GEOLOGICAL SURVEY OF CANADA

OPEN FILE 2659

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ASSESSMENT OF MINERAL AND ENERGY RESOURCE POTENTIAL IN THE LAUGHLAND LAKE TERRESTRIAL AREA AND WAGER BAY MARINE AREA, N.W.T.

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June, 1993

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[1] Although this report has received cursory proof reading from its authors and from reviewers on selected portions, it has not been fully refereed and has not undergone the customary Geological Survey of Canada editorial process for formal publications. This release is for the purpose of public review; any comments received by the first author and/or MERA committees (see INTRODUCTION) will be carefully considered as part of the MERA process.
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EXECUTIVE SUMMARY

In 1978, Canadian Parks Service (CPS) identified the area around Wager Bay and parts of Southampton Island (Figs. 1, 2) as likely candidates for a national park. As part of the inter-agency Mineral and Energy Resource Assessment (MERA) planning process, Jefferson et al. (1991) conducted field work and assessed these terrestrial areas between 64° and 66°40' N, east of 92°. Although fieldwork was not done west of 92°, they also outlined the approximate area of the Prince Albert Group (PAG) as being moderate to high in potential for lead, zinc, copper, nickel or gold, because it is an important hinterland factor regarding the transportation potential of Wager Bay.

Continued planning by CPS identified the marine waters of Wager Bay and the Laughland Lake terrestrial area (headwaters of the Brown River west of 92°) as part of the park study area. This report concludes two years of field and laboratory studies on these additional areas, and is provided to aid in the public consultation parts of the MERA and park planning processes.

Figure 1 summarizes the geological resource assessment domains in the Laughland Lake area and Wager Bay region. Table 1 summarizes all of the assessments by domain, for all deposit types whose attributes compare favourablly with the geological setting of the study area. Table 2 explains the seven-point scale of ratings from VH (Very High) to VL (Very Low). Some of the more prospective deposit types and their respective ratings are:

- Carving stone (soapstone): H
- Gold (Au) in iron formations: H
- Nickel (Ni) + copper (Cu) in komatiites: MH
- Au in sheared volcanics & intrusions: MH
- Ni + Cu + Platinum Group Elements in gabbro & anorthosite: MH
- Diamond-bearing kimberlites: M

Field examination of Wager Bay was not possible due to the expensive nature of marine geoscience work. Examination of aeromagnetic data and the limited bathymetric measurements for Wager Bay indicate that the floor of Wager Bay is relatively deep, and is likely underlain by Paleozoic strata. Based on this very limited database, low-to-moderate potential (LM) is tentatively assigned for fluid hydrocarbons.

The above assessments of the Laughland Lake area were based on two short mapping seasons and laboratory analyses of several hundred rock and sediment samples collected in the Laughland Lake area (the headwaters of Brown River, west of 92°). The PAG around Laughland Lake comprises abundant biotite psammite, phyllite and biotite schist (not thick greywacke turbidites), a central north - south belt dominated by komatiites, and numerous elongate belts of ultramafic rocks (komatiite, ultramafic schist and fine-grained amphibolite) which are commonly parallelled by iron formation and quartzarenite.

The komatiite suite in the Central Complex of the Laughland Lake area forms a major anticline of middle amphibolite grade, and preserves primary cumulate and spinifex textures. The komatiites are depleted in chalcophile elements such as nickel and copper, but enriched in zinc and light rare earth elements. The erupting melt is thus interpreted to have been contaminated by supracrustal rocks, causing it to be saturated in sulphur which scavenged and separated the chalcophile elements from the silicate phase. The komatiites are thus considered favourable hosts for the stratiform copper-nickel sulphide deposit type.

The PAG thus records a continental shelf environment which was rifted with concomitant volcanism and hydrothermal activity. The assumed granitoid basement to this shelf is interpreted to be partially preserved among the undivided tonalites of the Brown River Gneiss. The PAG was intruded successively by foliated tonalite (also included in the Brown River Gneiss), metagabbro, layered anorthosite with related amphibolites, foliated porphyritic granite (A') and massive fluorite granite. Metamorphic grade ranges from upper greenschist southwest of Laughland Lake, through amphibolite to migmatite northeast of the map area. Bedding-parallel foliations, crenulations, refolded isoclines and the granitoid intrusions record collisional orogeny.

The >90% Quaternary cover includes crag-and-tail structures in till which record north-northwesterly ice flow. Numerous eskers and sand to boulder plains were created by meltwater flow in the same direction. Angular boulders and huge blocks of anorthosite along an esker complex in the central area record a catastropic release of ice dammed water. An ephemeral lake occupied the Brown River valley, was bordered by fluviodeltaic deposits on its west side, and developed weak wave terraces in some larger eskers.

The 165 km^2 part of the proposed park area which is rated as high (H) in potential, is small in proportion to both the whole of Domain 1A (~8,400 km^2). Nevertheless it is considered a unique part of Domain 1A because of the moderate metamorphic grade and unusually thick komatiites in this part of the PAG, the associated anorthosite of Domain 3A (~150 km^2; not distinguished elsewhere beside Domain 1A), and the spatial association of elevated gold values and iron formations with several intersecting arrays of faults and shear zones.

Table 1. Summary of resource potential ratings for selected deposit types in each domain, combined from this report and Jefferson et al. (1991).

Domain 1A, Prince Albert Group	
◦ Carving stone (soapstone):	H
◦ Chemical Sediment-hosted Gold (Au)	H
◦ Ultramafic-Associated Nickel-Copper (Ni-Cu)	MH
◦ Volcanic-Associated Shear-Zone Au	MH
◦ Intrusion-Associated Shear-Zone Au	MH
◦ Sediment-Hosted Zinc + Lead + Silver	LM
◦ Sediment-Hosted Zinc + Platinum Elements	LM
◦ Pyritic Paleoplacer Gold + uranium	L
◦ Iron-Rich Sedimentary Strata	L
◦ Volcanic-Associated Massive Sulphide	L
◦ Clastic Sediment-Hosted Gold	L
◦ Ultramafic-Associated Asbestos	VL
Domain 1B, Disrupted Supracrustal Rocks	
◦ All of the above Au, Cu, Ni, Zn, PGE:	LM
Domain 2, Grey Gneiss	
◦ NIL	VL
Domain 3A, Laughland Lake Anorthosite	
◦ Minerals for Collecting (Piedmontite)	H
◦ Gabbroid-Associated Ni, Cu and PGE	MH
◦ Stratiform Mafic/Ultramafic-Hosted Chromite	LM
Domain 3B, Foliated Porphyritic Granite	
◦ Intrusion-Associated Vein Gold	LM
Domain 4, Penrhyn Group	
◦ Sediment-Hosted Zinc + Lead + Silver	LM
◦ Sediment-Hosted Zinc + Platinum Elements	LM
Domain 5, Paleoproterozoic Plutons	
◦ Skarn Tungsten, Lead, Zinc, Silver	LM
◦ Porphyry Cu, Mo, Tin, Tungsten, Rare Metals	L
Domain 6, High Strain Zones	
◦ Intrusion-Associated Vein Gold	LM
◦ Cu, Ni, PGE (in Daly Bay Complex)	LM
Domain 7A, Undivided Paleozoic strata on White & Southampton islands	
◦ Carbonate-Hosted Zinc + Lead	M
Domain 7B, Oil Shales on Southampton Island	
◦ oil shale	H
Domain 7C, Wager Bay marine area	
◦ Fluid hydrocarbons	LM
All Domains	
◦ Diamondiferous kimberlites	M

Table 2. Mineral and hydrocarbon potential rating categories (after Jackson and Sangster, 1987 and Scoates et al., 1986), based on the applicability of deposit-type[1] models (e.g. Eckstrand, 1984a) to the geology, mineral occurrences and sparse geochemistry of domains.

Potential		Criteria
VH	Very High	- Geologic environment very favourable - Significant deposits[1] are known - Presence of undiscovered deposits very likely
H	High	- Geologic environment very favourable - Occurrences[2] are known - Presence of undiscovered deposits likely
MH	Moderate to High	- Intermediate between moderate & high - Reflects greater uncertainty due to less data
M	Moderate	- Geologic environment favourable - Occurrences may or may not be known - Presence of undiscovered deposits permissible
LM	Low to Moderate	- Intermediate between low and moderate - Reflects greater uncertainty due to fewer data
L	Low	- Some geological criteria favourable but limited - Few occurrences may or may not be known - Presence of undiscovered deposits unlikely
VL	Very Low	- Geologic environment unfavourable - No occurrences known - Presence of undiscovered deposits very unlikely

1 "Deposit": a non-renewable resource of developable size and grade.
2 "Occurrence": a drilled or exposed non-renewable resource that may or may not be part of a hidden deposit.

Table 3. Geological units[3] / assessment domains[4], Figure 2.

Q[3]	NA[4]	Quaternary: thick glacial drift cover
OSo	7B	Area shallowly underlain by oil shales
W	7C	Marine water bodies, including Wager Bay
OSs	7A	Ordovician and Silurian platformal strata
MM	NA	Mesoproterozoic Mackenzie dykes
MT	NA	Mesoproterozoic Thelon Formation
Ps	6	Paleoproterozoic shear zones
Pgy	5	Paleoproterozoic granitic and syenitic rocks
Pb	4	Paleoproterozoic mafic & supracrustal rocks
A'g	3B	Archean/Paleoproterozoic granitic rocks
A'b	3B	Archean/Paleoproterozoic diorite and gabbro
Ag	3B	Archean granitic rocks
Aab	3A	Archean foliated anorthosite and gabbro
A'gs	2	Archean/Paleoproterozoic granitic/mixed gneiss
Ags	2	Archean granitic and mixed gneiss
A's	1B	Archean/Paleoproterozoic disrupted supracrustals
AP	1A	Archean Prince Albert Group supracrustal rocks (1A includes Woodburn & Ketyet groups)
Aus	1A	Archean unsubdivided supracrustal rocks (1A includes these rocks as well)
UM	NA	Areas where geology not compiled for this report

3,4 Sources & explanations in Fig. 2 (order differs) & text.

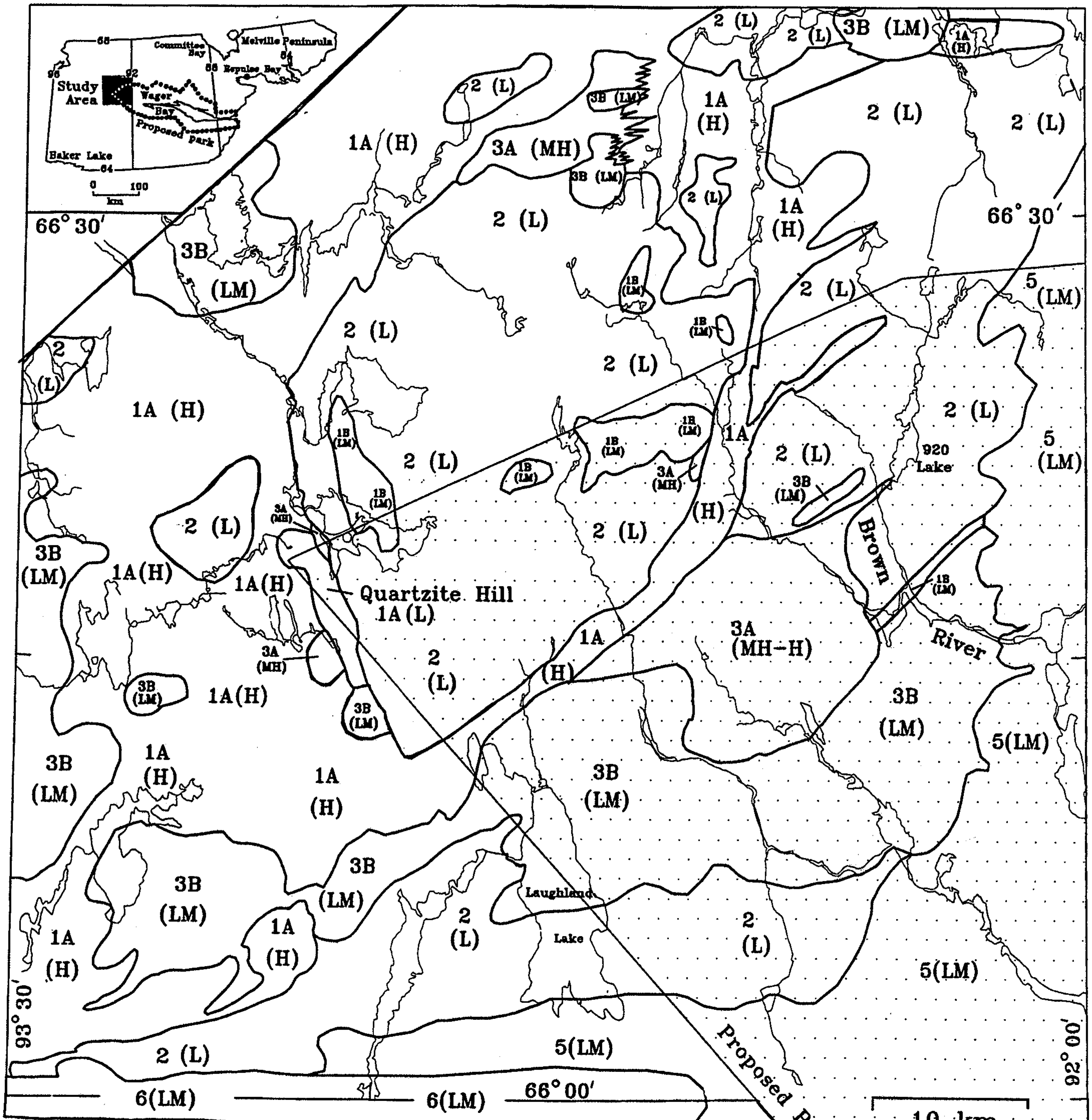
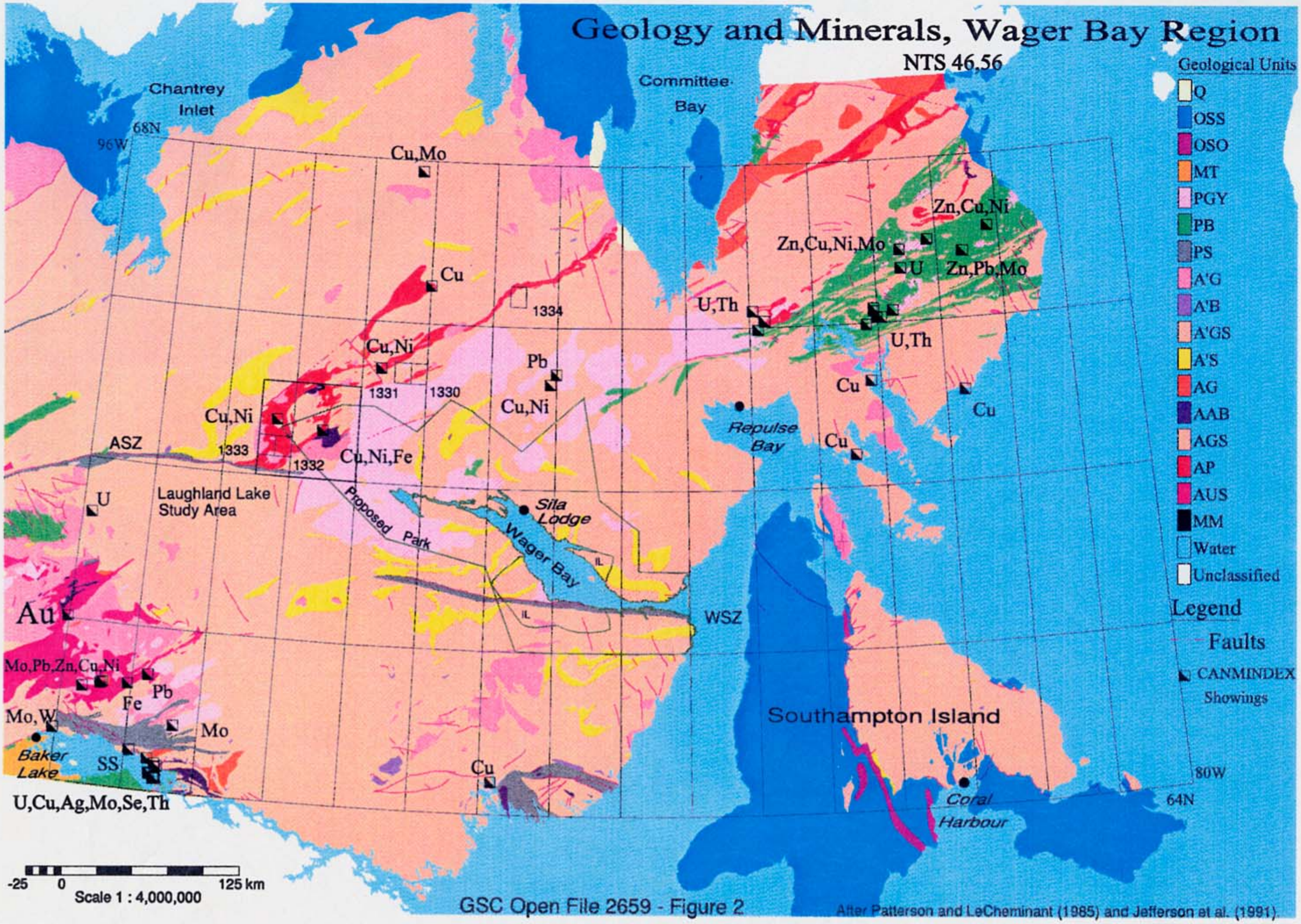


Figure 1. Summary mineral potential of the Laughland Lake area. Domains (1 to 6) and ratings (L to H) are explained in tables 1, 2. Inset shows context in Wager Bay region. The mineral and energy potential of areas surrounding Wager Bay were assessed by Jefferson et al. (1991). In the event of park establishment, provision has been made for potential access corridors to Wager Bay tidewater from the hinterland, subject to environmental assessment, legislation and regulations, and public consultations. Access through Inuit Settlement Land (IL on Fig. 2) would be subject to negotiation with the local communities.


Geology and Minerals, Wager Bay Region
NTS 46,56
Geological Units
Q
OSS
OSO
MT
PGY
PB
PS
A'G
A'B
A'GS
A'S
AG
AAB
AGS
AP
AUS
MM
Water
Unclassified
Legend
Faults
CANMINDEX Showings
Chantrey Inlet
Committee Bay
68N
96W
80W
64N
Cu,Mo
Cu
1334
Cu,Ni
1331
1330
Pb
Cu,Ni
Cu,Ni
1333
1332
Cu,Ni,Fe
ASZ
U
Laughland Lake Study Area
Proposed Park
Sila Lodge
Wager Bay
IL
WSZ
Repulse Bay
U,Th
Zn,Cu,Ni,Mo
U
Zn,Cu,Ni
Zn,Pb,Mo
U,Th
Cu
Cu
Cu
Southampton Island
Coral Harbour
Au
Mo,Pb,Zn,Cu,Ni
Fe
Pb
Mo,W
Mo
Baker Lake
SS
U,Cu,Ag,Mo,Se,Th
Cu
-25 0 125 km
Scale 1 : 4,000,000
GSC Open File 2659 - Figure 2
After Patterson and LeCheminant (1985) and Jefferson et al. (1991)

INTRODUCTION

MERA Terms of Reference

The Mineral and Energy Resource Assessment (MERA) process in northern Canada has been described by Sangster (1983), Scoates et al. (1986) and continues to evolve (Jefferson 1992). The purposes of Mineral and Energy[1] Resource Assessment (MERA) are:

(1) to ensure that the economic and strategic significance of mineral and non-renewable energy resource potential is duly considered in the national park establishment process in the Yukon and Northwest Territories;

(2) to ensure that, in making recommendations regarding the withdrawal of land for parks purposes, the Minister of Indian Affairs and Northern Development is advised on the balance between the values of the land with respect to park establishment criteria and the potential for the exploration, development and use of mineral and energy resources which may inhere in the land;

(3) to prepare an assessment of the mineral and energy resource potential of areas in the Yukon and Northwest Territories which are being considered for administration as national parks.

The first and second purposes are fulfilled by the Senior MERA Committee - the Assistant Deputy Ministers or Deputy Ministers of:

° Indian and Northern Affairs Canada (Chair)
° Environment Canada, Parks Service, Environment Canada
° Mineral Policy Sector, EMR
° Geological Survey of Canada, EMR
° Appropriate agency, Yukon Government
° Appropriate agency, NWT Government.

A parallel MERA Working Group is directed by the Senior MERA Committee.

This Open File was prepared to fulfil the third purpose. The park establishment process includes on-going public and internal government consultations at local, community, territorial and national levels. The MERA results presented herein will contribute to the public information base for consultations on the proposed Wager Bay national park. Any criticisms or additional information are welcomed by the first author and the MERA committees.

History of Wager Bay MERA Studies

Parks Canada (1978) first outlined an oval shaped study area centred on the head of Wager Bay (Figs. 1, 2). Additional planning led to a MERA survey of a terrestrial area east of 92° and between 64° and 66°40' N by Jefferson et al. (1991), who assessed moderate to low potential for metallic minerals in Archean tonalitic and supracrustal gneisses, and high potential for oil shales in lower Paleozoic strata of Southampton Island. Continuing studies by Environment Canada, Parks Service have suggested including the headwaters of the Brown River west of 92° (Laughland Lake Area, Fig. 1) and the marine waters of Wager Bay. MERA field and laboratory studies for the Laughland Lake Area began in 1991 (Jefferson and Schau, 1992; Chandler et al., 1993) and are concluded in this report.

Physiography and Climate

The Laughland Lake area is typical of above-treeline tundra in the continuous permafrost zone of northeastern continental Canada: a rolling peneplain transected by linear eskers, with undulating poorly drained uplands, broad boulder plains and gentle, marshy river valleys. Rivers are torrential in June, taper to trickles through August, and freeze solid in winter. Barren sand exposed along rivers and eskers is driven southeasterly by winter winds.

The Wager Bay area is a relatively warm marine arctic oasis, bordered by highlands to the west and south, gently sloping terrain to the north, and connected by a polynya[2] to Roes Welcome Sound on the east. The Ford Lake area to the northwest has rugged domal topography drained by U-shaped valleys containing lakes dammed by moraines, suggesting mountain glaciation. Southern and southwestern shorelines of Wager Bay are relatively steep, and waters deepen rapidly offshore around Wager Bay. Tides are strong and range from 10 to 20 metres, creating a polynya at the mouth of Wager Bay and reversing falls at the outlet of brackish Ford Lake. Marine currents flow clockwise, bringing broken ice and associated marine mammals westerly along the south shore during July breakup.

Access and Infrastructure

The Wager Bay region is very remote, poorly known, and has very expensive logistics away from tidewater. The nearest communities in this part of Nunavut are located some distance from central Wager Bay: Repulse Bay (180 km), Coral Harbour (310 km), Chesterfield Inlet (200 km), Rankin Inlet (320 km) and Baker Lake (350 km). The historic Wager Bay post is a previous Hudson Bay trading post, located on a deep northern inlet of tidal Ford Lake. An improved raised beach (?wave-washed esker) at privately owned Sila Lodge on the north side of Wager Bay provides year-around air access, as do a raised beach south of Paliak Islands, and rare flat-topped eskers inland. Winter and early spring access is possible in many localities by snow vehicles and ski-equipped aircraft.

The Laughland Lake study area (Fig. 3; NTS map sheet 56K SE) lies about 200 km north-west of the head of Wager Bay (see Figure 1). Access to this remote location was facilitated by twin otter aircraft from Baker Lake and Rankin Inlet and by helicopter also from Rankin Inlet. Overland access from Wager Bay is by snow machine in winter. In the event that a national park is established surrounding Wager Bay, provision has been made for potential access corridors to Wager Bay tidewater, subject to environmental assessment, legislation and regulations, and public consultations. Access through Inuit Settlement Land (IL on Fig. 2) would be subject to negotiation with the local communities.

The base camp was set up just southeast of 920 Lake (UTM 531541E, 7358606N), with twin otter access to a flat-topped esker at UTM 530643E, 7362858N. The Central, Western and Southwestern areas were accessed by helicopter and on foot from fly camps.

Previous Work

Previous work for the region east of 92° is summarized by Jefferson et al. (1991) who indicated moderate to low potential for metallic minerals in highly deformed and metamorphosed Archean tonalitic and supracrustal gneisses which are transected by the Wager Shear Zone (Henderson et al., 1986, 1991b; Henderson and Broome, 1990; Broome, 1990; LeCheminant et al., 1987) and high potential for oil shales in lower Paleozoic strata on Southampton Island.

The bathymetry of Wager Bay has only been surveyed by a single line of soundings from its mouth to Douglas Harbour. The Arctic Pilot, a book published by the Department of Fisheries and Oceans, indicates deep water throughout most of the Bay (Ian Marr, Canadian Coastguard, pers. comm., 1991). The seabed is unstudied.

In the Laughland Lake area, little bedrock mapping predates this assessment, since the 1:1,000,000-scale reconnaissance by Heywood (1961), notes on the geology and mineral potential by Schau (1974, 1975a, 1975b, 1977) and Eckstrand (1975), and the Bulletin with 1:250,000 map by Schau (1982).

Studies of similar rocks in the Woodburn Group (Henderson et al., 1991a), Mary River Group and Piling Group in northern Baffin Island (Jackson, in press), and around Wager Bay (references in Jefferson et al., 1991) have aided our understanding of the bedrock in the Laughland Lake area.

The surficial geology of the Laughland Lake area has been mapped by Thomas and Dyke (1981). The glacial features they mapped indicate north northwesterly directions of both paleo-ice flow and paleo-drainage. They also mapped fluviodeltaic patterns that entered the Brown River valley from the southwest.

An extensive surficial geochemical reconnaissance survey for the Polar Gas Pipeline Project (unpublished maps by A. Dyke and W.W. Shilts) suggests relatively high copper, cobalt, nickel and zinc in the southeast and northwestern corners of the Laughland Lake map area, but the lone three samples in the Laughland Lake area are too widely spaced and the analytical data insufficiently registered against modern standards to be incorporated in this study. The History of Exploration is summarized in the chapter on ASSESSMENT OF MINERAL AND ENERGY RESOURCE POTENTIAL.

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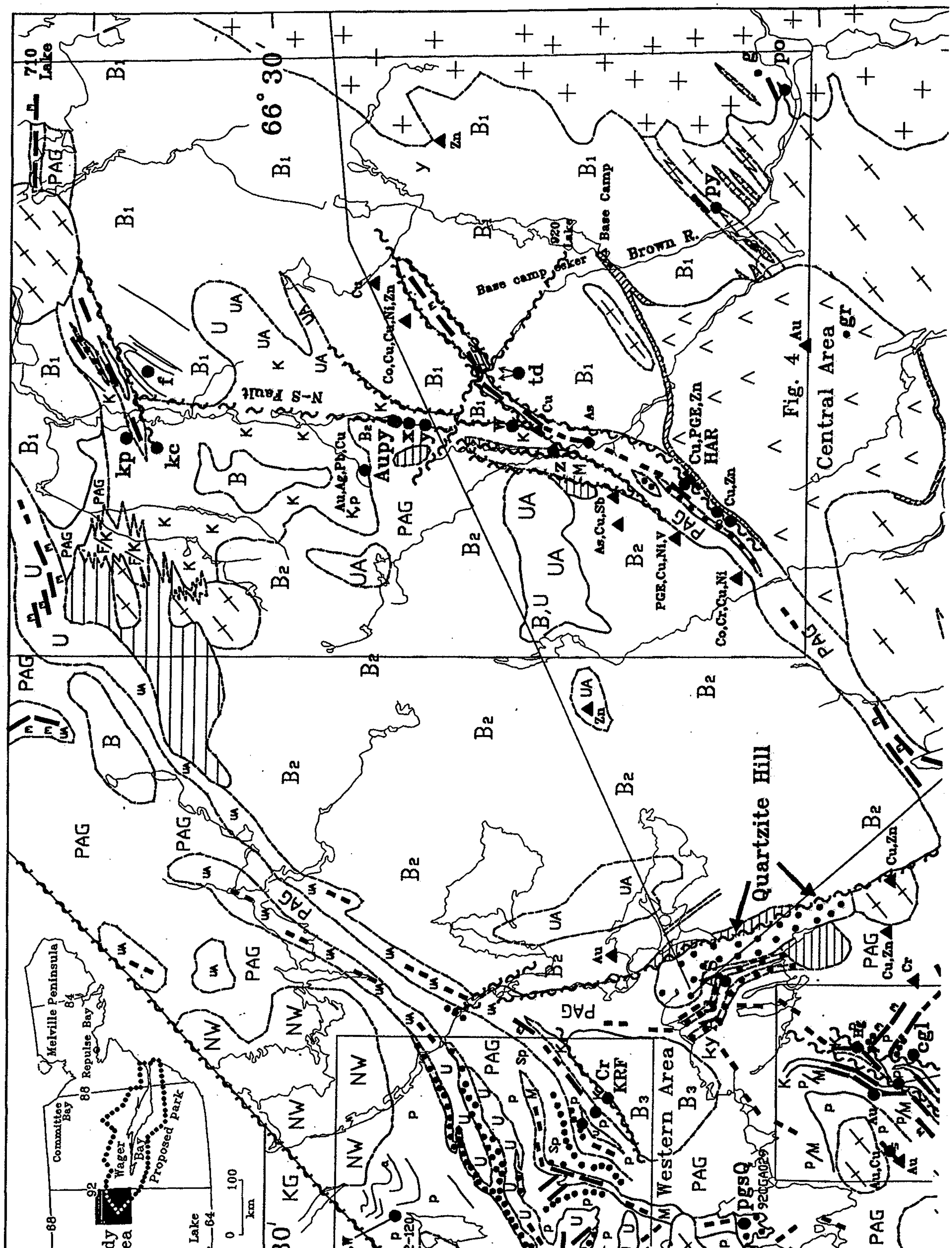
[1]Throughout this report the term "energy" refers to non-renewable energy. Hydroelectric power is dealt with on a case-by case basis by the Senior MERA Committee.

[2]A polynya is a tidal channel that maintains open water all year in otherwise seasonally frozen waters.

Fig. 3 N


Study Area
Baker Lake
Wager Bay
Proposed Park
Committee Bay
Repulse Bay
Melville Peninsula
66° 30'
710 Lake
920 Lake
Base Camp
Base camp esker
Brown R.
N-S Fault
Fig. 4
Central Area
Western Area
Quartzite Hill
HAR
KRF

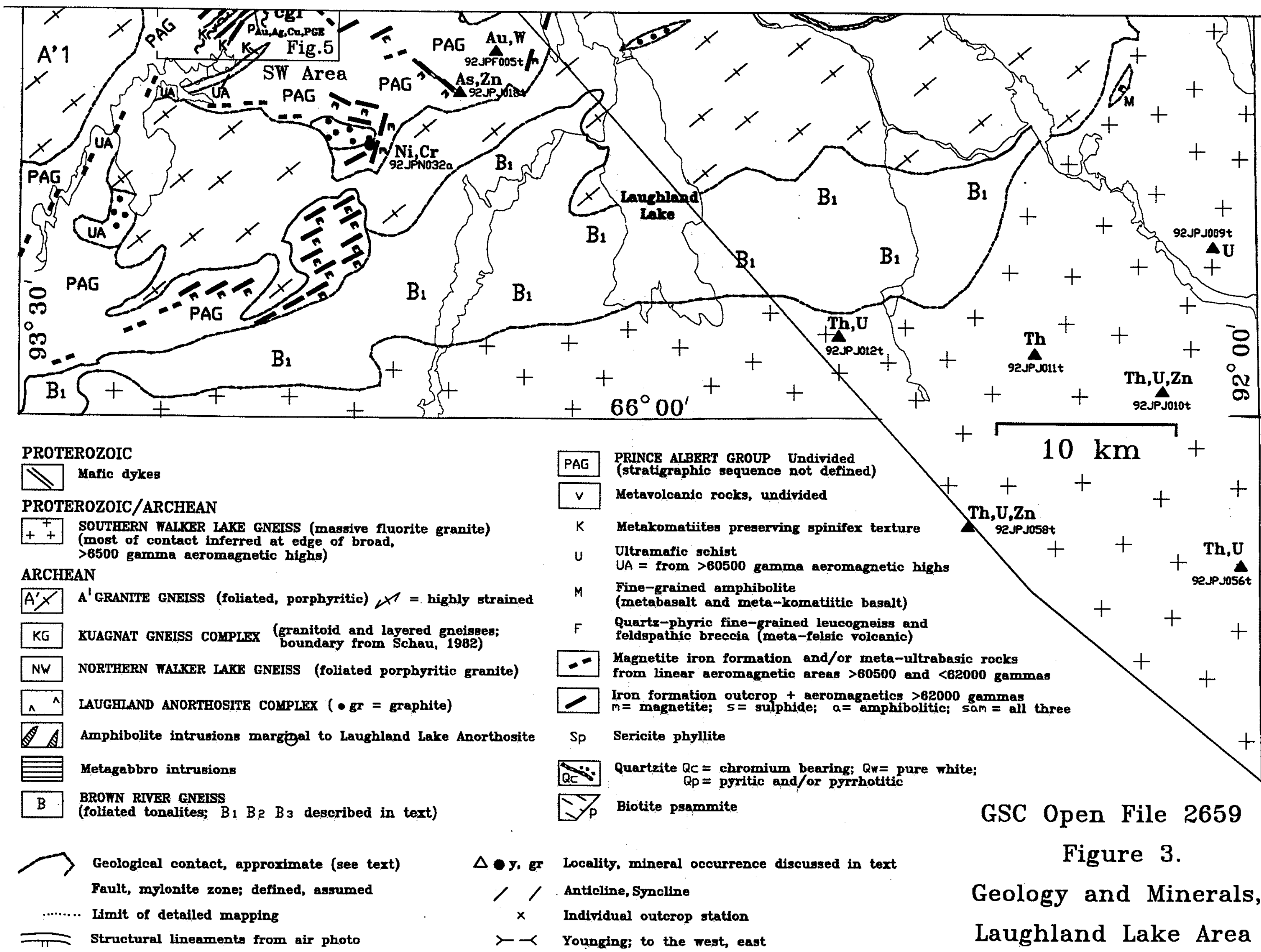


Figure 3S. Geological sketch map and selected elevated geochemical results of southeastern Laughland Lake map area. Most gneiss and granite contacts are interpreted from aeromagnetic data, with limited testing and corroboration by new outcrop data obtained for this study and incorporated from primary data of Schau (1982) and Heywood (1961). Descriptions of map units and their geophysical expression are provided in text. Labelled large dots are localities described in text, (e.g. Aupy = 160 ppb gold in sulphidic sheared tonalite). Boxes locate Figures 4, 5. Side legend applies also to Figs. 4, 5. Mineral abbreviations are explained in Appendix IV. Hydrography modified after digital data from Surveys and Mapping Sector of EMR.

Method of Assessment

The MERA method aims to upgrade the geoscience data base as much as possible with a view to applying mineral deposit analogues such as summarized by Eckstrand (1984a). The MERA committees decided that costs of marine sampling prohibited field study of Wager Bay, so that field work was concentrated on the mineral resource potential of the Laughland Lake area. The submarine geology and non-renewable resource potential of Wager Bay were determined by inference from local and regional geology.

The Laughland Lake project began with a review of available data (including interviewing previous workers) in 1991. Archived primary field data of Heywood (1961) and Schau (1982) were also added to the database. Two weeks of field studies in August 1991 (Jefferson and Schau, 1992) set up the logistical and geological framework for a 1:50,000-scale 1992 survey of 56K1, 56K2 and adjacent areas (Fig. 3; Chandler et al., 1993). The 1992 season was initially planned for two months but bad weather, logistical problems and limited funds restricted field work to one month.

During field work, geological units were investigated while keeping in mind the attributes of relevant mineral deposit types. Outcrops of each geological unit were described and sampled for lithogeochemistry, and prospected in areas of perceived high mineral potential (generally gossans). The limited time and less than 2 per cent outcrop led us to concentrate foot traverses in key areas which were either critical to the park proposal (the central komatiite belt and north-south fault zone) or provided sufficient outcrop to define map units (the southwestern area, quartzite hill and the western area) (Fig. 3). Remaining outcrops were accessed by helicopter during till and esker sampling. The komatiites were systematically sampled for petrochemical study by K.L.Fitzhenry as a B.Sc. thesis at Queens University.

Aeromagnetic data (Geological Survey of Canada, 1977, 1984a) were used a great deal to extrapolate map contacts by Jefferson et al. (1991) and Jefferson and Schau (1992). Such data were not available in the study area in the early 1970's although Schau (1975b) showed that the magnetic response of iron formation, metamorphosed ultramafic units and magnetite-bearing granites accounted for most of the magnetic pattern near Walker Lake (Fig. 2). The inferences made by Jefferson and Schau (1992) in the Laughland Lake area were vindicated by field tests in 1992, and aeromagnetic data were used further to extend and modify interpretations made from outcrop data during compilation of Fig. 3.

Iron formations in this area are characterized by linear extreme aeromagnetic highs (500 to 1500 gammas), flanked by extreme lows (-300 gammas). The komatiites correspond to moderate highs (50 to 250 gammas) flanked by lows, reflecting magnetite generated by breakdown of iron-bearing magnesian silicate minerals to low-grade metamorphic minerals such as serpentine. The magnetite in some flows affects the compass at ground level. Broad -300 gamma lows are not distinctive by themselves because they correspond variably to gneiss, pelite and quartzite. The NE structural trends of the magnetic patterns, parallel to measured gneissossities and compositional layering, lend credence to their use in regional mapping and are particularly useful in tracing PAG map units from upper greenschist metamorphic facies toward higher grade rocks along strike to the NE, especially beneath thick surficial deposits.

The surficial geochemical study was designed so that results could be compared directly with those of the previous survey by Smith (in Jefferson et al., 1991), while providing more detail commensurate with the bedrock mapping and sampling. Till geochemical samples were randomly distributed to provide unbiased regional coverage; in addition fences of till samples at 1-2 km spacing were positioned 1-3 km down-ice from belts of iron-formation and ultramafic rocks. Eskers were sampled in fences also, one across the southeast to monitor incoming sand, one across the centre, and one across the northwest (paleo-flow was southeast to northwest). Details of the analytical method are provided in the TILL GEOCHEMISTRY chapter. Till geochemical results provided supplemental information on inferred bedrock composition, as well as on mineral potential.

Field data were compiled in Fieldlog version 2.83 (Brodarick and Fyson, 1989) on 486 notebook computers at the base camp. Data were either entered directly from hand-written notes, or uploaded from specially formatted digital files which were typed at each outcrop into hand-held computers (Struik et al., 1991). Digital hydrography was purchased from Surveys and Mapping Sector of EMR and formed the base in AutoCAD to which station information was registered by means of Fieldlog. Geological sketch maps on air photographs and selected aeromagnetic contours were manually digitized in AutoCAD and registered to the hydrography by means of UTM coordinates marked on the air photographs. Further interpretations of the data and the maps presented here were made in AutoCAD. Summary station data, and the results for geochemically analysed samples, were manipulated in FoxPRO and are tabulated in Appendices I and II.

Rock types are listed in the legend of Figure 3. Localities mentioned in the text are also shown in Figure 1 and some are repeated in appropriate detailed maps (Figs. 4, 5). The many geological units were grouped into 7 major domains in order to reduce the number of times each deposit type was applied to the geology. All data pertaining to each major geological domain were compared with analogues of mineral deposit types which have been found in other parts of Canada and the world. Based qualitatively on how many critical attributes of each deposit type are present in the domains, a mineral potential rating was assigned for relevant deposit types.

Confidence in this Assessment

The Laughland Lake part of this assessment is considered to be well within Phase 2, whereas the Wager Bay Marine part is unavoidably low in Phase 1 with respect to data available. Phase 1 assessment involves primarily literature research, whereas Phase 2 assessment involves collection of substantial amounts of new data by field work and subsequent laboratory analysis (Scoates et al., 1986).

Many of the conclusions here were reached by literature study and review, although new field data enhanced our understanding of the metallogenic history of the area. The geochemical sampling and prospecting done for this assessment were relatively intense compared to previous MERAs, particulary that to the east by Jefferson et al. (1991). Even though we consider our data base to be the best possible given the time and resources available to do the assessment, the data points are of variable density because of the large size and limited bedrock exposure of the study area.

The assessments presented herein are based on current knowledge of geology and mineral deposit types (e.g., Eckstrand, 1984a; Cox and Singer, 1986; Sheahan and Cherry , 1993). Some deposit types are more predictable based on quantitative geochemical and petrochemical study of large systems than others. For that reason, considerable relative geochemical and petrographic study in this assessment went toward the ultramafic - associated nickel-copper deposit type which, though complex, appears to be a result of some relatively well constrained broad scale magmatic processes that leave their mark throughout the beautifully crystallized rocks we call komatiites. Gold deposits on the other hand, were formed by a variety of much less constrained processes, operating in much smaller systems, if we are to judge by the lack of consensus on some of the larger deposits which are hosted by iron formations (see summary of opinions in Kerswill, in press). For that reason, much more effort went into documenting field relationships and lithogeochemical prospecting of potential host rocks (iron formations) than into reconnaissance petrographic studies. Many clues are known for gold deposits, but their application is much more subjective than for nickel-copper at the scale of this assessment.

As noted in Scoates et al. (1986) final assessments of resource potential cannot be made. Areas should be reassessed periodically as new data become available, as new concepts are developed, as new uses and extractive technologies are devised, and as the local and world economies change. Some of the areas that have little identifiable resource potential may contain new types of mineral deposits. Experience in the past decade of conducting resource assessments (e.g. Jefferson, 1992) has taught us that such new deposits (or known deposit types in new environments) may be recognizable and exploitable in the very near future, or well into the distant future.

Experience has shown that even superior geoscience databases in well explored and long-inhabited terrains of southern Canada and other parts of the world cannot be considered definitive. The Lisheen zinc-lead-silver deposit in south-central Ireland exemplifies this hidden nature of mineral resources. Ireland has been relatively densely inhabited for thousands of years, but the concept that an economically viable buried base metal deposit might be found here was only imagined in the 1960's, and the search for buried base-metal deposits of this type began in earnest only in 1984 (Hitzman, 1992).

The discovery of the Lisheen deposit came only after six more years of persistent and diverse exploration, including regional and detailed bedrock geology, soil geochemistry, a variety of sophisticated geophysical surveys, and diamond drilling which provided three-dimensional information. The explorers had been encouraged through this long process by the general similarity of the Lisheen geology to other areas which contain economic lead-zinc deposits, and by the presence of minor surface showings which are in the same class as the economic lead-zinc deposits. The data base in 1984 was similar to (although much more comprehensive and detailed) that which this study has established for the Laughland Lake area, and corresponds to the very high (VH) mineral potential on the standard MERA rating scheme which we use here (Table 2).

Subtle clues at Lisheen included a 75 metre-wide soil geochemical "anomaly" containing a mere 150 ppm zinc. Diamond drilling in the vicinity of this minute anomaly intersected strata and units recording hydrothermal alteration (a regional dolomite front within limestones, and local "black matrix breccia") which are very similar to those adjacent to known economic deposits in the same country. By comparison, our Laughland Lake geochemical survey was designed (within the time and dollar budget available) to detect regional-scale anomalies which might suggest favourablility for mineralization on a district scale, rather than to detect individual deposits. The odds of our till survey (greatest density 1 km spacing) intersecting a 75 metre-wide geochemical anomaly are very small.

Users of this study must keep in mind the element of temporal change and the scale of this study. The Laughland Lake study area is approximately 6,000 km^2 as is Wager Bay Marine area. The terrestrial area of the Wager Bay park proposal covers about 22,300 km^2. Because of the MERA process our published geoscience knowledge base of the Laughland Lake area is now as modern as that of the provinces, and far superior to that of adjacent areas in the NWT which were mapped more than 25 years ago by helicopter reconnaissance on eight-mile spacings. However, our density of observations is similar to that of the southern parts of the provinces about 90 years ago.

Information on the marine part of the Wager Bay park proposal is more limited than any MERA area to date. Published bathymetric information is a single line of soundings from the mouth of Wager Bay to Douglas Harbor, and the only data directly applicable to the marine area are aeromagnetic and gravity maps.

Local Factors Affecting Economic Potential

This report analyzes the mineral and hydrocarbon potential of a very remote area in Canada's Arctic. The resource potential was evaluated according to geological criteria which do not take into account numerous economic factors such as as politics, proximity to market, operating costs versus technology in the Arctic, and high northern salaries which are known to change dramatically over time.

Responsibilities of the Authors

The first author was responsible for designing and managing the project, compiling and producing this report and geological maps, interpreting the exploration geochemical data, and assessing the non-renewable resource potential.

F.W. Chandler led the mapping in 1992, was responsible for the geology of the southwestern and western areas, and shared with C.W. Jefferson the coverage of quartzarenites for their paleoplacer gold and uranium potential, coverage of iron formations for their depositional environment and gold potential, and the geological history of the Prince Albert Group.

L.J. Hulbert provided advice on assessments of nickel, copper and platinum-group-elements, and supervised petrochemical research on the Laughland Lake komatiites by K.L. Fitzhenry, who provided most of the text and figures thereon.

J.E.M. Smith planned, conducted and compiled the results of the surficial geochemical survey.

K. Powis maintained the Geof-Fieldlog-Autocad data base, produced the tables and maps of geochemical results, and assisted in digitally producing geological maps.

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Polar Continental Shelf Project contributed significant helicopter support in 1991 and 1992; aircrew G. Fawcett and L. Voll provided reliable service. E. Seale of Environment Canada, Parks Service collaborated with logistics and joined us on traverse. Baker Lake Lodge provided logistical coordination and radio communication in 1991 and 1992; M. Tatty in 1992. GSC administrative staff G. Allen, P. Kochan, L. White and B. Rankin, and Supply and Services Canada efficiently implemented contract logistics; J. Angotingoar and W. Crawford reliably emplaced fuel in 1991.

Logistics were enhanced by coordination with E. Seale (Environment Canada, Parks Service) in 1991 and 1992; and by J. Hicks (Sila Lodge), S. Tella, and R.A. Olson Consulting in 1992. B. Wentzell of Aero Arctic provided excellent piloting. G. Joanasie assisted cheerfully in the field, and Mark Samborski capably assisted in the final production of this report.

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R. Lancaster provided technical advice and with P. Belanger expedited processing of rock samples and analyses. Management and staff of Analytical Chemistry Subdivision provided rapid, high quality analyses of critical samples for petrochemical studies. Electron microprobing, scanning electron microscopy and advice by D. Harris and D. Walker improved our understanding of gold in the quartzarenites.

The following people helped with the surficial geochemical part of this assessment: P. Lindsay in advising on methodology and expediting contract analyses; W.A. Spirito (GSC), L. McCormack and E. Smith (Ontario Ministry of Environment) in statistical treatment of data; A. Roy and G. Myslik (Ontario Ministry of Environment) for allowing J.E.M. Smith flexible work hours to complete her contract on this project while undertaking new work at OME; D. Paré (Consorminex) for quick and reliable separation and preliminary identification of heavy minerals from esker sands, and J. Stirling (GSC) for probing the heavy minerals.

Mikkel Schau introduced us to the geology of the Laughland Lake area and computer mapping, and collaborated in 1991 mapping with CWJ. He contributed many ideas, his original unpublished field data from mapping in the 1960's, and shared responsibility for the geology and mineral potential of the Laughland Lake Anorthosite.

O.R. Eckstrand provided guidance on ultramafic rocks, notes on his earlier work in the area, and advice on the mineral potential. Thoughtful reviews by S. Tella, G.D. Jackson and W.D. Sinclair of earlier manuscripts contributed to our interpretation of the data.

S.M. Roscoe was keenly interested in the potential of the quartzarenites to host paleoplacer gold and uranium deposits. He had originally planned to join us to test this potential, however other priorities prevented his participation in the field. His continued interest and advice strongly encouraged, and was vindicated by, our discovery of elevated gold in pyritic quartzarenite at the base of Quartzite Hill.

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REGIONAL GEOLOGICAL DOMAINS FOR RESOURCE ASSESSMENT

Jefferson et al. (1991, Open File 2351) defined seven regional geological domains for resource assessment purposes. These domains are retained (except 2 and 3 are switched) and subdivided for this assessment in order to present geological entities in approximate age sequence and to make the format of this report compatible with that of Open File 2351. These domains are listed in Tables 1 and 3, outlined in Figures 1 and 2, and summarized below. Full summaries are provided for regional domains relevant to this MERA of the Laughland Lake and Wager Bay Marine areas; the reader is directed to Open File 2351 and references therein for fuller descriptions of the other domains. Letters in brackets in the following titles are cross-referenced to Figure 2 and Table 3.

Domain 1, Archean Supracrustal Rocks (AP, Aus, A's)

Domain 1 of Jefferson et al. (1991) (Disrupted Supracrustal Rocks) is here renamed and divided into two sub-domains. Domain 1A comprises relatively well preserved Archean supracrustal rocks that form coherent, contiguous belts, such as Prince Albert Group, Woodburn Group and Chantrey Group. Domain 1B is the previous Domain 1: Disrupted Supracrustal Rocks of inferred Archean age.

Domain 1A, Prince Albert Group (AP, PAG) *and Related Archean Supracrustal Rocks* (Aus)

The Prince Albert Group (PAG) is an Archean assemblage of supracrustal rocks, areally dominated by psammites and including phyllites, pelites, quartzites, iron formations and metavolcanic rocks. Komatiites, ultramafic schists and layered to massive amphibolites (metabasalts) constitute <10% of the PAG, but dominate in specific complexes and linear belts paired with quartzites and iron formations (examples under **Structural Geology** in ROCK UNITS, LAUGHLAND LAKE AREA). Intermediate volcanic rocks are unknown and felsic volcanic rocks minor in abundance (rare in the Laughland Lake area).

The PAG was defined and regionally mapped by Heywood (1967) and its various component belts have been mapped and described by Frisch (1982), Frisch et al. (1985), Schau (1982) and Henderson (1983). The PAG extends at least 500 km northeast from the Amer Shear Zone (part of Domain 6A) to the northern coast of Melville Peninsula. The PAG underlies a single contiguous area in the Laughland Lake map sheet; to the northeast the PAG forms a number of narrow linear belts which are separated by gneisses and have an across-strike breadth of more than 100 km. The PAG is tectonic (and stratigraphic?) basement to and structurally interleaved with the Penhryn Group (Henderson, 1983) on Melville Peninsula.

Schau (1978) reported an Archean age of acid volcanic rocks in the PAG on Melville Peninsula, and argued that the main deformation and prograde metamorphism (from greenschist to upper amphibolite facies) were also Archean. He noted local prograde metamorphism around small plutons; and attributed the regional greenschist facies retrograde metamorphism to Paleoproterozoic extensional tectonism.

The intensities of metamorphism and deformation are low enough to permit reliable measurement of sections in only a few areas such as the psammite section measured by F.W. Chandler southwest of the Laughland Lake study area (Fig. 3). Detailed mapping in the Laughland Lake area (Fig. 3) has shown that most exposures are structurally repeated, although part of the previously measured section recorded NW of Laughland Lake by Schau (1982, table 4) may be homoclinal. Cross-sectional sequences described in Schau (1978 and 1982) nevertheless provide good indications of lithological proportions in the PAG.

The PAG has been inferred by Schau and Ashton (1988) to be stratigraphically equivalent to Archean supracrustal rocks around Baker Lake which have been informally named Woodburn Lake group (Ashton, 1982), Woodburn group (Henderson et al., 1991a), and Ketyet River group (Schau et al., 1982; Schau, 1983). Current informal usage appears to favour the term Woodburn group, which will be used for further references in this report. Ashton (1988) determined a 2621 Ma U-Pb zircon are for unfoliated granite that intrudes the Woodburn group near what Ashton (1982) informally labelled Pipedream Lake. The Woodburn group, as summarized by Henderson et al. (1991a), appears to contain all of the rock types of a typical Archean greenstone-greywacke belt in Slave or Superior Provinces, plus the subordinate but extensive komatiites and quartzites that typify the Prince Albert Group.

The Woodburn group is complexly deformed, and the complete stratigraphy is uncertain because of structural repetitions (both documented and suspected) (ibid.), and incomplete exposures. The general lithologic sequence presented by Henderson et al. is as follows: basal intermediate volcanic rocks, conformably overlying thick-bedded psammitic greywacke, spinifex-textured komatiites, pillowed metabasalts, quartzite, felsic volcanic rocks and, in a number of stratigraphic positions, magnetite-quartz iron formation with lesser silicate and sulphide iron formation. Annesley (1989) has observed the same rock units, but has interpreted the quartzarenites as the youngest, and the ultamafics as among the oldest in the area. Ashton (1982) had previously interpreted the quartzarenites as the oldest unit. Regardless of relative ages, the close stratigraphic and structural association of iron formation with ultramafic rocks in both groups is considered an important feature for the purposes of this resource assessment.

Other strata included in Domain 1A for assessment purposes are the Chantrey Group (A'c) and parts of other uncorrelated but mappable supracrustal rocks (A'sv, A'q, A's and A'v) of Patterson and LeCheminant (1985).

Domain 1B, Disrupted Supracrustal Rocks (A's)

Domain 1B comprises variously shaped areas characterized by the presence of 10 to 30% highly metamorphosed, attenuated and disrupted supracrustal gneisses, interlayered with granitoid gneisses. The supracrustal rock domain includes the Paliak Belt and other similar but less well documented belts around Wager Bay (Jefferson et al., 1991), and other uncorrelated but mappable supracrustal rocks (A'sv, A'q, A's and A'v) of Patterson and LeCheminant (1985).

Domain 1B includes many of the same lithologic components as, and may be equivalent to, the Prince Albert Group (PAG) (this study) and Woodburn group (e.g. Henderson et al., 1991a), but the disrupted supracrustal rocks are treated as a separate sub-domain because they form much narrower and more intensely deformed map units which are well separated by, and small in proportion to, the enclosing gneisses. One reason to believe that the disrupted supracrustal rocks are remnants of PAG, is that apophyses of supracrustal rocks extend continuously into the grey gneisses of Domain 3 northeast from the Laughland Lake area, and the metamorphic grade northeast of that area reaches upper amphibolite grade, including much migmatite. Fraser (1988) has shown similar interfaces northeast of the Woodburn group. Metasedimentary rocks in the areas of migmatite are very difficult to distinguish from gneisses of granitic parentage, and only the ultramafic, iron formation and quartzitic rocks are readily mapped as PAG. Around Wager Bay, extensive biotite gneisses are interpreted as being metasedimentary and placed in Domain 1B mainly because they have garnet-rich portions and they are spatially associated with quartzite, iron formation, amphibolite and ultramafic schist.

Domain 2, Grey Gneiss (Ags; includes Brown River Gneiss)

Domain 2 is the former Domain 3 of Jefferson et al. (1991). It has very wide regional distribution and includes mainly grey weathering, banded, biotite granitic to tonalitic gneiss in a variety of metamorphic grades (mainly amphibolite, but also large areas of granulite grade), and is typical of orthogneiss from many Archean terranes. The grey gneiss around Wager Bay is injected by minor to major anastamosing sheets mainly of foliated granite (part of Domain 3C), aplite and pegmatite. The grey gneiss contains numerous lenses and boudins of supracrustal rocks on scales up to km.

Parts of the grey gneiss are inferred to predate the supracrustal rocks of Domain 1; Schau (1975b, 1978) argued that the granitoid gneisses which border the PAG are older, because they are amphibolite grade whereas the PAG ranges as low as greenschist in the Laughland Lake region. Other parts of the grey gneiss (foliated tonalite) are known to post-date the Archean supracrustal rocks (Chandler et al., 1993). The metamorphic and relative age distinctions are lost in regions such as north of Walker Lake and north of Woodburn Lake because both gneiss and supracrustal rocks have been metamorphosed to upper amphibolite (Schau, 1978) and granulite (Fraser, 1988) grades respectively.

For assessment purposes, Domain 2 includes the unassigned Archean/Paleoproterozoic gneisses (A'gs of Patterson and LeCheminant (1985).

Domain 3, Foliated Crystalline Rocks (Ag, Aab)

Foliated crystalline rocks cross-cut the grey gneisses. Domain 3 (modified after Domain 2 of Jefferson et. al., 1991) is here subdivided into 3A (Foliated Anorthosite), 3B (Foliated Porphyritic Granite), and 3C (Foliated Equigranular Granite). Locally abundant pegmatites also cut the supracrustal rocks, grey gneiss and foliated granite, but form pods and dykes too small and separated to constitute a regional domain.

***Domain 3A, Laughland Lake Anorthosite* (ʌ) *and Gabbro* (Aab)**

The Laughland Lake Anorthosite, a slightly flattened 12 x 20 km plug located halfway between Laughland and 920 lakes (Fig. 3), is the only part of the Wager Bay region where anorthosite forms a large enough body to warrant separation into Domain 3A. The deformed gabbro plugs in the same vicinity are also included in Domain 3A. Other anorthosites and gabbros are either not divided from the backround grey gneisses because of scale, or are included in other domains because of their tectonic associations (e.g. anorthosites of the Daly Bay and Kramanituar complexes remain in Domain 6B).

***Domain 3B, Archean/Paleoproterozoic Foliated Porphyritic Granite* (A'g)**

Domain 6B is the regional A' granite (unassigned Archean or Paleoproterozoic) unit of Patterson and LeCheminant (1985). Schau (1982) and Jefferson and Schau (1992) noted that the A' granites in the Laughland Lake area are foliated and K-feldspar-phyric, contain foliation-parallel xenoliths of Brown River Gneiss and supracrustal remnants, and dip under and intrude the amphibolite border of the Laughland Lake Anorthosite. The name A' has been used by regional mappers in the northeastern District of Keewatin (as summarized by Patterson and LeCheminant, 1985) for granites of uncertain age, which may be Paleproterozoic (Aphebian) or Archean. The granitic rocks that belong to this domain are widely distributed in the Quoich River 1:1,000,000 map sheet, but were grouped in with the gneisses of Domain 2 (former Domain 3) for the regional assessment by Jefferson et al. (1991). Domain 3B is thus applicable only to this relatively detailed MERA of the Laughland Lake 1:250,000 sheet.

***Domain 3C, Foliated Equigranular Granite* (A'g)**

Domain 3C is the former Domain 2 of Jefferson et al. (1991). It includes widely distributed (Fig. 2) granitic gneisses which may or may not form circular plutons but lack expression on aeromagnetic maps and do not have any characteristic anomalies in till or lithogeochemical samples. Southwest of Paliak Islands, it also includes sheets of granite to quartz diorite which are salmon pink to white, well foliated, moderately magnetic and moderately radioactive. These gneisses are spatially associated with the disrupted supracrustal rocks of Domain 1B.

Domain 4, Paleoproterozoic (Aphebian) Strata and Mafic Intrusions (Pb)

Domain 4 (Fig. 2) includes a variety of Paleoproterozoic rocks around Baker Lake (Amer Group, Pitz Formation, etc.) and a southwest-tapering wedge of allochthonous (structurally emplaced) metasedimentary rocks of the Penhryn Group which have been described by Henderson (1983) on Melville Peninsula and extended into the Ford Lake area by Jefferson et al (1991). These strata are intruded by Ca 1825 Ma plutons (e.g. north of Ford Lake; LeCheminant et al., 1987).

In an effort to simplify the number of classes for computer generation of Figure 2, Domain 4 was broadened to include diorite, gabbro and ultramafic rocks of Paleoproterozoic age.

Domain 5, Paleoproterozoic (Aphebian) Plutons (+; Pgy)

Domain 5 has been locally referred to south of Wager Bay as "Fluorite Granite" and "Base Camp Granite" (Henderson et al., 1991b), northwest of Wager Bay as "Ford Lake Plutonic Complex" (LeCheminant et al., 1987), and in the eastern part of the Laughland Lake area as "Southern Walker Lake Gneiss". Grouping of these granitic rocks into one domain does not necessarily indicate contemporaneity, however they are broadly similar in lithology and assumed intrinsic mineral potential. Further description of this domain and its contact relationships is provided under ROCK UNITS, LAUGHLAND LAKE AREA.

Domain 6, High Strain Zones (Ps)

Domain 6 includes two types of geological entities which at first consideration may seem disparate, but which appear to be temporally and may be tectonically related: 6A, regional scale dextral shear zones (commonly mylonitic gneiss) and 6B, anorthosite and ultramafic complexes which have been tectonically emplaced from the southwest and rest on gently southerly dipping mylonite zones (e.g. the Daly Bay and Kramanituar complexes; along trend between these, A.N. Lecheminant is investigating eclogitic samples collected during helicopter reconnaissance mapping in the 1960's).

***Domain 6A, Wager and Related Shear Zones* (Ps)**

The Wager shear zone (Henderson and Broome 1990) is a linear feature separating and cross-cutting some domains. This prominent east-west shear zone delimits the southern margin of Wager Bay and extends across much of the study area (WZS, Fig. 2). It is at least 25 km wide, and is developed in supracrustal rocks as well as pink-and-grey gneisses and foliated granite. Henderson and Broome (1990) have documented the right-lateral ductile strain recorded by this shear zone.

The Base Camp granite (Henderson and Broome, 1990), the I-type pluton (Domain 5) south of Paliak Islands, is intercalated with the gneisses of domains 1 and 3 on its margins, and is structurally isotropic except along its southern margin where it is cut by the Wager Shear Zone. Zircons from the granite were dated by the U-Pb method at 1808 +/- 2 Ma by Henderson and Roddick (1990). This age is considered a maximum for the Wager Shear Zone, because the granite is mylonitized and drawn out into a central straight part of the shear zone. Parts of this granite also intrude as massive-textured concordant wedges into sheared gneiss in the outer, northern side of the shear zone, suggesting that the intrusion of the granite took place during shearing.

The Amer Shear Zone (also Amer Mylonite Zone and Amer Lake Shear Zone) is similar to the Wager Shear Zone in its fabric, metamorphic grade and composition (it includes mylonitized equivalents of most of the adjacent map units). The development of the fluorite granite at its eastern termination is also similar to, although much more extensive than, that of the base camp granite. Both are situated at major east-west changes in gravity and aeromagnetic patterns associated with their mylonite zones (discussed in INTERPRETIVE SUMMARY...).

Similar smaller dextral shear zones within the area of Fig. 2 are interpreted from their aeromagnetic patterns and dextral offsets of major map units which they transect (including iron formations and the PAG-gneiss contacts)..

***Domain 6B, Daly Bay Complex* (Ps)**

This structural-metamorphic complex was not examined in the field for this assessment, but was included for completeness on the map of the study area (Ps grey and Ags pink east of Cu showing, Fig. 2). As described and mapped by Gordon (1988), the complex consists of orthogneiss and metasediments of probable Archean age which have been intruded by gabbro and gabbroic anorthosite. At about 2050 Ma these rocks were metamorphosed to granulite facies, and by about 1950 Ma they had been structurally emplaced on top of the surrounding Archean gneisses, from which they are now separated by an inward dipping ductile shear zone.

The supracrustal rocks at Daly Bay include quartzofeldspathic granulite, minor amounts of marble with associated quartzite, sillimanite schist and biotite-garnet paragneiss, and ultramafic rock. These rocks are located within the complex and in the outer shear zone. Gossans and rusty zones are associated with disseminated graphite and minor pyrite or pyrrhotite; a small gossan at 64°12'N and 89° 50'W contains minor chalcopyrite and pyrrhotite (Cu on Fig. 2).

Similar rocks and structural associations are present in the Kramanituar complex (Schau et al., 1982; Schau, 1983) (Aab and Ag east of Baker Lake, Fig. 2). The gently south-dipping mylonite zone at the base of the Kramanituar Complex is postulated by Mikkel

Schau to be a crustal scale thrust fault, continuous on the east with that of the Daly Bay Complex, and linked on the west to the sinistral Snowbird Tectonic Zone (e.g. Fig. 1 of Tella et al., 1993).

Domain 7, Paleozoic Strata (OS, OSo)

Domain 7 is here subdivided into three sub-domains for resource assessment purposes: 7A, undivided Paleozoic; 7B, Oil Shales on Southampton Island; and 7C, Wager Bay Marine area under which Paleozoic strata are inferred.

***Domain 7A, Undivided Paleozoic Strata on Southampton and White islands* (Os)**

The regional stratigraphy of Paleozoic strata on Southampton and White Islands is summarized in Table III of Jefferson et al. (1991) after Sanford (in Heywood and Sanford, 1976), Jefferson and Hamilton (1987), Hamilton (1987), Dewing et al. (1987) and Dewing (1988). Aside from a very thin basal clastic unit, these strata comprise fossiliferous limestones with a number of oil shale units of regional extent. Paleozoic strata on Southampton Island dip very shallowly to the west, with local exceptions, and rest directly on peneplaned gneisses of Domains 1 to 6. Circular patterns representing compactional drape over bioherms are present in a number of places and represent one possible structural control for hydrocarbon accumulation in the subsurface.

Both depositional and fault contacts have been observed between the Paleozoic and Precambrian rocks on White and Southampton islands. Some of the faults trend at high angles to the strike of the contact, and appear to have dip-slip offset. Other faults trend obliquely or parallel to the contact; the curvature of their traces suggest that they are steeply dipping reverse faults. Because the basement unconformity is tilted in these places, basement deformation appears to have been involved, with Paleozoic cover acting as a passive rider (Jefferson and Hamilton 1987).

Heywood and Sanford (1976) related development of the major northwest-trending faults in the Southampton Island region to a "post-Middle Silurian epeirogeny". Sanford et al., (1985) subsequently related the same faults to continent-wide patterns propagated from more intense deformation on the margins of North America related to plate tectonics. White and Southampton Islands lie on the Bell Arch which is a continuation of the Boothia Arch. Okulitch et al., (1985) specifically related post-Silurian unconformities, westward-directed folds, and thrust faults involving the basement, to compression during plate convergence recorded by the Caledonian Orogeny in Greenland. Such structures could have acted as conduits for base metal mineralization, even though no mineral occurrences have been reported on White and Southampton islands.

***Domain 7B, Oil Shales on Southampton Island* (Oso)**

Domain 7B was not specifically defined by Jefferson et al. (1991) but was outlined as 7e (high oil shale potential) on their Figures 1 and 2, after Hamilton (1987). The oil shales continue onto the southeastern peninsula of Southampton Island (not shown on Fig. 2) and are extensive in the subsurface of Hudson Bay (Sanford et al., 1985; Sanford and Grant, 1990).

Domain 7C, Wager Bay Marine Area

The shores of Wager Bay and associated water bodies coincide with several orientations of structures which originated in Precambrian time. The steep local relief and lack of deformation of these linear structures suggests that they were also reactivated in Paleozoic to Recent times. The northwest-trending shorelines of Wager Bay and Ford Lake are approximately parallel to indistinct offsets of magnetic lineaments visible on the aeromagnetic maps of the area (Fig. 1; GSC, 1984a; Broome, 1990). Some of the northwesterly offsets correspond to faults mapped in bedrock by Henderson et al., (1986), LeCheminant et al., (1987) and Schau, (1982), which and also trend parallel to and beneath the main part of Wager Bay. Other northwesterly lineaments are straight and correspond to diabase dykes presumed to be part of the Mackenzie suite (1267 +/- 2 Ma; LeCheminant et al., 1989). Both straight and curved, northwest and east-west lineaments are highlighted by differences in magnetic intensity. The south and southwest sides of lineaments have much higher magnetic intensities than the north sides. The spectacular cliffs on the southwest side of Wager Bay coincide with one such offset of magnetic intensity. These observations suggest that these faults have significant vertical offsets, north and northeast sides down.

The fresh appearance and steep sides of some northwesterly and easterly trending gullies are interpreted to represent minor Quaternary movement on brittle faults, and/or excavation of these faults zones by ice flowing parallel to them, toward the southeast (Smith, 1990). Based on the above observations, the shape of Wager Bay is here interpreted to be fundamentally influenced by Precambrian structures which were reactivated one or more times in the Phanerozoic to create a compound half graben whose northeast-side-down master fault is elbow-shaped. The development of such faults is very clear on Southampton Island (Heywood and Sanford, 1976; Jefferson and Hamilton, 1987) where Paleozoic rocks are preserved on land.

The possibility of Paleozoic limestone flooring Wager Bay must be considered for its relevance to mineral and fossil fuel potential. No outcrops of Paleozoic sedimentary rocks have been found in the central Wager Bay area, although limestone cobbles and pebbles are abundant along the shores of Wager Bay, and limestone characterizes the western part of Southampton Island. Mapping on White Island (Jefferson and Hamilton, 1987) has shown that Paleozoic rocks are locally preserved in minor grabens bounded on each side by basement gneisses. By comparison, Wager Bay appears to be a significant and complicated graben structure, outlined by late linear features as follows.

It is very unlikely that limestone could have been transported into Wager Bay by the Laurentide ice sheet, because ice-directional indicators show that ice was centred on, and flowed outward from Wager Bay (Smith, 1990 and in Jefferson et al., 1991).

The limestone could have been transported into Wager Bay by modern sea ice. Sea ice was observed to enter Wager Bay from Roes Welcome Sound and move anti clockwise around Wager Bay, driven by strong tidal currents and the Coriolis effect.

One method of ascertaining the presence and thickness of Paleozoic strata beneath the waters of Wager Bay would be by analyzing the sharpness and intensity of magnetic patterns (e.g. Fig. 5) which transect Wager Bay. For comparison, the basement aeromagnetic patterns continue across northern Southampton Island beneath Paleozoic cover, and are relatively subdued and more diffuse here than in areas of exposed basement. Similar subdued aeromagnetic patterns cross Wager Bay, suggesting the presence of Paleozoic cover rocks under the Bay. It was not possible with the available data to calculate the different amplitudes and frequencies of the patterns, nor to relate these parameters to depth of sedimentary cover and/or water depth in Wager Bay.

QUATERNARY HISTORY OF THE WAGER BAY REGION

Surficial Deposits

The following is after Jefferson et al. (1991). The history of late glacial ice-flow directions and ice sheet disintegration of the Keewatin Sector of the Laurentide Ice Sheet in the Wager Bay region has been determined from glacial geomorphological interpretations (Smith, 1990) which provide more detail on the general history of the Ice Sheet as documented by Shilts (1985). The Laurentide ice divide trended on average northeasterly across the Wager Bay region and had a multi-stage growth and decay history recorded by locally abundant and locally opposing paleo-ice flow indicators such as striae on bedrock and sculpted landforms (e.g. drumlins and crag-and-tail structure).

Glacial features indicate the following sequence of constructional glacial events in the Wager Bay region: A) ribbed moraines (now preserved in patches) were created by a large ice sheet flowing toward the south from an area north or north-northwest of Wager Bay; B) glacial flutings, ribbed moraine and ice-scoured bedrock indicate that the ice sheet subsequently flowed toward the southeast from an origin located northwest of Wager Bay; C) ice flowing toward the north, from the southern part of the study area, then shaped the subglacial sediments into hundreds of crag and tail flutings but did not obliterate the parts of the ribbed moraine that were preserved as scattered patches in frozen valley floors.

Glaciofluvial landforms indicate a complicated melting pattern of the final, stagnant ice mass which was initially centred on Wager Bay. Nested meltwater channels indicate that as the edge of the stagnant ice sheet melted northward for the final time, the ice sheet was dissected into remnant ice masses left in depressions.

Seismic Activity

Unpublished seismic records kindly provided by J. Drysdale (Geophysics Division, GSC) show that Wager Bay straddles a northwest-trending belt of seismic activity, with earthquakes ranging up to 6 on the Richter scale (one event just south of Chantrey Inlet in 1991; three before 1963 at 5 or greater in Daley Bay and Roes Welcome Sound; many in the range of 3). Geologically these may be linked to the fault arrays documented by Sanford et al. (1985), one in particular transecting Southampton Island, Melville Peninsula and arcing north along Boothia Peninsula. The earthquakes could be due to continued compression or extension along these faults. The possibility of an earthquake of magnitude 5 or greater in the immediate vicinity of Wager Bay is inferred to be high, based on the past record of activity. A magnitude 5 earthquake could cause damage to large man-made structures if not properly designed, but one-story buildings should not be threatened if located on bedrock, permafrost or thin surficial deposits (J. Drysdale, pers. comm., 1993).

ROCK UNITS, LAUGHLAND LAKE MAP AREA

The Laughland Lake map area (Fig. 3) is underlain by seven of the regional domains and subdomains (1A,1B,2,3A,3B,5,6A). Crystalline rocks underlie more than 3/4 of the Laughland Lake map area. From 92° to 92°20' W, and extending westward south of Laughland Lake, variably strained tonalitic and granitic gneisses of ***domains 2 (grey gneiss)*** and ***3B*** (foliated porphyritic ***A' granite***) trend NE and are cut by massive equigranular ***fluorite granite*** of ***Domain 5***. Small units of disrupted supracrustal rocks (***Domain 2B***) are enclosed by the crystalline rocks. The Kuagnat Gneiss Complex (northwest corner of Laughland Lake area) has not been investigated in this study.

The ***Laughland Lake Anorthosite***, a slightly flattened 12 x 20 km plug located halfway between Laughland and 920 lakes, is the only part of the Wager Bay region where anorthosite forms a large enough body to warrant separation into ***Domain 3A***.

The northwestern quarter of the Laughland Lake area is underlain by contiguous Archean supracrustal rocks of ***Domain 1A, Prince Albert Group*** (PAG), transected by many faults, interrupted by a huge oval of ***Domain 2*** (grey ***Brown River Gneiss***) and by oval to amoeboid plutons of foliated porphyritic granite (***A' Granite, Domain 3B***). The PAG does not include the typical greenstones and thick-bedded graded greywacke turbidites that characterize the Slave and Superior structural provinces, and the Woodburn group (cf. Henderson et al., 1991a). Instead, the PAG is dominated by thinly bedded and poorly graded biotite psammites, with smaller but important volumes of quartzarenite, sericite phyllite, iron formation, ultramafic and very minor felsic volcanic rocks. ***Domain 1A*** is exemplified by the ***Central Complex*** (a komatiite and fault complex also known informally as the Omingmak Complex); and better exposures in the ***Southwestern***, ***Western*** and ***Quartzite Hill*** areas.

Rocks in all domains except the areally restricted anorthosite become increasingly foliated, and the foliations rotate clockwise, toward the south. Along 66° N, the foliations trend east-west and the various domains merge westerly into the ***Amer Shear Zone***, one of the dextral regional shear zones of ***Domain 6A***.

The geology of the Laughland Lake area is detailed by domain and contained map units in the following. Because the numbering of domains has been continued from that of Jefferson et al. (1991) to maintain consistency, the domains numbers do not represent relative age. For logical presentation in geological terms, the domains are described below in relative temporal order, from oldest to youngest (1A, 2, 3A, 3B, 5, 6A and 7). The letters in brackets after each sub-title are cross-referenced to Figs. 3, 4 and 5.

Domain 1A, Prince Albert Group (PAG)

***Biotite Psammite* (P)**

Recessive biotite psammite appears to underlie 2/3 of the area mapped by Schau (1982) as uAp and by us as "PAG". It is grey, brown to grey-weathering schistose meta-sand-stone comprising quartz and feldspar with subordinate biotite, local garnet, and local hornblende. Parallel bedding on a scale of millimetres to centimetres is typical. The beds are in places graded from a pale, sharp-based sand layer through recessive, darker, finer-grained, locally laminated metasiltstone (Fig. 5a of Chandler et al., 1993). In most of the area younging is unclear. One exposure of low-angle cross lamination resembles hummocky crossbedding. Subordinate facies include thick bedded granular light-buff weathering, essentially mica-free quartzose metasandstone and very recessive, thin-bedded, schistose, dark grey pelite. The predominant bedding-parallel lamination and grading are reminiscent of storm beds (Johnson, 1978) and distal turbidites (Walker, 1984). The massive, granular, light buff sandstones could be A.A.A. turbidites (ibid.).

A section of well preserved biotite psammites was measured in a 2000 m fluvioglacial spillway 15 km southwest of the map area (E461388, N7326461, Grid Zone 15). The 590 m stratigraphic thickness comprises massive, normally-graded and laminated sand-to-mud layers 1-2 cm thick which resemble thin storm deposits or distal turbidites. Some sandstone layers sharply overlie mudstones and grade through laminated siltstone into mudstone (Fig. 5a of Chandler et al., 1993). In the middle of the psammite sequence, a 50 m unit of rippled (?) quartzarenite may be a sand sheet deposit. A 3 m-thick laminated magnetite-chert iron formation is 30 m below the top of the psammite section.

***Sericite Phyllite* (Sp)**

A sequence of silver- to grey-weathering phyllite with quartzarenite interbeds is 750 m thick in the Western Area (Fig. 3) and is mapped in the southern part of the Central Complex (Fig. 4) where it forms 100 % of chips in frost boils. Elsewhere it is very thin or recessive. The interbedded quartzarenites and lack of dark minerals suggest that the phyllite was derived from a well weathered source area.

***Quartzarenites* (Q,)**

The quartzarenites form mappable units, 10's to 1000's of metres wide and are continuous along strike on the order of kilometres. All quartzarenites are strongly foliated and most form decimetre- to metre-scale massive beds. White quartzarenites (Qw) within large units of biotite psammite and sericite phyllite are 10 to 35 m thick and 0.1 to 6 km in length.

Rare cross-bedded quartzites in the PAG were illustrated by Schau (1982), who reported crossbeds up to 10 m thick near Laughland Lake, suggesting an eolian origin. Crossbeds in the Laughland Lake area are moderately well preserved only on Quartzite Hill. There we observed a few large (1-3 m), low-angle (10-15°) foresets, and many 5 to 25 cm tabular and trough types, as well as variations in bedding thickness from cm to m scale. The foresets are planar to gently concave. Rare higher angles suggest synsedimentary deformation of the foresets. The quartzites have a translucent vitreous appearance. Glacially polished surfaces display clearly detrital textures.

Tabular bedding and cross beds are accentuated by muscovitic partings and 0.5-2 mm dark grey laminae which in the field were thought to contain heavy minerals, but in thin section show chlorite and muscovite. Aside from these partings, thick quartzarenites, such as those which form the 1200 m-wide Quartzite Hill, contain only sparse muddy strata.

A series of varicoloured quartzite outcrops 10 to 50 m wide parallels the west edge of Quartzite Hill separated from the white quartzites, by about 500 m of pale to dark, variably rusty, locally auriferous (see Bedrock Trace Element Geochemistry) pyrrhotitic chloritic quartzarenites and some metavolcanic rocks. Compositional changes at the boundaries of these quartzite units are gradational. As facing directions are not available, it is not known whether these are structurally repeated stratigraphic equivalents of Quartzite Hill (Jefferson and Schau, 1992), or additional stratigraphic units in a westward-younging sequence (Chandler et al., 1993).

Bright green, fuchsitic quartzarenites (Qc) are closely spatially associated with iron formations and komatiites (Figs. 3 - 5). The chromium has been interpreted as derived by paleoweathering of the komatiites (Schau, 1982, p. 28); alternatively it could have been introduced by the same hydrothermal processes which deposited iron formation.

A very gently dipping rusty weathering grey pyrite-garnet-sillimanite quartzite (Qp) sequence (25 m + 15 m gap + 15 m) overlies biotite psammite at locality pgsQ (92CGA) of Fig. 3. Garnet-biotite-rich beds (pelites?) comprise no more than 5% of this sequence. Three upward-facing herringbone crossbeds recording opposed paleocurrents were observed in the 25 m part, and festoon (trough) crossbeds in the 15 m part.

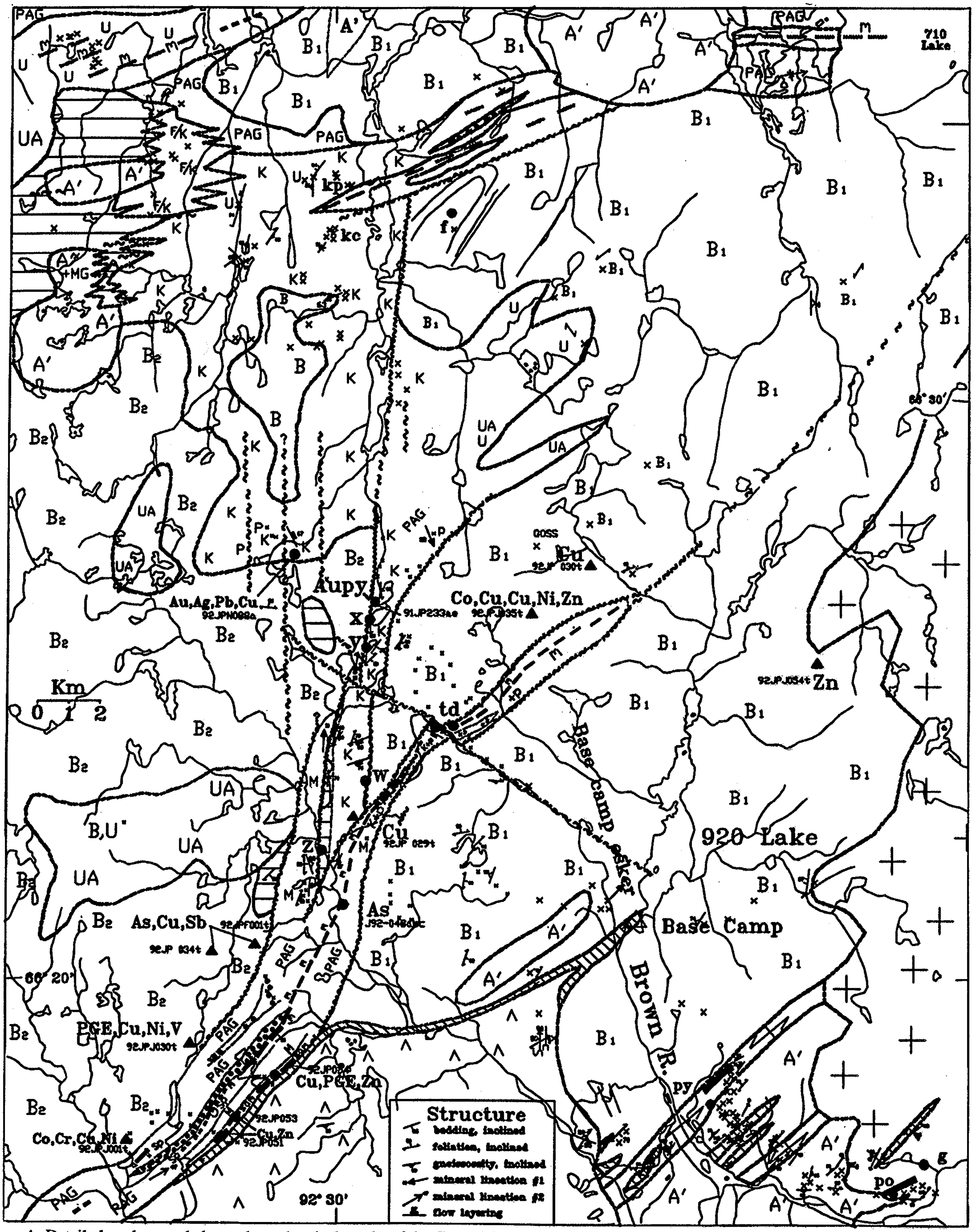

Figure 4. Detailed geology and elevated geochemical results of the Central Complex. Location and legend are given in Fig. 3. Further explanation and interpretation are provided in text.

Insufficient large crossbeds have been found to support eolian (Walker and Middleton, 1977) genesis of the quartzarenites. Nor have mud chips, mud cracks or vertical accretion deposits of braided streams (Walker and Cant, 1984), been found. Such mud-free, extensive, cross- and planar-bedded quartz sand bodies are characteristic of marine shelves and epeiric seas (Johnson, 1978) swept by vigorous traction currents. Opposing crossbeds permit the possibility of tidal currents. Schau (1982) interpreted decimetre-scale lateral facies changes of the thinner quartzites to sericite schist and phyllite (Sp) as deposits of river, dune or offshore bars; these could also record turbiditic channel fills or dismemberment by deformation.

***Conglomerate and Pebbly Mudstone* (cgl)**

At locality "cgl" one outcrop of stretched (4:1) quartz-pebble orthoconglomerate, 30-35 m thick and 300 m in strike length, lies within biotite psammite and contains one exposure that displays size grading and a range of angularity. Clasts comprise mainly white to grey quartz, with rare clasts of banded magnetite-quartz iron formation and amphibolite (Fig. 5b of Chandler et al., 1993). Three hundred metres northeast of locality "cgl", one exposure of paraconglomerate, about 170 m thick, comprises similar clasts in a wacke matrix, and sparse diffuse beds of quartz pebble orthoconglomerate, 15 to 30 cm thick.

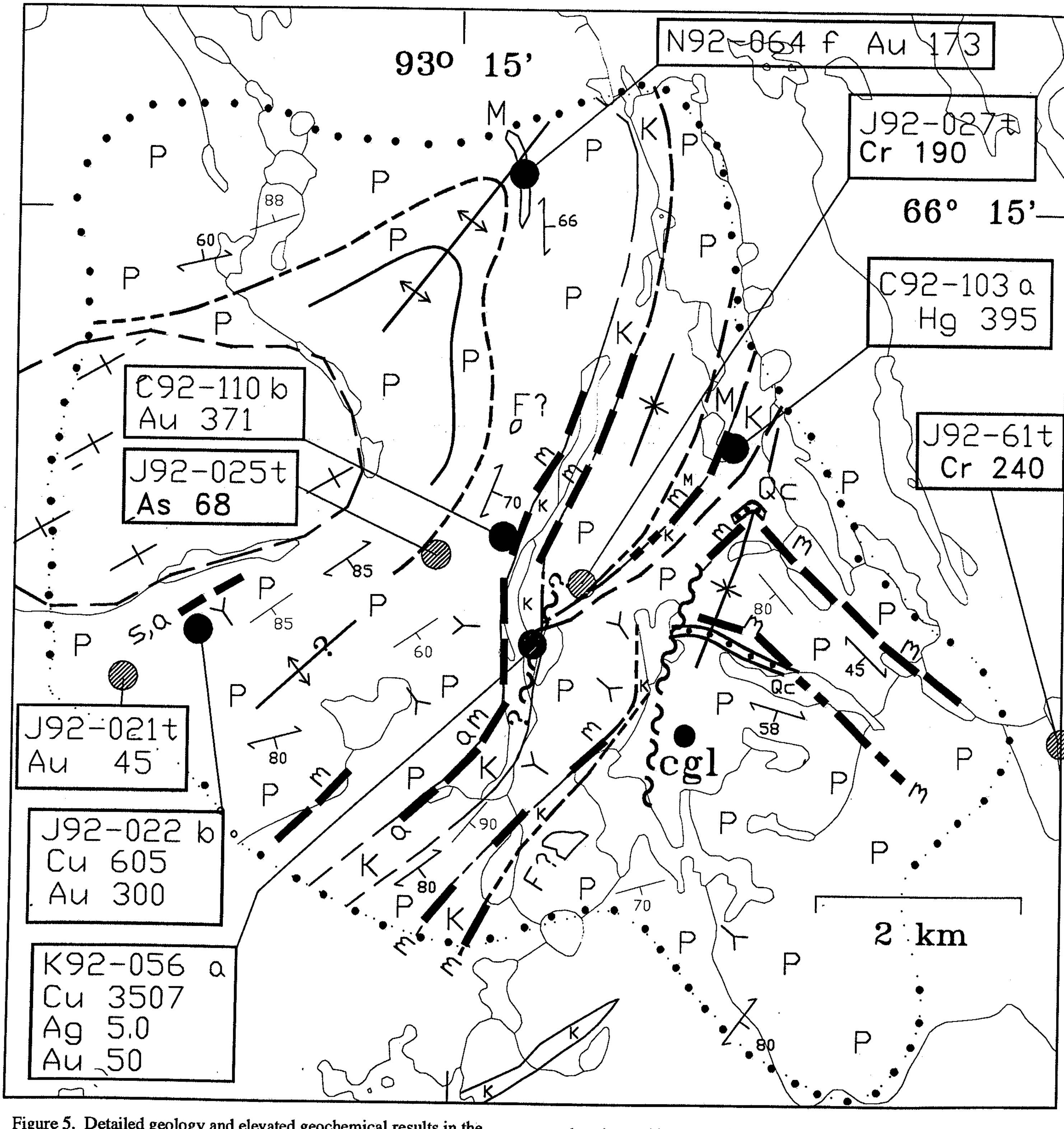

Figure 5. Detailed geology and elevated geochemical results in the Southwestern Area. Location and legend are given in Fig. 3. Further explanation and interpretation are provided in text.

Polymict conglomerates with highly flattened psammitic cobbles were also sampled in the same area, but were not recognized until samples were cut and polished.

The psammite host, the grading and lack of continuity of these conglomerates suggest proximal turbidites and debris flows in channels cutting a deep shelf or base of continental slope (Walker, 1984). Their rarity, general compositional maturity and the absence of dropstones are not supportive of a glacial origin. On the other hand, many cryptic polymict paraconglomerates may be present but were not recognized due to deformation, metamorphism, lichen and till cover.

Carbonate Units

Carbonate rocks are too minor to map as separate units at 1:50,000 scale; most are associated with the ultrabasic and basic rocks. However, at least 22 m of interbedded psammite and brown-weathering laminated dolomite are just east of locality cgl. A 40 m-thick carbonate unit mapped by Schau (1982; his Fig. 8) also appears to be metasedimentary.

Many of the amphibolite units contain abundant dolomite as matrix to breccia zones which appear to be stratiform, oriented parallel to the mapped strike of the amphibolite units. These breccia zones are strongly reminiscent of carbonate-rich volcanic breccias at the volcanic-sedimentary interfaces of supracrustal belts in the Archean Slave Province (e.g. Sequence B around the Back River volcanic complex, as described by Jefferson et al., 1992a).

Iron Formations (m, s, a)

Schau (1978, 1982) recognized abundant magnetite iron formation and noted the use of linear aeromagnetic highs to indicate their locations. He mapped them as outcrop in two places and described them as alternating quartz and iron mineral laminae. Jefferson and Schau (1992) applied this knowledge to generate magnetite iron formation map units defined by linear aeromagnetic highs (>62000 gammas on Geological Survey of Canada, 1977) which were calibrated from two known outcrops. Mapping of additional iron formation outcrops in 1992 confirmed the previous calibrations. Exposed magnetite iron formations are up to 60 m thick and 3 km in length.

The correlation between magnetite iron formation and aeromagnetic anomalies is very strong but one-sided: aeromagnetic anomalies >62000 gammas are guaranteed to overlie iron formation, but thin magnetite iron formations are not always expressed in the published data (e.g. in the northwestern area around station 92JPN-120A). Aeromagnetic anomalies are also lacking over a number of gossanous, non-magnetic iron formations and/or iron-rich strata which are dominated by sulphide and silicate minerals, some being very fine-grained sulphidic amphibolite. Many iron formations are paired with metavolcanic rocks, a few are isolated within thick psammite sequences, and some are closely paired with chromian quartzarenites.

Komatiites (K)

Komatiites, ultramafic schists and amphibolites constitute <10% of the Group, but dominate in the Central Complex. Most meta-komatiites (K) in the Central Complex have orange-weathering cumulus zones directly overlain by relatively recessive grey to green spinifex zones, with sheared interflow contacts (Fig. 6a) and lack the complete sequence typical of Archean komatiites (Fig. 6b). Rare features include columnar joints (locality kc) and younging indicators such as flow top breccias, differential weathering with vegetation at spinifex-cumulate contacts, and foliate zones between cumulate and spinifex zones. About 30 m of flattened lenticular structures interpreted as pillowsor flow tubes, ultramafic flows (locality kp) and massive dark grey metabasaltic flows cap the komatiites in better exposures north of the Central Complex (Fig. 4), suggesting a dominantly subaerial volcanic environment with late submergence.

Eckstrand (unpublished notes, 1974) described similar features in the Central Complex, as well as to the northeast between Hayes River and Walker Lake. North of Hayes River, Eckstrand observed a number of massive, relatively undeformed ultramafic lenses, ranging from several to 30 m thick and 300 to >1000 m long, hosted by metasedimentary rocks. One such body is bounded on both sides by layers about 1 metre thick of metasediment containing disseminated sulphides. The border phases of the ultramafic lenses are clearly defined pyroxenite and the core zones are peridotite - dunite. Eckstrand considered the textures to be clearly magmatic and the bodies to be shallow intrusions. He also noted similar intrusive bodies in the Central Complex of Laughland Lake, even though the majority of ultramafic rocks here are demonstrably extrusive.

The komatiite sequence in the Central Complex is in the order of several kilometres thick. Given the above regional context, many of the predominant cumulate - spinifex couplets which do not show flow top breccias and have unclear facing directions in the Central Complex, may be shallow sills. If so, harrisite could be an appropriate textural term for the bladed (spinifex) zones.

Meta-Ultramafic Rocks (U)

Strongly foliated talc-actinolite schist, locally interlayered with brown dolomite, and brecciated dolomite-talc-amphibolites are mapped as meta-ultrabasic (U) and interpreted as altered komatiite. Both komatiites and meta-ultrabasic rocks contain magnetite and are coincident with linear, aeromagnetic highs >60,500 gammas. Similar highs which have not been investigated in the field are mapped as "UA".

Inferred Meta-Ultramafic Rocks (UA)

The poorly exposed meta-ultramafic units (UA) enclosed by the central oval tonalite are here inferred from moderate aeromagnetic anomalies (>60,500 gammas) to be meta-ultramafic rocks, and could be either basinal fold keels or inclusions. One bedrock outcrop checked in a "UA" area during till sampling contains ultramafic and tonalitic gneiss, but most of these areas are completely mantled by unconsolidated deposits, and the interpretations are tenuous. Unchecked linear aeromagnetic anomalies >60,500 gammas within the PAG are much more certain to be ultramafic because of their context.

Fine-Grained Amphibolite (Meta-Mafic Volcanic Rocks) (M)

Fine-grained black to green amphibolites interpreted as metabasalt include minor lenses of brown dolomite with amphibolite breccia. Fine-grained amphibolites which contain garnet + sulphide +/- magnetite are interpreted as iron-formation. East of Brown River, inclusions (or fold keels?) in the Brown River Gneiss and A' granite comprise amphibolite and fine-grained biotite gneiss, associated with northeast-trending high strain zones in which the two foliations are distinct.

Felsic Meta-Volcanic Rocks (F)

Minor quartz-phyric leucogneisses are interpreted as felsic metavolcanics in the Southwestern Area ("F", Fig. 5). Quartz- and feldspar - phyric metavolcanic breccias and tuffs at the northeast corner of the Central Complex are interfingered with mafic and ultramafic metavolcanic rocks, and metasedimentary rocks (stations 73SMA107-109 of Mikkel Schau). Felsic metavolcanic rocks are more common several hundred km to the northeast (Schau, 1977).

In thin section, the volcanic interpretation of several specimens from the Southwest Area is supported by the presence of 0.3-0.5 mm highly altered and polygonized but still euhedral plagioclase, and monocrystalline to polycrystalline ovoid quartz grains, set in a matrix of finely polygonal quartz and feldspar with biotite and chlorite defining foliation. These large grains are interpreted as phenocrysts of reworked crystal tuffs that have been metamorphosed to upper greenschist facies and highly deformed.

Domain 1B, Disrupted Supracrustal Rocks

Disrupted supracrustal rocks form a minor component of the Brown River gneiss and are generally not abundant enough in large enough areas to separate as assessment domains. Nevertheless, along the Brown River east of the anorthosite, biotite +/- garnet gneisses include thin iron formations with negligible aeromagnetic signatures. These were sampled at two localities: northeast of locality "a" a few metres of alternating quartz and magnetite laminae are in a highly strained lense of garnet-biotite paragneiss, within Brown River Gneiss. Iron formation at locality "g" is also a few metres thick, is concordant with the SE margin of a kilometre-long xenolith of dark green fine-grained metabasalt, and is gossanous, including both magnetite-quartz laminae and disseminated pyrrhotite in medium-grained biotite schist.

Domain 2, Brown River Gneiss

The Brown River Gneiss as mapped by Schau (1982) and this study (Fig. 3) includes variably foliated, compositionally uniform grey hornblende tonalites around the Central Complex and Western Area, and foliated tonalites with amphibolite bands in the southeastern part of the map area. All such tonalites are characterized by broad undulatory aeromagnetic lows and are characteristically in fault contact with the PAG.

Foliated tonalite forms irregular masses (B1) transected by gneissic and massive granites to the northeast and south of the Laughland Lake Anorthosite Complex, a large oval (B2) in the west-central part of the area, and some smaller oval bodies (B) within the PAG. Pluton B3, the foliated "western tonalite stock" of Schau (1982), is here assigned to Brown River Gneiss based on texture, composition and its mylonitic northwest contact against supracrustal rocks with no contact metamorphism. Foliations are steep toward the pluton.

At locality **td** in the southernmost east-extension of the Central Complex (Fig. 4), foliated and locally mylonitic tonalite dykes transect iron formation and meta-komatiites, and one tonalite dyke contains ultramafic schist xenoliths. Spinifex is not preserved here, perhaps due to contact metamorphism against the tonalite, but the alternating green and tan komatiitic flow layering is clear enough to define folds. Foliated tonalites also intrude the PAG north of the Central Area.

The above intrusive contacts are exceptions; the margins of most tonalites truncate local structures in the PAG. Most exposed contacts with the PAG are brittle faults or mylonite zones (e.g py, w, x, y, z in Central Complex), even though regional foliations in the Group wrap around larger tonalite bodies. Foliations within the tonalites are overall northeasterly, lenticular on a mm scale, and are interpreted as two intersecting fabrics. Northwest of 920 Lake, anastomosing mafic dykes cutting the tonalite have two foliations (similar dykes SW of 920 Lake also cut A' granite). Broad folds in tonalite interpreted from air photographs at locality **f** (northeast corner of Central Complex) are truncated by contacts with the PAG and may indicate that the tonalite here is basement to the PAG.

A number of different tonalite phases are suspected but could not be mapped with available logistics. The age relationships between PAG and foliated tonalites (Brown River Gneiss) appear to be complex and varied. Some parts of Brown River Gneiss may be basement to the PAG, as interpreted by Schau (1982). Other grey foliated tonalites which have been mapped as Brown River Gneiss are clearly intrusive, and perhaps belong to the A' suite. Detailed mapping, petrology and geochronology of the Brown River Gneiss may provide better constraints on age relationships. Further discussion of key contacts is provided in **Structure** below.

Domain 3A, Laughland Lake Anorthosite (∧) and Related Metagabbros

The Laughland Lake Anorthosite crops out as a body about 12 km by 20 km, centred at 66°15'N / 92°30' W, northeast of the lake for which it is named. It forms prominent chalky white hills and is clearly delineated by its own characteristically rugged landforms, epecially to the south. The pluton is deformed and recrystallized, yet compositional layering is locally recognized. A thin, thinly layered border phase of amphibolite is interpreted as strained leucogabbro and gabbro. At locality "gr" graphite nodules several cm across are contained in sugary coarse-grained anorthosite.

The scenic qualities of the Anorthosite region are those of a barren upland with small cliffs and could provide an attractive landscape to wilderness hikers.

The anorthositic rocks consist of sugary, locally coarse grained and closely packed plagioclase crystals, with local mafic rims. They weather a chalky to greyish white to pale yellow and pistachio green colour with rare pink veins and masses. The surrounding thin border phase of amphibole-rich rocks is locally layered, massive or locally plagioclase porphyritic. In thin section the rocks are seen to consist of labradorite, now altered to albite and zoisite or epidote; mafic minerals are hornblende or actinolitic amphiboles. The chalky white is a direct result of this low-grade metamorphic transformation and few original minerals remain. Some relict layers persist, but much of the mass has been recrystallized to a granular aggregate. For this reason it is not known whether the rare flecks of graphite found within the body are primary or secondary.

New chemical analysis of hand specimens confirm the calcic nature of the anorthosite. New trace element data of selected samples do not include elevated chromium, nor are the mafic portions enriched in iron or titanium rich. The positive europium anomaly

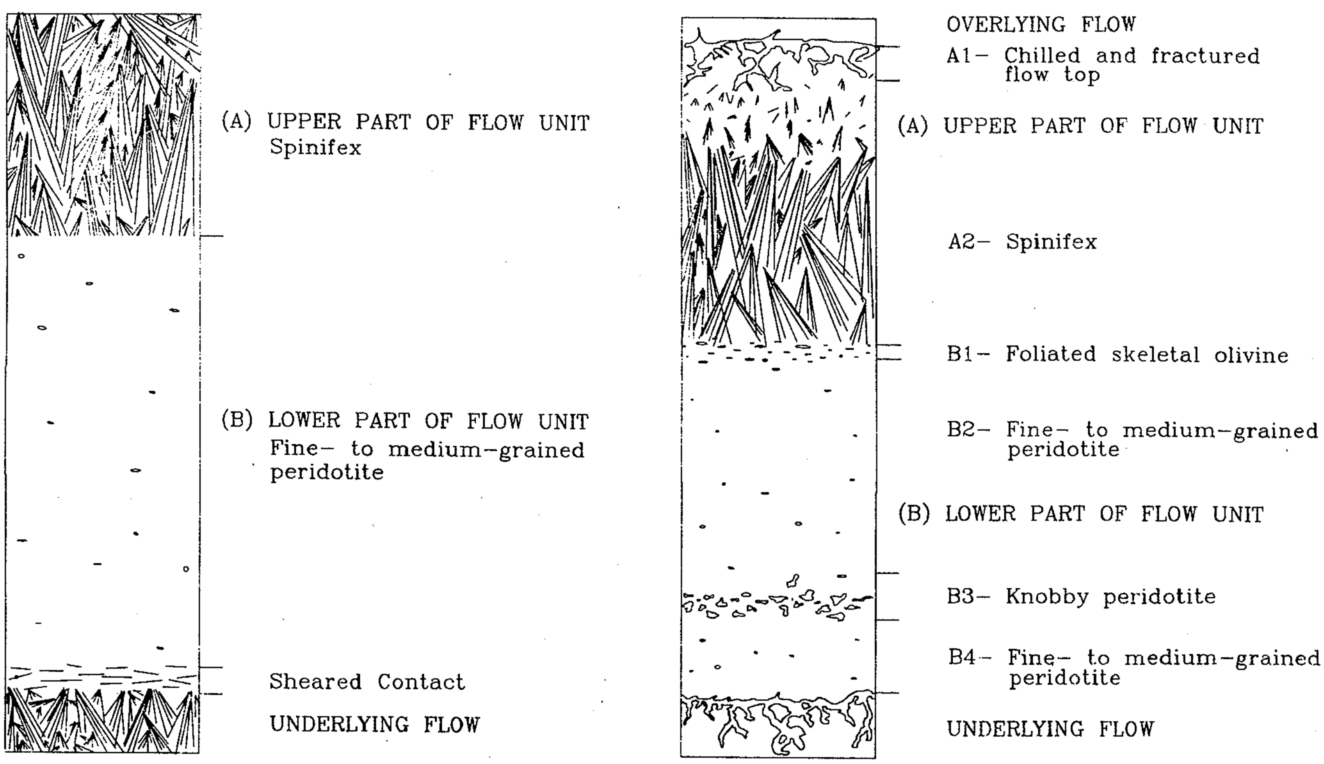

Figure 6. (a) Cumulate-spinifex pairs of the Central Complex; (b) Type komatiite flow of Arndt et al. (1977).

together with the relict layering and coarse grain size confirm that the rocks were in part formed by fractional crystallization.

Schau (1982, p.19) suggested that the anorthosite cuts the Brown River Gneiss and the PAG, is complexly deformed, and is Archean. Although the only two exposed contacts are mylonite zones against the PAG and A' Granite (see below), the overall shape of the anorthosite and its relative lack of deformation support its post-Brown River and post-PAG age.

The marginal amphibolite on the south side of the anorthosite is cut by thin granitic dykes thought to be from the A' granites. Both dykes and marginal anorthosite are flattened with the same northeast fabric as the A' Granite. The anorthosite contains local shear zones parallel with both the N-S trends in the Central Complex and with the northeasterly trends that dominate in the eastern half of the Laughland Lake map-area.

Large amphibolite pods on the northeast periphery of the anorthosite, and a discontinuously exposed fringe of amphibolite on its western and southern margins, are interpreted to be part of its marginal phase. Along the northwest margin (locality **cpy**) and southernmost margin the layering in the border phase is 45° to 85° inward-dipping mylonite. Well developed C/S fabrics and vertically raking stretching lineations indicate upward and outward emplacement of the anorthosite at these locations.

Other coarser grained resistant amphibolite bodies northeast of the anorthosite appear to be lenticular boudins of metagabbro dykes that intrude Brown River Gneiss and supracrustal gneiss lenses in NE-trending regional high-strain zones. At location "a" a 10 x 30 m pod is massive in its core, foliated on its margins, and forms an isoclinal hook which is open to the north-northeast and truncated on its west side by a sequence of annealed mylonitic granodiorite and biotite-hornblende phyllonite. The core of the hook preserves biotite-hornblende schist. The hook is interpreted as a large deformed boudin included in a ductile shear zone.

No encouraging prospects for minerals have been found within the Anorthosite, although a few locations may be of interest to mineral collectors. The emplacement of such a large mafic body into metasediments at shallow levels would have generated local high gradients in temperature. Contacts of the anorthosite with sulphidic layers of the Prince Albert Group may contain interesting mineral assemblages.

Gabbroic Intrusions

Oval gabbros with distinct aeromagnetic lows occur on the margins (mainly north and east) of the large foliated tonalite oval. These are medium to coarse grained and massive to intensely foliated hornblende + chlorite + plagioclase +/- quartz. Some gabbros are enclosed by tonalite; others are interfingered with or laterally adjacent to the Group. It is uncertain whether the interfingering is tectonic or primary. Even though there is no direct spatial association, for assessment purposes these are grouped with the Laughland Lake Anorthosite.

Domain 3B, Archean/Paleoproterozoic (A') Foliated Porphyritic Granites

A' granites (Jefferson and Schau, 1992) in the Laughland Lake area are foliated and K-feldspar-phyric, contain foliation-parallel xenoliths of Brown River Gneiss and supracrustal remnants, and dip under and intrude the amphibolite border of the Laughland Lake Anorthosite. The name A' has been used by regional mappers in the northeastern District of Keewatin (as summarized by Patterson and LeCheminant, 1985) for granites of uncertain age, which may be Paleproterozoic (Aphebian) or Archean.

A large northeast-trending belt of A' granite underlies the southern parts of the Laughland Lake map area. Intrusive contacts with Brown River Gneiss are folded and obliquely transected by the northeast foliation. The granite wraps around and dips under the Laughland Lake anorthosite at about 45° to 80°, and thin dykes possibly derived from the A' granite transect and are deformed with the marginal amphibolite of the anorthosite. The southwestern end of the granite was interpreted from aeromagnetic and sparse outcrop data to include apophyses which curve toward the Amer Shear Zone.

West of 93°, individual plutons form rounded hills surrounded by linear valleys. Pegmatite and quartz veins, and increased metamorphic grain size in adjacent psammites support Schau's (1982) intrusive interpretations. The westernmost A'1 pluton has a marginal phase of coarse-grained feldspar-phyric to pegmatitic white-weathering massive granite. Southern outcrops of the Northern Walker Lake Gneiss (NW on Fig. 3) resemble A' granite, and clearly truncate the folded compositional layering of the psammites and iron formation.

The locally megacrystic eastern orthogneiss component of the A' granite ranges from tonalite to quartz monzonite in composition, with biotite- and hornblende-rich phases. The structure of the A' granite varies from non-layered in western plutons to conspicuously layered in the east, most layering having the appearance of intrusive contacts that are transposed parallel to the strong biotite-hornblende foliation. Lenticular xenoliths within the eastern A' granite orthogneisses, metres to kilometers in length, comprise biotite fels and amphibolite with local iron formation, garnetiferous layers and disseminated pyrrhotite. Xenoliths and their contained fabrics are oriented sub-parallel to the northeasterly gneissossity and foliation.

Domain 5, Fluorite Granite (+; "Southern Walker Lake Gneiss")

The A' granite orthogneiss (Domain 10) and its contained xenoliths are discordantly intruded on the east by locally red-stained, equigranular granite characterized as weakly foliated to massive, with minor biotite and local muscovite, accessory magnetite and fluorite. The granite contains polygonal blocks and lenses, metres to kilometres in scale, of all above-described units. Foliations in the blocks are concordant with those in adjacent gneisses. The assemblage of fluorite granite and xenoliths has been regionally mapped by Schau (1982) as Southern Walker Lake Gneiss.

One of the larger blocks is dominated by fine-grained amphibolite (metabasalt) with concordant iron formation at locality "g". This amphibolite is intruded on the NW by gneissic white tonalite (a phase of the A' granite?), intruded to the SE by gneissic pink porphyritic granite (A'), and all are invaded by the equigranular granite.

No metamorphic aureole is apparent in the granitoid orthogneisses adjacent to the fluorite granite, and the gneissossities are undeformed by the granite, suggesting that the pluton stoped into the host gneisses during the late stages of regional metamorphism.

The small outcrop areas of granite mapped by this study coincide with spotty, 60,500 - 62,000 gamma aeromagnetic highs (Geological Survey of Canada, 1977) which frame the south and eastern margin of the map area and extend well away to the ease and north. Only about 3 km of the sharp western contact of the granite has been mapped in outcrop west of locality "g". The remainder of the irregular contact of the granite (mapped as Southern Walker Lake Gneiss by Chandler et al., 1993) was extended to the north and south by helicopter and foot traverses of small outcrops and by tracing the western edges of the series of small aeromagnetic highs which characterize the belt.

The presence of muscovite and absence of hornblende suggest the equigranular fluorite granite may be related to the muscovite-bearing granites to the north (Schau, 1982), but the latter are foliated and contain biotite, minor hornblende, accessory tourmaline and sphene in addition to magnetite but lack fluorite (Schau, 1982) The undeformed nature and red staining of the fluorite granite are similar to those of the $1805^{+10}/_{-5}$ Ma Base Camp Granite south of Paliak Islands (Henderson et al., 1991b). Circular to elliptical plutons of similar Proterozoic hornblende-biotite granites, which locally contain fluorite (LeCheminant et al., 1987), extend from south of Brown Lake, NE to Curtis Lake..

The Southern Walker Lake Gneiss Complex was described by Schau (1982, p. 22) as characterized by gneissic granite and/or granodiorite, and inclusions or septa of almost flat-lying biotite-rich layers containing large porphyroblastic K-feldspar crystals. Some rocks assigned to the southern part of the Walker Lake Gneiss Complex within the Laughland Lake area by Schau (1982) do include porphyritic foliated granites, and grey amphibolitic gneisses, and these are interpreted as equivalents of the A' granites and Brown River Gneiss which have been preserved as roof pendants to the Paleoproterozoic granites. For practical purposes, and until these relationships are resolved by further ground observations and/or more sophisticated geophysical analyses, the mixture of massive fluorite granite with foliated tonalitic to granitic gneisses, which has a spotty high aeromagnetic pattern, is shown undivided in Figures 2 and 3 as Fluorite Granite (Domain 5).

Both massive (equivalent to Domain 5) and foliated (equivalent to Domain 2 or 11?) granite intrude PAG correlatives to the south of the Amer Shear Zone (Heywood, 1961).

Domain 6A, Amer Shear Zone

The Amer Shear Zone was not specifically examined for this study, because of other priorities. The following description is compiled from limited outcrop information from this study, original base maps of Heywood (1967), unpublished data provided by A.N. LeCheminant and J.R. Henderson in 1993, and the aeromagnetic data (Geological Survey of Canada, 1977, 1984a). The Amer Shear Zone is very similar to the Wager Shear zone in that foliations on the north and south side bend into it, and the composition of it is highly strained components of the gneisses around it. Even the fluorite granite, which is relatively unstrained in the exposures north of Brown River, becomes intensely foliated to the south and west. Iron formations, quartzites and psammites of the PAG, the Brown River Gneiss, and A' granite also bend into and are incorporated in the mylonites. The Amer Shear Zone is not deliniated on Figure 3 because it's boundaries are gradational and it is best developed south of 66° and west of 93°; its outline is generalized on Figures 1 and 2 for resource assessment purposes. Other individual northeasterly trending high strain zones mapped in Figure 3 are interpreted as splays from the Amer Shear Zone (see Structural Geology below).

Structural Geology

Complex folds of at least two generations are exposed in PAG NW of Laughland Lake (Schau, 1982). An older fold generation is isoclinal and contains strongly oblique to bedding-parallel mineral foliation on the limbs. A younger fold generation is open in style and associated with axial planar crenulation cleavage. The younger folds and cleavage are restricted to local structural domains. The isoclinal folds are suggested in many areas, but are clearly documented mainly in the Western Area. The crenulation cleavage and open folds are well defined in the Western Area and around Quartzite Hill. Northerly and northeasterly high strain zones are present across the Laughland Lake map area

Complex relationships among the various PAG units and the adjacent crystalline rocks were investigated in the detailed map areas and are described by area below.

Northeasterly Shear Zones

In the eastern part of the study area, regional foliation, gneissic layering, ductile shear zones, and orientations of supracrustal xenoliths and keels trend NE with steep NW dips. Gneissossity is folded about gently NE-plunging axes, locally showing subhorizontal attitudes (e.g. A' Granite between localities "a" and "g"). Northeast-trending ductile shear fabrics characterize the A' granite orthogneiss. Two zones of more intensely deformed, and locally sulphidic lenses and keels of PAG are shown by the iron formation symbols between localities "a" and "g" in the eastern part of the map area. Significant northeast-trending shear zones are clearly indicated to transect the Central Complex and Western Area (below). Retrograde metamorphism and fluid flow along such shear zones may be the cause of some weakly elevated gold abundances, particularly in the Southwestern Area.

The northeast trending shear zones cannot be mapped continuously because of the poor outcrop, but the aeromagnetic patterns and bending of foliations toward the south strongly suggest that they are splays from the Amer Shear Zone. Close to the shear zones, the foliated tonalite contains a series of thin intensely foliated (high strain) zones which contain muscovite schist that resembles supracrustal rocks. These highly foliated zones increase in number and thickness toward the main northeasterly shear zones.

Central Complex (Komatiites and Faults)

This structural and lithological focus is cored by a komatiite sequence with minor metabasalt and few exposures of metasediments. Komatiite outcrops are scattered to clustered, ice-sculpted, north-trending knobs. The komatiites are in apparent stratigraphic contact with metasediments on the north and south, and in fault contact with tonalites on the east and west. These contacts and the internal structure of the complex are described in the following.

The broader, northern part of the Central Complex exposes minor metasediments intercalated with the komatiites. Younging directions are overall northerly to northwesterly, although northeast and southwest facing directions indicate local folds and/or block rotations within high strain zones, particularly along the northeasterly extensions into Brown River Gneiss. The compositions of the ultramafic rocks are dominantly komatiite but become basaltic toward the northwest, near the poorly exposed volcanic-sedimentary rock interface. A small felsic volcanic centre appears to be interfingered with the komatiites and metasediments on the northwest corner of the Central Complex (from Schau, 1982 and unpublished notes by Schau).

Within the thin, southern part of the Central Complex ("w x y z"), north-trending ice-sculpted clusters of outcrops expose abundant spinifex texture and moderate northeast- to southeast-dipping flows. Easterly stratigraphic tops are indicated by the graded cumulate-spinifex couplets. Some outcrops are bounded by recessive highly foliated ultramafic schists whose fabrics dip steeply and trend N-S, truncating the layering. At the south end of the complex, basaltic komatiites are bounded and interdigitated with iron formation, quartzarenite and psammite along an intensely strained northeasterly shear zone.

North-south and northeasterly zones of deformation transect the Central Complex and demark all of its exposed contacts with the Brown River Gneiss (e.g. localities "w" to "z" on Fig. 4). The faulted east and west boundaries of the narrow central komatiite belt were figured by Schau (1982) as strands of his "North-South Fault Zone". A new interpretation of this fault zone was suggested in Fig. 2 of Jefferson and Schau (1992) and it is further re-interpreted here in Figs. 3 and 4. None of these interpretations can be considered definitive due to the lack of constraining outcrop data.

Kinematic indicators such as C/S fabrics and stretching lineations record west-side-down vertical movement and subhorizontal sinistral shear on the few exposures of the north-south faults. Metamorphic grade in PAG tends to be lower than that of the gneisses (ibid.). The complex also terminates to the south against the Laughland Lake Anorthosite. Although north - south and northeasterly fabrics, and linear features on air photographs are present in the anorthosite, it seems to have been little affected by them except for a slight flattening along the northeast trend.

Localities "x", "y" and "Aupy" on the western contact between komatiites and gneiss are linked by a moderately well exposed high strain zone that is thought to exemplify more poorly exposed gneiss - komatiite contacts. The zone includes both strands with an east-side-down brittle component (not exposed), and strands with an earlier development of mylonitic fabrics, with subhorizontal extension lineation, at or near contacts of both Brown River Gneiss and the komatiites.

A critical re-examination of a proposed unconformity between gneisses and conglomerates to sandstones (Schau, 1982, p.11) at locality "x" showed it to be a mylonite (straight gneisses, mica phyllonites and mylonitic komatiites) and fault gouge zone containing boudins of a distinctive local aplite dyke. The suggestion of an unconformity remains possible at locality "y", a few kilometres south of "x". Here, steeply dipping S-striking protomylonitic tonalite on the NW is separated by a one-metre NE-trending covered interval from a moderately SE-dipping komatiite flow with spinifex textures suggesting facing to the SE. The covered contact zone truncates the gneissosity. The great differences in strain and metamorphic grade, and the lack of on-strike continuity of the ductile shear fabric, so well developed in the protomylonite but absent in the serpentinized komatiite, suggests that the contact is an unconformity. The high ductile strain elsewhere along this contact (see description of locality "z" below) and the possibility of superimposed brittle faults require that these uncertainties be resolved by future mapping, precise geochronology and metamorphic petrology to determine the relative ages of rock units and the structures that separate them.

Along the mylonitic contact from "x" to "Aupy" finely laminated mylonites of felsic to ultramafic parentage are exposed. Gossans are developed in overburden and outcrop along this contact; pyrite is locally abundant in both mylonitic tonalite and laminated felsic mylonite. The elevated gold values here are discussed in Bedrock Trace Element Geochemistry below.

At locality "z" tectonic incorporation of tonalite within the komatiite belt is marked by a steeply dipping, north-south striking tectonic melange whose exposed thickness is about 30 metres. The melange comprises interleaved mylonitic gneiss, amphibolite, and ultramafic lenticular schist that contains isolated spheroidal tectonic clasts of gneiss and amphibolite.

The eastern boundary of the komatiites is constrained at locality W (Fig. 4) to a north-trending covered interval a few metres wide. The southeasterly facing komatiite flow trends are truncated by the komatiite-gneiss contact, as well as by high strain zones at the margins of outcrops. At the tonalite-komatiite contact, little north-south fabric is developed in either gneiss or PAG, therefore this is interpreted as a brittle fault, west-side-down and probably also with a strike-slip component.

Large lenses and elongate extensions of PAG iron formations, komatiites and quartzites project to the northeast into the Brown River Gneiss, across the north-south faults from the Central Complex. The extensions may represent fold keels because they appear to be continuous with larger areas of PAG. The extreme elongation of these lenses, their expression on aeromagnetic maps, and the intense mylonitic fabrics with subhorizontal stretching lineations tell us, however, that the main structures are strike-slip shear zones. The lenses and blocks of well preserved komatiite along these shear zones have variable orientations (including perpendicular to their northeast trends) and folds ranging from tight bends of komatiite flow layering to intense crenulation of felsic (ex-tonalite?) mylonitic laminae. The variable orientations are interpreted as resulting from roller-bearing rotations during dextral shear.

At the southern end of the north-south fault zone, aeromagnetic anomalies interpreted as iron formation and komatiites follow closely, and were used in 1991 to predict the presence of the narrow supracrustal extension that passes through locality "td". This extension continues southwesterly, transecting the projected north-south fault zone with an approximate 4 km sinestral jog. Scattered outcrops of iron formation and intensely mylonitic rocks along this trend confirm the underlying lithology. It is therefore apparent that the northeast-trending shear zones post-date the main movement on the north-south faults.

The Central Complex is also transected by a number of northwest-trending brittle faults, one of which is shown transecting locality "td" and offsetting the north-south komatiite-gneiss contact (Fig. 4). A related mylonite zone, within the gneiss about 200 m SW of locality "y", also trends NW and contains a vertical extension lineation. Local C-S fabrics and minor folds suggest dominant NE-side-down movement. There is no obvious offset of the nearby komatiite-gneiss contact along this fault. These faults are thought to be part of the family of faults that are shown to regionally transect the Quoich River 1:1,000,000 map sheet and influence the shape of Wager Bay and Brown Lake (Fig. 2).

The north-south deformation zone possibly represents the site of feeders to the PAG komatiites and the gabbro stocks (Schau, 1982, p. 32). Overall, the Central Complex is interpreted as a komatiite volcanic pile which was erupted onto an unknown substrate, although the petrochemical study (below) strongly suggests contamination by a substrate of zinc-bearing supracrustal rocks. Some (or much?) of the Brown River Gneiss may also have been present as basement further below the supracrustal substrate. Only the very latest stage of the volcano records magmatic differentiation, expressed as the thin basaltic komatiites and the local felsic centre.

The volcano was mainly subaerial with minor marine incursions recorded by interpreted pillows. Transgression after volcanism is recorded by the iron formations, quartzarenites and psammites which overlie the komatiites.

The volcanic pile was then folded into a very large, tight, northeast-trending anticline, as suggested by the steeply dipping, regionally opposed younging directions and compositional changes summarized above. Additional smaller folds may also be present, but outcrop is insufficient to define them. The kilometre-scale fold pattern in Brown River Gneiss at locality f may have formed at this time.

North-south ?extensional faulting preserved the komatiites in a graben between tonalites of the Brown River Gneiss. Such folds are part of an array that may have localized mantle-derived feeders to the komatiites, and have since been reactivated several times. The spatial coincidence of the crustally derived Laughland Lake Anorthosite with the southern termination of the north-south faults may also be a result of the anorthosite having being emplaced preferentially into the same structurally weakened area, but at a much later time.

Northeasterly trending dextral shear zones, probably related to and splayed from the Amer Lake Shear Zone, transect the southern part of the Central Complex, but to the north are developed only on the east side of the Complex. This puzzling asymmetry may be a result of dextral shear being transmitted for short distances along previously developed north-south faults before resuming their northeasterly trajectories.

Western Area

In the far west a southwesterly to southeasterly curved belt comprising 1 to 2 km of ultramafic schists with intercalated iron formation, outlined by discontinuous decametre-thick quartzarenites and enveloped in biotite psammite, is interpreted as a refolded isoclinal fold. To the southeast, the following apparently homoclinal southeast-dipping sequence is faulted to the southeast against a foliated tonalite pluton (B3):

- 20 m magnetite iron formation (at base).
- 250 m covered.
- >15 m ultramafic schist.
- >60 m fine-grained amphibolite.
- ~750 m gently-dipping silver to grey sericite phyllite with white quartzarenite subunits.
- ~750 m complex of biotite psammite with subordinate iron formation, sericitic quartzite, dense aluminous rusty rock, interlayered recessive brown carbonate / mafic schist, and a gabbro sill (cf. Table 4 of Schau, 1982).
- ~500 m southeast-facing komatiite flows pinch out to the west into biotite psammite; are possibly represented to the northwest by brown carbonate and mafic schist at top.

In the far northwest, open angular folds in psammites and iron formation are truncated by a foliated granite which resembles the A'granite suite, and has previously been mapped as part of the Northern Walker Lake Gneiss (NW)

Southwestern Area (Fig. 4)

The western part of Fig. 4 illustrates a northeast-plunging antiform in biotite psammite, cored by an oval A' granite. The moderately dipping psammite contains minor pyrite-chert and garnet-amphibole iron formation, and discontinuous lenses of fine-grained amphibolite and quartz-phyric leucogneiss (meta-volcanics?). Foliation is sub-parallel to bedding.

East of the antiform lie three structurally repeated, north-trending belts of steeply dipping komatiite, amphibolite (metabasalt?) and iron formation separated by psammite. Fold closures are interpreted from map patterns and high cleavage-bedding angles in psammites.

Farther east a northerly fault truncates a syncline with limbs defined by a unit of paired iron formation and fuchsitic? quartzarenite in psammite. A second exposure of quartz-phyric leucogneiss is south of the iron formation. The only two conglomerate units in the study area outcrop at locality cgl.

Quartzite Hill (Fig. 3)

Quartzite Hill may be either a bent isocline (Jefferson and Schau, 1992) or a bent homocline with remarkably blunt lateral terminations (Chandler et al., 1993). A 100 m-thick fining-inward quartzarenite zone with inward-facing cross beds was used by Jefferson and Schau (1992) to define a core isoclinal syncline on Quartzite Hill. The thick-bedded, massive- to cross-bedded, vitreous-white quartzarenites grade inward to tabular, decimeter-bedded quartzarenites with mm-cm muscovitic partings every 5-10 cm. These in turn grade inward to thinly bedded very fine-grained, laminated muscovite green and hematitic red quartzites which form the core of the syncline. The thinly laminated beds, are intensely crenulated and contain lenticular mylonitic laminae.

The red hematitic zone along the syncline axis is most intense in the thin bedded, fine grained and muscovitic stratigraphic units. Thinly laminated strata here are hematitic in layers several metres thick. In tabular bedded strata near the axis, alternating intense red and white colouration outlines layers a few cm thick parallel to the thin bedding. A fainter red hematitic colouration is disseminated in thicker, more vitreous quartzite layers in the same vicinity. Some hematite is earthy and postdates the metamorphic micas. It may be a product of alteration during late, more brittle stages of deformation which preferentially affected thinner bedded strata.

The presence of numerous west-facing crossbeds in vitreous quartzarenites west of the hematitic core zone was used by Chandler et al. (1993) to suggest that the core syncline may be only a minor fold, with the overall quartzarenite sequence younging mainly to the west. Hematitic mylonitic quartzites similar to those at the core were mapped on the west side of Quartzite Hill, compatible with the concept of overall westerly younging with minor structural repetition. The cryptic nature of the laminae in these vitreous quartzarenites means that facing directions could not be determined at frequent enough intervals to resolve the two interpretations of Quartzite Hill, although observations in the southwestern and western areas clearly indicate large isoclinal folds..

A mineral foliation sub-parallel to bedding is most intense along the syncline axis, in a laminated quartzite phyllite, and on the west side of the Quartzite Hill in similar phyllites, possibly the anticlinal complement. The fabric is weak in thick bedded quartzites and metavolcanic rocks in the same vicinity. The fabrics clearly predate a NE-trending steeply dipping crenulation cleavage. A stepped, subhorizontal mineral lineation is developed only on the surfaces of thicker quartzite beds and is possibly related to flexural slip during folding (kinematics require investigation). A steeply SW-plunging mineral lineation penetrates both the vitreous quartzites and the laminated rocks.

Relatively younger, more open folds in the Quartzite Hill area trend NE, refolding the earlier structures and forming Type 2 interference patterns at the north end of Quartzite Hill. These steeply plunging folds are associated with locally intense zones of NE-striking, sub-vertical crenulation cleavage.

Surficial Geology

The Quaternary geology of the Laughland Lake area has been mapped by Thomas and Dyke (1981), and the adjoining area to the east by Smith (in Jefferson et al. 1991). The bedrock is extensively mantled (>90%) by a rich variety of glacially deposited material and their post-glacially reworked products.

Glacial-Constructional Landforms: Paleo-Ice-Flow Indicators

Glacial-constructional deposits range from a thin veneer of till on broad uplands to thicker deposits under swampy tundra meadows, and tails of till developed on the north-northeast side of striated and glacially fluted outcrop crags. The quartzites have sustained the highest glacial polish and the finest development and preservation of striae. All of these constructional features record north-northwesterly ice-flow directions.

The tails of till through much of the area are remarkably long (.5 to 3 km) and slim (~100 metres), and are interpreted as formed by fast thin ice during the last stages of glaciation.

The crags expose amphibolite, quartzite, parts of foliated to massive large intrusions, komatiite, and magnetite-quartz iron formation. The large granitoid plutons also form domal hills thinly covered by till.

Glacial-Fluvial Landforms: Surficial Aggregate Deposits of Deglaciation

Recessive units in addition to all other bedrock units in Laughland Lake map area are best exposed in topographic lows where glacial-fluvial meltwater channels have sorted and/or removed glacial tillrecording northerly flow. Many outcrops are in glacial meltwater channels, a lesser number in Recent fluvial systems, and a few at heights of land. Systems of kames, eskers and meltwater channels indicate that major meltwater flows were toward the north and northwest. Southeasterly flows are suggested only in the southeasternmost part of the Brown River valley.

A train of angular debris in the valley immediately west of "a", on the SE side of the Laughland Lake Anorthosite, terminates abruptly at its SE end and is associated with a kame-esker system. Large blocks of anorthosite sit on Brown River Gneiss and were derived from the W-NW. The debris is interpreted as deposited by a SE-directed mass flow, possibly originating from a broken ice dam.

Large fields of rounded boulder deposits, several metres thick with little or no fine-grained matrix, are spatially associated with meltwater channels, preserve very large channel forms visible from the air, and are interpreted as the beds of large meltwater streams which removed sand and clay from till, leaving extensive boulder fields as lag deposits.

Post-Glacial Deposits

Post-glacial fluvial processes have had little effect on the landscape compared to the immense flow volumes and velocities of the fluvioglacial waters produced during melting of the Laurentide ice mass. The main fluvial flow in the Laughland Lake area is now southeasterly into the Brown River valley, opposite to the syn- and immediately post-glacial flows.

Recent high-velocity winter winds have been reworking the finer sand deposits, particularly along the Brown River system, creating large blow-outs and sand-covered stretches of tundra trending toward the SSE.

BEDROCK OUTCROP GEOCHEMISTRY

Trace Element Analyses

A variety of bedrock types, especially all known mineral showings, all sulphidic rocks (generally gossans), all facies of iron-formation, and the komatiites were sampled for lithogeochemistry. The grab samples were cut or broken to less than 50 gram portions which were sand blasted before pulverizing in ceramic mills (GSC) or metal puck mills (laboratories outside GSC). Specific analytical methods are listed with each set of results in Appendix I. Digestions for trace element analyses were done outside the GSC, using partial extraction methods, in order to determine the metal contents of potential ore minerals. Major elements which are listed together with trace elements in Appendix I are only from partial extractions and should not be used for nrmative calculations.

Selected samples of komatiites and other mafic to ultramafic rocks were analysed in GSC's Analytical Chemistry Subdivision for whole rock and rare earth elements, to support petrochemical studies by K.L.Fitzhenry and L.J.Hulbert. The method at GSC ensured total dissolution of the complete pulverized aliquot.

Quartzarenite samples that returned elevated results in gold were probed to determine the setting and texture of the gold. Olivines and chromites in selected komatiite samples from the Central Complex were probed for base metal contents as a means of inferring their degrees of crustal contamination and, hence, mineral potential.

Elevated geochemical results are summarized and interpreted below by area of context, and in order by year and station number/letter. All locations are shown on Fig. 8 and details are shown in appropriate area maps. Appendix I lists exact rock sample locations in UTM coordinates, as well as the complete results of analyses on each sample. Abbreviations and codes are explained in Appendix IV. The results of till samples are interepreted in a separate chapter.

Autoradiographs

Fourteen samples of gossanous quartzarenite, quartz pebble conglomerate and other rock types containing sulphide minerals +/- elevated gold were selected for polishing and production of autoradiographs to check for possible uranium mineralization. The samples were ground flat (but not polished), then placed on X-ray film for one week before developing. The sample results were negative except for suggestions of weakly radioactive heavy minerals like zircon; a list of samples with descriptions is included in Appendix I(i).

Elevated Geochemical Results, Central Complex (Fig. 4)

Sample 74EL246 is a relatively fresh-appearing orange weathering cumulate portion of a komatiite flow in the northern part of the Central Complex. It was one of a few 1991 samples which were analysed four times for gold in the process of determining all other trace elements, and comparing methods. Results were as follows: Neutron Activation (NA): 15 ppb; Fire Assay (FA): 11 ppb; FA: 3 ppb (Appendix I(c), I(g)) and FA: 65 ppb. This variation may have been caused by the nugget effect, but the last re-analysis was part of a repeated complete batch, with the most care and accuracy suggested by the standards. The repeat had been requested because the previous results of the same batch had returned unacceptable results on blind standards. Previous to the last (65 ppb) result, no attention had been paid to this sample, but now it is

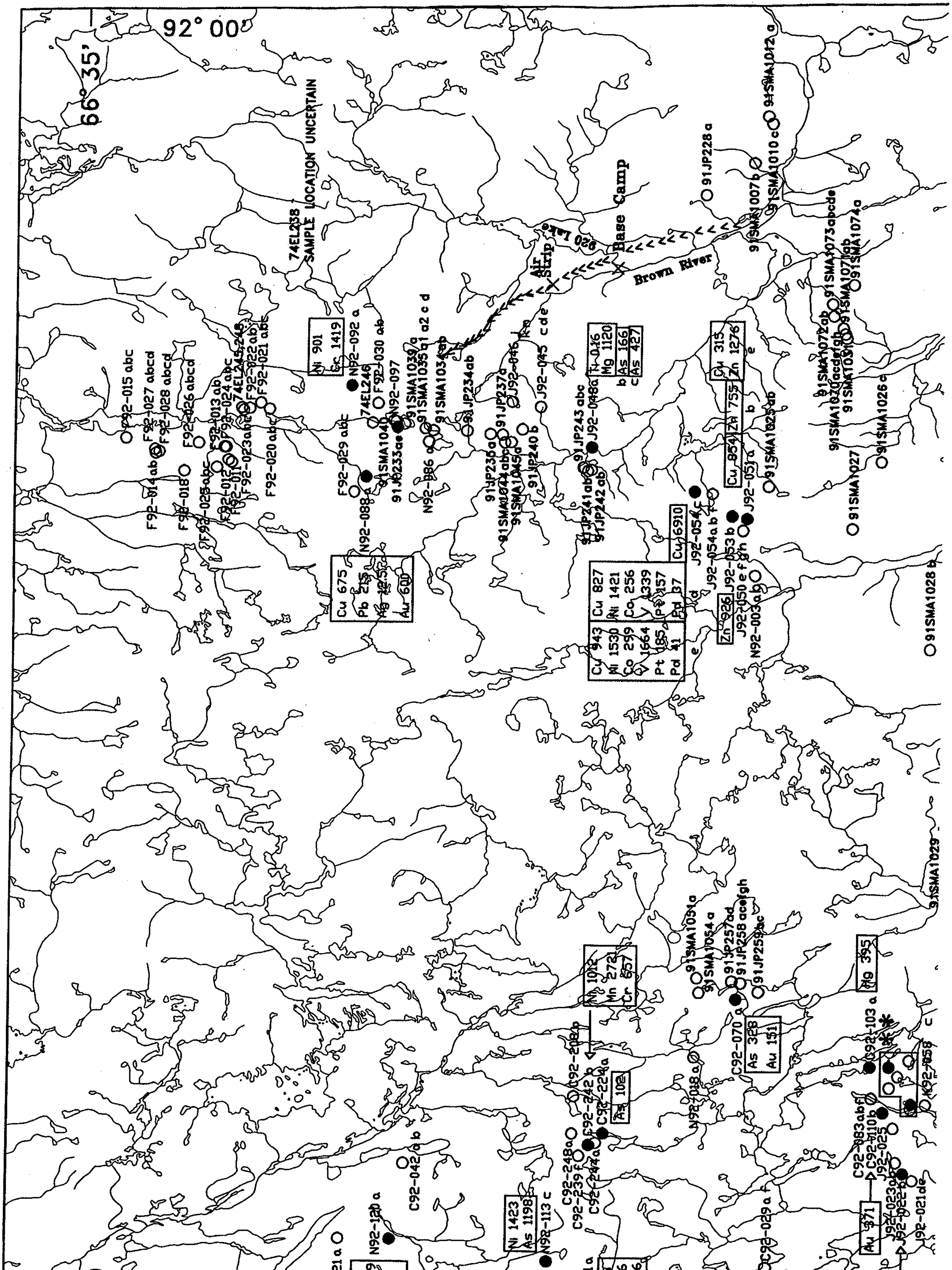

Fig. 7 North Half.

Fig. 7 South Half.

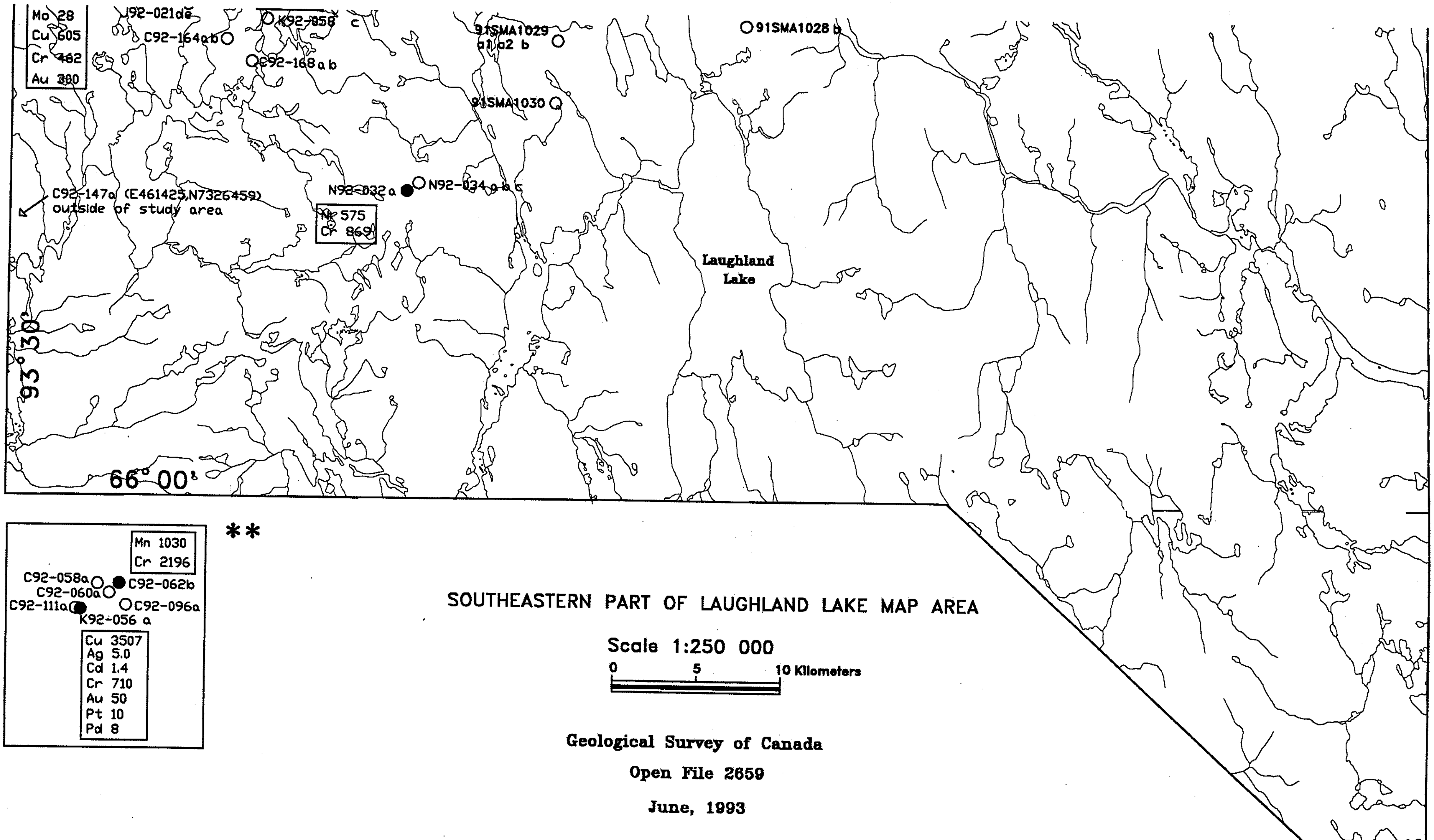

Figure 7. Locations (○) and elevated results (●) of rock geochemical samples. Results are in ppb for Au, Pt, and Pd; all others are in ppm. All other results are listed in Appendix I.

considered to have slightly elevated gold which perhaps warrants prospecting its locality for other evidence of mineralization. The results of ***Sample 91JP242B*** (orange cumulate transected by dolomite veins) are similar to, but more consistent than those of 74EL246: NA: 21 ppb; FA: 21 ppb; FA: 42 ppb; FA: 38 ppb. This sample was taken from near the eastern fault contact of the southern part of the Central Complex.

Sample 91JP233E (160-177 ppb Au), a rusty garnet-muscovitic schist with disseminated euhedral pyrite, was one of a series taken from a traverse recorded on airphoto A14824-70, west of a small lake, just north of an isthmus which separates it from a paired lake to the south. Sample 233E was taken from a north-south elongate zone of gossan, mostly expressed as orange frost boils of till which carry mainly angular fragments like 233E and erupt through felsenmere of foliated tonalite and rounded glacial erratics. The monolithologic and angular character of the mylonite fragments in the orange frost boils suggests that sample 233E is representative of bedrock beneath the gossan. The elevated gold result was duplicated in a repeat analysis that also confirmed no other elements are appreciably elevated.

The traverse crossed, from southwest to northeast, a series of discontinuous solid and heaved outcrops and felsenmere which suggest a sheared contact between Brown River Gneiss and Prince Albert Group komatiites:

91JP233A: foliated pyritic granodiorite gneiss with 56 ppb Au,
233B: mylonitic pyritic granodiorite gneiss,
233C: leucocratic mylonite of interpreted tonalitic protolith,
233D: pyritic leucocratic mylonite of interpreted tonalitic protolith,
233E: pyritic muscovitic leucocratic mylonite of possible tonalite or psammitic origin with 160-177 ppb Au, and
91SMA1040/92JPN097: a large glacially rounded knob of interlayered light and dark mylonites and fine-grained intensely foliated pyrrhotitic hornblendite, transected obliquely by mylonitized pyritic aplites. The protoliths of the mylonites and hornblendite on this knob are tentatively interpreted as komatiite, tonalite and gabbro.

This fault zone has also been interpreted as an unconformity between the Brown River Gneiss and Prince Albert Group by Schau (1982) who interpreted the leucocratic mylonites as metasedimentary rocks. Jefferson and Schau (1992) reinterpreted the same rocks as mylonites. The similar, relatively low SiO^2 contents (56-72%) of the mylonites and the tonalites are compatible with the tonalite protolith, as is the elevated (50 ppb) gold in the foliated pyritic tonalite (233A) which grades into mylonite. A psammitic protolith for some of the mylonites is not ruled out. Further discussion of the regional nature and interpretation of the north-south fault zone is provided in STRATIGRAPHIC - STRUCTURAL RELATIONSHIPS above.

The elevated gold is interpreted as not highly anomalous, but as an indication that gold was mobile in the north-south shear zone. The coincidence with euhedral pyrite suggests that the gold was introduced together with sulphur (and iron?) into the mylonites and tonalite during relatively late, brittle deformation of the fault zone. The north-south fault zone is thus permissive for shear-zone-related gold deposits, provided that the appropriate structural and chemical host rock environments (e.g. brittle structures and/or iron-rich rocks) are present.

Sample 92JP-054C (6910 ppm Cu) is from a drilled showing (previously the HAR claims) of pyrrhotite-pyrite + 20% magnetite schlieren in an intensely strained, 20 m-thick amphibolite which is exposed in three north-northeast-elongate hills with parallel intense foliation. A boulder filled stream gully and considerable till cover separate these outcrops from the anorthosite to the east. Transecting minor chalcopyrite veinlets are visible in hand specimen. A maximum of 0.6% copper in drill core assays was reported by Boerner (1971, 1972). It is not clear whether the intense aeromagnetic anomaly in this vicinity is a result of this unit, or a magnetite quartz iron formation located 500 metres to the west, or both. Along strike to the south-southwest, a number of gossans are associated with low outcrops of intensely rusty weathered, highly foliated rock of amphibolitic appearance (92JP-51, 53). The southern of these (51) is part of a series of outcrops that provides a near-continuous cross-section through quartzites, sericite phyllites, biotite psammites and fine-grained intensely foliated amphibolites into the anorthosite. Sections of these supracrustal rocks are mylonites; one appears to be a mylonitized tonalite or felsic volcanic rock. The amphibolites which border and grade into the anorthosite are more competent and resistant weathering than those to the west, but also are intensely foliated and contain c/s fabrics with extension lineations that indicate vertical, west-side-down shear.

In polished thin section, a series of grab samples representative of the drilled, hill-forming, gossanous amphibolites show considerable compositional variation. Samples 92JP054A,B,C (476, 630, 6910 ppm Cu) comprise massive interlocking hornblende with interstitial saussuritized feldspar and disseminated magnetite euhedra, intermixed and invaded by abundant pyrite and pyrrhotite (altered to marcasite) containing minor blebs of chalcopyrite. Large patches also of saussuritized feldspar and sphene replace hornblende and magnetite. Quartz is a minor constituent closely associated with the sulphides. Chalcopyrite also fills common very thin veinlets transecting all other minerals, approximately perpendicular to the foliation. In sample 54F polygonal quartz is abundant, hornblende and sphene are major components and the same opaque minerals are present but in minor amounts. In samples 54D (827 Cu, 1421 Ni, 1339 V, 157 ppb Pt, 37 ppb Pd) and 54E (943 Cu, 1530 Ni, 1664 V, 185 ppb Pt, 41 ppb Pd) the sulphides are massive, forming a network enclosing the silicates. The mineralogy of these samples is the same as the others, with the addition of 0.2 x .05 mm blebs of a pink anisotropic mineral ?pentlandite? (not probed) within magnetite.

The low, gossanous-weathering amphibolitic-appearing outcrops (92JP051, 053) are actually highly weathered sulphidic mylonites comprising 60-70% quartz with 10-20% biotite, chlorite and magnetite; invaded and included in 20-30% 0.1-.5 mm poikilitic pyrrhotite euhedra. Minor to locally abundant silicate minerals include garnet and dark green tourmaline. Chalcopyrite forms 5% blebs within pyrrhotite, is complexely intergrown with pyrrhotite associated with mgt (replaces Pyrrhotite?), and is rarely within the silicate minerals. Magnetite forms large octahedral crystals which crosscut the mylonite fabric but are, much altered and partially replaced along the outside and along crystallographic planes by pyrrhotite. Magnetite also forms tiny euhedral laths which crosscut the silicate foliation, and are in turn enclosed and invaded by pyrrhotite. The chlorite is concentrated in and oriented parallel to mylonite laminae, together with polycrystalline (recrystallized) cloudy plagioclase porphyroclasts. The chloritic laminae are crenulated. The 755 and 1276 ppm Zn reported in samples 51B and 51E are assumed to be in sphalerite, but none was observed in the polished sections. Sample 51E also has a spongy textured sulphide enclosed by the pyrrhotite - an earlier pyrrhotite?

Boerner (1971) interpreted the drilled, hill-forming gossanous amphibolite as a mineralized gabbroic marginal phase of the Laughland Lake Anorthosite. This interpretation is favoured by its nearness to the anorthosite, by the presence of other similar amphibolite bodies extending out from the northeast side of the anorthosite, and by the elevated nickel, cobalt, vanadium and platinum which suggest a magmatic origin. Alternatively the showing may be a hydrothermally altered magnetite-silicate iron formation which was tectonically mixed with a hydrothermally altered metagabbro sill (amphibolite) which had been intruded into a sedimentary environment. This interpretation is favoured by the abundance of magnetite and locally abundant quartz within the amphibolite, and by its association along strike with mylonitized metasedimentary rocks which also contain elevated copper (but zinc instead of nickel). In either case, the resistant amphibolite appears to be a boudin within the major northeast-trending shear zone that transects the southern end of the Central Complex. Perhaps both magmatic and sediment-hosted styles of mineralization are tectonically juxtaposed here. In any case, the PGE values are an order of magnitude higher than any others obtained in our study and are considered to be a result of magmatic processes.

Sample 92JP048A,B,C (high magnesium and arsenic) is from a series of low outcrops along the sandy stream which is the western headwaters of Brown River. The outcrops are laminated magnetite chert iron formation transected by minor arsenopyrite veins, and account for the intense aeromagnetic anomaly here. There is no evidence of precious metal mineralization in these outcrops.

Sample 92JPN-088a (600 ppb Au, 12.5 ppm Ag, 675 ppm Cu, 215 ppm Pb) is one of a series of rusty, sparsely sulphidic, massive quartz veins up to several cm across, which transect interbedded ultramafic volcaniclastic rocks and biotite psammites, in turn interlayered with rusty metakomatiite flows. This sample was not examined petrographically because of the sparse sulphides. This locality is close to a north-south fault zone shown by Schau (1982) and warrants further detailed investigation for volcanic-associated vein and shear zone gold.

In summary, elevated geochemical results for gold are spatially associated with fault zones. The results are not highly anomalous but consistently suppport the concept that gold was mobilized in the vicinity of the north-south fault zones which cut or mark the margins of ultramafic units.

Elevated Geochemical Results, Quartzite Hill (Fig. 3)

Sample 92-CGA-070A (150 ppb Au) was taken from a low gossanous outcrop of quartzarenite on the western flank of Quartzite Hill. The gossanous pyritic zone appears to be bedding parallel and about 15 cm thick. The enclosing quartzarenites (92CGA70B) are weakly rusty to light grey weathering, pale grey fresh. Compositional layering is defined by grey laminae which, in thin section, are rich in chlorite, sphene and muscovite (not heavy minerals).

The hand sample containing the gold is very rusty and crumbly weathering, grey with abundant flecks of pyrite, quartz granulestone. In polished thin section, the quartz granules are composed of intensely strained equant polygonal quartz. The granules are elongated 2:1 to 4:1 and separated by pressure solution cleavage marked by chlorite and muscovite. Chlorite is retrograde, randomly to weakly oriented parallel to grain elongations.

The pyrite grains range from small (0.1mm or smaller) to large (1-2 mm) euhedra, of the same order of size as the granules of polygonal quartz (1-5 mm) but not perhaps of paleo-hydrodynamic equivalence. The pyrite euhedra clearly crosscut the metamorphic-tectonic fabric. The pyrites are poikiloblastic, containing abundant blebs of pyrrhotite, single to polygonal grains of strained metamorphic quartz, and minor irregular blebs of chalcopyrite, all ranging from 0.1 mm to sub-microscopic.

Scanning electron miscroscopy detected three points of native gold in one section but the gold could not be identified optically, nor could its mineralogical association be determined. Probing confirmed the chalcopyrite within the pyrite. Many pyrites are weathered, most plucked so perhaps gold was "removed from the polished thin section" but there is no proof of the mineralogical association of the gold. Autoradiograph of the auriferous sample did not detect any radioactivity. This location may be a candidate for clastic sediment-hosted gold or pyritic paleoplacer gold.

Elevated Geochemical Results, Southwestern Area (Fig. 5)

Sample 92-CGA-110B (371 ppb Au) is an iron formation taken from the low, west side of a prominent knob of ultramafic schist, on the west side, north end of a long narrow lake, approximately at the centre of air photo A15740-73. The sample is very dark rusty weathering and dark green-grey on the fresh surface. Coarsely crystalline grunerite and pyrrhotite crosscut metachert-magnetite iron formation laminae. The host iron formation (92CGA110A) is finely interlaminated: 20% magnetite, 30% polygonal qtz (metachert) with 50% hornblende in reaction zones between the magnetite and quartz laminae; in many laminae all of the quartz has been converted to hornblende. The main fabric is expressed by flattened quartz, magnetite and pyrrhotite oriented perpendicular to laminae. Minor tiny pyrrhotite blebs are sparse in the magnetite.

The obviously crosscutting mineralized zone (92CGA110B) contains much coarse pyrrhotite with cracks altering to marcasite. Some small grains of chalcopyrite are dispersed in the pyrrhotite. Very coarse, abundantly twinned grunerite invades and crosscuts the pyrrhotite which is concentrically poikilitic, with quartz inclusions concentrated in circular zones and oriented tangentially. The coarse grunerite is randomly oriented, crosscutting the quartz mineral foliation. Parts of the large pyrhotite grains appear to crosscut in turn the grunerite and are cracked and transected by marcasite-hematite weathering rinds. Irregular chalcopyrite blebs within and at the margins of large pyrrhotite grains are not altered to marcasite but are transected by cracks and hematite rinds.

Sample 92-JPK-056A (3507 ppm Cu, 5 ppm Ag, 50 ppb Au, 10 ppb Pt) was taken from the top of a massive knob, at the north end of continuous outcrop which forms a narrow isthmus between a long north-trending lake and a smaller oval lake (north-centre of air photo A15740-72). The outcrop is not noticeably rusty. The hand specimen is dark green, rusty-brown-green weathering, fine-grained, massive amphibolite with abundant finely disseminated pyrrhotite containing chalcopyrite.

The geological context of samples 56A and 110B is summarized in Figure 5. Both samples are close to the junction of two discontinuously exposed belts of paired ultramafic schist and iron formation, the long one the west being interpreted as continuous, and the belt to the northeast interpreted as the faulted eastern limb of a syncline. Just north of 56A the outcrop is a whaleback shape and consists of interlayered meta-ultramafic schists and amphibolites (92CGA081). The massive amphibolite knob of 56A is surrounded by low outcrops of highly foliated ultramafic schist. Other knobs to the south are also cored by massive amphibolite and surrounded by foliated ultramafic schists along the length of the isthmus. This alternation is broken by massive quartzarenite at the highest point on the isthmus; some well laminated amphibolitic quartzarenite or metachert is exposed at water level on the west side of this quartzarenite.

The mineralization of the amphibolite and iron formations in these adjacent localities is interpreted as a result of their relative competence, their iron-rich compositions, and their positions within or close to a high strain zone. These competent and chemically reactive units would have sustained dilatant fractures along which fluids and alteration could have proceeded, bearing precious metals with them. In contrast the schistose ultramafic rocks which surround the amphibolites would have flowed under stress, and sustained few open fractures. The main significance of the elevated gold values is the demonstration that gold was mobilized in this area, and potential is good for mineralization of iron formations or other suitable hosts that intersected the high strain zone. The lack of ore-grade geochemical results is not considered discouraging, considering the reconnaissance nature of the sampling.

Sample 92CGA103A (395 ppm Hg) is a fine-grained massive amphibolite containing disseminated pyrrhotite and magnetite, with zones of coarse garnet. The sample is associated with amphibolite - pyrrhotite - magnetite iron formation, situated at the interface between thin komatiite and fine-grained amphibolite interpreted as mafic metavolcanic rock. The sample is not itself gold bearing but the abundance of mercury is one of the tell-tale signs of the kind of hydrothermal processes that may have carried gold. This adds to the above evidence suggesting high potential for precious metal mineralization in the Southwestern Area.

Elevated Geochemical Results, Western Area (Fig. 3)

Sample 92JPN120A (181 ppb Au, 91,449 ppm As, 206 ppm Cu, 15 ppm Hg, 822 ppm W) is a heavily sulphidized biotite-garnet-magnetite-arsenopyrite-quartz iron formation which is interbedded with lean, grey, biotite-magnetite-quartz-amphibolite iron formation and hosted by grey biotite-garnet-quartz schist (ferruginous psammite?). This iron formation is exposed on the northwest side of a north-flowing stream, and is the only one of a number sampled in this area which returned elevated gold. This northwestern corner of the map area is one of the few large areas of relatively well exposed biotite psammite. The iron formations in this psammite, though magnetite-bearing, do not have an identifiable aeromagnetic response on the published maps (Geological Survey of Canada, 1977). No iron formations were observed on the southeast side of the stream in the psammites. The angularly folded psammites and iron formations are truncated on the northeast by foliated granite (NW, Northern Walker Lake Gneiss), appear to wrap around a foliated tonalite to the west (B, Brown River Gneiss), and flank a northeast-trending belt of quartzarenites and komatiites on the southwest. Their contact with the Kuagnat Gneiss on the northwest is not exposed, but was interpreted by Schau (1982) as a fault or high strain zone. This locality holds promise for further detailed investigation.

Samples 92JPN106a (344 ppm As) and ***92JPN111a*** (376 As, 945 Ni, 936 Mn) are examples of numerous (or structurally repeated?) garnet-amphibolite-magnetite iron formations located within ultramafic schist. Sample 113c is a relatively massive ultramafic schist containing disseminated pyrrhotite. These are all located at the southwest end of a refolded isocline cored by ultramafic schist and iron formation, and outlined by discontinuous quartzarenite. The nickel and manganese values are considered background for this ultramafic setting, as are the arsenic results.

Samples 92CGA224a (pyrrhotitic amphibolite-magnetite iron formation with 102 ppm As), ***242b*** (gossan zone over amphibolitic schistose iron formation with 196 pp Cu, 1012 ppm Ni, 2721 Mn, 657 Cr) ***and 244a*** (pyrrhotitic garnet amphibolite iron formation with 153 ppm Cu, 743 ppm Ni, 2194 ppm Mn and 224 ppm Cr) were taken in the vicinity of the 3-15 by 1500 metre gossan thought to be the KRF showing of King resources (Brisbin, 1970; Laporte, 1974) which returned assays of up to 0.51% Ni and 0.02% Cu. Despite the elevated copper and abundance of the sulphides in these rocks, gold is not elevated in the samples collected for this study.

PETROCHEMICAL STUDY OF THE CENTRAL KOMATIITE COMPLEX

Purpose

Petrochemical study of the komatiites in the Central Complex was required in order to quantitatively compare them to ore-bearing and non-ore-bearing komatiites found in the Kambalda District of Western Australia, and other parts of the world. Such studies of ultramafic rocks are extremely useful to regional-scale resource assessments because if the results are clear (as they are in this case) they characterize the mineral potential of the entire magmatic suite (the entire geological domain) with considerable confidence. The confidence in applying petrochemistry to ultramafic-hosted deposits is greater than similar studies of other deposit types, because the magmatic processes that give rise to ultramafic rocks are relatively closed systems that respond in a relatively predictable and traceable way to cooling and contamination in the upper crustal and surficial environment. The source and host rocks are the same.

Other ore-generating processes such as for gold and sediment-hosted base metals have many more variables, including uncertain source rocks and a variety of potential hosts, and can therefore only be assessed (at our present state of knowledge) by finding clues directly associated with the deposits and showings themselves.

Methods of Investigation

In komatiites, documentation of field characteristics, petrology and geochemistry permits interpretation of changes in melt composition upward through the stratigraphic sequence. Sulphur, nickel, magnesium and rare earth elements especially are compared within this sequence and with those of other komatiites, to assess whether the komatiites were contaminated by crustal sulphur, and thus whether nickel, copper and other chalcophile elements are likely to have segregated into massive sulphide deposits in the Laughland Lake area.

Part of the Central Complex (Figs. 3, 4) was mapped in August 1991 by C.W. Jefferson and Mikkel Schau, and in the remainder July and August of 1992 by K.L. Fitzhenry, C.W. Jefferson, F.W. Chandler and S. Nacha. After initial bedrock mapping of the komatiites, samples were taken from a series of outcrops transecting 7.5 km of the northern part of the Complex.

In the laboratory, about 50 thin sections were studied petrographically. Geochemical analyses were obtained for 56 samples (Appendix I) which were taken by O.R. Eckstrand in 1974, C.W. Jefferson and Mikkel Schau in 1991, and K.L. Fitzhenry in 1992. Six olivine grains and 17 chromite grains were analysed by electron microprobe. The results were compiled and interpreted by K.L. Fitzhenry (1993) as a B.Sc. thesis under the supervision of H. Helmstaedt (Queen's University), L.J. Hulbert and C.W. Jefferson. The following chapter was adapted from the thesis.

Previous Work

Previous regional geological studies are summarized above, in the INTRODUCTION. The history of mineral exploration is provided below, in the ASSESSMENT OF MINERAL AND ENERGY RESOURCE POTENTIAL. The ultramafic rocks were first described and recognized as komatiites by Schau (1974, 1975a, 1977) and by Eckstrand (1975) who recognized their high potential to contain nickel and copper deposits and noted similarities to ultramafic rocks containing nickel sulphide deposits in a number of terranes including the Abitibi Greenstone Belt in Ontario and Quebec, the Yilgarn and Pilbara blocks of western Australia, and the Rhodesian Craton. Eckstrand (unpublished notes, 1974) also contrasted the Prince Albert Group metallogenically with the Thompson Nickel Belt. Fryer and Jenner (1978) further documented the petrochemistry of komatiites north of the study area, on Western Melville Peninsula.

Annesley (1981, 1989) mapped and studied the petrochemistry of the komatiites in the Woodburn group, although he did not pursue the crustal contamination issue and did not assess their economic potential (see comparisons with PAG in SUMMARY OF STRATIGRAPHY AND TECTONICS below). More detailed maps and descriptions of field characteristics of the komatiites in the Laughland Lake area were made by Jefferson and Schau (1992) and Chandler et al. (1993).

Definition and Classification of Komatiites

The term 'komatiite' was first coined by Viljoen and Viljoen (1969) for ultramafic lava flows associated with mafic flows in the Barberton Mountain Land, South Africa. They claimed that the Barberton komatiites were distinguishable on the basis of their "extrusive origin" features (chilled flow tops, spinifex texture and pillow-like structures) as well as chemical characteristics such as high a Fe/Mg ratio, low SiO2 and alkali elements and especially high CaO/Al2O3 ratios (Ardnt et al., 1977).

Subsequent work by Brooks and Hart (1974) led to the definition of a komatiite based purely on the following chemical criteria: SiO2 <53%, MgO >9%, K2O and TiO2 >0.9% and CaO/Al2O3 >1. With the discovery of other komatiitic occurrences in Canada, Zimbabwe, India and Australia that were not exact chemical prototypes of the Barberton komatiites, the strict definition had to be altered. The revised definition of a komatiite is an ultramafic rock with >18% MgO and recognizable textures and structures indicating an extrusive origin. Several authors have suggested a further breakdown of komatiites into smaller divisions based on % MgO content.

Field Characteristics of the Komatiites in the Central Complex

The komatiites located in the central complex can be described as "fairly underdeveloped typical Munro Township" komatiites (Fig. 6). Although the spinifex and cumulate zones can be distinguished in every flow, the smaller B subdivisions (B1-foliated skeletal olivine and B3- knobby peridotite) are only rarely seen. Eckstrand (pers. comm., 1993) has indicated that the lack of these zones is not critical, because at Munro Township, B1 is common but not ubiquitous and B3 is uncommon to rare. Flow thicknesses range from 3-4 m throughout the section. Komatiites located elsewhere in the Laughland Lake area are poorly preserved, being intensely deformed and altered.

Rare but distinct flow top breccias locally indicate stratigraphic tops. The best example occurs in an overhanging bluff at station 92JPF-023 (Appendix I(j)) on the underside of a cumulate zone (Plate 1 of Fitzhenry, 1993). Yellow, rusty material outlines large (approximately 20-25cm) round "blocks" inside of which are smaller, rounded to sub- rounded "clasts" (which may be hyaloclastite). Clast sizes range from a maximum of 6x3cm to a minimum of 0.5x0.5cm but average 3.5x2cm. Clasts are surrounded by a black, vesicular "pseudo-matrix" (Plate 2 of Fitzhenry, 1993). The entire zone is approximately 5cm in stratigraphic thickness where it us abruptly overlain by an orange-weathering cumulate zone.

One flow (at 92JPF-027) exhibits a "flow top" in the form of polygonal joints. Fragments are angular in shape, with the matrix between them weathered out. The weathered surface has a scoriaceous texture (Plate 3 of Fitzhenry, 1993).

The spinifex zone is light bluish green on fresh surfaces. It weathers dark green but, locally, (station 92JPF-027) it weathers brownish orange, much like the cumulate zone. Spinifex blades are visible in nearly every flow and range in size from 2 to 20cm, most being 3-4cm. Locally (station 92JPF-022) loose blocks of spinifex contain blades up to 50cm in length. Generally, smaller blades cannot be seen on fresh surfaces, but the larger blades are more apparent and exhibit a very light bluish white colour with a black magnetic to non-magnetic material in between.

In other komatiitic sequences described in the literature, a zone of smaller spinifex blades is just below the flow top breccia (Fig. 6). This apparent gradation from smaller blades (0.5-1cm) downward to the larger "average" blades (3-5cm) was seen only in two flows by the writer and was noted in the southern part of the central komatiite belt by Jefferson and Schau (1992), where facing directions based on this criterion are southeasterly.

In approximately 95% of all flows examined, the flow top breccia and the upper spinifex zone discussed above are missing from the sequence. Their absence is interpreted as a result of either atmospheric erosion between flow events or thermal erosion during eruption of overlying flows. As few interflow komatiitic sediments were observed, the latter explanation is assumed to have been dominant. It is also possible that many of the komatiitic layers are sills.

Spinifex zone thickness is fairly constant throughout the 7.5km measured section. The average spinifex zone is 1.25-1.5 m thick with a maximum and minimum thickness of 2.5 and 0.5 m respectively. The majority of flows have cumulate zones bounded on each side by spinifex zones. On both sides the contact between the spinifex and the cumulate is sharply gradational in a span of 1-2cm (Fig. 6).

The cumulate zone is usually a massive zone within the flow with a weathered surface of orange-brown and a fresh surface of dark grey. The majority of carbonate veins occur within this zone. The light, orange-yellow veins range in abundance from sparse to composing 2% of the rock and in many places appear to be amorphous 'blobs'.

Most of the flows do not exhibit all of the smaller subdivisions which have been identified within the cumulate zone of Munro Township komatiites (Fig. 6). The B1-foliated skeletal olivine zone directly beneath the spinifex zone was observed twice. At station 92JPF-013, the zone of foliated cumulate is about 5-7cm thick (Plate 4 of Fitzhenry, 1993). The B3-knobby peridotite zone could not be distinguished in any flows. The cumulate zone, in general, appears to be massive, fine grained peridotite (B2-B4) with little else distinguishable. Cumulate zone thickness is fairly constant throughout the section with an average of 2-2.5m.

At the highest stratigraphic level sampled for this study (92JPF-015 in Appendix I(j)), an outcrop of lenticular structures with distinct vesicular selvages was documented (Plate 5 of Fitzhenry, 1993) and interpreted as flattened pillows or flow tubes.

Petrography

Thirty-nine samples of the Prince Albert Group komatiites were cut, thin-sectioned and examined for primary/secondary mineral assemblages and textures. The samples represent a systematic sampling of basal cumulate, upper cumulate, spinifex and flow top breccia zones through a stratigraphic section of the central komatiite belt. (See appendix A for sample locations.)

Metamorphism (low to medium grade) has completely altered the primary mineral assemblage. Relict textures in both cumulate and spinifex samples are beautifully preserved (Plates 6 and 7 of Fitzhenry, 1993).

Flow Top Breccias

The flow top breccia hand specimen (F023c) has a fragmented appearance. On the microscopic scale, needles of tremolite and minor serpentine form a mesh texture suspended in an isotropic cryptocrystalline matrix.

Fractures separating the breccia fragments are lined with carbonate and chlorite. Relict igneous textures of olivines and clinopyroxenes (now altered to chlorite) are well preserved. Carbonate and magnetite commonly line the remnant textures but, where these minerals are absent, tremolite grows perpendicular (or sub-perpendicular) to the relict grain boundaries.

Pyrrhotite blebs are randomly distributed throughout the section. Rare chalcopyrite blebs are visible in close association with the pyrrhotite. Thin rims of chalcocite envelop the chalcopyrite grains. Magnetite constitutes the majority of the opaques throughout the section and varies from equant cubes to blebby sub-rounded shapes.

Spinifex Zones

The spinifex zone consists of parallel to subparallel blades arranged in a booklet or sheaflike fashion surrounded by an interblade matrix.

The blades are primarily composed of chlorite with minor serpentine - alteration products of the primary igneous olivine with secondary magnetite outlining the blades (Plates 6 and 8 of Fitzhenry, 1993). Blade thicknesses range from 0.4-0.05mm and usually span the width of the thin section.

The interblade matrix consists of mainly clinopyroxene, chromite and glass that has been altered to tremolite and magnetite. On average, these zones tend to be thicker than the blades. Tremolite tends to be oriented perpendicular to the relict olivine blades. Carbonate is distributed throughout the thin section, particulary along the chlorite- tremolite interface.

Cumulate Zones

The cumulate zone by far depicts the most variation from thin section to thin section, consequently making any generalizations of this zone very difficult. A total range of possible alteration of the primary mineral assemblage exists - from partially altered primary olivines, to completely altered and serpentinized olivines with only relict outline textures remaining, to metamorphic olivines that pseudomorphed primary igneous olivines. Chromites also display various degrees of alteration - from chromite to an intermediary ferrit-chromit stage, to magnetite.

The metamorphic olivines are round to subround, well fractured and brown-yellow in colour (Plates 10 and 11 of Fitzhenry, 1993). Grains range in diameter from 1.5mm to 0.05mm. Chlorite oriented perpendicular to the outer edges forms rims around the olivine grains. Serpentine fills the remainder of open spaces created by the fractures.

Partially altered olivines have a more pronounced brown colour and mottled appearance. Magnetite commonly lines the outer edges of fractures as a product of metamorphic alteration of the olivine. Grains retain their original size and shape, but grain margins are indistinct.

In completely altered samples, the olivine is replaced by intermeshed tremolite needles surrounded by a chloritic matrix. Actual grain boundaries have been completely obliterated but relict grain textures are crudely defined. (Plates 12 and 13 of Fitzhenry, 1993). In several samples, matrix and primary olivines have been completely serpentinized. Minor carbonate is distributed throughout most of the sections.

Cumulate sections contain up to 1-2% pyrite and rare chalcopyrite, but the majority of the opaques are magnetite. Several sections also contain ferrit-chromits - opaques consisting of a small chromite core, a wide ferrit-chromit inner rim and a thin outer rim of magnetite. Ferrit-chromit grains can be differentiated from magnetite by their equant shape and often visible zoning. The chromite core is dark grey surrounded by a lighter grey ferrit-chromit which is in turn surrounded by a still lighter magnetite rim. Where differences in reflectivity cannot be seen, ferrit-chromits are termed "cryptically zoned" if they can be demonstrated to be compositionally zoned (Bliss and MacLean, 1975).

Metamorphism

Most komatiitic suites have undergone some degree of metamorphism. Hydrating and carbonating fluids exchange elements during the breakdown of primary minerals resulting in a chemical alteration of the rock (Gole et al., 1987). The total extent of the changes in bulk rock chemistry is difficult to assess. Mineralogical changes, however, provide insight into the degree to which metamorphic reactions occurred (Evans, 1977).

The majority of the komatiites has been altered to a tremolite-chlorite-magnetite assemblage (Fig. 8A; Appendix I(k)). The highest metamorphic grade attained by the Prince Albert Group komatiites is the amphibolite facies. This is defined by the presence of anthophyllite and the lack of enstatite which provides an upper bounding limit to the metamorphic facies.

A simple interpretation of the metamorphic history of these ultramafic rocks is as follows:

a) Serpentinization of fresh komatiitic flows destroyed primary olivines; secondary magnetite rims around igneous chromites are also a result of serpentinization processes:

$$3Mg_2SiO_4 + 4H_2O + SiO_2 \dashrightarrow 2Mg_3Si_2O_5(OH)_4.$$

b) Increasing temperature and pressure conditions crossing the Di+Atg --> Fo+Tr+V isograd created a tremolite-chlorite-magnetite assemblage (with some antigorite):

$$8CaMgSi_2O_6 + Mg_{48}Si_{34}O_{85}(OH)_{62} \dashrightarrow$$
$$18Mg_2SiO_4 + 4Ca_2Mg_5Si_8O_{22}(OH)_2 + 27H_2O.$$

c) Continuous increase in temperature and pressure caused antigorite to break down to form talc:

$$Mg_{48}Si_{34}O_{85}(OH)_{62} \dashrightarrow$$
$$18Mg_2SiO_4 + 4Mg_3Si_4O_{10}(OH)_2 + 27H_2O.$$

d) The maximum temperatures reached were between approximately 600° and 700°C and, if regional metamorphism is assumed, pressures anywhere from 6.5 to 13 kbars (Fig. 8A) as indicated by the presence of kyanite in the quartzarenite units (D.M. Carmichael, pers. comm. 1993). Talc and olivine were broken down to form anthophyllite:

$$4Mg_2SiO_4 + 9Mg_3Si_4O_{10}(OH)_2 \text{ ---> } 5Mg_7Si_8O_{22}(OH)_2 + 4H_2O.$$

During periods (b) through (d), magnetite rims reacted with chromite cores to produce Al- and Mg- poor ferrit-chromit zones (Bliss and MacLean, 1975).

The lack of enstatite indicates that the temperatures and pressures were not high enough to cross the Fo+At --> En+V isograd, therefore, this is the upper limit to the metamorphic grade.

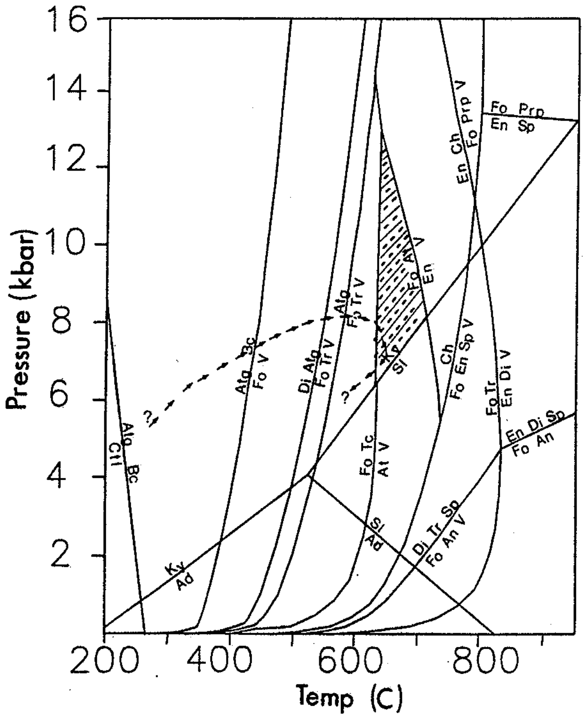

Figure 8A. Temperature-Pressure conditions for komatiites in the Central Complex.

Geochemistry

Fifty-six samples of the Prince Albert Group komatiites have been analyzed for major oxides and trace elements. Twenty of the fifty-six samples have also been analyzed for rare earth element contents. Five cumulate samples were analysed by electron microprobe by K. Fitzhenry - two to determine compositions of olivines and three to determine chromite compositions. Major element, trace element, rare-earth-element analyses and electron microprobe data are presented in Appendix I.

The major problem with studying the geochemistry of Archean komatiites is the fact that they have all been metamorphosed to some degree. The mineral assemblage of the Prince Albert Group komatiites indicates that they are no exception. Whereas it is clear that the rocks have been hydrated and carbonated, it is difficult to establish whether the contents of other constituents have also been affected.

Major Oxides and Trace Elements

The fifty-six samples are subdivided into one of three groups based upon the zone from which they were collected (ie one group - cumulate; another group - spinifex) and their MgO content. Any rock with 10%<MgO<20% is classified as a pyroxenitic komatiite (the third group). This group includes only several spinifex and flow top breccia samples. Samples collected from spinifex zones are termed "spinifex textured komatiite - peridotite" and those from cumulate zones retain their name, often with a B or T to note whether they were collected from the base or the top (respectively) of a flow.

Cumulate samples are the most magnesian of the suite, having MgO>30%. This is the result of the accumulation of phenocrystic, Mg-rich olivine at the base of the flow. Nickel values are generally higher for these zones - typically 1400-2500 ppm because of the ability of the olivine to take the nickel into its structure. Chromium values are low relative to the spinifex textured samples.

Spinifex textured rocks are thought to most closely resemble the original melt composition because they represent the chilled magma as it first erupted. Magnesian values average 28% MgO. Low nickel values indicate that the primary liquid was depleted with respect to Ni, probably the result of scavenging of chalcophile elements by a sulphide phase within the melt. Chromium values are typically between 2700-4800 ppm, the greatest of all three groups sampled.

Pyroxenitic komatiites are depleted with respect to MgO, Ni and Cr but are surprisingly rich in Cu, alkalic (Rb, Na, K) and calc-alkalic (Ba, Sr, Ca) elements. These elements are commonly mobile during metamorphism and, as a result, may have moved out of the cumulates (where few metamorphic minerals were capable of taking them into their structure (Lesher, 1989) and down into the flow top breccias and MgO depleted (pyroxenitic) spinifex zones.

Distribution plots (Figs. 8B-8D) of major oxides are consistent with the crystal fractionation of olivine. Following Bowen's reaction series, clinopyroxene and possibly plagioclase crystallization follow the cessation of olivine fractionation. This is exemplified in the CaO vs MgO, Al_2O_3 vs MgO and TiO_2 vs MgO plots. With decreasing MgO% (ie. decrease and ultimately cessation of olivine crystallization), CaO and Al_2O_3 increase greatly (introduction of clinopyroxene and plagioclase). The TiO_2 mimics the CaO plot as Ti readily substitutes for Si in the clinopyroxene structure (Best, 1982).

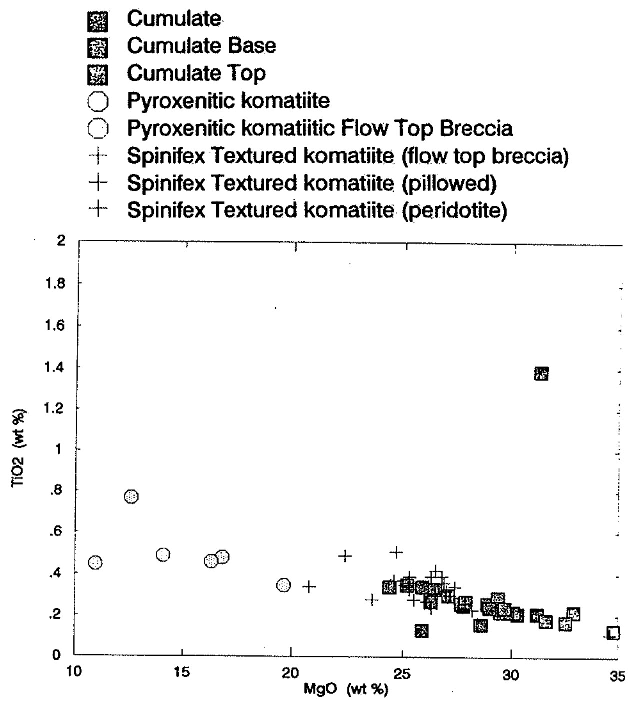

Figure 8B. Symbols for figs. 8B to 8H (4 cm) and distribution of TiO2 vs MgO.

Eckstrand (pers. comm., 1993) has commented that the break in slope between cumulate/spinifex and pyroxenitic komatiites in most plots (Figs. 8B-8G) suggests different processes in these two environments: 1) cumulate/spinifex: differing proportions of olivine and liquid, the latter crystallizing in situ; 2) pyroxenitic komatiites: fractional crystallization of the liquid.

Viljoen and Viljoen (1969) stressed that high $Ca{:}Al_2O_3$ were characteristic of komatiites, but now with more data available, it is evident that most komatiitic sequences have an appreciably lower $CaO{:}Al_2O_3$ ratio. The komatiites of the Prince Albert Group are no exception with an average ratio of 0.74.

Nickel values also show a consistent relationship with the MgO% values: as MgO% increases, the Ni values increase (Fig. 8E). This is due to the fact that Ni readily goes into the olivine structure. Consequently, with decreasing olivine content, Ni ppm will also drop. This is consistent with the fractional crystallization model.

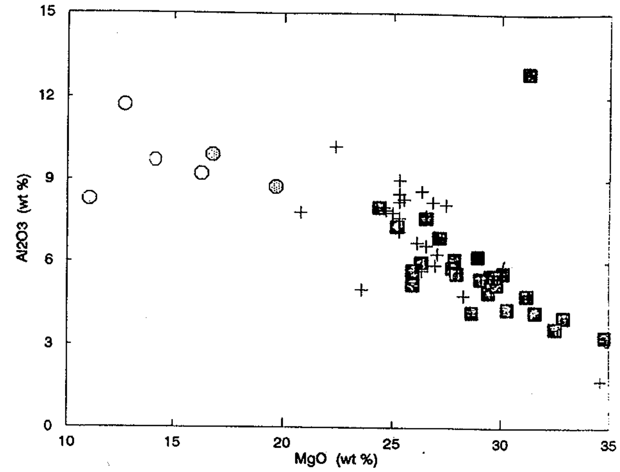

Figure 8C. Distribution of Al2O3 vs MgO (symbols explained in 8B).

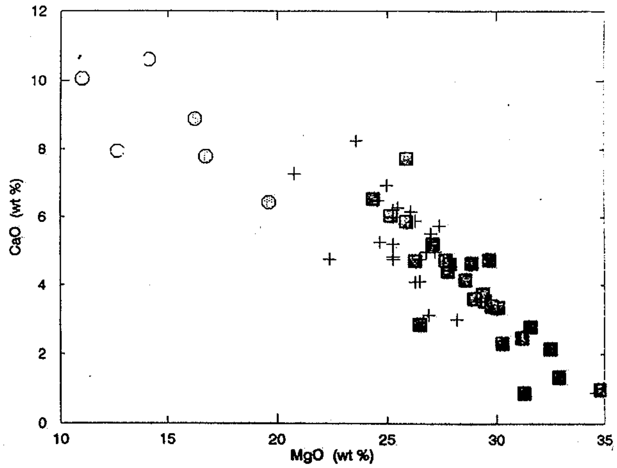

Figure 8D. Distribution of CaO vs MgO (symbols explained in 8B).

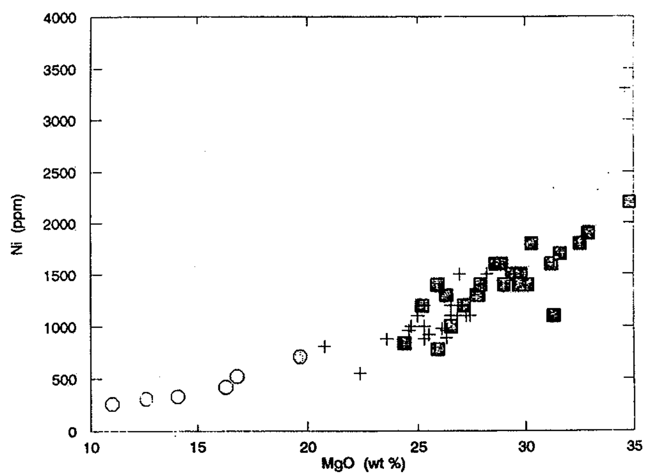

Figure 8E. Distribution of Ni vs MgO (symbols explained in 8B).

The Cr content of the rocks increases with decreasing MgO% until approximately 20% MgO (Fig. 8F), representing chrome's incompatibility in olivine. At this point, the amount of Cr decreases with decreasing MgO%. This could be due to the fact that clinopyroxene crystallization has commenced and, as a result, scavenges Cr from the melt.

No apparent trend is discovered upon comparing the distribution of Cu with respect to MgO% (Fig. 8G). There are two anomalously high Cu values however. These high Cu contents appear to be concentrated in the pyroxenitic flow-top breccia samples. This is corroborated by the presence of chalcopyrite discovered in this zone during petrographic studies.

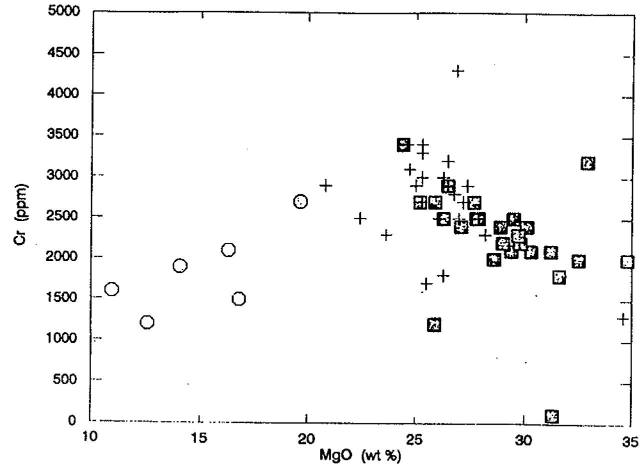

Figure 8F. Distribution of Cr vs MgO (symbols explained in 8B).

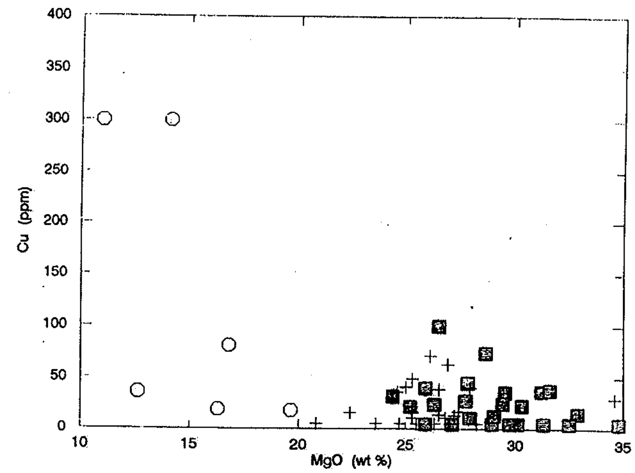

Figure 8G. Distribution of Cu vs MgO (symbols explained in 8B).

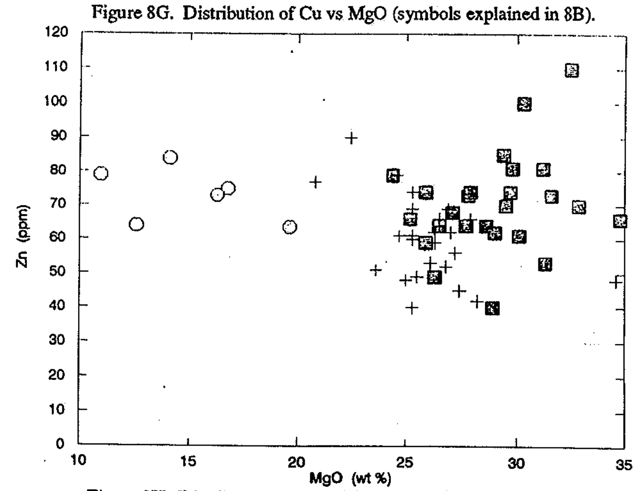

Figure 8H. Distribution of Zn vs MgO (symbols explained in 8B).

The whole-rock zinc content, ranging from 40-90 ppm, does not vary with MgO% (Fig. 8H). This can be interpreted in two ways depending on the magmatic process assumed.

1) If the distribution of zinc is assumed to be influenced by fractional crystallization, one would expect similar trends as the other elements, therefore the zinc is not derived from the same source as the other trace elements. It follows that some external source of zinc is required. Abundant zinc could be introduced into the system if the upwelling magma assimilated zinc-rich supracrustal rocks during its ascent to the surface.

2) (from O.R. Eckstrand, pers. comm., 1993): Zinc is not especially chalcophile or oxyphile; its apparent uniform distribution could just reflect partition coefficients near 1. The absolute zinc levels are low, well within normal levels for ultramafic rocks.

Rare Earth Elements

Twenty samples (including both cumulate and spinifex zones) were analyzed at GSC for their rare earth element abundances (Appendix I(h). These abundances have been plotted in the form of chondrite normalized spider plots (Fig. 8I). The distribution of the REE indicate that these komatiites are enriched with respect to the primary mantle (whose composition has been interpreted from chondritic meteorite samples). Enrichment of heavy rare earth elements (HREE) ranges from about 1.5 to 5 x chondrite. A wider variation in light rare earth elements (LREE) (0.5 to 9.5 x chondrite) is probably a result of mobility of these elements during metamorphism. The Eu anomalies of sample 92-021A and 92-028B are also indicators of alteration (Sun and Nesbitt, 1977).

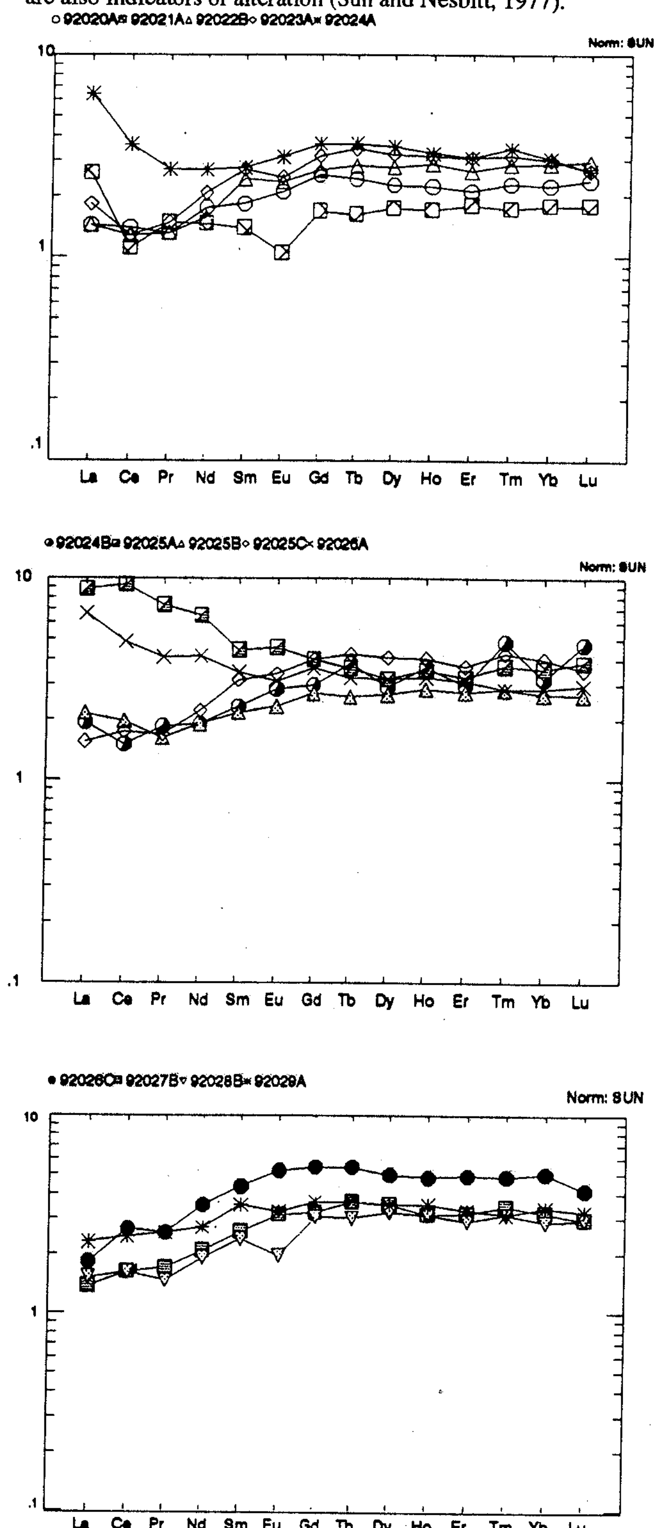

Figure 8I. Chondrite normalized rare earth element spider plots.

Jahn et al. (1981) proposed that komatiites can be subdivided into three groups on the basis of their HREE contents as follows:

Group 1	HREE flat
Class 1	REE flat(La/Sm-1.0)
Class 2	LREE depleted (La/Sm<1.0)
Class 3	LREE enriched (La/Sm>1.0)
Group 2	HREE depleted (Gb/Yb>1.0)
Class 4	LREE depleted (La/Sm<1.0)
Class 5	LREE enriched (La/Sm>1.0)
Group 3	HREE enriched (Gb/Yb<1.0)

The REE abundances of the PAG komatiites (Fig. 8I) favour classification as Group 1 (HREE flat). Comparison of La and Sm values indicate that some of the komatiites are of Class 3 (LREE enriched) whereas others are Class 2 (LREE depleted).

The majority of other komatiitic sequences, regardless of mineralization, (e.g. Kambalda, Munro Township and Scotia) have REE distribution patterns that indicate LREE depletion. These distribution patterns therefore do not appear to lend any conclusive evidence as to the mineral potential of the suite. The fact that some of the Prince Albert Group komatiites are enriched in LREE could be indicative of some sort of contamination of LREE-rich crustal rocks during their ascent to the surface.

The flat HREE patterns are similar to those of MORB samples, and therefore it can be concluded that the partial melting and fractional crystallization history is similar. The LREE distribution in the Prince Albert Group komatiites, however, differs from that of MORB samples (ie La/Sm vs Sm values greater than those of MORB). Sun and Nesbitt (1977) concluded that, in general, LREE patterns reflect the nature of the source and not necessarily the partial melting or fractional crystallization history. Combining information about LREE and HREE, a possible interpretation is that the Prince Albert Group komatiites were partially melted and fractionally crystallized in a manner similar to that of MORBs, but from a compositionally different source.

Electron Microprobe Analyses

Five cumulate olivines and 17 chromites were analysed by electron microprobe (Appendix I(l) and I(o)).

Olivines

The analyses show that the olivines are depleted in magnesium and chromium and significantly enriched in ferric iron and nickel with respect to those analyzed from Kambalda (Lesher, 1989) and Barberton (Smith and Erlank, 1982). A reasonable interpretation of these results is that, although the olivines have a primary textural appearance, they have changed composition during metamorphism. To prove this, the Mg:Fe ratios of the olivines can be compared to those of spinifex rocks - the closest estimation obtainable for the liquid composition using whole rock chemistry. If the Mg:Fe ratios of the olivines do not agree with those of the liquid composition, some alteration must have occurred. The comparison can be done by using the partition coefficient described by Roeder and Emslie (1970):

$$Kd = [MgO/FeO]_{li} \times [FeO/MgO]_{ol}$$

where $Kd = 0.333$.

Results (Appendix I(l)) indicate that the two Mg:Fe ratios do not correspond. We therefore interpret that the olivines changed in composition during metamorphism. The high NiO content (average 0.55%) of the olivines could be a result of mobility during metamorphism. In comparison, komatiites from Kambalda have an average NiO content of 0.4%.

Chromites

Probe analysis of the chromites suggest that they are actually ferrit-chromits (zoned grains with chromite-rich cores, inner rims of ferrit-chromit and an outer rim of magnetite). The chromite cores are homogeneous, having a constant composition of 50% Cr_2O_3, 12% Al_2O_3 and 33% FeO throughout. The ferrit-chromit zone decreases in Cr_2O_3 and Al_2O_3 content and increases in FeO with increasing distance outward from the core. The outer magnetite rims are characterized by an FeO content of 87% and a low Cr_2O_3 content.

The chromite cores are significantly enriched in zinc oxide (2-2.5%) and slightly enriched in nickel oxide (0.25%) with respect to chromites from Kambalda komatiites (1.5% ZnO, 0.15% NiO)

(Groves et al., 1977). Nickel oxide values increase greatly (up to 0.81%) in the magnetite outer rims and are probably the result of metamorphic processes. High zinc contents most likely result from assimilation of a significant volume of zinc-rich supracrustal rocks during emplacement (Lesher, 1989).

Geochemical Composition Throughout Magmatic Evolution

Magma composition commonly changes throughout the eruptive history of the sequence as olivine is fractionally crystallized out of the melt. Various diagrams can be employed to determine the extent, if any, of this compositional change in the original liquid.

The first of these diagrams is the Jenson plot (Fig. 8J). This plots the trends of composition of ultramafic rocks with respect to Al_2O_3, MgO and FeO^*+TiO_2. With decreasing MgO content, a liquid with an original komatiite peridotite composition will take on a komatiitic basalt composition, followed by a tholeiitic composition and finally one of an andesitic basalt composition. This sequence of komatiite peridotites to basalts is seen in many flow sequences such as Kambalda and Barberton. By plotting the spinifex textured zones upward through the sequence (Fig. 8J), it can be seen that the composition of the magma remained in the komatiitic peridotite zone for the samples included in this study of the Laughland Lake area. This indicates either a non-differentiating magma source or a magmatic source with differentiated layers of such great depth and volume, that only the uppermost of these layers was extruded during the eruptions that created the flows of the Prince Albert Group.

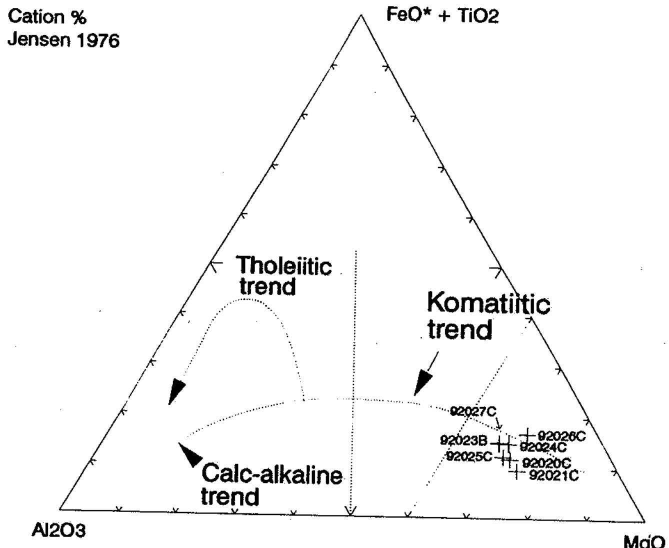

Figure 8J. Cation variation with stratigraphic position (after Jensen, 1976).

Another method of depicting geochemical changes throughout the sequence is through whole rock geochemical profiles (Fig. 8K). By plotting the variation in the weight percent of major oxides, anomalies can be easily recognized (Lesher, 1989). The profiles of the Prince Albert Group komatiites vary little in weight percent MgO and TiO_2, but have small blips in the Al_2O_3, CaO and FeO_T (less than 4 weight percent). Changes in CaO are probably due to mobility during metamorphism. Overall, the small degree of variation throughout the section leads to the same interpretations as above.

REE plots indicate an enrichment in heavy rare earth elements at the top of the sequence. This could indicate crustal contamination by a source rich in these heavy rare earth elements. The earliest flows were probably erupted very rapidly upward through unheated conduits and therefore could not assimilate great volumes of crustal material. Later flows would have erupted more slowly through a heated conduit and therefore could have incorporated more crustal material into the magma (Lesher, 1989). If the crustal source was enriched in heavy rare earth elements, this enrichment would be reflected in the later komatiitic flows - as depicted by the rare earth plots.

Late-stage crustal contamination is also suggested in the Zn, Cr and Cu profiles (Fig. 8K). All three show the highest abundances at the highest section levels. The Cu profile best exemplifies this whereas the Zn and Cu have secondary peaks at a lower level.

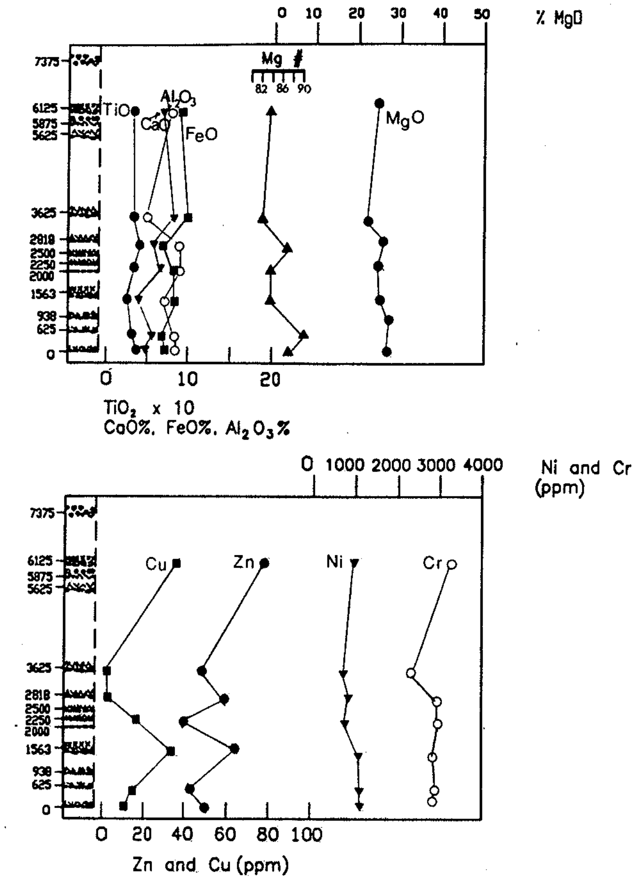

Figure 8K. Major oxide and trace metal variation with stratigraphic position (after Lesher, 1989).

Summary of Komatiite Petrochemistry

Komatiites of the Archean Prince Albert Group, located in the Central Complex, comprise spinifex-cumulate couplets with rare flow top breccia zones. A 7.5 km discontinuous section was sampled in order to document geochemical variations throughout the stratigraphy and assess the mineral potential of the komatiitic suite.

Spinifex zones have been altered from bladed olivine to an assemblage consisting of chlorite, tremolite and magnetite. Cumulate zones, once consisting of phenocrystic olivine and chromite in a glassy matrix, now comprise a chlorite-tremolite-serpentine assemblage. Higher metamorphic grade assemblages also include talc, anthophyllite, olivine and common ferrit-chromit. Kd relationships suggest that the fresh olivines are metamorphic rather than primary magmatic in origin.

Geochemical analyses of major and trace elements indicate that these komatiites underwent fractional crystallization of olivine. This is assumed to have taken place at some point prior to eruption because the thin flows would have cooled too rapidly to allow fractional crystallization to have taken place at surface. REE abundances show that the Prince Albert Group komatiites fall under the Group 1 - Class 2,3 (LREE enriched, depleted respectively) category, suggesting that some crustal contamination took place during their ascent to the surface. The strongest evedence of contamination is provided by the exceptionally high zinc contents (2-2.5%) of the chromite cores. Depletion of chalcophile nickel within the sequence and high magma:sulphide ratios (very little sulphide was observed in any of the samples collected) are both compatible with (but not proof that) some sort of some sort of segregation of sulphide from silicate melt. Such segregation, if it took place, would probably have been initiated by saturation of sulphur that resulted from the assimilation and contamination of zinc-, LREE- and S-rich supracrustal rocks.

Segregation of a sulphide liquid leads to the scavenging of chalcophile elements from the silicate phase of the melt. This favours the formation of stratiform nickel sulphide deposits. On the basis of this information, the Prince Albert Group komatiites are favourable potential hosts of this deposit type.

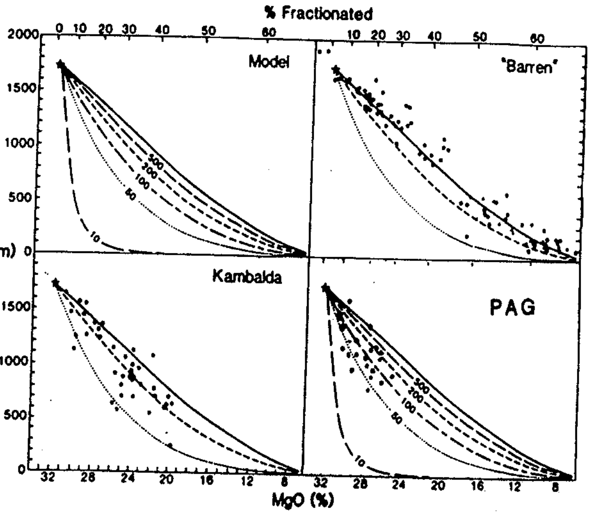

Figure 8L. Magma:sulfide ratios for mineralized, barren and PAG komatiites (after Lesher, 1989).

SURFICIAL MAPPING AND TILL GEOCHEMISTRY

Method

Surficial mapping was conducted prior to the field season by cross-checking air photograph interpretations with the existing map by Thomas and Dyke (1981). The map was further verified using aerial and ground observations during the geochemical sampling program. The map was found to be generally accurate, and we verified their paleo-ice and -glaciofluvial flow directions. Therefore, it was not updated as it provided sufficient information for the purpose of this project.

The glacial till sampling method followed that of a previous study in the adjacent Wager Bay area (Jefferson et al., 1991; see also Shilts, 1977). In July 1992, till samples were obtained from 62 mudboils at a sample spacing of 1 every 10 km (1/100 km2) regionally and 1 every 2 km (1/4 km2) in areas of high mineral potential. The clay size fraction was separated from these till samples by Bondar-Clegg and Company Limited. Approximately 3 g of this fraction were analyzed by Activation Laboratories Limited for 35 elements, using the neutron activation method. An additional 1 g of the clay size fraction was analyzed in the Analytical Chemistry Section, Mineral Resources Division of the GSC for 7 elements using reverse aqua regia extraction and detection by Atomic Absorption (AA) and Inductively Coupled Plasma (ICP).

Two lake-sediment standards provided by J. Lynch (1990) were submitted with the tills to guage the accuracy of the geochemical analyses. A bulk till sample was obtained from one sample location (92-JPJ-052T), prepared and split into five unbiased portions for submission as blind duplicates to test precision.

The till geochemical data from the 2 laboratories were combined and are listed in Appendix II. The mean, standard deviation, minimum value, maximum value and number of values below the detection limit were determined and compared to the 1986 till geochemistry from the Wager Bay area (Jefferson et al 1991). In addition, all values for most of the elements were sorted from highest to lowest. All data were graphically presented in frequency histograms by means of SPSS and Harvard Graphics software (33 original drafts; representative histograms are provided in Appendix II). AA data for SPSS histograms exclude results of bulk and control samples.

C.W. Jefferson used the frequency histograms, statistical parameters, ranked elements, precision and accuracy analyses to determine the elevated values to be recorded on summary maps (Figs. 3-5, 9). Conversion of the database to map representations was done by K. Powis.

PRECISION AND ACCURACY

A comparison of the till geochemical data from the 1986 and 1992 field seasons indicated similar results with the following exceptions: 1992 had higher values of arsenic and barium but lower values of rubidium, manganese, lead and zinc.

The accuracy analysis showed that zinc and nickel analyzed by atomic absorption were not as accurate as the other measured elements. Zinc analyzed by neutron activation appeared to be the least precise. The remainder of the elements were within an acceptable deviation of the bulk sample mean.

ELEVATED RESULTS AND INTERPRETATIONS

The map of elevated till geochemical results (Fig. 9) shows neither large clearly defined, nor small point source dispersal trains. This is discounted as a serious factor, given the regional nature of the sampling program. However, the till samples taken immediately down ice from several parts of the supracrustal belts have elevated concentrations of cobalt, chromium, copper, nickel, zinc and locally tungsten.

In the southwest area (Fig. 5), Sample 92JP-21t contains 25 ppb gold, and 25t contains elevated arsenic, Cr, Ni, Co and Cu, and 27t and 92JPJ61t contain elevated chromium. The arsenic and gold are only slightly elevated, but support the evidence from lithogeochemistry that the southwest area experienced mineralization processes that transported gold. The elevations of chromium, cobalt, nickel and copper are also slight, and may simply reflect a high proportion of ultramafic rock in the till.

Similarly elevated cobalt, chromium, copper nickel and zinc in the western area, the central area and down ice of a northeasterly shear zone (sample 92JP030t) are interpreted to at least reflect the ultramafic rocks which outcrop sporadically in these areas.

Three till samples taken from the general down-ice vicinity of the one known copper showing in the map area (92JPJ034t, 92JPJ030t and 92JPF001t) contained similar, slightly elevated abundances of copper, chromium and nickel. This can be interpreted in several ways:

1. The copper contribution from the showing is too limited in relative concentration and areal extent to cause a significant anomaly,
2. The copper may be expressed in till but our samples were too widely spaced to detect it in the till.
3. The copper anomaly is diluted by till derived from unmineralized terrain.

Sample 92JPJ054t, with replicated 170 and 180 ppm zinc in the northeast of the map sheet, is puzzling because the bedrock here is dominated by granite and foliated tonalitic to granitoid gneiss. Perhaps these values reflect the presence of an amphibolite and/or ultramific xenolith in the granitoid gneisses. Perhaps a small deposit or a small part of a volcanic-associated massive sulphide deposit has contributed to the till in this area.

The southeast corner of the study area is characterized by relatively high concentrations of uranium and thorium in the overburden. These concentrations are considered to be typical background in the fluorite-granite domain, and are contained in accessory minerals such as zircon, monazite and allanite.

The surficial deposits have thus reflected known mineralization, corroborated lithogeochemistry, and suggested additional copper-nickel (?and zinc?) potential within the study area. The surficial geochemistry has also provided insight into the bedrock geology of the drift-covered areas, as in the Baker lake area (eg. Schau, 1983a).

HEAVY MINERALS FROM ESKERS

The heavy mineral analysis was designed to identify any kimberlite indicators. Thirty eight grains were isolated for probing, but no kimberlite indicator minerals were detected. D. Paré conducted the mineral separations, preliminary and final mineral identifications. J. Stirling conducted the microprobe analyses.

Method

The eskers within the study area were sampled at 29 locations, at a sample spacing of approximately once every 10 km (Fig. 9). The heavy minerals in the 250 um to 2 mm size fraction of the esker samples were separated at Consorminex Incorporated. All of the heavy minerals were examined and the the 63-250 um size fraction was systematically point counted for kimberlite indicators and general heavy mineral identification.

Results and Interpretation

The heavy minerals separated were all representative of normal regional metamorphic grade rocks typical of the Quoich River 1:1,000,000 map region. The results are tabulated in Appendix III. No positive indication was obtained of any kimberlites in the source region of the surficial deposits. The reader is cautioned that the heavy mineral survey was a single pass reconnaissance.

INTERPRETATION OF REGIONAL STRATIGRAPHIC AND TECTONIC HISTORY

Regional compositional variations of the PAG

On Melville Peninsula the PAG contains calc-alkaline volcanic rocks and greywackes typical of Archean greenstone belts (Schau, 1977); southwest toward Laughland Lake the strata are more mature; metavolcanic rocks are less abundant and characterized by bimodal ultramafic - minor felsic compositions. The tentatively correlated (e.g. Schau et al., 1982) Woodburn / Ketyet groups around Baker Lake tend to be more typical greenstone belts to which komatiites and quartzites have been added: basalts, andesites and coarse greywackes dominate toward the east (Henderson et al., 1991a), and the metasediments become finer grained and the komatiitic component is greater to the northwest (Annesley, 1989). In the Laughland Lake area all of the immature metasedimentary rocks are fine grained and finely laminated; komatiites and subaerial depositional environments dominate on the east, whereas komatiites are thinner, paired with equal basaltic units and subaqueous inappearance to the west. In summary there are no consistent apparent areal compositional trends that can be interpreted on a regional scale.

Stratigraphically, Campbell and Schau (1974) suggested that the PAG on Melville Peninsula comprises a lower volcanic + greywacke + iron formation assemblage and an upper orthoquartzite assemblage. In the Laughland Lake area, quartzarenites are at the interface between komatiites and biotite psammites in many places; komatiites being low in the sequence in the Central Complex and both ?high? and low in the sequence in the western area. In the Baker Lake area, quartzarenites have been interpreted as part of the upper sequence (Annesley, 1989, Ashton, 1988 and Henderson et al., 1991a). These inconsistencies in stratigraphic interpretations of quartzarenites, together with the likelihood of numerous structural repetitions (all of the above) means that it is not possible at present to make any regional stratigraphic generalizations either.

Paleogeography and Depositional Tectonics of the PAG

Schau (1977; 1982, p. 32) and Schau and Ashton (1988) favoured terrestrial supracrustal deposition of the PAG: eruption of komatiites onto a craton; intense weathering of komatiites to produce nickel-rich mafic sediments, weathering of gneissic uplands to produce quartz sands; sedimentation of weathering-derived quartzarenites in alluvial and aeolian environments, and iron-formations in lake basins. Campbell and Schau (1974) inferred shallow marine environments near Committee Bay, 200 km to the northeast. Chandler et al. (1993) also favoured cratonic conditions, but interpreted the thinner quartzarenite units to suggest a marine shelf and epeiric sea. The psammite with common quartzarenite lenses and isolated lenses of conglomerate (submarine channel deposits?) suggest mixed quiet water and high energy environments. The above interpretations can be reconciled if the Group as a whole was deposited in the Archean equivalent of a modern continental prism such as is found on the east coast of North America, in compatibility with Schau and Ashton's (1988) rifting origin for the Group.

The volcanic and shallow (quartzarenite) to moderately deep marine (psammite) association of the PAG favours a rift-related hydrothermal exhalative origin and Superior-type setting for the iron formations, although lithologically the absence of extensive carbonate rocks and the absence of oolitic or stromatolitic textures are more reminiscent of Algoma-type iron formation (cf. Gross, 1965). The absence of carbonates could also reflect different sea water chemistry due to climate.

The komatiites in the Laughland Lake area may thus be Archean analogues of continental tholeiites which are commonly associated with rifting of epicratonic quartzarenite + carbonate + Superior-type iron formation. The Central Area komatiites, gabbro plugs and Laughland Lake Anorthosite are associated with major north-south faults which may record early grabens.

Basement?

Despite the above broad agreement on a cratonic tectonic setting, we have failed to find outcrop proof of basement to the Prince Albert Group. The Brown River Gneiss was interpreted to be basement to the Group (Schau, 1982; and considered as possible by Jefferson and Schau, 1992) in part because strata adjacent to many of the foliated tonalites do not appear to have undergone contact metamorphism and some tonalites appear to be of higher grade than the PAG. On the other hand, neither has contact metamorphism been documented for the Anorthosite Complex which must be intrusive. Basal conglomerates have yet to be documented and contacts are faulted or mylonitic, including the inferred unconformity at locality y in the Central Area (Jefferson and Schau, 1992). Deformation recorded by steep mylonitic contacts may have telescoped contact metamorphic isograds, or been concentrated along unconformity surfaces. Subsequent metamorphism has also obscured evidence for basement versus intrusive relationships.

Deformational history

The intense multiple deformation in the few areas of good exposure suggests structural repetition of many of the units and, with the abundant plutonic rocks, collisional orogeny. Fabrics in the tonalites, gabbros, anorthosite and A' granites also record at least two intense deformations, one possibly during the Early Proterozoic. The youngest plutons, essentially unfoliated fluorite granites, are much like those around Wager Bay which have been dated at 1823 +/-3 and 1826 +4/-3 Ma by LeCheminant et al. (1987). On the other hand, unfoliated granites in the Woodburn Lake area which post-date multiple deformation have been dated as Archean (Henderson et al., 1991a). Further geochronology is required in the Laughland Lake area.

Regional Correlations of the Prince Albert Group

In the Quoich River region (Fig. 2), all structural trends in gneisses and shear zones indicate dextral offset totalling on the order of hundreds of kilometres. For example, structural trends lead northeasterly from the Woodburn group, through granulites (Fraser, 1988) and/or layered, medium grained biotite gneisses such as the informal Quoich River gneiss complex of Schau et al., (1982) which contain quartzites as the only clearly recognizable supracrustal lithology, to the Wager Shear zone (Henderson and Broome, 1990) and the disrupted supracrustal rocks, of the Paliak supracrustal belt of Jefferson et al. (1991). Conversely, extrapolating the PAG southwesterly along and through the Amer Shear Zone, it appears to be structurally on trend with Archean rocks farther west than the Woodburn / Ketyet groups, perhaps to Archean strata underlying the Thelon Basin.

Further to the above speculations on correlations, because the PAG, and the Woodburn/Ketyet groups are not typical calc-alkaline volcanic-sedimentary sequences but rather appear to be rift-like assemblages, it does not seem appropriate to apply the island arc / collisional collage model for this extensive belt of supracrustal rocks. It appears to be more like a continental foreland fold and thrust terrain, an older and more disrupted version of what Henderson (1983) interpreted the Penrhyn Group to be. If this is so, and if the quartzarenites were all unfolded and re-connected to each other, then the continental platform the quartzarenites were deposited on was a minimum of 1,000 km long and 400 km across.

All speculation aside, two lithologic associations and their metallogenic implications are shared among these Archean groups, regardless of whether they were physically connected. The most important lithologic association is the spatial association between iron formation and decametres- to kilometers-thick spinifex textured komatiite units (noted by all from Campbell, 1974, through Henderson et al., 1991a, to the present study). Both groups also contain pure quartzarenites with associated well foliated quartz-muscovite schist, generally structurally above or surrounding ultramafic rocks.

Subtle, and perhaps significant differences are apparent between the two groups, but may be only a result of fortuitous exposure of local areal variations within each group: (1) Felsic volcanic rocks are present in a number of stratigraphic levels and are associated with quartzites in the Woodburn group.

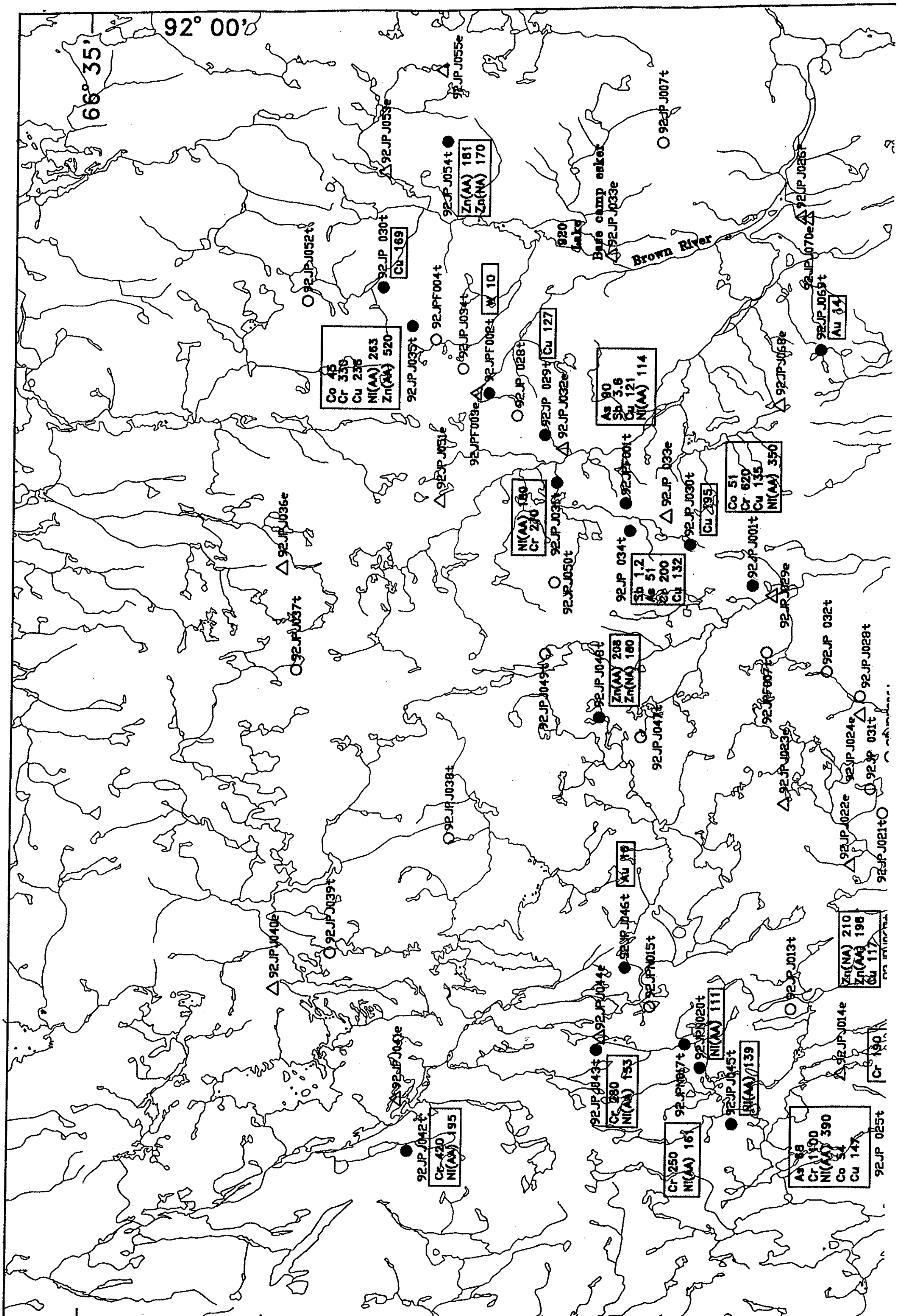

Fig. 9N

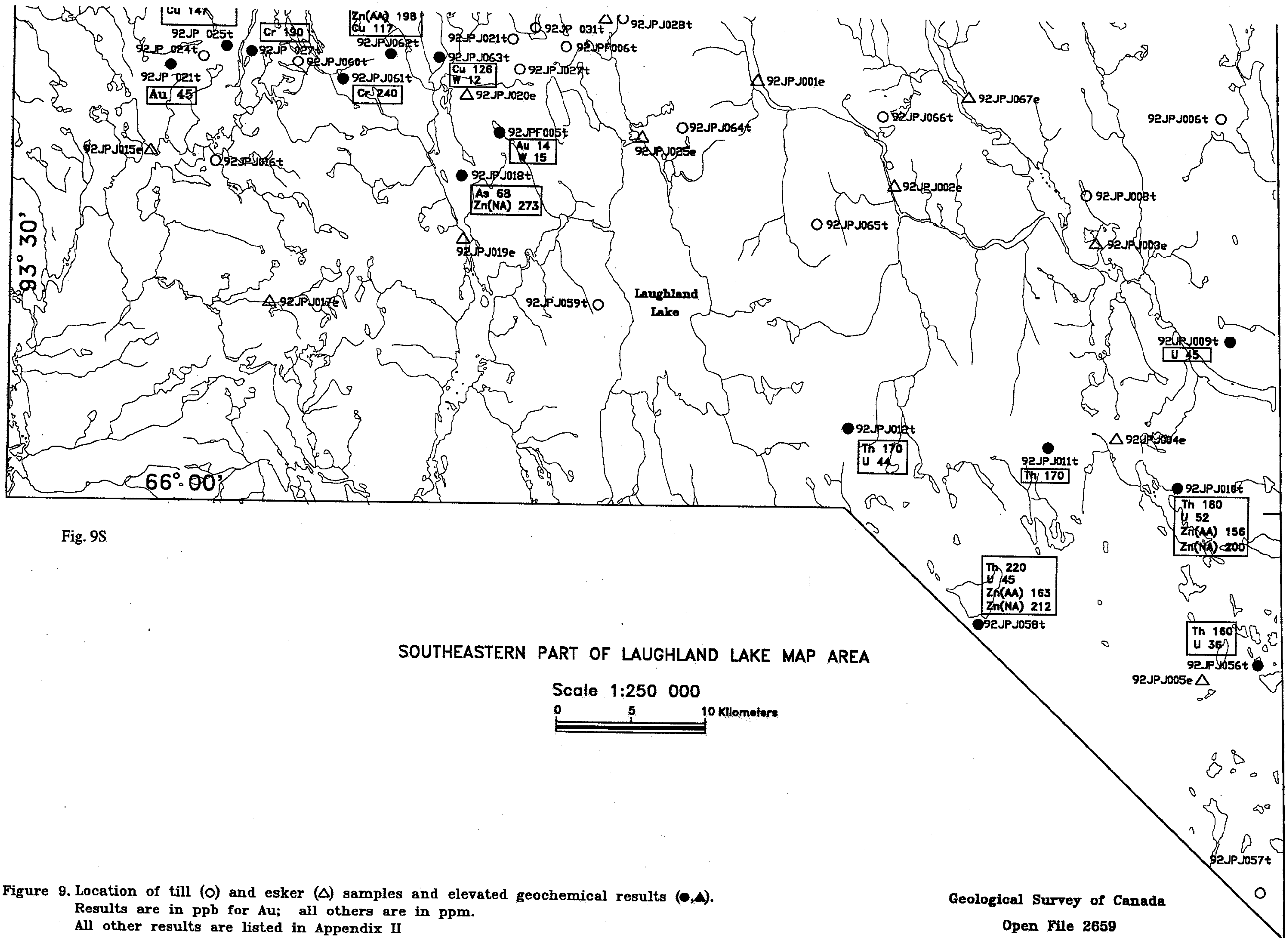

Fig. 9S

Figure 9. Location of till (○) and esker (△) samples and elevated geochemical results (●,▲).
Results are in ppb for Au; all others are in ppm.
All other results are listed in Appendix II

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Open File 2659

Felsic rocks are rare in the PAG, and have been found only in psammite and at the komatiite-psammite interface.

(2) Extensive pillowed metabasalt overlies both komatiites and greywackes in Woodburn group. Metabasalts (fine-grained carbonate-rich amphibolites) in PAG preserve no recognizable pillows and are thinly developed, although thin (up to several decametres) metabasalts, together with meta-ultramafic schist and magnetite-quartz iron formation, form extensive marker units in the southwestern and western areas of Laughland Lake map area (Chandler et al., 1993).

(3) Individual komatiite flows in the PAG tend to be thin and simple (Fig. 6) whereas those in the Woodburn group (as described by Annesley, 1981, 1989) tend to be thicker, in the range of 0.5 to 10 m, and contain more elements of the ideal komatiite flow (Fig. 6), such as flow top hyaloclastite and breccias, rusty thick weathering rinds, vesicular tops, distinct contacts between flows, the foliated zone between spinifex and cumulate, and polyhedral jointing. The PAG has few massive ultramafic flows and sills in the Central Complex, and meta-ultramafic rocks elsewhere are too altered to identify such units. In contrast, massive flows with abundant polyhedral joints, are common, and local sill-like bodies of peridotite have been described by Annesley (1981).

(4) Similar facies and lithological associations of iron formations are apparent in both groups, although in PAG the iron formations are also spatially associated (including in direct contact) with quartzarenites in several places.

(5) Woodburn group contains common, though minor conglomeratic units, whereas conglomerates are rare and of limited thickness and extent in PAG.

The Woodburn and Prince Albert groups differ significantly in two main aspects.

(1) Woodburn group includes a basal unit of intermediate volcanic rocks, but no intermediate rocks have been recognized in the PAG in the Laughland Lake area.

(2) The intermediate volcanic rocks in Woodburn group are conformably overlain by thick-bedded greywacke. In contrast, the background sedimentary rock type of PAG is thinly laminated biotite psammite.

The above similarities and differences are compatible with the Woodburn and Prince Albert groups being broadly contemporaneous parts of the same crustal block during sedimentation. They appear to have differed in their tectonic settings and evolutions, however, in that the Woodburn area was relatively mobile and island-arc-like, resembling greenstone-greywacke terranes of the Superior and Slave structural provinces. The absence of andesites, the laminated psammites instead of greywacke turbidites, the limited metabasalt (fine-grained amphibolite), the extremely limited conglomerates, the sericite phyllites, and the cross beds in quartzarenites all support a relatively stable shelf environment which was rifted and subject to continental volcanism (komatiites).

The eruption of the iron-magnesium-rich komatiites with concommitant development of vast iron formations may have been the surface expression of the mantle differentiation and depletion in iron and magnesium metals which led to a cool, buoyant, Archean mantle root beneath the Canadian Shield in this region (cf. Hoffman, 1990).

Development of the Wager Shear Zone

The relationship of the 1808 Ma Camp granite (near Paliak Islands, Fig. 2) with the shear fabrics, and analysis of the aeromagnetic trends suggest two components and two Paleoproterozoic stages to the Wager shear zone. 1) The regionally extensive part of the Wager shear zone is a gently curved (convex to the south) diffuse axis of high strain, into which linear aeromagnetic fabrics bend from both sides, as figured by Henderson and Broome (1990, Figs. 1 and 2). West of Paliak Islands, the bending-in appears to be equal on both sides. Detailed mapping by Henderson et al. (1991b) has shown that the Paliak granite intrudes and post-dates this bending-in fabric. 2) The more restricted second part of the Wager shear zone is very straight and obliquely transects the diffuse first phase. This straight zone is also figured by Henderson and Broome (1990, Fig. 4) and by Broome (1990, Fig. 9). It is a very sharp magnetic feature as far as 100 km west of Paliak Islands, but west of 100 km it loses definition. The straight zone is even more dramatic east of Paliak Islands where it sharply separates a pronounced magnetic high on the south from a very deep low on the north. Furthermore the equal bending-in of aeromagnetic trends has been lost here.

Genetic linkages are possible among 1) the change in nature of the Wager shear zone at Paliak Islands, 2) the presence of a granite at Paliak Islands, 3) the "peeling away" of the Paliak Islands supracrustal belt at Paliak Islands, and 4) the large "S" shapes in aeromagnetic trends north of Wager shear zone. It appears that all of these features were linked by ductile crustal scale responses to regional transpression and attempts by very large crustal blocks to wedge past each other in order to make room for a continental collision far to the west. Whatever was moving at depth was only partly coupled to the level of crust now exposed. The block north of Wager Shear Zone was trying to move dextrally past the block to the south, but was rotating counterclockwise at the same time. This caused development of the large "S" shapes of aeromagnetic trends. The extreme development of the "S" shape caused the Paliak belt to be pulled away from the Wager Shear Zone. Where the Paliak belt was being pulled away, a local relative pressure drop, possibly coupled with heating due to friction, could have induced partial melting and intrusion of the Base Camp Granite to fill the void. A similar origin is possible for the much more extensive fluorite granite (Domain 5) which marks the eastern termination of the Amer Shear Zone. Toward the end of dextral shear on the Wager Shear Zone, its straight zone developed after intrusion of the granite, and a limited amount of dextral offset was continued.

Some of the later movements along Wager Shear zone could have been sinistral, because the straight zone terminates to the west against a local sinistral recurve in a previously dextral bend-in. This would explain the discrete sinistral components mapped by Henderson et al. (1986) and referred to by Henderson and Broome (1990).

The Paleoproterozoic, ductile-strained components of the Wager and Amer shear zones were formed under deep crustal transpressive conditions that are unfavourable for the development of significant quartz veins containing gold or uranium.

The Wager Shear Zone also includes some very straight linear segments which are recessive weathering like the northwesterly lineaments. The east-west-trending south shore of Wager Bay is parallel to the Wager Shear Zone, but also corresponds to an extreme contrast in aeromagnetic anomalies which is not present west of Paliak Islands. In addition, straight and sharp, southeast-trending lineaments appear to terminate against the Wager Shear Zone. This combination of features suggests that late (Paleozoic and later?) north-side-down brittle movement took place along the same approximate zone as the dextral Proterozoic ductile shear, particularly east of Paliak Islands. The brittle fault component, similar to those described below, is interpreted to have contributed to the subsidence of Wager Bay, the dramatic difference in aeromagnetic response, and might have generated vein-hosted gold in dilatant zones.

ASSESSMENT OF MINERAL AND ENERGY RESOURCE POTENTIAL

History of Exploration and Resource Assessment

Showings of pyrrhotitic iron formations and ultramafic rocks in the Prince Albert Group have been investigated by Aquitaine Company of Canada Ltd. (Tech-No., 1971; Boerner, 1971; Danda and Klein, 1971), King Resources Company (Brisbin, 1970) and Cominco Ltd. (Grosh and Porng, 1975). H. Vuori (pers. comm., 1992) provided notes and analytical results of drilling and prospecting he supervised in the 1960's on the HAR claims (Station 92JP54c, northwest corner of the Laughland Lake Anorthosite, within the proposed park boundaries; Figs. 3, 4). The nature of the HAR showing is documented above in BEDROCK TRACE ELEMENTS GEOCHEMISTRY. The activities of these companies were reviewed by Laporte (1974); some examples of the showings investigated are provided his descriptions of work by King resources, with added information from Eckstrand (1975) as follows.

> A photogeological study, geological reconnaissance, prospecting and EM surveys outlined several sulphide showings.

Within the KR group on the Hayes River (66°47'/91°55') a sulphide zone 5 to 110 feet wide and less than 500 feet long within metagreywackes and metaquartzites was found to contain finely disseminated pyrite, pyrrhotite, minor bornite and chalcopyrite. Trench samples assayed 0.05% Cu and 0.18% Ni. This is locality B of Eckstrand (1975), who described the setting as "conformable ultramafic lenses occur in thin-bedded, mafic and quartzitic metasediments. These sediments contain abundant sulphides, mainly pyrite and pyrrhotite, in many cases immediately adjacent to the ultramafic lenses.......Some of the ultramafic rocks contain minor amounts of disseminated sulphides. Deformation, alteration and recrystallization of these rocks has been intense, and could account for the lack of spinifex textures. Nevertheless, the presence of interlayered tremolite-rich and chlorite-rich rocks suggests that they could represent flows of mafic to ultramafic composition."

On the KRA claims, 11 miles north of Walker Lake (66°57'/91°00'), disseminated pyrite and pyrrhotite in metasediments were investigated by detailed geological and geophysical surveys. These rocks assayed 0.03% Cu and 0.02% Ni.

Disseminated pyrrhotite with minor pyrite and bornite was found in a zone 10 to 50 feet wide and 3,500 feet long on the KRF claims, and it may extend into impure quartzite and schist. Samples from this zone (66°21'/93°15'; plotted on Fig. 3 as KRF) assayed up to 0.51% Ni and 0.02% Cu (context described in **Elevated Geochemical Results, Western Area** of this study).

East of the south arm of Curtis Lake (66°39'/89°96'), parallel and discontinuous bands of sulphide minerals up to 100 feet long are in greywacke, schist and impure quartzite striking NE. Samples assayed 0.10% Cu and 0.07% Ni.

A sulphide zone on permit 228 (67°21'/88°58') gave assays of up to 0.06% Cu and 0.01% Ni over a width of 5 to 30 feet and a length of 1,200 feet.

An ultramafic body on permit 225 (67°12'/89°47') is 2,000 feet long and parts of it assayed 0.06% Cu and 0.29% Ni (?) or 0.15% Ni (?).

A significant Ni-Cu showing worked by Aquitaine Company of Canada on northeastern Melville Peninsula (description from Eckstrand, 1975) is also relevant to this study:

"At locality F, a feldspathic meta-pyroxenite stock, about 150 to 300 metres wide, is conspicuous because of the extensive gossanous weathering developed on contained nickel-copper sulphides. Aquitaine Co. of Canada Ltd. drilled 2000 feet [700 metres] on this prospect in 1973 (Department of Indian Affairs and northern Development, 1974, p. 22). The outline of the stock appears to transect layering in the surrounding granitic and migmatitic paragneisses. The texture of the pyroxenite is medium grained, granular and unfoliated. The sulphides are most abundant at the margins, diminishing in abundance toward the centre of the stock. They are mainly disseminated, but are also found as fracture fillings. It appears that the pyroxenite mass with its attendant magmatic sulphides was intruded into the gneisses after their main period of deformation, but that later shearing and metamorphism have affected the mass."

Little mineral exploration activity has been recorded before 1970, and since Schau (1982) summarized the mineral potential of the Laughland Lake area. Schau listed the above reports of mining companies who have worked in the area, and cited Laporte's (1974) summary of nickel and copper exploration in komatiitic terrains. Eckstrand (1975) listed several similarities among the komatiitic rocks of the PAG, and ultramafic rocks of the Abitibi Belt (Canada), Yilgarn and Pilbara blocks (Australia), and indicated high potential for nickel, copper and chromium deposits in the PAG.

Jefferson and Schau (1992) reported a pyrrhotitic biotite schist preserved as part of a xenolith in the fluorite granite (southern Walker Lake Gneiss Complex) at locality "g" (Sample 91JP208). NE of locality "a", densely disseminated pyrite is in granitoid gneiss on the SE side of the magnetite-chert iron formation outcrop. None of the samples collected at these sulphide occurrences are geochemically anomalous.

Prospectors have reported that specimen grade piedmontite is present in the Laughland Lake Anorthosite (A.R. Miller, pers. comm. 1989).

In the Southwest Area, Comaplex Resources International Ltd. informed Mikkel Schau (pers. comm., 1990) that they had investigated arsenopyrite showings previously reported by Schau (1982) at the contact between PAG and A' granite (Fig. 3). This showing was not re-sampled in this study.

Schau (1982) reported a pale green to grey soapstone outcrop, 3 m by 3 m, located near Hayes River in the northwest corner of 56J. He shipped a small amount of this to Repulse Bay where local carvers found it very soft and easily carved.

Renewed exploration interest has been shown by R.A. Olson, who has taken out five prospecting permits covering parts of the PAG (Fig. 2) (Government of Canada, 1993, p. 514):

Number	Location (N.T.S.)	Permittee
1330	56-J-11NE	R.A. Olson
1331	56-J-11NW	R.A. Olson
1332	56-K-03NE	R.A. Olson
1333	56-K-03NW	R.A. Olson
1334	56-P-04NE	R.A. Olson

None of the permit areas is within the proposed park boundaries, but numbers 1332 and 1333 cover most of the southwest area (Figs. 3, 4) where our mapping and geochemical survey (our results were obtained after the application for permits was received by DIAND) has indicated some gold mineralization associated with shear zones, metakomatiites and iron formations.

Exploration for gold has intensified to the SW along strike of the PAG. Stratabound gold deposits have been found associated with sulphidic parts of magnetite iron formation (Au, representing the Meadowbank gold prospect in southwestern Figure 2) (Henderson et al., 1991a, Armitage et al., 1991) and in altered metakomatiites (Annesley et al., 1991) in the Woodburn Group, an equivalent of PAG to the SW (Schau et al., 1982; Schau and Ashton, 1988). Henderson et al. (1991a, p. 154) wrote that "the highest concentration of gold occurs in the vertical hinge region of an F_2 fold, where vuggy quartz-pyrite-gold mineralization overprints earlier quartz-pyrrhotite-gold mineralization in iron formation (Barham and Mudry, 1990). Introduction of gold-bearing fluids apparently occurred during both F_1 and F_2 by hydraulic fracturing of brittle magnetite-quartz iron formation. Most favourable areas for prospecting appear to be where F_2 fold hinges occur in iron formation adjacent to ultramafic schist, and where there has been more than 10 per cent replacement of magnetite".

Earlier work in the Baker Lake area (Schau et al., 1982, p. 149) had noted the following mineral occurrences which are considered to be applicable (although not necessarily constituting mineral deposit types) to the Laughland Lake area: "(1) sparse molybdenite in quartz veins with pyrite in foliated granite.....; (2) sparse molybdenite and scheelite in biotite pegmatites in metasediments.....; (3) pyrrhotite layers in metasediments at the same locality as (2); (4) oxide iron formation....; and (5) galena in gossans in quartzose metasediments along the Quoich River (Roscoe, personal communication, 1981)." Schau et al. (1982) also noted soapstone (SS, Fig. 2) associated with ultramafic granulites of the the Kramanituar Complex on the north side of Baker Lake.

Deposit Types

Summaries of mineral deposit types by Cox and Singer (1986), (Eckstrand, 1984a), and in the recent literature (e.g Hulbert et al., 1992) were systematically reviewed to ascertain which types might be applicable to the Laughland Lake and Wager Bay marine area. The following mineral deposit types were considered as potentially applicable only to the Laughland Lake study area (except hydrocarbons which are applicable only to Wager Bay marine area and diamondiferous kimberlites which apply to the entire Wager Bay region). Each of these types is here evaluated according to a comparison of their documented characteristics in the literature compared with the information gathered in this study (except for hydrocarbons). They are listed in approximate decreasing order of likelihood of economic* deposits being present:

*Economic only in the sense of relative likelihood of the deposit type being mineable compared to other sources of the metal in the rest of the region or world, given the distance from inexpensive transportation (in this case, tidewater) and our present state of technology.

Carving Stone (Serpentinized Komatiites and Other Ultramafic to Mafic Rocks)

This industrial deposit type is listed first because it is of considerable interest to local economies in northern Canada. Under present circumstances, the Laughland Lake region is uninhabited and soapstone at the headwaters of Brown River is unlikely to be of economic interest because soapstone of similar quality is probably available around Baker Lake and on Melville Peninsula closer to tidewater. Also, according to E. Seale (pers. com., 1992), the Inuit name for Wager Bay means "carving stone", and it is quite likely that soapstone is also present there, at or near tide water. On the other hand, if social and political circumstances change in the future, Inuit may again be living in the Brown River valley, and local soapstone might then be of economic and social interest. Although carving stone localities were not specifically identified in the study area, Schau's (1982) locality is very close and soapstone (serpentinized ultramafic rock) is expected to be abundant and probably of a quality suitable for working (assessment rating high, H) in Domain 1A.

Given the appropriate tools, any competent stone of any hardness in the Wager Bay region could be made into attractive carvings (Jefferson et al., 1991).

Chemical Sediment-Hosted Gold (Gold in Iron Formation)

Kerswill (1993) has usefully divided iron-formation-hosted gold into stratiform (sheet - like) and stratabound (tabular zones localized within a sheet-like host) types. He has noted that both deposit sub-types commonly attain bulk rock tonnages in the order of 1 million (at 10 grams per tonne, containing 10 tonnes of gold) to 10 million (containing 100 tonnes of gold). Kerswill's four largest examples are of the stratiform type, containing about 100 tonnes to greater than 1000 tonnes of gold. At a conservative gold price of $350 per ounce ($12.30 per gram), one tonne of gold is worth about $12.3 million. Mining companies typically spend more than 70% of this value on local and national economies in the process of searching for and extracting the gold.

The key factors in assessing the potential for both deposit types are present in the Laughland Lake area:

- Presence of iron formation (BIF).
- Presence of sulphide minerals.
- Elevated gold in and around iron formation.
- Structural complexity.
- Both deposit types can occur in sediment-dominated settings or in mixed volcanic-sedimentary settings.

One factor that may have been considered negative a few years ago, for both types of iron formation-hosted gold, is that the PAG is not a typical greenstone belt: few basalts are present, greywacke-turbidites are lacking and the metamorphic grade is generally amphibolite or higher. On the other hand, the presence of economically interesting gold prospects being drilled by Comaplex Minerals in nearly identical geological settings of the Woodburn Group (Armitage et al., 1991; Henderson et al., 1991a) demonstrates that the stratabound iron formation-hosted gold deposit type can be present.

The age of mineralization could be either Archean or Proterozoic. The George Lake iron-formation-hosted gold deposit (Jefferson et al. 1992b) is marked by the spatial association of iron formations with straight high strain zones that appear to be Proterozoic in age. Aspler et al. (1989), Aspler and Bursey (1990) and Miller (1989, 1992) have noted the potential for Proterozoic gold in Archean rocks. Schau (1978) has noted evidence of Proterozoic retrograde metamorphism in the Prince Albert Group, associated with regional steep faults.

The following additional features diagnostic of non-stratiform deposits (after Kerswill, 1993) are also present in the Laughland Lake area:

- Gold is not restricted to sulphide-BIF.
- Sulphide-BIF is not laminated: sulphide minerals are massive.
- Sulphide minerals are clearly controlled by veins and late structures.
- Sulphide minerals are relatively undeformed and post metamorphic.
- Sulphidation textures are common.
- Oxide-BIF is the ubiquitous (exposed) potential host.
- Available data suggest relatively high (>8) gold to silver ratios (Au ppb/Ag ppm), exemplified by the two samples of iron formation which yielded >100 ppb Au: 92JP022b (250); 92JPN120a (89).

Other sulphidic iron formations which contain only detectable gold (say 10 ppb), have similar high Au/Ag ratios. These ratios are also similar to those in elevated gold occurrences in metakomatiites, amphibolites and quartzites.

The best example of a setting for stratabound gold in the Laughland Lake area is the belt of folded and sheared pairs of iron formation and mafic-ultramafic rocks, in the Southwest Area. The several elevated gold analyses here are described in the BEDROCK OUTCROP GEOCHEMISTRY and TILL GEOCHEMISTRY chapters above. Particularly favourable comparisons with the gold prospects in the Woodburn group include the spatial association of sulphide-bearing magnetite iron formation and altered chlorite-talc schist, and the mapped structural complexity including tight folds and shear zones. The detection of 45 ppb gold in till sample 92JP021t in a down-ice position from the above rocks further strengthens the likelihood of a gold deposit here. Finally, the exploration interest shown in this locality by the permits of R.A. Olson must have been based on additional, independent geochemical indications of gold.

The presence of extensive sulphide-BIF and associated stratiform gold is still considered moderately likely but less certain than the stratabound type, given the limited outcrop exposure, the limited exploration and mapping history, and the relatively invisible nature of such iron formations to aeromagnetic surveys. Samples 92JP022 and 92JP023 from the Southwestern Area (Fig. 4) are considered to have potential to be part of a stratiform occurrence because of the lack of magnetite iron formation in their vicinities, the apparent stratiform nature of sulphidic meta-chert - amphibolite rocks in limited exposures there, and the relative lack of structural complexity in the dominantly psammitic succession which hosts the carbonaceous sulphidic metachert. On the other hand, the proximity of this site to the clearly intrusive A' Granite provides a possible igneous source for the elevated gold and/or a heat engine to drive the gold-bearing fluids through favourable host rocks.. Copper is not listed by Kerswill as a discriminating factor, but the unusually high copper (605 ppm) in this sample is compatible with the presence of elevated copper at Lupin (Kerswill's prime example of the stratform type). as well as an igneous hydrothermal origin.

In conclusion, the potential for iron formation-hosted gold is rated as high (H) in Domain 1A because the geologic environment is very favourable, occurrences are known, and the presence of undiscovered deposits is likely. Subdividing this assessment, the potential for stratabound gold is high (H), whereas that for stratiform gold is moderate (M), because occurrences of the Lupin type are not known in the Prince Albert Group, nor in lithologic equivalents such as Woodburn group.

In Domain 1B (includes UA within Brown River Gneiss), the potential is low to moderate because of the destructive effects of gneissification and the uncertainty as to the original rock types comprising this domain. The only areas in Domain 1 which exclude gold in iron formation are thick, pure quartzarenite. However their immediate margins and thin impure quartzarenites are considered to have potential because of their mapped association with iron formation and because of the example of 371 ppb Au in sample 92CGA-070 (pyritic-pyrrhotitic quartzite on the west flank of Quartzite Hill).

Minerals for Collecting

Although no mineral specimens of collectable quality were identified in the study area, the report of specimen grade piedmontite in the Laughland Lake Anorthosite reminds us that the presence of collectable minerals is likely. Lack of specific investigation in the course of this study lends some uncertainty, thus the rating is moderate-to-high (MH) in Domain 3A.

Ultramafic-Associated Nickel - Copper (A Comparative Analysis of the Laughland Lake Komatiites with the Kambalda District of Australia)

A key attribute of the ultramafic-hosted Ni-Cu deposit model (Eckstrand, 1984b) to consider in this resource assessment is contamination of the ultramafic magmas by sulphidic supracrustal rocks (Duke, 1990). Assimilation of crustal sulphur related to such deposits probably occurred at depth, rather than by thermal erosion of footwall rocks as the komatiite lavas flowed across the substrate (ibid.).

In the Laughland Lake area, the thickest komatiites are in the Central Complex (Fig. 4) which is bounded by gneisses and contains few exposed intercalated metasediments. All flows observed are tabular, some as thin as 20 cm, and only one northern outcrop appears to be pillowed, therefore the environment seems to have been subaerial. Preliminary observations by Jefferson and Schau (1992), incorporating work by Schau (1982) and Eckstrand (1975) suggested that the metasedimentary rocks overlie the komatiites. This was further supported by the mapping of Chandler et al. (1993). From these observations, it seemed to Jefferson and Schau (1992) that the komatiites in the Central Complex were likely to have erupted directly through granitoid basement and were thus less likely to have been sulphur-contaminated, nor favoured for Ni-Cu deposits. Nevertheless, the petrochemical study was focused on the komatiites of this area because of their superior preservation, better exposure and anomalous apparent thickness, and because the Central Complex covers the headwaters of the Brown River, thus being most important for the resource assessment.

The results of the PETROCHEMICAL STUDY OF THE CENTRAL KOMATIITE COMPLEX (separate chapter above) were surprisingly favourable for nickel-copper potential, as follows.

Komatiite-associated nickel deposits can be subdivided into four groups, based on two lithological groups, each with two types of morphology (Lesher, 1989; Nesbitt et al., 1979):

A. Komatiitic Peridotitic-Hosted Deposits.
   i) Stratiform deposits: small, high-grade (2-4% Ni) deposits of massive, matrix, or disseminated sulphides at the base of komatiitic peridotites.
   ii) Strata-bound deposits: medium-sized, low grade (<1% Ni) deposits ofdisseminated or blebby sulphides within komatiitic peridotites.

B. Komatiitic Dunite-Hosted Deposits.
   i) Stratiform deposits: small to medium-sized, high grade (1.5-3.5% Ni) deposits of massive, matrix, or disseminated sulphides at the base of komatiitic dunites.
   ii) Strata-bound deposits: large, low grade (<1% Ni) deposits of finely disseminated sulphides within komatiitic dunites.

Geochemical analysis suggest that potential for Group B - komatiitic dunite-hosted deposits is low in the komatiites studied here. Petrographic studies show that there are few sulphides throughout the exposed part of the studied section, therefore, the potential for strata-bound komatiitic peridotite-hosted deposits is also limited. The best potential for the Prince Albert Group komatiites lies in the form of a stratiform komatiitic peridotite deposit. The best means of assessing this potential is to compare its attributes to that of a suite of komatiites that host this type of deposit - i.e. the Kambalda district in Western Australia.

Several attributes characterize mineralized komatiitic suites: high zinc contents in chromites, depletion of chalcophile elements within the sequence, depletion of nickel in primary olivines, high magma:sulphide ratios, and local stratigraphic zones with elevated nickel and copper abundances.

Anomalously high zinc contents within chromites (anything greater than 0.5% Zn) (Groves et al., 1977) are reasonably reliable indicators of contamination of the magma during its ascent to the surface. The assimilation of zinc-rich sulphidic crustal rocks would have caused saturation of S within the magma. The result of this saturation would have been segregation of a sulphide liquid from the magma, which in turn, scavenged chalcophile elements. No xenoliths of sediment are preserved within the Prince Albert Group komatiites to prove this hypothesis, however it is favoured by geochemical trends documented here. High levels of zinc within the chromites, are a good indication that these komatiites were, in fact, contaminated upon ascent.

Zinc contents of chromites from Kambalda range from 0.53 to 2.92% but average only 1.52%. Microprobe analyses of chromites from the Prince Albert Group yielded zinc contents (on average) of 2.06%. These higher values could result from the assimilation into the melt of a very zinc-rich crustal source or a very large volume of crustal material. Either way, the high zinc contents suggest some degree of crustal assimilation, which greatly increases the potential for base and precious metal mineralization within these komatiites.

Another indicator of mineral potential within peridotitic komatiites is a low NiO content in primary olivines. This reflects in situ separation and equilibration of the olivines with sulphides (Duke, 1986). Nickel abundances within primary olivines from Kambalda range from 0.22-0.55 weight percent. Those from the Prince Albert Group range from 0.38-0.65%. These values are somewhat higher, but, as proven earlier by Kd values, the olivines probed may have been affected by compositional changes during metamorphism. Therefore, the NiO contents neither support nor detract from the potential of the komatiites to host base metal sulphides.

The depletion of chalcophile elements (e.g. Ni, Cu and Co) in the silicate phase is accomplished by their preferential partitionment into the sulphide phase relative to the silicate melt (Lesher, 1989). Therefore, the amount of these elements should be a direct reflection of the proportions of equilibrated magma and sulphides. Barren sequences (Fig. 8L) plot along a trend that corresponds to a sulphide-unsaturated model. Plots of Ni vs MgO% for samples from Kambalda show a significantly depleted nature relative to the barren sequences. Plots of the Ni abundances relative to MgO% of the Prince Albert Group komatiites (Fig. 8L) show that this sequence, too, is depleted with respect to nickel. The major concentration of points representing the olivine:sulphide ratio is along the 100:1 contour. This itself is higher than the 200:1 ratio indicated by the Kambalda diagram. This factor significantly enhances the potential for Ni-Cu deposits.

All of the above information combined, indicates that the Prince Albert Group komatiites have moderate-to-high potential (MH, Table 2) to contain nickel-copper deposits of the komatiitic peridotite - stratiform type. This rating is applied despite the lack of occurrences which are normally required for this rating, because of the high level of confidence we place in the quality of the petrochemical analyses, and the relatively predictable petrochemistry of ultramafic-hosted base metal deposits.

Follow-up work to test this potential could include detailed surficial geochemistry in order to take advantage of the till cover. Any anomalous areas could then be drilled to probe the underlying basal units of flows which could host a stratiform nickel sulphide deposit.

Volcanic-Associated Vein and Shear Zone Gold (in Komatiites and Metabasalts)

Intrusion-Associated Gold (Veins in Subvolcanic Diorite to Gabbro Bodies)

The above two deposit types (as described by Thorpe and Franklin, 1984a and 1984b respectively) are considered together, because they share a common genetic origin for the gold, a common structural concept for localization of the gold, and differ only in the specific physical and chemical natures of the potential ore hosts. In the following criteria, features which are applicable to the Laughland Lake area are underlined, and Laughland Lake examples are provided in [square brackets].

a. Such deposits are in <u>veins and irregular bodies of quartz along fractures and faults, or along zones of slightly to highly altered and schistose rock</u> [Central Complex with intersecting north-south and northeasterly, reactivated shear and brittle fault zones; Southwestern Area; Western Area; contacts of Brown River Gneiss with supracrustal rocks].
b. The native gold is associated with <u>sulphides</u>, disseminated, or as small irregular patches, in <u>quartz</u> and closely adjacent host rock [many pyritic and pyrrhotitic samples were taken from throughout the study area, most within or near such shear zones].
c. Current models in both cases invoke scavenging of gold from large volumes of rocks, and its deposition in structurally favourable sites <u>(fractures, faults and shear zones)</u> in relatively competent rocks [examples as in 1].
d. <u>Hydrothermal alteration, commonly including carbonatization</u>, is a feature of both [as for 2; also the komatiites and amphibolites commonly contain carbonate rich alteration zones, although some of these may be syn- or immediately post-volcanic in origin].
e. In the volcanic-associated type, <u>thin komatiite units, highly altered (especially carbonatized) rocks, and sulphide bearing quartz veins)</u> are cited as additional exploration guides [the Western and Southwestern areas are typified by these rocks; in addition, parts of the Central Complex, specifically around Sample 92JPN088a, contain thin komatiites intercalated with metasedimentary rocks].
f. In the intrusion-associated type, host intrusions can include subvolcanic intrusions, syenitic intrusions, and <u>subvolcanic diorite to gabbro bodies</u> [some of the massive fine-grained amphibolites in the Southwestern Area, e.g. sample 92JPK056K appear to fit this category; as might the gabbro plugs which surround the central oval of Brown River Gneiss and are transected or bounded by faults in most cases. The copper-nickel-PGE-bearing amphibolite on the

lapsed HAR claims had been considered to also fit this category, although geochemical results do not indicate any gold mineralization (sample 92JP-054C)].

g. Associated minerals include arsenopyrite, scheelite and fuchsite [Elevated arsenic (As) values (100-91,500 ppm for rock samples and 50-90 ppm in tills) were detected in the Central, Western and Southwestern areas; Tungsten (W) values of 10-15 ppm in tills along the northeast shear zone which transects the map area; fuchsite is present in several of the quartzites and is discounted as of sedimentary, diagenetic or exhalative origin].

h. "Gold is where you find it" [this old truism is supported by the elevated gold results as presented in BEDROCK OUTCROP GEOCHEMISTRY and TILL GEOCHEMISTRY

Based on the above criteria, a rating of moderate-to-high (MH) is assigned to both volcanic-associated vein gold and shear zone gold in Domains 1A and 1B.

Gabbroid-Associated Nickel, Copper and Platinum Group Elements (in the Laughland Lake Anorthosite and Associated Gabbroic Rocks)

This deposit type was summarized by Eckstrand (1984b) as forming conformable lenses, stratiform layers, central pipe-like bodies or irregular marginal zones of various mafic phases in intrusive complexes, including norite, gabbro, troctolite, feldspathic pyroxenite, amphibolite, gabbro-diabase or picrite. The underlined phases are present in association with the Laughland Lake anorthosite, particularly as marginal phases; gabbro plugs are also present around the circumference of the central oval of Brown River tonalitic gneiss.

Eckstrand's guides to ore include:

- layering in the intrusions [layering has been identified in the anorthosite by Mikkel Schau and includes gabbroic phases].
- basal contacts and immediately overlying zones are the ideal sites where immiscible sulphide minerals accumulated [these are not exposed in the Laughland Lake area, but at least they are preserved].
- PGE-rich zones tend to occur as thin, sparsely sulphide-bearing layers within the intrusion.
- Differentiated, multiple phase intrusions [the Laughland Lake Anorthosite includes at least a gabbroic and an anorthositic phase].

Other guides to ore include bulk geochemical detection of elevated PGEs [the HAR showing is the one example found; grab samples 92JP-054D/E contain 157/185 ppb Pt and 37/41 ppb Pd respectively]; and petrochemical studies such as we have completed for the komatiites. Petrochemical study might have documented the anorthosite's initial magmatic composition, its evolution during crystalliation and any crustal contamination that could have given rise to PGE and Ni-Cu sulphide separation from the initial magma (e.g. Hulbert et al., 1988; Naldrett et al., 1992). Limited resources and our initial perception that an anorthosite-dominated complex such as this is not as prospective as more iron and magnesium-dominated suites of pyroxenites, harsburgites, dunites, gabbros and norites; discouraged us from pursuing its detailed petrochemistry, although such a study would probably have been rewarding.

According to Eckstrand (1975), one significant occurrence of this deposit type is at his locality F (northern Melville Peninsula) (described in **History of Exploration and Resource Assessment**) which is north of the Quoich River 1:1,000,000 map sheet, but still in the same geological setting as the Laughland Lake map area. Further evidence of this deposit type is the HAR showing noted above.

Based on the somewhat favourable geological environment, the existence of one significant occurrence far to the northeast, and one geochemically elevated showing within the study area, we assign a moderate to high (MH, with high uncertainty) potential for the presence of the Gabbroid - associated nickel, copper, platinum group elements deposit type in the vicinity of the Laughland Lake Anorthosite, especially within its marginal phases.

Diamondiferous kimberlites

The possibility that diamondiferous kimberlites are within or close to the proposed Wager Bay national park, and specifically within the Laughland Lake area, has become apparent with the discovery of significant prospects in the Slave Structural Province (Atkinson et al., 1992). One of the key regional geological requirements is the preservation of Archean mantle roots from which diamonds are carried by the kimberlites (Helmstaedt and Schulze, 1989). Seismic tomography strongly suggests the presence of a thick mantle root under the District of Keewatin, including the Wager Bay area (Grand, 1987; Hoffman, 1990).

As described in HEAVY MINERALS FROM ESKERS, systematic sampling of eskers in the Laughland Lake area yielded 29 samples, from which complete heavy mineral fractionss were separated and 38 individual grains were isolated for probing. No kimberlite indicator minerals (eg. Kjarsgaard, 1992) were identified (Appendix III). No suspicious circular lakes were observed, and no pinpoint aeromagnetic anomalies were noted on the existing maps (Geological Survey of Canada, 1974).

No specific assessment was made for diamondiferous kimberlites in the previous survey of the Wager Bay region east of 92° (Jefferson et al., 1991), although heavy minerals were examined for all of the tills and no pink garnets were observed.

Based on the above information, the overall geological environment for the entire Wager Bay region is favourable for kimberlites to be diamondiferous, but no evidence of kimberlites has been found. On the other hand, the Slave Province had been explored relatively intensively for decades before diamondiferous kimberlites were found and an intensive search for more than 10 years was required to find the kimberlites which were suspected in the Slave (C. Jennings, 1993); surficial deposits in the Laughland Lake area are thick and extensive; our esker survey and the previous till survey around Wager Bay were not dense (Dilabio, 1992, recommends 100m sample intervals to be sure), nor did we extract heavy minerals from the Laughland Lake tills. Helicopter-borne geophysical surveys at minimum 400m spacings are also recommended for exploration (Fisk et al. 1992). The rating for the entire proposed national park area is therefore moderate-to-high (MH), but very highly uncertain.

Stratiform Mafic/Ultramafic-Hosted Chromite (in the Laughland Lake Anorthosite and Associated gabbroic rocks)

According to the synopsis by Duke (1984a), chromitite seams are most commonly hosted by peridotite or its serpentinized equivalent, although anorthositic parts of layered intrusions are also suitable hosts. Much of the assessment of this deposit type follows the arguments noted for the above Ni-Cu-PGE deposit type, but the local evidence of such a deposit type is weaker:

- layering is a critical feature of the deposit type, and is weakly developed in the study area.
- a basaltic to ultramafic parent magma is preferred.
- no occurrences are known in the PAG or other Archean relatives in the region.
- the highest chromium (Cr) value in till samples is 1100 (92JP025t) which is located immediately down-ice from komatiites, a plausible "background" source.

Based on the above obserations and the minimal petrochemical data, the potential for the stratiform mafic/ultramafic-hosted chromite deposit type is rated at low to moderate (LM; uncertainty high).

Sediment-Hosted Zinc + Platinum-Group-Elements (in Psammites, Phyllites and Schists)

Sediment-Hosted Zinc + Lead + Silver Sulphides (in Psammites, Phyllites and Schists)

Both of the above deposit types are considered together because of the similarity of their depositional environments, even though the depositional processes may be considerably different. Stratiform zinc - lead - silver deposits are generally accepted as being the result of sedimentary-exhalative activity related to synsedimentary faults (sedex of Carne and Cathro, 1982; sediment-hosted sulphide of Lydon and Sangster, 1984). The newly recognized association of zinc-nickel-platinum-group-elements in black shales has been suggested as another form of exhalative deposit (Hulbert et al., 1992) but could also be considered as a result of upwelling and organic blooms with associated phosphate deposits (Jonasson, pers. comm., 1993). The latter was considered likely in the Penhryn Domain because of coincident nickel and zinc anomillies reported by Cameron (1979)

Even though all known such deposits are associated with Proterozoic and Phanerozoic strata of continental margin or intracontinental settings, the following criteria are met by the Archean strata in Laughland Lake map area [examples in square brackets]:

- intracontinental or continental margin basins with thick clastic sedimentary successions [biotite psammites with quartzite lenses].
- second-order basins and evidence of syndepositional fault activity [limited evidence, but the few local conglomerate lenses and the discontinuous nature of the quartzites suggest this].
- syndepositional geothermal activity [local minor felsic volcanic centres, local carbonaceous units and sulphidic metacherts in the Southwestern Area].
- presence of boron-rich (about 5% tourmaline in sample 92CGA-194) metaquartzite in the southwestern area.

The following criteria are absent (although our survey and the exposure were not extensive enough to rule out their existence):

- presence of other chemical sedimentary elements such as barium (barite), manganese (manganese is high in the iron formations so is difficult to identify as being specific to psammites), or phosphorus (apatite at this metamorphic grade is ubiquitous in minor amounts; none of the samples analysed were high in phosphorous).
- presence of concretions of silica or carbonate which might represent syndiagenetic fluid flow and sub-sea cementation
- a mappable zone of very fine-grained carbonaceous strata which might be interpreted as clastic-starved deposits in a euxinic basin.
- presence of thick clastic rocks of a previous continental margin prism (analogous to Neoproterozoic rocks which underlie the North American Cordillera) which could have served as a source for lead and zinc.

Based on the above criteria, the potential for the occurrence of the sediment-hosted sulphide deposit type is considered to be moderate (M). Discovery of such a deposit in this environment would be novel and considerably extend the conceptual age for this deposit type.

Hydrocarbons (in the substrate of Wager Bay marine area)

The assssment of hydrocarbons in the substrate of Wager Bay was not considered possible by Jefferson et al. (1991) due to inadequate information. As noted in the INTRODUCTION, the present assessment was required to proceed without obtaining any further information because our limited time and financial resources were considered inadequate to do any meaningful marine survey, and the cost of a proper marine survey was considered prohibitive. The bathymetry and composition of the floor of Wager Bay remain virtually unknown, and the following assessment is based on extrapolation of the Southampton Island assessment by Jefferson et al. (1991).

The potential for large reservoirs of fluid hydrocarbons on Southampton Island was rated as low, because of the immaturity of the oil shale source beds. In Hudson Bay offshore Southampton Island toward the south and southeast, there is a cline of increasing potential from moderate (M) in Evans Strait (>200 fathoms), reflecting the extensive distribution of the oil shales in the offshore, and their increasing maturity with depth (Macauley et al., 1990). Pinnacle reefs and a matrix of small faults to create hydrocarbon traps (Sanford et al., 1985, Sanford and Grant, 1990) complete the key criteria to imply high fluid hydrocarbon potential in the offshore.

Applying these criteria to Wager Bay, the description and discussion of the geological attributes of **Domain 12, Wager Bay Marine Area** raise the distinct possibility that fairly complete Paleozoic stratigraphy is preserved under Wager Bay, including the regionally extensive oil shales. Structures are clearly present. Whether the oil shales (if present) are mature enough to have generated fluid hydrocarbons is unknown, although the depth of Wager Bay (133 fathoms in two point locations) suggests that it is unlikely. In conclusion, the potential for large reservoirs of fluid hydrocarbons is considered low to moderate (LM), reflecting high uncertainty.

Pyritic Paleoplacer Uranium + Gold (in Quartzarenites and Conglomerates).

Roscoe (pers. comm. 1990, 1991) advised extension of his studies in the Slave Structural Province (Roscoe, 1990; 1992) to examine the potential of PAG quartzites for paleoplacer gold and uranium deposits (Roscoe, 1984). The exploration guides for this deposit type (ibid.) are to "examine any coarse grained, quartz-rich arenite that may be older than 2.25 Ga or of fluvial originand contains pyrite but no hematite. If there are concentrations, however slight, of radioactivity in coarser layers, seek higher energy environments (pebbly beds) within the succession. Explore such beds up the paleocurrent direction seeking coarsening of pebbles, thickening of pebble beds and increase in U:Th ratios."

Only one site (92CGA070a) was discovered in many traverses of the PAG quartzites, where relatively coarse-grained quartz-rich arenite contains pyrite in a stratiform zone. This site also yielded elevated gold abundance (151 ppb). This and all other sites examined yielded only background radioactivity over dark heavy mineral laminae and all other parts of the quartzites which we traversed. No other pyrite was found in the sedimentary laminae; in fact laminae thought to contain heavy minerals turned out to be chloritic. The pyrite in the auriferous quartzarenite is all euhedral poikilitic, ranging from finer to coarser grained than the quartz granules (please see **Elevated Geochemical Results, Quartzite Hill** above). Despite this lack of hydrodynamic equivalence and the post-tectonometamorphic texture in the pyrite, it is conceivable that the quartzite contained detrital pyrite and detrital gold. Most of the quartzarenites in the Laughland Lake area are relatively fine grained and distal; the few conglomerates are dominantly matrix-supported. There are orthoconglomerates in the southwest area and are in fine-grained psammite hosts, all relatively distal. It seems unlikely that proximal thick conglomerates will be found in the PAG. Furthermore, Roscoe's examination of quartzarenites in the Slave Province, tested many possible gold hosts and found that all paleoplacer deposits are small and very low in grade. Considering the potential tonnage and grade of iron-formation-hosted gold, versus the size of known paleoplacer deposits in highly deformed supracrustal belts like the Slave (Roscoe, 1992), this deposit type is not considered likely to constitute an ore deposit in the PAG. It is therefore rated as low (L) in resource potential.

Iron-Rich Sedimentary Strata (Iron Formations)

Iron formation of the Algoma type (Gross, 1984) is clearly abundant (potential very high, 1) in the Prince Albert Group and has been explored with a view to iron mining in coastal area of Melville Peninsula (reference to Borealis?). Chandler et al. (1993) and this study have interpreted the depositional environment of the iron formation as platformal marine, which characterizes the Superior type of iron formation, but the mineralogy (laminated chert-magnetite, garnet-amphibolite-magnetite and mixtures of these with sulphides) and associated rocks (komatiites, psammites, metabasalts) are more similar to the Algoma type, even though some iron formation is juxtaposed with quartzarenite.

This deposit type is not considered to be economically viable because we have not observed thicknesses normally required for economically mineable deposits (Gross, 1984; thicknesses in the order of 100 m and strike lengths of several km) compared to thicker reported iron formations at coastal locations on Melville Peninsula and on Baffin Island (Mary River iron formation, Gross, 1965; Jackson and Sangster, 1987). The iron formations in Laughland Lake area are far more important as potential hosts to gold mineralization than as potential ore in themselves. The rating for iron formations (as ore deposits in their own right) is therefore low (L).

Volcanic-Associated Massive Sulphide (in Komatiites, Metabasalts and Felsic Volcanic Rocks)

This deposit type (summarized by Franklin et al., 1984) requires several key lithologic associations which are minimal in the Laughland Lake area: a thick tholeiitic or calc-alkaline submarine volcanic sequence, felsic volcanic centres, rhyolite domes therein and hydrothermally altered zones. Given that the general geological environment is unfavourable, the rating for massive copper-zinc sulphides is low (L).

Clastic Sediment-Hosted Gold (in Veins and Shear Zones in Psammites and Quartzarenites)

Neither of the two subtypes summarized by Thorpe (1984), are considered to be likely ore types in the Laughland Lake area. The carbonaceous shale/carbonate-hosted type is discounted for lack of suitable host rocks and age (these deposits are typically Mesozoic to Tertiary in age, related to Laramide deformation and plutonism affecting Cambrian to Devonian strata. The turbidite-hosted vein and shear zone type is considered possible, but unlikely due to the general lack of distinctly thick bedded turbidites with carbonaceous shaly partings. Such deposits are also typically small and are unlikely to be economic given the remoteness of the study area. Therefore the clastic sediment-hosted gold deposit type is rated as low (L) in potential.

Porphyry Copper, Molybdenum, Tin, Tungsten and Rare Metals (in Fluorite Granite and Pegmatites)

Investigations by LeCheminant et al., (1987), Henderson et al., (1986), Jefferson et al. (1991) and by geochemical surveys for this study have revealed little evidence of uranium, molybdenum, tungsten, or tin being present in anomalous amounts although such elements are concentrated in some bodies of this type in younger geologic terranes. A few disseminated molybdenite crystals were noted in batholithic rocks. Minor chalcopyrite and malachite were found in migmatitic gneiss at one locality on the north shore of Ford Lake. Molybdenite rosettes (up to 4 cm) and chalcopyrite are also present in granite and pegmatite dykes that cross-cut the granites. Numerous small pegmatites, cutting the gneisses but older than the plutons, are also anomalously radioactive. Occurrences noted to date are very small and are explained by concentrations of allanite and possible uranothorite. Pegmatites in the Laughland Lake area are small, few and very simple, most being in the eastern area along the fluorite granite - gneiss contact, or in the west closely surrounding the A'granite.

As in the case of the anorthosite, sophisticated petrochemical studies on a regional scale might make it possible to apply criteria such as those provided by Cerny (1993). However, at present only the limited information base summarized above has been used to conclude that potential for these granite-associated deposits is low (L).

Ultramafic-Hosted Asbestos (Serpentinized Komatiites and Ultramafic Sills)

Chrysotile asbestos is deposited in fractures during deformation of ultramafic rock under relatively low-grade (greenschist or sub-greenschist) metamorphic conditions (Duke, 1984b), and is therefore very unlikely to be preserved (even if it once formed) in the Laughland Lake area, despite the abundance of ultramafic rocks. Its rating is therefore very low (VL).

Other Deposit Types

Aggregates, building stone and other deposit types not considered above, which are listed in Eckstrand (1984a), Cox and Singer (1986), Roberts and Sheahan (1988) and Sheahan and Cherry (1993), were reviewed for their applicability to the Laughland Lake area, and rejected as being either completely inapplicable or of low to very low potential, without requiring in-depth analysis. As indicated in the INTRODUCTION, it is likely that one or more of these rejected deposit types, and some that have not yet been discovered, are actually present and of economic grade in the Laughland Lake area; we simply had to stop somewhere. Future technology and new ideas will probably make their economic potential more obvious.

GEOLOGICAL ATTRIBUTES OF GENERAL INTEREST

The main geologic attributes of potential public interest in the Laughland Lake area are geomorphological, mostly related to Quaternary (very young) events. The bedrock ranges in age from greater than 2.7 billion years to about 1.8 billion years, and the next oldest materials are unconsolidated Quaternary deposits less than 10,000 years old. A huge time period of earth history is not recorded in the rocks of the Laughland Lake area.

Wager Bay appears to be a half graben structure (and Ford Lake a smaller half graben) whose south and southwest margins are steep because of down-dropping along east-west and northwest-trending faults. These faults are discussed in the description of Domain 7C, Wager Bay Marine Area. As noted in the section on Seismic Activity under Quaternary History, Wager Bay straddles a northwest-trending zone of abundant earthquake epicentres. These earthquakes may record continued extensional activity, thus continued active (though subtle) development of the Wager Bay half-graben.

About 10,000 years ago the area was covered by several miles of ice, which sculpted the bedrock terrain to its present shape and covered most of it with till as it flowed slowly and plastically to the north-northwest. Melting of this ice proceeded from both the north and the south, such that a residual ice mass occupied Brown River Valley and Wager Bay, resulting in major north-flowing streams orders of magnitude larger than those we see at present. These raging ephemeral watercourses created vast boulder plains by removing much of the fine material; locally these torrents completely removed the till, baring linear stretches and patches of the multi-billion year bedrock. In places the visitor will see bare rock with only a few scattered large boulders left behind as the melt-waters waned. Some of the isolated boulders are balanced fortuitously on others - some stacks are multiple, looking suspiciously like inukshuks.

A remarkable train of angular, very large blocks (some room-sized) of anorthosite is present associated with a north-northwest-trending esker which largely follows the western headwater tributary of the Brown River in the Central Complex area. The esker records gradual down-cutting of a stream which flowed across the top of the melting glacier. As the stream cut downward through the ice, sand and gravel trapped within the ice became the stream bed, and eventually reached the bottom, bedrock level. The train of angular blocks, on the other hand, records a catastrophic event which moved the large blocks quickly but relatively gently along the esker site. Such gentle transport could have been accomplished by a landslide or debris flow, perhaps due to break-through of surface ponded water on top of the ice sheet, to bursting of a thin ice dam when the glacier was nearly all melted, or to release of trapped water pocket beneath the melting ice sheet.

As the ice mass receded, an ephemeral lake developed in the Brown River valley, dammed by residual ice down the valley to the east. The lake is recorded by deltaic stream deposits from the west, and by faint raised beaches on the sides of a flat-topped esker within the valley.

Once melting of the glacier was complete, flow of the Brown River resumed its present day course, with a very minor flow compared to the immediate post-glacial period. In the winter, flow drops to zero as the stream freezes solid. Sand from the esker trains and river course dry out and are driven by northwesterly gales across the tundra, creating large blow-outs in parts of the eskers, and covering vegetarion with a veneer of pale sand.

Weathering and erosion of the 2.5 billion year bedrock continues slowly with yearly freeze-thaw cycles. Local "staircases" are formed on the edges of gently domal granite hills, as temperature changes and frost gradually split off huge horizontal sheets of granite. The Anorthosite weathers differently, being slightly more resistant and less fractured than the granite. It forms low but rugged white hills littered with angular blocks that have also been split off by frost. The quartzite hills are even more resistant, forming islands of polished glassy sandstone surrounded by boulder and till plains. The quartzite hills make good vantage points as well as markers for the long-distance hiker to focus on. In Archean times, 2.5 billion years ago, these quartzites were transported by broad braided streams to a continental shelf where marine currents washed them on beaches and shoals, finally depositing them in the shallow offshore.

The scenic geology of Wager Bay marine area is very appealing, as described by Jefferson et al. (1991).

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NOTES

APPENDIX I: LABORATORY ANALYSES OF ROCK SAMPLES

APPENDIX I(a). LOCATIONS AND DESCRIPTIONS OF 1991 ROCK-GEOCHEMICAL SAMPLES

NUMBER	EASTING	NORTHING	ROCK TYPE
74EL238-249	located on Fig. 8		komatiites; cumulates and spinifex
91JP228 A	535249	7353983	pyrrhotitic granite
91JP233 A	523509	7369241	rusty pyritic granitoid gneiss (more in text)
91JP233 B	523509	7369241	rusty pyritic mylonitic tonalite
91JP233 C	523509	7369241	laminated mylonitic tonalite
91JP233 D	523509	7369241	pyritic leucocratic mylonite
91JP233 E	523509	7369241	muscovitic pyritic schist (more in text)
91JP234 A	523292	7365842	brown cumulate of komatiite
91JP234 B	523292	7365842	green spinifex of komatiite
91JP235 A	523174	7364674	ultramafic cumulate
91JP237 A	523120	7364071	crenulated komatiite
91JP240 B	523446	7363072	micaceous meta-cumulate in komatiite
91JP241 A	521724	7359663	spinifex
91JP242 A	521439	7359568	serpentine komatiite
91JP242 B	521439	7359568	orange komatiite with ankerite veinlet
91JP243 A	521528	7359957	deformed spinifex
91JP243 B	521528	7359957	talc schist
91JP243 C	521528	7359957	massive talc fels
91JP257 A	495816	7352221	pyritic-msc-chl schist (metasediment)
91JP257 D	495816	7352221	laminated green chloritic quartzarenite
91JP258 A	495762	7351789	qtz-fine-grained amphibolite (metabasalt)
91JP258 C	495762	7351789	massive meta-intermediate volcanic, minor pyritic (altered bslt?)
91JP258 E	495762	7351789	massive bio meta-intermediate volcanic (altered bslt?)
91JP258 F	495762	7351789	pyritic meta-felsic volcanic rock? (in ts looks like metased)
91JP258 G	495762	7351789	pyritic meta-felsic volcanic rock? (in ts looks like metased)
91JP258 H	495762	7351789	layered pyritic meta-felsic volcanic rock? (ts looks like metased)
91JP259 B	495279	7350881	pyritic chloritic quartzarenite
91SMA1007 B	536876	7351549	muscovitic foliated granite
91SMA1010 C	538884	7350689	paragneiss
91SMA1012 A	539251	7350892	granitoid
91SMA1025 A	520748	7350680	anorthosite partly recrystallized
91SMA1025 B	520748	7350680	epidosite within anorthosite
91SMA1026 A	522032	7345148	sheared anorthosite (in ts resembles amphibolite)
91SMA1026 B	522032	7345148	gneiss (looks like dyke in field)
91SMA1028 B	512616	7342550	amphibolite (resembles dyke in field)
91SMA1029 A1	503627	7341786	sheared recrystallized gneiss in anorthosite
91SMA1029 A2	503627	7341786	sheared recrystallized gneiss in anorthosite
91SMA1029 B	503627	7341786	porphyroblastic anorthosite (ts resembles metased)
91SMA1031 B	528169	7346922	altered anorthosite
91SMA1031 C	528169	7346922	altered anorthosite
91SMA1034 A	523295	7367490	spinifex
91SMA1035 A1	523399	7367844	spinifex
91SMA1035 A2	523399	7367844	spinifex
91SMA1035 C	523399	7367844	talcose ultramafic schist
91SMA1035 D	523399	7367844	cumulate zone (komatiite)
91SMA1039 A	523611	7368872	pyritic tonalitic gneiss
91SMA1044 A	522652	7363920	spinifex komatiite
91SMA1044 B	522652	7363920	cumulate komatiite same flow as A
91SMA1045 A	522739	7363695	komatiite at brn-grn transition
91SMA1049 A	495994	7353458	quartzarenite
91SMA1051 A	495974	7353980	quartzarenite
91SMA1054 A	495181	7353856	bluish mica quartzarenite
91SMA1070 A	528310	7346938	anorthosite + mafic rosettes
91SMA1070 B	528310	7346938	mafic layer in anorthosite
91SMA1070 C	528310	7346938	sheared anorthosite
91SMA1070 D	528310	7346938	anorthosite (altered with epidote)
91SMA1070 E	528310	7346938	anorthosite (relatively fresh)
91SMA1070 F	528310	7346938	anorthosite (relatively fresh)
91SMA1070 G	528310	7346938	anorthosite (altered with pyrte)
91SMA1071 A1	528651	7347134	anorthosite, crystals to 2.5 cm; pink vein
91SMA1071 B	528651	7347134	fine-grained sugary leuco mylonite in anorthosite
91SMA1072 A	529239	7347563	anorthosite, massive
91SMA1073 A	529846	7347531	metagabbro-anorthosite
91SMA1073 B	529846	7347531	metagabbro-anorthosite
91SMA1073 C	529846	7347531	sheared metagabbro-anorthosite
91SMA1073 D	529846	7347531	sheared metagabbro-anorthosite
91SMA1073 E	529846	7347531	massive gabbro near anorthosite margin
91SMA1074 A	530781	7346678	massive gabbro, hornblende > plagioclase (amphibolite in ts)

APPENDIX I(b): 1991 WHOLE ROCK ANALYSES, Laboratory work by: Analytical Chemistry Section, GSC, majors in %; Ba - Zr in ppm.

SAMPLE	SiO_2	TiO_2	Al_2O_3	Fe_2O_3T	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	P_2O_5	S(t)	Ba	Nb	Rb	Sr	Zr	TOTAL
91JP228A	56.7	0.23	15.8	10.5			0.15	0.98	4.15	3.10	4.43		0.2	0.10	4.46	1500	<10	150	1400	130	101.1
91JP233A	67.3	0.43	15.6	3.80	1.2	2.3	0.11	1.34	3.15	3.50	3.05	1.1	0.6	0.14	0.25	840	<10	78	480	130	100.3
91JP233B	72.1	0.29	13.8	3.90	1.5	2.2	0.03	0.77	2.86	4.30	0.93	0.8	0.1	0.06	0.37	320	18	29	190	340	100.2
91JP233C	56.6	1.22	14.9	11.8	3.9	7.1	0.17	3.68	5.87	3.30	1.00	1.4	0.1	0.13	0.95	260	12	29	240	120	100.4
91JP233D	65.0	0.79	16.3	5.70			0.05	1.39	3.37	3.80	1.67		0.1	0.14	1.34	430	12	42	240	200	99.7
91JP233E	57.2	0.45	20.9	7.20			0.17	1.41	0.26	0.10	7.49		0.1	0.14	3.53	880	13	230	63	150	99.1
91JP234A	38.8	0.18	3.60	9.50	1.7	7.0	0.14	31.9	2.43	<0.03	<0.05	10.0	3.3	0.02	0.08	40	13	<10	43	10	99.2
91JP234B	41.3	0.38	6.70	12.4	5.1	6.6	0.15	26.3	4.72	0.10	<0.05	7.6	0.5	0.02	<0.02	40	11	<10	<20	17	99.5
91JP235A	40.0	0.13	3.10	8.40	1.7	6.0	0.10	34.9	0.92	<0.03	<0.05	10.6	1.4	0.02	0.10	<30	12	<10	<20	<10	99.0
91JP237A	45.4	0.24	6.00	12.4	5.1	6.6	0.22	25.6	4.66	0.10	<0.05	6.3	0.1	0.03	<0.02	40	15	<10	<20	11	100.3
91JP240B	32.8	2.01	11.6	8.80	2.2	5.9	0.14	29.7	2.11	<0.03	0.11	10.0	1.8	0.61	<0.02	130	25	15	28	280	99.1
91JP241A	41.2	0.49	7.90	13.6	4.9	7.8	0.11	24.7	5.21	0.10	<0.05	6.9	0.1	0.04	<0.02	30	<10	<10	<20	25	99.5
91JP242A	40.4	0.18	3.10	10.3			0.13	32.0	1.12	<0.03	<0.05	9.8	0.9	0.02	<0.02	50	10	<10	21	11	98.0
91JP242B	41.3	0.32	5.20	11.2	2.9	7.5	0.19	28.3	2.72	<0.03	0.27	8.2	1.9	0.03	0.27	70	11	11	61	24	99.1
91JP242B	41.4	0.32	5.20	11.2	3.1	7.3	0.19	28.4	2.72	<0.03	0.27	8.5	1.9	0.03	0.27	70	11	11	64	21	99.6
91JP243A	49.8	0.74	11.4	12.3	2.3	9.0	0.19	12.4	8.13	3.30	0.05	2.7	0.1	0.06	0.06	50	11	<10	100	51	100.3
91JP243B	39.2	0.40	6.10	10.3	1.7	7.7	0.14	25.2	4.73	<0.03	<0.05	6.2	7.1	0.03	0.05	30	13	12	80	28	98.6
91JP243C	47.9	0.66	10.6	12.4	2.2	9.2	0.18	14.9	8.63	2.20	0.05	3.4	0.1	0.06	0.05	<30	17	<10	50	48	100.1
91JP257A	54.8	1.77	25.1	5.80	1.2	4.1	0.05	2.79	3.23	1.60	0.75	4.2	0.2	0.29	0.05	200	17	24	430	210	100.3
91JP258A	50.9	1.51	22.8	10.3	1.7	7.7	0.11	3.48	4.25	3.00	1.13	3.3	0.1	0.24	<0.02	120	19	26	460	230	100.3
91JP258C	67.1	0.82	15.2	5.90	0.8	4.6	0.07	2.34	4.48	2.40	0.42	1.7	0.1	0.17	0.04	110	14	22	320	140	100.3
91JP258E	61.4	0.97	16.3	8.20	1.4	6.1	0.09	3.86	4.22	2.00	1.34	2.2	0.1	0.19	<0.02	230	16	50	220	150	100.3
91JP258F	75.4	0.13	13.1	2.50	0.3	2.0	0.03	1.36	3.27	2.60	0.35	1.1	<0.1	0.05	0.13	110	12	18	260	120	99.9
91JP258G	79.7	0.13	12.9	1.00	0.8	0.2	<0.01	0.42	0.41	0.60	3.33	1.6	0.1	0.03	0.04	660	11	86	98	120	100.3
91JP258H	75.9	0.13	13.7	2.40	0.6	1.6	0.02	1.21	1.31	1.40	2.46	1.7	0.1	0.06	0.04	500	<10	65	150	120	100.3
91JP259B	57.3	0.48	14.2	14.9			0.15	5.59	0.19	0.10	0.54		0.1	0.05	3.19	370	23	21	77	480	96.9
91SMA1007B	60.9	0.10	20.3	1.80	0.7	1.0	0.01	0.67	0.22	2.30	11.4	0.9	0.1	0.03	<0.02	3000	<10	500	130	92	99.0
91SMA1010C	44.4	1.17	18.6	14.9	5.1	8.8	0.21	6.76	5.22	2.40	4.71	2.2	0.3	0.39	<0.02	580	<10	320	480	230	100.5
91SMA1012A	74.2	0.15	13.6	1.40	0.7	0.6	0.04	0.28	0.97	3.40	5.13	0.3	0.1	0.03	<0.02	370	33	420	130	160	99.6
91SMA1025A	50.4	0.19	28.9	2.20	0.6	1.4	0.04	0.88	12.9	3.50	0.10	1.2	0.2	0.03	0.07	110	10	10	270	<10	100.5
91SMA1025A	50.2	0.18	28.7	2.20	0.8	1.3	0.05	0.91	12.8	3.50	0.10	1.1	0.3	0.02	0.07	110	<10	11	280	10	100.0
91SMA1025B	39.8	0.13	25.2	9.90	8.9	0.9	0.12	0.35	22.6	<0.03	<0.05	2.2	0.1	0.03	0.07	60	11	<10	310	11	100.4
91SMA1026A	47.5	0.32	29.4	3.50	1.1	2.2	0.06	1.68	14.8	2.20	0.38	1.0	0.1	0.04	0.10	110	11	46	260	13	100.9
91SMA1026B	61.4	0.61	16.3	6.60	2.2	4.0	0.10	3.03	6.61	3.00	1.27	1.1	0.2	0.17	<0.02	450	<10	84	460	150	100.1
91SMA1028B	57.8	0.85	15.9	8.60	3.0	5.0	0.12	3.47	6.72	3.50	1.79	1.1	0.1	0.29	0.11	710	<10	54	630	180	99.9
91SMA1029A1	69.0	0.44	14.0	4.00	0.7	3.0	0.08	1.37	4.42	4.40	0.60	0.7	1.2	0.09	0.03	390	11	29	190	130	100.1
91SMA1029A2	70.7	0.30	13.9	3.80	0.6	2.9	0.06	1.42	3.33	5.30	0.24	0.7	0.2	0.08	0.05	190	12	14	200	150	99.8
91SMA1029B	54.3	1.15	31.2	3.60	1.9	1.5	0.07	0.64	4.19	3.80	0.33	0.7	0.1	0.21	<0.02	190	15	12	380	260	100.2
91SMA1031B	52.8	0.10	27.5	1.50	0.5	0.9	0.03	0.87	10.8	4.70	0.17	0.8	0.3	0.08	<0.02	140	10	12	350	<10	99.6
91SMA1031C	48.4	0.10	30.7	2.00	0.6	1.3	0.03	1.14	15.5	2.10	0.13	0.6	0.1	0.02	<0.02	80	10	10	270	<10	100.7
91SMA1034A	42.9	0.34	7.20	11.3	4.6	6.0	0.16	25.2	5.96	0.30	<0.05	6.3	0.6	0.03	0.04	<30	14	<10	25	18	99.7
91SMA1035A1	39.0	0.37	8.80	14.3	6.3	7.2	0.13	25.3	4.84	0.10	<0.05	7.2	0.1	0.05	<0.02	50	15	<10	<20	19	99.4
91SMA1035A2	40.2	0.31	8.40	13.3	5.5	7.0	0.13	25.2	5.18	0.10	<0.05	7.1	0.2	0.04	<0.02	50	12	<10	<20	15	99.4
91SMA1035C	47.4	0.27	6.50	7.40	1.4	5.4	0.14	25.0	7.44	0.10	<0.05	5.9	0.1	0.02	<0.02	50	<10	<10	<20	13	99.7
91SMA1035D	40.6	0.20	5.10	10.2	2.8	6.7	0.16	29.7	3.29	0.10	<0.05	8.7	1.5	0.02	0.05	40	13	<10	34	<10	98.9
91SMA1039A	71.0	0.30	14.4	2.60	0.9	1.5	0.04	1.86	1.69	3.70	2.71	1.3	0.3	0.10	0.04	630	10	58	300	110	100.0
91SMA1044A	41.7	0.25	5.30	11.3	4.1	6.5	0.16	28.2	4.30	0.10	<0.05	8.1	0.9	0.03	0.02	30	11	<10	<20	10	99.6
91SMA1044B	40.1	0.21	4.70	10.5	2.8	6.9	0.16	31.2	2.32	<0.03	<0.05	9.8	1.1	0.03	0.06	<30	12	<10	<20	10	99.4
91SMA1045A	41.8	0.30	6.90	10.3	3.1	6.5	0.15	27.0	4.91	0.20	<0.05	7.7	1.0	0.03	0.02	30	10	<10	24	14	99.6
91SMA1049A	98.9	0.05	0.80	0.10	<0.2	0.2	<0.01	0.48	0.06	0.10	0.07	0.2	0.1	0.02	<0.02	<30	<10	<10	<20	24	100.9
91SMA1051A	98.0	0.04	1.30	0.30	<0.2	0.3	<0.01	0.36	0.05	<0.03	0.07	0.3	0.1	0.02	<0.02	<30	11	<10	<20	29	100.5
91SMA1054A	90.5	0.12	6.90	0.70	0.3	0.4	<0.01	0.21	0.01	0.10	0.45	0.9	0.2	0.02	<0.02	40	12	16	43	88	100.1
91SMA1070A	47.7	0.08	31.9	0.80	0.2	0.5	0.01	0.41	16.1	2.00	<0.05	0.8	0.1	0.02	0.02	30	12	<10	220	<10	99.9
91SMA1070A	47.5	0.09	31.8	0.70	<0.2	0.5	0.01	0.50	16.1	2.00	<0.05	0.8	0.2	0.02	<0.02	50	<10	<10	230	<10	99.7
91SMA1070B	40.7	0.05	28.8	5.40	2.1	3.0	0.06	3.71	15.5	0.90	1.34	4.0	0.1	0.01	<0.02	60	<10	87	180	<10	100.3
91SMA1070C	45.2	0.06	30.8	2.90	0.5	2.2	0.03	2.19	14.8	1.70	0.23	2.3	0.2	0.01	<0.02	80	10	19	210	<10	100.2
91SMA1070D	53.2	0.04	28.9	0.60	0.3	0.3	0.01	0.37	14.8	1.20	0.22	0.7	0.1	0.02	<0.02	70	10	21	210	<10	100.2
91SMA1070E	46.9	0.04	32.0	0.60	<0.2	0.4	0.01	0.37	16.0	2.20	0.15	1.5	0.3	0.02	<0.02	70	<10	14	220	<10	100.1
91SMA1070F	49.7	0.05	30.9	0.60	<0.2	0.4	<0.01	0.34	15.2	2.50	0.05	0.6	0.1	0.02	0.02	60	<10	<10	210	<10	100.1
91SMA1070G	47.4	0.06	32.6	0.60	0.3	0.3	0.01	0.32	16.5	1.80	<0.05	0.5	0.2	0.02	<0.02	60	<10	<10	230	<10	100.1
91SMA1071A	47.5	0.05	32.4	0.80	0.2	0.5	0.01	0.44	16.0	2.10	0.18	0.8	0.1	0.02	0.02	70	10	21	240	<10	100.4
91SMA1071B	74.4	0.06	14.7	0.40	0.3	<0.2	0.04	0.20	2.19	3.50	3.52	0.4	0.3	0.03	<0.02	150	41	110	68	38	99.8
91SMA1072B	50.4	2.32	13.7	14.7	3.5	10.1	0.20	5.80	9.90	2.20	0.07	0.7	0.2	0.02	0.06	90	<10	<10	230	<10	100.5
91SMA1073A	49.5	0.17	22.6	5.40	1.3	3.7	0.12	5.49	13.9	1.90	0.24	1.2	0.6	0.02	<0.02	40	12	19	150	<10	100.8
91SMA1073B	47.8	0.25	18.9	8.70	2.5	5.6	0.14	8.41	13.2	1.40	0.45	1.5	0.1	0.02	<0.02	40	<10	44	120	<10	100.3
91SMA1073B	47.4	0.23	18.9	8.70	2.6	5.5	0.14	8.48	13.1	1.40	0.45	1.5	0.1	0.02	<0.02	50	<10	49	120	<10	99.8
91SMA1073C	48.0	0.07	26.7	4.00	1.0	2.7	0.08	3.56	14.9	2.00	0.18	0.9	0.2	0.02	<0.02	<30	11	18	180	<10	100.3
91SMA1073D	47.3	0.14	24.9	4.80	1.5	3.0	0.09	4.47	14.8	1.90	0.19	1.5	0.1	0.02	<0.02	40	10	23	190	<10	99.9
91SMA1073E	46.1	0.11	24.2	6.90	1.8	4.6	0.10	6.14	13.9	1.70	0.21	1.2	<0.1	0.02	0.03	70	<10	28	180	<10	100.1
91SMA1074A	48.2	0.97	16.0	11.2	2.2	8.1	0.17	9.16	11.2	1.70	0.52	1.6	0.1	0.07	0.03	140	10	28	250	50	100.1
74EL238A	34.3	0.05	1.20	6.20	4.2	1.8	0.08	35.9	3.78	<0.03	<0.05	10.7	6.6	0.02	0.02	<30	<10	<10	85	<10	98.7
74EL240	37.8	0.29	2.50	10.4	6.4	3.6	0.05	36.6	0.04	<0.03	<0.05	11.8	0.2	0.02	0.13	50	13	<10	<20	<10	99.4
74EL245	42.9	0.33	7.60	10.3	2.5	7.0	0.12	25.0	4.66	0.30	<0.05	7.4	1.6	0.04	<0.02	30	11	<10	<20	15	99.5
74EL246	38.9	0.09	1.70	6.90	4.0	2.6	0.07	37.6	0.30	<0.03	<0.05	10.3	3.2	0.02	<0.02	40	12	<10	<20	<10	98.8
74EL247	42.5	0.30	7.00	11.3	5.4	5.3	0.14	24.8	7.09	0.60	<0.05	6.0	0.2	0.03	<0.02	40	13	<10	29	12	99.4
74EL248	44.8	0.35	7.80	11.6	2.9	7.8	0.19	20.0	6.88	0.70	2.27	4.3	0.7	0.03	<0.02	370	<10	66	<20	16	98.8
74EL249	39.4	0.05	1.10	8.70	3.0	5.1	0.17	41.2	0.18	<0.03	0.23	7.2	0.3	0.02	0.18	50	13	31	<20	<10	98.2

APPENDIX I(c): 1991 TRACE ELEMENTS, by X-Ray Assay Labs; Au FA, Pd, Pt, Rh by AcmeAnalytical Labs. fire assay. All results in ppm except Au, Pd, Pt, Rh in ppb; majors in % (see Note).

SAMPLE	Ag ICP	Al	As NA	As ICP	Au NA	Au FA	Ba NA	Ba ICP	Be	Bi	Br	Ca NA	Ca ICP	Ce	Li AA	Li ICP	Lu	Mg	Mn	Mo ICP	Na NA	Na ICP	Nd	Ni NA	Ni ICP	P	Pb	Pd	Pt	Rh	Rb
74EL238A	0.5	0.15	99	96	<5	1	<100	2	0.5	<3	10	2	2.26	<3		2	<0.05	18.80	0.05	<1	<0.05	0.02	<10	1400	1860	<0.01	<2	1	1	1	<30
74EL238B	0.4	1.45	2	<3	<5	13	300	32	0.6	<3	2	5	0.94	39		10	0.47	0.55	0.03	<1	1.60	0.23	20	<100	21	0.08	10	10	1	1	<30
74EL245	<0.1	1.75	3	<3	<5	3	<100	7	<0.5	<3	1	3	0.20	<3	10	5	0.13	4.67	0.01	<1	0.29	0.02	<10	700	403	0.01	34	1	1	1	<30
74EL246	0.5	0.25	2	<3	15	11	<100	7	<0.5	<3	<1	<1	0.07	<3	6	<1	<0.05	8.08	0.03	<1	<0.05	0.02	<10	1500	1370	<0.01	<2	1	2	1	<30
74EL248	0.3	2.63	<2	<3	<5	2	400	337	<0.5	<3	<1	3	0.50	6	27	28	0.18	4.90	0.04	<1	0.59	0.13	<10	400	400	<0.01	<2	8	3	1	40
91JP228A	0.7	0.42	<3	<3	<5		2000	21	1.2	<3	<1	<1	0.34	26		6	<0.05	0.19	0.03	1	2.10	0.05	10	<100	10	0.04	5				110
91JP233A	0.6	0.94	2	<3	56	53	1200	120	<0.5	<3	<1	1	0.55	40		16	0.10	0.58	0.06	<1	2.10	0.04	20	<100	8	0.06	<2	1	1	1	50
91JP233B	0.3	0.83	<2	<3	<5		400	206	<0.5	<3	1	2	0.08	31		5	0.40	0.38	0.02	1	2.90	0.05	10	<100	3	0.02	<2				30
91JP233D	0.8	1.17	<2	<3	<5		500	140	0.6	<3	<1	2	0.17	24		11	0.20	0.72	0.02	<1	2.50	0.06	10	<100	40	0.06	<2				30
91JP233E	3.0	0.49	<2	<3	160	173	1100	63	0.9	19	<1	<1	0.12	41		4	<0.05	0.04	0.01	10	0.10	0.02	20	<100	7	0.06	11	<3	<3	<5	200
91JP241B	0.3	1.61	2	<3	<5		300	33	0.7	<3	1	5	1.05	38		10	0.41	0.58	0.03	<1	1.50	0.26	20	<100	22	0.08	12				<30
91JP242B	0.6	1.33	2	4	21	21	<100	3	0.7	4	<1	1	0.74	<3		1	0.13	9.33	0.05	<1	0.05	0.02	<10	900	1150	<0.01	<2				<30
91JP243B	0.1	1.40	2	<3	<5		<100	4	<0.5	<3	1	2	2.87	<3		<1	0.09	4.45	0.06	<1	<0.05	0.02	<10	800	419	<0.01	<2	1	1	1	<30
91JP243C	0.3	1.45	<2	<3	<5		200	11	<0.5	<3	1	5	0.28	7		9	0.23	1.85	0.02	8	1.50	0.07	<10	200	112	0.02	<2				<30
91JP257A	0.2	2.28	<2	<3	<5		200	12	0.7	4	<1	2	0.35	38		21	0.37	1.19	0.02	<1	1.10	0.06	20	<100	46	0.13	<2				<30
91JP257D	0.2	1.57	<2	<3	<5		300	34	0.7	<3	1	4	1.04	36	17.00	11	0.43	0.58	0.03	<1	1.50	0.25	20	200	23	0.09	11				<30
91JP258A	0.4	2.76	<2	<3	<5	6	<100	7	0.9	4	1	2	0.33	34	56.00	38	0.30	1.56	0.04	<1	1.90	0.05	20	100	86	0.10	<2	1	1	1	<30
91JP258F	0.3	1.03	<2	<3	<5		<100	30	<0.5	<3	1	2	0.12	37		12	0.12	0.66	0.02	<1	1.90	0.06	10	<100	6	0.02	<2				<30
91JP258G	0.2	0.20	<2	<3	<5		900	31	<0.5	<3	<1	<1	0.02	7	31.00	1	0.06	0.03	<0.01	1	0.47	0.03	<10	<100	1	<0.01	<2				70
91JP258H	0.2	0.79	<2	<3	<5		500	26	<0.5	<3	1	1	0.11	33		12	0.07	0.48	0.01	2	0.94	0.03	10	<100	8	0.02	<2				400
91JP259B	0.9	3.64	51	34	18		500	27	1.2	5	<1	<1	0.03	96		30	0.72	2.53	0.06	<1	0.08	0.03	40	100	193	<0.01	<2				<30
91SMA1025A	0.2	5.10	2	<3	<5	17	<100	30	<0.5	<3	1	8	2.86	6	17.00	9	0.05	0.37	0.03	<1	2.50	0.85	<10	<100	8	<0.01	<2	5	3	1	<30
91SMA1025B	<0.1	1.51	2	<3	<5	18	100	22	<0.5	<3	<1	13	1.69	5		<1	0.17	0.08	0.01	<1	<0.05	0.02	<10	<100	4	<0.01	2	5	3	1	<30
91SMA1026C	0.1	1.67	<2	<3	<5	5	200	35	0.7	<3	2	6	1.10	38		11	0.41	0.60	0.03	<1	1.50	0.27	20	<100	23	0.08	11	9	2	1	<30
91SMA1029B	0.3	0.51	<2	<3	<5	8	200	77	<0.5	<3	1	2	0.29	60	62.00	16	0.20	0.17	<0.01	<1	2.80	0.06	30	<100	7	0.08	<2	1	1	1	<30
91SMA1031C	<0.1	10.80	<2	<3	<5	10	100	18	<0.5	<3	1	9	7.00	<3	15.00	6	<0.05	0.17	<0.01	<1	1.50	1.03	<10	<100	5	<0.01	<2	5	3	1	<30
91SMA1035C	0.1	1.79	48	43	20		<100	2	<0.5	<3	1	4	0.06	<3		2	0.12	4.16	0.01	<1	0.12	0.02	<10	1000	590	<0.01	<2				<30
91SMA1035D	0.4	1.32	2	<3	6	21	<100	1	0.5	<3	<1	2	0.52	<3	6.00	2	0.08	8.62	0.05	<1	0.13	0.03	<10	1300	987	<0.01	<2	14	2	1	<30
91SMA1039A	0.2	0.80	<2	<3	<5		800	95	<0.5	<3	<1	1	0.14	26		11	0.09	0.71	0.02	<1	2.50	0.05	10	<100	38	0.04	<2				40
91SMA1044C	0.2	1.45	2	<3	<5		200	31	0.6	<3	2	5	0.94	40	15.00	10	0.44	0.55	0.03	<1	1.60	0.23	20	<100	21	0.08	13				<30
91SMA1051A	0.3	0.08	<2	<3	<5		<100	2	<0.5	<3	<1	<1	<0.01	11		<1	<0.05	0.08	<0.01	<1	<0.05	0.02	<10	<100	9	<0.01	<2				<30
91SMA1054A	0.4	0.16	<2	<3	<5		100	3	<0.5	<3	<1	<1	<0.01	30		<1	0.10	0.02	<0.01	<1	0.08	0.02	10	<100	3	<0.01	<2				<30
91SMA1070A	0.4	13.10	<2	<3	<5	5	<100	13	<0.5	<3	<1	9	8.51	<3	13.00	6	<0.05	0.09	<0.01	<1	1.40	1.22	<10	<100	3	<0.01	<2	1	1	1	<30
91SMA1070G	0.4	13.00	<2	<3	<5	20	<100	15	<0.5	<3	1	8	8.60	<3		5	<0.05	0.07	<0.01	<1	1.30	1.11	<10	<100	2	<0.01	<2	10	1	1	<30
91SMA1073A	0.2	8.43	<2	<3	<5	5	<100	4	0.6	<3	1	8	5.52	<3	25.00	8	0.10	0.23	0.01	<1	1.30	0.94	<10	<100	7	<0.01	<2	1	2	3	<30
91SMA1073B	0.3	5.95	<2	<3	<5	1	<100	8	<0.5	<3	1	7	3.92	<3	64.00	30	0.09	0.67	0.01	<1	1.00	0.58	<10	<100	15	<0.01	<2	1	1	1	40
91SMA1073C	0.2	10.30	<2	<3	<5	1	<100	5	0.6	<3	1	9	6.74	<3	26.00	10	0.05	0.22	<0.01	<1	1.40	1.04	<10	<100	6	<0.01	<2	1	1	1	<30
91SMA1073D	0.3	9.16	<2	<3	<5	1	100	5	<0.5	<3	1	8	5.94	<3		11	0.06	0.24	<0.01	<1	1.40	0.96	<10	<100	6	<0.01	<2	1	1	1	<30
91SMA1073E	0.1	8.29	<2	<3	<5	2	<100	17	<0.5	<3	1	7	5.36	<3	76.00	27	<0.05	0.52	<0.01	<1	1.20	0.73	<10	<100	21	<0.01	<2	1	1	1	<30
91SMA1074A	0.3	2.48	<2	<3	<5	9	100	99	<0.5	<3	<1	6	1.42	15	23.00	13	0.21	0.68	<0.01	<1	1.30	0.36	10	100	51	0.03	<2	1	1	1	<30

SAMPLE	Cl	Co NA	Co ICP	Cr NA	Cr ICP	Cs	Cu	Eu	F	Fe NA	Fe ICP	Hf	K	La	Sb NA	Sb ICP	Sc NA	Sc ICP	Sm	Sr ICP	Th	Ti	U	V	W NA	Y	Yb	Zn NA	Zn ICP	Zr
74EL238A	1239	73	56	1200	194	<3	2.9	<0.2	125	4.4	3.19	<1.	<0.01	1	0.2	<55	.3	3.5	<0.5	62.5	<0.50	<0.01	<0.5	6	<4	1.1	0.2	<50	12.2	<0.5
74EL238B	1138	51	13	250	27	<3	316.0	1.8	453	10.4	3.10	4.	0.20	18	0.7	<537	.6	2.0	5.9	32.2	2.90	0.17	0.8	168	<4	11.5	3.2	160	68.1	8.4
74EL245	144	91	30	2800	1160	<3	12.1	0.2	71	7.2	2.11	<1.	<0.01	1	18.0	1528	.4	1.9	0.6	2.8	<0.50	0.01	<0.5	69	<4	1.4	0.9	100	26.9	0.5
74EL246	155	71	36	1600	383	<3	8.4	<0.2	<50	4.6	2.19	<1.	<0.01	<1	<0.2	<57	.6	1.9	<0.5	2.5	<0.50	<0.01	<0.5	13	<4	0.4	0.2	90	21.5	<0.5
74EL248	124	94	43	2600	1020	5	6.1	0.5	<50	8.1	3.32	<1.	1.78	<1	<0.2	830	.4	0.9	0.8	3.4	<0.50	0.05	<0.5	65	<4	1.3	1.1	140	34.7	0.9
91JP228A	<100	54	47	10	3	<3	889.0	0.8	594	6.8	5.19	3.	0.08	12	<0.2	<53	.5	<0.5	3.1	31.9	6.80	0.06	2.1	12	<4	3.7	0.8	70	28.4	5.4
91JP233A	168	10	7	10	6	<3	43.5	0.4	1604	2.4	1.69	3.	0.77	22	<0.2	<55	.3	0.8	2.4	17.4	2.60	0.11	0.8	21	6	3.3	0.5	<50	64.9	3.1
91JP233B	134	15	11	30	30	<3	123.0	0.6	173	2.4	2.23	7.	0.62	15	<0.2	<511	.0	5.3	3.1	4.5	2.20	0.12	0.8	39	<4	6.1	2.7	70	18.4	5.2
91JP233D	200	29	25	20	18	<3	146.0	0.5	389	3.6	3.27	5.	0.76	12	<0.2	<511	.5	5.6	1.6	5.4	2.50	0.13	0.7	65	<4	4.8	1.3	90	44.1	4.0
91JP233E	<100	14	12	10	1	<3	31.4	0.6	4279	4.7	2.91	3.	0.42	22	<0.2	<55	.8	<0.5	2.3	6.2	3.00	0.01	0.7	3	34	2.0	0.4	50	4.1	2.8
91JP241B	1056	48	14	230	31	<3	314.0	1.6	473	9.7	3.29	3.	0.22	16	0.9	<535	.0	2.4	5.3	35.8	2.50	0.17	0.9	188	<4	12.1	2.9	180	71.2	10.0
91JP242B	181	110	73	4500	2550	<3	61.2	0.3	313	7.3	4.11	<1.	0.02	1	0.5	<517	.3	7.8	0.6	38.0	<0.50	0.01	<0.5	68	<4	2.7	0.7	110	41.0	<0.5
91JP243B	242	96	33	3300	1350	<3	10.5	<0.2	140	6.7	2.30	1.	<0.01	1	0.3	<519	.3	8.4	0.6	58.8	<0.50	<0.01	<0.5	59	<4	2.4	0.5	80	19.4	<0.5
91JP243C	150	73	17	1400	313	<3	11.0	0.4	131	8.2	1.86	1.	<0.01	3	<2	<531	.8	1.5	1.5	2.1	0.60	0.02	<0.5	27	<4	0.9	1.3	150	21.2	0.8
91JP257A	211	8	5	260	87	<3	7.4	1.4	675	3.6	2.79	5.	0.03	18	0.8	<529	.7	6.9	3.8	16.8	2.00	<0.01	0.7	66	<4	5.3	2.6	140	77.5	9.8
91JP257D	1058	48	14	230	31	<3	325.0	1.4	468	9.3	3.34	4.	0.22	16	0.7	<533	.7	2.3	5.2	35.1	2.90	0.17	0.8	186	<4	12.2	3.0	200	75.6	9.4
91JP258A	202	35	25	210	120	<3	2.1	1.1	436	6.2	4.63	5.	0.05	16	0.2	<525	.8	6.7	3.6	10.5	2.20	0.02	<0.5	88	<4	7.8	1.9	150	77.8	2.9
91JP258F	<100	5	3	<10	2	<3	10.2	0.9	134	1.7	1.45	2.	0.15	20	<0.2	<52	.3	1.1	1.8	7.8	3.50	0.02	<0.5	6	<4	2.2	0.9	50	27.5	6.5
91JP258G	<100	<5	<1	<10	1	11	0.7	0.4	211	0.7	0.17	3.	0.12	4	0.4	<51	.5	<0.5	<0.5	5.0	1.20	<0.01	0.6	<2	<4	0.8	0.6	<50	1.8	11.3
91JP258H	<100	6	4	10	4	8	3.9	0.5	199	1.6	1.05	3.	0.10	18	0.3	<51	.5	<0.5	1.7	3.4	3.10	0.01	0.7	<2	<4	2.2	0.7	<50	19.8	7.3
91JP259B	<0	38	29	260	132	<3	16.2	1.5	534	10.1	7.08	11.	0.03	49	0.8	<535	.2	12.1	6.4	15.1	8.90	<0.01	4.5	87	7	1.7	4.3	400	267.0	27.7
91SMA1025A	186	6	4	10	8	<3	8.1	0.4	122	1.5	0.85	<1.	0.03	4	0.4	<53	.7	0.6	<0.5	76.9	<0.50	0.02	<0.5	15	<10	0.6	0.2	<50	17.1	0.5
91SMA1025B	150	<5	2	10	4	<3	3.3	0.5	80	6.7	0.82	<1.	<0.01	2	2.2	<57	.6	0.8	<0.5	34.4	<0.50	0.01	<0.5	13	<10	0.6	1.0	<50	6.6	1.3
91SMA1026C	1134	47	14	230	32	<3	336.0	1.8	451	9.5	3.43	4.	0.22	16	0.7	<535	.1	2.5	5.4	37.5	3.40	0.18	0.7	200	<10	12.2	3.0	220	77.0	10.1
91SMA1029B	134	6	1	50	16	<3	1.9	0.9	208	2.5	0.56	8.	0.14	32	0.3	<510	.9	3.2	4.7	6.6	3.70	0.04	1.2	29	<10	4.7	1.7	150	3.4	18.2
91SMA1031C	179	7	1	40	8	<3	1.9	0.3	175	1.4	0.33	<1.	0.02	1	0.2	<56	.9	0.7	<0.5	160.0	<0.50	<0.01	<0.5	8	<10	0.4	0.3	<50	6.5	0.6
91SMA1035C	231	80	29	2500	1360	<3	0.7	0.2	263	5.0	1.53	<1.	<0.01	1	0.4	<522	.6	2.0	0.5	1.0	<0.50	<0.01	<0.5	62	<10	0.4	0.6	70	17.3	<0.5
91SMA1035D	161	100	56	2400	1180	<3	33.7	0.2	64	7.1	3.49	<1.	<0.01	<1	0.3	<518	.5	5.9	<0.5	15.8	<0.50	0.01	<0.5	57	<10	1.8	0.5	120	36.3	<0.5
91SMA1039A	203	10	6	60	43	3	12.0	0.3	438	1.7	1.22	3.	0.47	15	<0.2	<54	.1	1.0	1.5	7.6	2.00	0.06	0.5	16	<10	2.6	0.6	<50	42.7	2.3
91SMA1044C	1152	49	12	240	28	<3	309.0	2.0	497	9.9	3.12	3.	0.20	17	0.7	<536	.4	2.0	5.6	32.2	2.20	0.16	1.2	168	<10	11.5	3.0	190	68.4	8.2
91SMA1051A	183	<5	<1	20	11	<3	1.3	<0.2	57	0.3	0.08	<1.	<0.01	6	0.2	<50	.5	<0.5	0.7	0.7	1.30	<0.01	<0.5	<2	<10	0.4	0.4	<50	0.9	3.3
91SMA1054A	134	<5	<1	30	5	<3	1.0	0.3	77	0.4	0.11	2.	0.03	16	<0.2	<52	.7	<0.5	2.0	2.0	6.70	<0.01	0.6	<2	<10	1.8	0.7	<50	1.3	19.0
91SMA1070A	201	<5	1	<10	2	<3	13.0	<0.2	53	0.5	0.24	<1.	0.02	1	<0.2	<51	.2	<0.5	<0.5	150.0	<0.50	<0.01	<0.5	4	<10	0.4	0.2	<50	3.5	0.7
91SMA1070G	195	<5	<1	<10	1	<3	2.7	0.3	55	0.4	0.18	<1.	0.02	1	<0.2	<50	.4	<0.5	<0.5	152.0	<0.50	<0.01	<0.5	<2	<10	0.2	<0.2	<50	2.3	0.7
91SMA1073A	248	28	2	250	18	4	5.8	0.2	227	3.7	0.32	<1.	0.03	<1	<0.2	<535	.0	1.7	<0.5	100.0	0.50	0.02	<0.5	9	<10	1.0	0.5	110	4.1	0.8
91SMA1073B	284	51	7	330	34	6	19.8	<0.2	195	5.8	0.81	<1.	0.22	<1	<0.2	<542	.6	3.2	<0.5	77.5	<0.50	0.02	<0.5	20	<10	0.5	0.5	70	8.2	0.5
91SMA1073C	127	23	2	50	5	<3	5.6	0.4	151	2.8	0.32	<1.	0.03	<1	<0.2	<59	.1	0.6	<0.5	121.0	<0.50	<0.01	<0.5	5	<10	0.2	0.4	70	3.9	<0.5
91SMA1073D	144	27	2	190	16	5	2.7	0.4	206	3.2	0.29	<1.	0.04	<1	<0.2	<524	.5	1.2	<0.5	117.0	<0.50	0.01	<0.5	9	<10	0.5	0.3	100	4.2	<0.5
91SMA1073E	121	44	10	50	4	3	66.6	0.3	82	4.7	0.63	<1.	0.10	<1	<0.2	<513	.0	0.7	<0.5	125.0	<0.50	<0.01	<0.5	6	<10	0.1	0.2	70	7.8	<0.5
91SMA1074A	133	57	12	410	40	3	66.6	0.8	168	7.8	1.01	1.	0.29	6	0.4	<533	.8	1.6	2.3	80.2	<0.50	0.05	<0.5	23	<10	1.2	1.6	90	14.2	<0.5

Note: All of the following elements were below detection limits for all samples: Cd<1, Ir<20, Se<5, Sn<10, Ta<1, Tb<1

APPENDIX I(d). LOCATIONS AND DESCRIPTIONS OF 1992 ROCK-GEOCHEMICAL SAMPLES

SAMPLE	EASTING	NORTHING	DESCRIPTION (More in text for those with elevated geochemistry)
92CGA-029 A	481648	7350444	pyritic qtzite, western limit of area; with garnet and sulphides.
92CGA-042 A	489155	7367142	gossanous quartz-chert rock from IF in basalts, western area.
92CGA-042 B	489155	7367142	magnetite-quartz fefm
92CGA-058 A	490635	7344449	dol-bio-qtz-hbl: meta-volcaniclastic at edge of amphibolite belt in psammite
92CGA-060 A	491085	7344187	gossanous amphibolitic pyritic metachert (polygonal quartz)
92CGA-062 B	491634	7344338	very gossanous pyrite-magnetite-chlorite-garnet-quartz meta-iron formation
92CGA-062 E	491634	7344338	same as 62B
92CGA-070 A	495001	7352036	rusty, 15 cm-thick pyritic coarse quartzarenite, low ground W of Quartzite Hill.
92CGA-083 A	490155	7344989	sulphidic metachert/fefm? PTS: qtz-chl-pho oxidized to marcasite and hematite
92CGA-083 B	490155	7344989	as 083A + grunerite + local chlorite + hematite
92CGA-096 A	492054	7343520	leucocratic fine-grained paragneiss: felsic metavolcanic/volcaniclastic rock.
92CGA-103 A	491713	7345424	amphibolitic-pyrrhotite-magnetite iron formation
92CGA-110 A	489600	7344381	weakly pyrrhotitic magnetite-quartz-hornblende-grunerite iron formation
92CGA-110 B	489600	7344381	marcasite-hematite-altered chalcopyrite-pyrrhotite-grunerite-quartz
92CGA-111 A	489442	7343361	hornblende-grunerite-magnetite-quartz iron formation cross-cut by 110 B.
92CGA-147 A	461338	7326461	rusty pyrrhotitic biotite-chlorite-psammite
92CGA-164 A	487777	7341837	black, very fine grained argillaceous magnetitic iron formation
92CGA-164 B	487777	7341837	rusty mottled coarse-grained garnet-horblende iron formation +/- komatiite
92CGA-168 A	489175	7340617	weathering corestone of pyrrhotite.
92CGA-168 B	489175	7340617	pyrrhotite-garnet-biotite psammite
92CGA-208 B	490131	7360102	laminated magnetite-metachert iron formation
92CGA-218 A	487863	7357962	magnetite-rich layer in ultramafic schist
92CGA-224 A	488333	7358776	rusty magnetite-amphibolite iron formation
92CGA-242 B	487744	7359340	gossanous dense micaceous dark rock: pyrrhotitic ultramafic schist?
92CGA-244 A	487938	7358970	schistose garnet amphibolite iron formation
92CGA-248 A	488268	7360158	sericite phyllite
92JP-021 D	486010	7343421	chip sample of graphitic-pyritic-metachert
92JP-021 E	486010	7343421	same as 21 D
92JP-022 A	486420	7343759	pyrrhotitic amphibolite-chert iron formation (?or exhalite?)
92JP-022 B	486420	7343759	pyrrhotitic garnet-amphibolite-chert iron formation (?or exhalite?)
92JP-022 C	486420	7343759	gradational contact between 22 B iron formation and psammite
92JP-022 D	486420	7343759	feldspar-porphyritic intermediate meta-volcaniclastic / tuff
92JP-023 A	486954	7344122	chip sample of pyrrhotitic meta-chert along strike from 22
92JP-023 B	486954	7344122	same as 23 A from different part of outcrop
92JP-025 A	488634	7344240	dark green amphibolite with dolomite stringers (10 m unit in psammite)
92JP-045 C	524596	7362218	rusty & white, pyr-msc-sil-qtz scst in high strain zone in foliated grey tonalite
92JP-045 D	524596	7362218	rusty pyrrhotitic leucocratic gneiss in high strain zone in grey foliated tonalite
92JP-045 E	524596	7362218	rusty muscovite-quartz schist
92JP-046 J	524947	7363783	pyrrhotitic crenulated tonalitic mylonite
92JP-046 K	524947	7363783	mylonitic-laminated chlorite-pyrrhotitic quartz schist (meta-quartzarenite)
92JP-048 A	522700	7359568	dark grey-green fine-grained laminated amphibolite (meta-argillite, base of fefm)
92JP-048 B	522700	7359568	pho-mag-grun-qtz (metachert) FEFM cut by quartz-arsenopyrite-pyr veins
92JP-048 C	522700	7359568	as 048C
92JP-050 E	518477	7351906	straight highly foliated amphibolite lense within sericitic schists
92JP-050 F	518477	7351906	as 50 E
92JP-050 G	518477	7351906	as 50 E
92JP-050 H	518477	7351906	as 50 E
92JP-051 A	519103	7351719	tourmaline-chalcopyrite-pyrrhotite-amphibole-chlorite-garnet schist/mylonite
92JP-051 B	519103	7351719	as 51A (sulphides late, poikilitic; see text for more))
92JP-051 C	519103	7351719	as 51A
92JP-051 D	519103	7351719	as 51A
92JP-051 E	519103	7351719	as 51A
92JP-052 A	518876	7351852	mylonitic anorthosite on western contact with suprcrustal rocks.
92JP-053 A	519088	7352322	rusty ser-scst with minor ampb
92JP-053 B	519088	7352322	as 51A; myln w layers: 1) qtz>>chlorite; 2) chlorite+feldspar (sulphides cut all)
92JP-053 C	519088	7352322	as 53 A, B
92JP-054 A	520362	7353468	cpy-pho-mgt-feldsp-hornblendite (metagabbro; more in text)
92JP-054 B	520362	7353468	drill core: as 54 A; note cpy in these is both dissem blebs and x-cutting veinlets
92JP-054 C	520362	7353468	as 54 A
92JP-054 D	520362	7353468	as 54 A + ?pentlandite?
92JP-054 E	520362	7353468	as 54 A + ?pentlandite?
92JP-054 F	520362	7353468	minor opaques as 54 A; polygonal qtz - chlorite - hornblende
92JPK-056 A	489636	7343371	massive fine-grained pyrrhotitic amphibolite (more in text)
92JPK-056 E	489636	7343371	meta-ultrabasic schist
92JPK-058 C	489819	7342797	meta-ultrabasic schist
92JPN-003 A	516285	7351287	spherulitic-textured magnetite-grunuerite-metachert iron formation
92JPN-003 B	516285	7351287	magnetite-grunuerite-metachert iron formation
92JPN-018 A	492097	7354049	rusty-pyrrhotitic quartzite associated with kyanite-fuchsite quartzarenite
92JPN-021 A	478312	7366499	amphibolite iron formation
92JPN-032 A	496559	7334547	fine-grained pyrrhotitic amphibolite (metabasalt?)
92JPN-034 A	497064	7334950	magnetite-amphibolite iron formation
92JPN-034 B	497064	7334950	magnetite-amphibolite-quartz iron formation
92JPN-034 C	497064	7334950	magnetite-amphibolite-quartz iron formation
92JPN-064 A	489609	7348051	pyrrhotite stringers in interlayered green/grey ultramafic/psammite mylonite
92JPN-088 A	521046	7370763	massive, rusty, cpy-pyr-qtz veins cut interlayered ultramafic/psammite
92JPN-088 C	521046	7370763	rusty cpy-pho umfc same O/C as 88A.
92JPN-092 A	525524	7371437	rusty weathering mafic (?tuffaceous?) biotite psammite (interlayered as 88A)
92JPN-097 A	523799	7369287	pyrite-magnetite-amphibolite iron formation
92JPN-106 A	480546	7361993	rusty grey garnet-graphite-ampb-qtz fefm (gar stretched 11:1) in ultramafic schist
92JPN-111 A	480583	7359919	rusty grey gar-graphite-ampb-qtz iron formation in ultramafic schist
92JPN-113 C	482014	7361394	massive umfc scst; in banded hbl-actinolite-serpentine-dol-chlorite umfc scst
92JPN-120 A	480053	7364911	bio-gar-asp-mgt-qtz fefm (hand spec highly magnetic but no aeromag; see text).

APPENDIX I(e). 1992 REGIONAL TRACE AND MINOR ELEMENTS, ROCKS, by ACME Analytical Labs, Vancouver. All major elements by ICP in %; minor and trace elements by ICP in ppm; Au, Pd, Pt, Rh by fire assay and ICP/graphite furnace, in ppb.

SAMPLE	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Bi	V	Ca	P	La	Cr	Mg	Ba	Ti	B	Al	Na	K	W	Li	Hg	Au	Pt	Pd	Rh
92CGA-029a	3	55	2	3	.5	20	2	365	2.52	116	5	2	102	.2	4	2	2	.25	.079	4	29	.04	37	.01	5	.23	.01	.01	1	1	110	3	3	3	5
92CGA-029f	1	340	18	108	.6	30	14	420	4.42	2	5	2	52	.5	2	2	229	1.43	.071	12	39	.69	38	.39	8	2.04	.51	.26	1	9	15	8	3	23	5
92CGA-042a	1	31	7	22	.1	19	5	843	5.32	2	5	2	11	.2	2	2	7	.43	.067	3	5	.69	2	.02	3	1.18	.03	.01	1	5	45	3	3	3	5
92CGA-042b	2	7	6	169	.1	51	2	218	5.98	2	5	3	1	.2	3	2	21	.09	.025	2	32	.77	2	.03	3	1.87	.01	.01	2	11	35	2	3	3	5
92CGA-058a	2	38	6	54	.3	11	9	1157	4.52	2	5	2	146	.5	5	2	24	4.54	.170	23	20	.58	21	.16	3	1.47	.39	.08	1	6	220	1	3	3	5
92CGA-060a	2	134	16	22	.5	172	35	139	8.16	2	5	4	4	.2	2	2	5	.21	.020	8	6	.25	2	.05	4	.33	.07	.01	1	1	40	2	3	3	5
92CGA-062b	1	44	6	55	.4	296	23	1030	13.35	72	5	2	1	.2	2	4	132	.02	.004	2	2196	.53	17	.04	2	2.15	.01	.01	1	6	20	1	13	16	5
92CGA-062e	1	23	11	3	.2	262	4	636	13.63	73	5	2	6	.2	2	2	12	.03	.010	3	27	.03	2	.02	3	.09	.01	.01	1	1	45	1	3	3	5
92CGA-070a	3	37	5	60	.5	103	34	123	6.06	328	5	3	1	.2	2	2	153	.01	.005	16	60	.93	12	.01	2	1.18	.01	.01	1	9	35	151	3	3	5
92CGA-083a	1	275	11	24	1.4	159	34	309	8.18	3	5	2	1	.2	2	2	10	.15	.010	2	192	1.13	5	.01	2	.86	.01	.01	1	3	50	6	3	3	5
92CGA-083b	1	131	5	15	1.0	87	18	274	5.69	2	5	2	2	.2	2	2	2	.10	.014	4	18	.62	2	.01	3	.48	.01	.01	1	2	65	1	3	3	5
92CGA-083f	9	52	73	310	.9	15	8	403	1.88	37	6	3	73	1.3	5	2	18	6.47	.052	12	12	.66	96	.05	7	.47	.05	.06	2	4	80	5	3	3	5
92CGA-096a	3	30	3	49	.1	20	9	209	2.23	10	5	2	25	.2	2	2	33	.35	.042	17	22	.49	103	.12	4	1.09	.12	.51	1	18	60	4	3	3	5
92CGA-103a	1	45	3	163	.3	72	12	785	7.90	2	5	2	4	.8	2	2	41	.81	.105	8	92	1.23	151	.18	2	2.40	.18	1.01	1	30	395	2	3	3	5
92CGA-110a	1	8	8	8	.1	10	1	41	26.32	5	5	2	33	.7	2	2	6	.81	.194	4	10	.06	11	.02	2	.28	.04	.02	1	1	85	14	3	3	5
92CGA-110b	1	90	12	10	1.0	29	8	159	11.81	2	5	2	15	.8	2	2	3	.59	.072	4	5	.12	26	.01	3	.52	.07	.05	1	1	45	371	3	3	5
92CGA-111a	2	1	6	15	.1	21	2	110	4.11	2	5	3	15	.5	2	2	11	.60	.036	12	49	.28	248	.11	2	1.43	.13	.86	1	12	20	10	3	3	5
92CGA-147a	1	55	17	66	.1	79	14	581	4.09	2	5	17	25	.4	2	2	74	.42	.094	37	266	1.81	93	.28	3	2.31	.06	2.10	1	31	30	3	3	4	5
92CGA-164a	1	3	3	174	.1	16	5	190	3.17	13	10	26	5	.4	2	2	12	.05	.013	47	12	.73	384	.15	3	1.80	.06	1.57	2	17	40	10	3	3	5
92CGA-164b1	2	50	3	11	.1	9	3	138	4.62	2	5	2	7	.4	2	2	7	.97	.080	2	17	.14	11	.01	2	.93	.14	.05	1	1	45	15	3	3	5
92CGA-164b2	2	47	8	11	.2	12	4	131	4.60	3	5	3	7	.2	5	3	8	1.00	.081	2	17	.14	9	.01	2	.91	.14	.07	1	1	40	16	3	3	5
92CGA-168a	1	211	2	13	1.3	194	73	394	41.45	3	5	2	1	.2	6	2	2	.05	.002	4	1	.09	3	.01	8	.11	.01	.01	1	1	50	6	4	3	5
92CGA-168b	1	16	5	80	.2	58	23	599	3.53	11	5	2	26	.4	2	2	55	2.04	.142	19	42	.51	80	.23	3	1.55	.21	.34	1	15	45	1	3	3	5
92CGA-208b	1	7	9	5	.1	8	1	53	23.09	2	5	2	18	.7	2	2	5	.32	.080	5	4	.09	470	.02	2	.34	.04	.10	1	3	25	1	3	3	5
92CGA-224a	1	19	30	86	.4	30	5	122	6.40	104	5	2	91	.2	2	2	12	.31	.074	5	10	.06	43	.02	2	.33	.01	.02	1	1	20	11	3	3	5
92CGA-239f	1	341	14	101	.6	29	13	397	4.06	2	5	2	52	.7	2	2	218	1.32	.064	12	38	.63	38	.38	6	1.97	.52	.27	1	7	20	5	3	17	5
92CGA-242b	1	196	7	87	1.3	1012	76	2721	13.91	2	5	2	4	.7	2	2	109	.26	.015	5	657	.33	8	.04	2	.72	.01	.01	1	3	10	1	5	3	5
92CGA-244a	2	153	10	16	1.1	743	76	2194	10.57	2	5	2	3	.2	3	2	36	.23	.020	6	234	.21	2	.02	2	.51	.01	.01	1	3	25	2	3	3	5
92CGA-248a	1	2	3	90	.1	56	4	355	2.92	50	6	16	7	.2	2	2	16	.03	.009	44	66	1.42	23	.01	2	2.10	.05	.08	1	22	10	1	3	3	5
92JP-021d	3	14	3	9	.1	11	1	310	1.56	2	5	2	1	.2	3	2	8	.07	.005	2	13	.09	31	.03	2	.27	.02	.15	1	1	25	5	3	3	5
92JP-021e	5	25	2	7	.1	15	3	76	1.46	2	5	2	1	.2	2	2	4	.04	.004	2	56	.04	10	.01	2	.10	.01	.06	1	1	45	2	3	3	5
92JP-022a	1	90	7	17	.1	301	24	504	4.74	2	5	2	25	.2	2	2	13	1.44	.051	13	120	.51	66	.06	2	.85	.13	.12	1	2	15	7	3	3	5
92JP-022b	28	605	7	19	1.2	636	52	615	10.13	2	5	2	15	.2	2	2	21	1.03	.009	2	462	.36	15	.05	2	.63	.10	.05	1	1	15	300	11	7	5
92JP-022c	1	29	2	31	.4	263	21	376	2.26	11	5	3	27	.2	2	2	26	.61	.031	22	346	1.09	180	.14	2	1.33	.15	.63	1	15	25	1	3	3	5
92JP-022d	2	45	2	21	.3	407	46	385	3.04	3	5	3	7	.2	2	2	27	.62	.018	5	493	.75	181	.11	4	1.00	.13	.44	1	10	30	4	9	6	5
92JP-023a	12	39	17	1	.3	6	1	35	1.20	3	5	2	2	.2	2	6	2	.01	.002	2	6	.02	9	.01	4	.04	.01	.01	1	1	15	3	3	3	5
92JP-023b	13	22	15	1	.6	10	2	37	1.99	7	5	2	1	.2	3	5	2	.01	.003	2	11	.03	10	.01	3	.04	.01	.04	1	1	15	3	4	3	5
92JP-025a	1	32	2	90	.1	103	14	519	7.18	10	5	6	11	.2	2	2	62	.14	.034	10	199	1.46	235	.30	2	2.96	.05	2.90	2	31	30	1	4	3	5
92JP-045c	1	3	4	8	.2	17	15	44	3.03	34	6	8	8	.2	3	2	4	.07	.031	7	4	.21	34	.02	4	.47	.02	.28	1	3	15	6	3	3	5
92JP-045d	2	19	2	10	.2	54	26	226	2.61	2	5	3	22	.2	3	2	14	.21	.070	15	29	.26	14	.05	5	.66	.07	.08	1	3	20	9	3	3	5
92JP-045e	12	5	10	2	.2	1	1	58	.66	23	7	3	7	.2	3	2	5	.01	.006	26	2	.02	11	.04	3	.33	.07	.07	1	3	15	2	3	3	5
92JP-046j	2	8	7	75	.6	4	1	517	1.52	2	5	4	32	.2	2	2	2	2.08	.006	30	12	.35	35	.07	4	2.70	.22	.62	1	7	10	2	3	3	5
92JP-046k	2	302	3	23	3.0	31	20	607	6.05	3	5	2	2	.4	3	2	4	.24	.005	2	8	.16	2	.01	2	.29	.02	.01	1	1	20	12	3	3	5
92JP-046m	9	56	77	308	.7	13	8	404	1.92	33	6	2	73	1.2	2	2	18	7.11	.051	11	12	.67	96	.05	7	.47	.05	.06	1	5	65	3	3	3	5
92JP-048a	1	7	13	64	.2	15	5	268	6.74	2	9	22	6	.2	2	2	26	.21	.041	21	23	1.10	1120	.16	2	3.33	.09	2.98	1	25	15	1	3	3	5
92JP-048b	2	15	2	10	.1	7	1	114	11.79	166	5	4	33	.2	4	2	22	.67	.065	5	40	.16	98	.06	2	.87	.11	.18	1	5	25	6	3	3	5
92JP-048c	1	22	2	7	.1	14	5	89	15.06	427	5	4	51	.2	4	2	21	.77	.078	6	29	.12	38	.06	2	.68	.09	.11	1	2	10	12	3	3	5
92JP-050e	1	117	3	29	.2	28	17	188	2.42	2	5	2	5	.2	2	2	66	.89	.047	7	20	.93	10	.12	2	1.12	.17	.05	1	3	10	1	3	3	5
92JP-050f	1	87	4	38	.1	26	16	249	3.27	2	5	2	5	.3	2	2	83	1.13	.043	4	37	1.21	5	.18	2	1.47	.22	.03	1	9	25	1	3	3	5
92JP-050g	2	18	17	57	.1	14	10	683	3.52	4	5	2	45	.2	8	2	47	3.06	.085	12	8	.77	116	.16	2	2.69	.31	.22	1	8	20	1	3	3	5
92JP-050h	1	9	2	76	.1	22	21	214	4.15	2	5	2	3	.2	2	2	107	.47	.046	6	36	2.51	9	.12	2	2.38	.07	.03	1	11	10	1	3	3	5
92JP-051a	8	854	2	142	1.6	102	62	687	16.96	2	5	5	1	.3	3	2	35	.07	.026	3	31	1.78	18	.07	3	2.51	.02	.11	1	35	40	5	3	3	5
92JP-051b	3	212	2	755	.2	9	15	1196	12.16	2	5	12	4	.2	2	2	4	.13	.022	76	2	3.02	45	.12	2	3.29	.02	.81	1	11	30	1	3	3	19
92JP-051c	2	352	2	354	.2	6	6	768	7.85	2	5	13	9	.2	2	2	16	.19	.033	84	8	1.95	106	.25	2	2.16	.06	2.05	1	10	35	4	3	3	5
92JP-051d	4	265	2	310	.5	22	27	1001	11.37	2	5	4	2	.2	2	2	25	.05	.012	8	23	2.78	6	.04	2	2.35	.03	.06	1	5	20	11	3	3	5
92JP-051e	1	315	2	1276	.1	84	29	1435	14.62	2	5	3	1	.5	2	2	99	.13	.038	16	112	4.91	4	.04	2	5.19	.01	.04	1	13	50	1	3	3	5
92JP-051f	1	80	18	99	.6	26	11	1264	3.11	13	5	2	74	.5	7	2	48	1.29	.072	16	34	.84	999	.09	7	1.27	.07	.12	1	10	790	2	3	3	5
92JP-053a	3	50	2	449	.1	5	3	1423	11.28	2	5	12	2	.2	2	2	10	.10	.032	59	9	4.35	17	.05	2	4.14	.01	.05	1	10	20	1	3	3	5
92JP-053b1	1	142	2	926	.3	12	11	1479	10.57	2	11	13	2	.2	4	2	8	.08	.033	81	5	4.62	17	.06	2	4.33	.01	.09	1	13	20	1	3	3	5
92JP-053b2	2	143	2	910	.1	11	10	1465	10.36	2	5	13	2	.2	2	2	8	.07	.033	80	5	4.53	17	.05	2	4.30	.02	.08	1	8	20	1	3	3	5
92JP-053c	4	21	2	338	.2	6	1	661	12.33	3	9	18	3	.2	2	2	2	.06	.018	57	6	4.88	21	.05	2	3.86	.02	.21	1	11	10	1	3	3	5
92JP-054a	1	478	2	23	1.3	462	150	96	31.84	4	5	3	1	.2	2	2	31	.25	.010	3	8	.21	3	.03	2	.30	.02	.01	1	1	20	15	3	3	5
92JP-054b	2	630	3	31	.8	311	99	167	15.70	3	5	25	8	.2	2	2	276	1.17	.189	56	1	.53	2	.06	2	.37	.10	.02	1	3	20	2	3	3	5
92JP-054c	1	6910	3	107	1.2	262	90	176	30.64	11	5	3	3	.3	2	4	45	.60	.030	4	25	.40	2	.05	2	.63	.05	.02	1	3	30	11	3	3	5
92JP-054d	1	827	7	30	.4	1421	256	97	30.19	2	5	22	3	.2	3	2	1339	.71	.136	34	4	.41	2	.06	2	.38	.05	.01	1	2	25	5	157	37	5
92JP-054e	1	943	7	32	.7	1530	299	73	33.62	3	5	18	1	.4	3	2	1664	.28	.046	18	1	.28	2	.05	2	.30	.03	.02	1	1	20	3	185	41	5
92JP-054f	6	26	4	22	.1	11	3	91	1.81	2	5	2	4	.2	3	2	32	.64	.025	2	10	.09	2	.64	3	.26	.02	.02	1	1	15	1	5	3	5
92JPK-056a	1	3507	3	102	5.0	734	63	511	3.32	5	5	2	39	1.4	2	3	32	1.85	.014	2	710	1.61	66	.04	2	1.05	.06	.11	1	4	5	50	10	8	5
92JPK-056e	1	42	6	7	.2	7	1	58	1.85	2	5	2	1	.2	2	2	4	.23	.012	4	9	.22	8	.02	2	.16	.04	.02	1	1	10	1	3	3	5
92JPK-058c	1	108	2	15	.1	29	9	366	3.58	2	5	2	8	.2	2	2	29	.86	.087	12	15	.85	117	.09	3	.87	.16	.40	1	1	50	3	3	3	5
92JPN-003a	1	207	2	7	.1	48	40	84	17.96	2	5	9	4	.2	2	2	18	.71	.118	12	44	.34	3	.06	6	.44	.09	.01	1	2	60	3	3	3	5
92JPN-003b	2	278	2	4	.4	71	61	67	13.62	2	5	15	3	.2	4	2	13	.44	.080	14	13	.19	2	.06	6	.34	.08	.03	1	1	30	1	3	3	5
92JPN-018a	3	26	2	2	.1	11	1	23	1.03	7	6	6	4	.2	2	2	2	.02	.003	20	52	.01	11	.01	3	.21	.02	.13	1	1	10	1	3	3	5
92JPN-021a	1	4	2	1	.1	1	1	48	1.71	4	5	2	12	.2	4	2	2	.29	.065	2	2	.08	17	.01	5	.15	.01	.06	2	1	5	1	3	3	5
92JPN-032a	1	74	2	22	.1	575	38	142	2.80	2	5	2	8	.2	2	2	50	.22	.012	2	869	3.57	8	.04	4	1.73	.02	.01	2	1	15	1	8	36	5
92JPN-034a	1	55	2	3	.1	531	23	1100	22.37	7	5	2	1	.2	2	2	7	.14	.007	3	11	.15	2	.01	10	.07	.01	.01	1	1	40	7	3	3	5
92JPN-034b	1	3	2	1	.1	12	1	250	.95	4	7	2	1	.2	5	2	2	.08	.002	2	18	.09	2	.01	3	.03	.01	.02	1	1	5	1	3	3	5
92JPN-034c	1	5	2	1	.1	40	2	224	1.46	2	5	2	1	.2	4	2	2	.04	.002	2	1	.04	2	.01	3	.01	.01	.01	1	1	10	2	3	3	5
92JPN-064a	3	25	2	9	.3	232	24	725	5.13	2	5	2	19	.2	3	2	20	.87	.030	2	304	.54	83	.07	5	.84	.10	.30	1	1	15	9	7	5	5
92JPN-064f	4	31	9	5	2.9	10	14	181	3.35	2	5	2	7	.2	2	13	2	.14	.047	17	3	.05	55	.03	4	.54	.01	.37	1	1	5	173	3	3	5
92JPN-086a1	23	59	5	52	.9	23	13	407	2.55	2	5	3	44	.2	2	4	19	.48	.081	20	22	.69	43	.17	4	1.15	.05	.87	2	1	10	5	3	3	5
92JPN-086a2	22	58	3	51	.5	22	13	395	2.51	2	5	2	45	.2	2	3	19	.48	.080	20	22	.69	42	.17	4	1.15	.05	.84	1	3	5	2	3	3	5
92JPN-088a	1	675	215	7	12.5	5	1	71	.70	2	5	2	2	.2	5	79	2	.02	.002	2	2	.02	4	.01	3	.02	.02	.02	1	1	25	600	3	3	5
92JPN-088c	1	227	8	245	1.0	692	48	465	6.80	4	5	2	4	.2	2	5	44	.08	.011	2	1386	7.47	520	.17	4	4.76	.24	6.30	6	1	15	9	8	12	5
92JPN-092a	1	39	8	22	.4	901	55	206	3.27	2	5	2	2	.2	2	2	52	.15	.008	2	1419	6.99	8	.03	26	2.18	.02	.05	1	1	30	9	9	12	5
92JPN-097	1	224	3	56	.4	85	30	540	3.82	2	5	2	15	.2	2	2	63	1.67	.026	3	88	1.45	133	.24	3	1.69	.20	.44	2	1	10	10	3	3	5
92JPN-106a	8	6	4	68	.2	12	2	123	3.71	344	5	8	63	.2	5	2	31	.12	.038	25	49	.33	436	.11	5	1.39	.03	.60	2	2	5	14	3	3	5
92JPN-111a	2	133	12	30	.2	945	59	936	2.95	376	5	2	6	.2	9	2	31	.44	.007	2	384	.22	142	.04	3	.78	.03	.14	2	1	1	13	13	11	5
92JPN-113c	1	40	2	22	.1	1423	59	501	3.27	1198	5	2	2	.2	4	2	38	.89	.008	2	836	.99	250	.10	3	1.63	.17	.52	1	3	1	32	18	19	5
92JPN-120a	1	206	2	52	1.8	430	127	522	15.74	91449	7	10	11	.3	2	113	27	.71	.190	12	29	1.62	31	.17	2	3.58	.01	1.41	822	4	15	181	3	3	5

APPENDIX I(f): 1992 Whole Rock Analyses, Komatiites; Lab Work by: GSC, Analytical Chemistry Section; majors in %; Ba - Zr in ppm.

SAMPLE	SiO_2	TiO_2	Al_2O_3	Fe_2O_3T	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	FeO	$H_2O(t)$	CO_2	S(t)	DIO S(t)	Ba	Nbf	Sr	Zr	TOTAL
92JPF012	42.3	0.30	6.90	11.8	2.2	8.6	0.18	27.1	5.21	0.40	<0.05	5.8	0.4	0.03	0.02	179.	<30	10	<10	<20	13	99.9
92JPF013A	44.0	0.28	8.30	8.50	2.6	5.3	0.12	25.5	6.28	0.30	<0.05	6.6	0.2	0.03	<0.02	<50.	30	11	11	<20	36	99.9
92JPF013B	48.5	0.24	5.70	9.60	1.8	7.0	0.22	26.3	4.08	0.10	0.05	5.7	0.2	0.03	<0.02	66.	40	16	13	<20	18	100.3
92JPF014A	42.7	0.53	9.80	16.4	5.1	10.2	0.31	13.0	11.9	2.70	0.56	2.3	1.1	0.04	0.02	196.	100	<10	13	52	26	100.5
92JPF014B	38.1	0.48	9.90	13.5	3.4	9.1	0.23	16.8	7.78	0.80	6.05	3.4	3.6	0.03	<0.02	68.	660	<10	160	90	16	100.0
92JPF015A	37.0	0.11	1.70	11.7	6.4	4.8	0.08	34.6	0.89	<0.03	0.05	8.9	5.0	0.01	0.20	1695.	<30	11	11	<20	<10	100.2
92JPF018	39.7	0.16	4.20	8.10	3.0	4.6	0.13	28.6	4.15	<0.03	<0.05	6.2	9.1	0.02	0.07	618.	50	11	13	45	<10	100.4
92JPF020A	41.1	0.24	5.40	9.40	1.8	6.8	0.16	29.0	3.60	<0.03	<0.05	8.3	3.3	0.02	0.05	457.	30	14	.13	<20	10	100.2
91JP241B	49.8	2.33	13.6	14.6	3.5	10.0	0.19	5.79	9.80	2.20	0.87	1.2	0.2	0.22	0.02	258.	230	<10	24	240	160	99.9
92JPF020B	38.8	0.18	4.20	9.80	2.0	7.0	0.14	31.6	2.79	<0.03	<0.05	9.4	3.5	0.02	0.12	1039.	40	<10	<10	30	<10	100.2
92JPF020C	42.6	0.39	8.20	8.40	2.1	5.7	0.12	26.8	4.96	0.30	<0.05	7.4	0.7	0.07	<0.02	53.	30	<10	<10	<20	21	99.8
92JPF021A	38.6	0.17	3.60	11.9	6.6	4.8	0.14	32.5	2.15	<0.03	<0.05	10.4	0.3	0.01	<0.02	103.	<30	<10	<10	<20	<10	99.7
92JPF021B	39.9	0.22	5.20	12.5	5.6	6.2	0.19	29.8	3.39	0.20	<0.05	8.4	0.3	0.02	<0.02	127.	<30	<10	10	<20	10	99.9
92JPF021C	42.7	0.34	8.10	6.70	1.7	4.5	0.08	27.4	5.74	0.40	<0.05	7.4	0.2	0.03	0.03	235.	<30	<10	<10	<20	14	99.1
92JPF022A	42.2	0.35	8.80	11.8	3.5	7.5	0.16	19.8	6.48	0.70	4.83	3.8	2.2	0.03	<0.02	<50.	730	<10	150	<20	17	100.8
92JPF022B	42.4	0.25	6.10	10.5	3.1	6.7	0.15	27.8	4.40	0.20	0.13	8.0	0.5	0.02	0.02	236.	40	13	15	<20	12	100.2
92JPF023A	42.5	0.33	7.60	13.1	4.3	7.9	0.15	26.5	2.86	0.20	<0.05	7.5	0.1	0.06	<0.02	153.	50	10	<10	<20	17	100.5
91JP233F	50.2	2.30	13.6	14.7	3.6	10.0	0.19	5.85	9.90	2.30	0.88	1.0	0.1	0.22	0.03	255.	240	15	26	240	160	100.4
92JPF023B	42.6	0.31	7.70	10.9	3.5	6.7	0.11	26.5	4.10	0.20	<0.05	7.3	0.1	0.03	<0.02	<50.	40	14	11	<20	14	99.6
92JPF023C	41.0	0.27	6.70	9.30	2.3	6.3	0.16	26.1	6.16	0.20	<0.05	6.9	3.3	0.03	0.03	274.	70	12	<10	<20	<10	99.9
92JPF024A	42.4	0.26	6.20	9.80	4.6	4.7	0.11	28.9	4.64	0.20	<0.05	8.0	0.2	0.03	0.06	609.	<30	13	<10	<20	12	100.8
92JPF024B	40.6	0.24	5.50	10.0	4.4	5.0	0.14	29.7	4.74	0.10	<0.05	7.4	0.9	0.02	0.03	374.	30	<10	<10	<20	12	99.3
92JPF024C	42.1	0.36	8.20	10.6	5.0	5.0	0.10	25.3	6.22	0.30	0.05	6.2	0.1	0.02	0.04	454.	40	12	10	<20	17	99.5
92JPF025A	43.8	0.27	6.00	11.8	5.0	6.1	0.15	26.3	4.71	0.30	<0.05	6.7	0.3	0.02	0.10	944.	30	11	<10	<20	13	100.2
92JPF025B	39.8	0.22	5.60	13.2	5.1	7.3	0.16	30.1	3.36	0.10	<0.05	6.6	0.4	0.02	0.03	402.	<30	<10	11	<20	11	99.2
91JP241B	49.8	2.32	13.4	14.7	3.1	10.4	0.20	5.80	9.80	2.20	0.88	0.9	0.1	0.22	0.02		230	<10	24	240	160	99.4
92JPF025C	41.6	0.39	8.60	8.70	3.4	4.8	0.10	26.3	5.89	0.30	<0.05	6.9	0.2	0.03	<0.02	91.	<30	10	<10	<20	21	99.0
92JPF026A	40.9	0.29	4.90	10.3	2.9	6.7	0.14	29.4	3.73	0.10	<0.05	8.7	1.5	0.04	0.05	518.	70	<10	<10	32	15	99.8
92JPF026B	41.1	0.27	5.60	11.3	4.2	6.4	0.15	27.9	4.62	0.20	<0.05	7.8	1.1	0.02	0.02	259.	<30	<10	10	33	12	99.8
92JPF026C	46.9	0.28	5.00	10.7	4.8	5.3	0.20	23.6	8.24	0.40	<0.05	4.7	0.1	0.07	<0.02	54.	<30	11	<10	<20	15	100.0
92JPF026D	43.6	0.32	6.30	9.80	3.8	5.4	0.15	27.0	5.51	0.20	<0.05	7.1	0.2	0.03	<0.02	53.	30	11	<10	<20	16	100.1
92JPF027A	43.0	0.49	9.70	16.5	5.4	10.0	0.30	14.1	10.6	2.50	1.25	2.5	0.6	0.03	<0.02	196.	190	<10	31	44	28	100.8
92JPF027B	43.0	0.34	8.00	11.5	4.2	6.6	0.16	24.4	6.54	0.30	0.05	6.4	0.1	0.03	<0.02	56.	<30	12	<10	<20	14	100.6
92JPF027C	43.4	0.37	8.00	10.4	3.1	6.6	0.17	24.6	6.49	0.30	<0.05	6.5	0.1	0.04	<0.02	66.	40	14	10	<20	17	100.2
91JP257D	49.7	2.32	13.5	14.7	3.7	9.9	0.20	5.76	9.80	2.20	0.89	1.0	0.1	0.22	0.04	254.	230	<10	31	250	160	99.6
92JPF027D	47.0	0.13	5.20	7.60	1.9	5.1	0.14	25.9	7.73	0.10	<0.05	6.0	0.5	0.02	<0.02	<50.	<30	12	13	<20	<10	100.0
92JPF028B	42.0	0.26	5.80	10.9	3.9	6.3	0.14	27.7	4.73	0.10	<0.05	7.9	0.3	0.03	0.03	398.	40	<10	11	<20	13	99.7
92JPF028D	41.7	0.46	9.20	14.5	4.2	9.3	0.20	16.3	8.87	1.50	3.42	3.0	1.8	0.04	<0.02	52.	370	<10	100	52	24	100.3
92JPF029A	41.6	0.34	5.70	11.6	4.4	6.5	0.16	25.9	5.87	0.30	0.07	6.7	1.5	0.02	0.07	655.	50	<10	12	81	13	99.6
92JPF029B	41.1	0.21	4.30	10.2	2.5	6.9	0.15	30.3	2.32	<0.03	<0.05	9.1	2.3	0.02	0.07	645.	<30	<10	<10	59	<10	99.8
92JPF029C	37.8	0.49	10.2	17.9	6.7	10.1	0.18	22.4	4.75	0.20	<0.05	7.2	0.1	0.03	<0.02	76.	<30	10	12	<20	21	100.6
92JPF030A	39.6	0.23	4.80	14.4	6.5	7.1	0.15	28.2	3.00	0.20	<0.05	9.4	0.3	0.02	0.03	373.	30	<10	12	<20	<10	100.0
92JPF030B	44.0	0.35	7.80	8.20	2.9	4.8	0.12	25.0	6.94	0.70	<0.05	6.1	0.2	0.03	0.03	300.	30	10	<10	21	18	99.4
91SMA1072B	50.5	2.33	13.7	14.8	3.8	9.9	0.20	5.80	9.90	2.20	0.89	1.1	0.1	0.22	0.03	253.	240	15	27	230	160	100.9
91JP234A	43.1	0.35	7.30	11.5	5.1	5.8	0.16	25.2	6.04	0.30	<0.05	6.4	0.1	0.03	0.04	411.	<30	12	14	<20	20	100.4
91JP234B	40.7	0.42	6.60	12.7	5.4	6.6	0.15	26.5	4.75	0.10	<0.05	7.4	0.5	0.02	<0.02	92JPF.	<30	<10	<10	<20	18	99.6
91JP235A	40.1	0.13	3.30	8.50	1.9	5.9	0.10	34.8	0.98	<0.03	<0.05	10.6	1.4	0.01	<0.02	458.	40	14	<10	<20	<10	99.7
91JP237A	44.0	0.25	6.00	12.4	5.1	6.6	0.21	25.6	4.48	0.10	<0.05	6.3	0.2	0.03	<0.02	95.	<30	<10	<10	<20	13	99.3
91JP240B	33.6	1.39	12.9	8.60	2.6	5.4	0.08	31.3	0.88	<0.03	0.19	11.0	0.5	0.32	<0.02	57.	150	20	25	<20	58	100.3
91JP241A	40.8	0.51	7.90	13.8	5.5	7.5	0.10	24.7	5.26	0.10	<0.05	6.5	0.1	0.05	<0.02	53.	<30	12	<10	<20	25	99.5
91JP242A	38.5	0.22	4.00	11.2	3.6	6.8	0.13	32.9	1.34	<0.03	<0.05	10.1	0.1	0.02	<0.02	55.	<30	11	10	<20	15	98.3
91JP242B	41.1	0.36	5.90	11.3	3.3	7.2	0.26	26.9	3.13	<0.03	0.41	7.8	2.0	0.04	0.37	3087.	60	<10	21	63	28	99.4
91JP243A	50.0	0.77	11.7	12.1	2.8	8.4	0.19	12.6	7.94	3.40	0.06	2.7	0.2	0.06	<0.02	138.	<30	11	<10	100	55	101.0
91SMA1034A	43.1	0.34	7.10	11.4	5.1	5.7	0.16	25.3	6.00	0.30	<0.05	6.4	0.1	0.03	0.03	439.	<30	10	12	<20	17	100.1
91SMA1071H	50.1	2.32	13.6	14.8	3.6	10.1	0.20	5.80	9.90	2.30	0.88	1.1	0.1	0.22	0.02	296.	260	16	30	250	160	100.4
91SMA1035A1	39.2	0.39	9.00	14.4	6.7	6.9	0.12	25.3	4.83	0.10	<0.05	7.2	<0.1	0.05	<0.02	<50.	<30	13	11	<20	19	100.4
91SMA1035A2	39.9	0.33	8.50	13.4	6.1	6.6	0.13	25.3	5.21	0.20	<0.05	7.3	0.1	0.04	<0.02	<50.	40	12	16	<20	17	100.2
91SMA1035D	40.7	0.22	5.50	10.5	3.2	6.6	0.15	29.5	3.55	0.10	<0.05	8.7	1.1	0.02	0.05	581.	<30	<10	12	20	11	99.8
91SMA1044A	41.4	0.26	5.80	11.8	4.8	6.3	0.15	27.9	4.53	0.20	<0.05	7.8	0.7	0.03	0.02	247.	<30	12	<10	<20	15	100.4
91SMA1044B	40.1	0.21	4.80	10.6	3.3	6.6	0.16	31.2	2.47	<0.03	<0.05	9.5	0.9	0.02	0.07	773.	<30	10	<10	<20	12	99.7
91SMA1045A	41.8	0.30	6.90	10.2	3.2	6.3	0.15	27.2	4.98	0.30	<0.05	7.7	0.9	0.02	0.02	272.	<30	12	<10	<20	15	100.2
74EL238A	34.5	0.05	1.20	6.20	4.3	1.7	0.08	36.6	3.55	<0.03	<0.05	11.2	6.0	0.01	0.02	146.	<30	<10	<10	73	<10	99.6
74EL240	38.0	0.26	2.40	10.1	6.4	3.3	0.05	36.9	0.13	<0.03	<0.05	11.7	0.2	0.02	0.14	1313.	<30	13	17	<20	<10	100.0
74EL245	43.1	0.35	7.60	10.5	2.9	6.8	0.11	25.3	4.75	0.30	<0.05	7.1	1.2	0.03	<0.02	102.	40	10	<10	<20	19	100.0
74EL246	38.2	0.09	1.70	7.30	4.3	2.7	0.07	37.9	0.30	<0.03	<0.05	10.4	3.3	0.01	0.02	269.	<30	12	15	<20	<10	99.5
74EL248	44.7	0.34	7.80	12.0	3.3	7.8	0.19	20.8	7.28	0.70	1.87	4.9	0.6	0.03	<0.02	56.	300	<10	59	<20	15	100.8
74EL249	40.2	0.08	1.90	9.00	3.3	5.1	0.17	39.9	0.83	<0.03	0.39	6.9	0.3	0.02	0.15	1417.	30	10	46	<20	<10	100.1
120-92-68	38.7	0.17	4.20	9.80	2.2	6.8	0.14	31.6	2.75	<0.03	<0.05	9.4	3.3	0.02	0.12	1153.	40	10	<10	24	<10	99.9
120-92-69	42.9	0.36	8.60	10.6	5.0	5.0	0.10	25.1	6.26	0.30	0.05	6.2	0.2	0.02	0.04	439.	50	11	12	<20	13	100.6
120-92-70	40.8	0.25	5.70	11.8	4.8	6.3	0.15	27.8	4.47	0.20	<0.05	7.8	0.7	0.02	0.02	268.	70	<10	<10	<20	14	99.5

APPENDIX I(g) 1992 TRACE ELEMENTS OF KOMATIITES. Elements As to Rh (left half); lab. work by ACMEAnalytical, Vancouver, B.C.** Elements Be to Zn (right half), lab. work by Analytical Chemistry Division, GSC**

SAMPLE	As	Sb	Bi	Ge	Se	Te	Au	Au*	Pt	Pt*	Pd	Pd*	Rh	Rh*	Be	Cl	Co	Cr	Cu	Cl	La	Ni	Sc	V	Y	Yb	Zn
74EL238A	91.6	.1	.1	.1	.1	.1	1	4	2	6	2	5	1	<5	<0.5	1295.	64	1100	<10	102.	<10	2100	4.4	9	<5	<0.5	17
74EL240	12.4	.1	.3	.1	.1	.1	1	5	7	<3	4	10	1	<5	0.5	1029.	130	1700	<10	442.	<10	2400	10	64	<5	<0.5	23
74EL245	.1	.1	.1	.1	.1	.1	1	6	8	14	6	12	1	<5	<0.5	<100.	81	2700	11	68.	<10	1000	25	140	6	<0.5	60
74EL246	2.2	.1	.3	.1	.1	.2	3	65	1	<3	1	<3	1	<5	<0.5	144.	70	1600	<10	63.	<10	2600	6.9	26	<5	<0.5	66
74EL248	.1	.1	.1	.1	.1	.1	1	1	3	11	1	7	1	<5	<0.5	<100.	85	2900	<10	52.	<10	810	24	160	8	0.5	77
74EL249	22.8	.1	4.6	.1	.1	.1	1	1	5	<3	1	<3	1	<5	0.9	262.	100	4900	<10	511.	<10	2500	4.9	30	<5	<0.5	150
91JP234A	.7	.2	.5	.1	.1	.1	1	1	4	8	12	10	1	<5	<0.5	148.	93	2700	22	71.	<10	1200	17	130	7	<0.5	66
91JP234B															<0.5	131.	88	3200	14	62.	<10	1200	20	150	5	<0.5	64
91JP235A	14.4	.3	.1	.1	.1	.1	2	8	2	<3	1	<3	1	<5	<0.5	102.	90	2000	<10	63.	<10	2200	12	57	<5	<0.5	66
91JP237A	.3	.1	.1	.1	.1	.1	1	6	7	9	9	7	1	<5	<0.5	<100.	60	3100	20	<50.	<10	950	15	90	<5	<0.5	45
91JP240B	.6	.1	.1	.1	.1	.1	1	3	3	3	2	<3	1	<5	<0.5	147.	90	110	<10	419.	<10	1100	15	97	10	<0.5	53
91JP241A	3.1	.1	.1	.1	.1	.1	13	3	11	14	10	10	1	<5	<0.5	127.	84	3100	<10	91.	<10	1000	27	160	8	<0.5	61
91JP241B	1.4	.7	.2	.1	.3	.1	3		2		1		1		1.3	961.	50	220	310	425.	16	91	33	400	30	2.6	150
91JP241B	1.4	.6	.1	.1	.3	.2	2		2		4		1		1.3		51	230	310		15	90	34	400	30	2.4	160
91JP242A	13.2	.3	.3	.1	.1	.1	16	9	4	5	6	4	1	<5	<0.5	178.	90	3200	15	88.	<10	1900	12	72	<5	<0.5	70
91JP242B	2.0	.2	2.4	.1	.3	.2	42	38	11	5	4	5	3	<5	<0.5	165.	95	4300	63	390.	<10	1500	17	96	6	<0.5	69
91JP243A	.1	.1	.3	.1	.1	.1	1	7	3	18	1	10	1	<5	0.5	<100.	58	1200	36	152.	<10	310	32	200	15	1.1	64
91JP257D	1.2	.6	.1	.1	.2	.1	20		2		1		1		1.2	1075.	47	220	320	440.	12	85	34	400	30	2.2	150
91SMA1034A	1.1	.2	.4	.1	.1	.1	7		4		1		1		<0.5	<100.	84	2700	22	70.	<10	1200	23	130	7	0.5	61
91SMA1035A1	.1	.1	.1	.2	.1	.1	11	7	4	13	3	5	2	<5	<0.5	<100.	100	3400	17	<50.	<10	1000	28	180	6	<0.5	74
91SMA1035A2	.1	.1	.1	.2	.1	.1	13	4	9	13	11	5	1	<5	<0.5	<100.	96	3300	49	<50.	<10	1000	27	150	6	<0.5	69
91SMA1035D															<0.5	<100.	95	2500	36	53.	<10	1500	18	97	<5	<0.5	70
91SMA1044A	.8	.1	.1	.1	.2	.1	4	5	6	6	8	9	1	<5	<0.5	<100.	100	2500	40	<50.	<10	1400	18	100	6	<0.5	66
91SMA1044B															<0.5	<100.	98	2100	37	51.	<10	1600	15	87	<5	<0.5	81
91SMA1045A															<0.5	<100.	86	2700	13	80.	<10	1100	21	100	6	<0.5	56
91SMA1070H	1.2	.8	.1	.1	.2	.1	4		4		4		4														
91SMA1071H															1.1	1055.	40	190	300	481.	12	83	31	370	28	2.1	140
91SMA1072B	1.3	.6	.1	.1	.2	.1	12		1		3		1		1.2	973.	44	210	290	446.	12	86	31	380	28	1.9	140
92JPF012	1.7	.1	.1	.2	.1	.3	4	1	1	5	1	5	1	<5	<0.5	200.	100	2400	<10	82.	<10	1200	21	110	6	<0.5	68
92JPF013a	.1	.1	.1	.1	.1	.1	6	<1	1	11	1	8	1	6	<0.5	305.	66	1700	<10	69.	<10	920	17	86	9	0.6	49
92JPF013b	.3	.1	.1	.1	.1	.2	2	3	1	3	1	5	1	6	<0.5	144.	62	1800	<10	190.	<10	890	16	68	7	<0.5	62
92JPF014a	.3	.1	.1	.2	.1	.3	8	3	2	18	5	19	1	<5	0.5	254.	77	1600	300	56.	<10	260	35	220	14	0.9	79
92JPF014b	.1	.1	.2	.1	.1	.1	4	1	5	14	8	16	1	7	<0.5	171.	87	1500	81	72.	<10	520	23	150	8	0.5	75
92JPF015a	6.3	.1	1.5	.2	.4	.5	8	9	1	3	1	8	1	<5	<0.5	117.	150	1300	30	89.	<10	3300	7.1	31	<5	<0.5	48
92JPF018	.3	.1	.5	.1	.4	.2	8	9	1	<3	1	9	1	11	<0.5	161.	91	2000	74	55.	<10	1600	14	73	<5	<0.5	64
92JPF020A	1.6	.1	.3	.1	.1	.1	4	3	1	8	1	17	1	11	<0.5	128.	86	2200	13	59.	<10	1400	17	86	<5	<0.5	62
92JPF020B	2.1	.1	.7	.2	.3	.2	3	3	4	7	1	10	1	<5	<0.5	109.	99	1800	38	61.	<10	1700	14	76	<5	<0.5	73
92JPF020C	.1	.1	.1	.1	.1	.1	6	5	10	15	4	9	1	<5	<0.5	<100.	83	2800	11	<50.	<10	1100	26	140	9	0.8	52
92JPF021A	.2	.1	.2	.3	.1	.3	6	<1	4	11	1	11	1	<5	<0.5	1024.	99	2000	<10	<50.	<10	1800	13	59	<5	<0.5	110
92JPF021B	.1	.1	.1	.1	.1	.1	1	1	1	10	1	12	1	<5	<0.5	657.	120	2200	<10	<50.	<10	1500	16	86	5	<0.5	81
92JPF021C	.3	.1	.1	.1	.2	.2	14	2	7	12	9	15	1	<5	<0.5	126.	67	2900	17	78.	<10	1100	24	140	7	0.6	45
92JPF022A	.7	.1	.1	.1	.1	.1	11	1	2	11	3	12	1	<5	<0.5	132.	84	2700	18	59.	<10	710	24	140	8	0.5	64
92JPF022B	.8	.1	.2	.3	.2	.3	8	4	1	7	11	6	3	5	<0.5	<100.	93	2500	45	<50.	<10	1300	20	110	5	<0.5	73
92JPF023A	.1	.1	.1	.1	.1	.1	24	5	6	14	11	15	1	5	<0.5	112.	90	2900	100	61.	<10	1000	24	170	5	<0.5	64
92JPF023B	.1	.1	.1	.1	.1	.1	16	2	6	16	7	9	1	<5	<0.5	152.	96	2900	39	<50.	<10	1100	23	120	5	<0.5	66
92JPF023C	.1	.1	.1	.1	.1	.1	29	4	1	9	2	6	2	<5	<0.5	157.	79	2500	71	64.	<10	980	22	95	6	<0.5	53
92JPF024A	1.5	.1	.1	.1	.3	.1	13	2	4	<3	15	<3	3	<5	<0.5	424.	130	2400	<10	159.	<10	1600	19	100	7	<0.5	40
92JPF024B	1.1	.1	.1	.1	.1	.1	4	1	1	4	16	6	2	<5	<0.5	613.	94	2300	<10	70.	<10	1400	18	97	5	<0.5	74
92JPF024C	2.0	.6	.1	.1	.4	.2	13	1	1	12	11	14	1	<5	<0.5	177.	66	3000	16	90.	<10	880	25	140	7	<0.5	40
92JPF025A	1.4	.2	.2	.1	.2	.1	16	1	1	5	9	7	3	<5	<0.5	231.	97	2500	24	251.	<10	1300	20	110	7	<0.5	49
92JPF025B	1.3	.1	.1	.1	.1	.1	8	3	13	13	15	13	2	6	<0.5	381.	110	2400	<10	114.	<10	1400	17	84	5	<0.5	61
92JPF025C	.9	.1	.1	.1	.1	.1	9	2	18	11	12	9	2	<5	<0.5	195.	67	3000	<10	59.	<10	960	26	140	7	<0.5	59
92JPF026A	3.6	.2	.2	.2	.3	.2	2	3	1	4	1	4	1	<5	<0.5	112.	93	2100	25	84.	<10	1500	16	84	6	<0.5	85
92JPF026B	1.9	.2	.1	.2	.2	.2	4	1	1	8	1	11	1	<5	<0.5	<100.	100	2500	11	57.	<10	1400	19	110	5	<0.5	74
92JPF026C	2.0	.1	.1	.2	.1	.2	8	1	1	9	1	13	1	<5	<0.5	<100.	75	2300	<10	69.	<10	880	20	110	9	<0.5	51
92JPF026D	2.0	.1	.1	.1	.1	.1	10	3	1	10	1	4	1	<5	<0.5	<100.	84	2500	<10	53.	<10	1200	21	95	7	<0.5	62
92JPF027A	.1	.1	.1	.1	.1	.1	18	9	4	18	17	15	1	11	0.6	277.	78	1900	300	64.	<10	330	33	210	17	1.3	84
92JPF027B	1.0	.1	.1	.2	.1	.2	21	1	3	13	3	15	1	<5	<0.5	123.	90	3400	32	<50.	<10	840	23	130	6	<0.5	79
92JPF027C	.3	.1	.1	.1	.1	.1	1	3	3	14	8	15	1	<5	<0.5	124.	90	3400	36	50.	<10	960	23	120	5	<0.5	79
92JPF027D	.5	.1	.1	.3	.1	.3	7	2	1	4	1	4	1	<5	<0.5	115.	76	1200	<10	58.	<10	780	15	56	5	<0.5	59
92JPF028B	.3	.1	.1	.1	.1	.1	15	3	1	7	5	7	1	<5	<0.5	112.	96	2700	28	55.	<10	1300	19	110	6	<0.5	64
92JPF028D	.5	.2	.1	.3	.1	.4	1	1	6	18	18	16	1	<5	<0.5	229.	87	2100	19	67.	<10	420	33	220	14	1.1	73
92JPF029A	1.6	.2	.1	.1	.1	.1	16	7	6	11	5	10	1	<5	<0.5	145.	99	2700	40	69.	<10	1400	21	120	7	<0.5	74
92JPF029B	3.1	.1	.1	.1	.3	.3	8	5	6	5	5	7	1	<5	<0.5	136.	110	2100	23	83.	<10	1800	18	74	<5	<0.5	100
92JPF029C	.1	.1	.1	.1	.1	.3	10	5	6	13	12	<3	1	<5	<0.5	129.	130	2500	16	70.	<10	550	36	230	8	<0.5	90
92JPF030A	.7	.1	.1	.1	.1	.3	18	1	2	18	7	19	1	<5	<0.5	1069.	130	2300	<10	63.	<10	1500	18	92	5	<0.5	42
92JPF030B	.2	.1	.1	.1	.2	.4	48	5	2	12	11	12	1	<5	<0.5	338.	77	2900	41	58.	<10	1100	30	140	8	0.6	48

*re-analyzed samples

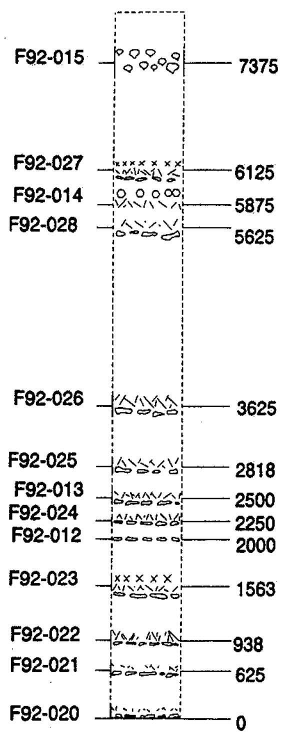
**Au, Pt, Pd, Rh by fire assay and analysis by ICP\graphite furnace. All other samples analyzed by hydride ICP.

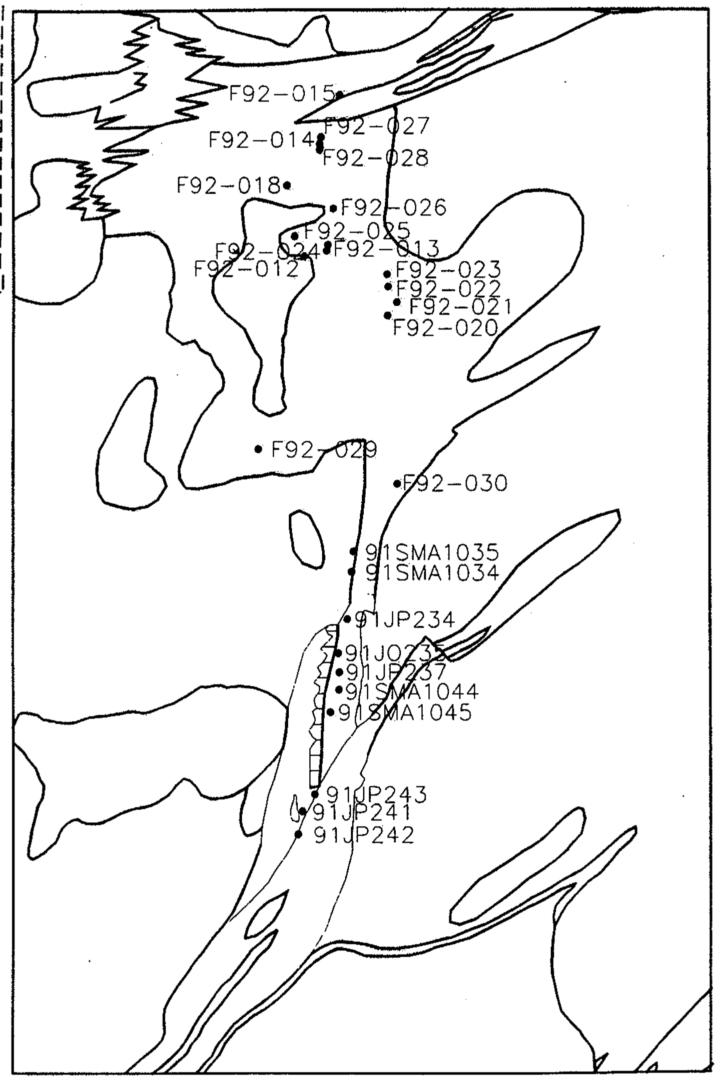
APPENDIX I(h). 1992 RARE EARTH ELEMENTS OF KOMATIITES, Lab. work by: ICP-MS Laboratory, Analytical Chemistry Subdivision, GSC

SAMPLE NUMBER	Ce ppm	Dy ppm	Er ppm	Eu ppm	Gd ppm	No ppm	La ppm	Lu ppm	Nd ppm	Pr ppm	Sm ppm	Tb ppm	Tm ppm	Y ppm	Y MS ppm	Yb ppm
92JPF020A	1.2	0.77	0.47	0.16	0.70	0.17	0.4	0.08	1.1	0.17	0.37	0.12	0.0	4.6	4.6	0.49
92JPF021A	0.95	0.59	0.40	0.08	0.46	0.13	0.8	0.06	0.9	0.19	0.28	0.08	0.0	3.4	3.4	0.39
92JPF022B	1.1	0.95	0.59	0.18	0.74	0.22	0.4	0.10	0.9	0.17	0.49	0.14	0.1	5.8	5.8	0.63
92JPF023A	1.1	1.1	0.69	0.19	0.87	0.24	0.6	0.09	1.3	0.19	0.55	0.17	0.1	6.2	6.2	0.66
92JPF024A	3.1	1.2	0.69	0.24	1.0	0.25	2.1	0.09	1.7	0.35	0.56	0.18	0.1	7.6	7.6	0.67
92JPF024B	1.3	1.0	0.67	0.22	0.82	0.28	0.6	0.16	1.2	0.24	0.47	0.19	0.1	6.2	6.2	0.70
92JPF025A	8.0	1.1	0.73	0.35	1.1	0.27	2.9	0.13	4.1	0.96	0.90	0.18	0.1	8.2	8.2	0.79
92JPF025B	1.7	0.92	0.62	0.18	0.75	0.22	0.7	0.09	1.2	0.21	0.44	0.13	0.1	5.8	5.8	0.59
92JPF025C	1.5	1.4	0.83	0.26	1.1	0.31	0.5	0.12	1.4	0.22	0.64	0.21	0.1	9.0	9.0	0.88
92JPF026A	4.2	1.1	0.70	0.24	1.0	0.25	2.2	0.10	2.6	0.53	0.70	0.16	0.1	7.8	7.8	0.63
92JPF026C	2.3	1.7	1.1	0.40	1.5	0.37	0.6	0.14	2.2	0.33	0.88	0.27	0.1	11.0	11.0	1.1
92JPF027B	1.4	1.2	0.71	0.24	0.88	0.24	0.4	0.10	1.3	0.22	0.52	0.18	0.1	7.4	7.4	0.70
92JPF028B	1.4	1.1	0.65	0.15	0.84	0.24	0.5	0.10	1.2	0.19	0.48	0.15	0.1	6.3	6.3	0.63
92JPF029A	2.1	1.2	0.74	0.25	1.0	0.27	0.7	0.11	1.7	0.33	0.71	0.18	0.1	7.3	7.3	0.74
92JPF029B	1.8	0.58	0.38	0.17	0.54	0.12	0.7	0.07	1.2	0.22	0.33	0.09	0.0	3.7	3.7	0.38
91JP234A	1.8	1.4	0.83	0.25	1.1	0.30	0.6	0.13	1.6	0.27	0.58	0.21	0.1	7.8	7.8	0.83
91JP235A	0.51	0.28	0.19	0.04	0.23	0.05	0.1	0.04	0.3	0.06	0.11	0.04	0.0	1.8	1.8	0.20
91JP240B	19.0	2.3	1.1	0.39	2.7	0.51	8.2	0.15	9.9	2.3	2.2	0.47	0.2	12.0	12.0	0.73
91SMA1035D	1.2	0.89	0.58	0.15	0.72	0.19	0.5	0.09	0.9	0.16	0.42	0.13	0.1	5.5	5.5	0.57
91SMA1044B	1.3	0.68	0.46	0.13	0.60	0.15	0.5	0.07	0.9	0.18	0.34	0.11	0.0	4.3	4.3	0.46

APPENDIX I(i): Auto-Radiograph Samples (All nil results).

Sample	Rock Type	Comments
92-CGA-029a	pyr gar qzte	
92-CGA-042a	pyr qzte	rusty granular fine-to-coarse quartzarenite
92-CGA-070a	pyr gar qzte/cgl	15 cm gossanous zone in granule conglomerate
92-CGA-070b	pyr gar qzte	dark mineral band, mainly chlorite
92-CGA-123a	hem qzte	mottled red & green intensely foliated sericitic qzte
92-CGA-029a	pyr gar qzte	
92-CGA-029a	pyr gar qzte	
92-CGA-029a	pyr gar qzte	
92-CGA-029a	pyr gar qzte	
92-CGA-029a	pyr gar qzte	





I(J)L. Stratigraphic Section, Northern Half; Assuming no Structural Repetitions

I(j)R. Location map.

APPENDIX I(I): Stratigraphic Locations of Komatiite Samples, Central Complex.

APPENDIX I(k). Metamorphic Mineral Assemblages.

SAMPLE	OLIV	MG CHL	FE CHL	TALC	TREM	ANTH	SERP	CARB	BRUC	CHRO	MAGN
F020a		●	●		●		●	●			●
F020b		●	●		●		●				●
F020c		●			●						●
F021a	●	●			●		●			●	●
F021b		●	●		●			●			●
F021C		●			●						●
F022A		●			●			●			●
F022b					●		●	●			●
F023a		●			●			●			●
F023b		●	●		●			●		●	●
F023c		●	●		●						●
F024a	●	●	●		●						●
F024b		●	●		●					●	●
F024c		●	●								●
F025a	●	●	●		●	●	●				●
F025b		●			●	●	●	●			●
F025c		●	●		●	●					●
F026a	●	●			●		●			●	●
F026b											●
F026c		●	●	●	●		●	●	●		●
F026d		●	●	●	●		●	●			●
F027a		●	●		●						●
F027b		●			●		●				●
F027c		●	●		●			●			●
F027d		●			●			●			●
F028a		●			●		●				●
F028b		●	●		●			●		●	●

APPENDIX I(l). Electron Microprobe Analyses of Olivine.

Sample	24ai4	24ai1	24ai2	21ai5	21ai4	21ai2
SIO2	41.04	40.64	40.41	40.71	39.31	43.78
TIO2	0.00	0.00	0.00	0.00	0.00	0.00
AL2O3	0.07	0.22	0.14	0.11	0.12	0.15
CR2O3	0.06	0.05	0.31	0.08	0.16	0.11
FEO	15.60	18.76	19.82	17.99	15.96	10.19
MNO	0.32	0.36	0.29	0.46	0.42	0.17
MGO	44.33	42.46	39.40	43.21	41.97	38.82
CAO	0.13	0.00	1.40	0.00	0.13	0.28
NA2O	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.00	0.00	0.04	0.00	0.05
NIO	0.54	0.45	0.50	0.65	0.63	0.52
ZNO	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.07	0.00	0.05	0.00	0.00	0.07
total	102.17	103.89	101.07	103.25	98.70	94.15
Mg #	0.835088	0.801321	0.779853	0.810612	0.824133	0.871609

APPENDIX I(m). Kd Values for Olivines versus Liquid Compositions.

Sample	24ai	21ai
FeO (oliv)	18.06	14.71
MgO (oliv)	42.06	41.33
FeO/MgO (oliv)	**0.4294**	**0.3659**
FeO (liq)	9.54	6.03
MgO (liq)	25.3	27.4
MgO/FeO	2.6520	4.5439
0.333/(MgO/FeO)	**0.1256**	**0.0733**

APPENDIX I(n). Electron Microprobe Analyses of Chromite

SAMPLE	SIO2	TIO2	AL2O3	CR2O3	FEO	MNO	MGO	CAO	NA2O	K2O	NIO	ZNO	V2O3	TOTAL
24biic6	0.53	0.27	12.72	49.79	31.54	0.29	3.09	0.10	0.00	0.00	0.21	2.03	0.13	100.69
24biic7	0.55	0.26	14.08	48.11	31.37	0.56	3.38	0.20	0.00	0.03	0.23	2.01	0.21	100.98
24biic8	0.43	0.66	3.87	44.68	45.12	0.67	1.93	0.17	0.58	0.05	0.43	1.08	0.25	99.90
24biic9	0.56	0.15	13.29	49.03	31.29	0.51	3.44	0.16	0.00	0.00	0.39	1.48	0.00	100.31
24biir9	0.48	1.15	0.63	28.84	64.39	0.50	1.03	0.11	0.34	0.00	0.67	0.56	0.69	99.39
26biic6	0.56	0.56	4.32	46.34	43.30	0.76	2.03	0.13	0.76	0.00	0.49	1.26	0.19	100.70
26biir6	0.43	0.59	0.55	33.04	57.88	1.44	0.65	0.07	0.45	0.00	0.60	0.97	0.32	97.00
26biic8	0.61	0.22	11.67	49.98	32.44	1.26	1.71	0.13	0.00	0.00	0.57	1.94	0.14	100.67
26biir8	0.45	0.45	0.42	24.05	69.37	1.03	0.48	0.04	0.30	0.03	0.81	0.65	0.33	98.41
26biic9	0.56	0.22	12.07	49.38	32.74	1.35	1.81	0.14	0.00	0.00	0.48	2.45	0.17	101.37
26biir9	0.42	0.38	0.41	23.81	68.86	1.06	0.52	0.08	0.28	0.03	0.67	0.53	0.30	97.34
26biic10	0.54	0.15	11.67	49.21	33.70	0.95	1.61	0.13	0.11	0.03	0.13	2.44	0.23	100.90
26biir10	0.44	0.25	0.35	16.55	75.32	0.59	0.47	0.05	0.15	0.00	0.68	0.69	0.22	95.75
26biic4	0.62	0.20	11.82	50.34	32.89	1.21	1.68	0.12	0.14	0.00	0.19	2.48	0.09	101.79
26biir4	0.43	0.30	0.34	17.56	75.70	0.56	0.47	0.17	0.20	0.00	0.76	0.24	0.18	96.92
26biic5	0.53	0.25	11.52	48.99	33.00	1.16	1.68	0.08	0.00	0.03	0.27	2.49	0.20	100.19
26biir5	0.39	0.36	0.31	23.71	68.22	0.82	0.45	0.10	0.36	0.00	0.74	0.83	0.30	96.59

APPENDIX II: SURFICIAL GEOCHEMICAL DATA

APPENDIX II(a). 1992 TILL, ESKER AND OTHER SURFICIAL STATION DATA, UTM MAP GRID 15 (?texture?)

Station	East	North	Z	Airphoto	LF	BC	CV	AC	CP	CO	OX	SZ	SH	TX[1]	AB	MC	OC	WH
92JP 021t	485829	7343332	45	A15740-073	fl	5	ms	in	d	ob	n	5x5	ro	s	y	mm	n	d-c
92JP 024t	487593	7343816	45	A15740-073	tn	5	ms	in	c/d	g-b/ob	n/n	5x5	ro	s	y	wt	n	d-c
92JP 025t	488696	7344045	45	A15740-073	dr	5		ac	c/d	g/g	n/n	5x10	og	s	y	wt	y	d
92JP 027t	490189	7344122	50	A15740-073	ct	5		ac	c/d	g-b/b	y/y	7x10	og	ps	y	wt	y	d
92JP 028t	524196	7363445	40	A14824-071	ct	5		ac	c/d	g/o-b-g	y/y	12x8	ro	sc	y	mm	y	d
92JP 029t	523035	7362020	50	A14824-071	dr	5		ac	c/d	g-b/l-b	n/n	12x.5	ro	sc	y	mm	y	d
92JP 030t	530522	7370432	40	A14824-070	dr	15	ms	ac	c/d	gn-bn/o-b	y/y	11x8	ro	sc	y	mm	y	d
92JP 031t	505401	7345536	20	A15794-016	tn	20		ac	c/d	g-b/g-b	n/n	14x8	ro	ps	y	mm	n	d-c
92JP 032t	511310	7347850	50	A15794-016	ct	10		ac	c/d	lt-g/s-g	n/n	10x12	ro	ps	y	dp	n	d
92JP 033e	519183	7356005	25	A14824-010	esk						n	50	rc	s(f)			n	
92JP 034t	518350	7357759	10	A14824-010	tn	25	ms	in	c/d	g&o/g&o	y/y	3x15	og	sc	n	mm/sf	y	c-d
92JPF001t	519746	7357995	30	A14824-010	hm	20	lc	in	d	b-g	n	14x6	og	psl	y	mm	y	d
92JPF002t	525183	7365074	15	A14824-071	tn	30	lc	ac	d	b-dk-g	n	9x5	og	s(f)sl	y	wt	y	d
92JPF003e	525168	7365360	30	A14824-071	esk						y	30	rc	s(c)			n	
92JPF004t	527954	7367653	45	A14824-071	hm	50	so	ac	d	dk-b-g	y	8x8	ro	s	y	dp	y	d
92JPF005t	503464	7339840	15	A15794-016	ct	35	lc	in	c	lt-g	n	8x8	ro	s	y	dp	n	c
92JPF006t	506995	7344497	45	A15794-016	ct	5	lc	in	c/d	b/lt-g	y/n	14x8	og	ssl	n	wt	y	d
92JPF007t	512251	7350919	40	A15794-016	rm	7	lc	in	c/d	rd-b/lt-g	y/n	10x5	og	s(f)sl	y	wt	y	d
92JPJ001e	517371	7342814	10	A14824-007	esk						n		fc	s			n	
92JPJ001t	515615	7351649	30	A14824-010	ct	10	lc	in	c	b	n	3x6	og	psslc	n	wt	y	c
92JPJ002e	**524657**	**7337228**	10	A14824-077	esk	5					n		rc	s			n	
92JPJ003e	**535544**	**7334356**	10	A14824-125	esk	1					y		fc	s			n	
92JPJ004e	**536683**	**7323724**	10	A14824-122	ej	1					n		fc	ps			n	
92JPJ005e	**541636**	**7311474**	10	A15744-159	esk	1					y		fc	ps(nf)			n	
92JPJ006t	**542171**	**7341036**	10	A15744-153	ct	10	lc	ac	c/d	b/g	n/n	3x3	ro	sslc	y	dp/sf	n	d
92JPJ007t	538017	7356358	10	A14824-129	ct	10		ac	d	gn-g	n	6x6	ro	psslc	y	dp	n	d
92JPJ008t	534994	7336889	30	A14824-125	ct	40	lc	ac	d	rd-b	n	3x3	ro	psslc	y	mm	n	d
92JPJ009t	542777	7329211	35	A15744-154	ct	40	lc	ac	d	b-g	n	8x6	og	sslc	y	wt	n	d
92JPJ010t	540028	7321300	10	A15744-157	dr	40	lc	in	c	b-g	y	12x8	og	pssl	y	wt	n	c
92JPJ011t	533172	7323355	10	A14824-122	dr	10	lc	ac	c/d[2]	rd-b/g-b	y/n	1.5x1.5	ro	sc	y	wt	y	d
92JPJ012t	**522446**	**7324156**	5	A14824-079	dr	40	ms	in	c	g-b	y		ro	s(c)	y	wt/sf	y	c
92JPJ013t	494274	7349557	5	A15325-063	dr	10	lc	ac	d	g-b	n	1.5x1.5	ro	sc	y	mm	y	d
92JPJ014e	491074	7346980	10	A15740-073	esk						y	20	fc	s(c)			n	
92JPJ015e	485218	7338447	10	A15740-071	esk						y	100-150	rc	s(c)			n	
92JPJ016t	488327	7338140	5	A15740-071	dr	10	lc	ac	d	b-g	n	11x6	og	sc	y	wt	y	d
92JPJ017e	491412	7330726	10	A15740-071	esk						y		fc	ps(c)			n	
92JPJ018t	501547	7337527	10	A15325-065	ct	10	lc	in	c	b-g	n	18x15	og	ps(c)s[3]	mm	n	c	y
92JPJ019e	501722	7334218	20	A15325-065	esk						y		rc	ps(c)			n	
92JPJ020e	501667	7341965	20	A15325-065	esk						y		fc	ps(c)			n	
92JPJ021t	504169	7344846	5	A15794-016	dr	10	lc	ac	c	b-g	n	1.5x1.5	ro	sslc	y	wt	y	d
92JPJ022e	501695	7346205	10	A15325-063	dcx						n		fc	ps(c)			n	
92JPJ023e	504692	7349989	10	A15794-016	dcx						y		fc	ps(c)s		n		
92JPJ024e	509231	7346053	10	A15794-016	esk						y		fc	ps(c)			n	
92JPJ025e	511297	7339862	20	A15794-016	esk	1					y		fc	s(m)			n	
92JPJ026f	535776	7349307	5		rw						n	40	rc	s(f)			n	
92JPJ027t	504551	7343227	10	A15794-016	ct	5	ms	in	c	b	y	6x6	ro	ssl	n	wt	y	c
92JPJ028t	510043	7346089	5	A15794-016	ct	5	lc	in	d	g	n	3x3	ro	ssl	y	dp	y	d-c
92JPJ029e	515211	7350687	20	A14824-010	esk	0					n	200		s(f)			n	
92JPJ030t	517724	7354844	15	A14824-010	ct	25	ms	in	d	g-b	n	12x8	og	sslc	y	wt	y	d
92JPJ031t	520710	7361497	5	A14824-071	ct	5	lc	ac	c/d	dk-b/g-b	y/y	9x9	ro	sslc	n	mm	y	d
92JPJ032e	522459	7361207	20	A14824-071	esk	0					n	50	fc	s(f)			n	
92JPJ033e	532266	7358819	25	A14824-130	esk	1					n	200	rc	ps(c)			n	
92JPJ034t	526500	7366215	5	A14824-071	ct	5	lc	ac	c/d	dk-b/g-b	y/n	9x8	og	sslc	n	wt	y	d
92JPJ035t	528595	7368858	5	A14824-071	hm	40	lc	in	c	g-gn	n	6x8	og	ssl	y	dp	y	c
92JPJ036e	516375	7375418	20	A14824-014	esk	5	lc				y	100	fc	ps(c)			y	
92JPJ037t	511193	7374524	20	A15325-036	dr	25	ms	ac	c/d	dk-b/g-b	y/y	15x8	og	sslc	y	wt	y	c
92JPJ038t	502770	7366695	10	A15325-036	dr	5	ms	ac	c/d	rs-b/g-b	y/y	6x3	og	sslc	y	wt	y	d
92JPJ039t	496930	7372655	10	A15325-058	dr	1	ms	ac	c/d	rs-b/b	y/y	9x9	ro	sslc	y	wt	y	c-d
92JPJ040e	495129	7375484	30	A15325-058	esk	.5	lc				y	50	fc	ps(c)			y	
92JPJ041e	489634	7369216	40	A15740-078	esk	0					n	30	fc	s(m)			n	
92JPJ042t	487062	7368875	20	A15740-078	dr	1	lc	ac	c/d	rs-b/g-b	y/y	9x7	og	sslc	y	wt	y	c-d
92JPJ043t	492117	7359217	20	A15740-075	ct	1	ms	ac	c/d	rs-b/g-b	y/y	9x7	og	ssl	y	mm	n	c-d
92JPJ044e	492741	7359054	30	A15740-075	esk	0	lc				n	20	fc	s(m)			n	
92JPJ045t	488551	7352767	5	A15740-075	dr	2	ms	ac	c/d	rs-b/g	y/n	7x7	ro	slc	n	wt	y	d-c
92JPJ046t	496200	7357798	20	A15325-062	dr	.5	ms	ac	c/d	dk-b/g-b	n/n	24x24	ro	slc	n	wt	n	d-c
92JPJ047t	507975	7357156	20	A15794-018	tn	5	ms	in	c/d	sa-b/g-b	n/n	9x6	og	sslc	y	dp	n	d
92JPJ048t	509146	7359192	15	A15794-018	tn	10	ms	ac	c/d	sa-b/g-b	y/y	9x6	tr	psslc	y	wt	y	d
92JPJ049t	512135	7361919	15	A15794-018	ct	5	ms	ac	c/d	dk-b/b	y/y	7x7	ro	slc	y	wt	y	d-c
92JPJ050t	515751	7361480	5	A14824-012	hm	1	lc	ac	c/d	b/g	n/n	7x5	og	sslc	y	mm	n	c
92JPJ051e	519940	7367290	35	A14824-012	dcx	0					n	100	fc	s(m)			n	
92JPJ052t[4]	529910	7374173	40	A14824-069	ct	1	ms	ac	c/d	dk-b/g	n/n	6x6	ro	sslc	y	wt	n	d
92JPJ053e	536438	7370313	25	A14824-132	esk	1	lc				y	40	fc	s(c)			y	
92JPJ054t	537952	7367169	5	A14824-132	ct	3	lc	in	d	g	n	9x6	tr	sslc	y	dp	n	d
92JPJ055e	541773	7367481	20	A14824-184	esk	2	lc				y	30	rc	s(c)			y	
92JPJ056t	544383	7311765	10	A15744-158	dr	2	ms	ac	d	sa-g	n	9x6	og	sslc	y	dp	n	d
92JPJ057t	544755	7299595	30	A15744-161	ct	1		ac	d	g-b	n	12x8	og	sslc	y	dp	n	d
92JPJ058t	529255	7313846	30	A14824-081	ct	1		ac	c/d	g-b/dk-b	y/y	9x6	og	ps(c)slc	y	wt	n	d
92JPJ059t	508857	7330757	30	A15794-014	ct	1	ms	ac	c/d	sa-b/g-b	n/n	21x12	og	ps(m)slc	y	mm	n	d
92JPJ060t	492647	7343519	20	A15325-064	tn	.5	ms	in	d	g-b	n	9x9	ro	ps(c)sl	wt	n	c-d	n
92JPJ061t	495148	7342672	35	A15325-064	ct	.5	ms	in	d	rs-b	y	7x9	tr	sslc	y	dp/sf	n	d
92JPJ062t	497636	7343971	40	A15325-064	dr	5	so	ac	c/d	g/rs-b	n/y	18x7	moon	slc	y	mm/sf	y	d
92JPJ063t	500189	7343830	25	A15325-064	dr	2	ms	in	c/d	rs-b/g	y/n	7x6	og	sslc	y	mm	y	d-c
92JPJ064t	513289	7340180	35	A14824-006	ct	.5	ms	in	d	g-b	n	7x7	ro	sslc	n	mm/sf	n	d
92JPJ065t	520549	7335138	30	A14824-006	ct	1	ms	ac	c/d	dk-b/g-b	n/n	24x150	og	ssl	y	dp	n	d
92JPJ066t	524020	7340909	25	A14824-076	ct	10	ms	ac	d	g-b	y	75x75	ro	ssl	y	wt	y	d
92JPJ067e	528662	7342047	10	A14824-076	esk	0					y	200	fc	s(f)			n	
92JPJ068e	524806	7350367	25	A14824-074	esk	5					y	150	rc	ps(c)			y	
92JPJ069t	527610	7348515	25	A14824-074	ct	25	ms	ac	d	l-b	n	18x9	og	slc	y	mm	y	d
92JPJ070e	534307	7349029	25	A14824-128	esk	1					n	70	rc	s(f)HML			n	
92JPN015t	494332	7356603	20	A15740-075	dr	40		in	d	b	n	15x5	og	slc	n	wt	n	d
92JPN017t	492406	7354873	25	A15740-075	dr	20		ac	d	lt-b	y	10x7	tr	ssl	y	wt	y	d
92JPN020t	491277	7354064	15	A15740-075	ct	40		in	d	b	n	20x12	og	sslc	y	wt	n	d
BASE CAMP	531682	7358666	0	A14824-130														

ABBREVIATIONS EXPLAINED

- AB- Air Bubbles
- AC- ACtivity
- ac- active
- b- brown
- BC- Boulder Cover (%)
- bold numbers- from satellite
- c- CP: carapace, TX: clay
- cg- coarse grained
- CO1- COlour of 1st component
- CO2- COlour of 2nd component
- CP1- ComPonent 1 of mudboil
- CP2- ComPonent 2 of mudboil
- cr- centre
- ct- crag-and-tail
- CV- CoVer
- d- diapir
- dcx- delta complex
- dk- dark
- dp- damp
- dr- drumlin
- ej- esker junction
- esk- esker
- (f)- fine-grained
- fc- flat crested
- fl- fluting
- fz- frozen
- g- grey
- gn- green
- hm- hummocky moraine
- hml- heavy mineral laminae
- in- inactive
- ka- kame
- l- olive
- lc- lichen
- LF- LANDFORM
- lt- light
- MC- MOISTURE CONTENT
- mg- medium grained
- mm- medium
- ms- moss
- nf- no fines
- o- orange
- ob- organic brown
- OC- ORGANIC CONTENT
- og- oblong
- OX- OXIDIZATION
- p- pebbly
- rb- raised beach
- rc- ridge crested
- rd- red
- rm- ribbed moraine
- ro- round
- rs- rusty
- rw- reworked in stream
- s- sand, sandy
- sl- silt
- so- soil
- SP- SHAPE
- st- side-terrace
- SZ- SIZE (c in dm; esk in m)
- t- suffix on sample- till
- tn- till-plain
- tp- top
- tr- triangle
- TX- TEXTURE
- WH- WHAT SAMPLED
- wt- wet
- Z- depth (cm);

[1] Texture is noted in order of decreasing size fraction present (psslc: pebble sand silt clay) with specific modifiers where necessary [(c) (m) (f)] = [coarse medium fine-grained].
[2] Sampled unoxidized clay-rich sand surrounding boulder, together with oxidized sandy carapace.
[3] Texture of sample is esker-like.
[4] Bulk sample for internal standards in analyses.

APPENDIX II(b). CHEMICAL ANALYSES OF TILL SAMPLES*. Lab. work by Activation Laboratories

SAMPLE	Ag	As	Au	Ba	Br	Ca	Ce	Co	Cr	Cs	Cu*	Eu	Fe*	Fe	Hf	Hg	Ir	La	Lu	Mn*	Mo	Na
92-JP-021T	<5	18.0	45	1100	30.0	<1	380	29	130	4	80	3.1	34070	4.82	6	<1	<5	160	0.70	606	<1	2.81
92-JP-024T	<5	21.0	<2	920	24.0	3	240	20	77	4	59	2.1	28650	4.30	3	<1	<5	110	0.50	486	11	2.90
92-JP-025T	<5	68.0	8	760	3.3	1	140	54	1100	8	147	1.9	54060	8.05	4	<1	<5	91	0.43	565	<1	1.83
92-JP-027T	<5	44.0	<3	970	22.0	<1	250	36	190	16	79	2.3	57510	8.34	4	<1	<5	110	0.57	804	11	2.51
92-JP-028T	<5	6.0	<2	620	31.0	<1	220	21	74	4	102	2.1	38620	5.75	3	<1	<5	96	0.39	458	6	2.41
92-JP-029T	<5	39.0	6	670	51.0	<1	250	30	160	5	127	2.5	54750	8.37	3	<1	<5	120	0.55	698	8	1.98
92-JP-030T	<5	4.6	7	710	26.0	<1	210	28	94	7	169	2.2	59310	9.85	3	<1	<5	97	0.47	627	12	1.91
92-JP-031T	<5	2.6	<2	990	<0.5	<1	280	15	55	3	26	2.3	25450	3.58	6	<1	<5	130	0.49	462	<1	3.00
92-JP-032T	<5	9.9	4	1100	<0.5	<1	350	15	54	3	40	2.9	22580	3.79	6	<1	<5	160	0.64	527	<1	3.14
92-JP-034T	<5	51.0	7	690	14.0	3	280	34	200	5	132	3.0	61780	10.50	4	<1	<5	140	0.74	417	11	1.84
92-JPF-001T	<5	90.0	<2	770	13.0	<1	250	29	150	7	121	2.3	54500	7.64	4	<1	<5	130	0.53	532	9	2.35
92-JPF-002T	<5	4.5	<2	710	30.0	2	260	23	81	3	88	3.0	43060	5.50	4	<1	<5	130	0.71	599	13	2.43
92-JPF-004T	<5	3.9	8	730	44.0	<1	300	22	100	4	98	2.9	33310	5.03	4	<1	<5	150	0.60	461	13	2.96
92-JPF-005T	<5	3.0	14	990	<0.5	4	390	13	39	4	68	3.7	21760	3.39	15	<1	<5	180	0.75	409	<1	5.26
92-JPF-006T	<5	0.7	<2	1000	9.6	<1	360	17	38	3	17	2.4	21270	3.12	6	<1	<5	120	0.47	570	7	3.02
92-JPF-007T	<5	<0.5	<2	1300	<0.5	<1	250	13	29	4	33	2.1	32910	4.22	6	<1	<5	120	0.66	598	<1	3.99
92-JPN-015T	<5	14.0	7	1100	11.0	2	260	21	130	4	49	2.6	26210	5.13	6	<1	<5	120	0.58	422	8	3.64
92-JPN-017T	<5	30.0	3	910	8.6	<1	210	28	250	5	94	2.4	39040	6.25	5	<1	<5	140	0.57	653	<1	3.11
92-JPN-020T	<5	18.0	<2	840	6.0	3	210	21	160	4	71	2.3	31410	4.76	5	<1	<5	95	0.55	435	5	3.03
92-JPJ-001T	<5	9.3	7	660	18.0	<1	260	51	620	5	135	1.9	35910	5.34	5	<1	<5	94	0.40	749	5	2.35
92-JPJ-006T	<5	<0.5	7	970	5.6	3	350	17	47	5	21	3.0	34200	5.81	6	<1	<5	190	0.81	677	<1	2.84
92-JPJ-007T	<5	1.3	<2	830	6.8	2	250	17	29	3	9	1.9	20230	3.63	4	<1	<5	93	0.46	420	<1	2.40
92-JPJ-008T	<5	2.9	<2	740	16.0	<1	440	25	53	8	49	3.0	42100	6.15	7	<1	<5	170	0.81	771	15	3.43
92-JPJ-009T	<5	<0.5	7	1100	15.0	<1	460	13	38	2	15	4.0	28780	4.75	8	<1	<5	230	1.41	659	<1	3.21
92-JPJ-010T	<5	3.4	3	1000	<0.7	<1	750	23	100	5	28	5.6	41440	9.26	10	<1	<5	400	1.26	809	<1	3.52
92-JPJ-011T	<5	0.7	9	1000	<0.5	<1	690	18	57	3	25	4.0	27400	6.35	15	<1	<5	290	0.97	522	14	3.52
92-JPJ-012T	<5	0.9	6	990	7.6	<1	880	25	71	4	41	4.9	32320	6.76	12	<1	<5	360	1.14	926	27	3.60
92-JPJ-013T	<5	36.0	9	990	2.7	<1	250	21	180	3	64	2.5	27330	4.67	5	<1	<5	110	0.59	401	8	2.86
92-JPJ-016T	<5	4.9	<2	970	8.2	<1	250	16	53	4	42	2.3	32080	5.07	4	<1	<5	110	0.53	570	8	2.70
92-JPJ-018T	<5	68.0	6	1200	11.0	<1	700	31	140	5	34	4.2	23190	5.36	9	<1	<5	180	0.67	412	13	3.60
92-JPJ-021T	<5	9.9	<2	1000	4.2	<1	300	18	150	3	36	2.9	20430	4.21	7	<1	<5	130	0.62	325	9	2.89
92-JPJ-027T	<5	21.0	3	960	9.8	<1	500	32	110	3	61	3.3	22710	5.27	7	<1	<5	140	0.53	548	<1	4.97
92-JPJ-028T	<5	3.2	<3	920	14.0	<1	460	16	61	5	45	4.3	40870	6.64	5	<1	<5	190	0.98	719	22	3.11
92-JPJ-030T	<5	19.0	6	770	20.0	<1	420	40	130	5	195	3.2	52280	7.54	4	<1	<5	150	0.57	757	10	2.20
92-JPJ-031T	<5	27.0	7	610	40.0	<1	230	38	270	3	71	2.2	41330	5.98	3	<1	<5	120	0.46	515	<1	3.37
92-JPJ-034T	<5	2.2	3	650	30.0	1	200	21	69	3	97	2.0	26000	4.17	3	<1	<5	92	0.39	439	<1	3.10
92-JPJ-035T	<5	3.4	<2	720	6.3	<1	160	45	330	4	236	2.0	45100	7.40	5	<1	<5	76	0.47	471	<1	2.42
92-JPJ-037T	<5	4.8	5	740	22.0	<1	330	21	70	4	76	2.5	35000	5.01	5	<1	<5	130	0.60	475	10	2.83
92-JPJ-038T	<5	3.7	<2	1000	7.2	<1	290	14	57	4	58	2.9	32850	5.14	6	<1	<5	140	0.65	298	12	3.12
92-JPJ-039T	<5	15.0	9	810	14.0	<1	230	20	110	4	92	2.4	46240	6.47	5	<1	<5	110	0.62	542	6	3.56
92-JPJ-042T	<5	27.0	<2	1100	5.2	2	190	30	420	5	69	2.1	39730	6.24	4	<1	<5	87	0.51	499	7	2.56
92-JPJ-043T	<5	36.0	9	1100	7.0	<1	240	29	280	6	75	2.7	43730	7.51	5	<1	<5	130	0.63	565	6	4.51
92-JPJ-045T	<5	36.0	6	1200	8.3	<1	260	26	150	7	106	2.6	53450	7.90	4	<1	<5	130	0.53	628	8	2.15
92-JPJ-046T	<5	8.2	16	1100	32.0	<1	400	22	100	5	76	3.8	44870	7.43	6	<1	<5	170	0.77	792	18	2.77
92-JPJ-047T	<5	4.5	<2	390	5.0	<1	210	15	49	3	65	2.0	48420	3.66	3	<1	<5	82	0.34	906	<1	1.78
92-JPJ-048T	<5	<0.5	<3	940	34.0	<1	540	24	55	6	98	4.6	36580	5.99	4	<1	<5	200	0.99	773	<1	3.04
92-JPJ-049T	<5	3.2	5	810	30.0	<1	360	24	63	5	93	3.9	31140	4.88	5	<1	<5	180	0.65	605	7	2.67
92-JPJ-050T	<5	5.3	3	960	12.0	<1	270	25	82	3	92	2.8	27010	5.21	7	<1	<5	130	0.62	391	9	3.06
92-JPJ-052T	<5	3.8	<2	840	6.1	<1	160	19	55	4	85	1.7	30910	4.76	4	<1	<5	86	0.37	507	7	3.09
92-JPJ-054T	<5	<0.5	<2	930	11.0	<1	230	29	72	10	89	2.1	47210	8.17	4	<1	<5	130	0.50	788	9	2.26
92-JPJ-056T	<5	1.2	7	1100	5.6	<1	570	18	83	3	22	4.1	32030	5.82	12	<1	<5	270	0.61	503	<1	3.82
92-JPJ-057T	<5	<0.5	3	1200	<0.5	<1	350	16	84	4	38	2.8	26900	4.76	7	<1	<5	210	0.46	436	10	3.12
92-JPJ-058T	<5	1.1	3	890	27.0	<1	830	18	67	6	66	4.4	42070	5.44	4	<1	<5	290	1.33	839	28	2.19
92-JPJ-059T	<5	<0.5	3	1200	8.2	3	320	15	57	4	31	2.2	25430	4.21	4	<1	<5	150	0.48	578	<1	3.03
92-JPJ-060T	<5	22.0	6	1000	7.1	2	450	25	83	4	53	2.5	26760	4.34	6	<1	<5	140	0.54	637	16	3.09
92-JPJ-061T	<5	33.0	4	990	10.0	3	330	27	240	4	76	3.1	45370	7.22	6	<1	<5	150	0.83	579	12	2.58
92-JPJ-062T	<5	8.1	6	1200	<0.5	<1	280	26	180	8	117	2.7	50870	6.88	4	<1	<5	200	0.46	757	9	2.46
92-JPJ-063T	<5	8.7	7	1100	8.5	2	320	16	74	5	126	3.0	40230	5.53	5	<1	<5	130	0.70	614	11	2.90
92-JPJ-064T	<5	2.0	<2	950	12.0	<1	430	15	41	4	31	2.9	26110	3.63	8	<1	<5	150	0.65	624	<1	3.88
92-JPJ-065T	<5	<0.5	<2	1100	9.3	2	390	12	22	3	19	2.8	20080	3.61	7	<1	<5	170	0.78	519	11	3.42
92-JPJ-066T	<5	2.0	<3	810	61.0	<1	330	15	66	8	22	2.4	42240	6.34	5	<1	<5	140	0.74	715	18	1.76
92-JPJ-069T	<5	2.8	14	730	60.0	<1	460	22	50	9	82	3.1	33840	5.17	3	<1	<5	170	0.77	645	<1	2.01
MEAN	3	14	5	922	15	1	345	24	133	5	71	2.9	35360	5.78	6	1	3	152	0.65	566	7.6	2.93
SD	0	19	6	182	14	0.9	158	8.8	160	2	46	0.82	12434	1.64	3	0	0	62.2	0.22	173	6.5	0.71
MAX	<5	90	45	1300	61	4	880	54	1100	16	236	5.6	61780	10.50	15	<1	<5	400	1.41	926	28	5.26
MIN	<5	<0.5	<2	390	<0.5	<1	140	12	22	2	9	1.7	20080	3.12	3	<1	<5	76	0.34	298	<1	1.76
#<DL	62	8	24	0	8	46	0	0	0	0	0	0	0	0	0	62	62	0	0	0	21	0

[1] All by Neutron Activation except * by AA; ** by ICP; all ppm except Ca,Fe,Na in % and Au in ppb.

APPENDIX II(b) cont'd.CHEMICAL ANALYSES OF TILL

SAMPLE	Nd	Ni*	Ni	Pb	Rb	Sb	Sc	Se	Sm	Sn	Sr	Ta	Tb	Th	U	V**	W	Yb	Zn*	Zn	MASS[2]
92-JP-021T	110	62	270	23	190	<0.1	12.0	<3	17	<100	550	2.5	2.2	73	11.0	66	<1	4.5	82	130	3.125
92-JP-024T	74	45	<25	2	150	<0.1	10.0	<3	12	<100	<500	<0.5	<0.5	63	13.0	51	<1	3.1	43	110	5.318
92-JP-025T	57	390	590	2	160	0.9	18.0	<3	10	<100	<500	0.9	<0.5	44	2.4	130	<1	2.3	104	97	5.727
92-JP-027T	71	110	<39	15	220	0.4	14.0	<3	13	<100	<500	3.1	<0.5	88	17.0	130	4	3.7	99	170	2.619
92-JP-028T	67	44	120	3	170	<0.1	8.8	<3	11	<100	<500	<0.5	<0.5	41	9.9	78	<1	2.2	93	98	5.491
92-JP-029T	87	98	<31	13	140	0.9	9.1	<3	14	<100	<500	1.5	<0.5	60	15.0	120	<1	3.7	111	130	3.451
92-JP-030T	64	58	<27	26	190	<0.1	10.0	<3	12	<100	<500	1.8	2.0	61	15.0	150	7	3.0	152	160	4.503
92-JP-031T	72	18	270	36	210	<0.1	9.9	<3	12	<100	<500	2.7	<0.5	60	10.0	48	<1	3.2	57	110	4.329
92-JP-032T	90	23	<26	24	220	<0.1	11.0	<3	16	<100	<500	3.2	1.9	65	11.0	45	<1	3.8	69	120	5.461
92-JP-034T	100	106	<34	30	170	1.2	11.0	<3	16	<100	<500	<0.5	<0.5	74	15.0	140	9	3.9	119	110	3.074
92-JPF-001T	82	114	230	19	220	3.6	12.0	<3	13	<100	<500	<0.5	<0.5	54	12.0	87	<1	3.2	127	130	4.788
92-JPF-002T	99	63	<26	12	170	0.2	10.0	<3	17	<100	<500	1.5	<0.5	62	15.0	86	10	3.8	88	91	5.124
92-JPF-004T	110	65	<39	12	140	0.3	9.6	<3	18	<100	650	<0.5	2.8	53	14.0	57	<1	3.2	120	100	2.376
92-JPF-005T	160	28	<36	22	180	0.6	11.0	<3	21	<100	<500	4.0	<0.5	93	22.0	39	15	5.0	42	119	0.591
92-JPF-006T	100	27	<21	29	190	<0.1	8.3	<3	13	<100	690	3.2	<0.5	84	13.0	39	<1	3.4	76	93	1.221
92-JPF-007T	72	24	<32	26	360	<0.1	15.0	<3	12	<100	<500	2.3	<0.5	61	11.0	49	<1	3.5	67	90	3.820
92-JPN-015T	75	76	180	15	210	<0.1	13.0	<3	13	<100	<500	3.4	<0.5	63	9.4	51	<1	3.3	80	110	3.426
92-JPN-017T	85	161	<32	17	210	0.5	14.0	<3	14	<100	<500	<0.5	<0.5	59	5.6	76	<1	3.3	121	90	4.037
92-JPN-020T	65	111	<25	18	190	0.4	13.0	<3	12	<100	<500	2.1	1.6	54	6.8	60	5	3.4	86	120	5.434
92-JPJ-001T	90	350	310	48	170	0.3	10.0	<3	12	<100	<500	1.8	<0.5	48	8.4	75	<1	2.6	111	148	1.224
92-JPJ-006T	110	36	<31	19	270	<0.1	14.0	<3	18	<100	<500	3.2	2.2	90	16.0	60	<1	4.6	116	89	4.153
92-JPJ-007T	66	19	<22	6	160	<0.1	7.8	<3	11	<100	<500	2.3	<0.5	67	12.0	37	<1	2.6	64	84	5.040
92-JPJ-008T	140	32	<25	29	260	0.5	14.0	<3	21	<100	<500	3.4	2.0	100	29.0	90	<1	4.6	125	133	1.235
92-JPJ-009T	150	11	<39	44	230	<0.1	12.0	<3	26	<100	800	4.3	<0.5	100	45.0	56	6	8.1	103	120	2.970
92-JPJ-010T	210	36	<55	51	330	<0.1	18.0	<3	35	<100	<500	<0.6	4.3	180	52.0	77	<2	7.6	156	200	2.158
92-JPJ-011T	220	26	<33	55	240	<0.1	14.0	<3	28	<100	540	4.9	<0.5	170	28.0	46	<1	6.7	71	133	0.810
92-JPJ-012T	300	27	<35	56	160	<0.1	15.0	<3	37	<100	<500	6.5	4.4	170	44.0	57	9	7.5	98	175	0.863
92-JPJ-013T	74	82	<28	20	190	0.4	13.0	<3	13	<100	<500	1.5	<0.5	51	7.4	49	<1	3.3	99	120	4.296
92-JPJ-016T	68	23	<27	20	190	0.2	11.0	<3	12	<100	<500	2.9	<0.5	63	12.0	53	<1	3.2	85	72	4.231
92-JPJ-018T	200	31	<49	18	230	0.7	15.0	<3	26	<100	<500	3.0	3.5	110	21.0	46	<2	5.3	66	273	0.329
92-JPJ-021T	120	33	<21	13	190	0.3	12.0	<3	17	<100	<500	3.5	2.0	79	15.0	40	<1	4.7	58	154	1.360
92-JPJ-027T	130	46	<50	14	270	0.4	9.7	<3	18	<100	<500	4.8	<0.5	100	17.0	43	<2	4.6	112	198	0.299
92-JPJ-028T	130	27	<35	24	280	<0.1	13.0	<3	24	<100	<500	4.8	<0.5	120	28.0	83	<1	5.9	117	130	3.378
92-JPJ-030T	110	103	210	26	170	0.7	11.0	<3	17	<100	<500	2.5	<0.5	69	14.0	100	8	3.4	176	140	4.512
92-JPJ-031T	75	180	270	2	99	0.5	8.7	<3	12	<100	<500	<0.5	<0.5	43	17.0	79	<1	2.6	54	150	2.325
92-JPJ-034T	62	58	<23	4	150	0.3	8.0	3	10	<100	<500	<0.5	<0.5	43	9.1	46	<1	2.2	80	87	5.613
92-JPJ-035T	53	263	300	20	170	0.4	14.0	<3	10	<100	<500	<0.5	<0.5	32	6.1	78	<1	2.6	520	78	4.283
92-JPJ-037T	85	42	<26	19	170	<0.1	9.9	<3	15	<100	<500	2.9	<0.5	65	14.0	65	<1	3.6	90	120	4.883
92-JPJ-038T	87	36	130	23	200	<0.1	11.0	<3	15	<100	<500	3.1	<0.5	88	17.0	74	<1	4.1	131	150	3.527
92-JPJ-039T	77	74	<37	20	170	0.7	10.0	<3	13	<100	<500	<0.5	<0.5	55	8.4	86	<1	3.3	88	120	2.561
92-JPJ-042T	58	195	210	18	180	0.4	14.0	<3	10	<100	<500	<0.5	<0.5	53	8.3	78	<1	2.9	98	130	3.950
92-JPJ-043T	87	153	280	21	220	0.4	16.0	<3	14	<100	<500	<0.5	1.9	58	7.0	75	<1	3.5	117	150	4.359
92-JPJ-045T	85	139	150	26	260	0.3	15.0	<3	14	<100	<500	2.0	1.9	72	15.0	96	<1	3.4	148	140	4.295
92-JPJ-046T	120	42	<44	28	210	0.4	13.0	<3	21	<100	<500	4.0	2.3	98	23.0	90	<1	5.0	121	140	2.357
92-JPJ-047T	81	58	<20	35	93	0.3	6.4	<3	11	<100	<500	2.4	1.5	47	9.4	98	<1	2.4	137	100	1.454
92-JPJ-048T	150	38	<34	40	200	<0.1	13.0	<3	26	<100	700	3.5	<0.5	130	28.0	72	<1	5.6	208	180	4.041
92-JPJ-049T	120	54	<30	21	190	<0.1	10.0	<3	20	<100	<500	3.0	<0.5	67	14.0	56	<1	3.9	126	110	4.328
92-JPJ-050T	95	51	150	24	200	<0.1	13.0	<3	15	<100	<500	3.1	<0.5	51	11.0	51	7	3.6	87	<50	3.346
92-JPJ-052T	58	34	<32	38	200	<0.1	10.0	<3	9	<100	<500	2.1	<0.5	33	4.8	58	<1	1.8	137	120	3.118
92-JPJ-054T	81	58	<29	24	310	<0.1	15.0	<3	12	<100	<500	2.1	<0.5	72	14.0	110	<1	3.1	181	170	4.814
92-JPJ-056T	210	30	<35	46	220	0.3	13.0	<3	27	<100	<500	5.0	<0.5	160	36.0	55	<2	5.1	47	141	0.688
92-JPJ-057T	100	47	<33	28	290	0.2	12.0	<3	16	<100	<500	<0.5	<0.5	84	10.0	46	<1	2.7	121	160	3.799
92-JPJ-058T	250	33	<37	56	250	<0.1	17.0	<3	33	<100	<500	5.9	4.5	220	45.0	90	<2	9.1	163	212	1.217
92-JPJ-059T	97	28	<27	26	320	<0.1	12.0	<3	13	<100	<500	2.8	<0.5	83	11.0	46	<1	2.9	117	110	4.818
92-JPJ-060T	130	55	210	34	190	0.4	11.0	<3	16	<100	520	1.8	1.9	100	17.0	50	<1	3.8	76	139	1.066
92-JPJ-061T	99	99	150	39	200	0.6	14.0	<3	17	<100	<500	4.2	<0.5	91	14.0	97	<1	4.9	89	160	3.393
92-JPJ-062T	120	84	<28	22	270	0.3	17.0	<3	16	<100	<500	2.0	<0.5	60	9.4	85	<1	2.5	198	210	5.793
92-JPJ-063T	99	45	<27	26	240	0.2	12.0	<3	17	<100	580	<0.5	<0.5	77	13.0	72	12	3.9	98	99	4.799
92-JPJ-064T	140	19	<28	28	210	<0.1	9.3	<3	19	<100	<500	0.9	2.3	110	24.0	46	<1	4.5	46	92	0.821
92-JPJ-065T	110	16	<29	44	260	<0.1	11.0	<3	18	<100	<500	2.5	<0.5	98	20.0	33	<1	4.6	83	68	4.433
92-JPJ-066T	90	33	<30	49	260	0.6	14.0	<3	15	<100	<500	2.8	<0.5	110	27.0	84	<1	5.0	146	110	3.867
92-JPJ-069T	120	39	140	28	200	0.3	9.3	<3	20	<100	<500	2.4	2.1	81	27.0	64	<1	4.9	99	140	3.439
MEAN	108	70	82	25	209	0.3	12	2	17	65	364	2.3	0.99	81	17	69	2	4.0	108	128	3.357
SD	49	73	111	14	52	0.5	2.6	0.1	6.1	0	107	1.5	1.1	37	10	29	3	1.5	66	40	1.569
MAX	300	390	590	56	360	3.6	18	3	37	<100	800	6.5	4.5	220	52	150	15	9.1	520	273	5.793
MIN	53	11	<20	2	93	<0.1	6.4	<3	8.9	<100	<500	<0.5	<0.5	32	2.4	33	<1	1.8	42	<50	0.299
#<DL	0	0	44	0	0	27	0	61	0	62	54	15	43	0	0	0	11	0	0	1	0

[2]Mass (g) of sample analysed by neutron activation.

APPENDIX III(a) Microprobe Analyses on Heavy Minerals Selected from Esker Samples.

SAMPLE	NA2O	SIO2	K2O	FEO	AL2O3	CAO	MNO	MGO	TIO2	CR2O3	TOTAL
1	.000	35.393	.000	36.883	20.556	5.358	.798	.557	.035	.029	99.610
2	.015	26.866	.001	14.030	54.145	.008	.210	1.292	.519	.060	97.147
3	.039	26.387	.002	13.000	54.910	.021	.340	1.307	.485	.064	96.556
4	.000	.834	.022	.000	.004	1.633	.000	.000	.087	.000	2.579
5	.000	34.790	.000	16.436	19.672	5.458	20.352	1.182	.040	.047	97.978
6	.000	35.618	.000	15.138	19.825	6.502	20.638	1.196	.167	.028	99.111
7	.005	36.572	.000	32.726	20.912	3.999	2.616	2.938	.068	.088	99.924
8	.001	35.301	.001	35.614	20.556	6.520	.236	.874	.042	.013	99.159
9	.016	29.230	.023	1.579	2.245	27.809	.169	.030	34.874	.000	95.975
10	.643	53.159	.001	8.780	.847	23.739	.328	12.993	.055	.133	100.678
11	1.194	53.185	.000	8.567	.676	22.771	.338	13.376	.043	.110	100.260
12	.007	35.265	.000	10.531	18.661	7.037	26.864	.438	.395	.034	99.231
13A	.000	.000	.008	.341	.068	.025	.023	.008	97.922	.197	98.593
13B	.000	102.388	.004	.010	.021	.008	.021	.007	.382	.013	102.854
14	.000	36.422	.000	13.076	13.064	33.882	1.548	.076	.152	.019	98.239
15	.000	36.060	.000	23.136	20.458	7.940	11.653	.701	.040	.037	100.026
16	.000	.000	.006	46.508	.036	.008	1.775	.163	50.455	.180	99.131
17	.000	.000	.000	45.361	.015	.011	2.256	.391	51.498	.080	99.613
18	.005	.000	.001	49.306	.034	.000	1.095	.239	48.174	.037	98.890
19	.015	26.875	.001	13.076	53.867	.014	.183	1.827	.477	.092	96.428
20A	.000	35.545	.005	37.514	20.432	4.622	.297	.826	.055	.035	99.330
20B	.000	40.114	.016	38.633	7.704	2.030	.186	5.646	.027	.028	94.383
21	.000	36.548	.002	33.101	21.197	1.985	.693	5.838	.033	.026	99.426
22	.000	35.821	.005	35.493	20.832	4.782	.531	1.910	.032	.022	99.428
23	.000	.066	.004	90.245	.225	.007	.000	.010	.018	.031	90.606
24A	.000	.077	.000	89.868	.238	.000	.000	.005	.115	.029	90.333
24B	.000	96.583	.000	3.531	.023	.013	.013	.007	.010	.012	100.190
25A	.000	35.906	.005	.085	63.670	.014	.001	.022	.020	.058	99.782
25B	.000	98.172	.034	.042	.185	.013	.000	.000	.013	.019	98.478
26A	.000	100.392	.010	.009	.028	.007	.003	.008	.012	.019	100.488
26B	.000	35.596	.001	.042	63.336	.013	.004	.018	.022	.039	99.071
27	.000	.066	.000	89.874	.151	.020	.212	.002	.085	.060	90.469
28	.000	35.904	.007	.073	63.708	.020	.006	.025	.017	.032	99.793
29	.063	25.585	.004	14.617	53.295	.010	.302	1.174	.379	.022	95.450
30	.000	34.492	.000	41.273	20.254	1.409	.372	.691	.035	.032	98.559
31A	1.409	39.079	.235	19.777	14.053	10.689	.278	7.943	.515	.028	94.004
31B	.000	.000	.008	48.821	.032	.036	.815	.045	49.445	.048	99.250
32	.018	26.393	.000	14.174	53.850	.015	.278	1.580	.656	.058	97.023
33	.000	.000	.002	48.460	.055	.018	.746	.393	49.603	.039	99.318
34	.000	.000	.000	48.140	.042	.010	.792	.375	49.803	.044	99.205
35	.003	36.214	.000	14.569	20.231	2.759	25.353	.997	.098	.032	100.258
36	.009	29.213	.004	2.093	2.009	28.223	.169	.050	34.342	.000	96.112
37	.020	29.549	.012	2.299	2.955	28.482	.158	.058	33.158	.004	96.695
38A	.000	29.003	.000	1.966	1.944	27.575	.227	.048	34.569	.000	95.333
38B	.000	100.797	.008	.013	.023	.183	.005	.025	.254	.019	101.327

APPENDIX III(b). Mineralogical Identification of Esker Heavy Mineral Grains Selected for Microprobing.

Grain n°	Stereoscopic mic. i.d.	Microprobe interpretation	Comments
1	Or. gar	Ca Almandite	Not kimberlitic.
2	Staurolite	staurolite	Easily recognized in epoxy mount. low order birefring. Easily confirmed
3	Staurolite	staurolite	in airmounts (binoc. or petro. mic.) and should be.
4	Staurolite	Likely staurolite	was grain probed ?(total =2.7%). Furniture varnish?
5	Or. garnet	Or. garnet	Not enough Mg to be considered kimberlitic.
6	Or. garnet	Or. garnet	Not enough Mg to be considered kimberlitic.
7	Or. garnet	Or. garnet	Not enough Mg to be considered kimberlitic.
8	Or. garnet	Or. garnet	Not enough Mg to be considered kimberlitic.
9	Sphene	Sphene	Chemistry is good match. Less easily distinguished from garnet.
10	Diopside	augite	Chemistry is good match. Cr too low for kimberlite indicator.
11	Diopside	augite	Chemistry is good match. Cr too low for kimberlite indicator.
12	Or garnet	garnet	Spessartite
3A	Rutile	rutile	Chemistry is good match.
3B	Quartz	quartz	102% qtz. (inclusion in rutile).
14	Or garnet	garnet	Ca seems very high for garnet (33%)
15	Or garnet	garnet	Spessartite
16	Ilm or chrom	Mn ilmenite	Not associated with kimberlite.
17	Ilm or chrom	Mn ilmenite	Not associated with kimberlite.
18	Ilm or chrom	Mn ilmenite	Not associated with kimberlite.
19	Staurolite	Staurolite	
20A	Or. garnet	Or. garnet	Not enough Mg to be considered kimberlitic.
20B	inclusion	Or. garnet	
21	Or. garnet	Or. garnet	Not enough Mg to be considered kimberlitic.
22	Or. garnet	Or. garnet	Not enough Mg to be considered kimberlitic.
23	Ilmenite	Magnetite?	Contamination?
24A	Ilmenite	Magnetite?	Contamination?
24B	inclusion	Quartz	
25A	Amphibole	sillimanite	colourless elongated almost fibrous.
25B	inclusion	quartz	
26A	inclusion	quartz	
26B	Amphibole	sillimanite	colourless elongated almost fibrous.
27	Ilmenite	Magnetite?	Contamination?
28	Amphibole	sillimanite	colourless elongated almost fibrous.
29	?	?	SiO2=25.6%; FeO=14.6; Al2O3=53.3; Mg=1.2 Fe2O3=? total=95%
30	Or garnet	Or garnet	Not enough Mg to be considered kimberlitic.
31A	Hornblende	hornblende	
31B	grey inclus.	ilmenite	with .815% Mn.
32	Staurolite	Staurolite	
33	Ilmenite	Ilmenite	0.74% Mn
34	Ilmenite	Ilmenite	0.79% Mn
35	Or garnet	spessertite	
36	Sphene	sphene	
37	Sphene	sphene	
38A	Sphene	sphene	
38B	Quartz	quartz	