THE PROTOLITH

OF THE

CARBONATE RICH ROCKS OF THE LARDER LAKE BREAK

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BY

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ABSTRACT

The rocks of the Larder Lake Break at the Misema River road cut are predominantly schists, green carbonates, porphyries, lamprophyres, quartz and an iron formation. The schists and green carbonates have been metamorphosed, altered, and intruded by feldspar rich porphyries, lamprophyres, and quartz veins and stringers. The schists and green carbonates are komatiitic in composition and are characterized by concentrations of iridium, nickel, and chromium which are similar to known values for relatively unaltered Precambrian ultramafic flows.

The presence of spinifex texture in schists and green carbonates suggests that these rocks were rapidly cooled crystal free ultramafic lavas.

Gold is preferentially concentrated in sulphur rich felsic porphyritic intrusions.

ACKNOWLEDGEMENTS

Dr. J.H. Crocket suggested the topic and I would like to thank him for his guidance and sage advice. Special thanks also go to Andy Fyon and Frank Ploeger for the insight gleaned from them during discussions, and to Mr. A. Kabir who was more than generous with his time and patience in the lab.

Otakar Mudroch did the XRF, Len Zwicker prepared the thin sections. Jack Whorwood assisted with the photography and Maureen Czerneda typed the manuscript.

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Background

Purpose and Scope

The purpose of this thesis is to investigate the hypothesis that the protolith of the carbonate-rich rocks along the Larder Lake Break are extrusive ultramafic lava flows. An understanding of the origin of these carbonate-rich rocks will hopefully lead to a better understanding of the source of the gold which is found in economic quantities along and in the vicinity of the Break.

After examining the outcrop and collecting a representative suite of samples the primary methods of investigation were neutron activation for gold and iridium, X-ray fluorescence for major and minor elements and a petrographic study of the samples collected.

Location of the Study Area

The exposure which was studied is the Misema River road cut on Highway 66 in the southeast corner of Gauthier Township District of Timiskaming in northeastern Ontario, 1 1/2 miles west of the town of Larder Lake and about 15 miles east of the town of Kirkland Lake (Fig. 1). The outcrop has excellent exposure as it is bordered by the Misema River on the west and is cut by Highway 66 giving a road cut several hundred feet long and up to 30 feet high on the south side of the highway (Fig. 2), and a much smaller road exposure on the north side of the highway. There are also numerous and smaller

GENERAL LOCATION OF THE STUDY AREA

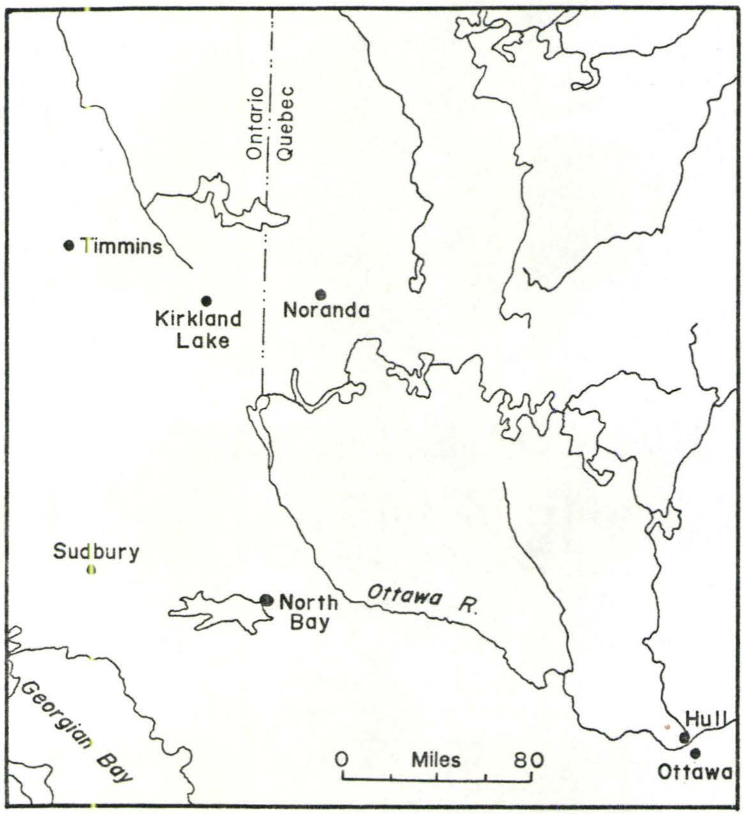


FIGURE 1

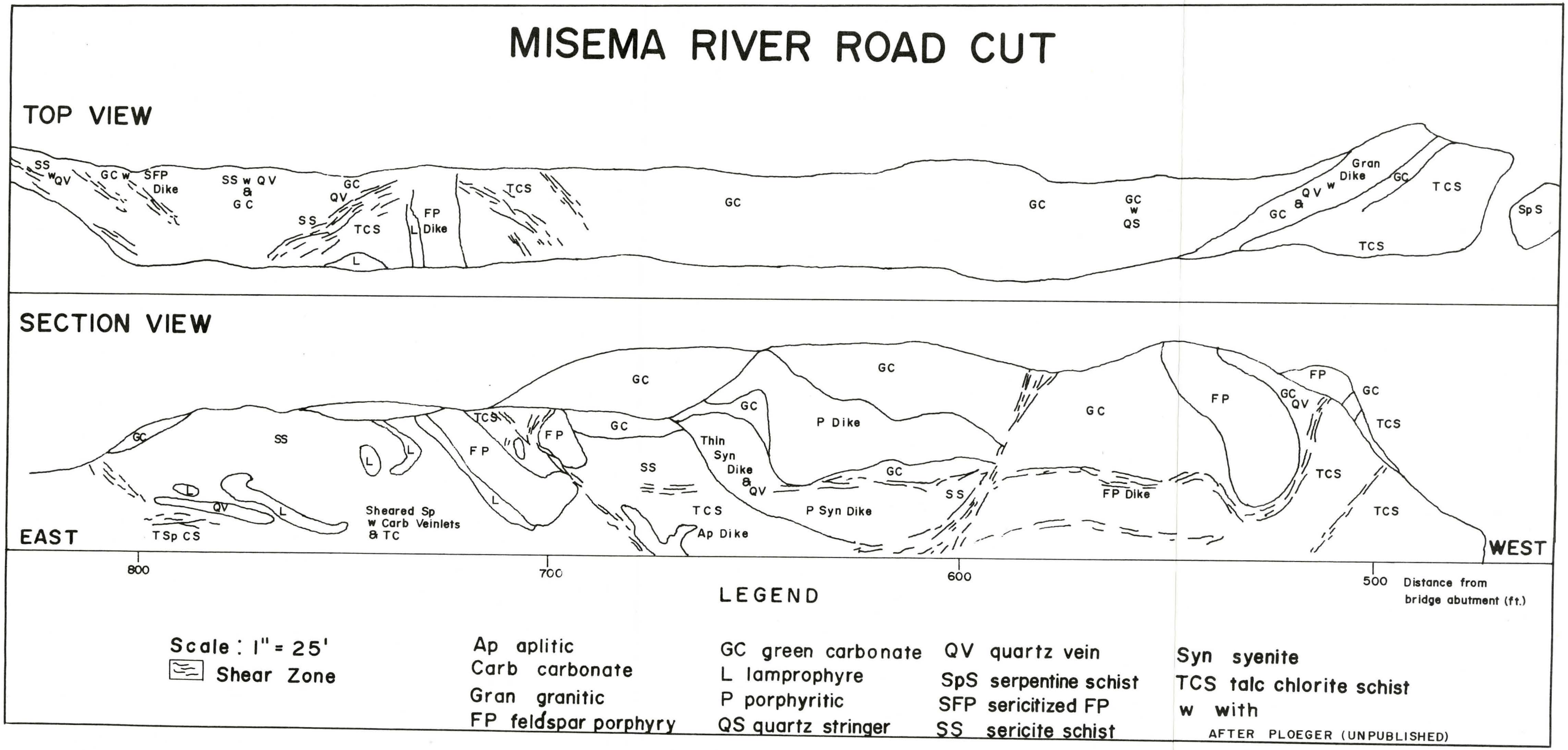

MISEMA RIVER ROAD CUT
TOP VIEW
SS w QV
GC w SFP Dike
SS w QV & GC
GC
QV
SS
TCS
L
FP Dike
L
TCS
GC
GC
GC w QS
Gran Dike
GC
QV w
GC &
TCS
TCS
Sp S
SECTION VIEW
EAST
GC
SS
L
L
QV
L
TSp CS
Sheared Sp w Carb Veinlets & TC
TCS
FP
FP
L
GC
GC
GC
SS
Thin Syn Dike & QV
TCS
Ap Dike
P Dike
GC
P Syn Dike
SS
GC
FP Dike
FP
GC QV
FP
GC
TCS
TCS
TCS
WEST
800
700
600
500
Distance from bridge abutment (ft.)
LEGEND
Scale : 1" = 25'
Shear Zone
Ap aplitic
Carb carbonate
Gran granitic
FP feldspar porphyry
GC green carbonate
L lamprophyre
P porphyritic
QS quartz stringer
QV quartz vein
SpS serpentine schist
SFP sericitized FP
SS sericite schist
Syn syenite
TCS talc chlorite schist
w with
AFTER PLOEGER (UNPUBLISHED)

Figure 2

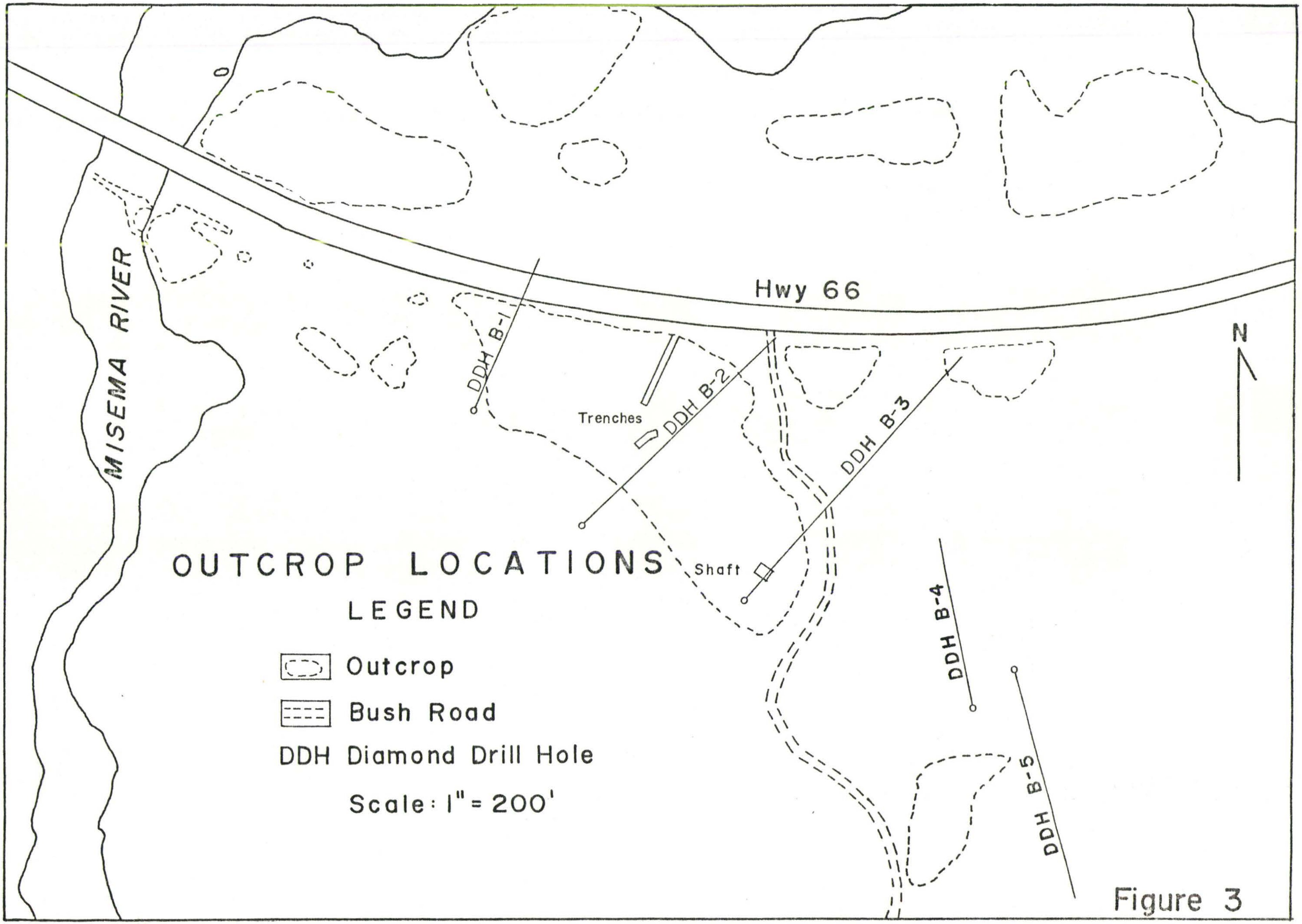

OUTCROP LOCATIONS
LEGEND
Outcrop
Bush Road
DDH Diamond Drill Hole
Scale: 1" = 200'
Hwy 66
MISEMA RIVER
N
DDH B-1
DDH B-2
DDH B-3
DDH B-4
DDH B-5
Trenches
Shaft

Figure 3

outcrops farther from the highway (Fig. 3), one of which has had several hundred square feet of overburden stripped off it to reveal some interesting textures. This is all found in the zone of carbonitization known as the Larder Lake Break (Thomson and Griffis, 1941).

Previous Work

The first geological map of Gauthier Township was made by Burrows and Hopkins in 1914 and was later revised by Burrows in 1917. The township was again mapped in greater detail by Hopkins in 1923. During the 1940s, Thomson carried out a detailed study of the Kirkland Lake-Larder Lake area. It was during this study that the term "Larder Lake Break" was coined.

In 1944 a drilling program was carried out by Olivet Gold Mines but nothing of economic consequence was discovered in the outcrop area (Olivet Gold Mines, 1944). There is one open shaft and several trenches on the large southern outcrop which probably date to the 1920s or 30s (Ploeger, pers. commun.). Other more recent geological studies include those of Goodwin (1965), Ridler (1970), Jensen (1976a), Stricker (1978) and Hyde (1978). Specific work pertaining to the Break itself or to the geochemistry and economic mineralogy of the carbonatized rocks has been done by S.L. Tihor, L.H. Tihor and J. Crocket (1977, 1978), Crocket (1979) and Ploeger (unpublished).

General Geology

The general geology of the Kirkland-Larder Lakes area is presently being reinterpreted by Jensen (1977-1978) and has been studied by others

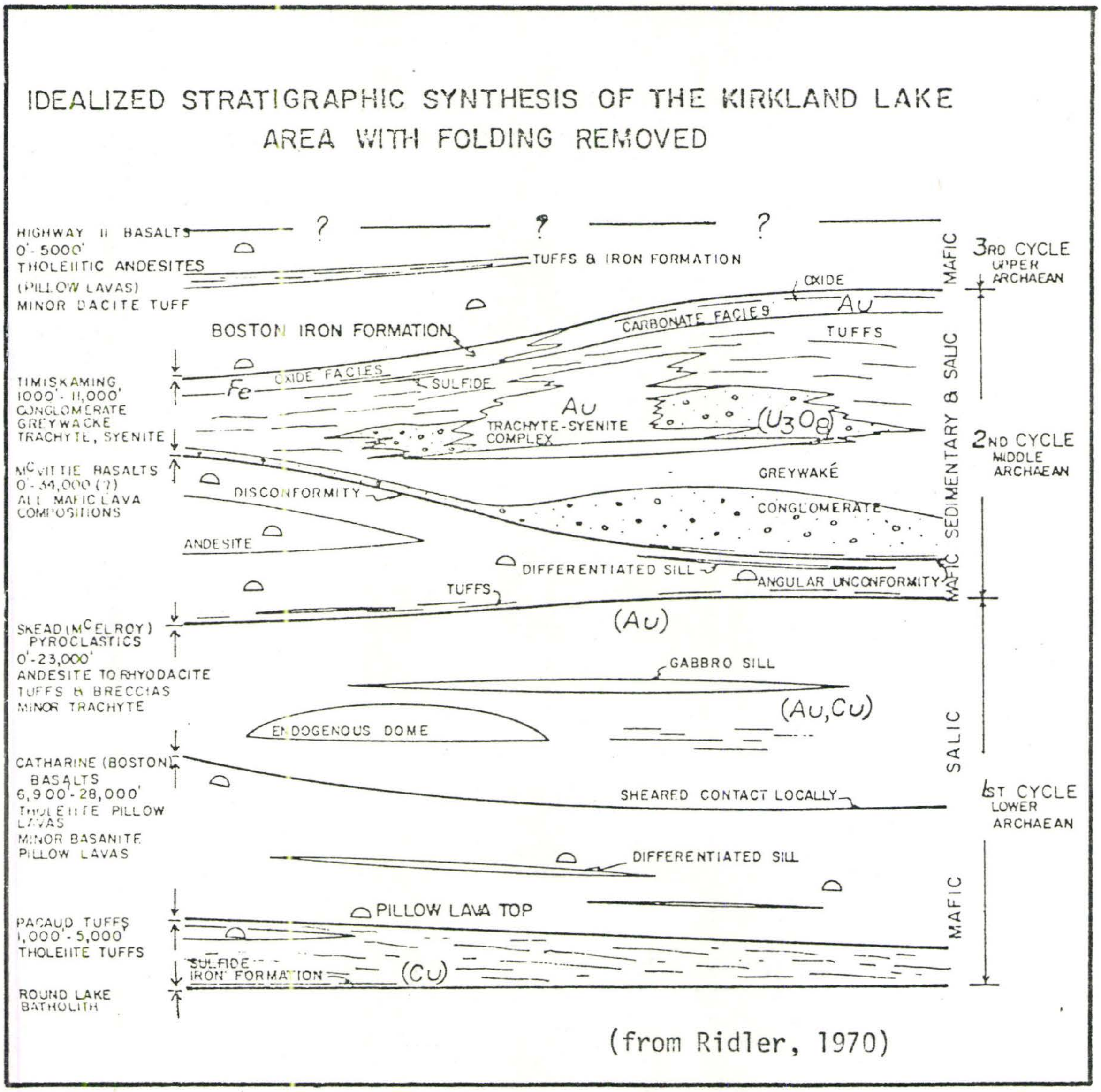
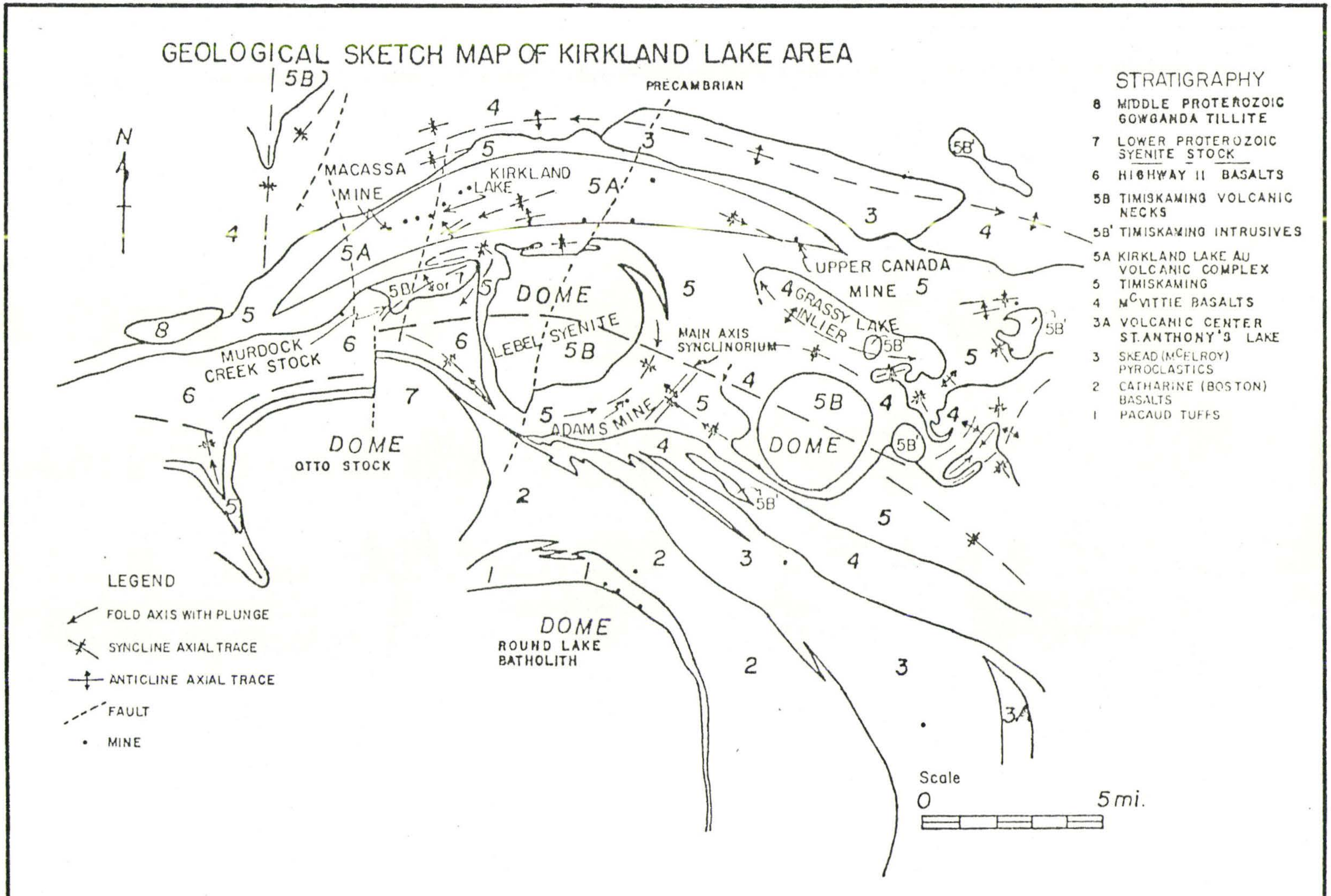

IDEALIZED STRATIGRAPHIC SYNTHESIS OF THE KIRKLAND LAKE AREA WITH FOLDING REMOVED
HIGHWAY 11 BASALTS
0'-5000'
THOLEIITIC ANDESITES
(PILLOW LAVAS)
MINOR DACITE TUFF
TUFFS & IRON FORMATION
OXIDE
Au
CARBONATE FACIES
BOSTON IRON FORMATION
TUFFS
TIMISKAMING
1000'-11,000'
CONGLOMERATE
GREYWACKE
TRACHYTE, SYENITE
Fe
OXIDE FACIES
SULFIDE
Au
TRACHYTE-SYENITE COMPLEX
(U_3O_8)
McVITTIE BASALTS
0'-34,000'(?)
ALL MAFIC LAVA COMPOSITIONS
DISCONFORMITY
GREYWAKÉ
CONGLOMERATE
ANDESITE
DIFFERENTIATED SILL
ANGULAR UNCONFORMITY
TUFFS
SKEAD (McELROY) PYROCLASTICS
0'-23,000'
ANDESITE TO RHYODACITE
TUFFS & BRECCIAS
MINOR TRACHYTE
(Au)
GABBRO SILL
(Au,Cu)
ENDOGENOUS DOME
CATHARINE (BOSTON) BASALTS
6,900'-28,000'
THOLEIITE PILLOW LAVAS
MINOR BASANITE PILLOW LAVAS
SHEARED CONTACT LOCALLY
DIFFERENTIATED SILL
PILLOW LAVA TOP
PACAUD TUFFS
1,000'-5,000'
THOLEIITE TUFFS
SULFIDE IRON FORMATION
(Cu)
ROUND LAKE BATHOLITH
MAFIC
SEDIMENTARY & SALIC
MAFIC
SALIC
MAFIC
3RD CYCLE
UPPER ARCHAEAN
2ND CYCLE
MIDDLE ARCHAEAN
1ST CYCLE
LOWER ARCHAEAN
(from Ridler, 1970)

Figure 4

previously (Ridler, 1970; Lovell, unpublished; Hyde, 1978). Since Jensen's interpretation of the stratigraphy is still in the process of being formulated and Lovell's is in general agreement with Ridler's, the following account is based mainly on Ridler's (1970) stratigraphic interpretation.

Except for the rare Jura-Cretaceous dikes of kimberlite the rocks in the area are of Archean and Proterozoic age.

The Archean rocks can be divided into three cycles (Fig. 4). The stratigraphically lowest and oldest cycle forms a thick structurally conformable sequence of potash deficient tholeiite pillow lavas (Catherine Basalts), their associated quartz-gabbro phases, other basalts and banded tuffs. These basic rocks are succeeded by mainly andesitic dacitic breccias (Skead Pyroclastics), tuffs, and their hypabyssal equivalents. The overlying second cycle is distinguished by a resumption of basic volcanism represented by a sequence of pillow lavas, flow breccias and their associated gabbroic phases (McVittie Basalts). Andesites, tholeiites, alkali basalts and feldspathoidal basalts are also present. This sequence corresponds to the "Keewatin" of the two fold division of the Archean. Overlying these rocks, in part with a distinct angular unconformity, is the Timiskaming, a volcano-sedimentary complex made up of greywacke, polymict conglomerate, iron formation and salic igneous rock consisting of trachytes, syenites, and other alkaline rocks. Volcanics are usually pyroclastic but flows are known. These rocks are overlain by the third and youngest cycle, a sequence of tholeiitic pillow lavas and their



(from Ridler, 1970)

Figure 5

gabbroic phases (Highway 11 Basalts). Minor iron formation and tuffs occupy the highest observed stratigraphic levels. Syenitic stocks, and granitic batholiths of diverse age intrude the entire volcano-sedimentary sequence. Some of the syenites such as the Otto and Lebel are probably young (1.1 to 1.5 b.y.) but others, particularly the small auriferous syenites associated with the gold mineralization, are probably of Timiskaming age (2.6 to 2.8 b.y.) (Crocket, pers. commun.).

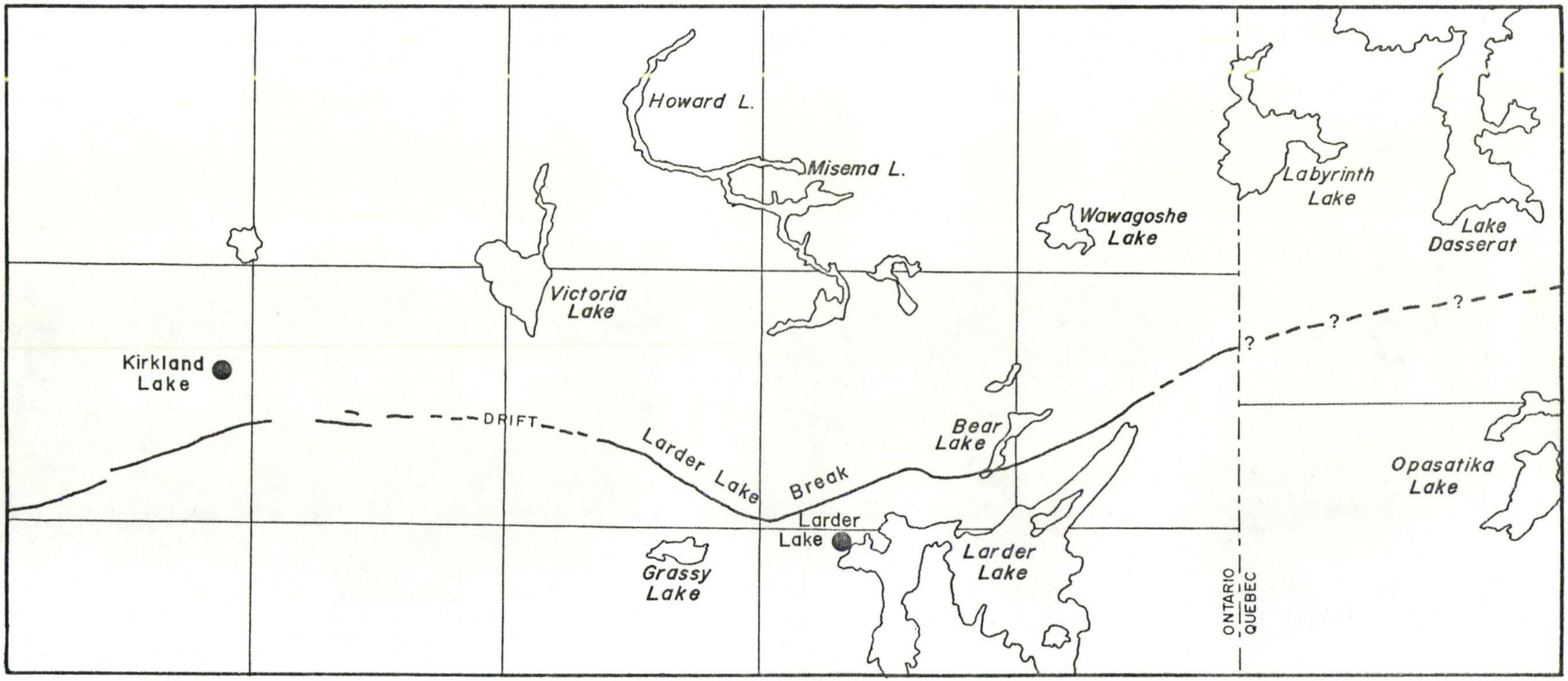
Tectonics

The Kirkland Lake area comprises three tectonic blocks: a stable shelf south of the Timiskaming mobile belt, the Timiskaming mobile belt itself, and a volcanic basin north of the Timiskaming mobile belt (Fig. 5).

The Timiskaming complex has been considered a south-facing homocline bounded on the north by a pronounced unconformity and on the south by a regional shear zone known as the Kirkland-Larder Lake Break.

Pre-Timiskaming volcanism created a thick platform of basalts with large local pyroclastic domes. The thickest zones probably subsided prior to McVittie volcanism along a hinge coincident with the Timiskaming mobile belt because the McVittie volcanics in the northern basin are much thicker than the volcanics to the south. Deformation and erosion of these Pre-Timiskaming rocks north of the mobile belt resulted in a pronounced angular unconformity at the northern edge of the Timiskaming complex. Since the Timiskaming and McVittie are disconformable to the south, the shelf has apparently experienced little

LARDER LAKE BREAK



After Thomson (1941)

0 2 4 6
SCALE
in
miles

Figure 6

deformation.

After Timiskaming time the entire mobile belt complex was deformed about its axis into a synclinorium. This occurred at about the same time as uplift of the Round Lake Batholith and doming of the shelf deposits.

Syenite stocks probably related to Timiskaming volcanics created an interference pattern of subconcordant domical structures and crossfolds causing axial plunges and bedding planes to become almost vertical to sub-vertical. This deformation post-dates all the non-plutonic Archean rocks.

The entire area was later cut by a series of post-Archean north-northwest trending vertical faults having both vertical and horizontal components.

The Larder Lake Break and Origin of the Carbonates

Thomson (1941) used the term Larder Lake Break to describe a zone of intensely sheared rock accompanied by carbonate replacement of varying intensity (Fig. 6). Its width is variable measuring up to 700 feet in places. Where there is little replacement, the rock along the shear zone is a soft talc-chlorite schist. In Gauthier Township the sheared zone is sometimes represented by a highly schistose talc-chlorite rock which at many places has been heavily carbonatized and cut by a network of quartz veins (Thomsom and Griffis, 1941). Locally the carbonate material was sometimes referred to as dolomite. However, Thomson (1941) believed that the rock was more an ankerite because it was analyzed as a carbonate of iron, lime, and magnesium. S.L. Tihor (1978) found that the carbonates were mostly dolomite and magnesite and possibly ankerite. Generally associated with the carbonate is an emerald green mica thought to be fuchsite. Where the green mineral occurs with the carbonate, the rock is referred to by the field term "green carbonate".

According to Thomson (1941) the carbonate was formed as a result of the alteration of pre-existing rocks through the action of circulating hot solutions originating from a deep seated source. From observations at the Kerr-Addison mine he suggested the period of carbonitization was sometime after the injection of syenites, but prior to the formation of the auriferous quartz veins. In the ore bodies on the south side of the Kerr-Addison ore zone and adjacent to the large masses of carbonate rock there are quartz veins and stringers without any sign of attendant carbonitization. This could only occur if the veins were introduced after the carbonitization.

Ridler (1970) proposed that the carbonate-rich rocks of the area were submarine volcanic exhalations within the carbonate facies of a regional exhalite, the Boston Iron Formation. He believed the Boston Iron Formation of the Kirland Lake area is a low grade iron formation in which one facies usually predominates. The most important variation appears to be lateral with the oxide facies found south of the axis of the synclinorium toward the shelf and the carbonate facies north of the axis towards the basin. In addition the carbonate facies is found from just west and north of the Lebel syenite, east to at least the Quebec border, while the oxide facies apparently ends just east and south of the Lebel syenite.

Due to its chemical composition, physical nature and stratigraphic position, the carbonate facies has suffered relatively more deformation and recrystallization than other rocks of the area resulting in its common sheared appearance. Ridler proposes that the great carbonate ore bodies of the Larder Lake area are in fact auriferous carbonate facies iron formation, probably correlative with the Boston Iron Formation. They were deposited as an exhalitive volcanic sediment low in iron and rich in gold. Subsequent recrystallization and segregation of some silica and gold into dilational stockworks occurred during metamorphism, deformation and relaxation.

Tihor and Crocket (1977, 1978) proposed that the carbonate rich rocks are an alteration product of extrusive ultramafic lava flows. This contention was based on mineralogical, compositional, and textural data.

CHAPTER TWO

Petrography and Mineralogy

Introduction

The twenty three slides which were examined were divided into nine schists, eight porphyries, two lamprophyres, two relic quench textured specimens, a quartz vein and one banded iron stone.

When describing the mineralogy, the term "carbonate" is used in a general sense to describe a variety of carbonate minerals because various carbonate minerals could not be distinguished soley by optical means. S. Tihor (1978) used X-ray diffraction techniques, scanning electron microscope X-ray emission and chemical analysis to determine the mineralogy of the different types of carbonates found along the Larder Lake Break. Her results indicated that dolomite and magnesite made up the bulk of the carbonates in that area with the possibility that 5 to 10% ankerite might be present as a discrete mineral or in solid solution with the dolomite.

Schists

The term schist refers to low grade metamorphic rocks in which minerals of micaceous habit are abundant. The sub-parallel orientation of the minerals make the schistosity conspicuous and the segregation layering well developed (H. Williams et al., 1954). These features are usually well developed in thin section but in hand specimens the schistosity or foliation is not always obvious especially in samples of rocks which have the field name "green carbonate".

The major constituents of the schists in general order of abundance are chlorite, carbonate, quartz and opaques. These are almost ubiquitous. In several specimens, white mica and/or talc, and actinolite make up a large proportion of the mineralogy. Plagioclase, tourmaline and epidote are found in a few sections in minor and trace amounts.

The differentiation of talc and white mica by optical methods is at best questionable, so that the identification of these minerals can be accepted only in the broadest sense. The greasy or soapy feeling of hand specimens often suggested talc but again positive optical identification was difficult.

Description

Most of the schists have a definite foliation caused by the sub parallel alignment of chlorite or talc chlorite veins, which range in width from about 0.1 to 7 mm though they are usually only a few tenths of a millimetre wide. The chlorite generally consists of very fine needles (<< 0.1 mm) though a few spherulites are present. Occasionally chlorite bands or veins gently wrap around elongated carbonate quartz aggregates producing lensoidal shaped features and in a few cases the bands themselves are internally folded indicating at least two periods of deformation.

Chlorite content ranged from 5% to 40% in any one section.

Carbonate minerals occur as aggregates, single grains and less commonly in veins. The grains are xenoblastic ranging in size up to about 2.0 mm and commonly display glide twinning and bent lamellae.

Plate 1 Lensoidal shaped aggregates of carbonate grains with chlorite wrapping around the aggregates (25 X).

Plate 2 Opaque surrounded by a quartz pressure fringe (25 X).

Aggregates of carbonate grains, especially in sections which have high carbonate content are often lensoidal (Plate 1) with long axes parallel to foliation. Also, the veins of carbonates are usually parallel or subparallel to foliation.

Carbonate content ranges from 0% to 60% in the slides.

Quartz is present in most sections though generally making up less than 20% of the rock. It is xenoblastic, < 2.0 mm, and found as inclusions in chlorite veins, in narrow veins with carbonates and plagioclase, as inclusions in carbonate aggregates, and as pressure fringes around opaques (Plate 2). The larger grains often show strained extinction and sometimes sutured grain boundaries.

Talc and white mica (sericite) are always found as masses of minute needles giving a felty appearance to the groundmass, or are intimately associated with chlorite veins. In some sections tentative talc identification was aided by the characteristic soapy feel of the hand specimen.

Actinolite is probably present in some slides. Where observed, it occurs with and has the same textural features as chlorite.

Plagioclase occurs as small veins with chlorite in several sections. The plagioclase is xenoblastic. The veins are less than 1.0 mm wide, parallel to foliation and variable in width.

Minor amounts of tourmaline are present as angular fragments in what appears to be remnants of a vein (<< 0.1 mm wide). Minor amounts of rod like epidote (<< 0.1 mm) are present in veins of chlorite in one section.

Opaques are present in most sections and range in size up to

2.0 mm. They occur as xenoblastic to idioblastic grains and sometimes as needle-like aggregates.

The opaques, which were positively identified by reflected light microscopy, are in rough order of abundance: chalcopyrite, sphalerite, and pyrite. Leucoxene, ilmenite and gersdorfite were tentatively identified.

Feldspar Porphyry

The majority of the slides classed as porphyries have plagioclase feldspar porphyroblasts and a groundmass which consists of plagioclase carbonate and perhaps quartz. The porphyroblasts and some groundmass plagioclase were determined to be labradorite according to the Michel-Levy test. Other more minor constituents of the groundmass are apatite, veins of chlorite (and possibly chlorite altering to talc), white mica, epidote, and perhaps actinolite. A few of the slides lack porphyroblasts but are classified as porphyries because they have similar textures and mineralogy as the groundmass of porphyroblastic porphyries.

Description

The porphyroblasts average about 0.8 mm in size are usually lepidoblastic and constitute up to 25% of the slide. They commonly display bent lamellae, lamellae twins which are laterally displaced along a straight line and combinations of continuous, enclosed, and partial twins (after Spry, 1974, p. 70) in the same grain (Plate 3).

An ubiquitous feature of the groundmass is that it invariably consists of plagioclase carbonate and perhaps quartz. These constituents are always xenoblastic and are generally less than 0.1 - 0.2 mm.

Carbonates occur in all the sections as groundmass carbonates and as veins with the groundmass carbonates being disseminated evenly throughout. The carbonate grains in aggregates and veins are larger (up to 6.0 mm), xenoblastic, and usually display glide twinning. The larger quartz grains are characterized by strained and undulose extinction.

Other distinctive features include polysuturing and quartz-quartz boundaries which consist of minute quartz grains which probably were recrystallized. Narrow chlorite veins consist of fibrous masses of contorted chlorite fibres or needles. White mica is occasionally found as a constituent in the groundmass or in narrow short streaks or aggregates. The presence of quartz and carbonates in veins, aggregates and in the groundmass indicates at least two generations of these minerals. The glide twinning in the carbonates, strained and sometimes undulatory extinction of the quartz and the deformed and curved plagioclase twinning indicates some type of deformation process.

Opaques occur in the groundmass as xenoblastic to idioblastic grains varying from less than 0.1 mm to porphyroblasts up to 1.5 mm. They include a range of pyrite sizes often with the pyrite having inclusions of sphalerite or having rims of sphalerite on the pyrite grain boundaries. Magnetite is also present. Opaques form up to 10% of the slides and of this 10% about 8% is pyrite and the rest sphalerite and magnetite.

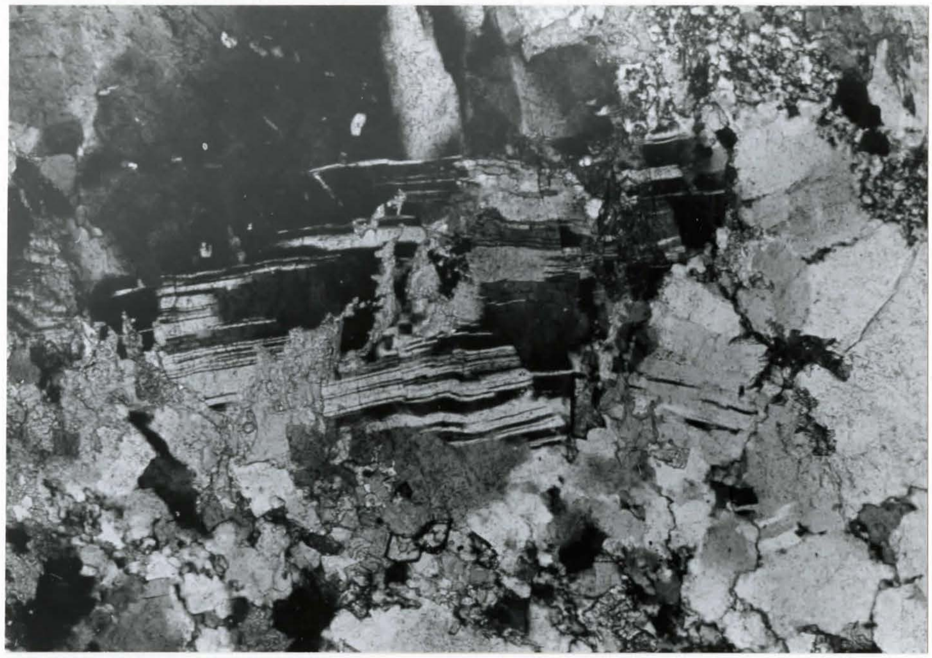


Plate 3 Plagioclase displaying deformed twin lamellae (63 X).

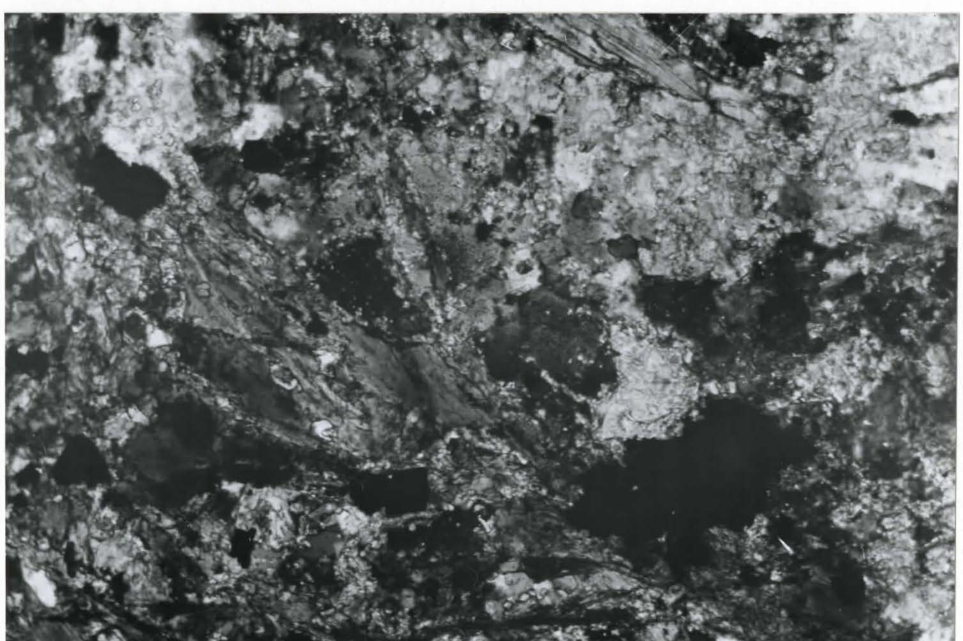


Plate 4 Lamprophyre displaying xenblastic biotite, opaques and perhaps chlorite (63 X).

Lamprophyres

According to Williams et al. (1954), lamprophyres are dark dike rocks having a pronounced porphyritic and panidiomorphic texture with euhedral mafic minerals commonly of two generations, many lacking feldspars and others having the feldspars restricted to the groundmass. The rocks which were studied differed from the definition in that they were not obviously porphyritic and the only euhedral mafic mineral which was observed was biotite and that was in hand specimens.

Description

These dike rocks consist of biotite, carbonate, feldspars and opaques with or without quartz.

Biotite comprises 30 - 35% of the slides and is found as xenoblastic laths and streaks up to about 3.3 mm in size. It also occurs in veins up to 7.2 mm wide. The biotite is characterized by an alteration which results in a dark green rim and a pale yellow-green interior. This bleaching is a common feature of lamprophyres (Harker, 1897). The larger biotite laths could possibly be classified as microphenocrysts though the distinction between a groundmass and phenocrysts is not very obvious. The groundmass would then consist of carbonates and feldspar (Plate 4).

The carbonates make up 30 - 35% of the rocks. They occur as a groundmass constituent in one slide consisting of xenoblastic irregularly shaped grains ≈ 0.8 mm in size. The other slide has carbonates predominantly found in veins as xenoblastic grains (< 0.6 mm) with some grains showing glide twinning.

The feldspar is found as xenoblastic irregularly shaped grains (< 0.2 mm) with a shattered appearance due to fracturing and displaced twins.

The opaques were identified as pyrite, sphalerite and magnetite. They occur as idioblastic to xenoblastic grains up to 1.6 mm in size. Some of the opaques are fractured while others are rimmed by chlorite.

Quench Textured Greenschists

These two slides are characterized by relic quench textures. They consist of actinolite (30 - 70%), chlorite (15 - 40%), carbonate (10 - 20%), and opaques (minor - 5%). Since the textures are both distinct they will be described separately.

Description

Section S-20 (Plate 5) is composed of two basic textures which are discrete and run roughly perpendicular to each other. The first is a crude foliation of fine grained actinolite separated by veins of chlorite. The actinolite consists of masses of fibrous needles which are aligned, laths up to about 1.0 mm long, and also bundles of needles. Carbonate occurs as anhedral grains, rounded, up to about 1.5 mm in size. The chlorite cuts through this as fibrous veins up to 2.0 mm in width.

The second texture consists of long needles ($\leq$ 7.0 mm) and shorter semi-parallel en echelon needles and grains of actinolite. These needles and grains show a spherulitic extinction. This is relic spinifex texture.

Section S-17 (Plate 6) consists of bundles of fine needles

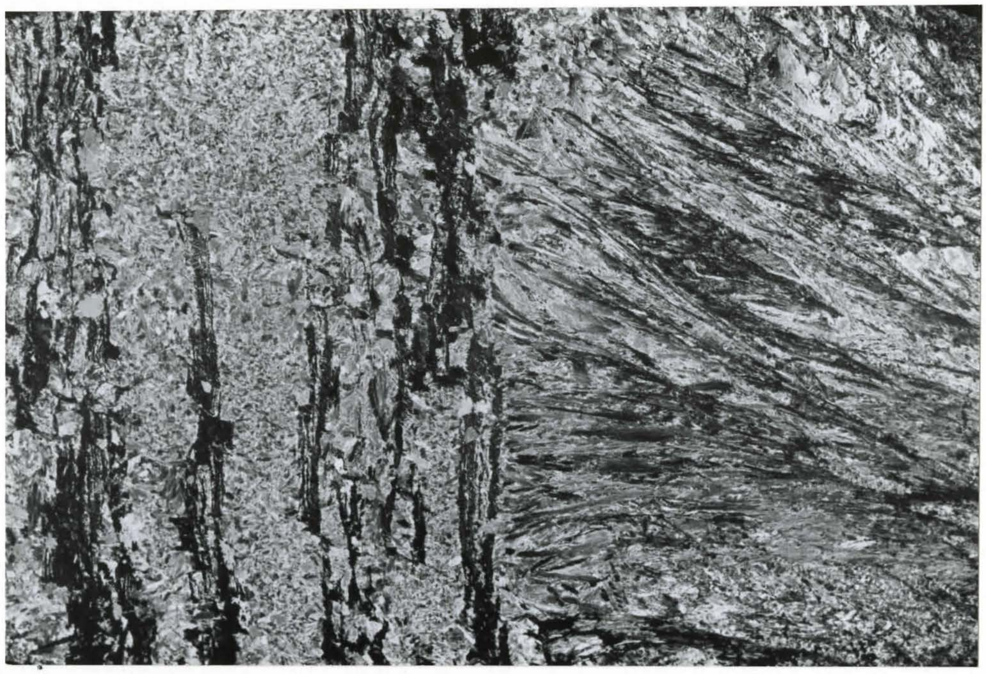


Plate 5 Relict spinifex texture from a schist (4.5 X).

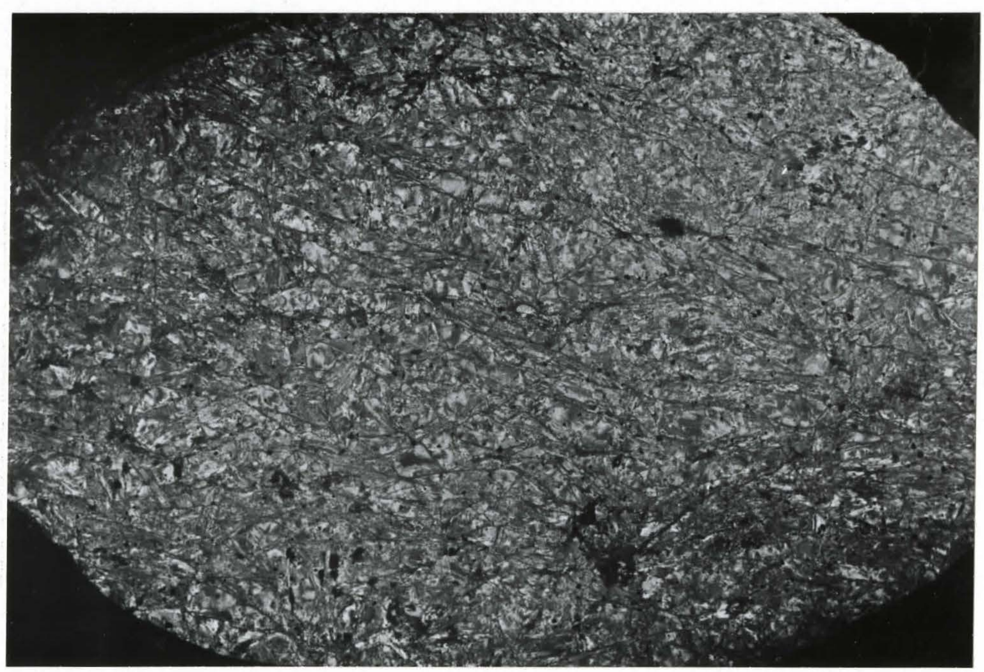


Plate 6 Slower cooling quench texture from a polygonal joint in the ultramafic flow sequence (4.5 X).

which are sub-parallel to radiating. These aggregates of closely spaced needles are up to 2.2 mm in size. They appear to have been larger but are dissected by narrow veins of chlorite giving it a mosaic like appearance. Under crossed nicols and when the stage is rotated, the aggregates show spherulitic extinction. The opaques are idioblastic, average about 0.2 mm, and are magnetite and sphalerite.

Quartz Vein

The quartz occurs as xenoblastic grains up to 8.0 mm in size. The grains show undulating and strained extinction and are often rimmed with very small quartz grains or fragments along their boundaries (Plate 7). Where the minute grains are absent polysuturing is present. Opaques are idioblastic and constitute less than 1 per cent of the slide.

Banded Iron Stone

This slide is composed of about 40% chlorite, 20% quartz, 10% carbonate, 8% white mica, 5% epidote, 2% plagioclase and 15% opaques.

Description

The slide is extremely well banded with trains of opaques and bands of chlorite interspersed by xenoblastic to idioblastic quartz and grains of xenoblastic carbonate and epidote fragments.

The chlorite, quartz, and carbonates are fine grained, generally less than 0.5 mm in size with the chlorite occurring as very fine minute parallel to sub-parallel needles.

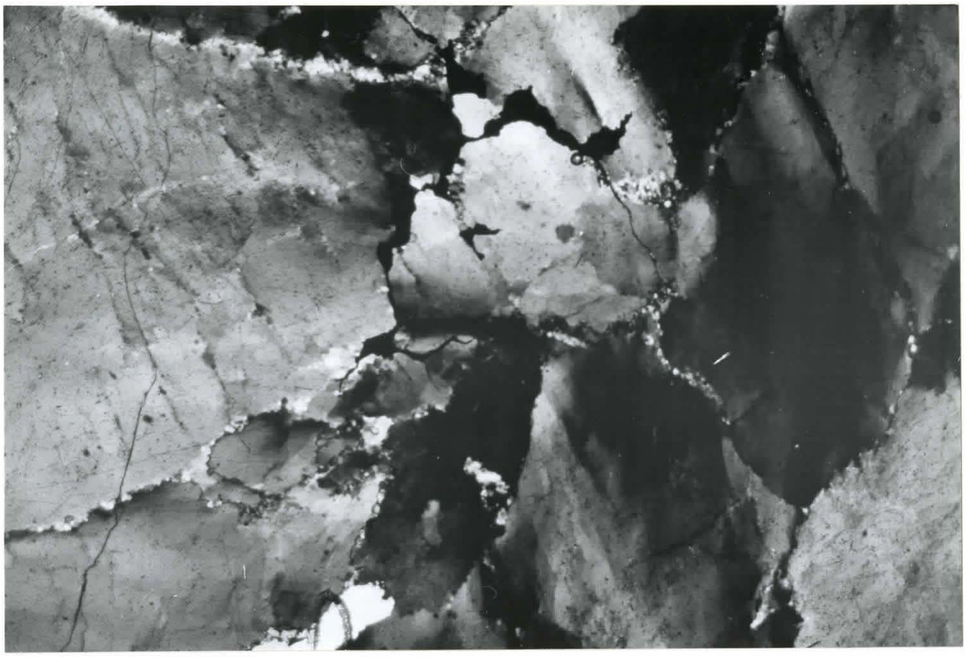


Plate 7 Quartz grains with strained extinction and microcystalline grain boundaries (25 X).

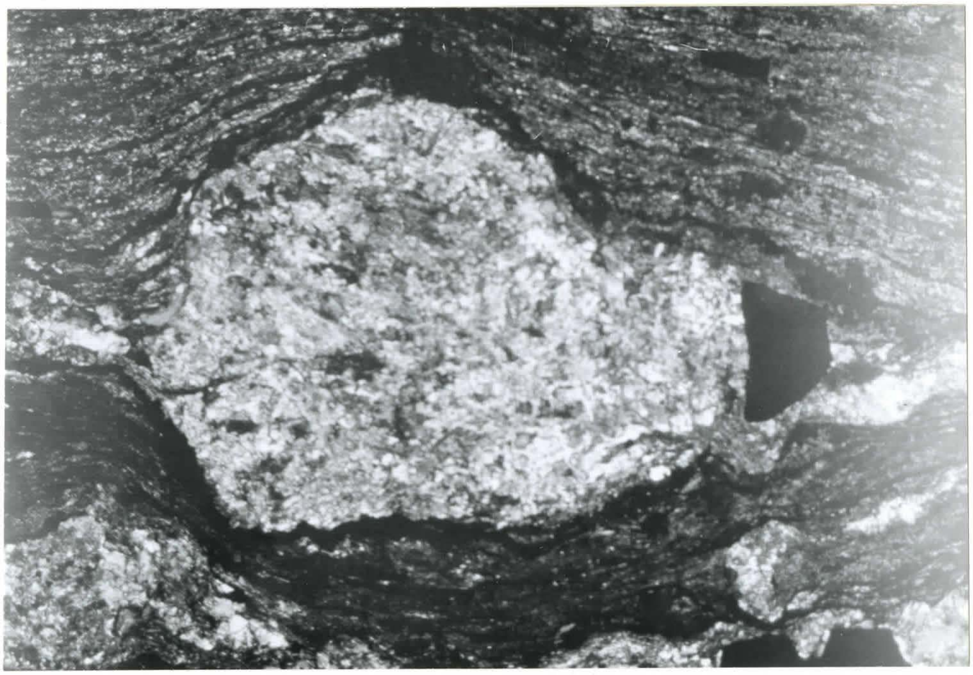


Plate 8 Chlorite bands wrapping around a quartz-carbonate aggregate. Black euhedral grains are opaques (25 X).

Where aggregates of quartz or carbonate and quartz occur, the opaque and chlorite banding wrap around the aggregate (Plate 8). This type of feature is common also where epidote grains are found. Where a large (7.0 mm) carbonate quartz vein cuts through the banding the carbonate grains usually show glide twinning and bent twin lamellae.

The opaques are generally euhedral, cubic and less than 0.5 mm in size. They are found as inclusions in the chlorite and epidote but rarely in the equigranular fine grained quartz or carbonate. The opaques which were identified are sub-idioblastic to xenoblastic pyrite (6%) up to 1.0 mm in size with inclusions of chalcopyrite (1%), and sub-idioblastic to idioblastic magnetite (8%) which shows a dark grey interior and a lighter grey exterior indicating two phases. The magnetite is usually less than 0.2 mm.

CHAPTER THREE

Chemical and Textural Features

Analytical Methods

Analyses for gold and iridium were carried out by neutron activation. Because only ten powered rocks samples could be irradiated at a time, two separate irradiations were required. For each irradiation, ten crushed rock samples each weighing about 200 mg along with two chemical standards and one rock standard were irradiated for 24 megawatt hours. These were allowed to cool for five days before they were brought to the lab. In the laboratory the gold and iridium were extracted using a carrier and wet chemistry methods. After extraction, the radioactivity of the gold samples and standards was counted. This was repeated for the iridium samples (Appendix Table 1 and 2). From these counts the gold and iridium content for each sample was determined (Table 1). This methods was modified after Crocket (Crocket et al., 1969).

Major and minor elements of 23 samples were determined using X-ray fluorescence (XRF) (Tables 2 and 3). Powdered pellets were used instead of fused pellets because it was feared that high sulphur contents of some samples might destroy platinum crucibles needed to make fused pellets.

XRF Results

The XRF data was converted to cation norms and the schists,

Table 1

Gold and Iridium Contents of Sample Rocks (In P.P.B.)

Sample Number	Au Content	Ir Content
	Experiment #1	
S-2	2.46	1.45
S-3	2.84	0.06
S-5	8.68	0.81
S-6	4.21	0.19
S-7	0.81	0.50
S-9	1.02	1.13
S-10	3.68	0.31
S-11	10.47	0.04
S-12	1.44	1.42
S-13	1.76	0.06
Standard PCC-1	0.72	6.86
	Experiment #2	
S-14	2.20	0.07
S-16	1.33	0.19
S-17	1.79	1.82
S-18	0.53	2.02
S-19	104.60	0.23
S-20	0.83	1.85
S-21	2.55	0.36
S-22	3.58	2.83
S-23	0.91	0.17
S-24	0.48	2.64
Standard BCR-1	1.92	0.07

Table 2

Major Oxides Normalized to 100 Per Cent

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	P_2O_5
(gc) S-1	38.36	6.48	17.23	26.69	7.75	0.80	1.99	0.40	0.27	0.03
(s) S-2	43.76	7.09	14.65	23.60	9.74	0.30	0.12	0.53	0.21	0.01
(p) S-3	62.78	15.40	4.57	2.65	3.37	9.61	0.53	0.59	0.14	0.36
(i) S-5	62.13	8.50	9.90	5.19	8.66	2.62	2.23	0.51	0.25	0.01
(p) S-6	53.95	12.51	6.22	10.60	7.86	6.85	0.68	0.71	0.16	0.47
(s) S-7	49.22	11.88	13.22	9.86	9.60	0.88	4.31	0.82	0.20	0.01
(p) S-8	56.72	15.86	6.55	4.61	4.68	8.94	1.00	0.92	0.22	0.49
(gc) S-9	47.06	6.72	15.22	22.90	5.06	0.34	2.06	0.40	0.21	0.02
(p) S-10	71.95	9.11	3.20	5.72	4.49	4.53	0.75	0.10	0.11	0.03
(p) S-11	61.67	15.47	1.42	3.96	6.85	8.89	1.18	0.39	0.09	0.10
(s) S-12	38.62	4.39	12.62	32.98	10.15	0.42	0.17	0.39	0.23	0.02
(l) S-13	46.44	6.18	8.54	17.99	12.35	1.82	4.91	0.87	0.20	0.71
(p) S-14	57.19	13.70	6.78	3.88	8.18	8.31	0.38	0.69	0.15	0.73
(p) S-15	49.55	11.52	8.94	9.99	11.13	4.57	2.24	0.99	0.21	0.86
(p) S-16	51.42	8.63	11.21	17.59	4.69	2.92	2.18	1.10	0.19	0.06
(s) S-17	45.72	11.16	14.71	15.55	8.14	3.38	0.14	0.93	0.24	0.01
(s) S-18	43.84	3.81	14.89	31.40	5.06	0.36	0.10	0.26	0.25	0.03
(q) S-19	90.98	0.96	1.06	2.96	3.29	0.33	0.20	0.07	0.09	0.06
(s) S-20	44.63	9.14	16.17	19.37	7.58	2.05	0.16	0.67	0.23	0.01
(s) S-21	43.98	4.75	14.35	29.74	5.92	0.41	0.16	0.42	0.26	0.02
(gc) S-22	36.34	10.16	22.65	18.39	6.59	0.33	4.63	0.57	0.29	0.04
(l) S-23	41.97	6.67	6.95	20.40	17.02	2.17	3.55	0.71	0.19	0.37
(s) S-24	41.48	6.06	14.62	28.37	8.38	0.30	0.13	0.39	0.26	0.02

p = porphyry
s = schist
gc = green carbonate
l = lamprophyre
q = quartz
i = iron formation

Table 3

X-Ray Fluorescence (In P.P.M.)

Elements

Sample	S	Ni	Cr	Co	Pb	Cu	Zn	As	Rb	Sr	Y	Zr	Nb
1	215	973	4874	90	14	65	82	822	49	501	10	82	-
2	983	1127	4701	65	14	85	80	-	-	215	5	52	-
3	5625	26	34	10	47	14	44	-	11	970	42	489	20
5	3807	595	4199	39	15	109	67	10	25	97	11	40	-
6	1647	217	544	23	18	47	51	10	17	530	29	235	19
7	161	378	2181	44	13	123	57	-	86	181	15	56	12
8	5549	41	29	18	25	191	47	-	17	670	53	276	45
9	133	1849	4777	88	18	22	56	-	49	167	-	46	-
10	81	202	196	-	-	12	44	163	11	361	7	109	-
11	2482	33	63	-	-	-	44	-	19	786	11	91	7
12	88	1842	4902	93	14	-	78	-	11	341	8	77	-
13	309	161	853	23	48	11	74	-	141	587	28	172	23
14	1675	29	24	-	121	144	51	-	7	1588	64	618	28
15	639	113	717	25	20	123	69	-	81	565	17	135	14
16	215	409	666	43	18	75	54	-	63	307	28	167	14
17	187	383	2822	80	14	143	79	-	1	37	10	33	-
18	101	1356	4980	101	15	14	89	-	3	48	5	23	-
19	959	63	224	-	10176	451	44	63	3	310	-	83	-
20	94	277	4070	95	16	107	81	-	2	76	10	36	-
21	66	1542	3488	116	-	12	104	-	5	13	6	16	16
22	133	2038	3351	146	16	39	76	14	117	366	9	67	-
23	601	287	714	30	26	25	57	-	125	866	19	120	15
24	82	2109	4637	112	18	-	68	-	1	223	6	56	-

including the green carbonates were plotted on the Jensen Cation Plot (Jensen, 1976b, Fig. 7). This is a ternary plot which enables classification of subalkalic volcanic rocks on a basis of cation percentages of Al_2O_3, $FeO + Fe_2O_3 + TiO_2$ and MgO.

The schists all plot within the komatiitic field and are characterized by a wide range in MgO cation proportions at relatively constant Al_2O_3 / $FeO + Fe_2O_3 + TiO_2$. Approximately two-thirds of the schist suite plots in the basaltic portion of the komatiite field with the remainder (high MgO members) falling in the ultramafic area. The three green carbonates all plotted in the basaltic komatiite field and displayed the same cation trend as the schists. The classification of these rocks must be regarded as tentative because the Jensen Cation Plot is meant to be used for relatively unaltered rocks.

Comparison of Major Element Composition With Other Known Ultramafic Flows

Pyke et al. (1973) compared the compositions of the ultramafic flows of Pyke's Hill in Munro Township with those from the Barberton Mountain Land in South Africa and the Abitibi Belt, Clergue and Dundonald Townships, Ontario (Viljoen and Viljoen, 1969; Naldrett and Mason, 1968). Only general similarities were found even though Naldrett (1972) had tried to use the CaO / $CaO + Al_2O_3$ ratio as a basis for comparison with Viljoen's data. Viljoen's rocks had CaO / CaO + Al_2O_3 ratios greater than 0.5 and they suggested this ratio was a characteristic and diagnostic chemical property of extrusive ultramafic flows. Naldrett and Mason's rocks, however, had ratios which varied from greater than 0.5 to less than 0.5. The data of Pyke et al. (1973)

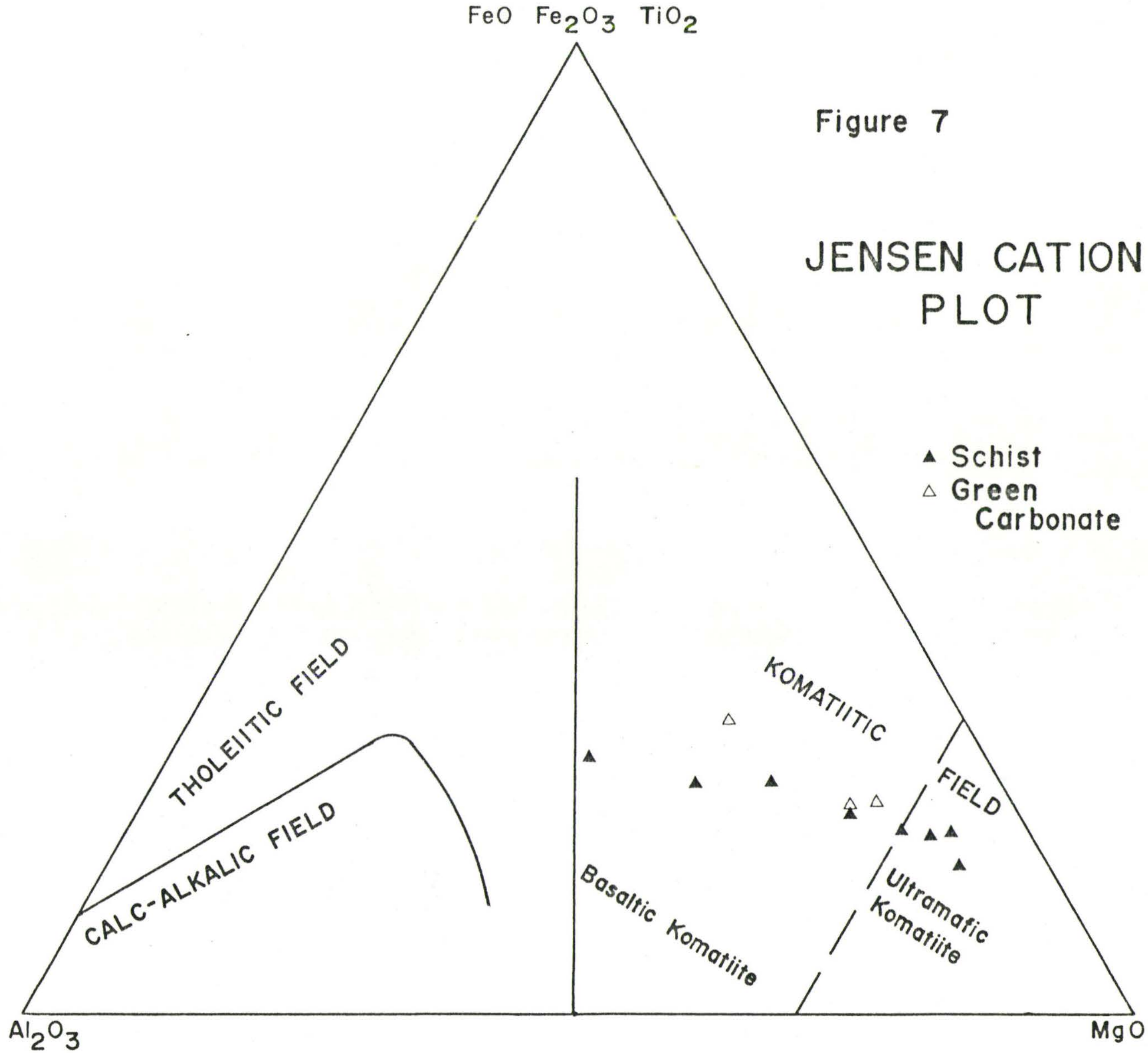


Figure 7

JENSEN CATION PLOT

indicated a similarity with Naldrett and Mason's results. The Misema River schists are comparable with ultramafic compositions from Pyke's Hill and Clergue and Dundonald Townships in terms of Ca / Al ratios. This incongruity with Viljoen's results places some doubts on the usefulness of Ca / Al ratios in the recognition of ultramafic flows and suggests the Barberton lavas are perhaps not typical of Archean lavas from other shields.

Arndt et al. (1977), in another study of the Munro Township flows found that most of the ultramafic komatiites were basal cumulates of peridotitic komatiite flows. They are ultrabasic (SiO_2 < 45 %) in composition with high MgO contents (> 30 %) and low in CaO, Al_2O_3, TiO_2 and alkalis. Less basic though still ultramafic periodotitic komatiites included spinifex textured rocks. Pyroxenitic and basaltic komatiites were found to have basic compositions with proportionately lower MgO, NiO, and Cr_2O_3 and higher CaO, Al_2O_3, SiO_2 and TiO_2 contents. As the mafic mineral content of komatiitic lavas decreased, MgO and NiO steadily decreased and CaO, Al_2O_3, SiO_2 and TiO_2 increased. Na_2O, K_2O, Rb and Sr also increased but their trends were complicated by migration during alteration, making them of little use for comparison purposes. The general trend in peridotite and pyroxenitic komatiite compositions was essentially one of decreasing MgO at constant CaO / Al_2O_3 ratio.

Chromium is usually found in concentrations greater than 1000 ppm in ultramafic rocks and averages 100 - 400 ppm in mafic rocks (Shiraki, 1978). In ultramafic rocks from Pyke's Hill in Munro Township, Cr ranges from 82 to 3080 ppm with the peridoties having high values (1762 to 3272 ppm) and pyroxenitic komatiites and tholeiites low values (82 to 1460 ppm). In comparison, the schists from Misema River have high chromium values ranging from 2181 to 4980 ppm and averaging 4071 ppm. The iron formation was also high in Cr while the porphyries, lamprophyres, and quartz were low (Table 3).

Similarly, the Misema River nickel values are correspondingly high in the schists averaging 1261 ppm. The other rocks generally have values lower than 400 ppm. In ultramafic rocks on a world wide basis, nickel averages about 1450 ppm while in Archean spinifex textured peridotites it averaged 1390 ppm (Turekian, 1978b).

Nickel and chromium display a strong covariance in basaltic and ultramafic rocks and in kimberlites. Although there are regional differences there appears to be a correlation between the two elements (Turekian, 1978b). The relationship between nickel and chromium values obtained by XRF is shown in Figure 8.

The mean Cr / Ni ratio for the schists was 4.73 which is considerably higher than the value Tihor (1977) obtained for the ultramafic volcanic rocks from Larder Lake (2.53) and Munro Township komatiitic peridotites (3.73).

The general trend is increasing nickel with increasing chromium. These high values compare well with the high values obtained from peridotitic komatiites of Munro Township (Arndt <u>et al</u>., 1977). The porphyries, lamprophyres, quartz, and iron formation were not as rich in nickel and chromium as the schists were.

Cobalt averages about 110 ppm for all ultramafics for which data is available (Turekian, 1978a) while for all other rock types the

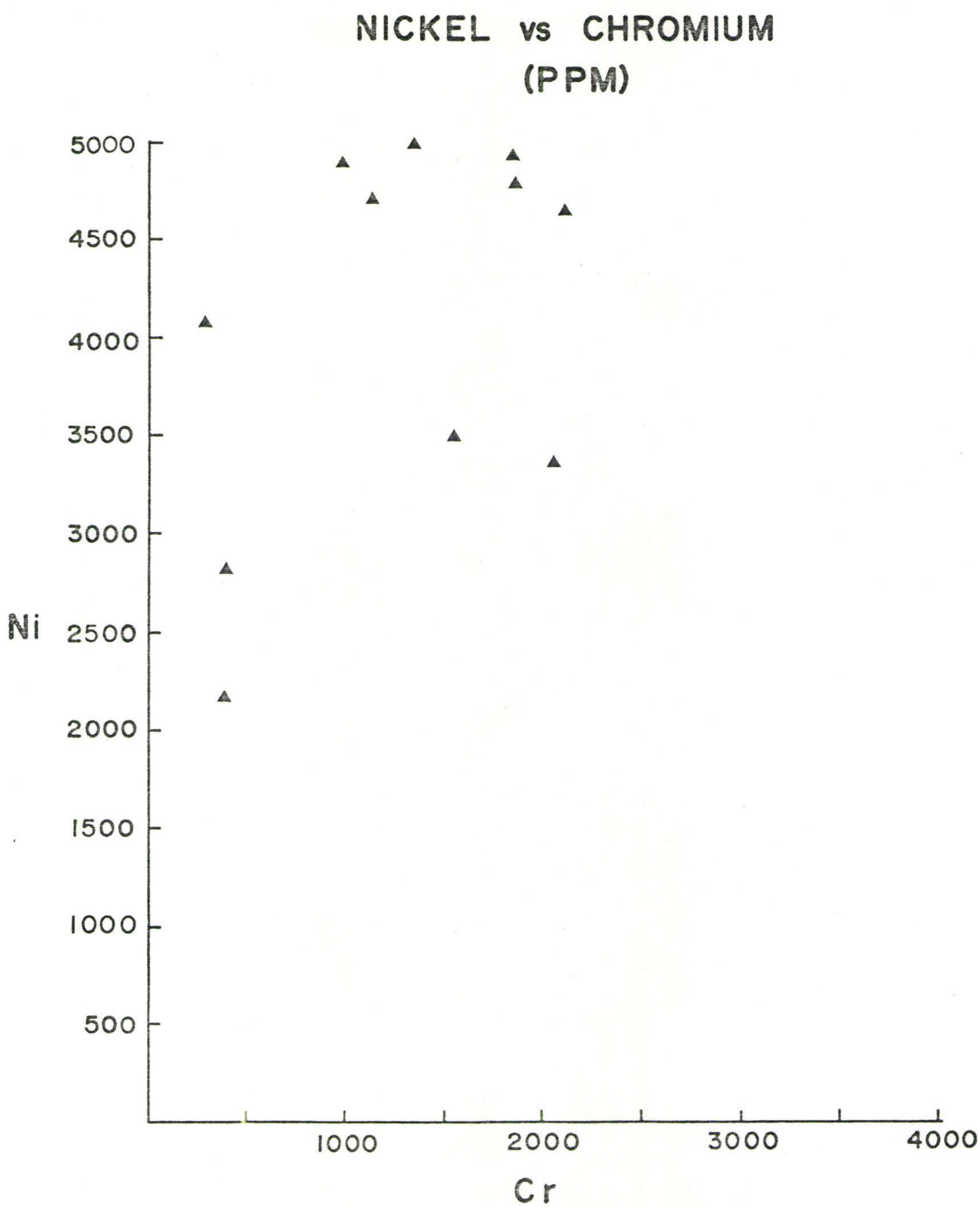


Figure 8

Ni vs Cr for schists

values are considerably lower. Co / Ni ratios for the schists averaged 0.11 which is lower than for the other rocks but is still close to the values (0.12) that Tihor (1977) shows for ultramafic volcanic rocks in the Larder Lake area and for the komatiitic peridotites in Munro Township (0.10).

Arth et al. (1977) found that trace elements, particularly rare earth elements reflect the processes that produced the Archean komatiitic and tholeiitic rocks of Munro Township and serve to further distinguish the komatiitic from tholeiitic lavas.

Iridium

Iridium is a platinum group metal which characteristically is present in concentrations of greater than 1 ppb in ultrabasic rocks and less than 1 ppb in basic rocks (Crocket, 1979).

Iridium values for the Misema River schists ranged from 0.04 to 2.80 ppb averaging 1.60 ppb. This compares favourably with the average content of 1.0 ppb for orogenic ultrabasics given by Crocket (1979) and from Pyke's Hill, Munro Township (1.03 ppb; MacRae and Crocket, in prep.). This high Ir level, together with the relatively high Ni and Cr values are consistent with an ultramafic parentage for for the Misema River schists. It may be noted that both green carbonates (S-9, S-22) are also characterized by Ir contents greater than 1 ppb. Thus the Ir content of both the very carbonate-rich rocks and the schists suggests both lithologies may be derived from alteration of ultramafic rocks.

Gold

On a world wide basis, gold content in volcanic rocks tends to decrease from mafic to felsic volcanics. Basalts of different petrochemical and tectonic affinities show a range of average gold content from 0.5 to 5.0 ppb. There is no clear correlation of gold content with major element chemistry so that gold probably acts as a neutral element with enrichment in the rock controlled by structural factors (Crocket, 1974).

The gold values for the schists ranged from 0.48 ppb to 3.58 ppb and averaged 1.55 ppb which is comparable to the 2.97 ppb content that Tihor (1977) showed for intermediate to mafic volcanics associated with a quartz carbonate horizon but not near known gold ore.

The porphyry samples have gold values ranging from 1.33 ppb to 10.47 ppb and averaged 4.12 ppb (Fig. 9). The two lampropyres averaged 1.34 while the iron formation had 8.68 ppb. The quartz vein had 104.6 ppb which is coincident with an anomalously high Pb (10,176 ppm) and Cu (451 ppm) content.

Important Textural Features

Textural features related to ultramafic flows were observed on the outcrops and also microscopically.

Spinifex textures were observed megascopically in a green carbonate (Plate 9), several schists, and possibly as a relic texture in an ultramafic flow sequence.

The ultramafic flow sequence (Fig. 10) was found 150 feet south of the highway on an outcrop which had been stripped of moss and trees.

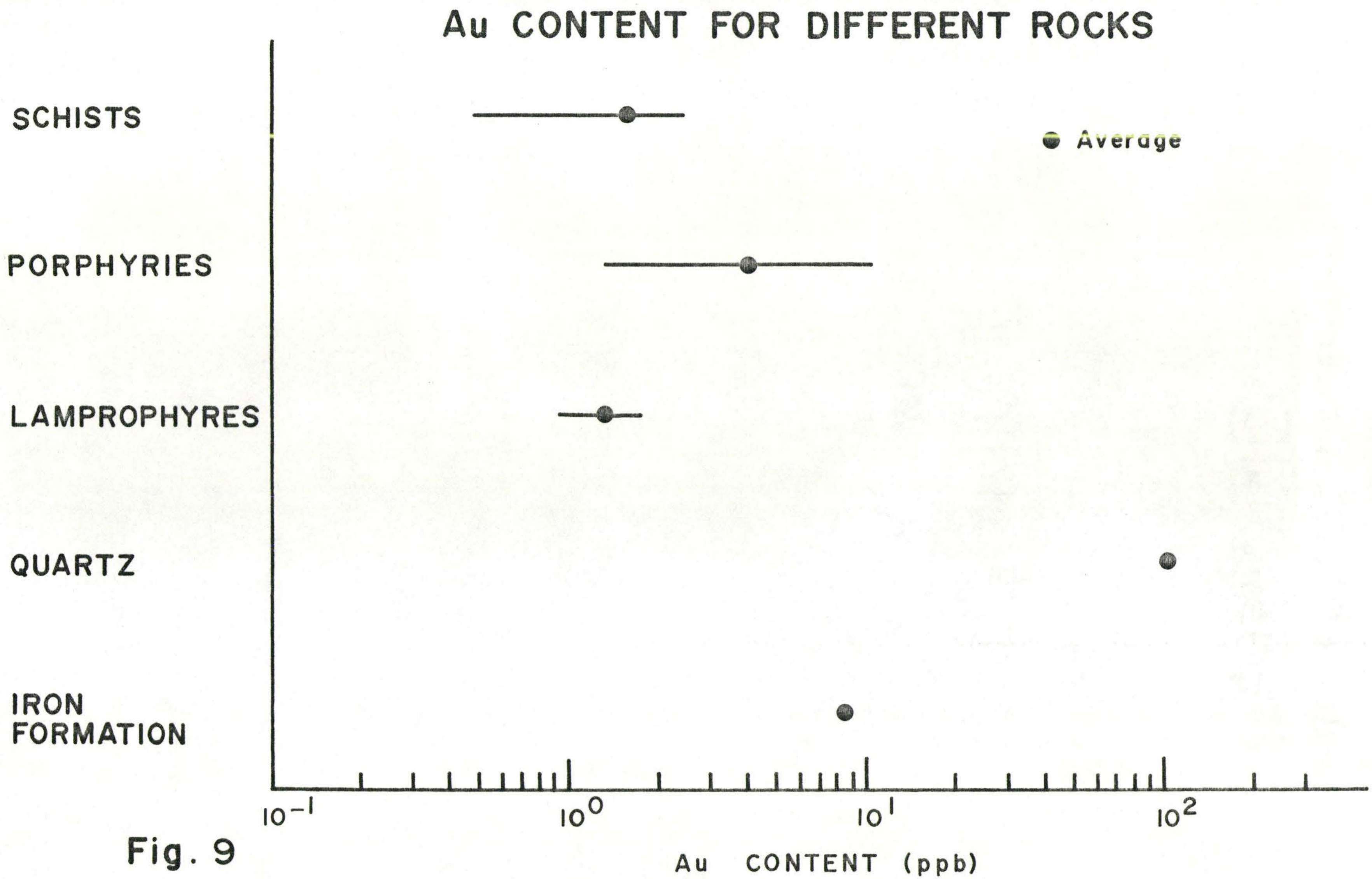

Au CONTENT FOR DIFFERENT ROCKS
SCHISTS
PORPHYRIES
LAMPROPHYRES
QUARTZ
IRON FORMATION
Average
10⁻¹
10⁰
10¹
10²
Au CONTENT (ppb)

Fig. 9

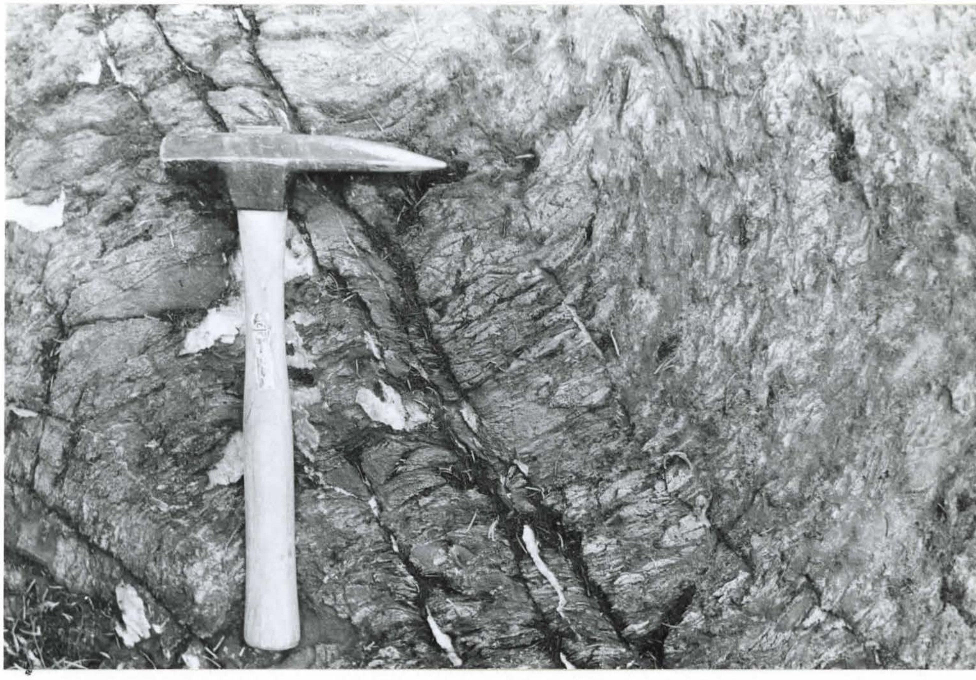


Plate 9 Spinifex texture in a green carbonate.

Plate 10 Flow top showing polysuturing.

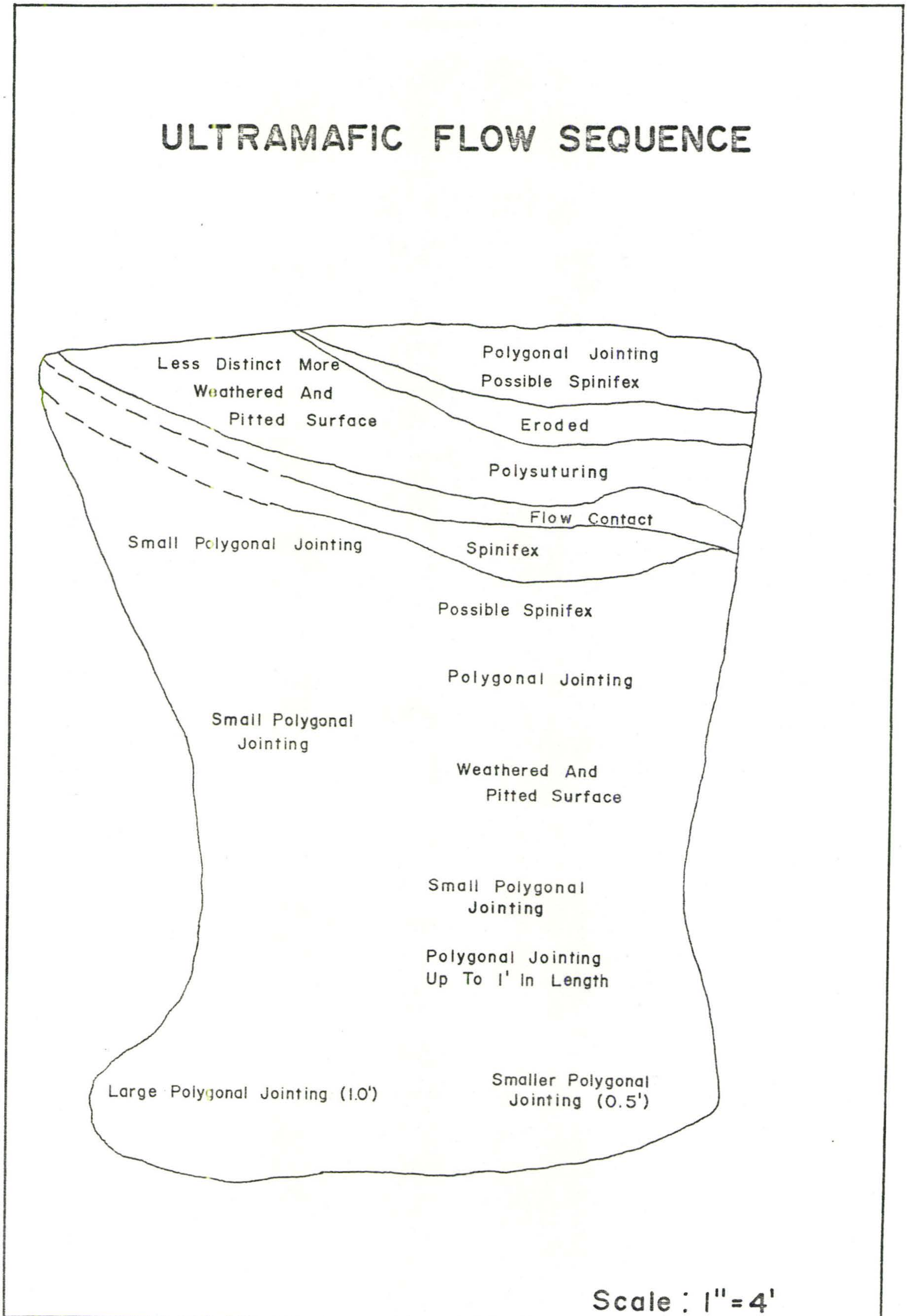

ULTRAMAFIC FLOW SEQUENCE
Less Distinct More
Weathered And
Pitted Surface
Polygonal Jointing
Possible Spinifex
Eroded
Polysuturing
Flow Contact
Small Polygonal Jointing
Spinifex
Possible Spinifex
Polygonal Jointing
Small Polygonal
Jointing
Weathered And
Pitted Surface
Small Polygonal
Jointing
Polygonal Jointing
Up To 1' In Length
Large Polygonal Jointing (1.0')
Smaller Polygonal
Jointing (0.5')
Scale : 1" = 4'

Figure 10

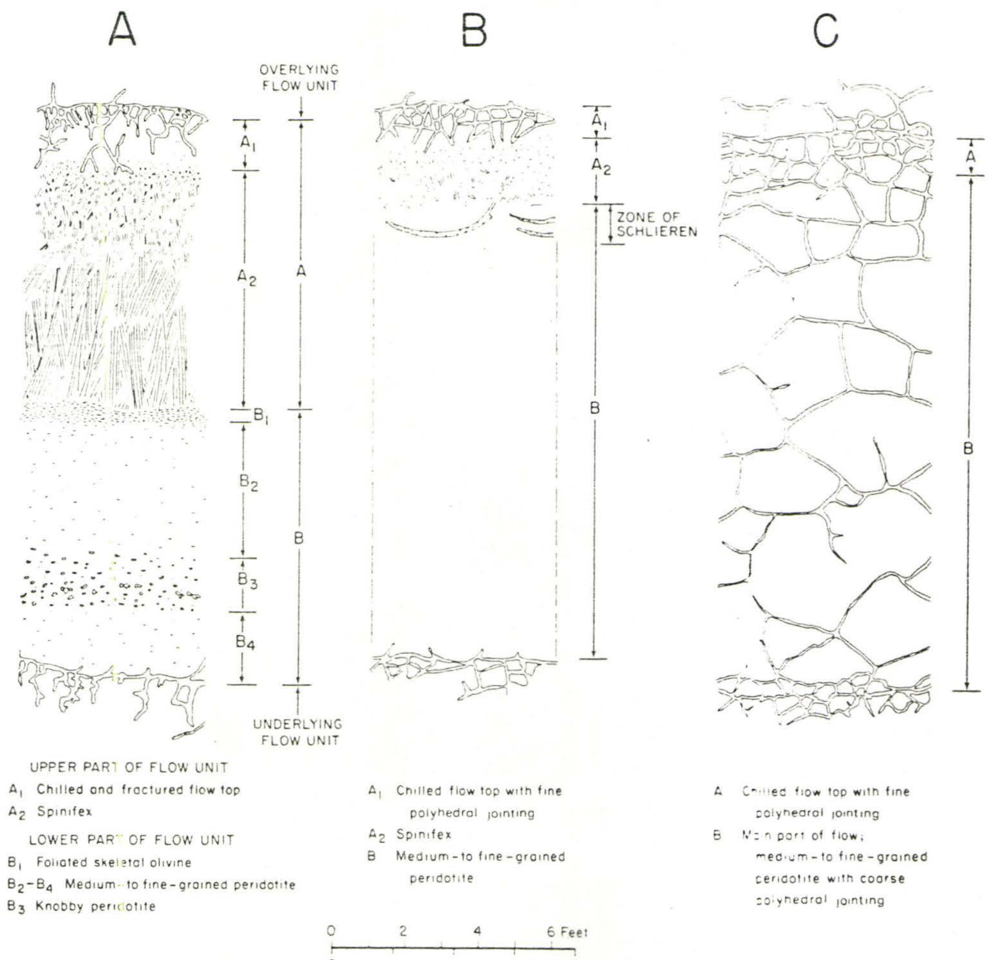
The bottom portion of the flow sequence consists of relic polygonal jointing which is obscured by the rough surface of the rock and the foliation. The joints vary in size from about 0.5' to 1.0' at the bottom and become smaller towards the spinifex zone. Between the spinifex zone and the polysutured or flow top zone above, is a sharp flow contact zone about 1.0' thick.

The polysutured zone consists of polygonal blocks of various sizes with the largest block measuring roughly 1.2' by 0.6' (Plate 10). The blocks are distinctive because of a prominent border or rind enveloping the central core. They decrease in size and loose their distinctive shapes towards the bottom part of the zone. Above the polysutured zone is another zone of polygonal jointing and possible spinifex texture. This sequence is comparable to the three types of flow sequences which Arndt et al. (1977) described from Munro Township (Fig. 11).

Although the Misema River sequence was not exactly the same as those of Arndt, there is enough similarity to suggest that both were formed by roughly the same mechanism. Both have flow tops with polygonal jointing, seen as polysuturing at Misema River, and two of Arndt's flows have a spinifex zone. One major difference is the presence of polygonal jointing (Plate 11) over most of the Misema River flow sequence. This is not apparent in the flows described by Arndt.

In thin section, relic spinifex and quench textures were observed in some samples of schist (Plates 5 and 6).

Viljoen and Viljoen (1969) observed striking geometric forms



Diagrammatic sections through three types of peridotitic lava flows: A, a flow with an upper spinifex zone; B, a flow with limited spinifex texture; C, a flow without spinifex texture.

Figure 11

Plate 11 Polygonal jointing in the ultramafic flow sequence.

consisting of chlorite-magnetite crystals or blades growing obliquely or parallel to bladed olivine crystals which were generally of somewhat skeletal nature. Arndt et al. (1977) described similar textures but the dominant mineral was pyroxene not olivine. This type of structure is now generally conceded to result from the very rapid cooling or quenching of a crystal-free ultrabasic magma and is called spinifex.

The dominant mineral in the rocks from the Misema River outcrops which display these features is actinolite. S-17 (Plate 6) does not display spinifex texture but was probably cooled slower than S-20 resulting in its distinctive texture. The structures are not as well developed as those described by Viljoen and Viljoen (1969) or Arndt et al. (1977). This is probably due to the metamorphism which these rocks have undergone. This may also account for the differing mineralogy.

CHAPTER FOUR

Discussion and Conclusions

The conclusions drawn about the carbonate rich rocks are based on several criteria. Field observations coupled with microscopic observations revealed textural features related to rapidly cooled lavas. XRF data when compared to data from other ultramafic flows was similar in several important respects. Iridium content, determined by neutron activation, revealed the schists to have relatively high concentrations indicative of ultramafic rocks.

Field Observations

Field observations indicated that there are several types of rocks present in the study area and that some have been metamorphosed to such an extent that the original rock type is not immediately apparent. The schists include green carbonates, believed to be highly altered ultramafic flows as well as highly schistose, chlorite-carbonate-talc rich rocks. These more schistose rocks have been deformed and show crenulation, foliation and sometimes very noticeable schistosity. They are probably altered ultramafic rocks as well. In some outcrops there appeared to be a gradational change from a green coloured highly schistose rock to a more massive green carbonate rock.

Lamprophyres and porphyries appear to be intrusions. They are relatively undeformed, probably as a result of their intrusion during or after the deformation event which produced the pronounced foliation in the carbonated rocks. The porphyries are characterized by a high pyrite content easily observed in hand specimen.

One outcrop is an undeformed iron formation. There are also abundant quartz veins, stringers and massive quartz present throughout all the outcrops.

Chemical Data

Using the Jensen Cation Plot the schists, including the green carbonates were consistently classified as basaltic and ultramafic komatiites.

When comparing major element data with those of other researchers, it was found that the CaO / CaO + Al_2O_3 ratio which was one of Viljoen and Viljoen's (1969) original parameters for distinguishing extrusive ultramafic rocks was not a good comparative parameter. This suggests that the rocks of the Barberton Mountain Land where komatiites were first defined are atypical. Naldrett and Cabri (1976) and Arndt et al. (1977) have formulated several chemical parameters involving FeO / FeO + MgO and TiO_2 and MgO,NiO and Cr_2O_3, which are consistent for ultramafic flows and are thus valuable for comparative purposes.

Chromium and nickel are relatively immobile elements and can be used to infer the pre-alteration protolith. The content of these elements in most schists were comparable to averages for ultramafic rocks. Any variations from ultramafic rock averages, if not too great, might result from migration due to metamorphism or may reflect normal Ni-Cr variation in ultramafic rocks. This is applicable to other elements such as rare earths, which can also be used for comparisons.

Iridium, which is a relatively immobile element should reflect the original rock type even for metamorphosed and highly altered rocks. The values which were obtained for the schists are very close to averages for ultramafic flows.

Cobalt-nickel ratios were similar to those reported by Tihor (1977) for ultramafic rocks.

Gold values were variable from one rock type to another with the quartz vein having a high value. This vein was apparently intruded after the emplacement of the green carbonates and schists. The porphyries are also richer in gold than the schists. The higher gold values for the porphyries are associated with very high sulphur content indicating an association between the gold and sulphur.

The high gold values in the quartz and porphyries suggests that gold may have been mobilized and concentrated by the same mechanism which was responsible for the intrusion of the quartz, porphyries, and lamprophyres. This is most evident when it is observed that the schists have a relatively low gold content.

Textural Features

Spinifex was observed megascopically in varying degrees of preservation in several rock types indicating that they all underwent similar cooling processes.

The flow sequence, which is very distinct, is similar to that described by Arndt *et al.* (1977) for ultramafic flows in Munro Township. This flow sequence, with its associated relic spinifex and cooling textures most definitely indicates an ultramafic flow sequence rock. Although the mineralogy is not original, probably because of metamorphism, some semblance of the original textures have been preserved.

The conclusions reached are as follows:

1) The schists are altered and metamorphosed mafic and ultramafic flow rocks.

2) The green carbonates or carbonate rich schists are also probably mafic and ultramafic flow rocks representing a more advanced or intense alteration than the schists.

3) Iridium, nickel, and chromium are relatively immobile elements and their concentrations suggest an ultramafic parentage for the schists.

4) The presence of spinifex in varying degrees of preservation in several rock types indicates that these rocks all had similar cooling histories.

5) Gold is preferentially concentrated in sulphur-rich felsic porphyries intruded into the altered ultramafic suite suggesting that gold mobilization and concentration are associated with intrusive events.

APPENDIX I

NEUTRON ACTIVATION LAB RESULTS

Misema River Samples

Experiment: 1 Date: December 19-21, 1978

Gold

Sample		Time (hr)	Chemical Yield		Metal Au	Weight (gm)
Field #	Lab #		Vial Wt. (gm)	(V+ Metal) Wt. gm	Energy = 412 KeV	
S-2	1	12.83333	2.94273	2.95512	2492	0.21711
S-3	2	16.13333	2.97789	2.99002	3270	0 26046
S-5	3	17.16667	2.96997	2.98179	5851	0.15836
S-6	4	18.20000	2.99854	3.01188	3696	0.18485
S-7	5	20.86667	2.95866	2.97450	1064	0.24042
S-9	6	21.90000	2.87379	2.88886	1197	0.22687
S-10	7	22.93333	2.92186	2.93383	3222	0.21581
S-11	8	24.30000	3.08105	3.09496	10420	0.21443
S-12	9	32.71667	2.87130	2.88472	1015	0.17266
S-13	10	34.06667	3.05665	3.06868	1563	0.24586
PCC-1	11	35.25000	2.93154	2.94422	577	0.21217
Chem. Std.	I	13.96667	2.95432	2.97274	11017	0.07614
	II	15.08333	2.90991	2.92830	10579	0.07032

Carrier Conc. = 10.29024 mg/ml Volume = 2 mls

Standard Conc. = 21.643 μgm/Kgm

Misema River Samples

Experiment: 2 Date: February 7-8, 1979

Gold

Sample Field #	Sample Lab #	Time (hr)	Chemical Yield Vial Wt. (gm)	Chemical Yield (V+ Metal) Wt. gm	Metal Au Energy = 412 KeV	Weight (gm)
S-14	1	17.83333	2.95263	2.96531	2766	0.18237
S-16	2	32.96667	2.90682	2.92267	1809	0.18590
S-17	3	19.16667	2.95026	2.96551	2785	0.19094
S-18	4	20.23333	2.95045	2.96268	659	0.19202
S-19	5	19.70000	2.91579	2.92829	150469	0.21633
S-20	6	20.80000	2.99060	3.00334	1053	0.18891
S-21	7	21.35000	2.90484	2.91695	2671	0.16541
S-22	8	17.28333	2.89788	2.91040	5585	0.22836
S-23	9	21.85000	2.94415	2.95221	675	0.17605
S-24	10	22.70000	3.01775	3.02935	558	0.19438
BCR	11	23.48333	3.00291	3.01144	1753	0.20992
Chem. Std.	I	41.91667	2.88892	2.90864	12883	0.06511
	II	41.38333	2.99159	3.01159	11592	0.07100

Carrier Conc. = 11.6491 mg/ml Volume = 2 mls
Lab # 1, 2, 3, 4, 5, 6, 7, 8

Standard Conc. = 21.643 μgm/Kgm

Carrier Conc. = 9.6879 mg/ml Volume = 2 mls
Lab # 9, 10, 11, I, II

Misema River Samples

Experiment: 1 Date: December 19-21, 1978

Iridium

Sample Field #	Sample Lab #	Time (hr)	Chemical Yield Vial Wt. (gm)	Chemical Yield (V+ Metal) Wt. gm	Metal Au Energy = 298/310 Kev	Metal Ir Energy = 317/468 KeV	Weight (gm)
S-2	1	21.18333	2.90888	2.91727	1015/1080	3790/1284	0.21711
S-3	2	33.21667	2.88481	2.89360	134/38	120/45	0.26046
S-5	3	35.33333	2.95211	2.96300	658/654	1515/640	0.15836
S-6	4	37.45000	2.86356	2.87328	187/121	401/163	0.18485
S-7	5	39.68333	2.99015	2.99878	497/388	1241/502	0.24042
S-9	6	41.80000	2.92515	2.93629	1280/1189	3239/1423	0.22687
S-10	7	43.88333	2.92789	2.94040	393/362	901/397	0.21581
S-11	8	46.00000	3.04362	3.05430	65/20	63/48	0.21443
S-12	9	56.43333	2.93846	2.94765	1000/957	2658/1055	0.17266
S-13	10	58.53333	2.95965	2.96788	69/51	143/40	0.24586
PCC-1	11	20.03333	2.99562	3.00707	7046/7226	20880/8080	0.21217
Chem. Std.	I	14.70000	2.83720	2.84500	2590/2686	7686/2782	0.07614
	II	15.85000	2.94621	2.95176	1770/1808	5274/1966	0.07032

Carrier Conc. = 2.0230 mg/ml Volume = 5 mls

Standard Conc. = 10.3844 μgm/Kgm

Misema River Samples

Experiment: 2 Date: February 7-8, 1979

Iridium

Sample Field #	Lab #	Time (hr)	Chemical Yield Vial Wt. (gm)	(V+ Metal) Wt. gm	Metal Au Energy = 298/310 KeV	Metal Ir Energy = 317/468 KeV	Weight (gm)
S-14	1	15.91667	3.02903	3.04662	73/49	138/40	0.18237
S-16	2	18.10000	3.09537	3.11330	167/122	341/172	0.18590
S-17	3	20.23333	3.03283	3.04824	1096/1167	3523/1270	0.19094
S-18	4	22.41667	3.12920	3.14664	1491/1458	4068/1640	0.19202
S-19	5	24.53333	3.19283	3.21164	231/262	386/215	0.21633
S-20	6	32.38333	3.15594	3.17263	1215/1164	3728/1486	0.18891
S-21	7	34.51667	2.96849	2.97215	61/39	143/46	0.16541
S-22	8	36.60000	3.15271	3.16599	1933/1817	5337/1973	0.22836
S-23	9	38.98333	3.12000	3.13520	100/106	224/110	0.17605
S-24	10	41.06667	3.10383	3.12082	1915/1858	5256/2089	0.19438
BCR	11	43.16667	3.06075	3.07928	92/47	151/54	0.20992
Chem. Std.	I	14.71667	3.00295	3.02221	3142/3036	9714/3370	0.06511
	II	13.50000	3.09660	3.11880	3146/3122	9092/3494	0.07100

Carrier Conc. = 2.0230 mg/ml Volume = 10 mls

Standard Conc. = 10.3844 μgm/Kgm

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