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The Geology of the Cal Graphite Flake Graphite Deposit

By

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FOREWORD

Over the last few years, there has been an upsurge in exploration for crystalline flake graphite deposits in response to technological advances resulting in increased demand for flake graphite, and uneasiness among the user nations over the economic and political situations of the present sources. In Ontario, several dozen occurrences of flake graphite are known, and several of those are currently the subject of exploration and evaluation by the private sector.

This report represents the results of a detailed study of one of these graphite deposits: Butt Township, brought into production by Cal Graphite Corporation of Kearney, Ontario. Detailed mapping of an area stripped by Cal Graphite Corporation over the main part of the graphitic body and petrographic and structural descriptions of the deposit are reported.

With both the increased interest in developing flake graphite deposits, and in the geology of the Central Gneiss Belt, this report will be of use to those in the industrial minerals industry, and will contribute to the geological data-base for the Grenville Province.

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The author would like to express appreciation of the support and continued help in preparation of this report by Cal Graphite Corporation, especially John Stirling, and their consulting geologist, Dave Constable, now with the Ministry of Northern Development and Mines.

1.0 ABSTRACT

Graphite occurrences in the Grenville Structural Province of Ontario are found in the Central Gneiss Belt within either siliceous metasedimentary or marble units, and in the Central Metasedimentary Belt within marble horizons. Graphite was mined in Ontario up to 30 years ago, primarily from deposits within the Central Metasedimentary Belt. Recently there has been an increased interest in all types of graphite deposits.

The Butt Township graphite deposit, presently owned by Cal Graphite Corporation of Ontario, lies within the Kiosk Domain of the lowermost thrust sheet of the Central Gneiss Belt. Graphite mineralization occurs disseminated in rusty, siliceous metasediments contained within quartzofeldspathic gneisses. The deposit itself is approximately 400 metres long, but appears to continue northeast for at least another 500 metres. Strike is approximately 020°, and the dip from 30 to 60° east. The deposit is open beyond depths reached by diamond drilling.

Cal Graphite Corporation obtained the mineral rights in 1985 and began their extensive exploration program bringing the deposit into production in 1990. Total reserves, proven, probable, and possible, are calculated at 49,705,786 tonnes grading 2.55 weight percent graphitic carbon. This study was designed to provide a three-dimensional picture of the graphite deposit, with direct

application to the development of the mine and estimation of the potential of other graphite horizons. Cal Graphite stripped an area of about two hectares over the main part of the deposit, and it is the geology of this area that is presented in this work.

Five lithologies were recognized:

1) Graphite-feldspar-quartz schist (unit 1a).
2) Feldspar-graphite-quartz schist (unit 1b).
3) Garnet-hornblende quartzofeldspathic gneiss (unit 2a).
4) Net-textured mafic rock (unit 2b).
5) Pegmatite (unit 2c).

Minerals are listed in increasing abundance. Graphite occurs mainly in the first two rock types, and only in small amounts in the third rock type.

The structure of the deposit is complex with both brittle and ductile deformation within the same unit. The graphitic units have been folded several times, resulting in a thickening of the graphitic horizons. The barren material occurs as disrupted blocks and lenses within the graphitic units.

Three folding episodes have been recognized:

1) Folding of the 1b unit within units 1a and 2a.
2) Isoclinal folding throughout the graphitic units and unit 2a.
3) A gentle warping of the entire horizon.

The deformation throughout the deposit varies; brittle boudinage and progressively deformed sheath folds have been observed within the same 10 metre area, and mineral textures range from migmatitic leucosome to granoblastic to almost primary sedimentary and igneous. This variation indicates an inhomogeneous stress regime during deformation.

In order to assess the geology in the third dimension, the geology on two sections through the main part of the graphite zone was interpreted from diamond drill results. The geology on these sections was then compared to the corresponding surface geology and a block diagram constructed. From the block diagram, it became apparent that the net-textured mafic unit and the garnet hornblende-quartzofeldspathic gneiss unit (both barren) are of the same shape in the third dimension as on the surface. As the blocks of barren material are large enough to be excluded, mining could possibly be selective, decreasing the dilution factor. To fully understand the nature of the deposit, and to be able to upgrade tonnage and grade calculations, the geology should be monitored on a continuous basis.

THE GEOLOGY OF THE CAL GRAPHITE CORPORATION GRAPHITE DEPOSIT IN BUTT TOWNSHIP, ONTARIO

by

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2.0 INTRODUCTION

An introduction and overview of the graphite industry, and a review of the geology of four graphite deposits within the Central Gneiss Belt was provided in "Graphite in the Central Gneiss Belt of the Grenville Province of Ontario", published as Ontario Geological Survey Open File Report 5649 (Garland 1987). Of these four deposits, the one in Butt Township is currently in production.

Cal Graphite Corporation has leased the mineral rights for the deposit. In the 1986 feasibility report (Constable and Dunks 1986), the proven and probable reserves were stated as being 13,387,200 tonnes with an average grade of 2.42% graphite by weight. Proven, probable, and possible reserves reported in the March, 1989 Report, Summary of Final Production Ore Reserves, by Dave Constable of Constable Consulting Inc. have been updated to 49,705,786 tonnes averaging 2.55% graphitic carbon (Constable 1989). For mining purposes, the company has delineated two zones within the deposit, and the reserves for each zone are summarized as follows:

<u>Hanging Wall Zone</u>

Proven	18,972,547 tonnes at 2.52% graphitic carbon
Probable	6,340,500 tonnes at 2.49% graphitic carbon

Possible	4,099,500 tonnes at 2.44% graphitic carbon	

Footwall Zone

Proven	10,564,090 tonnes at 2.56% graphitic carbon
Probable	5,418,695 tonnes at 2.66% graphitic carbon
Possible	4,310,454 tonnes at 2.61% graphitic carbon

Cal Graphite stripped 2 hectares and cleaned a 200 by 100 metre section of the stripped area. The resulting excellent exposure over part of the graphitic horizon presented a chance to study the geology of the graphitic unit in some detail; a task usually made difficult by poor outcrop exposure. Part of the 1987 field season was spent by the author mapping the stripped area at a scale of 1 centimetre to 2 metres. Coupled with the diamond drilling results obtained from the 1987-1988 drilling, as well as with information from some of the previously drilled holes, it was possible to reconstruct a three-dimensional picture of the geology for part of the deposit.

The goals of this study were:

1. To provide an indepth study of part of one of the graphitic horizons within the Central Gneiss Belt in order to increase the understanding of these units. Information of this nature will help to assess the economic potential of other graphitic

units, and to increase the geological database of the Central Gneiss Belt.

2. To provide a base from which to monitor the geology as the open pit develops.

3.0 GEOLOGY OF THE CENTRAL GNEISS BELT

3.1 REVIEW OF THE GEOLOGY

The Central Gneiss Belt forms an integral part of the Grenville Province, the youngest structural province within the Precambrian Shield. Grenville rocks are exposed in a belt extending from Lake Huron in Ontario, through Quebec to Labrador, and south into New York State. The Grenville Orogeny, which has affected the entire province, was a major compressional event, circa 1.070 Ga, resulting from a collision between the Precambrian Shield and a continent to the southeast (Moore 1986). The Grenville Province in Ontario is characterized by stacks of northwest directed thrust sheets; a result of the crustal shortening due to the continental collision (Davidson 1982a, 1982b, 1985; Davidson 1986).

In Ontario, the Grenville Province is subdivided into two belts and two tectonic zones: the Central Gneiss Belt (CGB), the Central Metasedimentary Belt (CMB), the Grenville Front Tectonic Zone (Wynne-Edwards 1972), and the Central Metasedimentary Belt Tectonic Zone (Hanmer et al. 1985). In both the CGB and the CMB, lithotectonic terranes have been differentiated on the basis of metamorphic grade, structural style, lithology, and contact relationships (Culshaw et al. 1983; Davidson and Morgan 1981; Davidson et al; 1982a, 1982b, 1985; Hanmer and Ciesielski 1984; Hanmer et al. 1985; Moore 1982; and Easton 1988, 1990). Both the Grenville Front and the Central Metasedimentary Belt Tectonic Zones consist of gneisses and high-strain tectonites, whose microstructures indicate movement to the northwest (Davidson 1986; Hanmer et al. 1985; Easton 1987).

Several separate thrust sheets have been outlined within the CGB by Davidson and co-workers (1981, 1982, 1985, 1986) as illustrated in figure 3.1. Each thrust sheet is composed of lithotectonic domains individual in their structural styles and to some extent, lithologies (map 2, back pocket). Work done by Marmont and Johnston (1987), Marmont (1988a and b), and Garland (1987) on various mineral commodities within the CGB is starting to reveal a pattern in the distribution of mineralization with respect to domains and thrust sheets. For example, the marble horizons of interest to farmers for agricultural lime (see: Marmont 1988a, 1988b) occur only within the Parry Sound Domain, and the siliceous graphitic horizons occur only within domains contained in the lowermost thrust sheet (Garland 1987).

3.2 GEOLOGY AND NATURE OF THE GRAPHITIC HORIZONS WITHIN THE CENTRAL GNEISS BELT

Disseminated flake and 'amorphous' graphite occurs in certain marble horizons within marble units in the Parry Sound Domain of the CGB, within siliceous gneiss units in the CGB, and within some of the marble units in the CMB. The deposits in the marbles of the CMB were mined up to 30 years ago (Hewitt 1965; Papertzian and

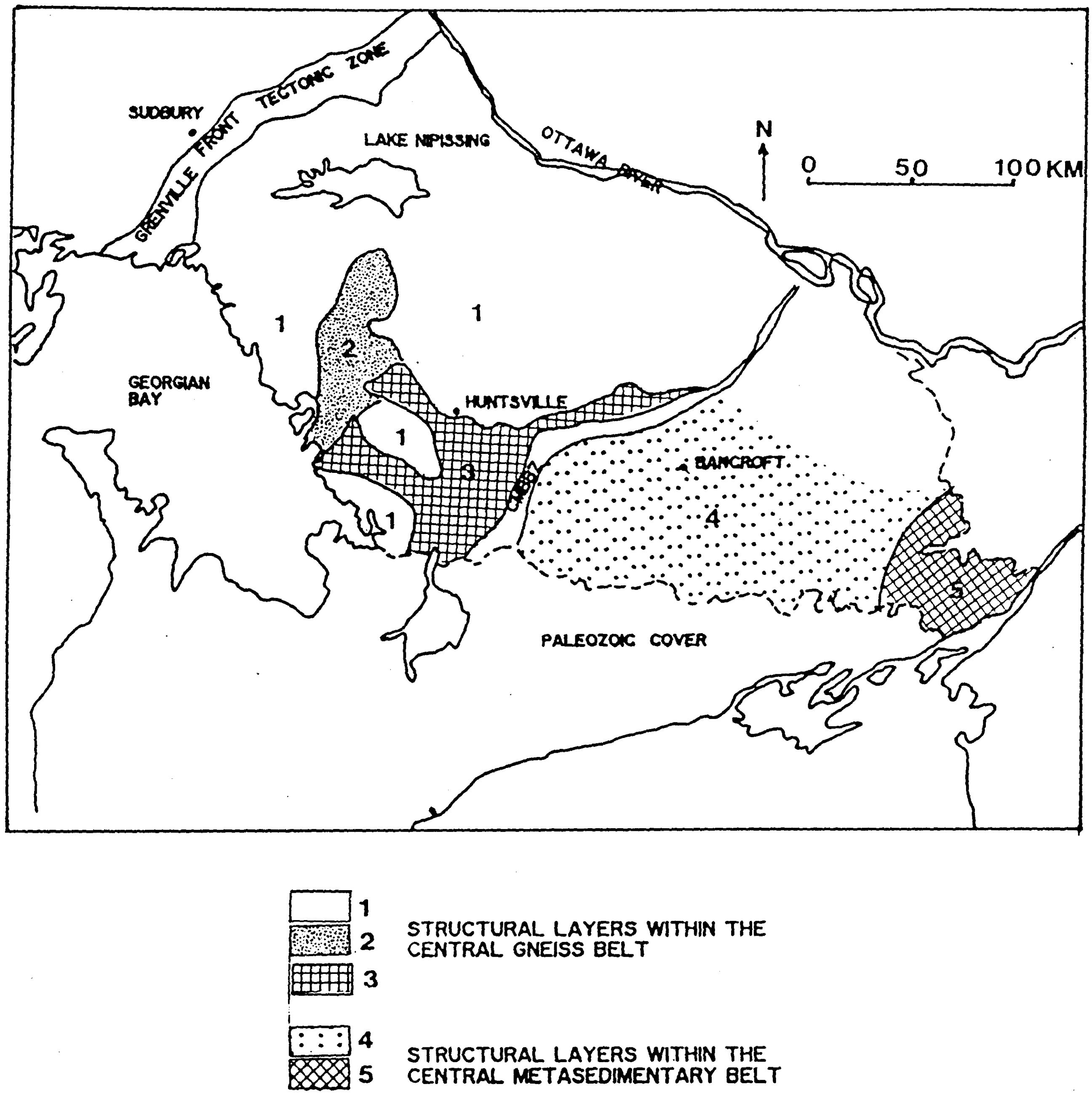


Figure 3. 1: Sketch map of the Grenville Province in Ontario showing the subdivision into structural layers (numbered 1-5), (after Schau and Davidson 1986).

Kingston 1984). The early mines concentrated on the mining of small, high-grade pods of graphite, and when these deposits were exhausted, interest in this type of graphite deposit waned. Interest by refractory manufacturers in a stable supply of high quality graphite caused a resurgence of graphite exploration in North America, particularly in Ontario and Quebec, and has resulted in renewed interest in graphite occurrences in the Central Gneiss Belt as well as in the Central Metasedimentary Belt.

The distribution of graphite-bearing units within the Central Gneiss Belt is shown in map 2 (back pocket), and they occur in all lithotectonic domains of the lowermost thrust sheet. They range in composition and texture from quartzofeldspathic gneisses to quartz-biotite schists to semi-pelitic gneisses. The mineralogy of these horizons is similar with respect to the major constituents: graphite is present in amounts up to 15% by volume, quartz is present in amounts from 50 to 80%, feldspar is present in varying amounts, usually albite plagioclase and microcline or orthoclase, and biotite is present in amounts up to 10%. The minor constituents vary with each unit: garnet can be present, usually in the parts of the unit deficient in graphite; sillimanite may or may not be present. Sulphides, usually pyrite and pyrrhotite, are ubiquitous, and generally oxidized, giving units a characteristic rusty weathering surface, which is a useful prospecting tool. Foliation in the units is defined by the alignment of both biotite and graphite flakes; lineation by quartz rods and quartz-feldspar ribbons.

The graphitic units themselves are long relative to their average width, a characteristic probably due to attenuation resulting from severe deformation (A. Davidson; Geologist, Geological Survey of Canada, Ottawa, Ontario, personal communication, 1988). There is no question that the units have been deformed; structural evidence ranges from the recrystallized nature of the rocks to the complex folding seen in most of the horizons (Garland 1987). Structural features seen on small scale, such as on an outcrop scale, seem to reflect a larger, overall structural pattern.

In summary, the following facts are known about the graphitic horizons studied within the scope of the project, and are thought to hold true for the other graphitic horizons within the Central Gneiss Belt:

1. They occur in packages of rocks restricted to the first thrust sheet within the CGB.
2. They are mineralogically simple, consisting principally of quartz, feldspar, biotite, and graphite.
3. They are structurally complex, now much longer and thinner than they once were.
4. They have the composition and texture of metasediments.
5. Graphite occurs along the strike length in varying amounts. Economic potential increases when both the grade of the graphite and the thickness of the unit are increased.

4.0 GEOLOGY OF THE CAL GRAPHITE DEPOSIT, BUTT TOWNSHIP, ONTARIO

4.1 INTRODUCTION

4.1.1 LOCATION

Butt Township is located approximately 15 kilometres east of the town of Burk's Falls on Highway 11 (figure 4.1). The western boundary of Algonquin Park divides the township into eastern and western halves. A gravel forest access road leads directly to the property from Highway 518 east from Emsdale. A new road has been constructed by Cal Graphite, with Ontario Government assistance, providing a new route to the Park, circumventing the mine area.

4.1.2 PREVIOUS WORK

Graphite was first discovered either in the late 1800's or early 1900's along the shores of the only northwest-trending lake in the township, suitably called Graphite Lake (figure 4.2). The graphite showings were staked by a prospector as early as 1917 (V. Sheehan, prospector, Kearney, personal communication, 1986), and again in 1940 by Noranda Mines Limited, in response to war-time markets for graphite. No further work was recorded for graphite in that area until 1973, when Noranda again acquired the mineral rights, and proceeded with a thorough exploration program over the showings (Assessment Files, Resident Geologist's Office, Dorset, Ontario). Noranda delineated an anomalous zone by geophysics, 2500 metres long with a maximum width of 300 metres, just south of Graphite Lake.

The showings along Graphite Lake were staked in 1976 by a prospector and again in 1980 by Dravo Corporation of Pittsburgh, Pennsylvania. The area was mapped but no other work was done by the respective parties. In 1981, Vesuvius Crucible Limited, a refractories company based in Pittsburgh, Pennsylvania, acquired the mineral rights and proceeded with mapping and diamond drilling (Assessment Files, Resident Geologist's Office, Dorset, Ontario). For corporate reasons, Vesuvius Crucible ceased exploration in 1983. Cal Graphite acquired 16 claims over the showings in 1985. The company now holds a 100% interest in 38 claims, of which several have been brought to lease, and has optioned an additional 12 claims northeast of the deposit.

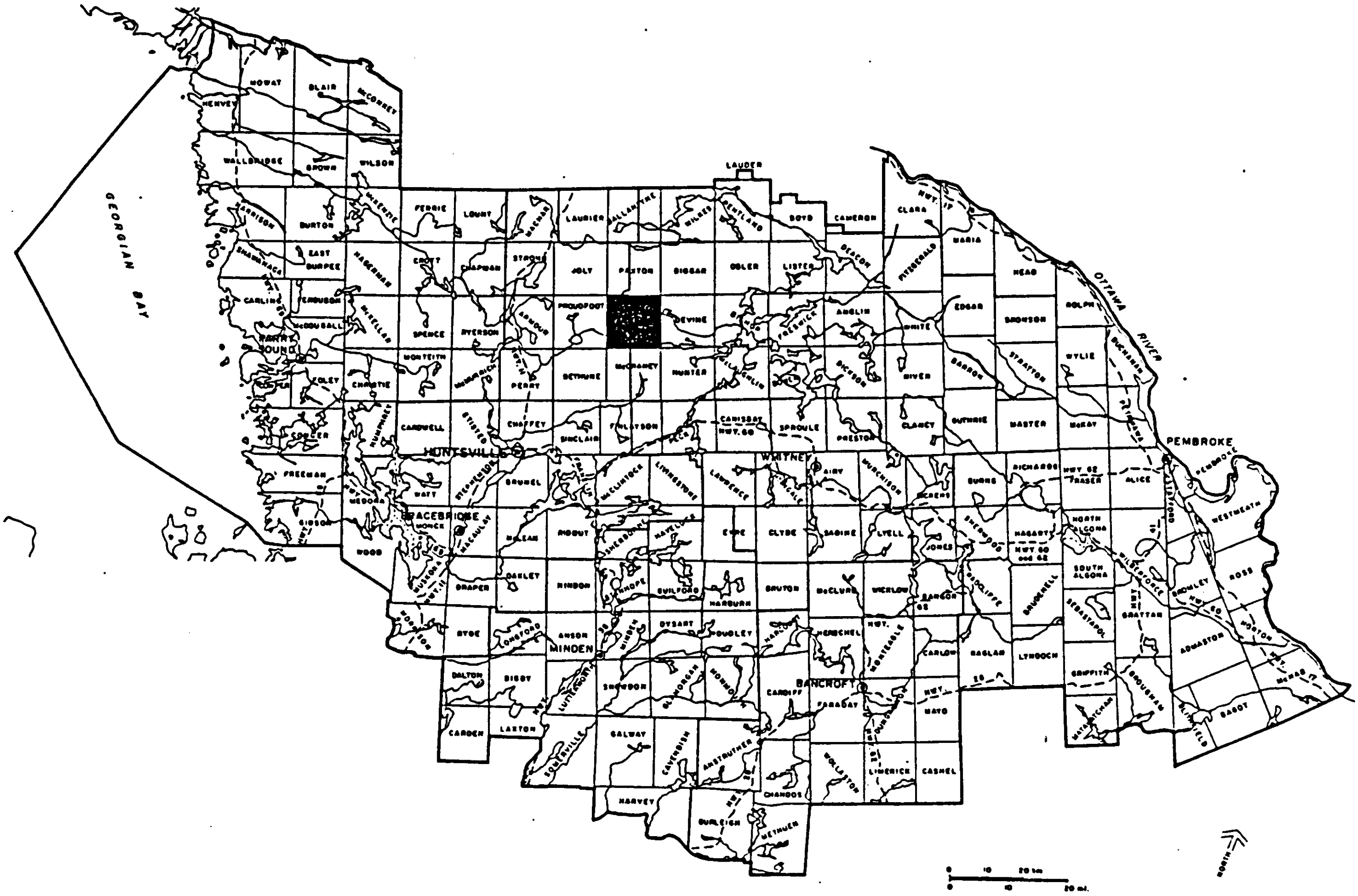


Figure 4. 1: Central Ontario, showing location of Butt Township.

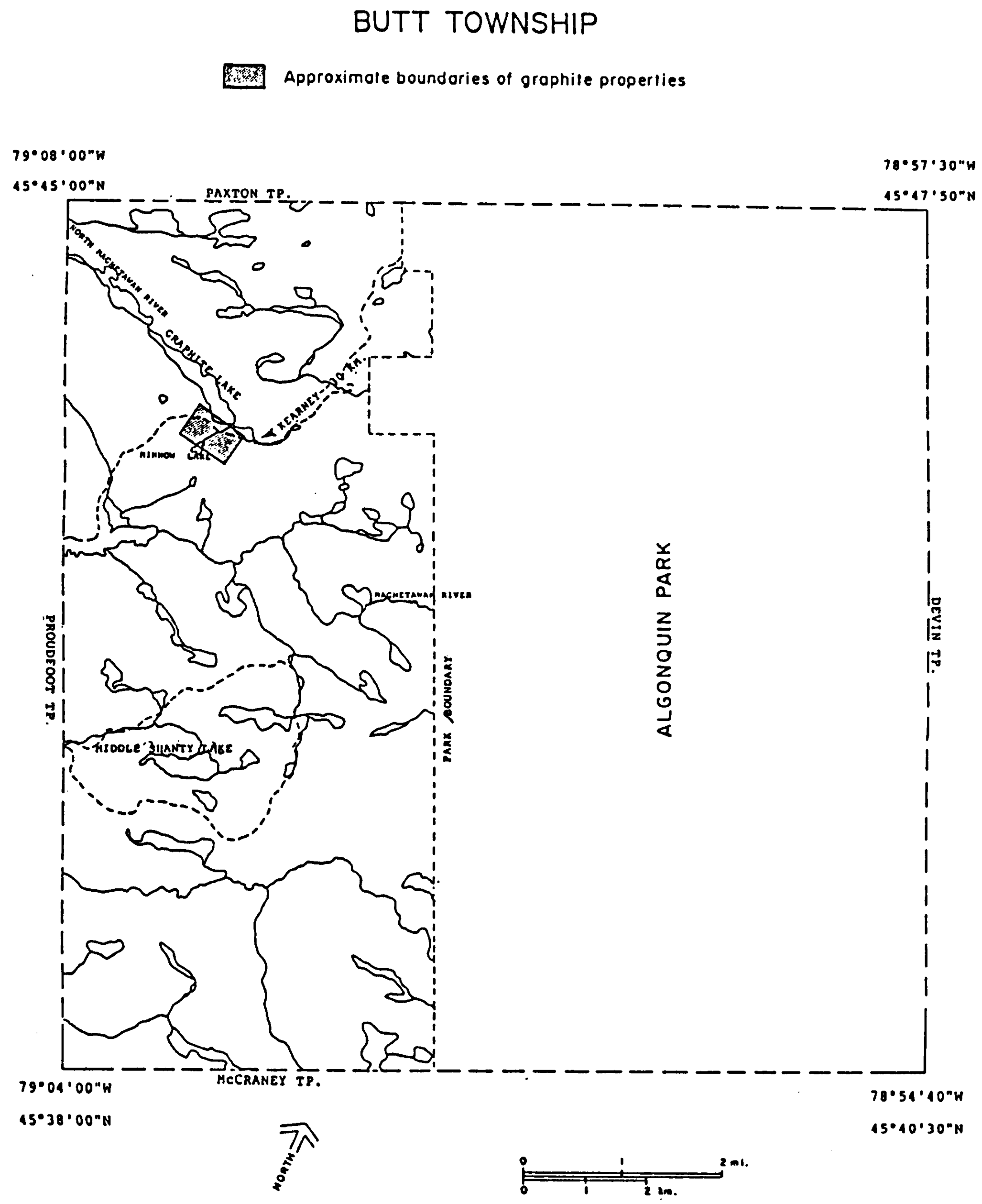


Figure 4. 2: Location map of the area of interest (shaded) within Butt Township.

4.2 LOCAL GEOLOGY

Butt Township lies within the Kiosk Domain of the Central Gneiss Belt. The Kiosk Domain is at the same structural level as the Britt and Rosseau Domain, all of which comprise the lower thrust sheet within the Central Gneiss Belt as described by Davidson et al. (1985). Structural trends in the Kiosk Domain swing from east-northeast to southwest, conforming to the southern termination of the Powassan Batholith (Lumbers 1975). Smaller orthogneiss bodies, similar to the Powassan Batholith, extend south and east of the Powassan Batholith from Highway 11 to east of Butt Lake in Butt Township. These plutonic bodies consist of meta-diorite, garnet-hornblende metamonzonite, and meta-quartzmonzonite, and occur within a series of mafic quartzofeldspathic, semi-pelitic, and pelitic gneisses (Davidson and Grant 1986). The pelitic gneisses, which contain the graphitic horizons, have been traced from Ryerson Township, west of Highway 11, to Butt Township, and through Algonquin Park. It is possible that the graphite occurrence in Maria Township is within the same band of pelitic gneisses as the occurrences in Ryerson and Butt townships (Davidson and Grant 1986; Garland 1987).

Davidson's 1985-1986 mapping (Davidson and Grant 1986) includes part of the Kiosk Domain containing the Cal Graphite deposit. A detailed map of the area between Graphite Lake and Minnow Lake was completed by the author as part of Open File 5649 (Garland 1987), and although it is now dated since the area has been stripped, the lithological description of the units is unchanged. The rocks in the vicinity of the graphitic horizons consist of a series of quartz-feldspar-biotite-garnet gneisses, exhibiting the fine-grained, granoblastic texture typical of high-grade metamorphism. The overall strike of the lithologic units is north to 020°, and the dip is to the east, from 30 to 60°.

The graphitic unit crops out over widths of 200 metres, for 400 metres along strike, from Minnow Lake to McGuire Lake, which is the southern extension of Graphite Lake (figure 4.3). The drilling done by Cal Graphite revealed two distinct graphitic zones, each of varying width, separated by a band of rocks different from the hanging or footwall gneisses. This was confirmed, in part, by the detailed mapping. The drilling also showed that the graphitic horizon continues to the north under McGuire Lake, and appears to be open along strike in this direction. The 1988 drilling has shown that the two zones unite at depth (130 vertical metres).

4.3 DETAILED GEOLOGY OF THE DEPOSIT

4.3.1 THE GRID

The area stripped and subsequently mapped comprises the eastern zone of the graphitic horizon exposed between Graphite and Minnow Lakes (figure 4.3). A baseline and crosslines were flagged at 10-metre intervals providing detailed control over the area. Sampling was done at 5-metre intervals on the lines with the aid of a masonary saw (see map 1a, map 1).

4.3.2 MAP LITHOLOGIES

Five lithologies were recognized:

1) Graphite-feldspar-quartz schist (map unit 1a).
2) Feldspar-graphite-quartz schist (map unit 1b).
3) Garnet-hornblende quartzofeldspathic gneiss (map unit 2a).
4) Net-textured mafic rock (map unit 2b).
5) Pegmatites (map unit 2c).

Rock units are named according to increasing mineral abundance. The graphite-feldspar-quartz schist and the feldspar-graphite-quartz schist are the major graphite bearing units. Graphite also occurs in narrow lenses which are sporadically distributed within the garnet-hornblende quartzofeldspathic gneiss (unit 2a). Graphite does not occur within the net-textured mafic rock, or within the pegmatites, but can be found concentrated along the edges of some of the pegmatites.

UNIT 1A -- GRAPHITE-QUARTZ-FELDSPAR SCHIST:

The graphite-feldspar-quartz schist (map unit 1a) comprises most of the map area. It is characteristically schistose in nature and very rusty (photo 4.1). It consists of, in decreasing abundance, quartz, feldspar (mostly plagioclase, some microcline), graphite, biotite, diopside, sillimanite, titanite, sulphides, and in a few samples, scapolite.

<u>QUARTZ</u>

Quartz varies in amount from 30 to 80% by volume, and is the most abundant mineral in the rock. The average amount of quartz in 21 samples is 48% by volume. In thin-section, it usually occurs as either highly strained ribbons and rods, up to 2 centimetres in length, or small recrystallized grains, 1 millimetre or less in size. The ribbons and rods exhibit well-developed strain shadows and are in evidence enough to define a fabric lineation (photo 4.2). The smaller grains can occur in either the strained or unstrained state. The unstrained quartz grains have usually been recrystallized from larger, highly strained grains and have readjusted to the stress regime. The smaller strained quartz grains tend to occur along the edges, or interstitial to larger quartz and feldspar grains. They appear to be the result of crushing (photo 4.3).

FELDSPAR

Plagioclase: In most of the thin-sections examined, plagioclase is the predominant feldspar, varying from 0 to 30% by volume, averaging 10%. Composition of the plagioclase, as determined by the Debye-Scherer albite twin method, is in the An30-50 range. Tiny microscopic inclusions are common, usually aligned along twin boundaries. Plagioclase occurs most commonly as small grains (less than a millimetre) interstitial to the larger quartz ribbons, and less commonly as larger (2-3 millimetres) grains. Alteration (sericite) is evident, starting along cleavages, and in some sections, obliterating the mineral.

Potassium Feldspar: Potassium feldspar is well-twinned microcline, and amounts vary from none to 40% by volume at one locality with an average of 9%. The microcline occurs as square, unaltered grains, usually less than a millimetre in size. In the thin-section with microcline approaching 40% by volume, grain size varies from less than a millimetre to 3 millimetres.

BIOTITE

Biotite occurs in most of the sections examined, in amounts varying from none to 10% by volume, averaging 5%. It occurs as chunky laths, pleochroic in brown, light brown, and red-brown. It is usually associated with flakes of graphite, clinopyroxene, and sulphides, when present. Biotite can be crystallographically interlayered with flakes of graphite (photo 4.4).

CLINOPYROXENE

Clinopyroxene occurs in some of the sections, as small ragged grains associated with titanite, biotite, and graphite. Analysis with the SEM confirmed the clinopyroxene to be diopside. The distribution of the sections containing diopside seems to indicate the presence of discrete, diopside-bearing bands within the unit 1a.

SILLIMANITE

Sillimanite occurs in most of the thin-sections as very tiny, oblong-shaped grains disseminated throughout the matrix. It also occurs less commonly as large (2 millimetres), wormy-looking, semi-fibrous grains which appear to be forming from a reaction involving quartz (photo 4.5).

GRAPHITE

Graphite is ubiquitous, occurring in amounts varying from 7 to 15%

by volume. The size of the graphite flakes reflects the overall grain size of the rock; in finer-grained parts of the unit the flakes are smaller (<1 millimetre), in coarser-grained parts the flakes are larger (up to several millimetres). Graphite flakes occur disseminated amongst the quartz and feldspar (photo 4.6), or they can occur interlayered with the biotite (photo 4.7). The graphite tends to be associated with the mafic minerals, biotite, diopside, and titanite, which tends to give the unit a banded appearance.

TITANITE AND SULPHIDES

Titanite occurs as small, rounded grains, associated with diopside, biotite, graphite, sulphides, and iron staining (photo 4.8). It is present in an average amount of 3% by volume. Some of the titanite occurs with a pervasive opaque mineral, which appears to be an iron oxide, probably ilmentite.

Sulphides, consisting of pyrite and pyrrhotite, occur as round blebs or in strung-out clumps in the quartz-feldspar matrix. The amount of sulphide varies from 0 to 3% by volume, usually averaging 2%.

UNIT 1B -- FELDSPAR-GRAPHITE-QUARTZ SCHIST:

The feldspar-graphite-quartz schist consists of discrete bands within unit 1a, identifiable mainly by a difference in weathering. Unit 1a weathers in a rubbly manner, reflecting the schistose nature of the rocks. Unit 1b weathers more in a blocky manner, and is thus recognizable as a separate band within the unit 1a. On the fresh surface, the two units are almost impossible to differentiate, varying only in subtle differences in amounts of the major constituents. The implication is that the difference on outcrop surface is probably due to a greater percentage of sulphides within unit 1a, resulting in the more extensive, friable weathering.

QUARTZ

Quartz in unit 1b is almost entirely recrystallized into small (1 millimetre or less) equant grains, with the outline of the original quartz rods still visible. The amount of quartz varies from 50 to 65% by volume averaging a consistent 56%, slightly higher than unit 1a. Strain shadows are not as evident, due to the amount of recrystallization, but some of the recrystallized grains are also elongate, indicating a continuous response to stress.

FELDSPAR

The predominant feldspar is plagioclase of An25-40 (Debeye-Scherer method). Amounts vary from 0 to 20% by volume averaging 9.5%. The plagioclase occurs as small, equant to slightly elongate grains, and show incipient to pervasive alteration to sericite (photo 4.9). Microcline, present in some of the thin-sections, occurs in lesser amounts than the plagioclase and is not sericitized.

BIOTITE

Biotite, when present, appears to be associated with graphite and iron oxide (photo 4.10).

CLINOPYROXENE

Clinopyroxene occurs as diopside, in small (less than one millimetre), ragged grains, usually interstitial to quartz. Chlorite alteration is pervasive along cleavages. Diopside appears to be restricted to certain bands of the 1b unit; it is not present in samples of 1b taken from the south end of the map area.

SILLIMANITE

Sillimanite is not nearly as common in this unit as it is in unit 1a averaging 1% by volume. It occurs as very tiny grains (0.1 millimetre) disseminated within the quartzofeldspathic matrix.

GRAPHITE

Graphite occurs in slightly higher concentrations in unit 1b, averaging 9.4% by volume. Flake size varies with overall grain size of the rock and can be up to 3 millimetres. The flakes commonly occur in aggregates. Since the usually associated minerals tend to be present in small amounts, the graphite appears quite clean.

TITANITE, SULPHIDES, AND IRON OXIDES

Titanite occurs in all thin-sections as dark, rounded grains and can be interlayered with the graphite. Pyrrhotite tends to be the predominant sulphide and, with pyrite, forms grains interstitial to the quartz and feldspar. Iron oxide occurs in veinlets of iron stain associated with chlorite, biotite, and graphite.

UNIT 2A -- GARNET-HORNBLENDE-QUARTZOFELDSPATHIC GNEISS

The main occurrence of garnet-hornblende-quartzofeldspathic gneiss is a fish-shaped lens approximately 100 metres long and 30 metres wide in the centre of the map area, tailing off to less than one metre wide at the south end. Unlike the main graphite-bearing units, unit 2a is gneissic, has inclusions which have been boudinaged, rotated, and folded, and contains both garnet and hornblende. Graphite occurs within the unit, but not with any regularity, and is restricted to thin lenses and disrupted bands.

QUARTZ

Quartz accounts for approximately 24% by volume of unit 2a. Most of the quartz occurs as large (1.5 to 5 millimetres) amoeboid grains, commonly enclosing the other minerals (photo 4.11). Quartz also occurs as tiny, angular grains interstitial to the other larger minerals.

FELDSPAR

No potassium feldspar was noted in thin-sections from this unit. Plagioclase occurs in similar amounts to quartz averaging 25% by volume. It occurs as large (>1 millimetre), grains with inclusions of small (<1 millimetre) equidimensional crystals, which can be inclusions within large quartz grains. The composition is in the An40-50 range (photo 4.12).

BIOTITE, HORNBLENDE AND CLINOPYROXENE

Biotite is strongly pleochroic, varying from red-brown to yellow. It comprises approximately 9% of the rock by volume and is commonly associated with hornblende and garnet in mafic aggregates, or with garnet and plagioclase in bands.

The hornblende is strongly pleochroic in dark green, light green, and brown. It occurs in large (3 millimetres), ragged or skeletal crystals, in patches with biotite, and constitutes 10% of the rock by volume. Two generations of amphibole have been noted: dark green hornblende forms a rim on a pale green to colourless amphibole (grunerite) (photo 4.13).

Clinopyroxene (augite or diopside), is present in some of the sections, varying in amount from 5 to 25% by volume. It occurs as broken-looking grains in bands with garnet and as a mosaic of crystals which appear to be growing at the expense of hornblende (photo 4.14).

GARNET

Garnet is ubiquitous in this unit occurring in amounts up to 50% by volume. The crystals are large (2-3 millimetres), fractured and broken, and full of inclusions (photo 4.15). Garnet can be seen segregated into bands alternating with titanite.

GRAPHITE

Graphite is present in very small quantities (<1% by volume), occurring as small flakes within selected bands or aggregates of the mafic minerals (photo 4.16).

UNIT 2B -- NET-TEXTURED MAFIC ROCK

The net-textured mafic rock occurs in the map area as distinct blocks which have the appearance of "floating" within the graphitic schist. The "net-texture" is due to the presence of anastomosing veinlets of a light-coloured plagioclase-quartz material forming a network around the darker hornblende-plagioclase cores (photo 4.17). In places the entire network is deformed; in others, the network becomes more deformed toward the edges of the block. Wider parts of the veins are coarser collecting in pockets to form pegmatitic patches. The coarser veins contain large (1-2 centimetres) plagioclase and quartz, and occasionally large garnet or hornblende crystals. The veins are restricted to the mafic blocks and do not cross contacts with the graphitic schist.

The mafic cores of the blocks consist of hornblende porphyroblasts up to 5 millimetres associated with garnet, biotite, and titanite. Clinopyroxene (augite) commonly occurs as a mosaic of crystals growing on a single hornblende (photo 4.18). There is no graphite in this unit.

UNIT 2C -- PEGMATITES

There are three distinct types of pegmatites: feldspar-quartz-biotite veins which have concentrated at the edge of the blocks of the 2b unit, and filling fractures in nearby units; quartz to quartz-feldspar, coarse-grained pegmatites with large crystals of either biotite, hornblende, or garnet, which cross cut the map units; and quartz-feldspar veins contained and deformed within the units, particularly unit 2a.

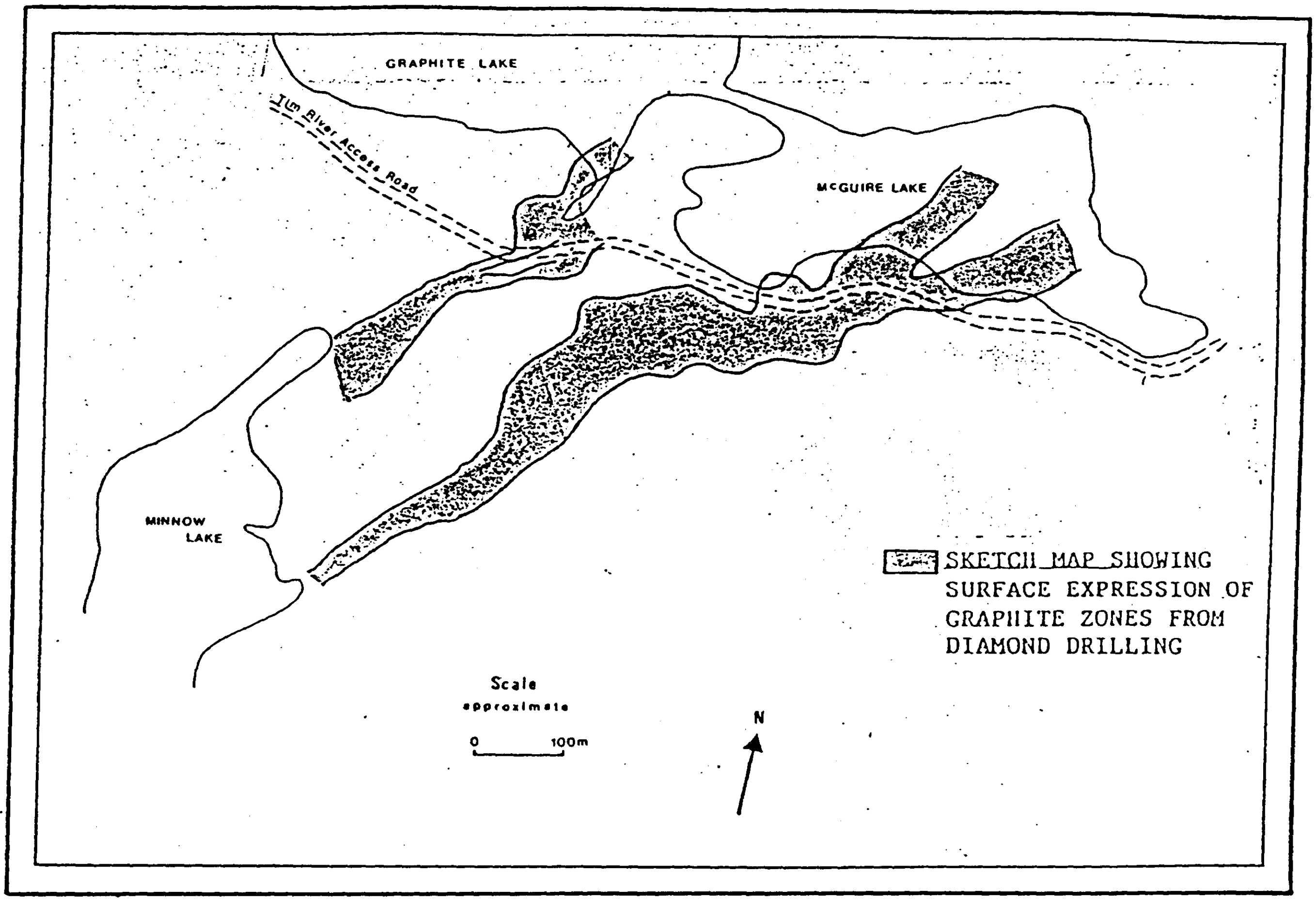
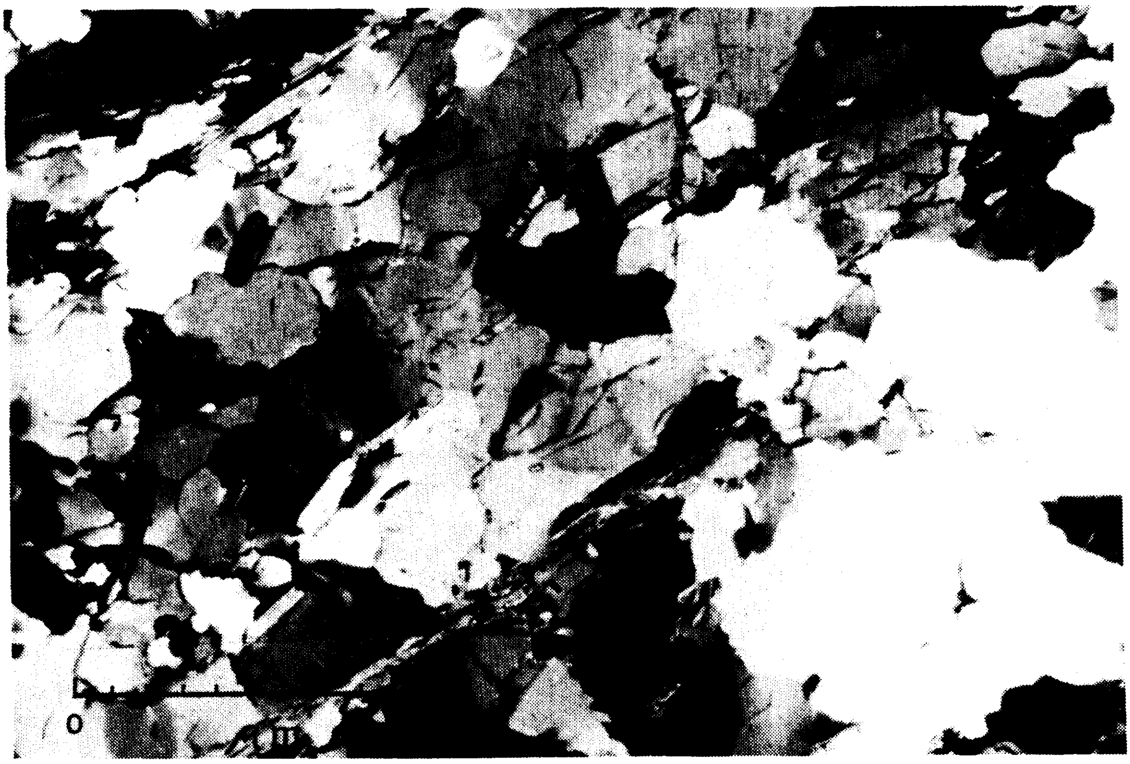


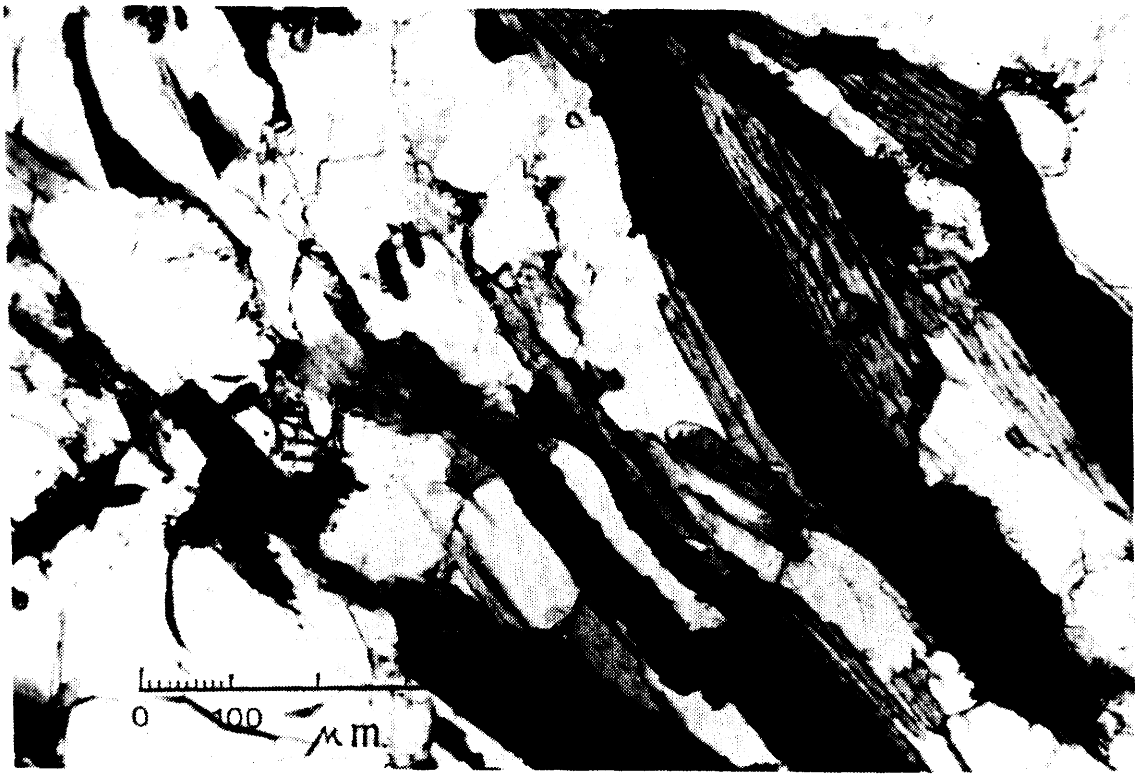
Figure 4.3: Sketch map showing the surface expression of the graphite zones interpreted from diamond drilling

4.1 View of the graphitic units, facing south.

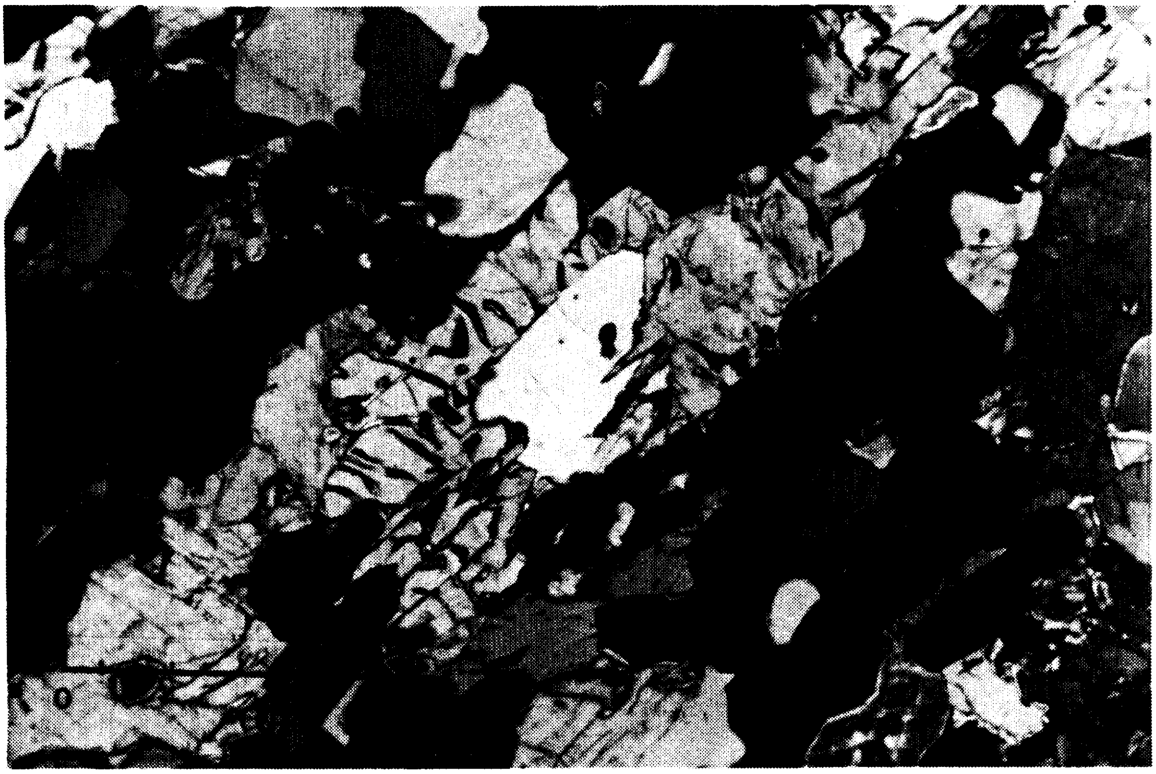


4.2 Recrystallized quartz grains in unit 1a. Lineation defined by biotite (B), graphite (G), and the outlines of the original quartz rods (Q), crossed polars.

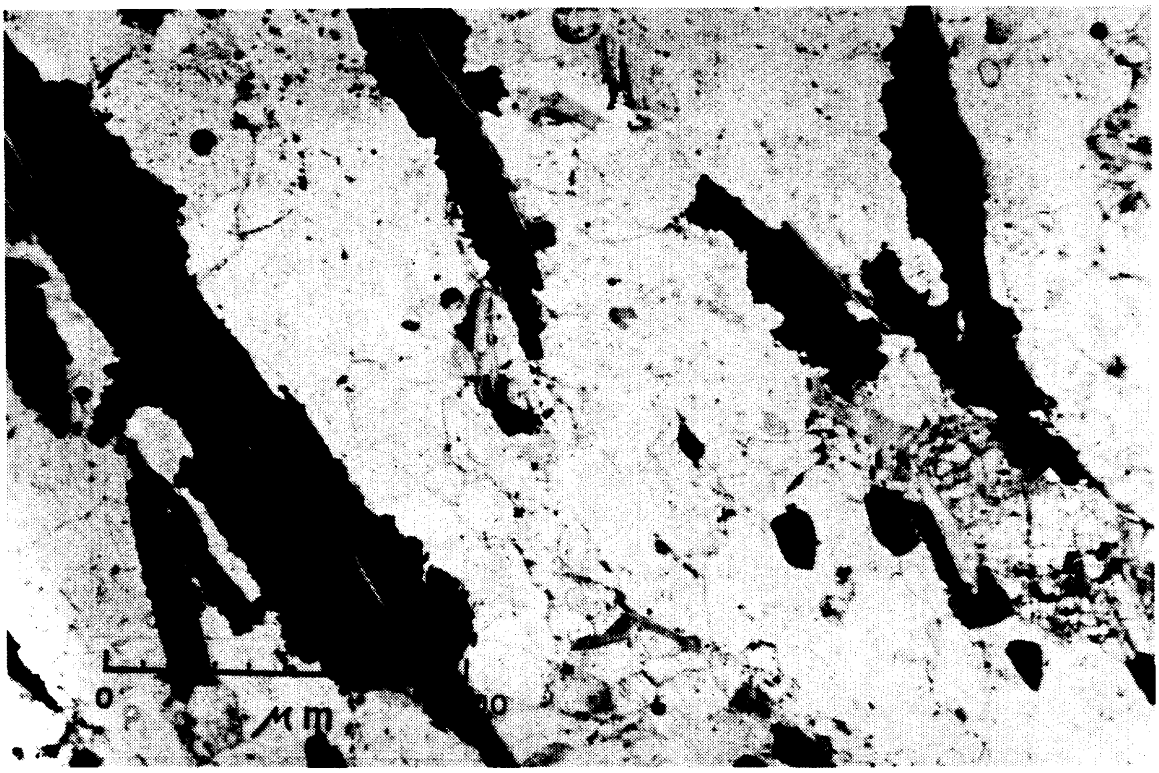
4.3 Small quartz grains along the edge of a large feldspar grain, probably the result of crushing, crossed polars.



4.4 Biotite with graphite interlayered within single crystals, plane light.



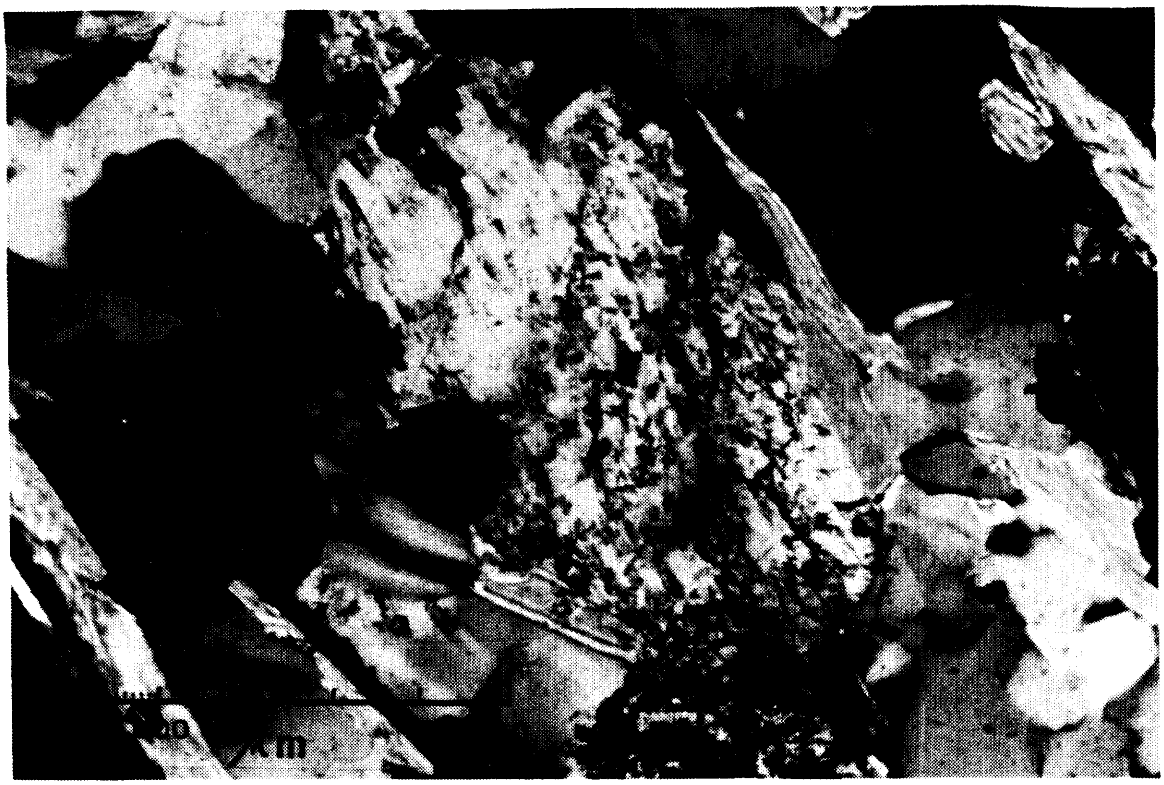
4.5 Wormy-looking sillimanite with quartz core, in unit 1a, crossed polars.



4.6 Clean graphite flakes disseminated throughout the matrix of unit 1a, plane light.

4.7 Graphite and biotite interlayered, from unit 1a, plan light. Note the size of the graphite flakes.

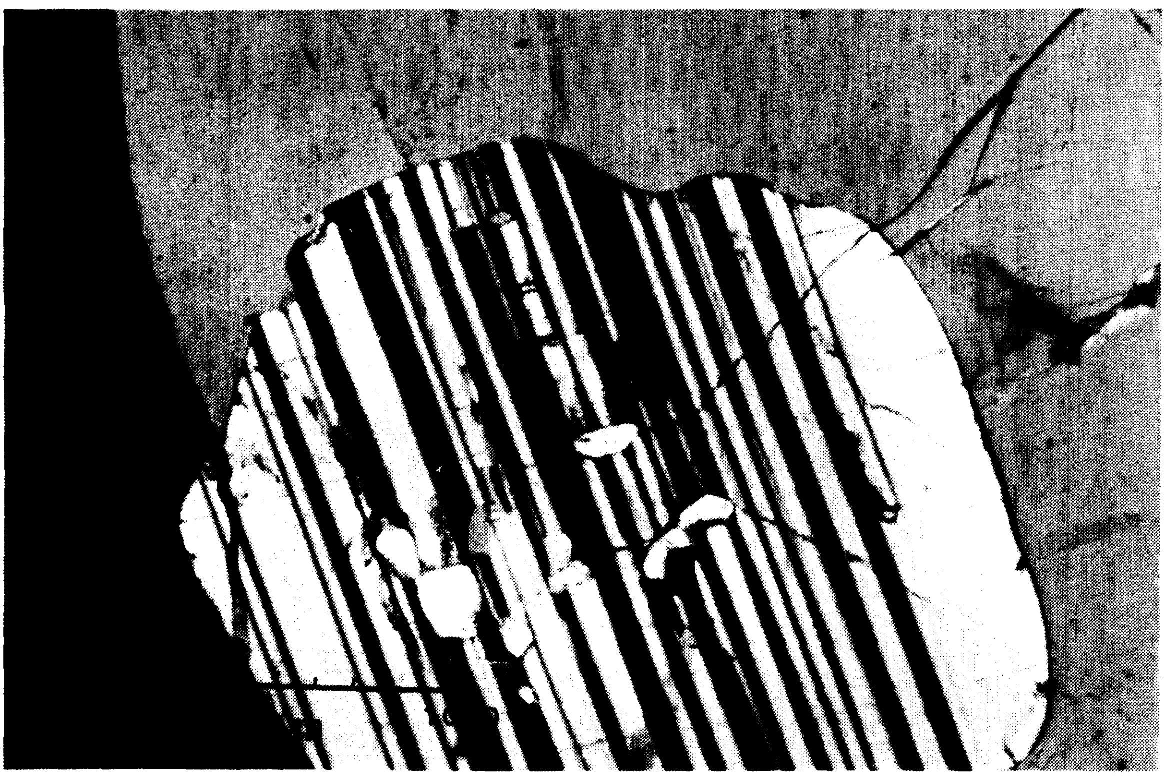
4.8 Grain of titanite (T), associated with clinopyroxene (CP), and biotite (B), plane light.



4.9 Sericite alteration of a plagioclase grain along cleavages, unit 1b, crossed polars.

4.10 The small amount of biotite in unit 1b is usually associated with graphite (G) and iron oxide (IO), plane light.

4.11 Large, amoeboid, strained quartz grain from unit 2a, crossed polars.



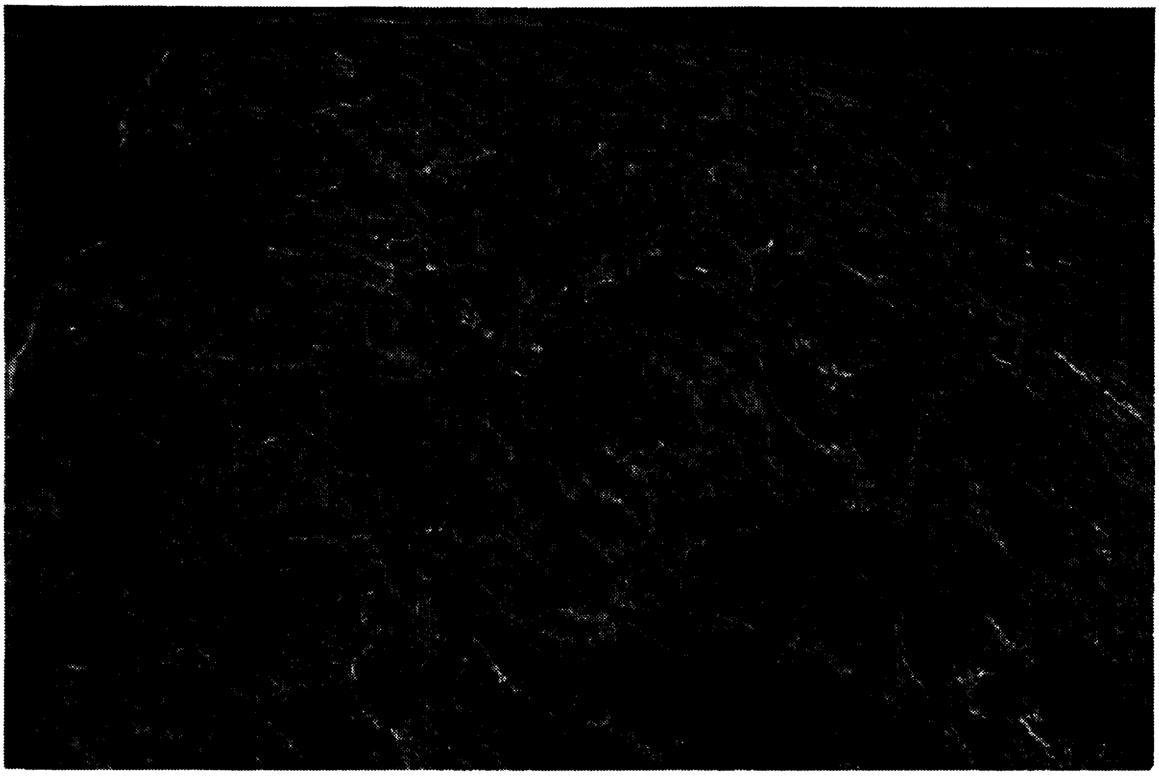
4.12 Large, rounded plagioclase grain with inclusions, unit 2a, crossed polars.

4.13 Green hornblende (H), forming a rim around a colourless amphibole (grunerite), unit 2a, plane light.

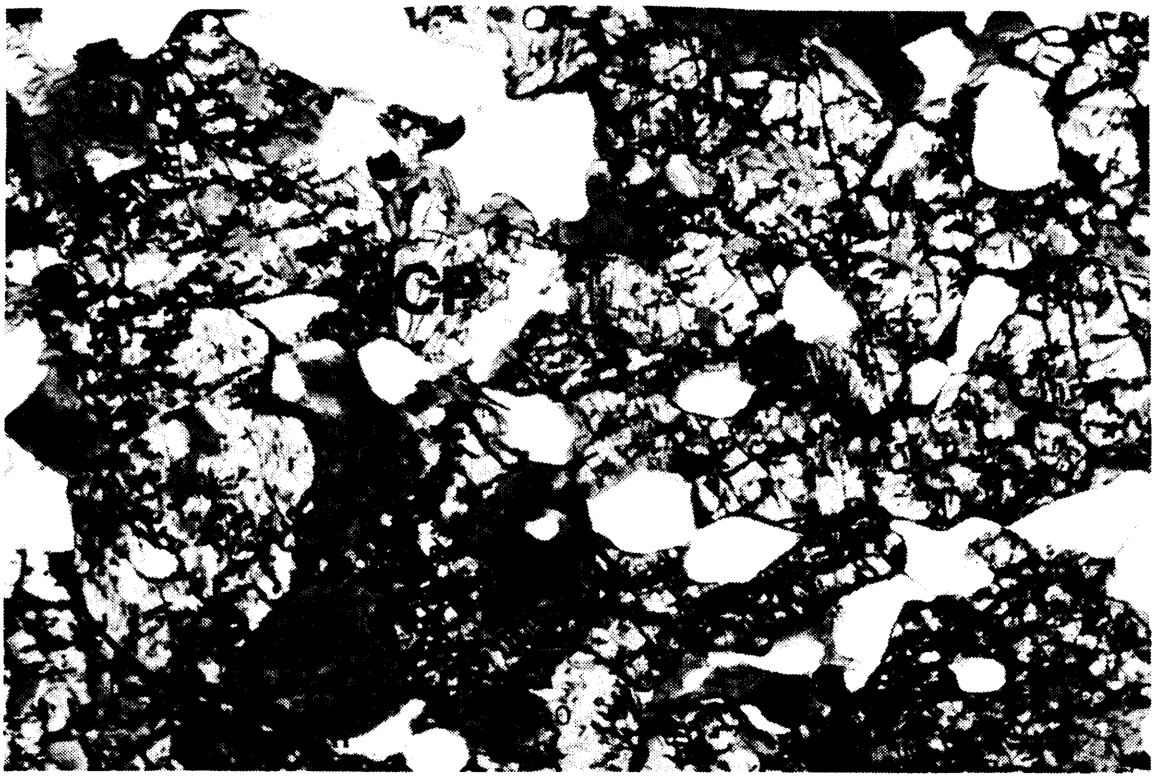
4.14 Clinopyroxene (CP) replacing hornblende (H), unit 2a, plane light.

4.15 A groundmass of garnet (GT), clinopyroxene (CP), and quartz (Q), from a band in 2a, plane light.

4.16 Graphite in unit 2a occurs in small amounts, within select bands, and usually is associated with biotite, plane light.



4.17 Unit 2b, illustrating the characteristic net-texture.



4.18 Mosaic of clinopyroxene grains (CP) replacing a single hornblende crystal (H), unit 2b, plane light.

4.3.3 STRUCTURE

The graphite deposits within the Central Gneiss Belt appear to have undergone severe deformation. They are attenuated, with strike length much greater than the width, and exhibit a variety of characteristics indicative of ductile shearing. It is possible that the graphitic units localized the stress, resulting in relatively narrow, highly-deformed zones, coincident with the graphitic horizons.

The Cal Graphite deposit strikes between 000 and 020^0 with an average dip of 40^0 east (map 1a). At the northeast end, the strike appears to curve to the east, a feature which is attributed to topography rather than just folding. A well-defined foliation in the graphitic units is parallel to the lithological contacts and isoclinal fold axes. Lineations are consistently to the east, with plunges averaging 50^0 and defined by either mineral ribbons or quartz rodding.
The structure exhibited is complex, and examples of both brittle and ductile deformation are evident. The graphitic units have been folded back on themselves and folded within themselves, while the non-graphitic units are manifest as disrupted blocks or assymetric lenses within the graphitic units. There are numerous examples of rootless folds, sheath folds, crenulated cleavages, rotated fragments, and rotated blocks to indicate a complicated structural history.

4.3.3.1 Boudinage Features

Unit 1b forms distorted lenses and boudins within unit 1a and unit 2a. Since 1b is fairly massive, there is not a noticeable difference in foliation direction between the boudins of 1b and the surrounding rock unless the boudin has been folded. This feature is most noticeable in the north part of the map area.

The most predominant boudinage features are large blocks of mafic rock that appear to be "floating" in the graphite-bearing units. The weak internal foliation defined by the network fabric varies in intensity and direction from block to block, indicating rotation with respect to each other and the surrounding rock. The internal fabric of the mafic blocks does not cross into that of the graphitic schist; in fact the graphitic schist appears to have flowed around these blocks (photo 4.19). If the block is relatively small, the graphitic unit will completely wrap around the block isolating it in the nose of an isoclinal fold (photo 4.20). In some places the graphitic unit appears to have "squeezed" in between the blocks of the unit 2b.

Unit 2a also exhibits boudinage, but not to the same extent as in the 2b unit. Unit 2a has been sheared, as shown by the fact that the leucosome is now parallel to the foliation, intrafolial folds are rootless, and inclusions have been rotated (photos 4.21, 4.22, 4.23). Locally in unit 2a the deformation has been brittle rather than ductile, resulting in abrupt breaks in the unit around which the graphitic material appears to flow (photo 4.24). In the northeast part of the map area, the shearing is intense and the graphitic and non-graphitic units are blended together in anastamosing shears (photo 4.25) making it very difficult to differentiate between units.

4.3.3.2 Folding

There are at least three folding episodes recognized: (i) folding of the 1b unit with the 1a and 2a units, (ii) isoclinal folding throughout the graphitic and 2a units, and (iii) a gentle warping of the entire deposit about a northwesterly trending axis (map 1a).

Unit 1b is difficult to differentiate from unit 1a except on the weathered surface and the two units are almost indistinguishable in drill core. The repeated juxtaposition of relatively thin bands of unit 1a and 1b only became apparent on mapping the weathered surface. Unit 1b forms interrupted lenses, sheath folds, and complexly folded bands within unit 1a (photo 4.26). The lenses of unit 1b within unit 2a appear to be large inclusions. The complexity of the geology in the northeast part of the map area is accentuated by the third dimensional view afforded by the change in topography from horizontal to sub-vertical. The repetition due to folding of the unit 1b is also more apparent in this part of the map area.

Both graphitic units and unit 2a have been isoclinally folded about north-east trending axes. The folding is visible only in the nose area; the limbs have been attenuated to the point of completely blending in with the surrounding rock (photo 4.27). The graphite flake in the noses of these folds is up to 30% larger in size and the grade is usually higher by several percent by volume (photo 4.28). The poles to the fold axes and to foliation plot in the same region of the stereographic net (figure 4a), which is the pole to a plan striking 45° and dipping 40° east, the average direction for foliation and isoclinal fold axes. It seems apparent that the isoclinal folding event was responsible for the development of the predominate foliation. Lineations plot at the intersection of the average foliation plane and the plane defined by poles to the fold axes (figure 4b). The thickening of the graphite unit in the deposit area is largely due to this isoclinal folding.

On examination of the map, a large warp about an axis trending approximately 340°, has affected the entire structure. The effect of this warping is greatly exaggerated by the third dimensional view of the geology.

4.3.3.3 Summary and Discussion

At any one place within the deposit, the structure appears to be overwhelmingly complex; however, on a larger scale there is a structural pattern although complications arise in the predictability of the pattern. The deformation ranges from brittle boudinage to progressively deformed sheath folds within metres of each other, and from recrystallized leucosome to almost primary mineral textures, all indicating an inhomogeneous stress regime during deformation. The structural features are the same as those encountered in a ductile shear zone, and it is possible that the incompetent graphitic semi-pelitic schists have acted as loci for shearing stresses. Hanmer (1988) suggests that in the Central Metasedimentary Belt Tectonic Zone, pelitic gneisses have localized thrust sheets. In the Central Gneiss Belt, the graphitic schists certainly appear to have concentrated shearing stress, although the regional significance of this is yet to be determined.

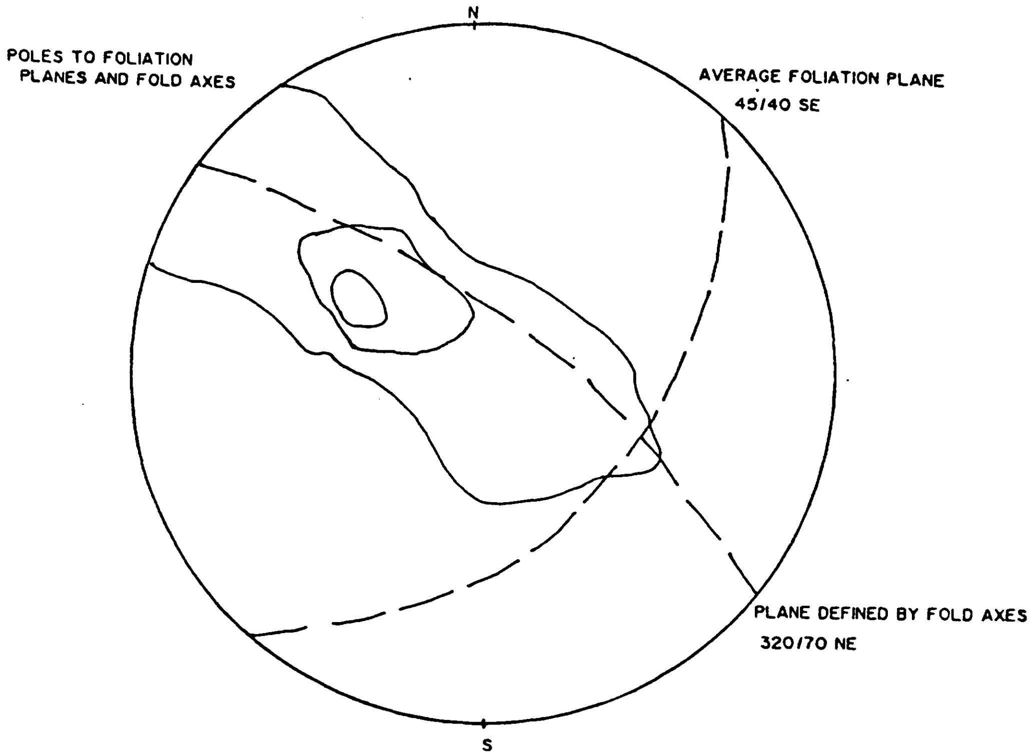


Figure 4. 4a: Stereographic projection of poles to foliation planes and fold axes (Wulff Net).

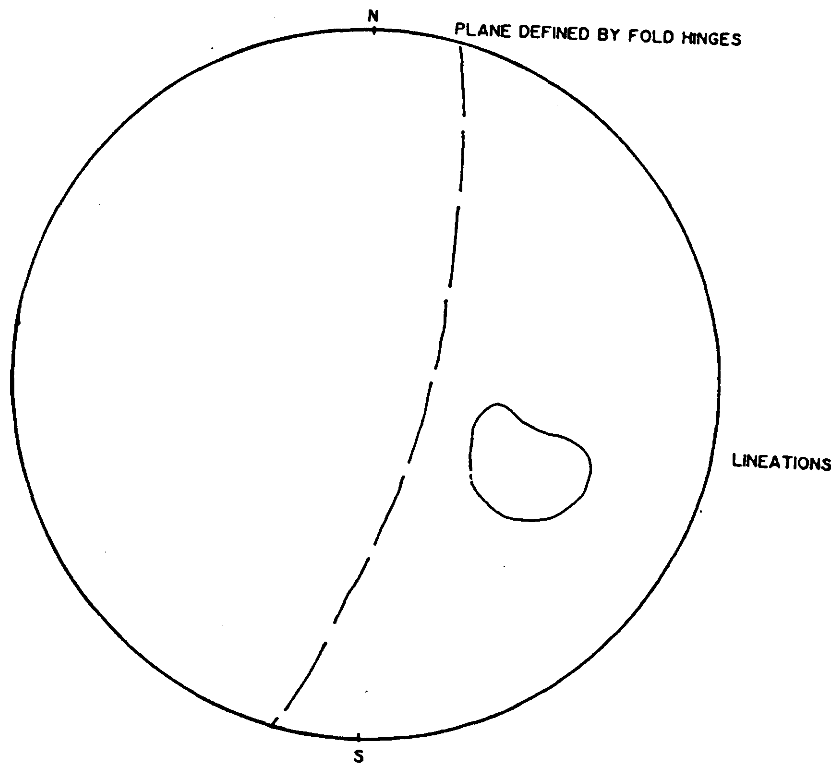
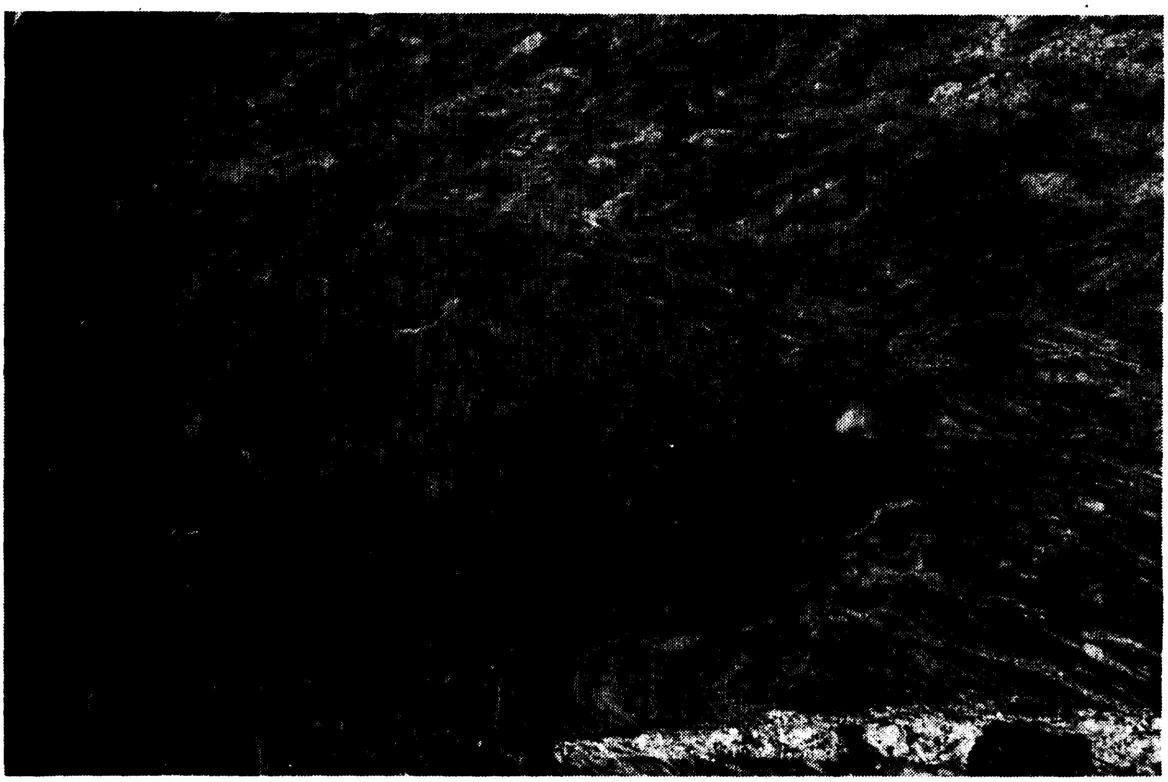
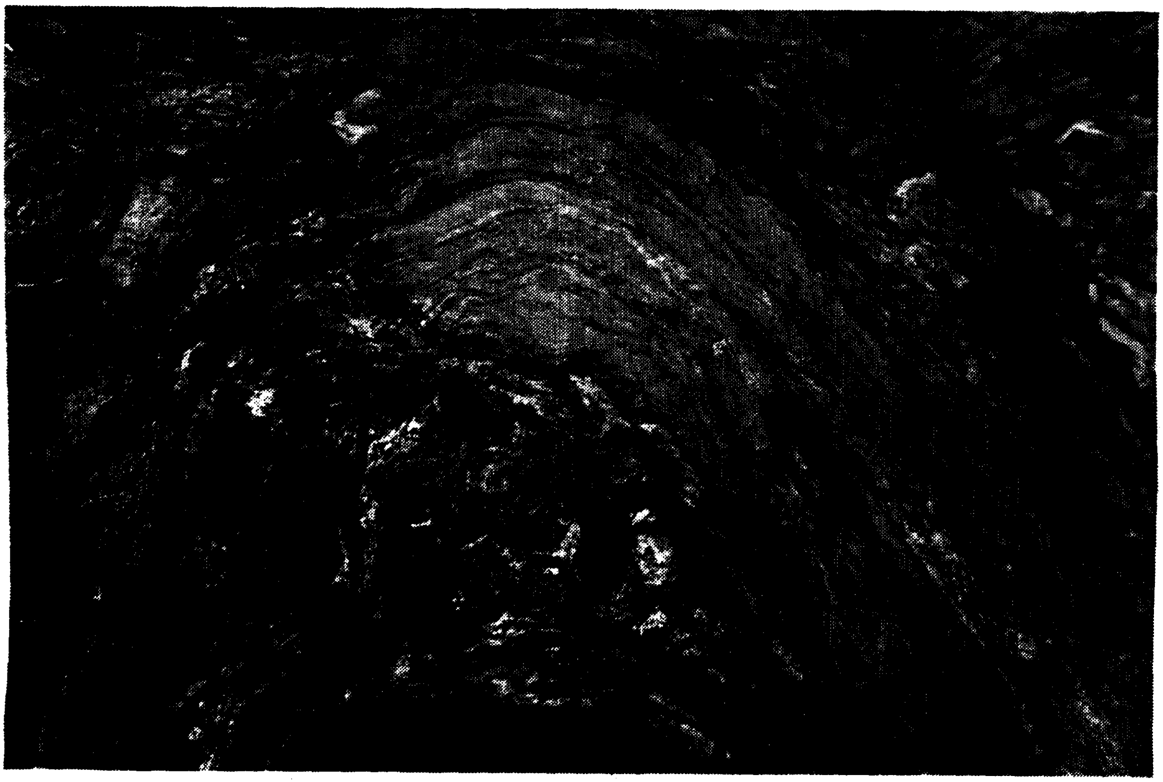


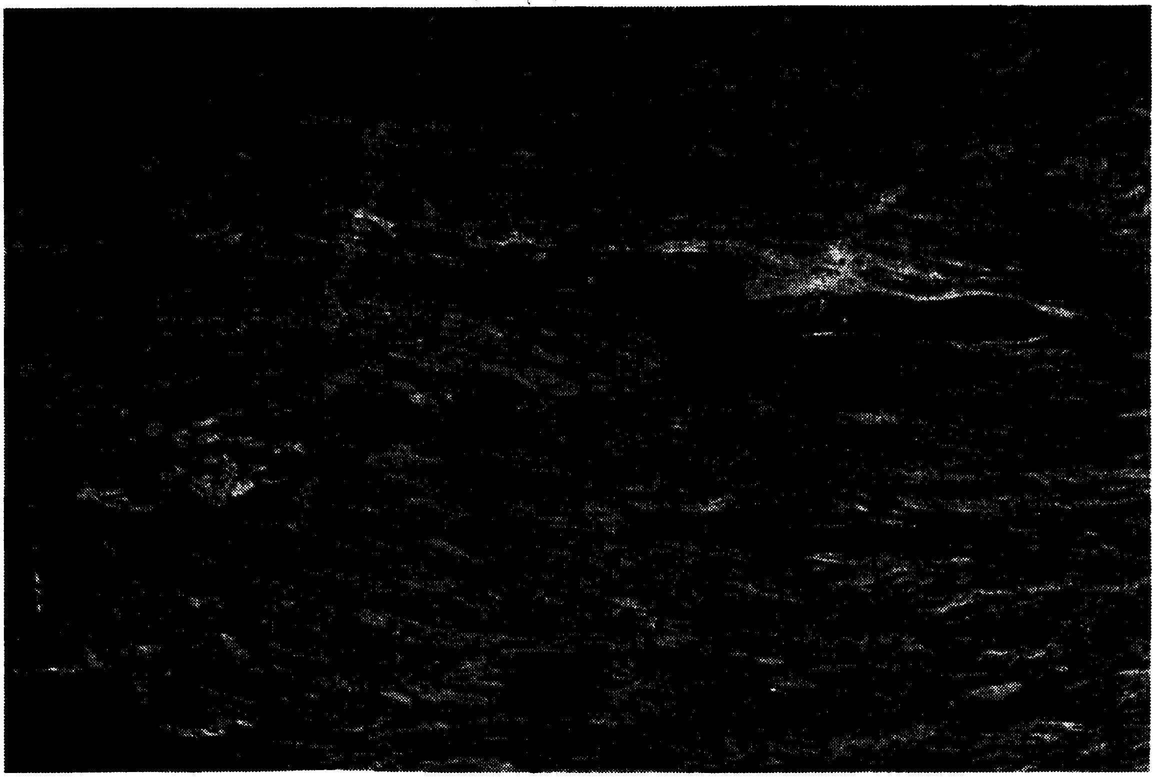
Figure 4. 4b: Stereographic projection of lineations (Wulff Net).



4.19 Block of 2b "floating" in a matrix of graphitic material (317W/38N).

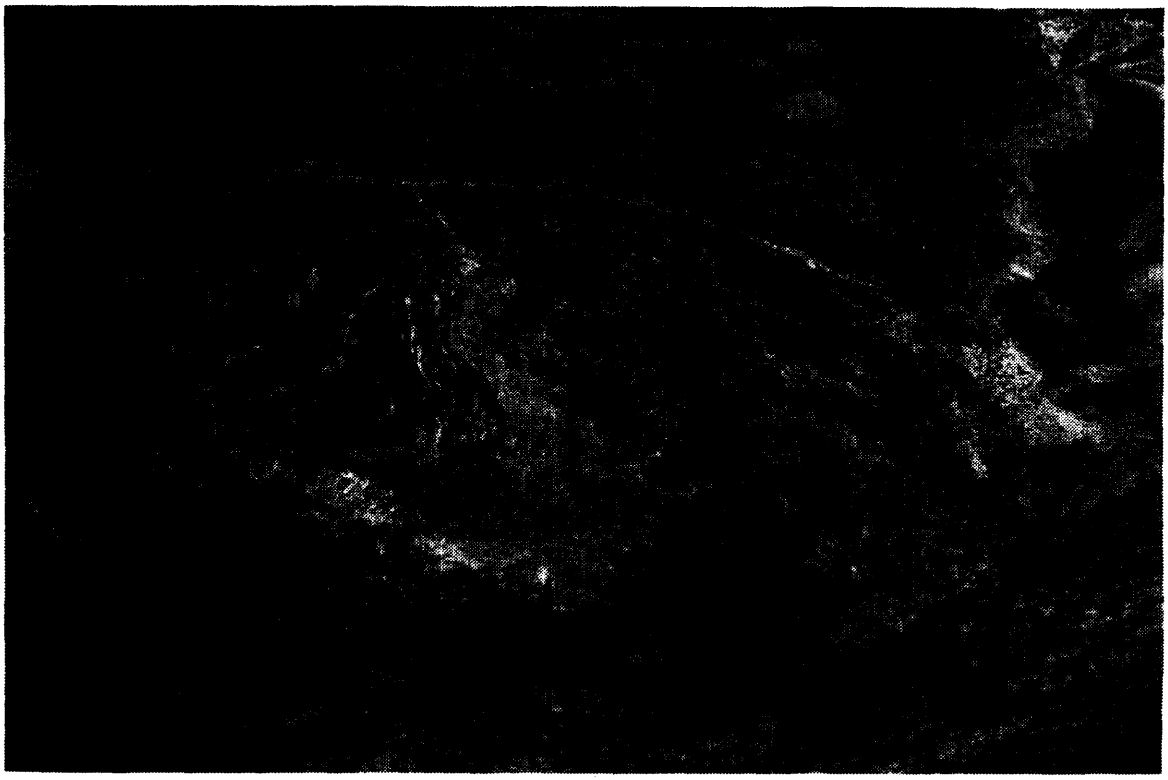


4.20 A small block of unit 2b isolated within a fold-nose in the graphitic schist (252W/13N).

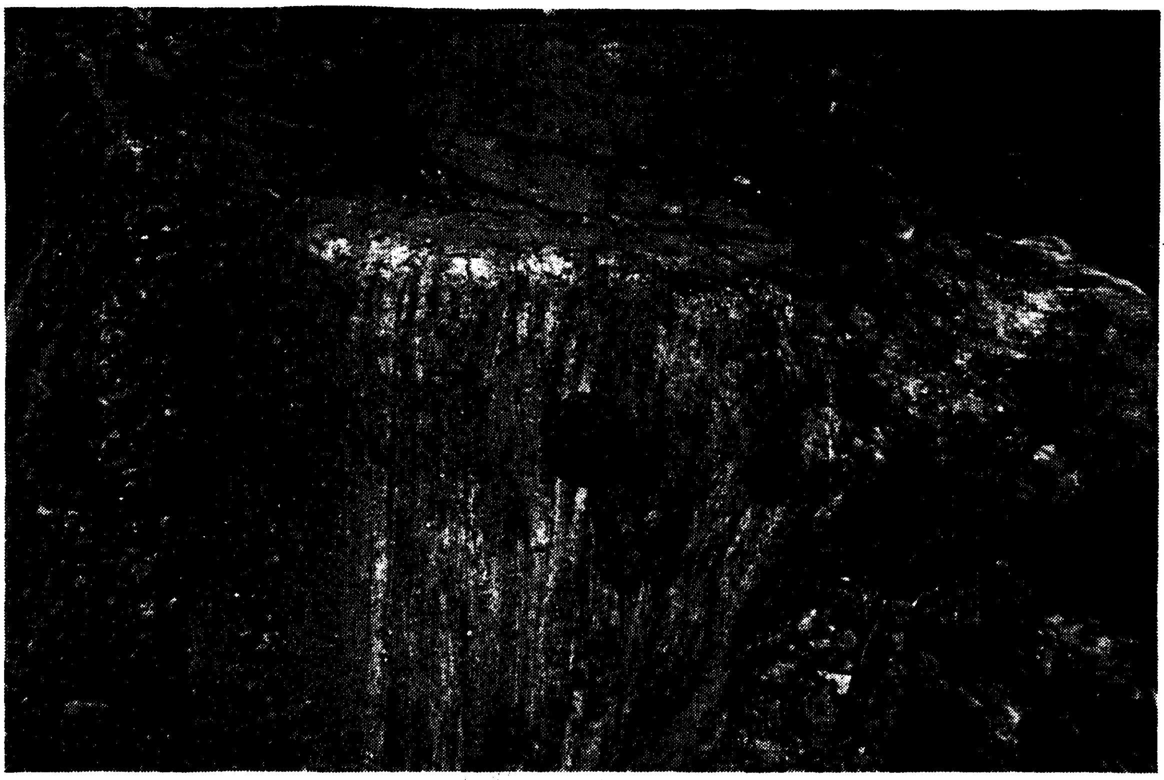


4.21 Lenses of leucosome material in unit 2a, parallel to the foliation (317W/39N).

4.22 Intrafolial folds in unit 2a, showing limbs stretched to the point of disappearing, forming rootless folds (370W/15N).

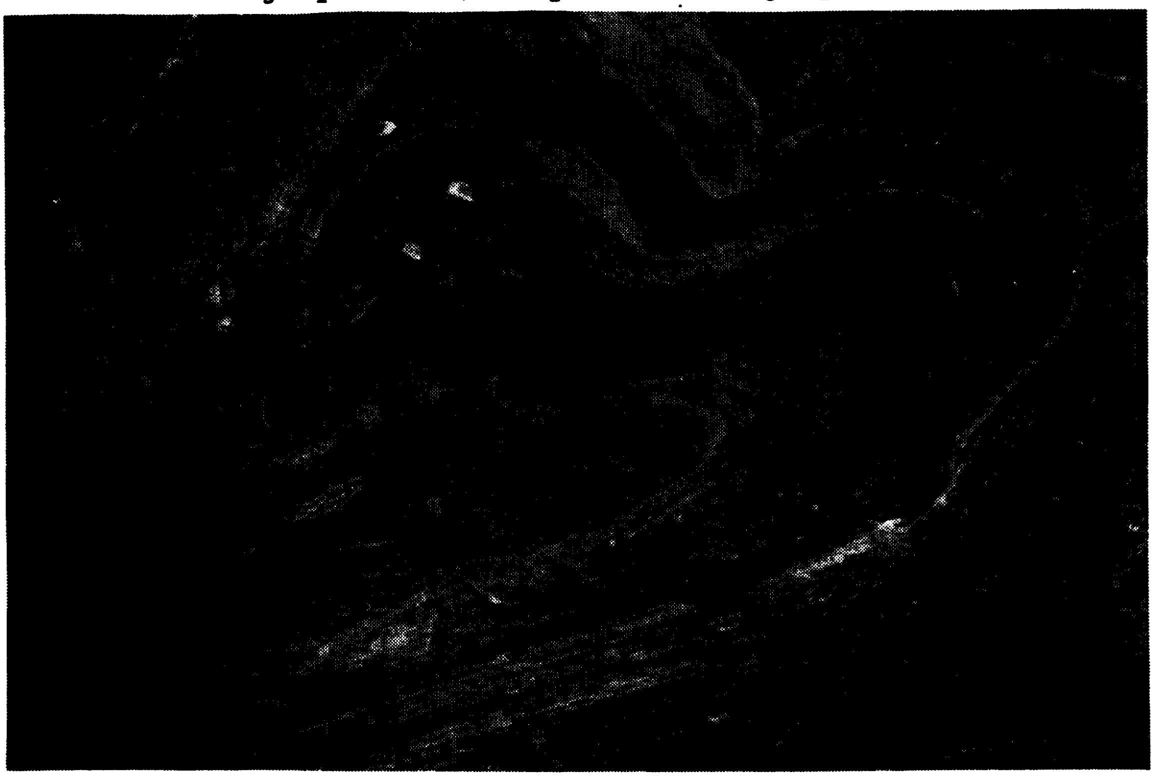


4.23 Rotated inclusion within unit 2a. Sense of shear is dextral (307W/40N).



4.24 Brittle deformation in unit 2a, around which the graphitic material appears to "flow" (351W/25N).

4.25 Northeast part of the map area, showing the intermixing of the graphitic (rusty) and non-graphitic units.



4.26 Fold of 1b material within unit 1a (332W/52N).

4.27 Several fold-noses within the graphitic units; the limbs blend together creating a wider-than-original unit (267W/28N).

4.28 Clumps of coarse-grained graphite in a fold-nose within unit 1b (347W/53N).

4.3.4 THE THIRD DIMENSION

The behaviour of the geology at depth is important for feasibility and mining considerations. The surface map indicates blocks of barren material which, depending on their continuity, or lack thereof, in the third dimension will affect the final reserve and grade figures for the deposit. If the lenses of essentially barren material are actually lenses in the third dimension and not continuous bands, then there may be graphitic material between the lenses. In order to examine the three-dimensional aspect of the deposit, the author used the only available drill holes in two sub-parallel sections throughout the widest part of the area mapped. The holes were drilled in 1982, 1986, and 1988 by Vesuvius Crucible and Cal Graphite. The sections are displayed with map 1 (sections 1b and 1c, back pocket), and the logs are given in appendix 1. A block diagram was constructed across the centre of the map area to illustrate the three-dimensional aspect of the deposit (map 1d, back pocket).

Although there has been a relatively large amount of drilling on the deposit, drill holes that actually intersect the map area in the appropriate location were done in the early days of exploration and tended to be short or incomplete. The non-graphitic units were recognizable in drill core, but separating unit 1b from 1a proved to be difficult.

When correlated with the outcrop map, it is apparent that the block-like nature of the non-graphitic units does extend to the third dimension. The graphitic units form the matrix around and between the blocks and lenses of non-graphitic rock. Where recognizable in drill core, unit 1b was extrapolated at depth to form bands within unit 1a, highlighting the folding present in the graphitic units. The net-textured rock, unit 2b, occurs in discrete blocks, slightly elongated in the third dimension. These blocks appear to be "floating" within the graphitic units. Unit 2a forms lens-shaped bodies, elongated both along strike and down-dip. The lenses are not continuous, but tail-out into the graphitic units or become so interlayered with the graphitic unit that the integrity of unit 2a is lost.

The implications of these three-dimensional sections are significant:

1. The complexity on the outcrop surface extends to the third dimension. This means that the folding and boudinage present on surface also exist at depth.
2. Calculations on mineable reserves should take into consideration the discontinuous nature of the barren units; large intact blocks of barren material might be selectively removed, diminishing the effect on dilution and grade calculations.
3. To fully understand the nature of the deposit, and to be able to upgrade tonnage and grade calculations, the geology should

be monitored on a fairly continuous basis during mining operations.

4. The inhomogeneous stress regime (section 4.3.3.3) which is evident on the surface, extends to the third dimension, and it is not unreasonable to expect this type of stress situation to be present along the entire strike of the graphite-bearing horizon.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

1. Graphite occurs as a crystalline flake within rocks of simple but specific mineralogy, consisting of quartz, feldspar, clinopyroxene, graphite, biotite, sillimanite, titanite, and sulphides.

2. The graphite-bearing rocks can be subdivided into units based on differences on the weathered surface, which may be a reflection of slight differences in amount of sulphide minerals. In fresh samples the difference between the units is negligible.

3. Structure seen on hand sample and outcrop scale is a mirror of the structure on a regional scale. For example, if drag folds are evident in outcrop, there is probably drag folding on a larger, regional scale.

4. The graphitic units, and unit 2a, have been isoclinally folded about northeast trending axes. The limbs of these folds have been attenuated, leaving only the fold-noses, which appear "rootless". The foliation within the deposit appears to be a result of the isoclinal folding event. Graphite flake in the nose areas of the folds is a slightly larger flake and tends to be more concentrated.

5. Examples of both brittle and ductile deformation are present: the graphitic units exhibit ductile deformation; the net-textured mafic rock (unit 2b), and in places unit 2a, exhibit brittle deformation. Unit 2a occurs in the form of large blocks or boudins "floating" within the graphitic units.

6. The structure observed on the surface expression of the outcrop is continued in the third dimension based on drill hole data. The blocks of 2b have finite dimensions at depth, and the graphite units weave around the blocks in section as well as in plan. This means that the geology of the barren material will have to be considered in order to follow the graphitic horizons and to maximize mining tonnage and graphite grade.

5.2 RECOMMENDATIONS

1. Economic deposits of graphite within the Central Gneiss Belt seem to occur within the "semi-pelitic" schist horizons. Although graphite is a fairly ubiquitous assessory mineral within this unit, there are places where the concentration of the graphite as well as the width of the unit has increased, forming what could be an economic deposit. Apart from a small concentration effect in fold noses and along pegmatites, there is no appreciable remobilization of the graphite. It therefore

seems reasonable to assume that the distribution of the graphite reflects the original distribution of the carbon precursor within the sediments. The widening of the host unit appears to be due to structural causes, and since structure on the large scale is seen also on the small scale, an important exploration tool should be a structural analysis of the area.

2. The geology of the deposit should be monitored on a continuous basis due to the unpredictability of the graphite units. A thorough understanding of the barren material and where it occurs within the mine might allow for selective mining and could decrease unnecessary dilution of the mill feed.

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APPENDIX I

DIAMOND DRILL LOGS FOR THE DRILL HOLES IN SECTIONS A-A', B-B'

DDH CAL-86-41

Map Coordinates:
Dip: -50
Azimuth: 305
Depth: 108 m

(The core for this hole was not in very good shape -- data is from the files of Constable Consulting Incorporated.)

DEPTH IN METRES From	To	UNIT DESCRIPTION
0.0	4.7	Casing
4.7	34.7	Garnet Gneiss - red to brown, contains lenses of graphitic gneiss (unit 2a?)
34.7	84.1	Graphitic - grey with coarse graphite flakes (1-3%) - some garnet sections - by 247.0 lenses of garnet gneiss more frequent
84.1	108.0	Garnet Gneiss - red to brown, with barren, coarse-grained sections, slightly (1-2%) mineralized sections and distinct graphitic gneiss sections - by 339.0 the graphite lenses decrease
347.0		End of hole

DDH VC 81-8A

Map Coordinates:
Dip: -45
Azimuth: 305
Depth: 75.8 m

DEPTH IN METRES From	To	UNIT DESCRIPTION
0.0	0.9	Casing
0.9	4.8	Unit 2b - mottled looking, consists of

		feldspar, amphibole (hornblende), and garnets -garnets occur between the hornblende and the feldspar
4.8	6.2	Unit 1a or 1b - fine-grained, distinctively lacking garnet - consists of quartz, feldspar, biotite, and graphite
6.2	9.7	Unit 2b - melanosome of 2b - medium-grained, consists of hornblende, plagioclase, and garnet - weakly foliated - leucosomes show as coarser areas, with quartz and feldspar as well as the other minerals - melanosome areas are from 0.6 - 1.5 m wide
9.7	28.8	Unit 1a or 1b - sharp contact with above unit -fine-grained, uniform-looking, weakly banded, well foliated - consists of quartz, feldspar, biotite, and graphite - flake size varies from <1 mm to 3.5 mm - lenses 3-10 cm in which biotite increases to 50%, and graphite decreases in amount - by 12.7 m graphite grade increases to 15% by volume - weakly magnetic - sulphides up to 2%
28.8	33.9	Unit 1a - white and green banded unit, consists of plagioclase, quartz, biotite, and graphite -graphite tends to be restricted to the quartz-feldspar bands - between 31.5 and 33.9 m - unit resembles 2a - finely banded, contains garnets
33.9	46.9	Unit 1b - fine-grained, sugary-looking, consists of quartz, feldspar, and graphite - graphite flakes bend around the feldspar crystals - blebs of pyrite and pyrrhotite disseminated throughout
46.9	47.9	Unit 2a - banded, feldspar, quartz, biotite, garnet, some graphite
47.9	68.3	Unit 1a - sulphides increase, graphite is <1% until 50 m - by 50 m unit becomes more fine-grained, graphite increases in amount

68.3	75.2	Unit 1b - textural change from unit 1a - 1b is finer-grained, and more uniform
75.2	75.8	Unit 2a - biotite, garnet feldspar, and quartz in bands
75.8		End of hole

DDH CAL-86-13F

Map Coordinates:
Dip: Vertical
Azimuth: N/A
Depth: 275.2 m

(Only the graphitic sections were kept; the core starts at box 29, 546 feet)

DEPTH IN METRES From	To	UNIT DESCRIPTION
--	177.3	Unit 2b - garnet-plagioclase-hornblende-biotite rock, medium-grained, slight foliation - 25% garnet, 30-40% plagioclase, up to 3% sulphides - some carbonate and chlorite veining - last 30 cm completely altered to chlorite and carbonate
177.3	222.1	Unit 1a and 1b (difficult to distinguish in drill core) - Quartz-feldspar-graphite-biotite, medium-grained - 10% graphite by volume, 3% sulphides, some carbonate veining - graphite flakes up to 2 mm in diameter 181.8-185.2: unit becomes very fine-grained and sugary, graphite up to 15% by volume 188.2-189.1: garnetiferous unit 191.5-196.4: banded graphitic unit, coarse-grained, graphite occurs in the biotite bands 196.4-197.0: garnetiferous unit 203.3-204.8: garnetiferous unit 215.8-216.4: garnetiferous unit

222.1	237.9	Unit 2b - plagioclase-hornblende-garnet rock, varies from finely banded to splotchy, medium-grained, 25-30% mafics
237.9	260.0	Unit 1b - fine-grained, finely banded graphitic unit, sugary textured, up to 10% graphite by volume - by 257 carbonate veining
260.0	271.8	Alternating bands of coarse-grained graphitic unit and garnet unit - graphitic bands are 15 to 25 cm wide
271.8	275.2	Garnet-hornblende gneiss, well developed banding
275.2		End of hole

DDH CAL-88-32

Map Coordinates:
Dip: Vertical
Azimuth: N/A
Depth: 70.6 m

DEPTH IN METRES From	To	UNIT DESCRIPTION
0	13.0	Casing
13.0	19.4	Unit 1a - fine-grained, uniform, weakly foliated - consists of quartz-plagioclase-biotite-graphite (5-10% vol), flakes <1 mm - sulphides disseminated throughout (2%) 17.1-18.5: garnetiferous unit - garnet-biotite-plagioclase-hornblende, about 40% mafics
19.4	23.3	Banded garnet-hornblende unit with some graphite disseminated and in bands, particularly within the mafic bands
23.3	27.3	Garnet-biotite unit - pinky-red garnets up to 25% in places - little if any graphite - quartz-

feldspar veining

27.3	28.8	Unit 1a - banded graphitic - graphite restricted to narrow bands and lenses, flake size 1-3 mm - graphite associated with sulphides, pyrite and pyrrhotite
28.8	70.6	Spotty garnet-hornblende-biotite unit - bands of 2a and 1a material 33.3-34.2: quartz-plagioclase-garnet band with some graphite flakes 41.2-42.1: large pyroxene crystals and massive graphite
70.6		End of hole

DDH 88-29

Map Coordinates:
Dip: Vertical
Azimuth: N/A
Depth: 213.6 m

DEPTH IN METRES From	To	UNIT DESCRIPTION
0	4.5	Casing
4.5	16.1	Unit 1a - fine-grained, weakly foliated, consists of plagioclase, biotite, and graphite - graphite flakes < or = to 1 mm - carbonate veining, with sulphides, veins up to 1 cm wide, cross-cutting foliation
16.1	20.3	Garnet-hornblende-biotite unit - consists of clumps of hornblende and garnet stretched into incipient bands
20.3	45.4	Banded graphite unit - very contorted banding - sulphides in clumps - by 28.2 m starting to see more evidence of alteration - chlorite and carbonate in matrix and in veins, hematization of feldspars

45.4	56.6	Black, slicken-sided graphite, about 70% by volume - lots of carbonate veining and brecciation - graphite appears to have been remobilized
56.6	84.8	Garnet-biotite gneiss, with feldspars altering and carbonate veining
84.8	196.3	Graphitic unit as above, remobilized graphite, black, vuggy carbonate veins, and hematite and chlorite alteration
196.3	213.6	Garnet gneiss as above
213.6		End of hole

DDH 88-28

Map Coordinates:
Dip: Vertical
Azimuth: N/A
Depth: 181.5 m

DEPTH IN METRES From	To	UNIT DESCRIPTION
0	5.8	Casing
5.8	9.7	Unit 2a - finely banded, medium-grained, plagioclase-biotite-hornblende-garnet gneiss - very minor amounts of graphite, in lenses - very garnetiferous, pinky-red garnets
9.7	11.4	Unit 1b - medium-grained graphitic unit, consists of quartz and graphite, some feldspar and sulphides - graphite flakes 1-2 mm in size, about 7-10% by volume
11.4	13.2	Unit 2a, as above
13.2	16.4	Graphitic unit, 1a or 1b - varies from quartz-graphite (1b) to banded micaceous plagioclase-quartz-graphite (1a) - graphite averages 5-7% by volume
16.4	17.1	Unit 2a - banded with quartz veinlets up to 4 cm wide

17.1	19.1	Graphitic unit - quartz-plagioclase-graphite, graphite up to 7% by volume
19.1	24.0	Unit 2a, as above
24.0	71.5	Unit 1b - mostly quartz and graphite - in the contact area, the graphite is coarser and the rock is friable - graphite flakes up to 3 mm in size - weakly foliated - texture resembles a quartzite - very little sulphide, non-magnetic - lenses within this unit where the amount of graphite reaches 15% by volume 67.9-69.4: band of 2a - garnet-hornblende gneiss
71.5	128.5	Unit 2b - clots of hornblende and garnet in differing degrees of straing, in places almost defining a banding - the plagioclase-quartz leucosomes form veins within the core - by 92.1 m, chlorite and pyrite on fractures - bands containing graphite towards the lower contact
128.5	166.4	Alternating bands of graphitic and garnetiferous material - the bands of graphitic material are similar to those described above - graphite up to 15% by volume
166.4	174.2	Unit 2b - coarse-grained, garnet-hornblende-plagioclase unit
174.2	178.5	Gneiss - distorted-looking, bands of iron-stained feldspar, quartz, hornblende, and biotite - bands are ruptured, forming boudins
178.5	181.5	Unit 2b
181.5		End of hole

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

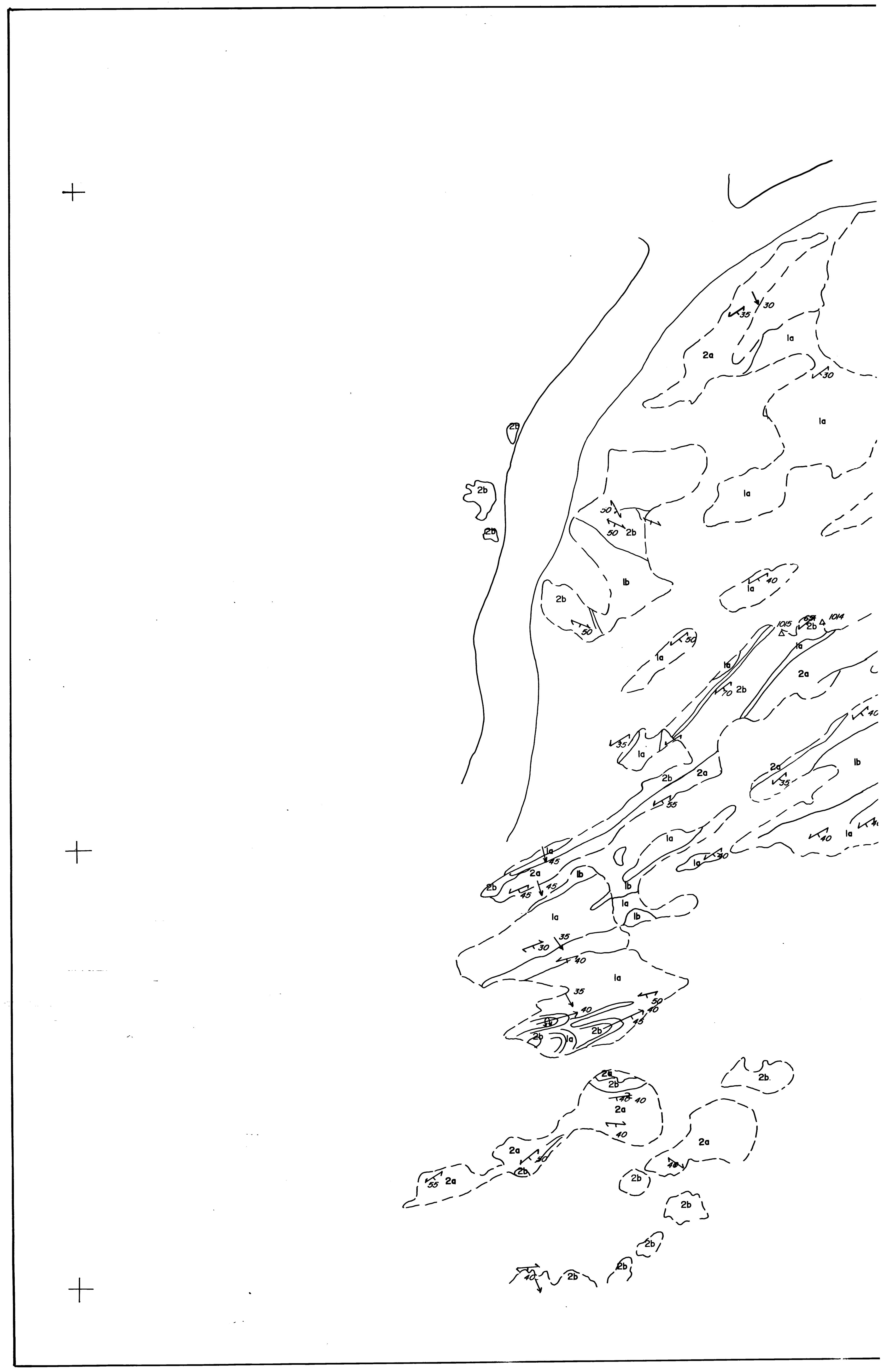
Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

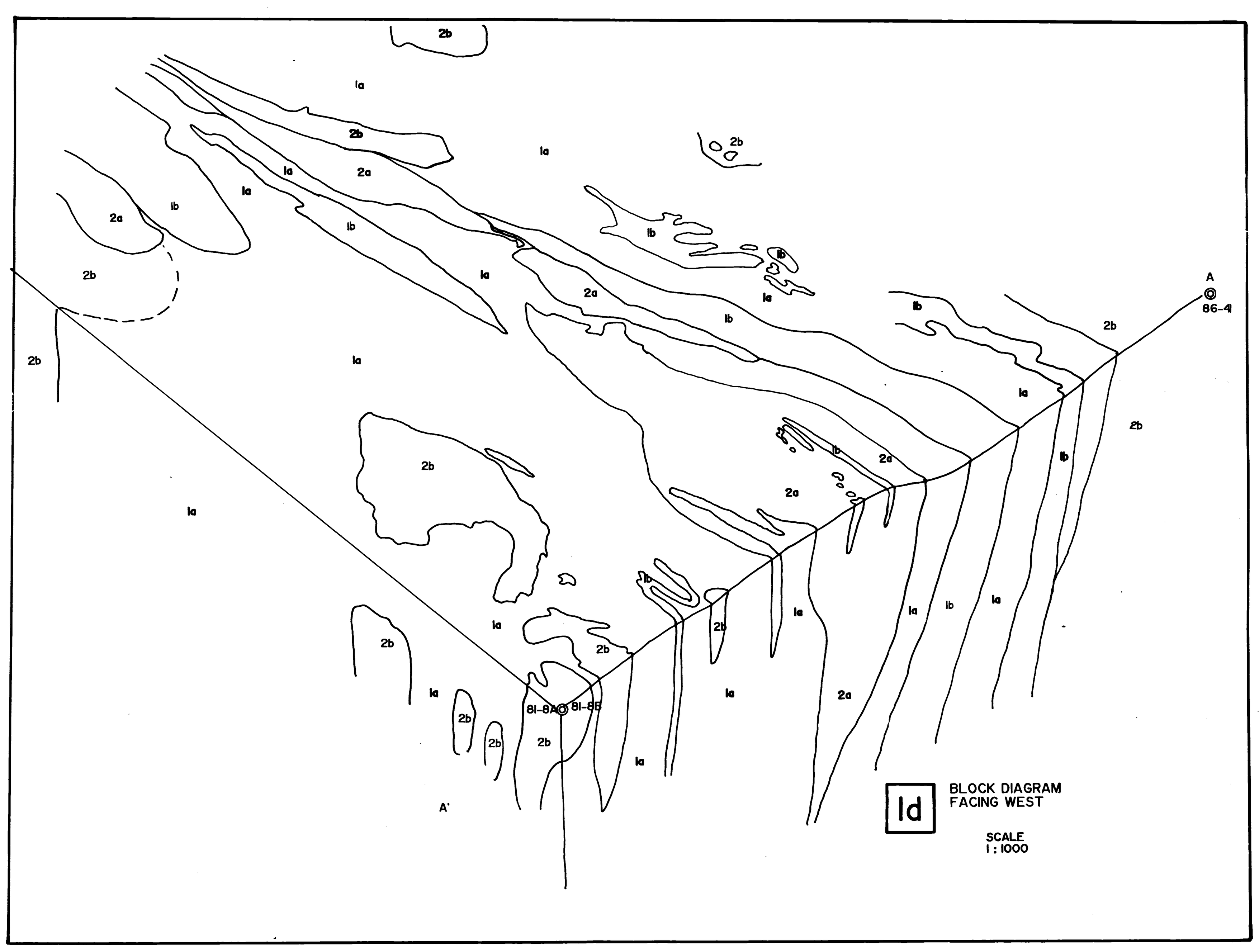
MAP I

Geology of Cal Graphite Flake Graphite Deposit (Ia) with Sections A-A' (Ib), and B-B' (Ic) and Block Diagram (Id)

LEGEND

- Ia GRAPHITE-FELDSPAR-QUARTZ SCHIST
- Ib FELDSPAR-GRAPHITE-QUARTZ SCHIST
- 2a GARNET-HORNEBLENDE-QUARTZOFELDSPATHIC GNEISS
- 2b NET-TEXTURED MAFIC UNIT
- 2c PEGMATITES
- DIAMOND DRILL HOLES
- 1000 SAMPLE LOCATION
- 1010 CHANNEL SAMPLE
- 45 STRIKE & DIP OF FOLIATION
- AZIMUTH & DIP OF FOLD AXIS
- ISOCLINAL FOLD
- 50 AZIMUTH & PLUNGE OF LINEATION
- EDGE OF STEEP EMBANKMENT





Id BLOCK DIAGRAM FACING WEST
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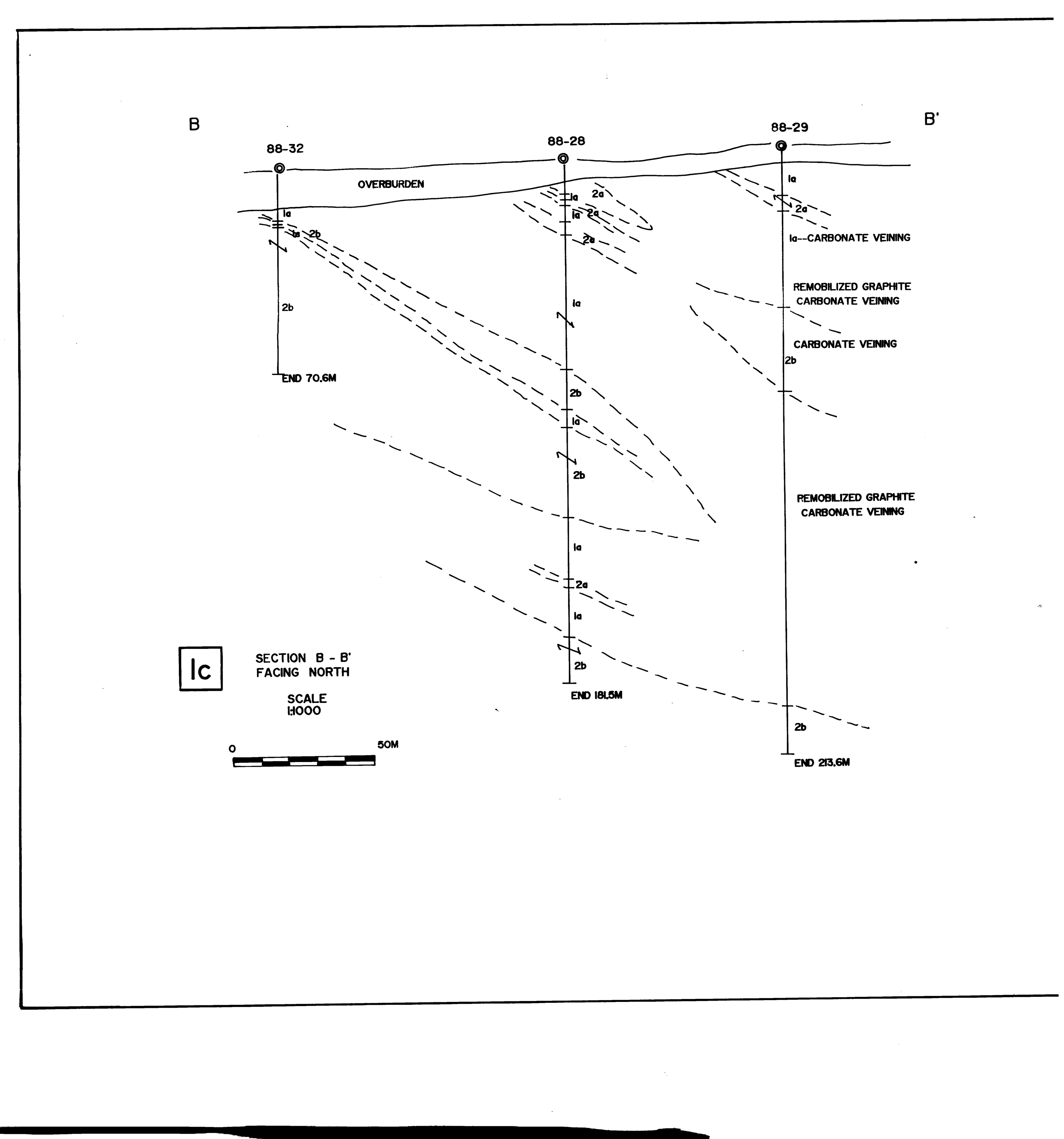

Ic SECTION B - B' FACING NORTH
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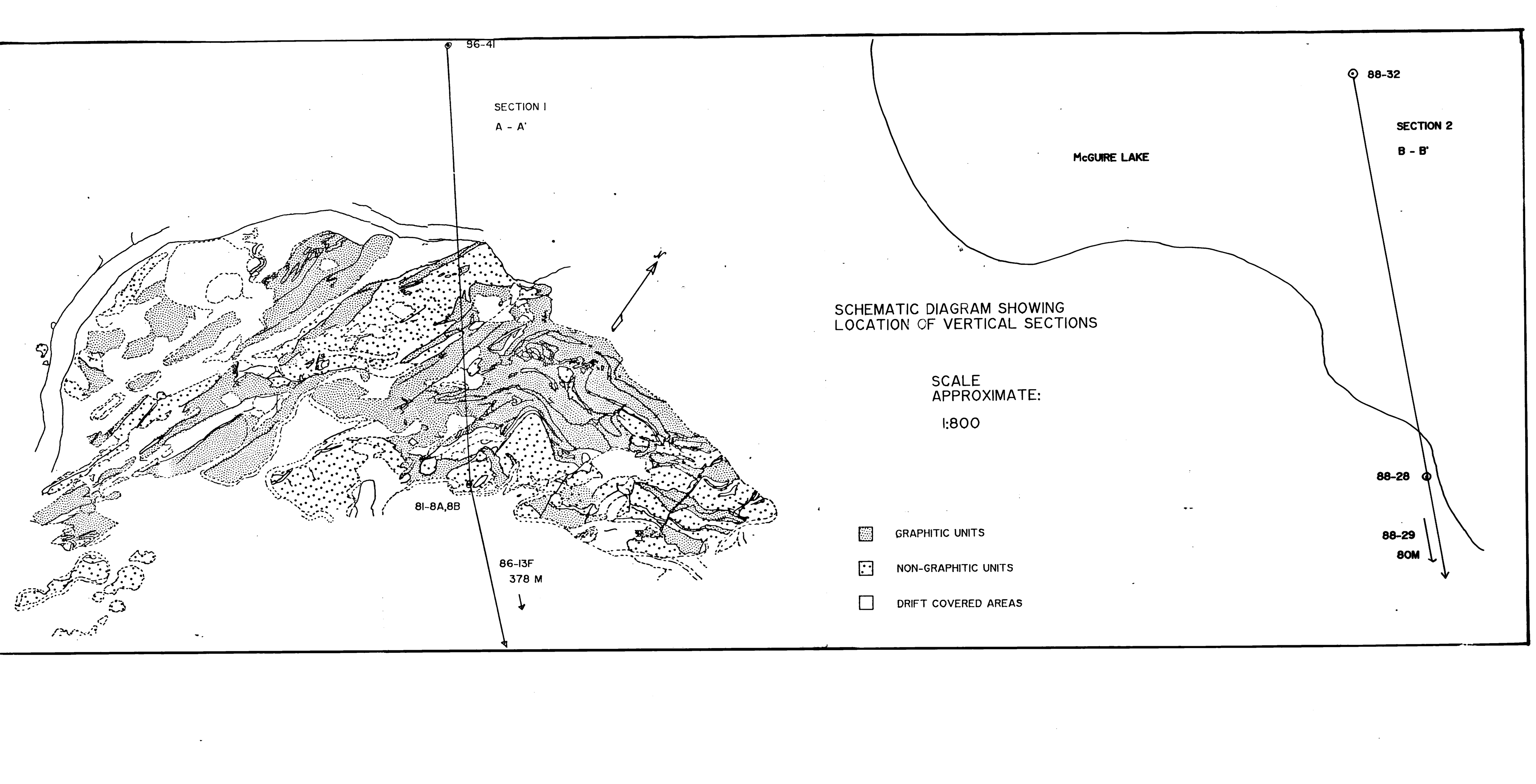
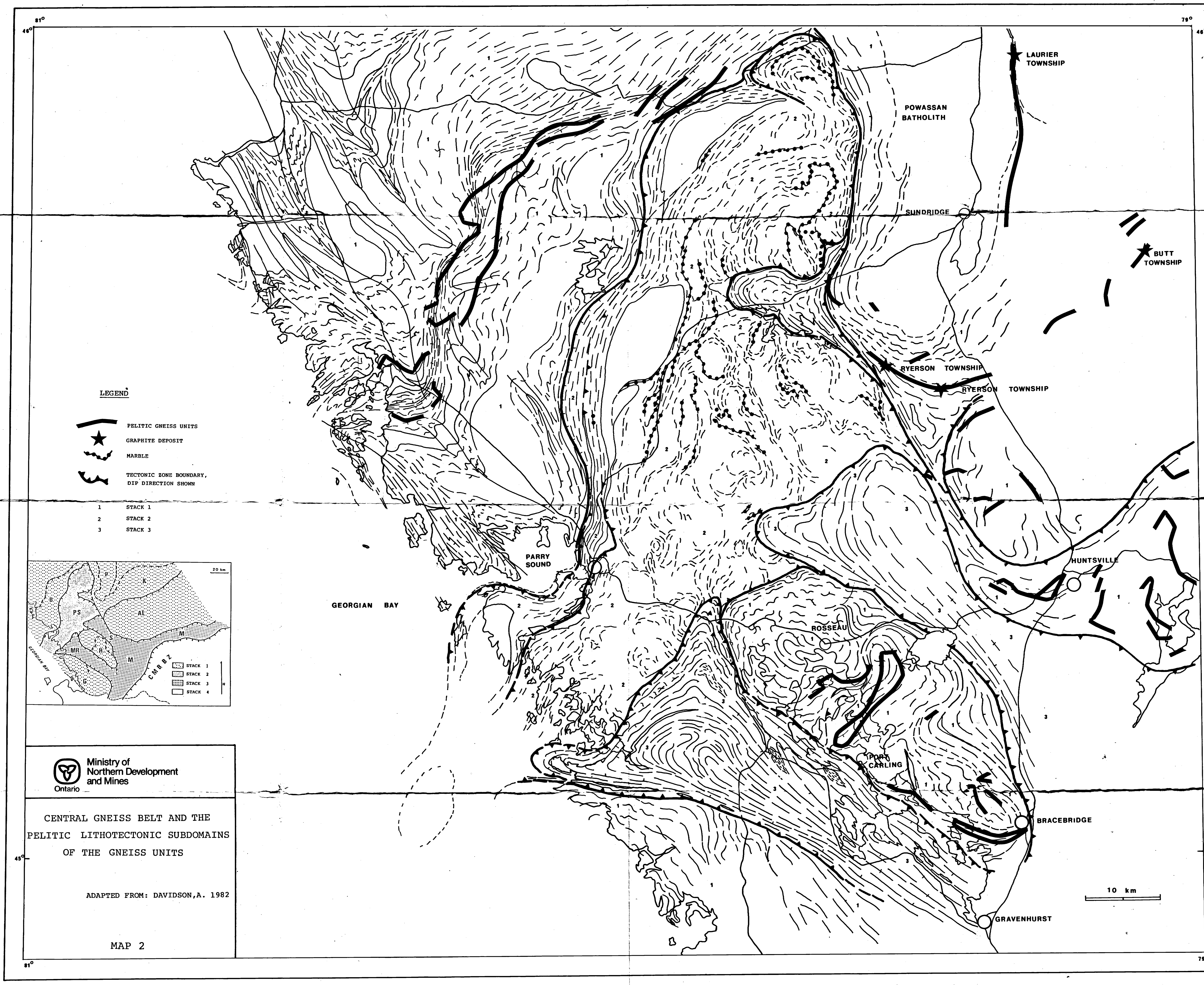


SCHEMATIC DIAGRAM SHOWING LOCATION OF VERTICAL SECTIONS

SCALE APPROXIMATE: 1:800



CENTRAL GNEISS BELT AND THE PELITIC LITHOTECTONIC SUBDOMAINS OF THE GNEISS UNITS

ADAPTED FROM: DAVIDSON,A. 1982

MAP 2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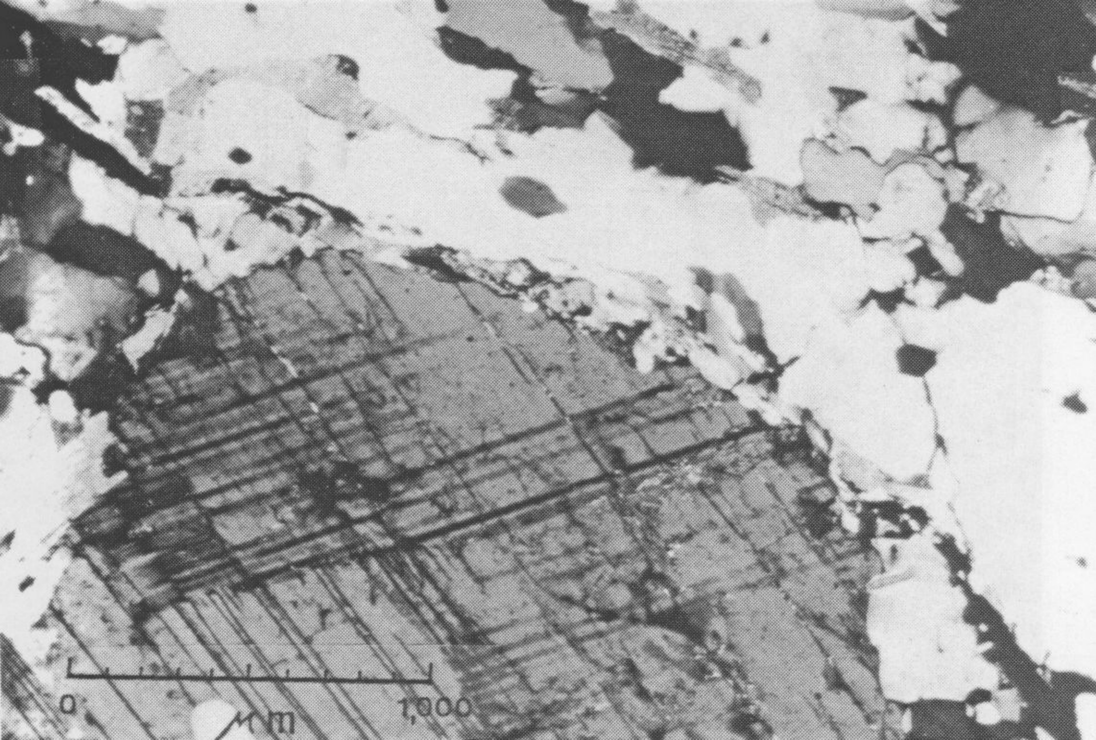

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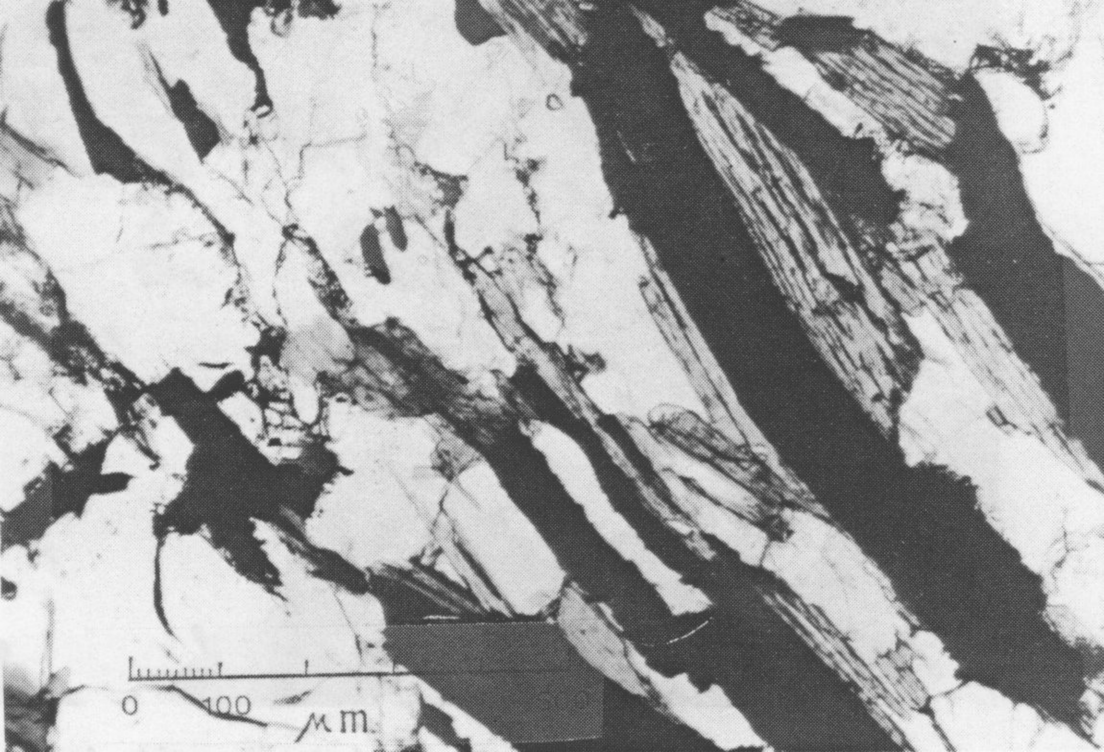

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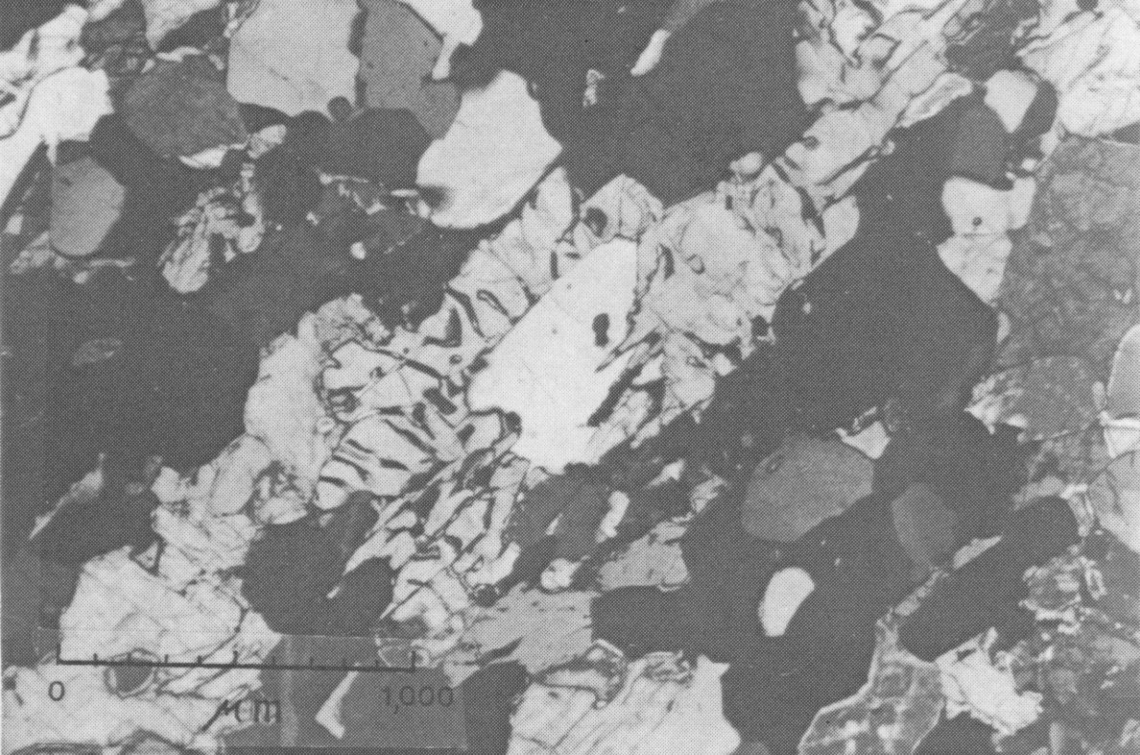
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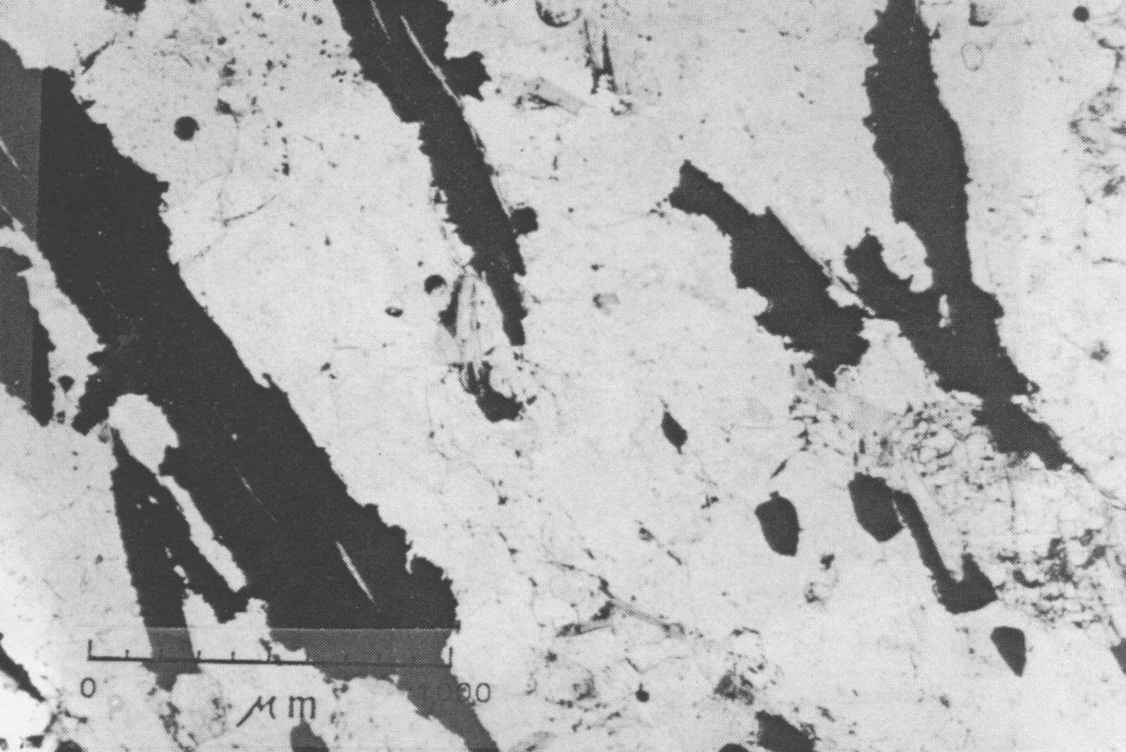
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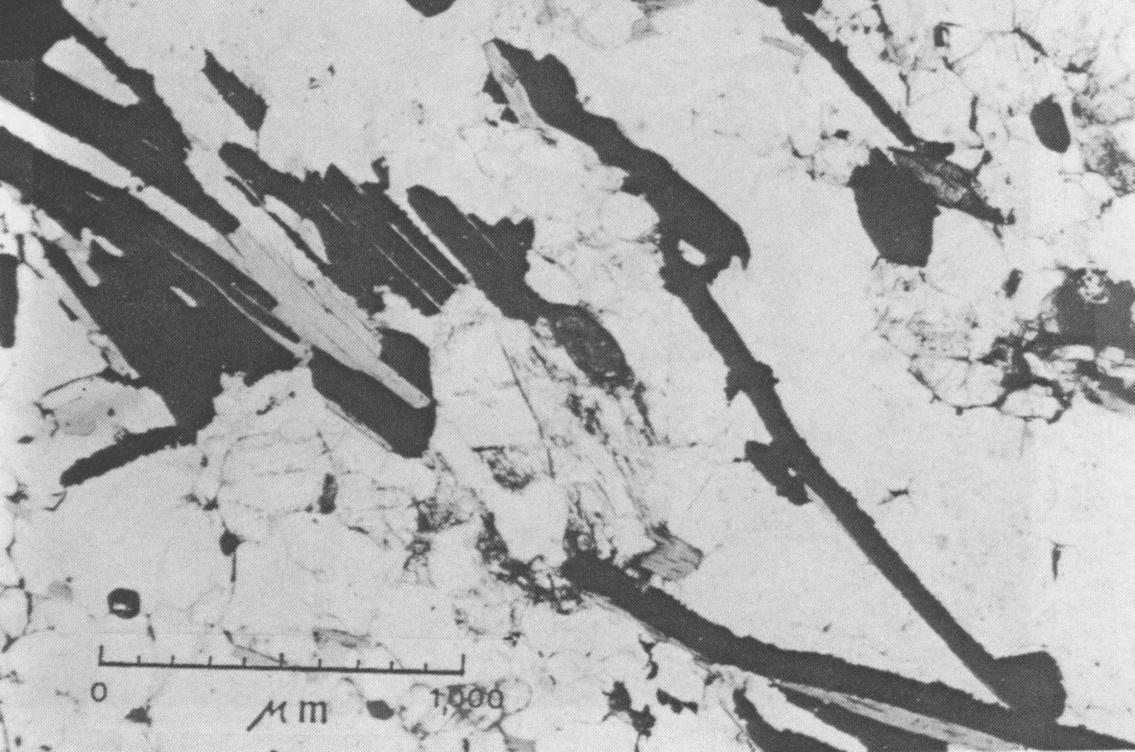
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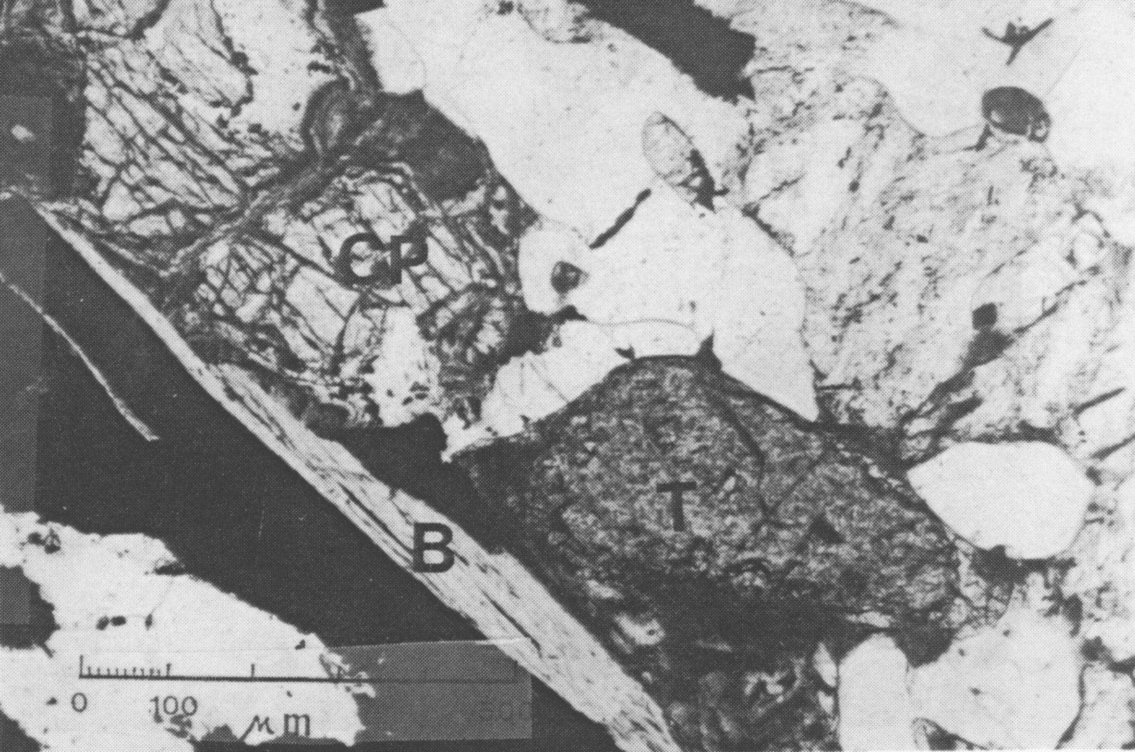

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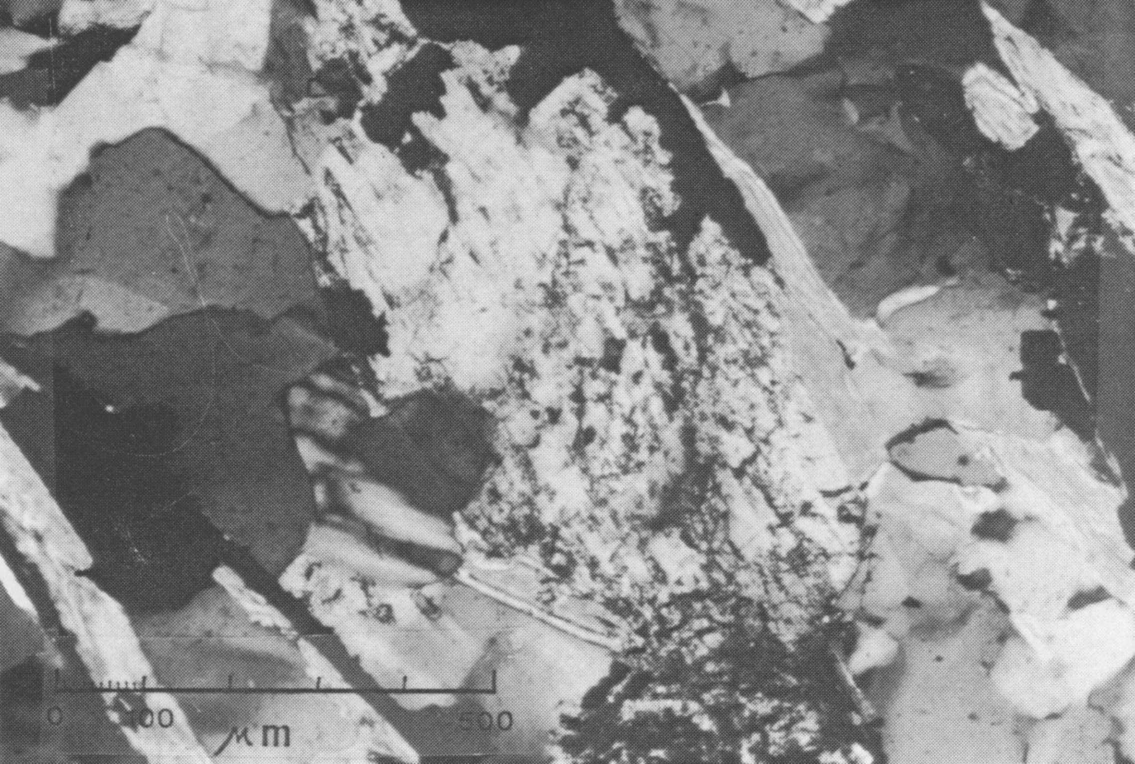
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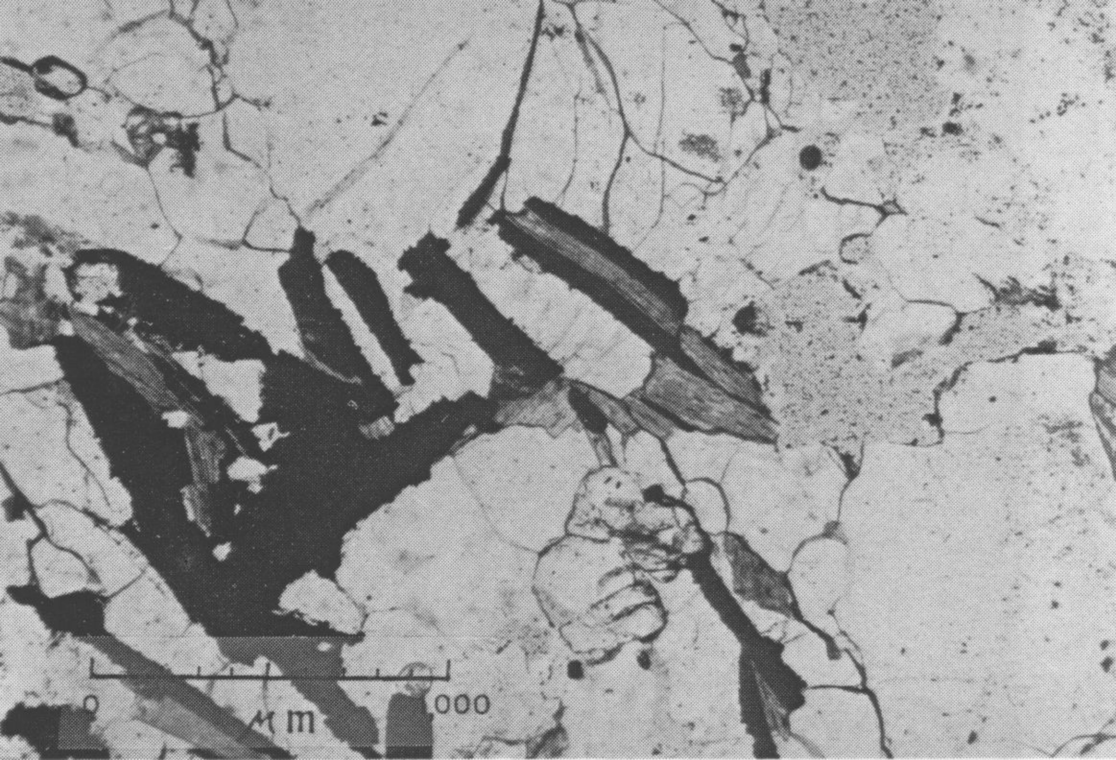
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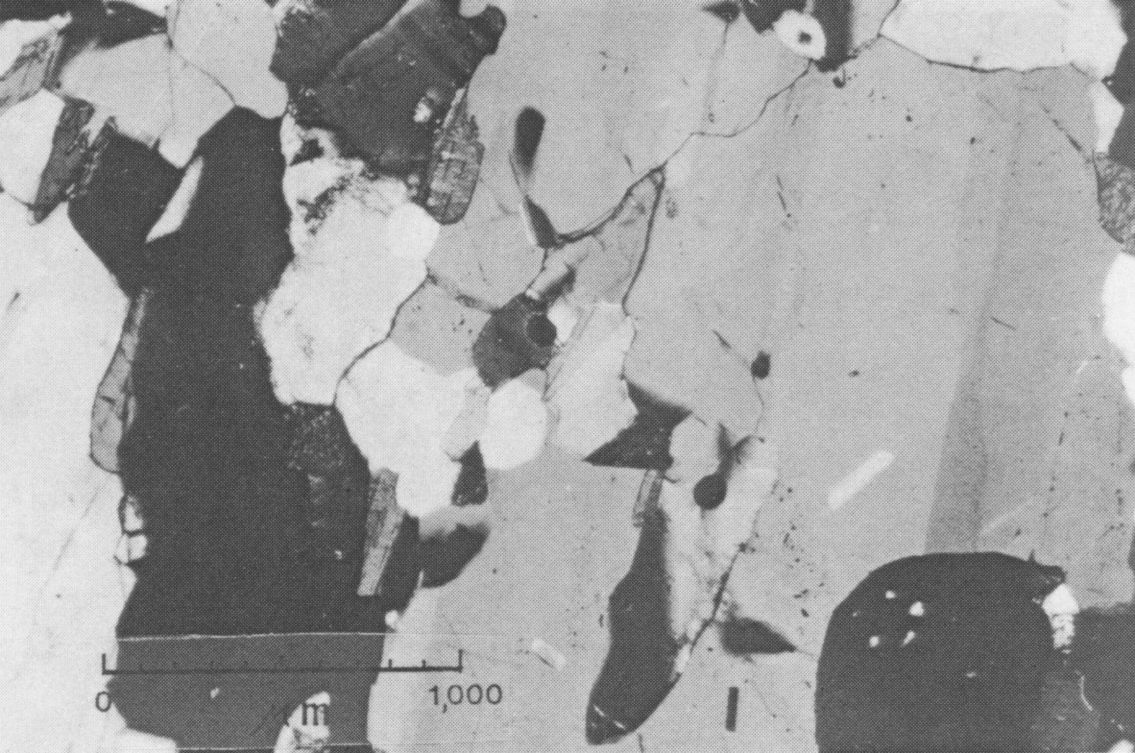
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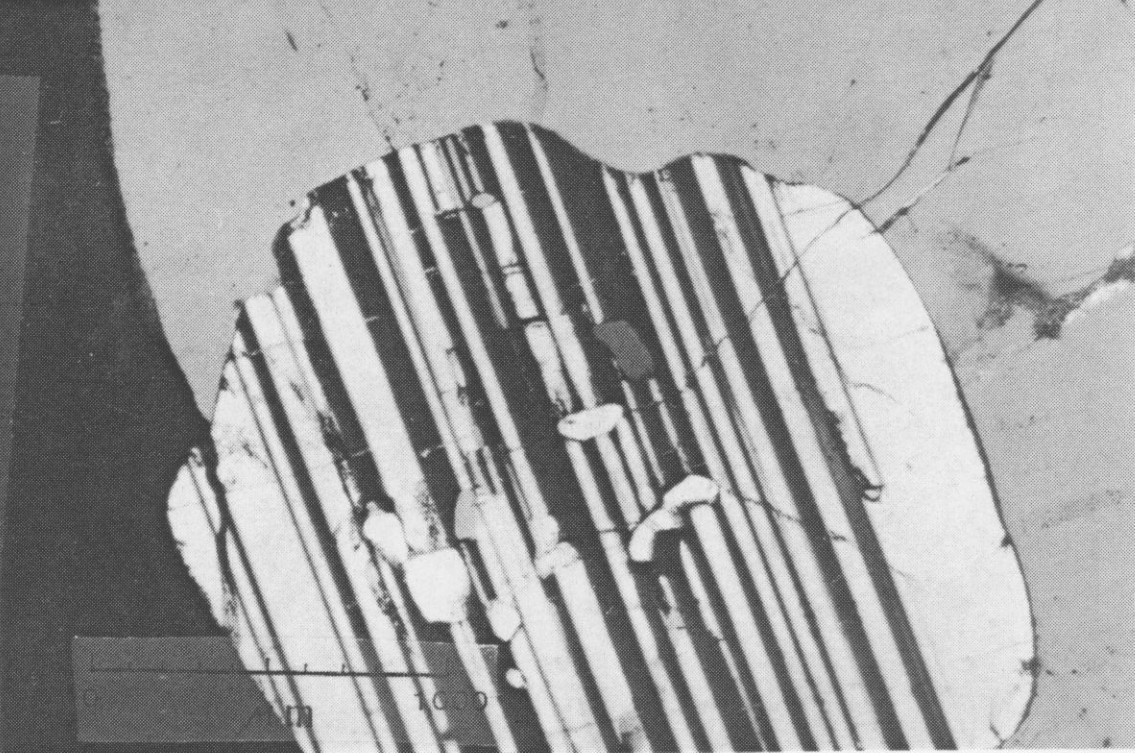
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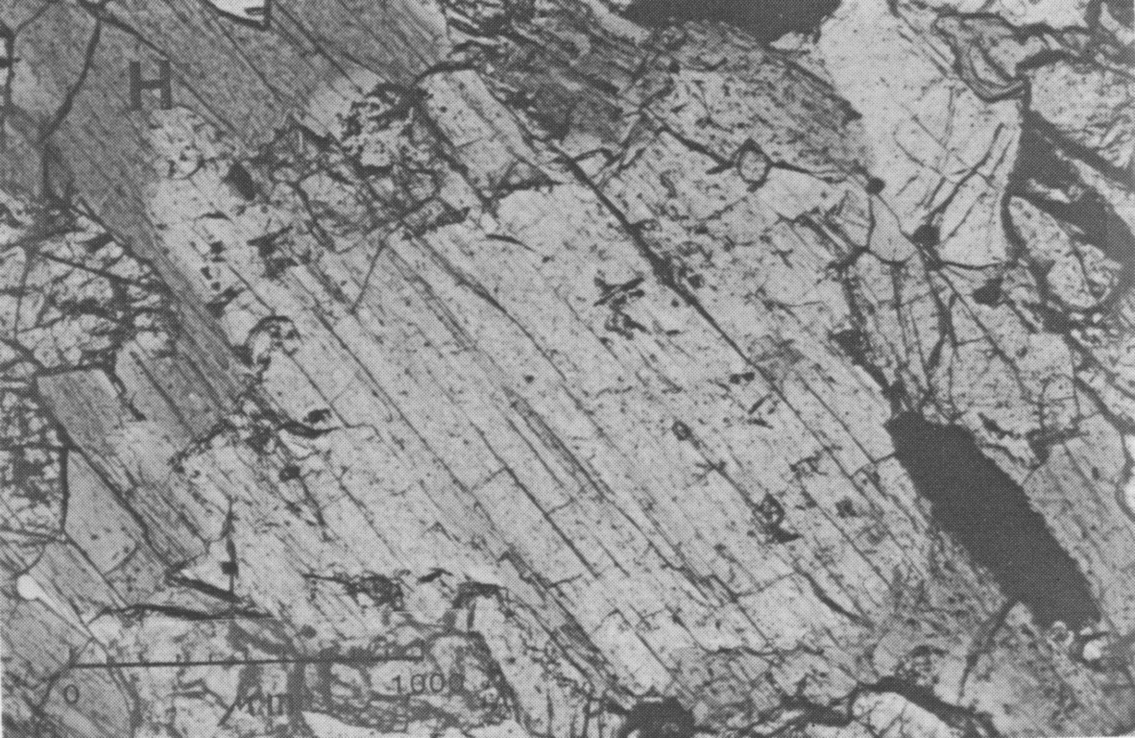
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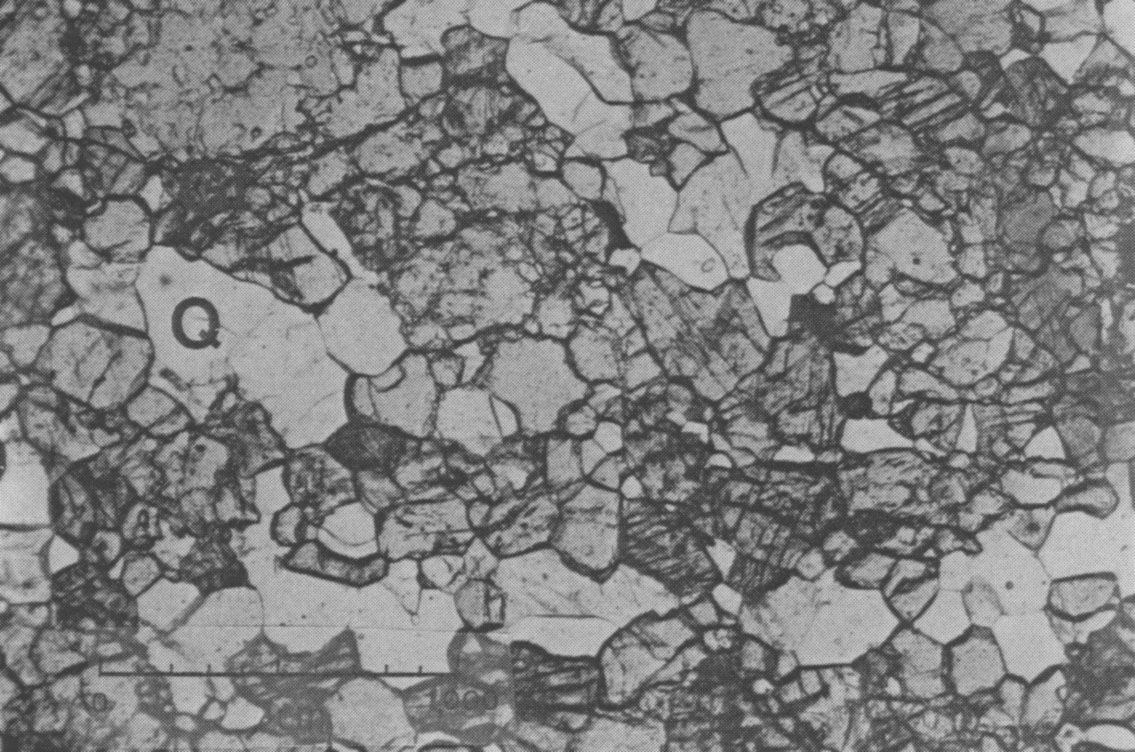
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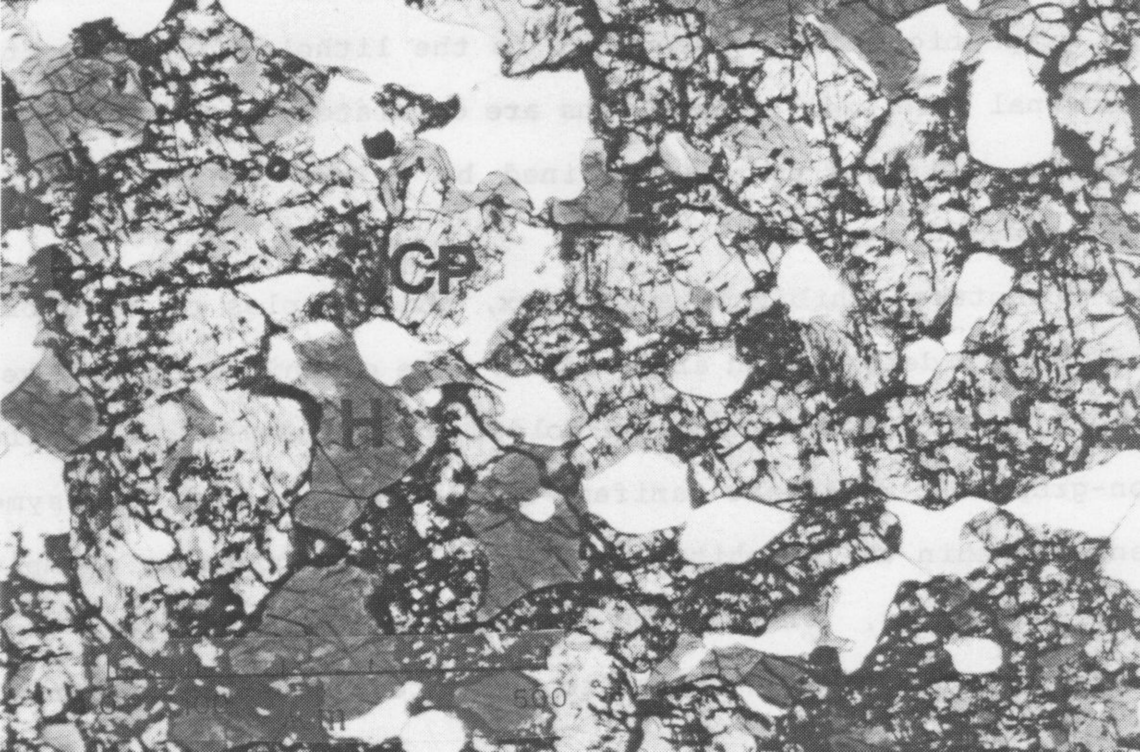
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