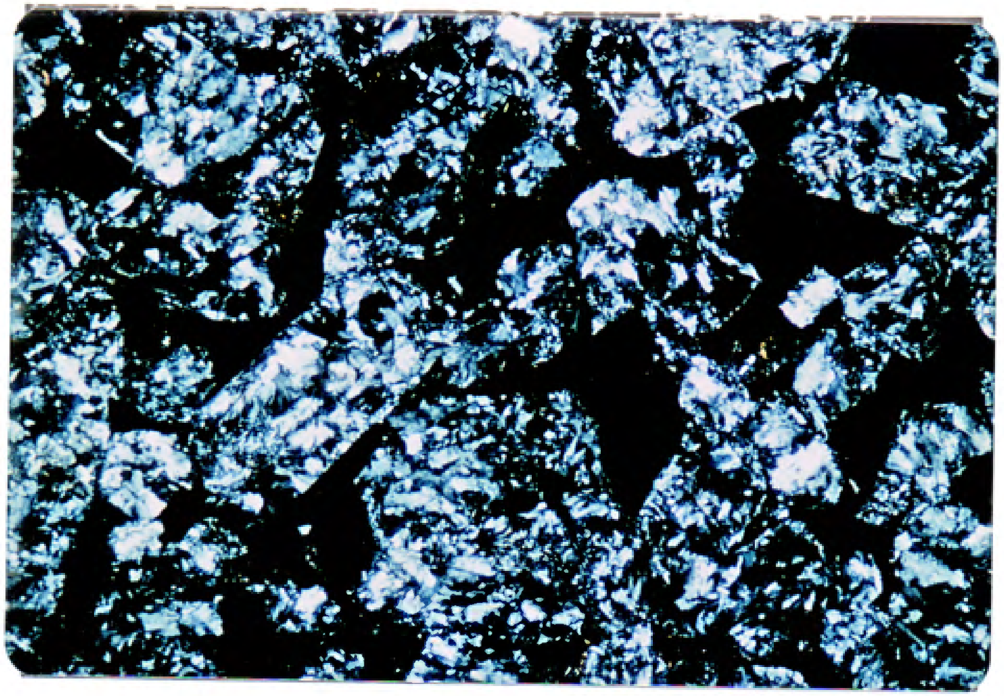


Figure 17 - WEST BOUNDARY (E8-1098). Euhedral pseudomorphs of antigorite after olivine with sulfides (black) (XN).

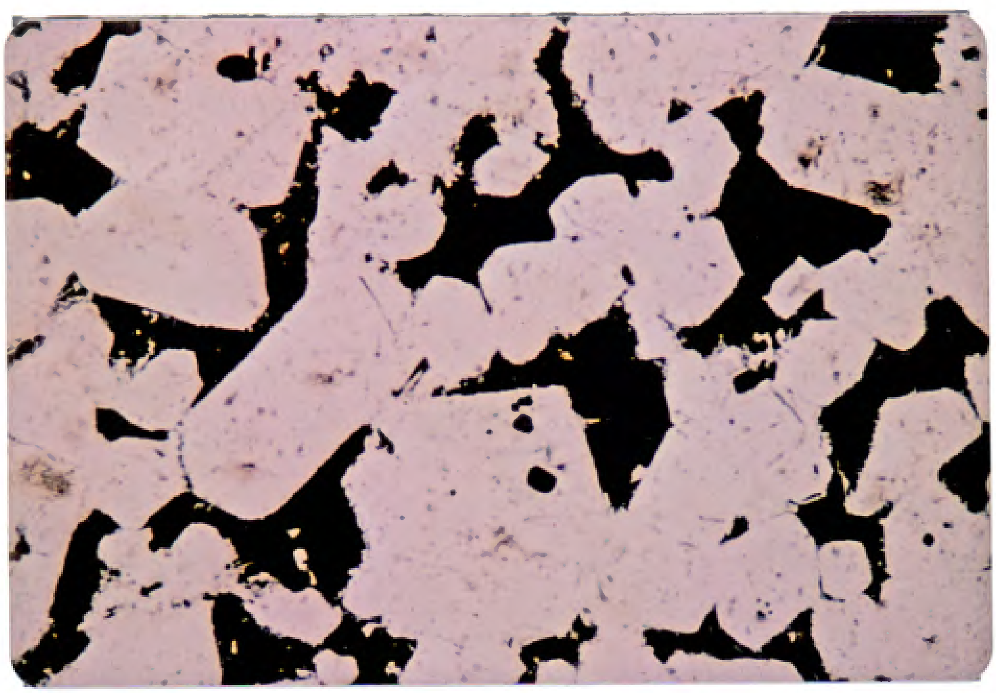


Figure 18 - WEST BOUNDARY (E8-109.8). Same photo as above, showing intercumulate sulfide phase unaffected by antigorite. (PL).

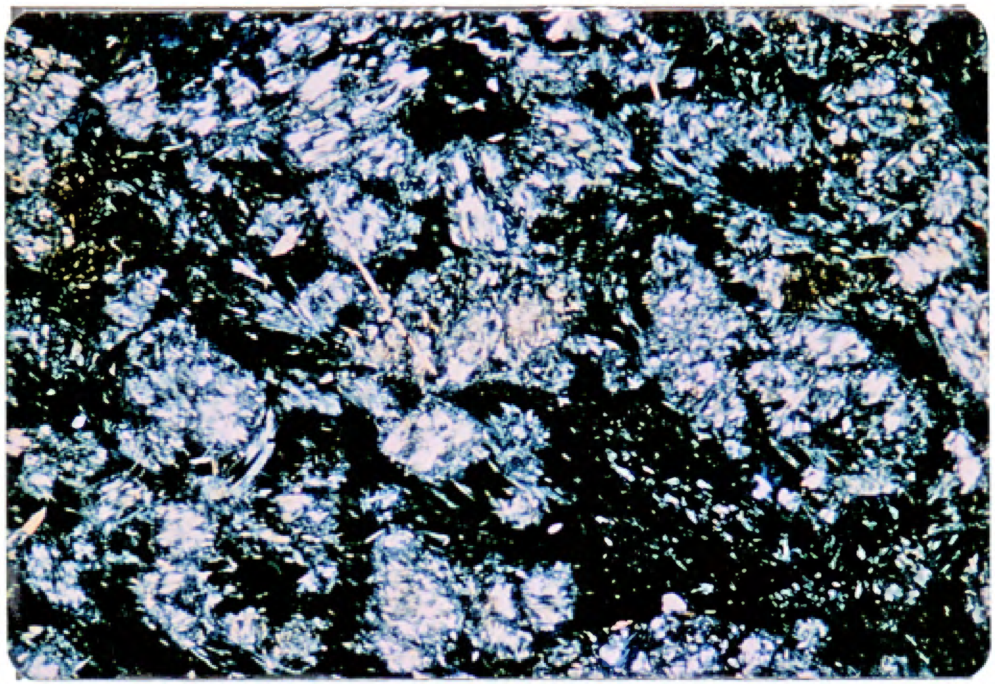


Figure 19 - WEST BOUNDARY (E 7-72.5). Colourless amphibole developing in olivine pseudomorphs and within interstitial patches of chlorite. Original texture nearly destroyed (XN).

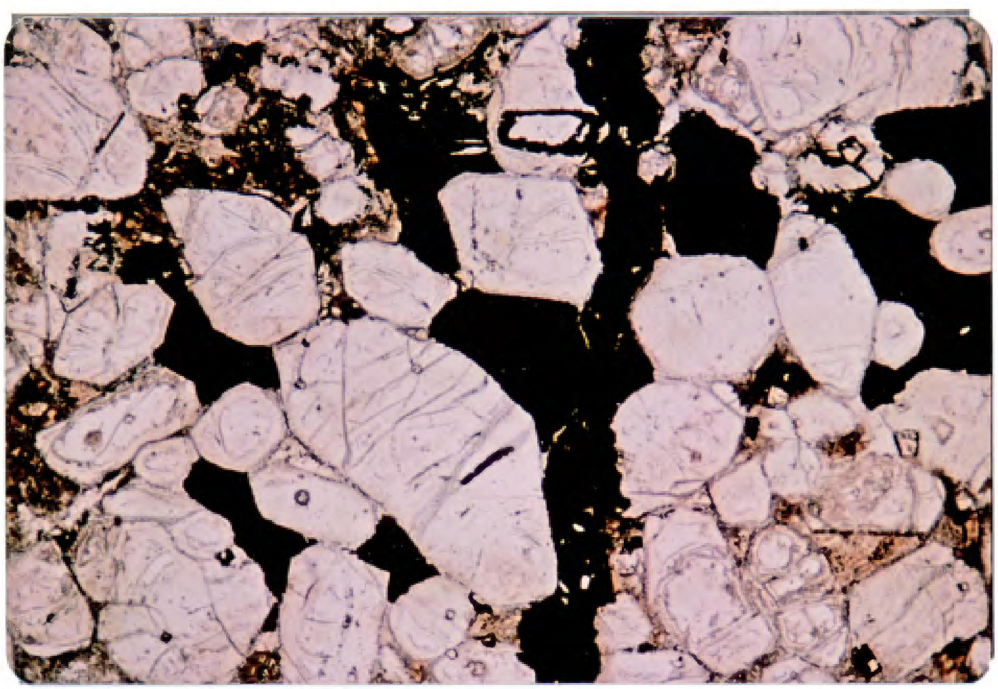


Figure 20 - BOUNDARY (E4-54.6). Euhedral pseudomorphs of antigorite after olivine with intercumulus sulfide and magnetite (black). Minor antigorite growth in sulfide (PL).

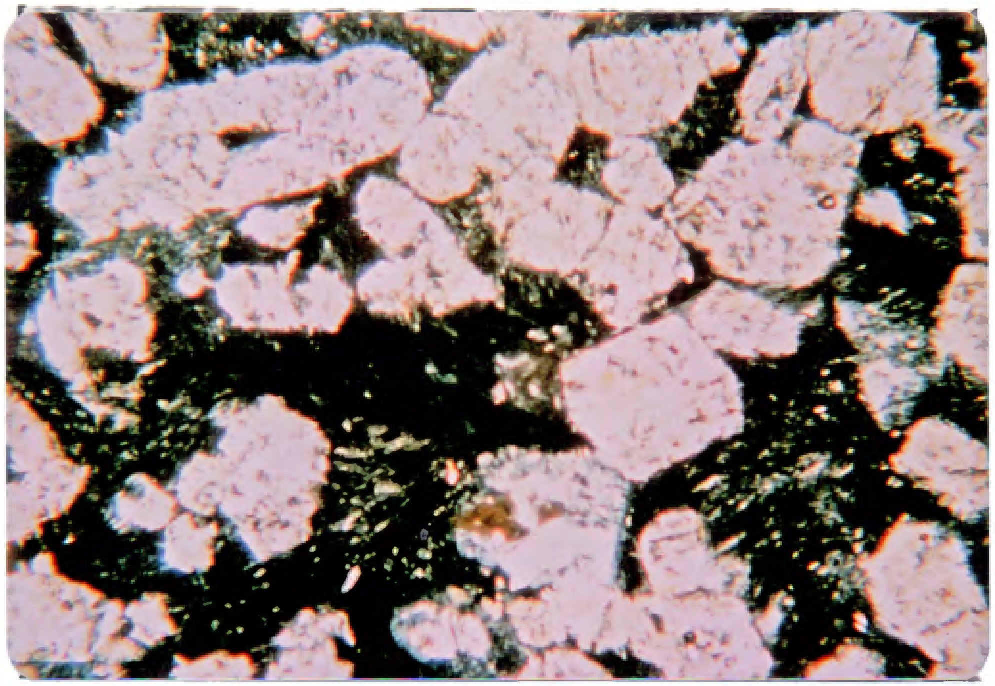
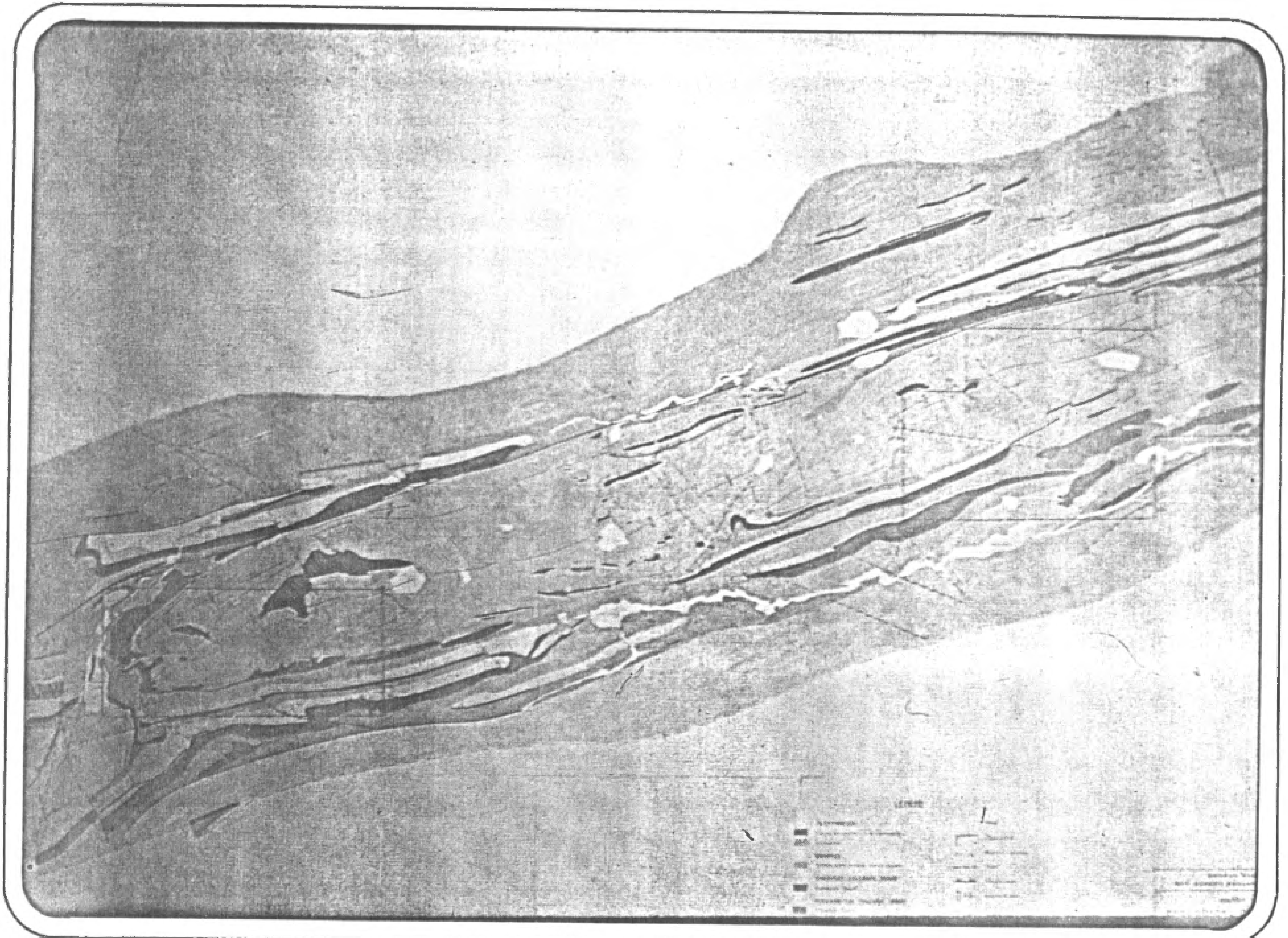
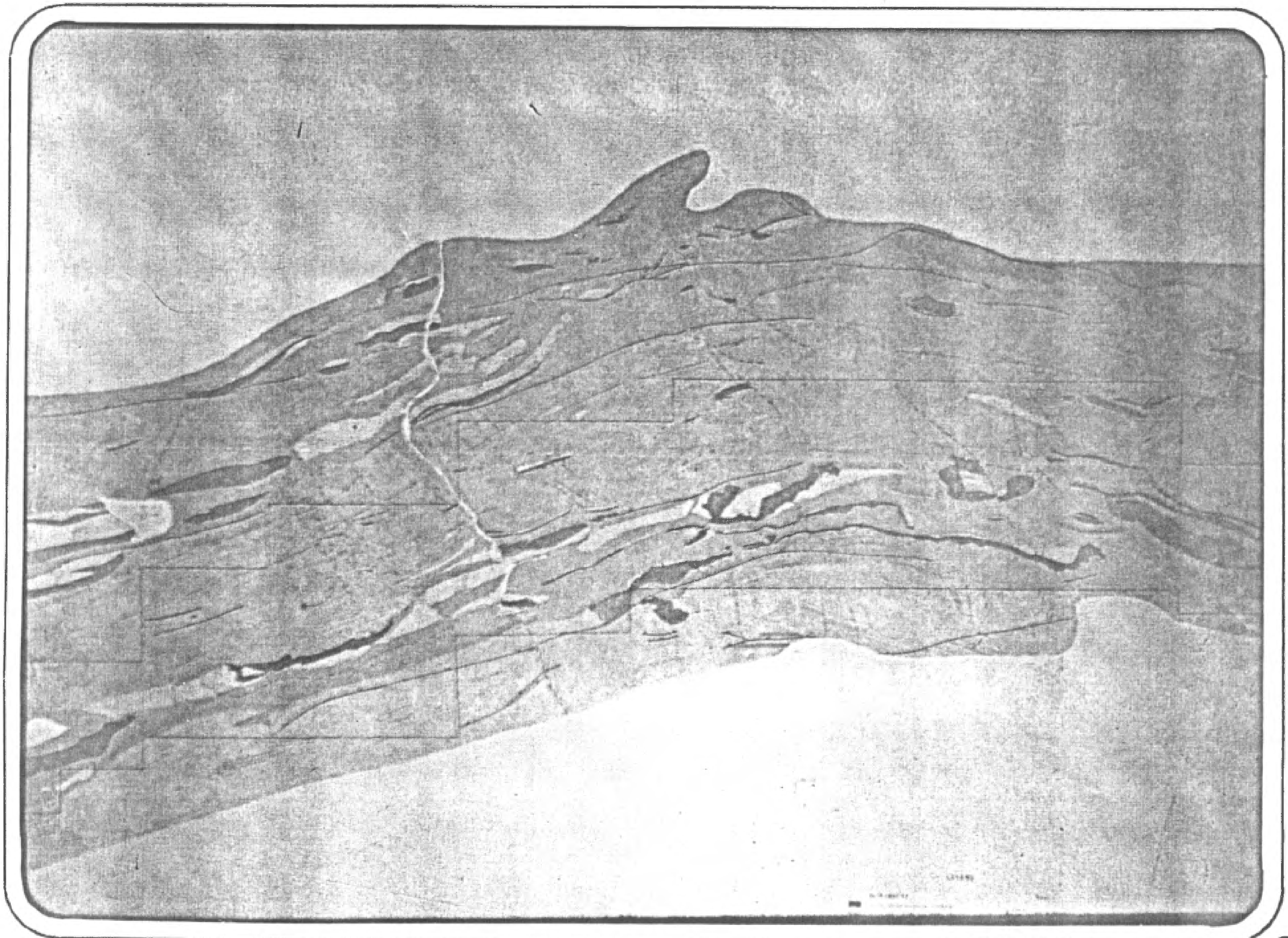
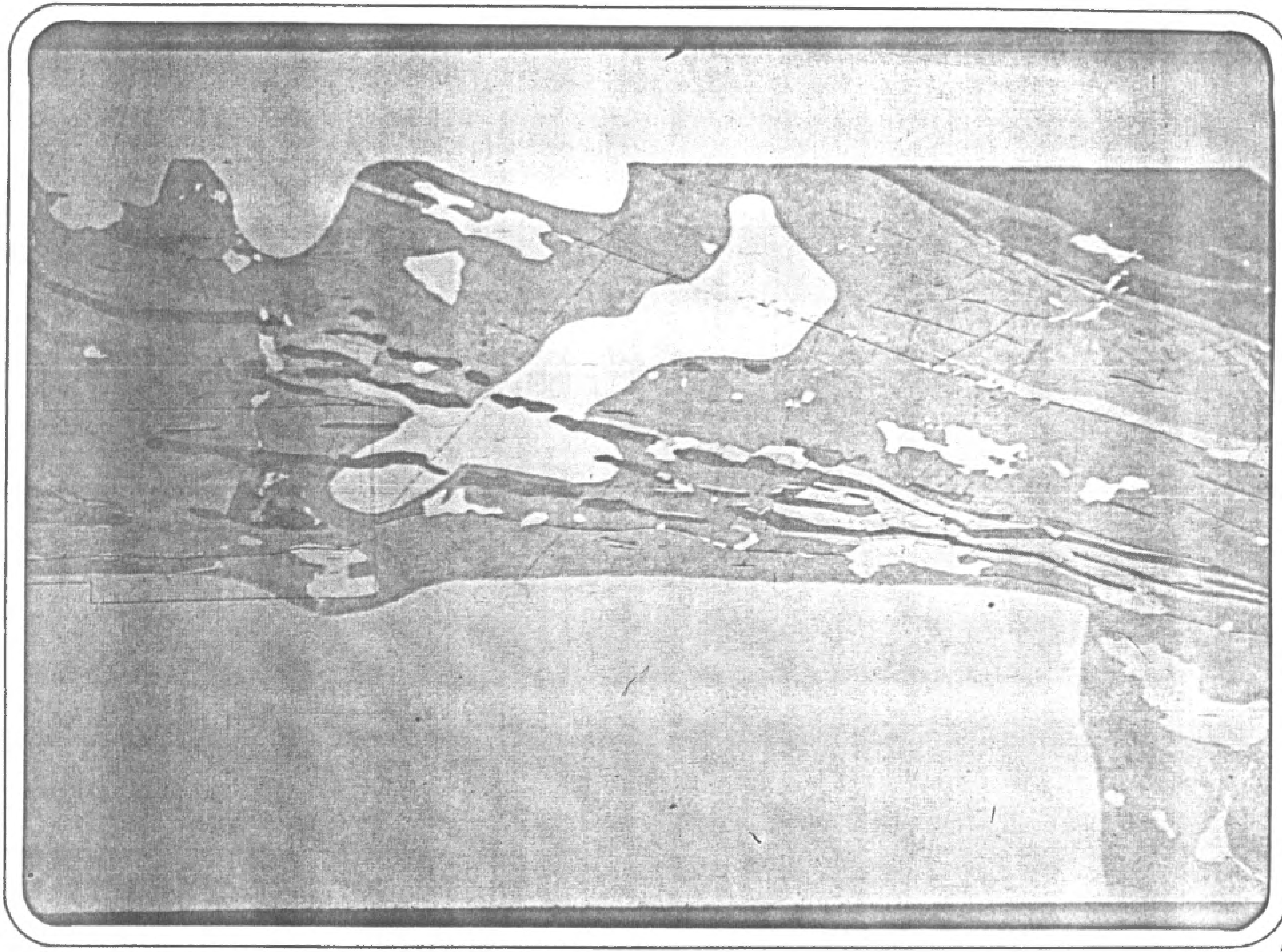


Figure 21 - DONALDSON ULTRAMAFIC. Serpentine and amphibole pseudomorphs after olivine in a dark, "quenched" fibrous matrix, now composed of chlorite and serpentine. This texture is regarded as being equivalent to that of Figures 11, 13, 14.



1





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