1

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1.6

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**Drift Prospecting and Till Geochemistry in Tintina Trench,
Southeastern Yukon.**

by

Alain Plouffe

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of
Master of Sciences.

Department of Earth Sciences, Carleton University
and
Ottawa Carleton Geoscience Centre

Ottawa, Ontario

September 18, 1989

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and Research acceptance of the thesis

DRIFT PROSPECTING AND TILL GEOCHEMISTRY IN TINTINA TRENCH,
SOUTHEASTERN YUKON.

submitted by Alain Plouffe, B.Sc.Hn.
in partial fulfilment of the requirements for
the degree of Master of Science

Thesis Co-supervisor

Thesis Co-supervisor

Chairman, Department of Earth Sciences

Carleton University

September 18, 1989

Abstract

Two tills and related deposits are the products of at least two ice advances over the Tintina Trench in the vicinity of Ross River, Yukon Territory.

The oldest sediments exposed in the area are nonglacial fluvial gravels bearing far-travelled South Fork Volcanic clasts at the Lapie River. Pre-McConnell Till overlies these gravels. Based upon till fabrics and till lithologies, it was deposited by an ice lobe which flowed west to northwest over the area. The retreat of Pre-McConnell ice was marked by the formation of a glacial lake in the Pelly River Valley and an open drainage system in adjacent areas.

At the onset of the next ice advance, the McConnell Glaciation, transported calcareous clasts and till fabrics indicate that a valley glacier flowed out of the Lapie River Valley and into Tintina Trench. At the apex of the McConnell Glaciation, the Selwyn Lobe of the Cordilleran Ice Sheet flowed west to northwest. During downwasting of the Selwyn Lobe, an ice tongue advanced up the Lapie River Valley. This ice tongue blocked the drainage of Lapie River and formed a glacial lake in the same valley. Post McConnell events are essentially the same as post Pre-McConnell, i.e., glaciolacustrine sedimentation in the Pelly River Valley and deposition of horizontally bedded outwash gravels in adjacent areas.

The silt plus clay size fraction of 204 till samples was analyzed for Au and the clay fraction for a series of 30 elements. The geochemical data for till down-ice from the Grew Creek Au-Ag mineralization show definite anomalous patterns for gold but not for pathfinder elements such as Ag, As, Hg, and Sb. Base metal occurrences and lithologies with distinctive geochemical imprints are reflected in the clay fraction of till down ice from their source. Other anomalies suggest the presence of undiscovered mineralization.

Acknowledgments

I would like to express thanks to Dr. L.E. Jackson Jr. (Geological Survey of Canada, Vancouver), who proposed this M.Sc. project, for guiding me through a profitable introductory field excursion in the study area, for numerous field discussions, and for valuable criticisms on an early version of the manuscript; Dr. W.W. Shilts (Geological Survey of Canada, Ottawa), for offering me this project, for supervising this thesis, for several discussions of the material presented here, and for improving the manuscript; Dr. F. A. Michel (Carleton University) for supervising this thesis and for helpful comments on the manuscript; S.R. Morison (Department of Indian Affairs and Northern Development, Geology Section) for logistical support in the field, for valuable field discussions, and for giving me the opportunity to present posters and a talk at geological conferences in Whitehorse and Vancouver; S.P. Gordey (Geological Survey of Canada) for helping me in identifying South-Fork Volcanics clasts; and I. Poliquin for providing cheerful field assistance. Dr. W. Mercer and Y. Nelson (Noranda Exploration, Vancouver) believed in my work and therefore, Noranda Exploration accepted to finance the geochemical analyses and heavy mineral separations. Noranda Exploration and especially these two individuals are greatly acknowledged. Field work was financed by the Department of Indian Affairs and Northern Development and by a grant from the Northern Research Group of the Ottawa-Carleton Geoscience Centre. Direct contributions are acknowledged in the text as personal communications.

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Chapter 1. Introduction

The discovery of a Tertiary epithermal gold-silver prospect in Tintina Trench, Yukon Territory, has raised interest in the potential for analogous deposits buried by drift elsewhere along this structurally controlled depression (e.g. Duke, 1986; Duke and Godwin, 1986; Jackson et al., 1986). Jackson et al. (1986) cited circumstantial evidence linking the occurrence of placer gold, ice flow directions, and Tertiary volcanics along the Tintina Trench. Essentially, this became a proposal for this M.Sc. thesis. The relationship between Tertiary volcanics and placer gold proposed by Jackson et al. (1986) could hardly be tested by conventional exploration techniques (e.g. bedrock mapping, bedrock geochemistry, geophysics) because of the locally thick and fairly continuous glacial drift cover. For that reason, drift prospecting was selected as a proper method to test the relationship between placer gold and Tertiary volcanics.

A detailed knowledge of Quaternary history and stratigraphy is essential to the success of the drift prospecting technique (e.g. Dilabio, 1985; Evenson and Stephens, 1978; Hicock, 1986; Johansson and Veikko, 1987; Kaszycki et al., 1988; Lamothe, 1986; Lehmuspelto, 1987; Maceachern and Stea, 1987; Mattila and Peuraniemi, 1979; Nenonen, 1984; Ofen and Olsen, 1986; Peuraniemi, 1987; Peuraniemi and Heinänen, 1985; Plouffe, 1986; Salminen, 1980; Salminen and Hartikainen, 1985; Sauerbrei et al. 1987; Shilts, 1971; 1973; 1975, 1984; Shilts and Smith, 1988; Sopuck et al. 1986; Vanderveer et al., 1987) . Therefore, this thesis is divided into two broad parts : (1) Quaternary geology, and (2) till geochemistry .

Study area

The study area (Fig.1) is a narrow band extending from Wolverine and Finlayson Lakes to just southeast of the town of Faro. It includes part of the Quiet Lake, Finlayson Lake and Tay River NTS map sheets (105 F, 105 G, and 105 K, respectively). Two major roads cross the area ; the Campbell Highway, along which most of the till sampling has been done, and the Canol Road which goes through the town of Ross River.

The Tintina Trench parallels the area and is confined by the Pelly Mountains to the southwest and the Pelly and Macmillan Plateaus to the northeast. Difference in elevation between the Tintina Trench and the surrounding terrain is significant. Elevations in the trench range from 760 to 910 m with a few high areas reaching 1070 m. The Pelly Mountains range in elevation from 1220 to 1830 m, with the highest peak reaching 2353 m in the Wolverine Lake area. Plateau surfaces vary in elevation from 910 to 1370 m.

Most of the region is covered by boreal forest, except in alpine areas where tundra and unvegetated cover are predominant. Discontinuous permafrost is encountered throughout the area.

Previous work

Glaciation in Yukon was first recognized by Dawson (1889). Multiple glaciations were proposed later by Bostock (1934) in the Carmacks area. Bostock (1966) described two series of end moraines related to two different glaciations . (1) McConnell (Wisconsinan age) and (2) the older and more extensive Reid Glaciation (Illinoian or early Wisconsinan age, Hughes (1987). Scattered deposits of till and outwash gravel and erratics occur

Figure 1 Yukon map with major roads and study area (shaded).

beyond the limit of the Reid Glaciation. They were deposited by two older ice advances : the Klaza (younger) and Nansen (older) Glaciations (Bostock, 1966). The study area is entirely within the limits of the Reid and McConnell Glaciations.

On the basis of air photo interpretation and limited ground observations, Hughes et al. (1969) reported that the Cordilleran Ice Sheet flowed west to northwest over the study area during the McConnell Glaciation. Campbell (1967) gave the name "Selwyn Lobe" to this sector of the Cordilleran Ice Sheet. Hughes et al. (1969) suggested that : "a stage of alpine glaciation preceded the McConnell advance in mountainous areas lying within the limits of the ice sheet." Duke-Rodkin et al. (1986) reconstructed the profile of the Selwyn Lobe using the inferred McConnell age moraines and ice marginal channels associated with nunataks in the Glenlyon and Tay River map areas (105 L and 105 K). Their work showed that the flow of the Selwyn Lobe was more analogous to that of a valley glacier than the extant Antarctic or Greenland ice sheets.

L.E. Jackson, Jr., Geological Survey of Canada, mapped the regional Quaternary geology of the Pelly Mountains and Tintina Trench area (Jackson, 1986a; 1986b, 1987). Gordey and Irwin (1987), Roddick and Green (1961), and Tempelman-Kluit (1977) mapped the bedrock geology in the study area.

Objectives

The main objective of this project was to verify the possible relationship between Paleogene volcanics and placer gold. In order to accomplish this objective, the following tasks had to be carried out : (1) detailed study of the Quaternary geology of the area including stratigraphy, and (2) investigation of the glacial dispersal of rock fragments in order to

deduce ice flow configurations and to aid in understanding reconnaissance geochemical maps for Au, As, Ag, Hg, Sb, Cu, Pb, Zn, Ni, and Co produced in this study.

Methods

Field methods

The field work was done during the summer of 1987. A total of 204 bulk till samples were collected with the use of a pick and shovel from river bank sections, road cuts, old trenches, and hand dug pits. Access was gained with the use of a truck, an all terrain vehicle, a motorized canoe, a float plane, and a helicopter. In areas of easy access, like along the Campbell Highway, the distance between till samples averages 2 km. Outwash and ice-contact gravel samples were also collected to determine their gold content. Till and gravel samples weighed from 3 to 5 kg each.

Till fabrics were measured in appropriate sections in order to estimate the direction of ice flow during till deposition. Azimuths of fifty elongated stones >2 cm were measured at each site (long axis : intermediate axis ratio $> 1.6 : 1$). All stones with a plunge greater than 60 degrees were eliminated. The fabric data were plotted in polar equal-area projections which were computed with the "Stereo™" program. In addition, the bearing of observed bedrock striations was recorded at a few sites.

Stratigraphic sections were measured with a Jacobs staff where access was possible. For cliff-face sections total height was estimated with an altimeter.

Laboratory Methods

Till and gravel samples were wet sieved in order to separate two size fractions : clasts larger than 4 mm and grains in the 125 to 250 μm size range. Dry sieving was performed on till samples only, to separate the silt plus clay size fraction ($<63 \mu\text{m}$). The clay fraction ($<2 \mu\text{m}$) of till samples was separated by centrifuge using standard procedures of the sedimentary laboratory of the Geological Survey of Canada. Determination of the silt/clay ratio was done by pipette analysis as described by Folk (1968).

Heavy minerals were separated from the 125 to 250 μm size fraction of till and gravel with a shaking table and methylene iodide (s.g. 3.3). These separations were done in a private laboratory (Overburden Drilling Management Ltd., Nepean, Ont.).

Geochemical analyses on the clay and silt plus clay size fractions were done by Acme Analytical Laboratories Ltd. in Vancouver, B. C. The clay fraction was analyzed for 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, and W by ICP (inductively coupled plasma) after a hot ($\text{HCl-HNO}_3\text{-H}_2\text{O}$) acid leach using 0.5 g samples. Hg was analyzed by flameless atomic absorption. The silt plus clay size fraction was analyzed for gold by atomic absorption using 10 g samples with a detection limit of 1 ppb. Heavy minerals were analyzed for Na, Sc, Cr, Fe, Co, Ni, Zn, As, Se, Br, Rb, Zr, Mo, Ag, Cd, Sn, Sb, Te, Cs, Ba, La, Ce, Sm, Eu, Tb, Yb, Lu, Hf, Ta, W, Ir, Au, Th, and U by neutron activation at Bondar-Clegg & Company Ltd., Ottawa, Ont.

Chapter 2. Bedrock Geology

The thesis area is located in the northern sector of the Omineca Belt as defined by Tempelman-Kluit (1979). The autochthonous rocks of the area consist of a sequence of unmetamorphosed sedimentary and volcanic rocks deposited along the western margin of the North American shelf (Fig. 2a and 2b). They vary in age from Late Precambrian to Triassic. In the collision of an island arc terrane with the continent, allochthonous rocks were superposed on the autochthonous assemblage. These allochthons are subdivided into two assemblages : the Nisutlin and Anvil allochthons (Tempelman-Kluit, 1979; 1977) (Fig. 2a and 2b). Intrusions of post-tectonic granite in mid-Cretaceous time were related to heating and thickening of the continental crust during the collision (Gordey, 1988). The only known extrusive equivalent to these granitic rocks in the Cordillera are the South Fork Volcanics on the Sheldon Lake and Tay River map sheets (Gordey, 1988) just northeast of the thesis area.

Between Late Cretaceous and mid-Eocene time, 450 km of dextral slip occurred along the Tintina Fault Zone (Fig. 2a and 2b) (Tempelman-Kluit, 1979). Recent work by Jackson et al. (1986) and Pride (in press) indicates the presence of a Paleogene bimodal volcanic province which consists of an assemblage of rhyolite and basalt. This province is thought to be related to crustal extension and transcurrent slip along the Tintina Fault (Jackson et al., 1986).

Several bedrock mineral occurrences and targets, and placer gold deposits have been found in the study area from exploration work conducted by private companies and prospectors (Fig. 3). All reported mineral occurrences and targets depicted on Figure 3 were gathered from a series of reports published by the Department of Indian and Northern Affairs in

Figure 3. Mineral occurrences and placer gold deposits and prospects (accurate to 1987) of the study area.

Whitehorse (D.I.A.N.D., 1981; 1982; 1983; 1985; 1986; 1987; 1988). Information about placer gold deposit occurrences was obtained from Debicki (1983; 1986).

Three mines are located in the study area and its close proximity : (1) a coal mine to the west-southwest of the town of Ross River, (2) the Faro massive sulfide Pb-Zn mine located just to the northwest of the study area within the Tintina Trench and, (3) the Ketza Mine, a sulfide-oxide gold ore, situated in the Pelly Mountains at the source of the Ketza River. Furthermore, the Grew Creek epithermal gold-silver prospect, well known to all Yukon prospectors, is located halfway between the towns of Faro and Ross River within the study area. Rocks preserved in a graben at Grew Creek consist of felsic volcanic and volcanoclastic units overlain by interbedded coarse clastic sediments, basaltic flows, and basaltic volcanoclastic beds (Duke 1986; Duke and Godwin, 1986) . K-Ar dates on unaltered basalt and pollen spores in volcanoclastic rocks indicate a mid-Eocene age (Duke and Godwin, 1986). Two zones of mineralization have been defined on the property : the Main and Tarn Zones. Intensive silicic and argillic hydrothermal alteration characterize Grew Creek mineralized rocks. High grade gold and silver mineralization occurs in chalcedonic quartz and K-feldspar veins in silicified material; these veins were intruded during volcanism (Duke and Godwin, 1986). Even though both gold and silver are enriched in samples from boreholes, mineralized outcrops are characterized by high gold levels only (T. Christie, oral presentation, Geoscience Forum, Whitehorse, Yukon, 1988).

Chapter 3. Quaternary Geology

All stratigraphic sections, from which the Quaternary history has been deduced, are exposed in the vicinity of the town of Ross River (Fig. 4). The best exposures are in river bank sections and major road cuts. All of these sections have been examined previously by L.E. Jackson, Jr. and some have been reported in Jackson (1989). As part of this study, more detailed work has been done on several exposures, including till fabrics and pebble counts. Table 1 illustrates a simplified view of the stratigraphy exposed in the area.

Postglacial sediment
Outwash gravel
Glaciolacustrine sediment
McConnell Till
Outwash gravel
Glaciolacustrine sediment *
Pre-McConnell Till
Fluvial gravel

Table 1. Generalized stratigraphic column for Quaternary sediments of the Ross River area. Sediment marked with an asterisk are confined to the Pelly River valley.

Glacial dispersal

In order to estimate direction of glacial transport, as an aid in understanding geochemical dispersal, certain bedrock units can be used as "lithological indicators" (Shilts, 1975). Lithological indicators or "bedrock tracers" are lithologies which can be identified from

Figure 4. Location map of Ross River area showing major stratigraphic sections.

clast-sized fragments in the till and can be related to a specific bedrock source. In order to define bedrock tracers for this area the 8 to 16 mm fraction of all till samples was divided into eight categories: clastic sedimentary, metasedimentary, calcareous, granitic, volcanic, ultramafic, basaltic, and others (includes quartz pebbles). Each of these rock types is associated with a broad provenance region (Shilts, 1981) as given in Table 2.

LITHOLOGY	PROVENANCE REGION
Clastic sediments	autochthonous rocks Nisutlin Allochthonous Assemblage Tertiary sediments
Metasediments	Nisutlin Allochthon Cambrian autochthonous rocks
Calcaerous sediments	Paleozoic autochthonous rocks, Anvil Allochthonous Assemblage
Granitic rocks	Cretaceous granitic intrusions
Tertiary volcanic	(see Fig. 3) along Tintina fault zone
South Fork Volcanic	(see Fig. 3) mid-Cretaceous calderas NE of the study area
Ultramafic clasts	Anvil Allochthonous Assemblage
Basaltic clasts	Anvil Allochthonous Assemblage Tertiary volcanics

Table 2. Provenance regions of pebble lithologies given in order of importance. For precise location of each lithologies refer to Fig. 2a and 2b.

The use of lithological indicators is hampered by (1) the fact that most geological units in the Ross River area strike northwest-southeast, i.e., parallel to ice flow direction as defined

by Hughes et al. (1969), (2) pronounced lithologic variations perpendicular to ice flow direction are rare, (3) geological maps are only available at the 1: 250 000 scale for the area, with the result that distinctive lithologies in till may not correlate with small bedrock sources not distinguished on the map, and (4) sampling was confined to areas of easy access, i.e., along the Campbell Hwy which parallels, more or less, the bedrock structure and ice flow direction.

Three main bedrock units have been used as bedrock tracers as an aid in reconstructing the Quaternary history of the study area. These include (1) calcareous autochthonous sediments which outcrop southwest of the Tintina Fault in the Lapie River Valley area (units COcs1 and OSs1 on Fig. 2a and 2b), (2) Tertiary rhyolitic volcanics which occur just northeast of the calcareous sediments but again along the main fault zone (unit Tur on Fig. 2a and 2b), and (3) the South Fork Volcanics mapped by Gordey and Irwin (1987) to the northeast of the study area (unit Ksf on Fig. 2a and 2b). These lithologies were found in sediments of McConnell and Pre-McConnell age.

Granite and ultramafic rocks were also used as lithological indicators in McConnell Till, the surface till of the area. The lack of granitic clasts in McConnell Till samples southeast and northeast of a granite body, at the southern end of the Tay River map sheet (105-K), suggests a glacial transport toward the northwest (Fig. 5). However, more sampling at the northwestern contact of the granitic intrusion is needed to confirm this hypothesis. Ultramafic clasts were found sporadically in some samples only to the west and northwest of known ultramafic outcrops. These two lithological indicators, are in agreement with a glacial transport toward the west to northwest during the McConnell Glaciation in the Tintina Trench as originally proposed by Hughes et al. (1969).

Figure 5. Dispersal of granite in till in the northwestern sector of the study area. Values in parentheses represent percent of granitic clasts (no value = 0%). Black dots represent sample sites. Granitic bedrock in stippled area, from Gordey and Irwin (1986).

Basaltic clasts were encountered infrequently in McConnell Till even in areas close to basalt outcrops, probably because this weathered lithology was easily and rapidly comminuted to smaller size particles down ice from its source.

Glacial striae are useful indicators of ice flow patterns and in some instances parallel the direction of glacial dispersal. Unfortunately, the poorly indurated and highly jointed nature of the bedrock in some parts of the region and the scarcity of bedrock outcrops restrain the measurement of striations. A few striated outcrops visited along the Campbell Highway bear marks of an ice flow with azimuths in the 270-305° range.

Pleistocene sediments

Two tills and related deposits of Pre-McConnell and McConnell age are exposed in the area.

Pre-McConnell Till

Exposures of Pre-McConnell Till are limited to the deep and wide Pelly River and Lapie River Valleys (see sections 044 and 076 below). The till is grey, massive, well compacted, silty, and pebbly to cobbly with few boulders. A few sand lenses were observed at the base of this till. Most fabric measured in Pre-McConnell Till strike east-west to northwest-southeast. At Lapie River, clast a-axes show a strong parallel orientation (Plate 1) in this till unit. At this same section, the base of Pre-McConnell Till is exposed and it shows a sharp erosional contact with the underlying fluvial gravel. The age of the Pre-McConnell Till is unknown. Therefore, its correlation with the Reid Glaciation is uncertain.

Plate 1. View of Pre-McConnell Till at section 044.
Notice pebble and cobble orientations. Knife
is about 18 cm long.

Plate 2. Outwash gravel exposure in a burrow pit along
the Robert Campbell Highway at about 2.5 km
east of the highway-Ketza River intersection.

Pelly River - 076

Figure 8. Stratigraphic column of section 076 with equal area stereographic plots of long axes of stones (50 measurements in each case). See text for description.

McConnell Till

McConnell Till is exposed in several sections throughout the area. It has characteristics similar to the Pre-McConnell Till; uniformly grey (brown when oxidized), compact, and pebbly to cobbly with rare boulders. The texture of Pre-McConnell and McConnell Tills seems to be slightly different. The silt/clay ratio was determined for a series of samples from both till units at two different sections (Table 3). In both localities, McConnell Till has a higher silt/clay ratio. This difference in texture is discussed below. The base of McConnell Till is exposed at several sections, and it shows a sharp erosional contact with the underlying outwash gravel. McConnell Till is massive in most sections. However, at a few sites intratill lenses of coarse sand and gravel have been observed.

SILT / CLAY RATIO

	Pre-McConnell Till	McConnell Till
	2.30	4.96
	2.81	4.01
	2.84	-----
average :	<u>2.65</u>	<u>4.48</u>

Table 3. Comparison of silt / clay ratio in McConnell and Pre-McConnell Tills.

Clasts in the McConnell Till often have a preferred orientation parallel to inferred ice movement direction and less commonly transverse to it (Fig. 6, 7, 8, and 9). Clast a-axes orientations both parallel and transverse to ice flow direction in lodgement till have been reported previously (Boulton; 1970; 1971; Åmark, 1986). For example, at section 080 two fabrics have been measured, and both show a strong preferred orientation perpendicular to inferred ice flow direction (Fig. 6). About 500 m east from this section,

along the same valley, two fabrics measured at site 081 (Fig. 7) reveal a bimodal distribution of clast orientations parallel and transverse to ice flow. Till lithologies are the same at both sections (mostly CPav and a minor amount of CTn; overlap Fig. 2 and 4) and are in agreement with glacial transport toward the west to northwest as reported by Hughes et al. (1969). Transverse fabrics in till may result from compressional ice flow which caused folding and reorientation of clasts (Åmark, 1986; Boulton, 1971). It was not possible to observe folds in the massive till.

Figure 6. Stratigraphic column of section 080 with equal-area stereographic plots of long axes of stones (50 measurements in each case)

Figure 7. Stratigraphic column of section 081 with equal-area stereographic plots of long axes of stones (50 measurements in each case).

A radiocarbon date on *Bison priscus* fragments found in a gravel bed underneath McConnell Till yielded a date of $26\,350 \pm 280$ BP which represents a maximum age for the

McConnell Till (Jackson, 1989). Preliminary radiocarbon dating on some fibrous peat stratigraphically above the McConnell Till yielded an age of 9610 ± 100 BP in the Selwyn Mountains at Howard's Pass (Jonasson et al., 1983). Also, to the northwest of the study area, in a section along the Pelly River, Ward (1989) reported an accelerator ^{14}C date of $12\,590 \pm 120$ BP (TO-931) on *Pisidium* sp. from the base of a silty marl formed in the bottom of a depression above McConnell sediments. These two last dates give a minimum age for the McConnell Glaciation.

Discussion- The higher silt content of the McConnell Till compared to Pre-McConnell Till in the Pelly River and the Lapie River areas, can be explained by different basal thermal conditions for both glaciers and/or different debris types for Pre-McConnell and McConnell glaciers. Indeed, as presented in section descriptions below, McConnell ice was flowing over outwash deposits and could have entrained large amounts of silt and sand from the outwash gravel. On the other hand, Pre-McConnell ice was probably advancing primarily over fine grained metasedimentary rocks or clayey unconsolidated sediments which may have produced a more clay-rich till.

The uniform color and texture, the massive structure, pebble fabrics oriented parallel and perpendicular to inferred glacier flow, and sharp erosional contacts at the base of Pre-McConnell and McConnell Tills suggest a lodgement origin for these two units (Åmark, 1986; Hansel et al. 1987). On the other hand, sorted intratill sand lenses found in some exposures of Pre-McConnell and McConnell Tills might be attributable to a melt-out origin for the till (Shaw, 1985).

Fluvioglacial deposits

Fluvioglacial deposits are common in the area as planar and terraced outwash or as kame. Two types of fluvioglacial sediments have been recognized : ice-contact deposits and outwash. Ice contact gravels are deposited on or against glacial ice. They show rapid changes in grain size and degree of sorting, and abundant internal deformation. Outwash is deposited by proglacial meltwater streams and is generally devoid of glaciotectionic deformation.

The best example of ice-contact gravel deposits is exposed at section 038. At this particular locality, they overlie McConnell Till. Individual beds vary from coarse and poorly sorted gravel to well sorted laminated sand. Contacts are abrupt and faulting is abundant. Also, exposures of outwash are common throughout the area. In some instances they represent thick accumulations of sediment which can reach 20 m (Plate 2). Again, texture and sorting of individual beds are extremely variable, but contacts are more gradational. No major faults have been observed. As recognized in sections, the formation of outwash fans at the ice front took place during both the Pre-McConnell and McConnell Glaciations.

Glaciolacustrine deposits

Silty and clayey deposits of glaciolacustrine origin have only been observed in the Pelly River and the Lapie River Valleys. These deposits are generally devoid of sand, but dropstones were observed sporadically. They are referred to as rhythmites with 3-10 cm thick couplets.

Holocene deposits

Much of the terrain throughout the area is poorly drained and is covered by an organic layer, generally less than 0.3 m thick. Land underlain by gravel generally lacks any significant organic cover. Permafrost is well developed where the organic cover is thick.

Alluvial fans are ubiquitous in steep terrain, especially at the front of the Pelly Mountains along the Tintina Fault (Jackson, 1987; 1986a). Slumped sediments abound on every hillside and are easily recognized in some instances by sheared organic layers.

In areas not affected by slumping, the White River Tephra (Downes, 1985) is generally exposed. It has been dated at 1.25 Ka and had a source in the Wrangell Mountains, Alaska (Downes, 1985). It was recognized in several sections throughout the area.

Stratigraphic sections

A study of four stratigraphic sections reveals key information for the Quaternary history. Therefore, the description of these sections is presented below.

Section 076

This section is exposed along the Pelly River, 3 km due east of the town of Ross River (Fig. 4). Access is possible by helicopter or by motorized canoe. It has been reported by Jackson (1989) and is equivalent to his section 14686 S-1.

The lowest unit exposed at this section is the Pre-McConnell Till (Fig. 8). It is overlain by glaciolacustrine sediments and horizontally stratified gravels. The gravel sequence coarsens

Figure 8. Stratigraphic column of section 076 with equal area stereographic plots of long axes of stones (50 measurements in each case. See text for description.

upward, suggesting that it was deposited in front of the advancing McConnell glacier. The overlying unit is the McConnell Till which is essentially overlain by the same sequence of sediments as below it: glaciolacustrine sediments and stratified gravels. These glaciolacustrine sediments are confined to the Pelly River Valley and are omnipresent in sections along the river downstream from the town of Ross River. The stratified gravel above these glaciolacustrine sediments is tentatively identified as outwash gravel deposited in front of the retreating McConnell Glacier on the basis of stratigraphic correlation with better exposures of outwash gravel along the Pelly River. At the top of the section, the White River Tephra is exposed in a well sorted fine sand and silt unit thought to be eolian in origin.

Erratics in Pre-McConnell and McConnell Tills at this section include a large amount of metasediments and clastic sediments, mostly from the Nisutlin Allochthon, with rare ultramafic, quartz, and calcareous clasts likely derived from the Anvil Allochthon (Fig. 2 and 4). Since clast lithologies in the two tills are similar, ice flow directions were probably parallel to sub-parallel during Pre-McConnell and McConnell glaciations in the Pelly River valley; i.e., toward the west to northwest.

Fabrics have been measured in both tills at this section (Fig. 8). The a-axes of clasts are mostly oriented northwest-southeast in the Pre-McConnell Till. Pebbles in the McConnell Till at this site do not have an obvious preferred orientation. This divergent orientation probably results from reworking of the drift by gravity flow after its deposition. The sharp erosional contact at the base of this till probably precludes the possibility that it could be a flow till.

Section 044

Section 044 is exposed along the Lapie River, about 8 km southwest of the town of Ross River (Fig. 4). A bush road connects the top of the section with the Campbell Highway. It was first reported by Jackson (1989), and is equivalent to his section 7686 S-2.

As illustrated in Figures 8 and 9, the stratigraphy at this section is very similar to that exposed in section 076 along the Pelly River. The oldest unit exposed is a poorly sorted, clast-supported, bouldery gravel, which is thought to be alluvial in origin. The interpretation of this unit is complicated by its relatively small exposure. A sharp erosional contact separates this gravel from the overlying Pre-McConnell Till. The contact between the till and the overlying outwash gravel sequence is abrupt. The outwash deposit is characterized by numerous beds of gravel, sand, and diamicton. These beds of diamicton are thought to be gravity flow deposits because they are draped over the underlying units (L.E. Jackson, Jr, pers. comm. 1987). Two cycles were defined in the outwash gravel without any major break between the two: a fining upward sequence going from the base of the unit to the middle of it and a coarsening upward sequence in the upper part. This suggests that these gravels were deposited during retreat of the Pre-McConnell glacier and advance of the McConnell ice or simply during fluctuations of the retreating Pre-McConnell ice front. They are overlain by one to two meters of McConnell Till. Finally, the section is capped by another two meters of outwash gravel and sand. White River Tephra is exposed at the top of the section in colluvium.

Clastic sedimentary and metasedimentary rocks, originating mostly from the Nisutlin Allochthon (unit CTn Fig. 2), are in the same ratio and by far the most abundant lithologies for both tills at this section. Till lithologies suggest that ice flow directions during the McConnell and Pre-McConnell Glaciations were toward the west to northwest

Figure 9. Stratigraphic column of section 044 with equal-area stereographic plots of long axes of stones (50 measurements in each case).

Four till fabrics were measured at this section (Fig. 9). Pebble orientations are mostly parallel and transverse to ice flow direction. Clasts may have been transported with the a-

axes parallel to the ice-movement direction and have been reoriented after deposition due to deformation by the active glacier (Boulton, 1970; Åmark, 1986).

Section 038

This section is exposed along the South Canal Road at the front of the Pelly Mountains (Fig. 4).

At section 038, the McConnell Till reaches a thickness of 18 meters and is overlain by 25 meters of ice-contact gravels (Fig. 10). Abrupt contacts and rapid grain size variation between individual beds, and abundant faulting characterize the ice-contact gravels at this section.

Lithological indicators were identified in the till at three levels in section 038 (Fig. 10). Tracers used at this section include metasedimentary (unit CTn Fig. 2) and calcareous sedimentary rocks (unit COcs1 and OSs1 Fig. 2). The lowest portion of the till is enriched in calcareous sedimentary clasts and depleted in metasedimentary rocks compared to the upper portion. This is best explained by a change in ice flow and ice provenance. The lower portion of the till was deposited by glacier ice which flowed out of the Lapie River Valley, whereas the middle and upper portions of the till unit were enriched in metasediments entrained in glacier flow west to northwest along the Tintina Trench. This explanation is complemented by till fabrics.

Three fabrics were measured where pebble counts were made. All show a-axes preferred orientation parallel to inferred ice flow directions (Fig. 11). The two lowest fabrics indicate

Figure 10. Composite stratigraphic column of section 038 with pie diagrams representing percentages of each lithology at three levels in till. Refer to Table 2 for sources of each rock type.

Laple River - 038

Figure 11. Equal-area stereographic plots of long axes of stones at section 038 (50 measurements in each case). Fabric locations are the same as pebble counts, see Figure 10.

an ice flow parallel to the Lapie River Valley whereas the upper fabric parallels the prominent regional ice flow of the area.

Section 032

Section 032 is located along the South Canol Road in the Pelly Mountains (Fig. 4). The stratigraphy exposed at this section is depicted in Figure 12. About 4 m of McConnell age till is exposed at the bottom of this section. A single till fabric analysis reveals that elongated clasts have a preferred orientation parallel to the Lapie River Valley. A few cobbles of South-Fork Volcanics (unit Ksf Fig. 2) were recovered from the till. The till is overlain by stratified sand and gravels. A paleocurrent towards the west southwest was measured on planar-cross stratified laminations in a well sorted sand bed. Pebbles of Tertiary rhyolite (unit Tur Fig. 2) were found in these gravels. One of them was thin sectioned to determine its source. The overlying unit consists of glaciolacustrine silt and clay reworked by gravity flow; primary laminations are rare and discontinuous.

The stratified gravels are interpreted as subaqueous outwash fan deposits based upon their stratigraphic position beneath glaciolacustrine sediments and their topographic location below the lowest possible outlet for the glacial lake. The water level elevation of this glacial lake was controlled by the water divide located higher up in the Pelly Mountains at about 1080 m; gravels at this section are at about 945 m.

Lapie River Valley - 032

Figure 12 Stratigraphic column of section 032 with equal area stereographic plot of long axes of stones (50 measurements)

Quaternary History

Before Pre-McConnell Glaciation

The only clue about conditions prior to the Pre-McConnell glacial event comes from the lowest gravels exposed at section 044 which indicate a period of fluvial aggradation. Cobbles derived from the South-Fork Volcanics (unit Ksf Fig. 2), were found in that gravel unit and a few of them were dug out of Pre-McConnell Till. Thin sections made from two of them were examined by S. Gordey, Geological Survey of Canada, who confirmed their source. The presence of South Fork Volcanic clasts in these gravels below the oldest till, indicates that they were transported into the Tintina Trench prior to the Pre-McConnell Glaciation. These clasts could have been transported into the Tintina Trench by the Ross River during the Pleistocene when it could have flowed over presently buried South Fork Volcanics outcrop. Tempelman-Kluit (1980) suggested that the Ross River might have flowed through the channel course of the Lapie River during Miocene-Pliocene times before the rise of the Pelly Mountains. South Fork Volcanic clasts could also have been transported into the Tintina Trench at that time. Finally, the possibility remains that some of these clasts could have been transported into the Tintina Trench during an older glaciation. South Fork Volcanic clasts were reworked during subsequent glaciations which explains why some of them were found in the Pre-McConnell Till at section 044 and in the McConnell Till in several road cuts northwest of the Canol Road along the Robert Campbell Highway.

Pre-McConnell Glaciation

Information gathered from the only two exposures of Pre-McConnell Till in the area unequivocally indicate that ice flowed towards the west to northwest during the Pre-

McConnell Glaciation. Occurrences of Pre-McConnell Till are probably erosional remnants and most of the drift was stripped off during the following glacial event.

Late Pre-McConnell events

During deglaciation a glacial lake formed in the Pelly River Valley and lasted for a long enough period of time to accumulate the thick sequence of laminated silt and clay now exposed at section 076 (Fig. 8). During that time, areas adjacent to the Pelly River Valley were characterized by glaciofluvial aggradation (Jackson, 1989). An open drainage system later developed in the Pelly River Valley (Jackson, 1989).

McConnell Glaciation

At the onset of the McConnell Glaciation, a valley glacier flowed out of the Lapie River Valley into the Tintina Trench as indicated by pebble counts and till fabrics at section 038 (Fig. 10, 11, 13a, and 13b). During this event calcareous clasts from the Lapie River Valley were transported into the trench. This was followed by the advance of the Selwyn Lobe (Hughes et al., 1969) which flowed west to northwest over the area (Fig. 13c). At the maximum of the McConnell Glaciation, the ice sheet covered most of the area except for the highest mountain summits which stood above the ice sheet surface as nunataks; glacier flow was concentrated as ice streams in major valleys (Duk-Rodkin et al., 1986). During the retreat of the Selwyn Lobe, high areas were the first to be freed of ice because of a rapid rise in the equilibrium line (Jackson, 1989). At the end of the McConnell Glaciation an ice tongue advanced up the Lapie River Valley (Fig. 13d). This is documented by South Fork Volcanics found in the McConnell Till and Tertiary rhyolites

Figure 13. (a) Map of the confluence of the contemporary Lapie River Valley with the Tintina Trench.

Figure 13. (b) Same area as at the onset of McConnell Glaciation with a valley glacier flowing out of Lapie River Valley.

Figure 13. (c) Selwyn Lobe flowing northwest over the Tintina Trench and ice thickening in the Lapie River Valley.

Figure 13. (d) Advance of an ice tongue into the Lapie River Valley and formation of a glacial lake. Although no work has been done in adjacent valleys because of the poor accessibility, it is proposed that minor advances could have taken place like the one denoted by a question mark.

in McConnell gravel which were transported at least 9 km up valley from the mountain front. That tongue of ice blocked the Lapie River drainage and a glacial lake was dammed at about 1040 m, as estimated from the highest occurrence of glaciolacustrine sediments (Jackson, 1989). The lowest outlet through the water divide to the south (at 1080 m) suggests that this proglacial lake may have reached a level higher than 1040 m. When the ice tongue retreated from the Lapie River Valley, the lake drained via melt-water channels along the front of the Pelly Mountains.

Late McConnell events

Late glacial events were essentially the same for Pre-McConnell and McConnell Glaciations. A glacial lake formed in the Pelly River Valley under conditions similar to the retreat of the Pre-McConnell glacier (Jackson, 1989)(see above Late Pre-McConnell events). Adjacent areas were characterized by deposition of outwash gravels (Jackson, 1989).

Holocene events

Holocene time was marked by a readjustment of slopes and streams from a glacial to a non-glacial regime (Jackson, 1989). At the foothills of the Pelly Mountains, numerous paraglacial fans were built from unstable glacial drift left by ice on the hillsides (Jackson, 1989). Streams, such as the Pelly River, changed from a braided configuration to a meandering one (Jackson, 1989) because of the decrease in available sedimentary material. Such changes in the channel planform has been documented elsewhere by Jackson et al. (1982).

(Fig. 2a, and 17). To better verify this hypothesis, more till sampling in closer proximity to these volcanic bodies would be needed, since the transport distance of anomalous gold concentrations in till was found to be fairly short, in the order of 250 to 500 m.

Follow-up on any of these anomalies should be undertaken with special care and as a first step an attempt should be made to reproduce the results presented here.

Gold pathfinders - Ag, As, Hg, and Sb in the clay size fraction

Metal partitioning in different size fractions of till was studied by Shilts (1984; 1975) and Salminen (1980), among others. Shilts (1984) indicated that in oxidized till, labile ore minerals, such as sulfides, are destroyed by weathering and metals released are scavenged by colloidal particles such as clay minerals, oxides and hydroxides. Clay minerals may also have metals in their crystal structures. Therefore, for most metals the highest concentrations are found in the clay size fraction ($<2\mu\text{m}$) of oxidized till. In geochemical practice, these authors highly recommend the use of the clay fraction, since "metal levels in standard -177 μm (80 mesh) or -74 μm (-200 mesh) analyses are strongly related to the amount of $<4\mu\text{m}$ material in those fractions, the coarser sand and silt-sized fractions acting essentially as diluents" (Shilts, 1984; p.101 and 104). Consequently, geochemical analyses for base metals and gold pathfinders were performed on the clay size fraction.

Correlation of pathfinders with gold

Four common gold pathfinders were analyzed to determine their possible use in drift prospecting in the study area. They are Ag, As, Hg, and Sb. Correlation coefficients calculated for these elements and for gold in the silt plus clay size fraction are depicted in Table 4. Correlation graphs for each pathfinder element and gold are presented in Figure

collected over various bedrock lithologies and areas of different topography. In addition, sampling was primarily confined to areas of easy access, i.e., along roads. For these reasons the use of a threshold for every element would not be applicable.

In this study, there is a relatively large distance between till samples. Therefore, if there is a dispersal train from an unknown mineralized source it is more likely that a single till sample will come from the large "tail" of that train than from the "head". It is important to note at this point that by definition the geochemical contrast between anomalous and background levels in the tail of a dispersal train is smaller than in the head (Shilts, 1984). Consequently, determination of a general threshold solely based on statistical parameters would not be appropriate because it could eliminate several subtle anomalies associated with mineralization. In order to show the spatial distribution of high values for every element measured in this study, without the use of a threshold, the 90th and 75th percentiles were calculated. They are presented on geochemical maps in this chapter, for Au in the silt plus clay size fraction, and Ag, As, Hg, Sb, Cu, Pb, Zn, Ni, and Co in the clay size fraction.

Au in the silt plus clay size fraction

It was assumed in this study, as it was in many others (e.g., Kaszycki et al. 1988; Olsen and Olsen, 1986; Sopuck et al., 1986) that gold is mostly present in the silt size fraction of till. Dilabio (1985; 1982b) demonstrated that gold in oxidized till (which is the case for most samples in the present study) is abundant in silt and finer sizes reflecting one or more of the following : "the original grain size of native gold; the grain size of gold released from weathering sulfides; and the grain size of gold adsorbing phases." In the case of unoxidized till, like samples collected in sections, "gold is most abundant in grain size fractions that reflect the grain size of the glacially liberated and comminuted native gold and oxide or

sulfide host minerals" (Dilabio, 1985). At Grew Creek, the only well known Au mineralization in the area, gold occurs in bedrock as native particles with an average diameter of 7.5 μm (J.L. Duke, pers. comm., 1988). Consequently, it is likely that in unoxidized till gold abounds in the silt and finer size fractions.

For these reasons gold analyses were run on the silt plus clay size fraction. Using coarser fractions for analysis would dilute the gold content and reduce any anomaly contrast.

Silt / clay ratio vs gold content

Textural analyses were performed on a series of samples to verify any possible relationships between the Au and silt contents. In other words, to determine if gold was preferentially concentrated in the silt size fraction compared to the clay size fraction.

As illustrated in Figure 14, the correlation between the variables is very low. It is concluded that (1) size distribution of the $<63 \mu\text{m}$ fraction does not affect gold values in this case and, (2) Au must be present in the clay fraction, probably bound as complexes to oxides, hydroxides, and/or clay minerals (see Boyle, 1979; Boyle et al. 1975).

At this point there is a lack of data to indicate if gold in the silt plus clay size fraction is detrital and/or chemically remobilized. Detailed work on gold particles recovered from this fraction (e.g., fineness) could clarify their mode of transportation : detrital or chemical.

Figure 14. Correlation graph of Au content and silt /clay ratio of the silt plus clay size fraction of till (C.C. = correlation coefficient).

Precision of analytical method

A total of 47 till samples were analyzed twice in order to estimate the precision of the analytical method. These samples were chosen at random throughout the entire set of 204 samples.

Results obtained after the first and second analyses are depicted in Figure 15 (using a graphic technique modified from Shilts, 1975). Vertical shading is above background (>7ppb or 90 th percentile) after the first analysis; horizontal shading is above background after the second analysis. Anomalous samples after both analyses are in the cross-hatched field. Finally, background samples are represented by dots in the clear field. Also shown in Figure 15 is a slope of 1, which is used here as a fast way to verify the precision of the analytical method. Since several samples plot well off the line, one can say that the

Figure 15. Graph showing results of duplicate analyses (using a graphic technique modified from Shilts (1975)).

precision is low. Samples falling in the cross-hatched field are most likely related to true anomalies. However, samples in the vertical and horizontal fields are not necessarily false anomalies because the analytical method has a poor precision.

The poor precision of the analytical methods for the silt plus clay size fraction is attributable to (1) heterogeneity of the samples; their handling can concentrate heavier gold particles prior to analysis and produce a nugget effect (R.Dilabio, pers. comm., 1988) and (2) most measurements, even anomalous ones, are close to the detection limit of 1 ppb (Thompson and Howarth, 1976).

Consequently, in order to evaluate whether a high value is worth following up or not, its spatial location with respect to other anomalies, geological setting, and reproducibility should all be considered.

Transport distance of anomalous concentrations of gold in till

In the Grew Creek area, where at least two mineralized zones are known, detailed till sampling was conducted to determine the distance of transport of anomalous concentrations of gold from the source of mineralization (Fig. 16).

The glacial transport of debris that form till is controlled by several factors (Shilts, 1975):

- 1- the surficial extent of mineralization over which ice is flowing,
- 2- the geochemical contrast between mineralization and country rock,
- 3- the easiness of erosion of mineralization,
- 4- the glacier flow and thermal regime (cold vs warm based ice),
- 5- the ice thickness, and
- 6- topography.

Assuming that the dispersal train depicted in Figure 16 is derived from a unique source, i.e., the Main Zone (see chapter 2), a single sample collected at 250 m from the mineralization would have been recognized as anomalous (above the 90 th percentile or 7 ppb) compared to other samples within the entire area. Furthermore, if the 75 th percentile is declared anomalous (5 ppb), mineralization could be recognized as far as 500 m. From these data, it is concluded that mineralization similar to Grew Creek might remain undetected with the sample interval of 2 km employed along the Campbell Highway. Any serious Au prospecting for epithermal deposits similar to Grew Creek along the Tintina Fault requires a till sample interval ≤ 500 m measured parallel to ice flow direction. More work should be done to define the width of the gold dispersal train at Grew Creek. This would help in defining a good sample interval measured perpendicular to ice flow direction.

Figure 17. Gold abundance in silt plus clay size fraction of till.

Geochemical map

A geochemical map for gold in the silt plus clay size fraction is depicted in Figure 17. To better understand the following discussion, Figure 17 should be used in conjunction with Figure 3.

High gold values are concentrated in the northwestern part of the study area between Ketza River and Grew Creek. The Grew Creek gold-silver deposit (Duke, 1986; Duke and Godwin, 1986) is well reflected in this size fraction of till as indicated by a series of anomalies directly over and to the northwest of the Tarn and Main Zones (Fig. 16). Anomalies were also detected in proximity to gold occurrences, shown on Figure 3, reported by Kindle (1946; p. 24) along the Lapie River. Abundant high values occur over and in proximity to acid and intermediate volcanic Tertiary bedrock mapped by Tempelman-Kluit (1977) along the Tintina Fault. They represent a good prospecting target for buried hydrothermal systems similar to the Grew Creek mineralization.

Placer gold deposits throughout the area are illustrated on the mineral occurrences map (Fig. 3). It is more likely that placer gold has a local source since nearly all of the McConnell ice originated locally within the study area (Jackson et al., 1986). High gold values encountered in till along the Pelly and Ross rivers could be related to the bedrock(?) source of river bar placer gold deposits which occur along both streams. To the southeast of Finlayson Lake, where several placer claims have been staked, the source of placer gold and of high Au levels in till could also be linked.

Jackson et al. (1986) suggested a link between Paleogene volcanism and placer gold in the area. Values above the 75 th percentile over and to the northwest of some of these volcanic bodies (Ketza River, Starr Creek, and northeast of Ross River) support this hypothesis

(Fig. 2a, and 17). To better verify this hypothesis, more till sampling in closer proximity to these volcanic bodies would be needed, since the transport distance of anomalous gold concentrations in till was found to be fairly short, in the order of 250 to 500 m.

Follow-up on any of these anomalies should be undertaken with special care and as a first step an attempt should be made to reproduce the results presented here.

Gold pathfinders - Ag, As, Hg, and Sb in the clay size fraction

Metal partitioning in different size fractions of till was studied by Shilts (1984; 1975) and Salminen (1980), among others. Shilts (1984) indicated that in oxidized till, labile ore minerals, such as sulfides, are destroyed by weathering and metals released are scavenged by colloidal particles such as clay minerals, oxides and hydroxides. Clay minerals may also have metals in their crystal structures. Therefore, for most metals the highest concentrations are found in the clay size fraction ($<2\mu\text{m}$) of oxidized till. In geochemical practice, these authors highly recommend the use of the clay fraction, since "metal levels in standard -177 μm (-80 mesh) or -74 μm (-200 mesh) analyses are strongly related to the amount of $<4\mu\text{m}$ material in those fractions, the coarser sand and silt-sized fractions acting essentially as diluents" (Shilts, 1984; p.101 and 104). Consequently, geochemical analyses for base metals and gold pathfinders were performed on the clay size fraction.

Correlation of pathfinders with gold

Four common gold pathfinders were analyzed to determine their possible use in drift prospecting in the study area. They are Ag, As, Hg, and Sb. Correlation coefficients calculated for these elements and for gold in the silt plus clay size fraction are depicted in Table 4. Correlation graphs for each pathfinder element and gold are presented in Figure

Correlation coefficients

	Au				
Au	1	Ag			
Ag	-.04	1	As		
As	-.071	.283	1	Sb	
Sb	-.105	.2	.357	1	Hg
Hg	.14	.445	.295	.232	1

Table 4. Correlation coefficients of gold with arsenic, antimony, mercury, and silver.

18. Correlation of gold with each of these elements is very low; hence the use of gold pathfinders in till exploration is not recommended in this study area. This poor correlation reflects the bedrock geochemistry of Grew Creek, where at shallow depths (outcrop level) gold mineralization is not associated with high As, Ag, Hg, or Sb concentrations (T. Christie, oral presentation, Geoscience Forum, Whitehorse, Yukon, 1988).

Geochemical maps

During the McConnell Glaciation, most of the ice originated locally in the study area (Jackson et al., 1986). Therefore, the homogeneous distribution of high metal levels depicted on the four geochemical maps, are probably associated with local bedrock sources.

None of the geochemical maps, illustrated in Figures 19, 20, 21, and 22, reflect the known gold mineralization of Grew Creek, or high Au values observed in the Lapie River area in the silt plus clay size fraction of till (Fig. 17). Although, high mercury levels (>90th percentiles) were measured to the northwest of Grew Creek along the Paleogene volcanic contact (Fig. 21), they are not believed to be associated with the known gold mineralization

Figure 18. (a) Correlation graphs of Au-Ag and Au-As. See text for explanation. Points overlapping control with roses, where number of arms equals the number of overlapping points.

Figure 18. (b) Correlation graphs of Au-Sb and Au-Hg. See text for explanation. Points overlapping control with roses, where number of arms equals the number of overlapping points.

Figure 19. Silver abundance in the clay size fraction of till.

Figure 20. Arsenic abundance in the clay size fraction of till.

Figure 21. Mercury abundance in the clay size fraction of till.

Figure 22. Antimony abundance in the clay size fraction of till.

of Grew Creek because as presented above, surficial expression of Au enrichment in the bedrock at this locality is not associated with high Hg concentrations. The source of these high mercury concentrations is still unclear. Anomalous levels of As, Ag, and Sb in proximity to Paleogene volcanic rocks east of Ross River, cannot be correlated with any known mineralization. The possibility remains that these high values are associated with another type of mineralization. To draw any further conclusions, more work has to be done in the study area on the type of mineralization in which these metals can occur.

Use of heavy minerals for gold exploration

The use of heavy mineral concentrates in drift prospecting for gold has been reported on several occasions (e.g., Often and Olsen, 1986; Sauerbrei et al., 1987; Sopuck et al., 1986; Stewart and Van Hees, 1983). In these studies, heavy minerals were found to be useful in defining gold mineralization.

Heavy minerals could be used in a reconnaissance drift prospecting program in the Tintina Trench but with certain site specific limitations (Shilts, 1978). Two examples of site specific limitations are the following : (1) most of the gold at Grew Creek is attached to quartz with a minor amount bound in pyrite (Duke and Godwin, 1986; Duke, 1986); gold in quartz is not recovered in the heavy mineral concentrate , and (2) surficial samples, as collected in reconnaissance surveys, are oxidized (except for certain areas where samples are collected in sections). Thus, gold in sulfides can be released and reprecipitated or fixed in finer size fractions. In both cases gold would go undetected in heavy mineral concentrates.

Heavy mineral separations, (s.g. ≥ 3.3) on the 125 to 250 μm size fraction, were done only for samples of the northeastern region to test the reliability of this fraction for gold

exploration in the Tintina Trench. No visible gold grains were detected in heavy mineral concentrates under binocular microscopic examination. However, as shown in Figure 23, the Grew Creek deposit is reflected in Au contents of heavy mineral concentrates of McConnell Till in a few samples down-ice from the known mineralization. Likewise, heavy minerals are enriched in gold in patterns similar to those observed in the silt plus clay size fraction along the Campbell Highway close to the Lapie River (Fig. 17). Dispersed anomalous gold values (above 90 th percentile), not associated with known mineralization, occur throughout the area (Fig. 3 and 23).

Most of the bedrock in the study area is not particularly enriched in heavy minerals. Consequently, till derived from it has the same characteristics. That explains why several till samples yielded only small amounts of heavy minerals. In some instances, like for certain samples down-ice from the Grew Creek mineralization, not enough heavy minerals were recovered for geochemical assays. In order to obtain a representative amount of heavy minerals for geochemical analysis (> 5 g), much larger till samples would have to be taken. This can represent a practical problem in a reconnaissance survey where numerous samples have to be collected over wide areas, and have to be carried long distances by the sampler.

Correlation coefficients were calculated for Au, Ag, and As in heavy minerals. Values obtained reveal poor correlations among these elements, with the exception of gold and arsenic and gold and antimony which gave correlation coefficients of 0.47 and 0.44 respectively. These values suggest that some gold might be bound in Sb-As sulfides such as tetrahedrite and tennantite. Therefore, the As and Sb content of heavy mineral concentrates might be used as a gold pathfinder, again with site specific limitations (Shilts, 1978).

Figure 23. Gold abundance in heavy minerals of till in the northwestern part of the study area.

Heavy mineral fractions of twelve glaciofluvial gravel samples were tested for gold. Except for one sample which yielded a value of 2810 ppb at section 044, all others had a moderately low gold content (Table 5). This suggests that glaciofluvial deposits are not particularly enriched in gold and consequently, were not a major source of gold for till after being reworked by the glacier.

sample	Au (ppb)	sample	Au (ppb)
014-2	74	076-2	352
043-1	21	078-2	23
044-3	2810	079-1	268
051-1	110	082-3	140
052-2	730	085-2	20
054-1	14	222-4	150

Table 5. Gold abundance of heavy concentrates of fluvioglacial sediments.

Based on these observations, it can be concluded that heavy minerals could be used for gold exploration in the Tintina Trench at a reconnaissance level, if sample size does not represent a practical problem. In follow-up surveys, where samples are recovered from below the zone of oxidation (from sections or overburden drill cores), heavy minerals may be particularly efficient in detecting mineralization, as was the case in the Casa Berardi area of Québec (Sauerbrei et al., 1987).

Base metal exploration

For reasons explained in a previous section on gold pathfinder elements, the clay size fractions of all till samples were analyzed for base metals (see Appendix for results). Only the Cu, Pb, Zn, Ni, and Co results will be discussed below.

Correlation among base metals

Correlation among elements was calculated using Statview 512™ on a Macintosh™ computer. Results are presented in Table 6.

Correlation coefficients

	Cu						
Cu	1	Pb					
Pb	7.921E-3	1	Zn				
Zn	.411	.145	1	Ni			
Ni	.637	-.067	.139	1	Co		
Co	.589	.068	.058	.79	1	Fe	
Fe	.705	.174	.212	.571	.693	1	Mn
Mn	.309	.343	.016	.422	.658	.619	1

Table 6. Correlation coefficients among copper, lead, zinc, nickel, cobalt, iron and manganese.

Strong correlations are arbitrarily selected in this study as those with a correlation coefficient higher than 0.4. Strong correlation between elements in till can be the result of at least two factors:

1- It can reflect bedrock provenance or primary associations of elements in a zone of mineralization. This is illustrated by the strong correlation between Cu and Zn or Cu and Ni.

2- Other strong correlations may be dependent on weathering processes. As explained by Shilts (1984), metals released during postglacial weathering are scavenged by oxides and hydroxides. High correlation of certain minor elements with Fe and Mn has been observed in soils in other studies (Rose et al., 1979, pp.203-206). Therefore, high correlations

observed between Fe and/or Mn with other metals, in this study, may suggest high adsorption of base metals on iron and manganese oxides and hydroxides.

Geochemical maps

A series of geochemical maps have been produced for Cu, Pb, Zn, Ni, and Co in the clay size fraction of till (Fig. 24, 25, 26, 27, and 28). As discussed earlier, the 75th and 90th percentiles are represented on these maps.

Cu and Ni - The very strong correlation between both elements in till (Table 6) is reflected on the geochemical maps. This strong correlation is illustrated at several sites, where concentrations of Ni and Cu are high. (Fig. 24 and 25). Three main anomalous zones are coincident on each map : (1) at the mouth of the Ross River, (2) along the Campbell Highway in the Finlayson Lake area , and (3) east of the town of Ross River. None of these high values can be linked to any documented Cu or Ni occurrences. However, the anomalies are located down-ice from basalt of the Anvil Allochthons (Fig. 2a, 2b, 24, and 25). This observation strongly suggests that Ni-Cu enriched till at these three localities was eroded from the basaltic rocks. The higher average level of Ni and Cu in basaltic rocks compared to crustal concentrations, has been discussed by Taylor (1964)

Other dispersed high values of nickel and copper measured in till, which cannot be linked to mineralization, could represent good prospecting targets (e.g. Lapie River Valley-Cu and Wolverine Lake -Ni)(Fig. 24 and 25).

A single sample enriched in copper at the southeastern tip of Wolverine Lake, in the Pelly Mountains, could be linked to a sub-economic Cu-Pb-Zn showing in that area (also known as the Fetish property) (Fig. 3 and 24). Other copper mineral occurrences are not reflected

Figure 24. Copper abundance in the clay size fraction of till.

Figure 25. Nickel abundance in the clay size fraction of till

on the geochemical map simply because till samples are located too far from known sources.

Co- Till eroded from ultramafic rocks was found to be enriched in Co in previous work by Shilts (1973; 1980). Because there is a large distance between till samples, no clear Co dispersal train, emanating from ultramafic bodies of allochthonous assemblages (Fig. 2a and 2b unit CPaub), was defined. However, samples located down-ice from these rocks have high cobalt contents. The high Co levels in till down-ice from ultramafic rocks is illustrated with samples along the Ketzia River, east of the town of Ross River, and in the Wolverine Lake area (Fig. 2a, 2b, and 26).

The very strong correlation between nickel and cobalt in the till (correlation coefficient 0.79) is likely related to the strong correlation of these elements in ultramafic rocks. This suggests that this rock type is a major source of Ni and Co in the till.

Pb and Zn - Several samples in the Lapie River valley, anomalous with respect to Zn, could belong to the reported zinc occurrence further downstream or to other nearby sources which may remain unmapped (Fig. 3 and 27). If there is no unknown mineralization upstream from these anomalous samples, debris enriched in zinc could have been transported at the end of McConnell Glaciation when a tongue of ice flowed up-gradient into the valley (Fig. 13d). The very high zinc and lead content (1084 and 45 ppm respectively : sample 151 in Appendix) of an isolated sample 10 km downstream from the source of the Hoole River could be linked with the mineral target for zinc, lead, and copper in that vicinity (Fig. 3, 27, and 28). Lead anomalies in the vicinity of Wolverine Lake could be associated with the Fetish property or with other undiscovered showing(s) (Fig. 3 and 28). Pb, Zn, and Cu concentration patterns do not correspond in the vicinity of this property which suggests that either there is more than a single source for these metals, or

Figure 27. Zinc abundance in the clay size fraction of till.

Figure 28. Lead abundance in the clay size fraction of till

that some of these metals have been remobilized by hydromorphic processes. A series of high Pb values to the east of the Grew Creek Au mineralization do not have a known source (Fig. 3 and 28). There have been no anomalous Pb values documented from the Au-Ag mineralization at Grew Creek. It is likely, therefore, that these anomalies are derived from an unknown source.

In conclusion, high levels of metals detected in the till reflect known as well as possible undiscovered mineralization and geochemically distinctive lithologies such as ultramafic and basaltic rocks.

Chapter 5. Conclusions

1. During the Pre-McConnell advance, ice flowed west to northwest over the area as indicated by pebble counts. This is supported by till fabrics parallel and transverse to ice flow direction.
2. At the onset of the McConnell Glaciation, ice flowed out of the Lapie River Valley and into the Tintina Trench as deduced from till fabrics and pebble counts measured in section 038 (Fig. 11, 12, and 14).
3. During the McConnell event, glacial transport was toward the west to northwest in the Tintina Trench based on dispersal of lithologies and geochemical anomalies in the surficial McConnell Till.
4. At the end of the McConnell Glaciation, an ice tongue flowed up the Lapie River Valley. During this episode, the Lapie River drainage was blocked and a glacial lake formed within the valley at the ice front.
5. The silt plus clay size fraction of till seems to be reliable for Au drift prospecting in the Tintina Trench, since it reflects known gold mineralization at Grew Creek, and is not influenced by textural parameters. On the other hand, reproducibility of Au analyses with the silt plus clay size fraction is very low. Reproducibility is low for two reasons : (1) gold particles in the clay-silt powder are heterogeneously distributed, hence producing nugget effects, and (2) geochemical results are all very close to the detection limit where precision is low. The problem of reproducibility can be solved in part by gold duplicate analyses. The second set of analyses can be done on samples which were found anomalous after the first run and samples collected at random throughout the entire data set.

6. Certain till samples located over and down-ice from Paleogene volcanics yielded Au concentrations above the 75 th percentile in the silt plus clay size fraction. This observation supports the hypothesis of Jackson et al. (1986) who suggested a possible relationship between placer gold and Paleogene volcanics. To better verify this hypothesis, more till sampling in closer proximity to these volcanic bodies would be needed since the distance of transport of detectable anomalous Au concentrations in till was found to be short, in the order of 250 to 500 m.

7. Pathfinders such as Ag, As, Hg, and Sb, analysed in the clay size fraction of till, are not recommended for drift prospecting of epithermal gold in this area, since their glacial dispersal does not reflect the mineralization at Grew Creek. However, there is a good correlation between gold and arsenic and gold and antimony in the heavy mineral fraction. Therefore, arsenic and antimony, analysed in the heavy mineral fraction of till, could probably be used as gold pathfinders with site specific limitations.

8. If sample size does not represent a practical problem, heavy minerals could be used at a reconnaissance level for gold exploration in the Tintina Trench.

9. The clay fraction of the till samples was analyzed for base metals and was found to be reliable in reflecting some known mineralization and geochemically distinctive lithologies such as the ultramafic and basaltic rocks.

10. Drift prospecting can be used as an exploration technique to locate lode gold or base metals in the Tintina Trench.

Chapter 6. Recommendations for drift prospecting in the Tintina Trench.

In this thesis, it was demonstrated that geochemical responses in till down-ice from known mineralized sources show definite anomalous patterns. Consequently, drift prospecting is worthwhile as a method for mineral exploration in the Tintina Trench and certainly in other glaciated terrain of Yukon.

In this chapter, a drift prospecting reconnaissance survey is divided into three stages. Procedures are proposed for each of these stages.

Sampling stage

Unfortunately, the sampling stage is generally overlooked and unqualified samplers are sent out in the field. The most important aspect is that the proper sediment be sampled (i.e., till) otherwise results can lead to unrevealing interpretations (Shilts, 1975). As an example, a sampling crew can consist of two diggers with one of them capable of distinguishing till from other sediment types. Various combinations within sampling crews are possible whether sampling is done by truck or along traverse lines.

Air photo interpretation and study of glacial stratigraphy in exposures should complement and facilitate the sampling stage. As an example, areas covered by thick glaciolacustrine sediments and devoid of till exposures should be avoided by samplers. Such areas are encountered to the north of the Pelly River within the limit of the glacial lake which existed at the end of the McConnell Glaciation.

Samples of 1 kg should be large enough to give at least 10 g of silt and clay for Au analysis and 2 g of clay for metals analysis. Some samples should be larger for duplicate analysis.

Sampling can be done properly with a mattock (pick) and shovel. Certain hand augers are efficient in areas of matrix-enriched till. Portable drills are available on the market and could be used in areas where till is covered by a veneer of poorly compacted sediments.

Along with sampling, notes should be taken on ice flow indicators. This should include careful measurements of striations and proper identification of boulder lithologies which can be used as tracers. Even pebble counts and till fabrics can be done in areas where ice flow patterns are thought to be complex. Also, samplers should note outcrop locations and signs of mineralization; bedrock samples could complement the drift survey.

A common problem at the sampling stage is to choose a proper sample interval. The distance between every sample should be dependent on the distance of transport of detectable geochemical anomalies in till. As outlined in chapter 4, in the section on gold in the silt plus clay size fraction, several factors govern the distance of transport. Ideally, a dispersal train from a known source should be clearly defined by a tight sampling grid to estimate the detectable distance of transport of a given element in the till. From these results, one can measure the farthest distance down-ice from the source that an enrichment can be detected in till and therefore, select a proper sample interval.

Base metals and gold ores generally occur in different concentrations and their size and the extent of their surficial expression are, in most cases, different. Therefore, geochemical responses of these ores in till are not expected to be of the same size. Consequently, the sample interval should not be the same whether drift prospecting is done for gold or base metals.

Analytical stage

Geochemical analyses should be done on a proper size fraction depending on the element sought and the nature of the postglacial weathering, otherwise a dilution effect could mask any anomaly contrast. In geochemical exploration for sulfide deposits, the clay fraction would yield the best results (Shilts, 1975). In cases where ore minerals are resistant to weathering (gold, cassiterite, chromite, etc.) coarser-grained fractions of near surface till is recommended for analysis (Shilts, 1984). In certain geological settings, analyses can be done on heavy mineral concentrates to increase the anomaly contrast.

If the best fraction to analyze is unknown, the following procedure can be used (Dilabio, 1985; Shilts, 1984) :

- 1- collect samples from areas of known mineralization or from areas which were found anomalous in previous testing,
- 2- sieve samples into different size fractions,
- 3- analyze each size fraction individually,
- 4- verify which fraction is the most enriched. Further prospecting should be done using this fraction for analysis.

Duplicate analyses

In order to verify the reproducibility of geochemical results and to make sure that intensive follow-up is not pursued on false anomalies, duplicate analyses should be run on (1) samples which were found anomalous after the first run, and (2) samples collected at random throughout the entire set.

False anomalies and "high-kick" are common in gold exploration because of the mode of occurrence of this element. Native gold particles generally occur in small amounts in till and

inhibit homogeneity (Harris, 1982). A single gold particle can greatly affect the geochemical response and produce the well known "nugget effect" (Dilabio, 1982b). Spurious results can derive also from the fact that gold concentrations in till are low and analyses are performed close to the detection limit where precision is low (Thompson and Howarth, 1976). For these reasons, in a gold exploration program, duplicate analyses should be a regular procedure.

Interpretation and follow-up

Identification of anomalies should be done carefully, especially in the case of gold, where the anomaly contrast is generally low and false anomalies are common. Any anomaly should be reproduced prior to undertaking a follow-up survey. At this point, investigators should know the direction of transport of till from information gathered in the field and in the literature, and should use it in an attempt to trace to source any anomalies.

Sampling on a tighter grid can be undertaken over anomalous areas to better define dispersal trains. In areas of thick drift cover, overburden drilling can be done to sample till at different levels and to better understand the Quaternary stratigraphy. Where a till veneer is predominant, surficial sampling might be found efficient in defining dispersal patterns. In a final stage, when the source is thought to be identified, diamond drilling can be performed.

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Appendix A
Geochemical results - clay fraction

sample#	UTM	UTM	Mo(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)	Ni(ppm)	Co(ppm)	Fe(%)	W(ppm)	Mn(ppm)
	eastng	northng									
001-1	612850	6880850	5	40	52	278	32	8	43	1	1030
001-2	612850	6880850	5	53	38	281	38	10	47	1	562
002-1	612750	6880900	5	50	39	289	32	8	451	1	742
002-2	612750	6880900	6	36	43	273	29	9	378	1	787
003-1	612600	6880950	4	42	29	199	26	6	363	1	537
004-1	612400	6881050	4	55	21	243	38	8	392	1	498
005-1	612350	6880950	4	42	27	196	28	7	375	1	475
007-1	611400	6880750	5	74	24	274	60	14	414	1	662
007-2	611400	6880750	4	56	34	251	35	8	405	1	467
007-3	611400	6880750	5	75	23	276	51	10	429	1	480
007-4	611400	6880750	4	20	23	122	9	7	2.8	1	347
007-B	611400	6880750	3	12	30	110	9	10	0.66	1	213
008-1	611500	6880850	5	64	22	239	47	10	425	1	409
009-1	611050	6881300	5	89	22	290	75	12	477	1	506
010-1	611050	6881300	5	72	26	272	60	12	476	2	388
012-1	611500	6880675	5	72	24	255	52	10	374	1	445
012-4	611500	6880675	4	29	37	197	25	8	317	1	797
013-1	611600	6880800	7	107	28	450	84	18	5.42	2	668
015-1	613050	6881800	5	93	27	300	60	12	4.9	1	711
017-1	613525	6881475	4	88	28	276	60	11	452	1	481
018-1	613750	6881875	5	89	20	269	62	14	5.26	1	605
018-2	613750	6881075	5	90	28	274	60	15	5.25	1	486
018-3	613750	6881075	5	101	29	300	69	19	5.75	1	581
019-1	614650	6880075	4	58	33	226	54	11	4.5	1	660
019-2	614650	6880075	4	53	35	238	44	11	4.46	1	552
020-1	616750	6878950	4	71	21	254	55	10	4.18	1	464
020-2	616750	6878950	5	71	26	250	57	12	4.1	1	658
020-3	616750	6878950	4	61	29	225	54	11	3.88	1	595
021-1	617250	6878900	5	82	29	266	56	11	4.34	1	498
021-2	617250	6878900	4	80	19	257	57	11	4.25	1	438
022-1	617950	6878800	5	90	22	260	62	13	4.49	1	603

sample#	easting	northing	Mo(ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Fe (%)	W (ppm)	Mn (ppm)
024-1	619550	6878800	5	82	16	494	57	13	4.51	2	528
027-1	621200	6876900	5	93	24	279	67	16	4.99	2	672
029-1	622850	6876500	4	78	21	243	56	12	4.58	1	599
029-2	622850	6876500	4	80	21	237	56	13	4.61	2	644
030-1	623500	6876050	4	89	24	242	69	16	4.87	1	758
031-1	625425	6874650	4	95	11	246	77	15	5.09	1	597
032-1	618500	6864150	7	97	16	380	63	12	4.06	1	413
034-1	620600	6864750	22	138	36	714	132	18	5.51	2	687
037-1	622650	6865050	13	130	26	688	109	17	5.23	2	619
038-1	626700	6866500	5	81	18	284	74	16	4.3	1	578
038-2	626700	6866500	5	71	12	282	58	12	3.84	1	447
038-3	626700	6866500	5	80	21	293	68	16	4.33	1	549
039-1	629650	6868200	5	84	23	343	75	16	5.14	1	614
040-1	631600	6868800	4	132	34	320	72	18	5.81	1	628
041-1	628800	6871450	3	106	15	221	82	23	5.5	1	642
042-1	626900	6869850	5	89	29	323	91	22	5.65	1	820
043-2	626750	6867850	4	79	11	291	79	15	3.93	1	649
044-2	626600	6872500	4	81	27	248	60	15	4.68	1	673
044-5	626600	6872500	4	84	24	268	63	15	4.56	1	621
044-6	626600	6872500	5	80	19	440	62	13	4.66	1	578
045-1	635050	6864625	5	85	21	281	58	12	4.7	1	581
046-1	633750	6866925	5	72	22	260	65	13	4.37	1	448
046-2	633750	6866925	5	87	26	297	66	11	4.61	1	432
047-1	635500	6865950	4	83	19	260	58	13	4.54	1	517
048-1	636250	6865725	4	89	24	262	73	17	4.96	1	591
049-1	637250	6864450	5	82	18	286	65	13	4.63	1	642
049-2	637250	6864450	5	85	22	301	67	14	4.64	1	553
052-2	642600	6859325	5	87	21	311	61	13	4.65	1	420
056-1	637625	6877000	5	124	30	430	106	16	5.51	1	678
057-1	628400	6873150	4	90	16	246	68	13	4.47	1	468
057-2	628400	6873150	4	91	11	258	71	13	4.6	1	496
059-1	630100	6873075	5	111	13	289	99	15	5.15	1	668

sample#	easting	northing	Mo(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)	Ni(ppm)	Co(ppm)	Fe(%)	W(ppm)	Mn(ppm)
059-1	633050	6872800	4	116	9	293	92	17	5.33	1	585
059-2	633050	6872800	4	111	13	288	93	19	5.17	1	626
060-1	633000	6870650	3	86	11	262	117	15	5.03	1	541
061-1	638350	6878225	8	120	20	422	59	12	5.42	1	363
062-1	638875	6880500	5	111	18	368	84	15	4.63	1	463
063-1	636000	6875900	5	117	22	338	94	18	5.31	1	680
065-1	611100	6881250	4	60	21	238	50	9	3.92	1	523
066-1	641000	6860550	6	93	24	338	73	12	4.66	1	453
067-1	645200	6858500	5	70	21	329	70	13	4.78	1	522
068-1	647050	6858625	7	109	33	377	80	16	5.25	1	543
069-1	648375	6858725	5	114	38	346	80	18	5.56	1	710
070-1	650550	6858200	5	107	22	332	74	14	5.52	1	546
072-1	655350	6857100	4	93	21	302	88	20	5.5	1	797
073-1	657675	6855325	5	87	23	375	63	13	4.79	1	467
074-1	344825	6854800	4	84	22	286	61	12	4.66	1	509
076-1	636550	6874250	4	133	20	337	141	20	5.19	1	542
076-3	636550	6874250	5	126	20	360	133	20	5.68	1	1047
077-1	645150	6853550	6	115	25	359	96	18	5.2	1	559
078-1	646250	6853350	4	87	28	293	84	22	6.34	1	935
078-3	646250	6853350	3	105	34	372	100	22	5.6	1	627
079-1	650250	6848750	5	111	24	349	92	19	6.32	1	751
080-1	638450	6875700	3	174	19	297	124	20	6.35	1	725
080-2	638450	6875700	4	115	19	259	99	20	5.05	2	652
081-1	658900	6875650	5	125	23	284	99	18	5.08	1	671
081-3	638900	6875650	6	127	21	374	93	21	5.17	1	766
082-1	645700	6865750	6	102	22	359	81	17	4.13	1	746
082-2	645700	6865750	4	94	24	299	83	18	4.26	1	678
082-3	645700	6865750	6	96	27	342	91	19	4.48	1	587
083-2	654250	6861900	5	100	24	292	93	19	4.58	1	685
083-4	654250	6861900	3	100	22	307	109	17	5.2	1	675
085-1	631200	6876850	4	85	14	233	90	18	4.28	1	795
086-1	630350	6877100	5	116	17	322	98	18	5.05	1	542

sample #	easting	northing	Mo(ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Fe (%)	W (ppm)	Mn(ppm)
087-1	647800	6852100	3	73	13	257	90	33	8.24	1	1077
088-1	652700	6849100	8	49	35	266	78	30	7.91	1	2110
089-1	652150	6846850	5	105	20	354	80	14	5.11	1	474
091-1	349100	6851450	4	83	24	287	55	11	4.51	1	377
093-1	359250	6847700	4	108	25	323	75	14	5.73	1	590
094-1	364950	6846450	4	101	28	307	69	14	5.04	1	562
095-1	368700	6844900	5	110	36	358	59	13	5.63	1	517
096-1	372400	6843750	4	85	31	288	68	16	5	1	681
097-1	376400	6843750	5	115	35	354	81	22	5.97	1	843
098-1	382300	6846500	4	93	18	282	67	14	4.67	1	487
099-1	637900	6873400	5	132	26	243	116	19	5.34	1	680
100-1	642500	6870000	5	118	16	342	93	14	5.31	1	524
101-1	648800	6861850	5	89	20	314	104	18	4.83	1	796
102-1	640650	6871300	9	203	23	398	112	18	5.22	1	573
103-1	612150	6880100	6	78	17	306	61	12	4.51	1	425
105-1	611300	6879300	5	89	18	263	87	17	5.43	1	685
106-1	355200	6845150	5	111	40	370	2120	33	6.15	1	963
107-1	355200	6845250	5	69	22	273	892	48	4.53	1	738
108-1	355650	6844600	7	123	48	369	100	34	6.13	1	1048
109-1	354900	6846350	6	122	53	396	126	18	5.11	1	519
113-1	376550	6841500	3	52	22	136	48	12	3.06	1	498
116-1	384050	6847150	5	104	23	270	84	22	5.97	1	833
117-1	392050	6848400	5	108	24	333	51	13	5.3	1	381
118-1	399300	6845550	5	94	27	333	72	16	4.89	1	650
119-1	404800	6842750	5	136	67	436	72	19	6.45	1	750
123-1	408850	6841150	7	137	36	430	79	17	6.26	1	714
124-1	410750	6839700	5	98	24	291	96	16	4.67	1	508
126-1	413900	6837900	6	87	22	253	106	14	4.9	1	565
128-1	418750	6836000	4	313	18	359	260	29	9.02	1	796
133-1	380600	6845850	4	72	2	233	52	13	4.35	1	423
134-1	378850	6844100	5	88	31	295	69	15	5.2	1	555
135-1	374850	6844200	5	88	32	322	59	11	5.03	1	402

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OF/DE

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MicroD

sample#	easting	northing	Mo(ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Fe (%)	W (ppm)	Mn (ppm)
136-1	363300	6846650	4	80	26	284	65	16	4.6	1	670
137-1	360900	6846500	6	99	20	369	62	12	5.04	1	413
139-1	655300	6855450	4	76	21	263	75	14	4.72	1	566
142-1	438850	6829400	7	75	26	326	58	11	4.35	1	424
143-1	433700	6832800	6	89	33	322	57	13	4.84	1	644
144-1	430650	6832550	5	106	15	267	146	16	4.8	1	576
145-1	427750	6832750	4	112	17	195	335	29	5.27	1	812
147-1	422650	6833900	7	143	24	225	196	18	6.01	1	836
148-1	621700	6873650	5	67	14	271	58	12	3.4	1	520
149-1	620550	6875900	6	68	23	278	71	16	4.99	1	576
150-1	361300	6828450	3	70	45	1084	113	16	4.85	1	727
151-1	356250	6833350	5	78	28	265	66	18	4.71	1	676
152-1	356650	6835600	7	96	23	347	60	12	4.45	1	359
153-1	351800	6841850	7	111	23	378	80	15	5.02	1	400
154-1	345750	6848700	5	72	27	196	86	21	6.51	1	863
155-1	343050	6846950	6	100	23	348	71	15	5.17	2	477
156-1	610500	6883700	4	82	19	225	72	14	5.76	1	425
157-1	608000	6885700	4	99	17	227	76	17	5.48	1	543
158-1	605550	6886750	4	78	12	223	62	12	4.35	1	617
159-1	603050	6887950	4	112	29	296	128	28	7.13	1	1112
159-2	603050	6887950	4	110	26	295	109	25	6.87	1	1003
160-1	600850	6889100	4	66	15	205	78	15	4.34	1	771
161-1	597650	6890800	3	106	27	35	106	24	6.83	1	697
162-1	595000	6892150	4	85	29	276	67	17	6.09	1	610
163-1	593550	6893000	5	88	22	277	77	17	5.09	1	720
164-1	591950	6893300	4	82	29	244	73	17	4.81	1	763
164-2	591950	6893300	4	78	18	240	70	12	5.1	1	620
165-1	589900	6893750	4	70	18	230	70	14	4.5	1	518
166-1	587850	6893650	8	79	20	347	74	13	4.5	1	620
166-2	587850	6893650	5	72	23	264	69	15	4.86	1	627
167-1	582900	6895100	4	71	34	298	56	15	4.71	1	756
168-1	585250	6893900	3	53	23	204	47	12	3.9	1	655

sample #	easting	northing	Mo(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)	Ni(ppm)	Co(ppm)	Fe(%)	W(ppm)	Mn(ppm)
159-1	589500	6890500	3	45	31	196	38	15	4.36	1	1017
170-1	587650	6892350	4	65	22	222	50	13	4.69	1	770
172-1	611150	6881300	5	46	30	227	51	13	4.44	1	626
173-1	610650	6881600	4	46	31	217	41	10	3.71	1	562
174-1	609500	6882350	5	89	29	217	75	15	6.16	1	579
175-1	608850	6882650	4	59	21	183	68	17	5.84	1	596
176-1	650200	6867700	7	113	30	242	218	25	6.95	1	745
177-1	649200	6866850	5	80	15	253	69	11	3.99	1	427
178-1	655300	6869850	5	81	11	246	80	15	4.06	1	532
179-1	656600	6871900	6	151	35	233	133	18	6.51	2	454
181-1	350000	6876800	5	149	35	329	153	25	7.67	1	1222
182-1	351400	6870950	6	128	17	266	304	48	5.97	1	897
183-1	352150	6872700	7	120	30	428	101	18	6.44	2	806
184-1	351400	6873900	5	77	8	298	56	11	4.3	1	356
186-1	359900	6869000	3	73	14	135	831	35	4.46	1	589
189-1	354400	6864700	7	184	37	435	171	32	8.05	2	862
190-1	354800	6867350	5	136	34	221	179	21	6.91	1	572
191-1	438500	6806900	8	65	65	223	82	27	6.79	1	1066
192-1	437600	6808750	18	91	112	285	70	19	6.32	1	797
193-1	429950	6817700	5	84	26	228	142	20	4.83	1	1015
194-1	430950	6816250	6	42	43	175	117	21	5.44	1	927
195-1	425200	6820350	4	80	20	334	111	20	5.18	1	792
196-1	432650	6815350	3	69	14	284	130	24	5.01	1	862
198-1	437050	6813000	8	127	36	285	151	31	7.78	1	1332
199-1	426950	6818400	17	53	17	353	84	20	8.58	1	605
203-1	416050	6808450	6	68	34	176	68	20	6.93	1	681
206-1	395350	6809450	3	126	2	153	195	48	9.71	1	816
207-1	369000	6830250	5	201	36	238	144	33	10.3	2	1691
208-1	368400	6828550	6	94	46	240	118	24	6.64	1	1667
209-1	393050	6818800	4	148	106	353	91	35	7.99	2	1500
210-1	385650	6827600	4	82	41	202	63	21	5.54	2	738
211-1	397100	6841700	6	79	36	191	66	26	6.91	1	919

sample#	easting	northing	Mo(ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Fe (%)	W (ppm)	Mn(ppm)
211-2	397100	6841700	5	114	22	272	128	24	6.01	1	850
212-1	395450	6841800	3	85	21	238	331	27	4.93	1	499
213-1	396750	6833150	5	132	26	265	127	30	7.58	2	721
214-1	371050	6855050	10	382	80	480	271	55	12.96	3	3203
215-1	369250	6855200	9	175	28	333	137	33	11.17	2	988
216-1	352300	6860350	5	93	21	274	111	24	5.83	1	785
218-1	350850	6857500	4	94	26	287	92	18	5.34	1	736
219-1	610100	6882000	5	43	25	220	56	16	5.73	1	615
221-1	650500	6859450	5	83	22	287	85	17	5.05	1	649
222-1	613600	6879400	5	55	26	300	49	11	3.98	1	729
222-2	613600	6879400	5	60	16	243	47	10	4.13	1	544
222-3	613600	6879400	5	42	29	208	37	9	3.5	1	761
223-1	656000	6853650	5	86	33	344	81	18	5.08	1	741

sample#	Au (ppb)	Ag (ppm)	As (ppm)	Sb (ppm)	Hg (ppb)	U (ppm)	Th (ppm)	Sr (ppm)	Cd (ppm)	Bi (ppm)	V (ppm)	Ca (%)
001-1	10(10)	01	22	2	140	5	15	59	1	2	31	2.74
001-2	2	01	24	2	180	5	11	58	1	3	45	1.68
002-1	14(10)	01	26	2	240	5	15	43	1	2	34	1.42
002-2	11	01	27	2	190	5	15	32	1	2	35	0.72
003-1	1	03	14	2	90	5	10	82	1	2	44	4.22
004-1	1	02	23	2	140	5	10	56	1	2	44	2.16
005-1	1	02	14	2	110	5	8	85	1	2	45	3.50
007-1	1	02	19	2	130	5	10	101	2	3	72	2.46
007-2	1	03	18	2	120	5	12	85	2	2	54	2.66
007-3	1	03	20	2	130	5	10	102	2	4	77	2.55
007-A	1	04	11	2	240	5	12	30	1	2	9	0.16
007-8	28	03	15	2	60	5	4	8	1	2	5	0.07
008-1	6	03	18	2	160	5	8	59	1	2	59	1.13
009-1	1	05	27	2	150	5	11	59	1	2	61	0.76
010-1	5	02	22	2	140	5	12	51	1	2	66	0.47
012-1	1	05	17	2	170	5	9	72	2	2	63	1.32
012-4	4	01	14	2	100	5	13	64	1	2	28	2.84
013-1	1	03	36	2	110	5	11	61	1	2	75	1.43
015-1	5(4)	04	27	2	270	5	9	85	3	3	60	3.11
017-1	7	04	23	2	210	5	9	86	2	2	65	2.89
018-1	1	08	27	4	280	5	11	60	1	5	58	0.87
018-2	2	03	29	2	260	5	10	71	1	2	60	1.41
018-3	7(1)	05	32	2	290	5	12	63	1	2	59	0.88
019-1	5	03	15	2	150	5	9	81	2	2	57	2.65
019-2	2	03	15	2	150	5	9	64	1	2	55	1.57
020-1	10	06	16	2	160	5	9	80	2	5	59	2.12
020-2	1	06	17	2	190	5	8	96	2	2	58	2.23
020-3	1	05	13	2	170	5	9	95	2	2	53	2.21
021-1	3	04	24	2	180	5	8	98	2	2	66	3.17
021-2	1	06	19	2	160	5	7	85	1	2	65	2.23
022-1	6	03	22	2	150	5	8	98	2	2	65	3.22

sample#	Au (ppb)	Ag (ppm)	As (ppm)	Sb (ppm)	Hg (ppb)	U (ppm)	Th (ppm)	Sr (ppm)	Cd (ppm)	Bi (ppm)	V (ppm)	Ca (g)
024-1	7	0.2	22	2	170	5	8	106	5	2	65	3.11
027-1	1	0.2	23	2	150	5	7	85	2	2	71	2.46
029-1	1	0.1	22	2	180	5	7	99	2	2	61	4.03
029-2	2	0.2	18	2	200	5	7	106	2	3	61	4.00
030-1	12(6,1)	0.1	26	2	170	5	8	94	2	2	62	4.26
031-1	5	0.2	27	2	210	5	8	83	2	2	71	3.13
032-1	5(5)	0.8	25	2	200	5	8	96	2	4	81	1.81
034-1	9	0.7	44	6	280	5	10	110	2	3	114	1.03
037-1	4	0.4	50	4	260	5	9	96	3	3	100	1.75
038-1	5(7)	0.5	23	2	170	5	9	88	2	2	68	1.61
038-2	3(3)	0.3	22	2	160	5	8	95	2	3	60	1.96
038-3	6	0.1	20	2	140	5	8	93	2	2	69	1.67
039-1	4	0.3	40	2	230	5	8	85	3	4	68	2.64
040-1	8(8)	0.1	43	2	210	5	11	65	2	4	62	1.43
041-1	7	0.2	35	2	120	5	14	57	1	2	60	0.70
042-1	9	0.5	37	2	190	5	9	67	2	2	64	1.60
043-2	16(7)	0.5	26	2	160	5	6	110	2	2	68	3.01
044-2	28(3)	0.4	22	2	150	5	11	97	2	4	64	2.41
044-5	3(8)	0.4	28	2	170	5	9	113	2	2	63	3.48
044-6	6	0.4	23	2	200	5	8	94	2	4	70	2.13
045-1	7	0.3	28	2	180	5	8	94	2	2	64	2.89
046-1	4	0.5	27	2	160	5	11	67	1	2	58	0.79
046-2	6	0.4	29	2	210	5	11	69	2	2	65	1.26
047-1	4	0.3	25	2	190	5	10	83	2	2	68	2.83
048-1	6(7)	0.1	24	2	270	5	11	64	1	4	63	0.86
049-1	5	0.2	24	2	210	5	8	116	2	2	72	2.91
049-2	6	0.3	26	2	230	5	9	98	2	2	75	1.81
052-2	4(5)	0.2	32	2	170	5	8	110	3	4	83	1.88
056-1	6(8,6)	0.1	45	3	460	5	10	57	2	2	98	0.43
057-1	5	0.7	27	2	270	5	7	83		2	70	1.54
057-2	14	0.3	28	2	260	5	7	90	2	2	73	2.31
059-1	7	0.3	27	2	220	5	8	79	2	2	66	1.34

sample#	Au (ppb)	Ag (ppm)	As (ppm)	Sb (ppm)	Hg (ppb)	U (ppm)	Th (ppm)	Sr (ppm)	Cd (ppm)	Bi (ppm)	V (ppm)	Ca (%)
059-1	6	0.1	26	2	210	5	6	78	2	4	87	1.40
059-2	11	0.1	24	2	260	5	6	82	2	2	88	1.72
060-1	6	0.3	27	2	210	5	7	74	2	4	81	2.31
061-1	7	0.7	45	2	320	5	9	61	2	2	97	0.41
062-1	6	0.6	28	4	280	5	10	63	2	2	92	0.48
063-1	6	0.3	31	2	260	5	9	62	2	3	94	0.44
065-1	25(5)	0.4	30	2	170	5	10	98	2	2	53	3.55
066-1	11(13)	0.4	22	2	190	5	10	75	2	4	77	1.22
067-1	39(6)	0.2	32	2	80	5	7	105	3	2	71	3.96
068-1	1	0.4	42	4	140	5	9	66	2	2	84	1.47
069-1	1	0.3	36	2	110	6	13	58	1	2	78	1.05
070-1	1	0.4	36	2	220	5	9	85	2	2	83	1.79
072-1	1(2)	0.3	47	2	210	5	8	97	3	3	66	4.23
073-1	1	0.4	31	2	160	5	7	80	2	4	83	2.14
074-1	2(4)	0.4	30	2	130	7	8	82	2	3	67	2.76
076-1	1	0.4	26	2	180	5	8	60	2	2	93	0.59
076-3	1	0.2	37	2	230	5	10	76	3	2	78	1.13
077-1	1(1)	2.4	37	3	160	7	9	60	1	2	84	0.63
078-1	2	0.3	23	5	200	5	7	58	1	2	93	0.81
078-3	4	0.4	29	5	180	5	10	48	1	2	89	0.62
079-1	2	0.1	53	4	270	5	6	63	2	4	94	1.66
080-1	2	0.3	50	2	360	6	5	68	1	4	98	1.02
080-2	1	0.3	21	2	190	7	7	70	2	4	96	1.35
081-1	1(1)	0.2	25	2	220	5	7	83	2	2	100	1.47
081-3	1	0.5	33	4	200	8	9	67	2	4	100	0.61
082-1	3(4)	0.6	23	3	210	5	8	94	3	2	87	1.47
082-2	7	0.5	26	2	170	5	8	82	2	2	76	1.21
082-3	6	0.7	32	6	200	5	8	71	2	2	73	1.04
083-2	7	0.6	30	2	190	5	8	82	2	2	79	1.33
083-4	5	0.3	32	2	160	5	8	78	1	5	76	1.83
085-1	5	0.3	17	2	200	5	8	80	2	3	73	1.34
086-1	4(4)	0.6	26	2	260	5	9	73	2	4	86	1.14

Sample#	Au (ppb)	Ag (ppm)	As (ppm)	Sb (ppm)	Hg (ppb)	U (ppm)	Th (ppm)	Sr (ppm)	Cd (ppm)	Bi (ppm)	V (ppm)	Ca (%)
087-1	2	0.2	16	2	190	5	5	98	1	4	91	1.18
088-1	7	2.7	72	3	220	8	4	40	1	2	107	0.46
089-1	3	0.4	35	3	270	5	8	62	2	2	88	0.66
091-1	3	0.6	27	2	180	5	9	68	1	4	82	1.43
093-1	2	0.4	46	2	160	5	11	47	1	3	68	1.06
094-1	2	0.7	49	2	250	5	10	55	2	4	66	1.21
095-1	2	0.9	145	2	420	5	19	33	1	2	60	0.57
096-1	1	0.2	42	2	230	5	11	71	2	3	65	2.31
097-1	3	0.7	73	2	340	6	11	61	2	2	62	1.52
098-1	4	0.4	29	3	200	5	9	64	2	2	69	2.35
099-1	9(1,10)	0.5	24	2	330	5	13	84	1	2	71	0.54
100-1	7(6)	0.4	38	2	260	5	8	68	2	2	78	1.72
101-1	2(2)	0.5	31	2	230	5	8	98	3	2	78	2.56
102-1	2	0.9	30	3	760	5	9	109	3	2	82	0.42
103-1	1	0.3	28	3	210	5	8	81	2	2	73	1.88
105-1	1	0.2	39	2	140	5	11	67	2	2	81	2.23
106-1	4	0.5	94	2	520	5	12	55	1	3	67	0.83
107-1	1	0.4	52	3	240	5	9	84	2	2	54	2.47
108-1	1	0.6	87	11	400	5	12	71	2	2	61	2.02
109-1	1	0.1	166	3	130	5	10	78	3	3	79	1.91
113-1	2(2)	0.3	44	2	160	5	4	246	2	2	34	18.54
116-1	2(3)	0.6	59	2	430	5	8	57	2	2	50	1.17
117-1	2(5)	0.7	33	3	600	5	8	57	1	2	74	0.75
118-1	2	0.4	20	3	270	5	9	40	1	3	69	0.65
119-1	2	0.7	53	3	560	5	10	36	2	3	68	0.64
123-1	2	1.2	49	3	480	5	11	41	1	2	76	0.91
124-1	2	0.5	24	3	210	5	11	40	1	2	66	0.37
126-1	2	0.5	30	6	270	5	9	45	1	2	74	0.70
128-1	1	0.1	15	2	170	5	28	9	1	2	148	0.12
133-1	4	0.3	55	3	220	5	8	85	2	3	53	3.90
134-1	1	0.2	40	2	220	5	10	73	2	3	67	1.44
135-1	2	0.2	29	2	200	5	9	52	2	2	66	1.38

sample #	Au (ppb)	Ag (ppm)	As (ppm)	Sb (ppm)	Hg (ppb)	U (ppm)	Th (ppm)	Sr (ppm)	Cd (ppm)	Bi (ppm)	V (ppm)	Ca (%)
136-1	4	0.2	45	2	330	5	12	94	2	2	53	4.79
137-1	1(3)	0.4	40	2	350	5	8	58	2	4	78	1.14
139-1	2	0.2	31	2	170	5	8	102	2	2	77	3.05
142-1	1	0.5	25	3	180	5	11	25	1	2	61	0.41
143-1	3	0.1	30	3	160	5	10	30	1	2	83	0.46
144-1	1	0.1	23	2	140	5	7	34	1	2	71	1.06
145-1	9	0.3	19	2	220	5	5	62	1	2	74	1.28
147-1	10(10,1)	0.2	38	3	560	5	8	140	1	2	81	0.52
148-1	2	0.3	19	2	170	5	7	135	2	2	64	3.87
149-1	1	0.2	28	2	90	5	9	39	1	2	80	0.49
150-1	1	0.3	53	2	120	5	12	105	4	2	57	5.13
151-1	1	0.3	46	4	220	5	12	156	2	2	57	4.57
152-1	24(1,1)	0.3	34	3	180	5	10	74	2	3	93	1.06
153-1	6	0.2	45	2	230	5	10	68	2	2	91	1.17
154-1	1	0.5	52	2	200	5	13	31	1	2	90	0.16
155-1	5(1,2)	0.1	34	5	220	5	9	61	2	2	105	0.94
156-1	3	0.6	31	2	340	5	12	76	1	5	61	2.46
157-1	1	0.4	29	2	380	5	10	78	1	4	60	3.09
158-1	1	0.4	21	2	210	5	8	87	1	5	67	3.91
159-1	4	0.6	35	2	270	5	9	106	2	6	65	2.73
159-2	1	0.6	35	3	350	5	8	90	2	2	66	2.78
160-1	1	0.4	17	2	160	5	8	98	2	2	64	3.73
161-1	1	0.9	40	2	360	5	10	75	2	7	52	1.54
162-1	3	0.2	38	2	320	5	13	62	1	6	42	1.42
163-1	2	0.3	43	2	180	5	8	89	2	5	62	2.51
164-1	5	0.2	34	2	150	5	7	120	2	5	62	4.46
164-2	1	0.1	28	2	120	5	8	86	2	5	66	2.87
165-1	1	0.4	26	3	160	5	8	76	1	5	64	2.04
166-1	1	0.1	24	3	130	5	10	87	3	4	79	2.36
166-2	1	0.3	22	2	150	5	9	86	1	5	76	2.14
167-1	4	0.3	33	2	170	5	11	105	3	4	56	4.70
168-1	1	0.2	23	2	100	5	11	128	2	2	52	5.87

sample#	Au (ppb)	Ag (ppm)	As (ppm)	Sb (ppm)	Hg (ppb)	U (ppm)	Th (ppm)	Sr (ppm)	Cd (ppm)	Bi (ppm)	V (ppm)	Ca (%)
169-1	3	0.1	16	2	120	5	14	84	1	4	53	2.61
170-1	2	0.2	24	3	110	5	14	89	2	5	59	3.16
172-1	16(14)	0.4	75	2	220	5	14	80	1	2	58	1.58
173-1	5	0.2	24	2	180	5	12	196	2	3	50	4.21
174-1	2	0.1	33	4	50	5	18	19	1	5	85	0.17
175-1	1	0.1	28	2	40	5	15	20	1	7	88	0.25
176-1	1	0.3	72	5	110	5	12	47	1	5	111	0.26
177-1	3	0.3	27	4	100	5	6	414	2	4	86	5.56
178-1	4	0.1	23	3	180	5	7	108	2	3	78	4.15
179-1	2	0.1	56	5	150	5	12	52	1	6	128	0.25
181-1	6	1	44	3	720	5	13	60	1	7	116	0.41
182-1	4	0.6	27	3	2900	5	5	94	1	4	100	2.45
183-1	1	1.2	47	7	330	5	8	78	2	6	106	1.03
184-1	1(1)	0.1	24	3	240	5	7	116	2	3	91	3.73
186-1	2	0.2	25	6	210	5	6	102	1	2	56	6.17
189-1	4	0.8	102	10	220	5	11	42	3	7	95	0.84
190-1	1	0.7	61	3	300	5	10	66	1	6	110	2.32
191-1	2	0.1	43	3	80	5	43	13	1	7	75	0.08
192-1	6(4)	0.1	95	6	220	7	29	41	1	12	110	0.11
193-1	7(2)	1.5	53	2	210	5	13	56	2	5	74	0.81
194-1	1(2)	0.1	17	2	20	5	33	19	1	5	78	0.20
195-1	1(1)	0.3	40	2	110	5	9	46	2	3	85	0.76
196-1	1(2)	0.8	18	2	130	5	9	51	1	2	77	0.97
198-1	6	0.8	61	2	160	5	11	37	1	7	124	0.24
199-1	4	0.1	38	2	60	5	28	20	1	7	101	0.36
203-1	1	0.1	7	2	50	5	10	17	1	2	111	0.20
206-1	1	0.1	45	2	60	5	9	12	1	3	129	0.12
207-1	1	2.4	59	3	210	5	11	45	2	9	73	0.58
208-1	1	2.2	61	4	250	5	12	69	2	4	89	0.79
209-1	1	0.1	171	2	80	5	55	21	1	9	72	0.19
210-1	1	0.6	39	2	140	7	13	73	1	6	76	1.10
211-1	1	0.3	31	2	150	5	8	66	1	6	94	0.68

sample#	Au (ppb)	Ag (ppm)	As (ppm)	Sb (ppm)	Hg (ppb)	P (ppm)	Th (ppm)	Sr (ppm)	Cd (ppm)	Bi (ppm)	V (ppm)	Ca (%)
211-2	4	0.6	36	3	190	5	9	59	2	3	83	1.69
212-1	1	0.7	15	2	230	5	8	39	3	2	69	0.70
213-1	1	0.7	57	2	120	5	12	35	2	4	88	0.53
214-1	1	3	357	6	680	5	8	47	4	5	90	0.59
215-1	1	0.4	131	2	110	5	8	27	2	6	81	0.55
216-1	1	0.5	41	2	130	5	9	54	2	2	82	1.63
218-1	1	0.7	46	2	280	5	10	68	3	2	72	1.99
219-1	3(2)	0.3	26	2	80	5	16	26	1	3	66	0.26
221-1	1	0.2	33	2	180	5	8	77	2	2	95	1.42
222-1	1	0.2	23	2	130	5	13	95	3	2	71	3.13
222-2	1	0.1	19	2	150	5	12	93	2	2	75	2.32
222-3	1	0.2	17	2	120	5	15	94	2	2	51	3.20
223-1	2	0.8	48	3	430	5	7	73	2	2	77	2.03

sample#	P(%)	La(ppm)	Cr(ppm)	Mg(%)	Ba(ppm)	Tl(%)	B(ppm)	Al(%)	Na(%)	K(%)
001-1	0.220	65	21	0.63	325	0.01	6	1.41	0.39	0.33
001-2	0.281	48	28	0.74	446	0.02	7	1.62	0.46	0.37
002-1	0.177	61	23	0.59	393	0.01	10	1.66	0.41	0.35
002-2	0.326	58	23	0.63	235	0.01	7	1.51	0.51	0.32
003-1	0.220	40	26	0.89	499	0.01	7	1.71	0.39	0.38
004-1	0.164	40	31	0.86	317	0.01	10	1.62	0.32	0.31
005-1	0.228	36	28	1.00	551	0.02	8	1.69	0.38	0.36
007-1	0.259	28	38	1.51	658	0.02	8	2.27	0.26	0.44
007-2	0.221	39	31	1.11	564	0.01	10	1.96	0.32	0.44
007-3	0.375	28	41	1.66	669	0.02	12	2.49	0.26	0.50
007-A	0.523	17	7	0.20	97	0.01	3	0.87	0.96	0.22
007-B	0.216	9	6	0.15	30	0.01	2	0.57	0.45	0.21
008-1	0.298	25	34	0.92	464	0.01	6	1.64	0.41	0.33
009-1	0.224	34	38	1.03	568	0.02	8	2.04	0.42	0.33
010-1	0.197	37	36	1.01	604	0.02	6	2.22	0.43	0.35
012-1	0.208	27	32	1.02	625	0.01	8	1.66	0.25	0.28
012-4	0.174	61	18	0.70	283	0.01	6	1.23	0.29	0.30
013-1	0.227	22	45	1.42	361	0.03	6	2.49	0.44	0.40
015-1	0.249	26	40	1.19	562	0.02	7	2.03	0.38	0.33
017-1	0.212	23	42	1.23	545	0.02	9	2.16	0.37	0.34
018-1	0.292	28	38	0.96	691	0.01	6	2.03	0.44	0.30
018-2	0.260	27	41	0.96	678	0.01	6	2.02	0.41	0.31
018-3	0.317	29	39	0.89	752	0.01	6	2.01	0.46	0.31
019-1	0.209	35	36	1.29	448	0.02	6	1.94	0.35	0.34
019-2	0.248	38	34	1.10	461	0.02	8	1.89	0.40	0.36
020-1	0.239	27	37	1.25	543	0.02	17	1.94	0.37	0.35
020-2	0.247	27	37	1.27	704	0.02	8	1.88	0.36	0.35
020-3	0.199	28	36	1.22	674	0.02	20	1.74	0.29	0.30
021-1	0.258	22	41	1.34	567	0.03	10	2.16	0.41	0.36
021-2	0.289	21	42	1.38	606	0.03	8	2.08	0.43	0.36
022-1	0.255	22	44	1.45	627	0.03	10	2.19	0.39	0.37

sample#	P(%)	La(ppm)	Cr(ppm)	Mg(%)	Ba(ppm)	Tl(%)	B(ppm)	Al(%)	Na(%)	K(%)
024-1	0.226	22	41	1.39	731	0.02	8	2.20	0.36	0.38
027-1	0.306	21	47	1.40	586	0.03	7	2.42	0.46	0.44
029-1	0.210	21	52	1.51	607	0.03	9	2.30	0.34	0.39
029-2	0.228	20	51	1.49	749	0.03	9	2.29	0.35	0.40
030-1	0.239	23	52	1.44	499	0.03	7	2.49	0.44	0.37
031-1	0.225	23	74	1.55	560	0.02	6	2.57	0.35	0.39
032-1	0.268	20	33	1.08	944	0.01	10	1.93	0.34	0.34
034-1	0.353	19	37	1.21	1048	0.02	8	2.11	0.45	0.43
037-1	0.347	20	39	1.31	986	0.03	14	2.27	0.46	0.43
038-1	0.240	21	41	1.33	784	0.02	5	2.05	0.31	0.33
038-2	0.250	22	37	1.29	837	0.02	7	1.82	0.29	0.30
038-3	0.270	22	41	1.34	882	0.02	8	2.07	0.36	0.34
039-1	0.484	21	43	1.31	570	0.04	8	2.20	0.63	0.34
040-1	0.247	27	58	1.60	500	0.03	5	2.71	0.40	0.41
041-1	0.415	29	61	1.78	552	0.02	9	2.70	0.51	0.40
042-1	0.342	24	47	1.29	451	0.04	3	2.16	0.50	0.29
043-2	0.358	19	46	1.48	781	0.03	8	2.02	0.42	0.36
044-2	0.190	26	50	1.59	694	0.03	5	2.53	0.26	0.41
044-5	0.235	23	44	1.66	582	0.03	5	2.37	0.33	0.39
044-6	0.394	23	50	1.61	747	0.04	10	2.38	0.42	0.45
045-1	0.461	21	46	1.27	644	0.03	8	2.18	0.57	0.37
046-1	0.245	26	42	1.08	598	0.02	5	1.97	0.35	0.30
046-2	0.247	27	49	1.09	493	0.02	10	2.24	0.38	0.33
047-1	0.219	25	47	1.36	621	0.02	9	2.23	0.32	0.36
048-1	0.302	25	56	1.57	554	0.02	15	2.54	0.44	0.42
049-1	0.307	23	47	1.44	851	0.03	8	2.26	0.44	0.38
049-2	0.259	22	49	1.43	805	0.03	11	2.26	0.39	0.37
052-2	0.237	21	45	1.44	849	0.03	16	2.30	0.34	0.36
056-1	0.407	20	46	1.02	598	0.01	9	2.11	0.53	0.33
057-1	0.303	20	60	1.31	919	0.02	10	2.10	0.37	0.36
057-2	0.225	20	54	1.27	865	0.02	8	2.19	0.29	0.37
058-1	0.362	19	55	1.24	694	0.01	7	2.21	0.43	0.34

sample#	P(%)	La(ppm)	Cr(ppm)	Mg(%)	Ba(ppm)	Ti(%)	B(ppm)	Al(%)	Na(%)	K(%)
059-1	0.313	17	78	2.01	701	0.04	9	2.56	0.39	0.34
059-2	0.261	17	81	2.01	699	0.04	9	2.57	0.34	0.32
060-1	0.235	19	218	1.82	581	0.02	17	2.63	0.36	0.35
061-1	0.264	19	43	0.98	628	0.01	11	2.23	0.38	0.34
062-1	0.292	20	52	1.15	672	0.02	13	2.10	0.36	0.32
063-1	0.271	19	59	1.38	776	0.02	10	2.41	0.39	0.35
065-1	0.191	36	32	1.08	511	0.02	9	1.90	0.38	0.32
066-1	0.299	23	48	1.70	704	0.03	9	2.44	0.39	0.41
067-1	0.219	21	44	1.43	453	0.04	10	2.16	0.36	0.36
068-1	0.258	21	45	1.35	460	0.02	7	2.35	0.37	0.37
069-1	0.266	35	48	1.69	466	0.02	8	2.73	0.36	0.42
070-1	0.285	24	63	1.63	658	0.03	20	2.56	0.44	0.40
072-1	0.387	26	50	1.66	509	0.05	7	2.48	0.62	0.32
073-1	0.294	21	46	1.45	620	0.03	7	2.32	0.46	0.35
074-1	0.228	21	46	1.34	573	0.02	14	2.35	0.38	0.32
076-1	0.291	19	85	2.13	649	0.03	18	2.49	0.38	0.31
076-3	0.320	23	68	1.80	755	0.03	20	2.45	0.36	0.35
077-1	0.315	21	52	1.37	628	0.02	18	2.16	0.45	0.30
078-1	0.323	20	59	2.00	365	0.10	13	3.12	0.87	0.33
078-3	0.348	23	63	1.59	494	0.04	7	2.76	0.68	0.34
079-1	0.475	18	51	1.54	381	0.07	19	2.48	0.86	0.31
080-1	0.483	17	84	2.03	765	0.06	17	2.43	0.60	0.25
080-2	0.211	17	85	2.18	739	0.05	18	2.71	0.33	0.29
081-1	0.285	18	75	2.17	781	0.03	14	2.72	0.30	0.34
081-3	0.366	19	55	1.61	754	0.02	17	2.56	0.36	0.37
082-1	0.347	20	41	1.34	996	0.01	15	2.25	0.25	0.40
082-2	0.250	22	50	1.38	1031	0.02	11	2.28	0.31	0.37
082-3	0.245	20	47	1.22	870	0.02	11	2.00	0.32	0.32
083-2	0.269	21	53	1.35	804	0.02	12	2.21	0.31	0.35
083-4	0.246	22	56	1.60	569	0.03	10	2.32	0.39	0.35
085-1	0.217	22	58	1.64	912	0.03	10	2.15	0.25	0.31
086-1	0.290	20	63	1.70	773	0.02	21	2.53	0.35	0.39

Sample#	P(%)	La(ppm)	Cr(ppm)	Mg(%)	Ba(ppm)	TI(%)	B(ppm)	Al(%)	Na(%)	K(%)
087-1	0.431	20	65	3.39	1402	0.12	4	3.77	1.20	0.26
088-1	0.695	26	67	1.12	553	0.04	20	2.58	1.32	0.24
089-1	0.249	20	49	1.12	584	0.03	22	2.06	0.39	0.30
091-1	0.222	21	45	1.17	495	0.02	11	2.30	0.34	0.34
093-1	0.355	23	52	1.42	275	0.03	7	2.55	0.47	0.37
094-1	0.300	22	44	1.17	443	0.01	10	2.39	0.40	0.36
095-1	0.320	29	41	1.06	304	0.02	6	2.20	0.45	0.32
096-1	0.262	25	44	1.32	465	0.03	8	2.53	0.41	0.37
097-1	0.390	26	55	1.49	462	0.03	11	2.39	0.49	0.29
098-1	0.225	20	50	1.30	461	0.01	10	2.53	0.34	0.38
099-1	0.253	26	65	1.85	744	0.02	24	2.68	0.34	0.45
100-1	0.263	21	54	1.46	579	0.02	10	2.30	0.40	0.35
101-1	0.272	20	59	1.62	794	0.03	12	2.32	0.37	0.40
102-1	0.380	22	55	1.51	938	0.02	13	2.54	0.29	0.45
103-1	0.237	22	46	1.28	631	0.02	15	2.14	0.36	0.35
105-1	0.211	20	81	1.83	470	0.06	5	2.81	0.38	0.63
106-1	0.482	28	82	2.29	541	0.02	10	2.17	0.58	0.28
107-1	0.343	22	154	5.69	360	0.02	20	2.02	0.48	0.28
108-1	0.537	28	47	1.43	371	0.03	6	1.93	0.58	0.25
109-1	0.231	23	81	1.71	548	0.01	7	2.67	0.36	0.30
113-1	0.413	11	32	1.07	782	0.01	3	1.50	0.63	0.14
116-1	0.386	19	47	1.38	406	0.02	7	2.15	0.46	0.27
117-1	0.293	21	43	1.12	543	0.02	5	2.26	0.43	0.33
118-1	0.251	22	42	1.18	313	0.02	6	2.48	0.40	0.35
119-1	0.387	21	47	1.18	358	0.02	16	2.34	0.51	0.32
123-1	0.287	23	46	1.31	371	0.02	5	2.38	0.46	0.29
124-1	0.244	23	64	1.46	509	0.02	8	2.59	0.43	0.35
126-1	0.250	21	73	1.78	380	0.03	11	2.74	0.42	0.43
128-1	0.552	48	191	3.07	79	0.01	2	4.85	0.87	0.19
133-1	0.246	17	40	1.15	391	0.01	9	2.31	0.42	0.30
134-1	0.212	22	51	1.36	832	0.02	14	2.68	0.39	0.35
135-1	0.216	21	47	1.28	434	0.02	6	2.55	0.37	0.35

sample#	P(%)	La(ppm)	Cr(ppm)	Mg(%)	Ba(ppm)	Tl(%)	B(ppm)	Al(%)	Na(%)	K(%)
136-1	0.256	23	39	1.21	503	0.02	3	2.15	0.44	0.28
137-1	0.385	21	41	1.13	469	0.01	10	2.09	0.45	0.32
139-1	0.250	23	49	1.79	379	0.05	8	2.35	0.41	0.33
142-1	0.232	21	32	1.02	339	0.01	8	2.22	0.38	0.33
143-1	0.244	24	44	1.16	895	0.02	16	2.68	0.42	0.40
144-1	0.210	17	118	2.11	360	0.03	8	2.70	0.41	0.33
145-1	0.180	14	259	4.19	374	0.05	8	3.26	0.36	0.32
147-1	0.221	23	144	2.85	470	0.05	7	3.25	0.52	0.46
148-1	0.243	19	33	1.48	1045	0.02	11	1.70	0.29	0.32
149-1	0.238	27	44	1.05	406	0.02	7	2.33	0.47	0.33
150-1	0.217	25	63	1.61	396	0.02	6	2.59	0.33	0.36
151-1	0.254	25	39	1.50	343	0.01	5	2.07	0.39	0.30
152-1	0.269	21	36	1.22	641	0.01	9	2.12	0.21	0.33
153-1	0.236	20	45	1.23	553	0.01	8	2.26	0.35	0.31
154-1	0.519	28	55	1.16	577	0.09	7	3.58	0.90	0.38
155-1	0.227	20	51	1.28	551	0.03	5	2.60	0.38	0.38
156-1	0.276	32	63	1.23	519	0.02	7	2.42	0.41	0.28
157-1	0.234	29	66	1.35	467	0.02	2	2.56	0.36	0.31
158-1	0.230	23	61	1.47	541	0.03	4	2.41	0.33	0.37
159-1	0.345	25	59	1.47	528	0.02	2	2.17	0.49	0.30
159-2	0.391	25	57	1.38	485	0.02	4	2.27	0.51	0.31
160-1	0.206	23	60	1.42	498	0.02	7	2.29	0.33	0.34
161-1	0.321	24	55	1.06	520	0.01	2	2.32	0.56	0.30
162-1	0.268	29	47	1.12	460	0.01	8	2.81	0.55	0.31
163-1	0.307	24	49	1.35	608	0.01	4	2.65	0.48	0.37
164-1	0.400	23	53	1.47	484	0.02	6	2.66	0.58	0.36
164-2	0.263	23	56	1.44	648	0.02	10	2.74	0.42	0.38
165-1	0.450	22	52	1.31	590	0.01	5	2.50	0.57	0.38
166-1	0.335	22	52	1.37	516	0.02	6	2.36	0.44	0.39
166-2	0.306	24	62	1.55	580	0.03	8	2.54	0.44	0.39
167-1	0.561	26	42	1.27	350	0.02	4	2.21	0.67	0.40
168-1	0.319	22	38	1.13	495	0.02	2	2.15	0.47	0.33

sample#	P(%)	La(ppm)	Cr(ppm)	Mg(%)	Ba(ppm)	Tl(%)	B(ppm)	Al(%)	Na(%)	K(%)
169-1	0.322	34	31	1.23	370	0.04	18	2.35	0.46	0.46
170-1	0.330	28	42	1.34	327	0.02	9	2.41	0.46	0.45
172-1	0.280	54	37	0.94	579	0.01	2	2.09	0.44	0.39
173-1	0.443	48	30	1.53	420	0.01	2	1.91	0.53	0.37
174-1	0.345	52	57	1.03	377	0.02	4	3.20	0.61	0.44
175-1	0.233	29	78	1.40	641	0.03	2	4.80	0.62	0.41
176-1	0.508	25	126	1.26	960	0.02	7	2.90	0.68	0.44
177-1	0.450	16	46	1.46	628	0.01	9	2.30	0.37	0.38
178-1	0.336	18	52	1.34	626	0.01	6	2.29	0.34	0.36
179-1	0.223	23	86	1.02	1141	0.01	2	3.72	0.51	0.31
181-1	0.875	25	55	1.18	554	0.02	18	2.64	1.16	0.32
182-1	0.354	17	109	0.98	1265	0.01	5	2.12	0.49	0.29
183-1	0.509	20	55	1.11	921	0.02	6	2.30	0.58	0.30
184-1	0.253	18	40	1.09	734	0.01	8	2.28	0.37	0.35
186-1	0.403	13	268	4.08	988	0.01	3	2.05	0.63	0.25
189-1	0.492	18	85	1.29	503	0.02	5	2.59	0.64	0.38
190-1	0.330	21	104	1.27	929	0.02	2	3.29	0.70	0.33
191-1	2.054	25	79	1.19	319	0.09	5	5.11	1.93	0.45
192-1	2.678	119	87	0.85	615	0.08	12	4.51	2.53	0.39
193-1	1.571	26	100	1.77	945	0.07	6	3.54	1.63	0.45
194-1	1.341	51	85	2.22	385	0.11	4	3.72	1.30	0.62
195-1	0.846	23	98	2.05	534	0.08	7	3.62	0.89	0.69
196-1	1.048	21	105	2.06	783	0.07	5	3.98	1.22	0.45
198-1	1.541	23	164	1.69	1340	0.05	8	5.15	1.61	0.39
199-1	2.080	49	74	1.74	355	0.07	10	3.24	2.22	0.65
203-1	0.928	31	120	2.22	458	0.10	4	5.61	1.22	0.83
206-1	0.986	16	193	3.27	299	0.13	2	7.36	1.31	0.62
207-1	1.973	28	130	1.68	368	0.01	3	2.69	2.19	0.24
208-1	3.038	47	99	1.23	533	0.03	13	3.24	2.96	0.35
209-1	1.169	66	91	1.62	272	0.05	5	4.46	1.30	0.44
210-1	2.063	27	74	1.35	394	0.05	12	3.84	2.26	0.43
211-1	0.653	22	83	1.85	1281	0.02	2	4.39	0.90	0.31

sample#	P(%)	La(ppm)	Cr(ppm)	Mg(%)	Ba(ppm)	Ti(%)	B(ppm)	Al(%)	Na(%)	K(%)
211-2	0.371	22	74	1.55	511	0.03	6	2.84	0.54	0.37
212-1	1.335	18	175	2.18	713	0.02	9	3.09	1.44	0.29
213-1	0.683	24	113	1.72	484	0.05	3	3.65	0.99	0.34
214-1	0.895	20	60	0.85	756	0.01	5	2.46	1.14	0.21
215-1	0.413	22	54	0.99	484	0.02	14	2.64	0.61	0.35
216-1	0.377	22	76	1.47	455	0.03	7	2.66	0.57	0.37
218-1	0.273	24	61	1.68	477	0.04	11	2.52	0.37	0.36
219-1	0.259	51	45	1.01	383	0.02	7	2.67	0.57	0.34
221-1	0.587	23	60	1.38	569	0.04	14	2.69	0.66	0.48
222-1	0.254	48	34	1.16	616	0.02	15	2.21	0.33	0.52
222-2	0.301	40	37	1.17	645	0.01	11	2.20	0.29	0.47
222-3	0.222	56	27	0.96	513	0.01	10	1.79	0.27	0.45
223-1	1.141	22	42	1.20	582	0.05	10	2.02	1.13	0.31

Appendix B

Geochemical results - heavy mineral fraction

sample #	Au (ppb)	As (ppm)	Ag (ppm)	Na (%)	Sc (ppm)	Cr (ppm)	Fe (%)	Co (ppm)	Ni (ppm)	Zn (ppm)	Se (ppm)	Br (ppm)
007-3	12	63	2	0.49	7.7	250	3.1	18	36	22	<5	<2
012-2	190	324	17	<43	48.5	4760	27.0	130	190	1300	<29	<13
012-3	490	405	10	<29	31.0	2300	15.0	43	77	760	<25	<10
019-1	22	57	12	<26	45.4	2700	18.0	62	66	1200	<21	<11
022-1	19	78	9	0.55	27.0	2800	11.0	54	99	1000	<10	<4
032-1	79	504	13	0.55	26.0	1300	37.0	210	490	1900	63	<4
036-1	150	52	5	0.29	56.8	4360	17.0	60	120	440	<5	<2
037-1	7	46	2	0.40	19.0	1300	7.2	32	130	470	<5	<2
038-1	281	681	8	<18	59.4	4220	29.3	190	300	470	<15	<2
038-2	67	847	11	<23	34.0	4270	31.0	220	390	980	38	<4
039-1	13	128	9	<18	85.0	6090	25.6	120	190	530	<12	<4.7
040-1	32	94	9	0.28	72.8	3380	24.3	160	110	310	<16	2.4
041-1	1400	117	14	<31	88.7	1200	15.0	91	<68	610	<34	<4
042-1	28	240	10	0.45	82.3	4920	25.6	100	140	650	<17	3.0
043-2	27	486	9	<22	42.8	6020	22.3	120	300	640	23	4.4
044-2	3340	391	10	<21	40.1	2060	32.0	280	250	500	28	<6.3
044-5	19	98	11	<29	78.3	5050	26.4	150	150	710	<17	<7.7
044-6	99	337	12	<25	47.7	3010	33.4	250	300	950	28	<8.4
045-1	37	99	14	<35	76.5	5110	26.0	130	210	1300	<10	<4
046-1	2600	144	11	<29	64.4	3930	28.8	97	190	740	<20	<8.1
047-1	16	47	11	<25	64.4	4170	21.8	110	230	780	<17	<7.9
048-1	49	342	11	<30	49.3	4320	36.6	280	360	990	<18	<6.5
049-1	30	92	13	<25	77.7	8310	25.0	110	260	780	<10	<10
049-2	30	117	10	<23	89.8	6460	27.9	110	200	660	<15	<6.3
052-1	23	98	14	<34	84.8	9550	25.0	110	250	1000	<10	<11
056-1	40	69	20	<65	77.4	2600	25.0	81	180	1300	<37	<13
057-1	1030	93	18	<59	64.4	9860	24.0	95	250	1100	<30	<4
057-2	1400	132	15	<42	58.3	9710	24.0	110	260	750	<25	<6.6
059-1	14	31	9	<19	96.9	4500	18.0	93	90	430	<12	<5.8
059-2	15	44	9	<23	99.2	5190	20.8	130	200	410	<11	<6.2
060-1	462	89	13	<32	78.5	9350	25.0	130	220	1100	<20	<9.8
061-1	31	117	15	<63	87.1	2200	26.0	83	160	1100	<27	<12

sample #	Au (ppb)	As (ppm)	Ag (ppm)	Na (%)	Sc (ppm)	Cr (ppm)	Fe (%)	Co (ppm)	Ni (ppm)	Zn (ppm)	Se (ppm)	Br (ppm)
062-1	72	469	11	<34	686	2860	31.4	140	270	920	<20	3.5
063-1	26	164	13	<42	578	9830	22.0	86	130	870	<21	<12
065-1	40	91	10	<33	776	4070	21.9	73	110	690	<18	<7.4
066-1	45	214	11	0.44	501	6030	22.0	110	170	910	<10	<4
067-1	13	68	9	0.47	899	7080	23.5	96	170	630	<13	3.7
068-1	14	85	9	<26	760	6140	24.4	99	140	480	<15	<5.9
069-1	232	167	10	<32	632	6110	32.6	360	200	410	<16	<6.9
070-1	22	77	13	<42	769	9020	25.0	99	200	860	<10	<10
071-1	19	54	11	<31	776	12800	24.2	89	240	510	17	<7.9
072-1	11	38	7	0.31	788	7840	21.3	89	210	370	<5	<2.0
073-1	25	62	14	<42	638	9360	22.0	98	190	890	<10	<4.0
074-1	21	46	12	<37	610	6400	18.0	58	160	610	<10	<4.0
075-1	12	16	8	0.43	1050	1400	25.1	78	100	510	<5	<4.6
076-1	54	422	10	<38	372	15700	30.3	170	350	830	29	<8.5
076-3	16	68	10	<39	585	16400	26.1	110	310	560	<17	<7.3
077-1	20	383	11	<38	675	6700	25.9	130	270	740	<19	<7.4
078-1	18	20	12	<28	99.4	5510	23.0	86	120	800	<10	<9.1
078-3	25	94	10	0.57	90.4	7680	27.3	110	220	440	<17	<6.8
079-1A	7	4	4	0.37	67.4	3430	20.5	140	300	300	<5	<2
080-1	120	206	8	<24	477	6460	20.6	120	190	420	<12	<5.6
080-2	54	179	7	<23	44.4	6620	20.0	130	210	400	<11	<5.3
081-1	17	37	9	<35	50.8	16700	20.3	77	130	700	<14	<7.8
081-2	12	33	8	<29	60.3	12100	20.1	80	210	490	<11	<5.3
081-3	92	525	15	<56	48.5	8340	31.0	150	260	660	<27	<14
082-1	160	634	12	<45	39.8	2400	39.0	200	440	1300	68	<9.7
082-2	287	779	11	<34	52.0	5180	42.3	240	520	1100	66	<7.6
082-4	37	143	17	<78	72.6	4390	27.0	91	220	1000	<29	<16
083-2	79	403	11	<39	40.0	5800	29.3	190	390	1400	40	<8.7
083-4	46	386	12	<39	64.7	18300	35.0	180	400	1000	<20	<8.4
085-1	120	551	9	<38	37.7	8270	31.6	190	390	750	34	<7.2
086-1	85	300	13	<60	48.8	10400	31.0	160	280	900	36	<12
087-1	12	16	8	0.35	123.0	3240	20.9	77	95	350	<5	2.7

sample #	Au (ppb)	As (ppm)	Ag (ppm)	Na (%)	Sc (ppm)	Cr (ppm)	Fe (%)	Co (ppm)	Ni (ppm)	Zn (ppm)	Se (ppm)	Br (ppm)
088-1	130	37	8	<30	94.2	7270	30.1	120	210	650	<13	<5.2
089-1	21	69.2	13	<56	79.1	12400	27.7	120	330	1100	<19	<9.9
153-1	28	248	14	<76	77.3	7720	35.9	170	520	750	<24	<10
154-1	21	50	13	<51	102.0	4640	33.6	100	220	430	<18	<8.6
155-1	28	67	15	<70	91.1	5900	28.0	120	320	860	<22	<12
156-1	42	57	14	<54	57.1	11100	36.0	220	690	800	<21	<12
157-1	23	90	13	<59	53.3	6460	39.0	140	270	740	<21	<11
158-1	55	116	17	1.10	63.2	11000	40.0	140	320	1200	<27	<15
159-1	43	61	14	<59	52.1	8820	24.0	85	190	880	<24	<4
159-2	50	156	15	<60	60.9	7730	33.0	130	240	1100	<24	<13
160-1	59	63	18	<57	56.3	7160	22.0	87	110	1500	<25	<4
162-1	4790	289	15	<56	46.7	5540	28.0	240	190	770	<30	<14
164-1	34	56	18	<88	82.5	14100	29.0	95	250	1200	<31	<15
164-2	28	45	16	<85	65.4	8470	20.0	71	170	960	<27	<16
165-1	30	118	16	<76	69.9	10000	26.0	130	210	1500	<28	<14
167-1	31	69	7	0.72	29.0	3400	13.0	69	83	360	<14	<5.6
169-1	180	104	18	<1.5	57.4	3000	25.0	140	<94	970	<33	<16
173-1	657	323	15	<71	72.6	4080	23.0	82	140	960	<30	<16
175-1	53	61	17	<73	65.8	5960	25.0	82	150	1300	<28	<17
221-1	39	64	15	<58	79.6	16800	30.0	120	330	680	<25	<12
222-1	72	154	13	<66	72.7	4000	21.0	99	<64	560	<23	<12
222-2	63	128	14	<66	66.4	3400	22.0	100	82	740	<23	<12
222-3	44	100	10	<99	65.0	3500	21.0	74	130	930	<25	<10
223-1	985	43	10	<46	75.8	5610	22.5	87	240	350	<15	<7.1

sample #	Rb(ppm)	Zr(ppm)	Y(ppm)	Cd(ppm)	Sn(ppm)	Sb(ppm)	Te(ppm)	Cs(ppm)	Ba(ppm)	La(ppm)	Ce(ppm)	Sm(ppm)
007-3	88	1500	6	<5	<100	26	<10	26	2100	34	60	7.7
012-2	55	34000	22	<41	<620	170	<110	<29	20400	527	940	79.1
012-3	77	72000	23	<25	<500	82	<50	<25	2600	170	330	27.0
019-1	47	31000	22	<30	<410	76	<71	<22	7300	240	380	40.1
022-1	49	3500	22	<23	<200	64	<55	<10	12300	180	310	26.0
032-1	<36	2200	60	<34	<540	51.6	<98	<22	32400	290	440	33.0
036-1	38	5900	13	<12	<100	91	<30	<05	23800	282	460	41.8
037-1	62	1000	23	<5	<100	100	<23	28	28800	130	220	20.1
038-1	24	4600	21	<20	<300	181	66	<14	16000	361	614	56.6
038-2	35	340	20	<28	<430	170	<76	<10	14500	270	420	40.0
039-1	<20	6200	12	<19	<230	102	<43	<14	13500	349	601	52.9
040-1	34	10000	18	<21	<250	120	<49	<15	13900	409	778	66.4
041-1	47	15000	17	<32	<410	100	<77	<24	26700	330	610	55.1
042-1	29	6300	18	<24	<340	152	<59	29	30300	393	674	58.7
043-2	<26	3700	21	<23	<340	191	<60	<16	15500	323	532	52.3
044-2	32	5400	22	<24	<360	266	<63	<16	11100	257	430	41.1
044-5	<29	6200	21	<27	<360	134	<61	<19	14900	362	585	52.9
044-6	32	2900	24	<29	<410	232	<71	<19	10300	257	420	36.4
045-1	<34	<1700	17	<33	<450	100	<76	29	11800	270	500	49.2
046-1	<30	7800	20	<27	470	126	<65	<19	15100	356	619	57.4
047-1	<27	4600	15	<25	<340	88	<58	<18	16600	312	570	50.5
048-1	<29	4700	32	<26	<320	249	<64	<17	28400	475	804	83.8
049-1	<32	3800	16	<31	<200	100	<67	<22	8300	260	450	38.0
049-2	33	4200	22	<24	<300	112	<52	<16	11200	357	644	59.6
052-1	35	1700	22	<32	<410	95	<71	<23	20300	260	460	39.0
056-1	<54	17000	13	<53	<740	150	<130	<33	>90000	1150	1920	179.0
057-1	<46	6900	21	<46	<600	150	<100	<31	23100	589	980	84.0
057-2	<38	510	20	<35	<480	160	<85	<25	16300	539	880	71.9
059-1	<19	3200	5	<21	<250	37	<43	<14	8350	237	400	45.1
059-2	<21	2000	16	<22	<270	42	<46	<15	15500	201	390	45.6
060-1	<31	6300	16	<32	<420	150	<72	<22	17200	350	560	52.7
061-1	<42	17000	24	<41	<500	190	<100	<25	69100	999	1800	146.0

sample #	Rb(ppm)	Zr(ppm)	Mo(ppm)	Cd(ppm)	Sn(ppm)	Sb(ppm)	Te(ppm)	Cs(ppm)	Ba(ppm)	L(ppm)	Ce(ppm)	Sm(ppm)
062-1	46	10000	28	<29	<400	310	<71	2.0	38400	657	1160	98.9
063-1	<36	7200	16	<35	<470	110	<84	<23	29700	485	850	65.6
065-1	<25	57400	17	<28	<310	90	<61	<1.7	7830	419	771	63.4
066-1	<28	3600	23	<28	<200	110	<64	2.3	13300	340	600	47.6
067-1	<22	3400	13	<22	<260	64	<46	<1.5	7110	280	480	43.1
068-1	<23	3300	16	<22	<270	82	<48	<1.5	13200	453	819	66.0
069-1	<27	4400	14	<25	<320	94	<55	<1.7	9500	406	703	63.4
070-1	<34	4500	18	<32	<410	74	<68	<2.2	12700	416	690	58.7
071-1	<28	3900	16	<27	<290	63	<57	<1.9	13700	355	645	53.6
072-1	22	3800	6	<16	<100	58	<33	<1.1	6300	267	450	43.2
073-1	<35	3500	<7	<36	<420	85	<76	<2.5	11100	35	520	55.1
074-1	38	4300	<6	<30	520	55	<63	<2.0	9200	300	500	51.0
075-1	<18	2100	10	<19	<210	20	<34	<1.3	320	110	200	23.5
076-1	<29	3600	18	<29	<380	140	<68	<1.8	29800	373	643	53.0
076-3	<27	6800	13	<26	<320	105	<57	<1.7	18200	559	983	83.4
077-1	<27	4000	14	<28	<350	146	<63	<1.8	23100	483	797	71.7
078-1	30	2600	11	<28	<200	24	<53	<1.0	4600	130	220	21.0
078-3	<26	4100	11	<25	<300	62	<53	<1.6	16100	420	764	70.2
079-1A	<10	1600	2	<11	<100	10	<10	<0.5	190	97	170	17.0
080-1	<19	2800	14	<21	<260	111	<47	<1.3	19200	249	490	39.3
080-2	<18	3200	9	<19	<230	100	<42	<1.1	11200	250	420	38.3
081-1	<24	6800	10	<25	<300	55	<51	<1.6	8390	268	500	39.6
081-2	<18	8000	8	<20	<230	54	<41	<1.3	9200	270	522	43.1
081-3	<42	7800	25	<44	<580	24	<100	<2.5	30900	533	900	72.6
082-1	39	3400	25	<36	<470	302	<86	<1.9	21200	320	549	48.0
082-2	<30	4400	17	<32	<410	279	<74	<1.9	12200	294	520	46.5
082-4	<44	2200	25	<51	<630	140	<110	<3.1	42700	471	770	69.0
083-2	32	2200	14	<30	<380	211	<70	<1.8	12700	272	420	40.0
083-4	<28	2900	11	<32	<370	162	<65	<1.9	9370	287	550	46.7
085-1	<25	3200	16	<27	<300	212	<60	<1.5	7990	313	511	43.2
086-1	<36	4600	29	<37	<470	200	<84	<2.3	16500	423	810	62.0
087-1	35	2000	5	<19	<100	19	<33	<1.2	370	100	200	22.8

sample #	Pb(ppm)	Zr(ppm)	Mol(ppm)	Cd(ppm)	Sn(ppm)	Sb(ppm)	Te(ppm)	Cs(ppm)	Ba(ppm)	La(ppm)	Ce(ppm)	Sm(ppm)
088-1	24	6500	9	22	210	59	39	14	1300	460	842	78.9
089-1	31	5300	15	35	410	112	72	21	28600	478	843	68.8
153-1	40	5400	27	40	490	263	87	24	30500	932	1650	152.0
154-1	31	3700	7	34	350	78	61	30	730	364	646	62.1
155-1	37	5000	20	42	480	68	86	25	26800	495	850	74.7
156-1	47	14000	16	40	450	100	80	25	13200	280	520	49.5
157-1	35	6400	18	38	430	120	75	23	13200	300	540	52.4
158-1	47	10000	27	50	560	150	100	28	24000	424	790	68.1
159-1	37	12000	15	41	450	77	75	24	6600	240	490	41.4
159-2	41	14000	18	44	490	140	88	26	8000	330	570	53.7
160-1	42	10000	17	49	480	89	99	30	8200	270	430	38.0
162-1	38	22000	19	44	550	202	100	25	10900	270	440	37.0
164-1	47	22000	11	51	570	100	100	30	12700	659	1190	100.0
164-2	42	15000	16	48	540	79	95	29	10000	511	810	63.0
165-1	41	15000	24	46	540	130	110	28	17700	457	830	65.9
167-1	41	7200	11	21	200	61	41	17	7890	435	731	52.2
169-1	58	12000	19	59	650	100	110	33	14600	2120	3040	220.0
173-1	39	90000	20	51	580	110	110	26	5200	340	630	54.6
175-1	38	37000	32	50	550	120	96	25	240	360	560	42.4
221-1	37	4000	17	46	430	120	78	25	15300	370	700	64.1
222-1	33	90000	17	44	430	100	86	23	7700	447	790	65.8
222-2	33	62900	12	43	460	92	81	22	5900	380	670	56.3
222-3	25	90000	35	53	500	91	130	25	8500	480	910	80.0
223-1	24	5000	6	28	290	77	51	1.7	8980	336	586	53.4

sample #	Eu(ppm)	Tb(ppm)	Yb(ppm)	Lu(ppm)	Hf(ppm)	Ta(ppm)	W(ppm)	Ir(ppb)	Th(ppm)	U(ppm)
007-3	<1	12	4	0.4	22	1.3	<7	<50	9.4	3.8
012-2	9	93	29	5.2	544	170	<43	<100	88.3	26.0
012-3	<5	63	45	8.2	1110	110	<20	<250	45.0	28.0
019-1	<2	64	26	5.3	512	94	<19	<100	43.9	20.0
022-1	<2	37	11	1.5	60	70	<14	<100	27.0	8.6
032-1	6	42	12	1.2	65	50	<19	<100	51.1	19.0
036-1	5	50	13	2.2	112	100	<8	<50	42.5	11.0
037-1	2	23	4	0.8	19	31	9	<50	20.0	7.3
038-1	4	50	14	2.2	81	110	<41	<50	60.1	14.0
038-2	4	48	10	2.0	54	79	<20	<100	46.3	12.0
039-1	6	62	17	3.1	120	130	<54	<50	60.5	14.0
040-1	8	110	35	5.3	202	230	<35	<50	88.7	29.9
041-1	12	160	60	<8.4	348	420	<45	<100	245.0	72.1
042-1	8	74	19	3.6	146	150	<65	<100	69.7	17.0
043-2	5	53	12	1.5	59	140	<24	<50	54.4	14.0
044-2	4	57	19	2.1	93	120	<27	<100	56.3	17.0
044-5	7	70	22	3.3	113	160	<36	<110	58.1	16.0
044-6	4	37	14	2.4	59	100	<18	<120	45.1	18.0
045-1	6	45	13	1.5	46	110	<23	<100	47.6	11.0
046-1	7	86	30	4.1	152	200	<35	<110	74.2	22.9
047-1	8	57	16	2.4	85	160	<20	<100	53.0	13.0
048-1	9	100	23	3.1	100	160	<27	<110	94.3	21.0
049-1	4	47	14	2.3	80	130	<22	<100	40.6	10.0
049-2	7	71	19	2.9	79	160	<30	<50	57.2	12.0
052-1	7	56	16	2.7	32	120	<23	<100	40.0	7.8
056-1	21	150	28	4.2	372	250	<160	<220	183.0	45.7
057-1	10	110	33	3.8	150	200	<50	<100	83.9	22.0
057-2	11	100	27	2.9	97	180	<34	<100	70.3	16.0
059-1	8	68	15	2.5	49	47	<16	<50	31.3	8.2
059-2	7	66	16	2.5	45	48	<17	<50	28.3	8.2
060-1	7	100	28	4.7	100	160	<24	<100	55.9	16.0
061-1	16	110	27	4.2	320	160	<29	<100	160.0	39.0

sample #	Eu(ppm)	Tb(ppm)	Yb(ppm)	Lu(ppm)	Hf(ppm)	Ta(ppm)	W(ppm)	Ir(ppb)	Th(ppm)	U(ppm)
062-1	9	74	19	28	198	130	<22	<120	95.8	26.2
063-1	11	71	17	28	140	110	<25	<100	70.2	160
065-1	6	100	53	91	981	180	<41	<110	82.6	35.2
066-1	7	39	12	20	67	92	<26	<100	41.3	94
067-1	6	54	17	27	78	140	<17	<50	41.0	91
068-1	8	71	22	32	76	180	<22	<50	58.9	110
069-1	7	80	25	40	105	140	<66	<50	65.9	160
070-1	7	71	19	36	87	170	<32	<100	57.8	100
071-1	7	73	24	35	86	150	<35	<100	57.6	110
072-1	5	55	18	26	72	140	18	<50	46.3	100
073-1	7	67	21	29	65	150	<36	<100	56.7	100
074-1	7	74	22	23	77	150	<61	<100	54.1	100
075-1	3	35	10	17	36	110	17	<50	20.0	4.3
076-1	5	44	8	13	70	54	<19	<110	55.6	100
076-3	12	92	25	34	124	160	<20	<100	93.9	160
077-1	7	71	17	20	80	150	<21	<110	70.5	140
078-1	4	39	10	13	34	87	<22	<100	17.0	2.8
078-3	7	73	23	33	81	180	<48	<50	72.4	120
079-1A	2	21	5	10	27	39	10	<50	15.0	20
080-1	4	33	9	12	59	43	<15	<50	34.3	8.2
080-2	3	36	7	14	65	51	<14	<50	37.4	7.6
081-1	3	40	11	20	137	75	<19	<50	44.2	120
081-2	4	44	13	19	145	73	<20	<50	47.2	130
081-3	<5	65	9	22	140	95	<31	<100	75.5	200
082-1	5	50	10	16	71	59	<24	<130	45.3	100
082-2	4	47	12	22	77	120	<32	<120	56.5	160
082-4	9	59	10	21	38	170	<40	<100	66.7	8.3
083-2	6	47	17	12	51	79	<23	<110	39.3	100
083-4	5	57	20	26	70	130	<24	<110	49.7	150
085-1	3	45	15	18	68	70	<19	<50	48.9	8.4
086-1	6	56	12	20	82	93	<34	<100	76.8	150
087-1	3	29	9	13	33	66	<17	<50	15.0	2.3

sample #	Eu(ppm)	Tb(ppm)	Yb(ppm)	Lu(ppm)	Hf(ppm)	Ta(ppm)	W(ppm)	Ir(ppb)	Th(ppm)	U(ppm)
088-1	10	7.2	21	2.7	126	16.0	24	<50	72.1	15.0
089-1	8	6.7	14	2.5	111	14.0	<28	<120	68.4	15.0
153-1	14	14.0	23	3.7	101	21.0	<77	<140	123.0	18.0
154-1	7	7.4	24	3.4	88	19.0	<31	<120	56.9	12.0
155-1	10	6.6	17	3.0	81	14.0	<35	<100	67.1	13.0
156-1	<2	7.0	20	3.1	223	13.0	<32	<100	54.2	16.0
157-1	4	6.4	18	2.5	120	15.0	<30	<100	64.1	15.0
158-1	6	7.6	29	3.1	180	16.0	<69	<100	78.1	19.0
159-1	5	6.6	21	3.7	219	19.0	<32	<100	59.1	18.0
159-2	5	8.1	22	3.9	259	23.0	<36	<100	72.1	22.0
160-1	<5	5.1	25	2.7	212	16.0	<40	<100	56.0	19.0
162-1	5	6.9	40	5.8	407	22.0	<35	<100	62.0	28.0
164-1	7	15.0	58	7.9	361	29.0	<120	<100	187.0	42.2
164-2	12	11.0	49	5.8	264	18.0	<42	<100	129.0	32.0
165-1	9	10.0	38	5.6	285	18.0	<48	<100	93.8	29.0
167-1	3	6.9	28	3.5	143	16.0	<56	<50	126.0	39.8
169-1	19	29.0	54	<6.4	242	21.0	<48	<200	566.0	69.8
173-1	<5	12.0	81	<15.0	1770	21.0	<40	<100	84.0	47.3
175-1	7	6.2	34	6.5	597	14.0	<42	<100	64.8	21.0
221-1	4	6.6	17	2.5	62	24.0	<36	<100	49.0	10.0
222-1	7	13.0	75	<12.0	1480	19.0	<34	<100	89.1	46.7
222-2	5	10.0	52	8.8	1010	20.0	<68	<100	73.1	32.0
222-3	<5	14.0	89	<15.0	2030	18.0	<46	<250	116.0	61.0
223-1	6	6.5	19	2.7	95	17.0	<38	<50	51.5	11.0

LEGEND

NE OF TINTINA FAULT

Tertiary

T

Tr, rhyolites dated as Paleogene; Tb, basalts dated as Paleogene; Tm, mixed volcanics of known Paleogene age; Tur, undated rhyolites likely of Paleogene age; Tub, undated basalts likely of Paleogene age; Ts, sandstone, conglomerate, and shale.

Mid-Cretaceous

K

Ksf, South Fork Volcanics : crystal lithic tuff; Ks, quartz monzonite, granite and granodiorite

Allochthonous Assemblages

Pennsylvanian and Permian

CPa

Anvil Allochthonous Assemblage : Cpa, undivided; CPav, basalt, tuff, and breccia, CPat, chert, and siliceous tuff; CPal, limestone; CPAub, dunite, peridotite, pyroxenite, and serpentinite.

Carboniferous to Triassic

CTn

Nisutlin Allochthonous Assemblage : metaquartzite, biastomylonite, phyllite, quartzite, schist, sand conglomerate

Autochthons

Carboniferous or Permian

Pc

limestone

Upper Devonian and Mississippian

uDMfcg

chert pebble conglomerate

Silurian and Lower Devonian

OSDqc

calcareous and dolomitic graphitic siltstone

Cambro-Ordovician

COr

shaly limestone to calcareous phyllite

Lower Cambrian

Cg

slate and siltstone and metamorphosed equivalents near intrusions

?Cambrian?

Pn

augen gneiss

SW OF TINTINA FAULT

Mid-Cretaceous

Kg

diorite, granodiorite, and granite

Autochthons

Ordovician to Devonian

ODsl

black siliceous and pyritic slate

? Ordovician and Silurian ?

OSsl

calcareous graphitic slate and graphitic siliceous and pyritic slate

? Cambrian, Ordovician, Silurian, and Lower Devonian ?

COSDsl

calcareous shale, siltstone, and argillaceous limestone

?Cambrian and Ordovician ?

COcsl

calcareous siltstone, argillaceous limestone

Symbols

Fault, thrust (teeth on upper plate)

Fault, steeply dipping (barb on downthrown side)

Dextral slip fault

Figure 2.(b) Legend for the geological map Fig. 2a, modified from Gordey and Irwin (1987), Tempelman-Kluit (1977); and Jackson et al. (1986)

END

1 9|0 9.9|0

FIN