Glacial Flow Patterns and Till Geochemistry in the Eastern Manson River

Map Area (NTS 93 K), Central British Columbia

By

Caroline Ann West

A thesis submitted to the Faculty of Science

in partial fulfillment of the requirements

for the degree of Master of Science

Ottawa-Carleton Geoscience Centre

and

Department of Earth Sciences

Carleton University

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Area (NTS 93 K), Central British Columbia

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in partial fulfillment of the requirements

of the degree of Master of Science

A handwritten signature in black ink, appearing to read 'M. Condell', is written over a horizontal dotted line.

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Abstract

The reconstruction of ice flow patterns and till composition data, with emphasis on rare-earth element (REE) content in till, are presented for a region which straddles the contact between the Intermontane Superterrane and the Omineca Crystalline Belt of central British Columbia.

Glacial ice flow history was reconstructed using ice flow indicators (striae, flutings, drumlins, crag and tails), fabric analyses, and vertical composition variability of till and glaciofluvial sediments. Results show that glacier ice in the study area flowed initially southward from the northern Wolverine Ranges into tributary valleys of the Manson River, at the onset of Fraser Glaciation. Ice flow then changed direction to flow eastward, parallel to the Manson River in the western part of the study area, and northward in the eastern part.

Four distinct geochemical anomalies in till occur along the Manson fault zone within the study area. Their extent and shape have been defined using glacial ice flow reconstruction, till geochemistry and till clast abundances. Anomalous concentrations of REE help to define two of the anomalous zones with characteristic geochemical and lithological dispersal patterns. Pegmatite and carbonatite dikes in the southernmost extension of the Wolverine Complex, are shown to be the source of high REE levels in the till.

A partitioning study conducted to determine the residence sites of the REE in till, along with geochemical and heavy mineral analyses demonstrate that REE concentrations are

highest in the fine sand - to silt-sized fraction of till, and are most likely bound in primary minerals (ie allanite). For future exploration purposes, analysis of REE in this size fraction range should be adequate to map the shapes of dispersal halos in till, and to ultimately define a bedrock source.

Acknowledgments

I especially thank Alain Plouffe of the Geological Survey of Canada for initially offering me this project, and for acting as my thesis supervisor. He provided me with invaluable guidance and constructive criticism throughout the project.

I also thank Dr. J.A. Donaldson of Carleton University for acting as my thesis supervisor. His assistance and helpful comments have been much appreciated. Thankyou for your confidence and support.

Many thanks to Dr. W.W. Shilts for acting as my initial external thesis supervisor, and teaching me a great deal about glacial geology.

I am grateful to A. Mouton, C. McPhee, and E. MacDonald for their assistance in the field.

Technical and financial support for this project were provided by the Geological Survey of Canada and Carleton University (NSERC Grant to J.A. Donaldson).

Special thanks go to my family for their ongoing love and support. Thanks to John for his technical help, to Sarah for her constant positive reinforcement, and especially to Mum and Dad for the use of their computer! I love you all.

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CHAPTER 1: *Introduction*

Along the boundary between the Intermontane and Omineca belts of the Canadian Cordillera, the potential for economic mineral deposits has to a great extent already been recognized and exploited on the basis of bedrock mapping and prospecting. In regions covered by Quaternary sediments, these approaches to exploration are greatly hampered and require alternative methods and approach. Geochemical exploration using glacial sediments (primarily till) is a valuable tool in such areas, and is the main focus of this thesis.

1.1 *Purpose and Background of Study*

As part of the Canada-British Columbia Agreement on Mineral Development (CBCAMD) which took place from 1991 to 1995, a reconnaissance till sampling program was implemented in central British Columbia (figure 1.1). Geochemical analyses of regional reconnaissance till samples collected during 1991 and 1992 indicated anomalous concentrations of rare-earth elements (REE), along the Manson fault zone (the contact between the Omineca Crystalline Belt and the Intermontane Belt), and more specifically to the northeast of Munroe Creek (Plouffe *et al.*, 1993). Pegmatite and carbonatite dikes in the southernmost extension of the Wolverine Complex, part of the Omineca Crystalline Belt, were inferred to be the source of minerals that contributed high REE values to the tills. Indeed, previous studies by Pell (1987) and Halleran and Russell (1993) indicated that both rock types (pegmatite and carbonatite dikes) are highly enriched in REE compared with the host

Figure. 1.1 Location of Study Area

rocks. No research has been conducted on the glacial transport and mode of occurrence of REE in till, however, and this thesis will endeavor to fill part of this gap.

Furthermore, the Wolverine Ranges located in the study area, a mountainous terrain characterized by peaks, cirques and aretes that reach 1500m above sea level, could have been a source of ice at the onset and/or at the end of the last glaciation. This prompted the need for further investigation into the glacial ice flow history.

Following these findings, a Master's of Science project was proposed which had a mandate to reconstruct glacial ice flow history in the study area, to define the extent of the geochemical anomalies and to determine their source, to link the shape of metal dispersal halos in till to regional ice flow directions, and to study the mode of occurrence REE in till by conducting a partitioning study of REE in different grain size fractions of till.

1.2 Objectives

The field portion of this study was carried out in 1993, and involved: (1) detailed sampling in the study area, with particular focus in places where pegmatite and carbonatite dikes are known to occur; (2) measurements of till fabrics; and (3) a local stratigraphy study to constrain the ice flow history of the area by defining source lithologies, glacial trains, and ice flow directions. Following the field work, geochemical analyses, pebble and heavy mineral counts were conducted in the laboratory. Also, a more detailed study was conducted on those samples with anomalous REE values, using size partitioning techniques in order to evaluate REE

origins, concentrations, characteristic grain sizes, and REE residence sites.

The objectives of this study were:

1. To reconstruct the glacial ice flow history of the study area by measuring ice flow indicators such as bedrock striations and till fabric analyses.
2. To determine the extent and shape of the geochemical anomalies in till by analyzing geochemical patterns of glacial dispersal using specific grain size fractions.
3. To define the potential bedrock sources of the geochemical anomalies by linking the till geochemistry and mineralogy with ice flow direction.
4. To study the residence sites of REE in till.

To document the glacial dispersal from the Wolverine pegmatite and carbonatite intrusions, till samples were collected from sites located on, up-ice, and down-ice from pegmatite and carbonatite dikes.

To define the source of the anomalies, till samples were analyzed geochemically, and studies of pebble lithology and heavy mineral counts were completed. The results were compared with bedrock samples also collected, to document the physical and geochemical nature of the bedrock mineralization.

To establish more concisely the ice flow history of the study area, numerous glacial sediment sections were examined, described and sampled in detail. Lithostratigraphic units were defined on the basis of texture, sedimentary

structures, colour, clast composition, contact relationships and lateral continuity.

To study the residence sites of REE in till, a partitioning study of selected till samples was conducted defining geochemical concentrations in specific grain size fractions of till.

1.3 *Previous Work*

The first studies of the glacial history of the interior of British Columbia were conducted by G.M. Dawson. From 1875 to 1890, Dawson studied the glacial features from the last glaciation known as the Fraser Glaciation (Late Wisconsinan) which affected north-central British Columbia. From these observations, he developed the concept of the Cordilleran Ice Sheet (Dawson, 1878; 1881; 1888; 1889). Armstrong and Tipper (1948) and later Armstrong (1949) refined this concept, observing that ice flow in the northern interior was generally to the east and northeast from a source in the Coast and Skeena mountains.

Subsequent studies have been made over the past several decades, adding to the complexity of this ice flow regime. Of particular relevance are studies by Tipper (1971a,b), who rejected the hypothesis of radial flow from a central accumulation zone during the last glaciation within the Cordilleran ice sheet (Dawson, 1889; Kerr, 1934; Flint, 1971), and proposed that piedmont glaciers flowed from three accumulation zones in the Coast, Omineca, and Cariboo mountains. More recently, detailed surficial mapping of the region has provided

data on ice flow patterns which concurs with this model for the last glaciation (Plouffe, 1991; 1992; 1993; 1995; 1996; 1997; Ryder et al, 1991a,b).

As part of the Canada British Columbia Mineral Development Agreement, the Geological Survey of Canada initiated a regional mapping project of the surficial materials in a region of north-central British Columbia, including the Manson River map area (NTS 93K) which contains the study area of this thesis. The project is headed by A. Plouffe of the Geological Survey of Canada in Ottawa, and the objectives of the project (of which this thesis is a part) are to map the surficial materials of the area, to test and develop drift prospecting techniques in this region of central British Columbia, to investigate and document the regional till geochemistry, and to establish more details of the glacial history (Plouffe, 1997).

The bedrock geology within and surrounding the study area was earlier investigated by J.E. Armstrong, who produced a 1:250 000 scale map of the area (Armstrong, 1949). This has been updated by 1:50 000 scale mapping completed by the British Columbia Geological Survey during the past decade (Ferri *et al*, 1988; 1989; 1990; 1994).

To evaluate the economic potential of the region, mineral occurrences in the region have recently been documented by the British Columbia Geological Survey (Melville, 1990; Melville *et al*, 1993). Among these, and of particular relevance to this thesis project specifically, is the occurrence of REE bearing pegmatites in the Wolverine Metamorphic Complex (Halleran *et al*, 1993), and the occurrence of

uranium and rare-earth elements in the Lonnie Carbonatite Complex along the Wolverine fault zone (Halleran, 1980; Pell, 1987; Ferri *et al*, 1988).

1.4 *Geochemical Dispersion by Glacial Processes*

Introduction

Although many studies have dealt with glacial processes and their effect on the dispersal of various elements, there is no standardized technique for displaying on maps the data obtained from mapping the geochemical analyses of materials derived from glaciated terrains. Such analyses are project specific, or even site specific, depending on the sampling medium and therefore, are not representative of any general technique developed to report geochemical dispersal created by glacial processes. Prior to discussing the geochemical dispersal patterns in relation to regional ice flow directions in the study area, using till as a sample medium, it is useful to briefly discuss how glacial processes in general, affect the geochemical nature of glacial sediments.

It is essential to understand specific characteristics of tills concerning their geochemical nature in order to fully comprehend what geochemical results may be derived from them. Every rock type has a specific chemical composition - a unique geochemical signature controlled by the proportion and variation of elements within the rock. This signature depends on the origin and geologic history of the rock, and can be used as a geochemical fingerprint to identify the individual clasts

found in till (Hawkes *et al*, pg.14).

Till is the glacial sediment most widely used in geochemical studies of surficial sediments because 1) it is the most common glacial sediment, comprising much of the overburden that obscures a very large portion of the bedrock terrain in the northern hemisphere (Shilts, 1976); and 2) it is considered the first derivative of bedrock. Till is defined as “a sediment that has been transported and deposited by or from glacial ice with little or no sorting by water” (Dreimanis, 1982), and therefore can have a chemical signature very similar to the bedrock from which it was derived. The utility of till sampling as a successful exploration tool has been recognized extensively over the past few decades (Coker *et al*, 1989).

In general, metal concentrations in till are greatest near the source and decrease exponentially with increased distance as a result of the comminution of minerals with distance (Shilts, 1976) and dilution resulting from the addition of geochemically barren material during glacial transport (Dreimanis *et al*, 1971; DiLabio, 1985; Whiting *et al*, 1991). The net result is a geochemical dispersal train with a shape that is influenced by many factors such as till thickness, the presence of multiple till sheets, ice flow directions and the presence of materials overlying the till (Govett, 1973).

Geochemical Partitioning - Residence Sites of Elements in Till

The chemical composition of till is related to texture. Glaciers produce till by crushing, abrasion and other mechanical means. The combination of these processes create different effects on various lithologies and mineral types, most notably with respect to grain size. Till is therefore composed of different size fractions of rocks and minerals, ranging from large boulders to clay-size particles. The particle size distribution in till depends on the bedrock lithologies and sediment types eroded by the glacier and the mode of transport: subglacial, englacial or supraglacial (Shilts, 1991; 1994).

Furthermore, through glacial action, rocks can be broken down into their natural mineral grain size or "terminal modes". A terminal mode is "the final product of glacial comminution and its particle size range for each mineral depends on the original sizes of the mineral grains while still in rocks, and on the resistance of each mineral against comminution during glacial transport" (Dreimanis *et al*, 1972). Glacial milling thus causes minerals to be broken down to characteristic grain sizes which is controlled by individual mineralogic traits such as mineral type, original grain size, cleavage and hardness (Shilts, 1994). Furthermore, minerals having peaks of abundance at specific grain size ranges allows for particular elements contained in the minerals to be concentrated in specific grain sizes or "residence sites" in till (DiLabio, 1988). Using this premise, a grain size partitioning study can be used to demonstrate chemical partitioning by size, whereby individual till samples are divided into specific grain sizes fractions and

are then geochemically analyzed.

A common problem when analyzing till geochemically is finding the correct grain size fraction to submit for analysis. If this is not accounted for, subtle geochemical anomalies might be missed, or the regional trace-element content of bulk till samples might be controlled by till texture (ie the inert rock-forming mineral content of the till) rather than the source area (Shilts, 1976; 1991; 1994; DiLabio, 1988). These problems can be accounted for by studying the elemental and mineral characteristics from known mineral occurrences, using detailed till sampling methods and fractionation techniques.

Limitations

Industry must increasingly rely on exploration strategies involving geochemical information derived from surficial sediments to aid in the discovery of mineral resources under varied thicknesses of glacially produced sediments. If the processes of glacial erosion, transport and deposition of these sediments can be correctly deciphered, then their geochemistry can be used for mineral exploration purposes. Thus the overburden becomes an aid rather than a hindrance.

The direction of ice movement, which can be the principal factor controlling the form of a geochemical anomaly defined in till, may change during the course of a single period of glaciation. Complexities in the local deposits and in the local glacial history naturally lead to a corresponding complexity in the dispersion

processes and the resulting geochemical patterns (Dreimanis, 1982).

The development, detection, and interpretation of geochemical anomalies in glacial overburden are complicated by the diverse nature and origin of glacial deposits. Sand and gravel, well sorted clay and till are sediment types of varied composition and permeability that may be intermixed or stratified, and over short distances their thicknesses may range from a few centimetres to many tens of metres. Furthermore, the material that constitutes these deposits may have been transported from its place of origin for distances reaching several kilometres. The glacial debris may have been further subjected to postglacial processes such as physical and chemical weathering (Shilts *et al*, 1990). Consequently, in the course of mineral exploration programs conducted in glaciated terrain, sediment types should be properly identified, and residence sites of sought metals should be investigated. Thus, exploration techniques must be chosen to incorporate these factors to accurately and economically meet their targets.

REE Partitioning Study

Generally, glacial sediments contain low concentrations of REE due to the average low level of REE in the continental crust (i.e. La - 30ppm; Taylor *et al*, 1981), a factor which hinders the study REE in till, particularly the partitioning of REE into different grain size fractions. Therefore, the REE anomalous zone in till, along the Manson River valley (Plouffe and Ballantyne, 1993) is an optimal region

for the study of REE in till.

The main objective of the REE partitioning study is to provide data on the residence sites of REE in till and to define the best grain size fraction to use in future drift prospecting studies near carbonatite and pegmatite dikes. Because of the particular nature of the study area, some of the conclusions drawn here might be specific to regions characterized by carbonatite and pegmatite dikes enriched in REE.

CHAPTER 2: *Description of the Study Area*

2.1 *Location and Access*

The study area encompasses the Manson River from Granite Creek in the west to the southern extension of Munroe Creek in the east (figure 2.1). It extends over NTS map sheets 93 N/8, N/9, O/5 and O/12, and is located between latitude 55 20' and 55 45', and longitude 124 00' and 124 30'. It is approximately 200 kilometres north-northwest of Prince George and is accessible by all-season gravel roads from either Fort St. James or Mackenzie.

2.2 *Physiography*

Topographically, the study area lies in a mountainous setting with varying degrees of relief, which includes U-shaped valleys bordered by rocky peaks. North of Manson River lies the Wolverine Range, a mountainous area characterized by aretes and cirques with reliefs from 1200 to 1800 metres above sea-level. To the east of these ranges lies the Rocky Mountain Trench, now occupied by Williston Lake.

To the south of Manson River, low relief mountains are covered with till and glaciofluvial sediments with outcrop exposed at higher elevations. The Manson River drainage system lies in a broad river valley roughly 1000 metres above sea-level. Glacial, glaciofluvial and fluvial sediments occupy much of this valley.

Figure 2.1
 Physiographic features
 within study area

Granite Creek drains from the north and Munroe Creek drains from the south, both feed into the Manson River drainage system. Manson River is a tributary of the Peace River system which flows into the Mackenzie River, and ultimately drains into the Arctic Ocean.

2.3 Regional geologic setting

The study area is transected by a complex zone of faults known as the Manson fault zone, which marks the boundary between the Intermontane and Omineca tectonic belts of the Canadian Cordillera (Mathews, 1986) (figure 2.2). The Intermontane tectonic belt or "Superterrane" is considered to consist of rocks accreted onto the ancient margin of North America, represented by the rocks east of the Rocky Mountain Trench. All rock types in the study area have undergone various degrees of structural deformation and various grades of regional and contact metamorphism.

2.4 Bedrock Geology of Study Area

The study area lies in an area composed of four major terranes, which from southwest to northeast are: Quesnel, Kootenay, Slide Mountain, and Cassiar. The Quesnel and Slide Mountain terranes belong to the Intermontane Superterrane, whereas the Kootenay and Cassiar terranes are a part of the ancient North American craton. These terranes are shown in figure 2.3 which provides a broad overview of possible sources of the glacial materials in the study area. The bedrock geology within the study area is depicted in Figure 2.4. Except where

Figure 2.2 Simplified map of the Canadian Cordillera showing the location of the study area with respect to the five geological belts.

Figure 2.3

Terrane map showing location of the study area.
 NA - Cratonic North America; CA - Cassiar Terrane;
 KO - Kooteney Terrane; SM - Slide Mountain Terrane;
 QN - Quesnel Terrane; QNHR - Harper Ranch Subterrane;
 CC - Cache Creek Terrane; ST - Stikine Terrane; (modified
 from Ferri et al, 1994).

Figure 2.4 Bedrock geology map of study area, modified from Ferri et al, 1989. Legend is located on next page..

Figure 2.4 (continued)

LEGEND

QUATERNARY

Alluvium deposits: poorly sorted sands and gravels

CRETACEOUS

GERMANSEN BATHOLITH

White to grey, biotite-muscovite granite

UPPER PALEOZOIC TO TRIASSIC

SLIDE MOUNTAIN GROUP

GRAPHITIC SEDIMENT DIVISION:
Dark grey to black graphitic phyllite or argillite; dark grey to black limestone;
grey ribbon chert ARENACEOUS WACKE DIVISION:
Grey-green to green phyllite, siltstone, arenaceous wacke; beige to grey fine
grained sandstone; buff weathering limestone or marble; amphibolite SILICEOUS SEDIMENT DIVISION:
Dark grey to dark green siliceous siltstone; grey, green, black, maroon siliceous
argillite to phyllite; grey-green mafic to intermediate flows, diorite sills and dykes;
grey-green lithic arenite and/or conglomerate BASALTIC DIVISION:
Dark grey-green massive basalt, pillowed basalt WOLF RIDGE GABBRO:
Green to dark grey-green, fine to very coarsely crystalline, hornblende-pyroxene
gabbro ULTRAMAFICS:
Buff to brown weathering, light to dark brown magnetite-magnetite-quartz-serpentine-
calc-ankerite schist

UPPER DEVONIAN - LOWER MISSISSIPPIAN

CARBONATITES

Syenite, monzonite and biotite or aegirine syenite. These have been metamorphosed
to upper greenschist or lower amphibolite grade

PROTEROZOIC

INGENKA GROUP

UPPER DIVISION:
Grey-green to green phyllite, siltstone; blue-grey to white limestone marble MIDDLE DIVISION:
Grey-brown metamorphosed quartzite, arkose or feldspathic wacke; green-brown to
silver garnet-biotite-muscovite schist; minor garnet amphibolite LOWER DIVISION:
Brown to silver, sillimanite-garnet-biotite-muscovite-feldspar schist and gneiss; grey
metamorphosed feldspathic wacke; minor diopside-bearing calc-silicate gneiss and
amphibolite gneiss

WOLVERINE COMPLEX

PELTIC DIVISION:
Dark grey sillimanite-garnet-muscovite-biotite-quartz-feldspar gneiss and schist; minor
garnet amphibolite and diopside bearing calc-silicate gneiss; minor granitic intrusions CALC-SILICATE AMPHIBOLITE DIVISION:
Garnet bearing amphibolite gneiss; garnet-diopside plagioclase calc-silicate gneiss;
grey to cream garnet-diopside marble; minor pegmatite, granite and granodiorite intrusions Granodiorite and Pegmatite
Pegmatites and related grey to beige garnet-muscovite-biotite granodiorite

Geological contact

Thrust fault

noted, most of the subsequent bedrock descriptions have been extracted from Ferri *et al.* (1994).

The Intermontane Superterrane

In the study area, the Quesnel Terrane is composed of volcanic and sedimentary rocks which are island arc-related. These rocks belong to the Takla Group, which is Middle Triassic to Lower Jurassic in age (Souther, 1991). The Takla Group has been divided into two successions. The lower succession is known as the Slate Creek succession and is composed of phyllite, argillite, limestone, tuffs, mafic volcanic rocks, and coarse epiclastic rocks. The upper succession is known as the Plughat Mountain succession, which is a thick volcanic sequence of mafic to intermediate pyroclastic rocks, massive flows and minor epiclastic rocks. The Takla Group is in fault contact with the Nina Creek Group of the Slide Mountain terrane.

The Slide Mountain Terrane has been described as a sequence of ophiolitic rocks (Monger, 1984), which can be traced almost continuously along the entire length of the Canadian Cordillera. The Slide Mountain Terrane is upper Paleozoic in age, and in the study area is represented by the Manson Lakes ultramafics rocks, along with ocean volcanic rocks, sediments and mafic igneous rocks of the Nina Creek group.

The Nina Creek group is divided into two units, the lower Mount Howell succession composed of siliceous argillite, chert, gabbro and siltstone, and the

upper Pillow Ridge succession, composed mainly of basalt. Only the Mount Howell succession is present in the study area; the Pillow Ridge succession outcrops 20-30km to the northwest of the study area. The base of the Nina Creek group lies conformably over sedimentary rocks belonging to the Big Creek group of the Cassiar Terrane.

Ancestral North America

The ancient North American Craton is represented in the study area by rocks belonging to the Cassiar and Kootenay terranes. The Cassiar terrane is composed of rocks of the Proterozoic Ingenika Group, the lower parts of which contain the Wolverine Metamorphic Complex. The Ingenika group is predominantly a clastic sequence that has been subdivided into four formations: the Swannell Formation composed of sandstone, feldspathic wacke, slate, and minor carbonate; the Tsaydiz Formation composed of slate, carbonate and minor sandstone; the Espee Formation composed of a thick carbonate sequence; and the Stelkuz formation composed predominantly of sandstone, slate and minor limestone.

Ingenika rocks east of the Wolverine fault zone in the study area are of considerably higher metamorphic grade and are impossible to correlate with the above mentioned formations. These rocks are a part of the Wolverine Metamorphic Complex located in the Wolverine Range, and consist of impure metaquartzite, paragneiss, schist, marble, and amphibolite and calcsilicate gneiss. Both the paragneiss and the amphibolite and calcsilicate gneiss contain intrusive rocks including pegmatite and granodiorite. Due to their high metamorphic grade,

these rocks are thought to be the lowermost parts of the Ingenika Group. The Wolverine fault zone therefore separates high-grade metamorphic rocks of the lower Ingenika Group (Wolverine Metamorphic Complex) from less metamorphosed rocks of the upper Ingenika Group.

The Kootenay terrane consists of a sequence of sandstone, impure quartzite, siltstone, argillite, marble and minor amphibolite. These rocks belong to the Boulder Creek group which is thought to be Proterozoic to Paleozoic in age. This package of rocks is in fault contact with Slide Mountain and Quesnel terranes, and outcrops in abundance along the Manson fault zone. These rocks bear similarities to those of the Ingenika Group, and are thus thought to be a fault sliver of the Ingenika Group which has been incorporated in the Manson fault zone (Struik, 1985).

Intrusive Rocks

Several different intrusive events have affected the rocks in the study area over geologic time, two of which are a part of the main focus of this study.

A series of dikes and sills of pegmatite and related granodiorite stocks intrude the strongly metamorphosed rocks of the Ingenika Group in the Wolverine Range. Monzonite, monzodiorite, syenite and associated pegmatites intrude Ingenika schists near Munroe Creek, just east of the Manson river. They form small stocks and dikes which carry significant amounts of REE minerals. Both

alkaline and subalkaline REE-bearing pegmatites occur here, with monazite as the most abundant REE-bearing mineral in the subalkaline pegmatites, and allanite as the most abundant in the alkaline pegmatites. These intrusions range in age from Cretaceous to Tertiary (Halleran *et al*, 1993).

A carbonatite complex intrudes the Ingenika Group at Granite Creek, just north of the Manson River within the study area. The complex is relatively narrow (50 metres wide, 500 metres long) and parallels the trend of the Wolverine fault zone. It contains various REE-bearing and uranium-rich intrusive rocks including biotite sovite, aegerine sovite, and syenite of Late Devonian to early Mississippian age (Pell, 1987).

Within the Manson fault zone, lenticular bodies of gabbro known as the Wolf Ridge gabbro are in places up to 3 kilometres wide and 15 kilometres long. The age of this gabbro is thought to be late Paleozoic. The southern portion of the study area is intruded by the Germanson batholith. This batholith is Cretaceous to Tertiary in age, and is a multiphase intrusion composed of granodiorite, two-mica granite, pegmatite and aplite dikes.

2.5 *Quaternary History*

Regional Quaternary Geology

The first work to be completed regarding the glacial history of the interior of British Columbia was G.M. Dawson in 1878. At this time, Dawson postulated that the grooves, striations, and polished surfaces observed on bedrock in many different locations, along with the abundance of glacial-like debris, were the result of glacial ice advance or advances. Also noted, but generally misunderstood, was the variation in direction of ice flow ranging roughly from east to northeast within the interior of British Columbia (Dawson, 1878).

Later, Dawson recognized drift deposits and lacustrine sediments at great heights above sea level (approximately 1520m). He concluded that the whole region may have been buried under a major confluent glacier, and that the sediments were deposited as this mass of ice retreated into the sea during a period of subsidence, or even a great lake contained by glacier-dams in the valleys of several mountain ranges (Dawson, 1881). However, it was not until 1888 that Dawson collected his thoughts and developed a theory of a great Cordilleran ice sheet which he believed covered all of British Columbia west of the Rocky Mountains. It was also suggested that the main gathering ground of this massive ice sheet extended between the Coast Ranges and the Rocky Mountains in north-central British Columbia, with ice-flow directions radiating out from its centre dome in all directions (Dawson, 1883; 1889).

Dawson's Cordilleran glaciation theory was generally accepted until Armstrong and Tipper (1948) and later Armstrong (1949) refined this concept by suggesting that ice flow in the northern interior was generally eastward and northeastward from a source in the Coast and Skeena mountains, and that wherever the ice was confined to valleys, it moved along them but always in an easterly, northeasterly, or southeasterly direction, as is the case in the study area of this project.

Tipper (1971a,b) used indications of ice flow directions from airphoto interpretation of central British Columbia to reject the hypothesis of radial flow from a central accumulation zone or ice dome (Dawson, 1889; Flint, 1971). He proposed that piedmont glaciers flowed from three accumulation zones in the Coast, Omineca and Cariboo mountains, and coalesced over the Interior Plateaus (figure 2.5).

Regional Ice Flow History

Recently, a more detailed interpretation of the Quaternary history of the north-central interior of British Columbia has been made in terms of trends in past ice flow directions. This is depicted in Figure 2.6. During the Fraser Glaciation, valley glaciers derived from accumulation zones in the Skeena and Coast Mountains coalesced to form piedmont glaciers and moved northeastward and eastward into the area where they later coalesced with glaciers originating from the

Figure 2.5 Direction of ice movement in central British Columbia of the Fraser ice sheet and late ice readvance (modified from Tipper, 1971).

Cariboo Mountains to the southeast. At this time, ice flow to the east appears to have shifted to a more east-northeasterly direction (Plouffe, 1991; 1992; 1995; 1996; 1997; Plouffe *et al*, 1993; Ryder *et al*, 1991a,b).

Local Quaternary Geology

A reconnaissance study of the glacial geology, along with regional surficial mapping of the Manson River Map area (NTS 93K) was undertaken (Plouffe, 1991; 1992; 1995; Plouffe *et al*, 1993). The main objectives of the program were to detail the region's Quaternary stratigraphy, provide regional background metal concentrations in till, and to test and develop drift prospecting methods in an area heavily covered in glacial drift (Plouffe, 1995). The surficial geology of a large part of the study area (NTS 93N/9 and 93N/8) has been mapped by Plouffe (1996) as part of his regional compilation and is shown in figure 2.7.

Figure 2.7
Surficial Geology of the study area (modified from Plouffe, 1996).

Description and distribution of surficial sediments

The surficial geology of the area has been mapped by Plouffe (1997) as part of the regional surficial mapping project undertaken by the Geological Survey of Canada. For the purposes of this study, the description of surficial materials presented by Plouffe (1996) has been classified into six categories:

1. Till: sediment deposits from glacier ice consisting of rock fragments of all sizes in a sandy to clayey matrix; this category is subdivided into a) till blanket - area underlain by >1m thick till with scarce bedrock outcrops; and b) till veneer - regions with <1m thick till with abundant bedrock outcrops. Regionally, till is the most abundant sediment type and both subdivisions of till are found throughout the study area.
2. Glaciofluvial sediments: sand and gravel deposited by glacial meltwater including ice contact deposits - coarse sand and gravel deposited in contact with glacier ice up to 3m thick, and glaciofluvial terrace sediments - stratified to massive coarse sand and gravel up to 10m thick occurring in terraces found above alluvial units and in ancient meltwater conduits. This category of sediments is found throughout the study area within and along valleys.
3. Glacial lake deposits: silt, with minor sand and clay deposited in a glacial lake. Average thickness of this unit: 2-4m. The distribution of this sediment type is confined to tributary valleys in the north central portion of the study area.

4. Colluvial deposits: Diamicton and rubble accumulate from mass wasting on steep slopes of valley walls. Average thickness of this unit: 1-3m. These sediments are confined to steep valley walls.
5. Alluvial (fluvial) deposits: sediment deposits made by streams and rivers including alluvial terrace and fan sediments. These deposits are composed of well stratified to massive silt sand and gravel with minor clay, and are found in valleys throughout the study area .
6. Organic deposits: peat and muck deposits up to 2m thick accumulated in poorly drained terrain such as fen and bogs found throughout the study area.

Quaternary Stratigraphy

Quaternary deposits in the study area consist mainly of sediments deposited during the Fraser Glaciation which include till, glaciofluvial sands and gravels, and glaciolacustrine fine sand, silt and clay.

The oldest sediments are sands and gravels that underlie the Fraser Glaciation succession, whose origin is not certain. These sands and gravels are horizontally interstratified, mature, and well oxidized. They are up to 15m thick and the contact with the overlying Fraser Glaciation succession is unexposed. These sediments are thought to be glaciofluvial sediments of unknown age.

The oldest sands and gravels are overlain by less mature unoxidized

glaciofluvial sands and gravels. They are horizontally stratified and are up to 24m thick. This unit is thought to be glaciofluvial sediments deposited at the onset of the Fraser glaciation, in front of an advancing glacier.

There is no evidence for more than one till in the study area, which lies above the immature glaciofluvial sediments. The till in the study area is generally composed of a silty sand matrix with abundant clasts of sedimentary and metamorphic origin and is up to 15m thick.

The till is overlain by horizontally stratified glaciofluvial and glaciolacustrine sediments up to 10m thick. The glaciofluvial sediments are thought to be possible outwash sediments deposited in front of the retreating ice at the end of the last glaciation. These sediments include both terrace and ice contact deposits.

Glaciolacustrine sediments are confined to Manson River tributary valleys in the north central portion of the study area. These sediments were deposited in a glacial lake(s) developed as a result of ice damming of the Manson River, during ice retreat.

CHAPTER 3: *Methods*

3.1 Field Methods

Introduction

The field portion of this study was carried out in 1993, and involved: (1) detailed sampling in the study area, with particular focus in places where pegmatite and carbonatite dikes are known to occur; (2) measurements of till fabrics; and (3) a local stratigraphy study to constrain the ice flow history of the area by defining source lithologies, glacial trains, and ice flow directions. Following the field work, geochemical analyses, pebble and heavy mineral counts were conducted in the laboratory. Also, a more detailed study was conducted on those samples with anomalous REE values, using size partitioning techniques in order to evaluate REE origins, concentrations, characteristic grain sizes, and REE residence sites.

Site Selection and Field Sampling

Regional bulk till samples (approximately 2kg) were collected at approximately equal intervals of 2 kilometres. The samples were selected from undisturbed roadside exposures of till, and were taken at a depth of approximately 1 metre in the C-horizon, below the post-glacial solum to minimize the effects of post-depositional weathering on the till geochemistry (Hawkes *et al*, pg. 221). This is illustrated in Figure 3.1. During sampling, pebbles larger than 7cm were removed by hand and discarded, and each bulk till sample was transferred to a

Figure 3.1 Sample site selected from undisturbed roadside exposure of till. The till sample was collected at the base of a freshly exposed section (approx. 1m).

labeled plastic bag. To document the nature of mineralization, representative bedrock samples were collected in both the Lonnie Creek and the Granite Creek areas.

A total of 102 till samples and 22 bedrock samples were collected from the study area and are illustrated in figure 3.2. Where no till was exposed in a section along the road, a pit was dug using a hand shovel, grub hoe, and hammer to an average depth of 1 metre to obtain a till sample. Sampling was carried out by two people over a period of 18 days, with an average of ten samples collected per day.

More detailed sampling was conducted near known occurrences of carbonatite and pegmatite dikes. On average, samples were collected at an interval of 300m at sites located on, up ice, and down ice from the dikes.

Field Observations

Field observations were made at every sample site, and generally wherever there was cause for observations. At each new station, a general sample site description was recorded which included: 1) minimum till thickness (total thickness of till if bedrock was exposed); 2) identification and descriptions of any nearby outcrops, including records of glacial striae; and 3) if a field sample was collected, the location and depth at which it was obtained and its description were recorded including matrix colour, an estimate of grain size (% sand, silt, clay), compactness, level of oxidation, and the size, shape, lithology and abundance of

clasts. Field stations were located on air photos and then transferred to 1:50 000 scale topographic map sheets to calculate UTM coordinates.

Bedrock sample descriptions included observations such as lithology, mineralogy, texture, degree of alteration, deformation and/or metamorphism, and structural measurements.

Photographs were taken at sample sites to provide a visual record of work done and samples acquired. All field station locations are tabulated in Appendix I.

Till Section Study - Quaternary Stratigraphy

To establish the glacial history of the study area, numerous glacial sediment sections were examined, described and sampled in detail (figure 3.3). Till sections greater than 2 metres thick were sampled at different stratigraphic levels to document the vertical variability in composition geochemically and lithologically, and to gain a better understanding of the local variations in Quaternary stratigraphy (figure 3.4). A total of 17 till sections were sampled in detail within the study area. At three sites, till samples were collected from the B-horizon to assess the post-depositional weathering of the till.

Detailed stratigraphic study of a 100m high section was carried out near the centre of the study area, 50m north of Manson River. Lithostratigraphic units were defined on the basis of texture, sedimentary structure, colour, clast

Figure 3.4 Till section sampled in detail (93PMA1020). Samples were taken at different stratigraphic levels to document variability in vertical composition.

composition, contact relation and lateral continuity. Samples were collected from each major unit for geochemical analysis and pebble counts.

Till Fabric Analysis

Till fabric analyses were conducted at four till sections to document ice flow patterns in the study area. At each site, a large bench was cut into the till, removing weathered material and exposing 3 fresh till faces, so that 50 oriented clasts could be measured horizontally, vertically, and laterally. Oriented clasts were chosen using the criteria of at least a 3:1:1 axial ratio (Hirvas *et al*, 1990). All measured pebbles had an a-axis with a minimum length of 2 cm. The trend and plunge of the long axis of each clast selected were measured (figure 3.5). If the plunge was greater than 60 degrees, the clast was rejected due to inaccuracy of determining the trend and the possibility of the reversal in plunge due to over-rotation. Each fabric analysis is represented on a rose diagram with 10 degree increments to document the local ice flow patterns.

3.2 Laboratory Procedure

Sample Preparation

For all till samples, geochemical analyses were conducted on the silt and clay-sized fraction (<0.063mm). Sample preparation prior to analysis was completed by Overburden Drilling Management LTD., in Nepean, Ontario. From the original till

Figure 3.5 Till fabric analysis conducted on a bench cut into till surface exposing 3 fresh till faces to accurately measure 50 oriented till clasts.

samples, 30 grams of silt and clay was dry sieved for bulk till geochemical analysis, a minimum of 100 pebbles in the 4-16 mm size range were wet sieved, 500 grams of bulk till was required to conduct the partitioning study, and the heavy minerals were separated from the fine and very fine sand-sized fraction (0.063-0.250mm). Figure 3.6 outlines the procedure described above, and follows each subsample through to its subsequent analysis, according to which objective it reflects.

Till Geochemical Analysis

Geochemical analyses were completed on a total of 102 till samples by Activation Laboratories Ltd., Ancaster, Ontario. All till geochemical analyses in this study were performed on the silt and clay sized fraction (<0.063mm), since previous studies have shown that most metals are enriched in the fine fractions of till (Shilts, 1975; 1984, 1994; DiLabio 1979; 1985; 1988). Results of analyses in these fractions enhances contrast between anomalous and background values. At least 30 grams of the silt and clay-sized fraction from each till sample was analyzed by instrumental neutron activation analysis (INAA) for Au, Ag, As, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ir, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Se, Sm, Sn, Sr, Ta, Tb, Th, U, W, Yb, and Zn. Table 3.1 lists the elements analyzed and their corresponding lower detection limits. Standard and duplicate samples were inserted at random within the sample set to insure accuracy and precision of the analyses. These quality control measures are explained and tabulated in Appendix X.

Figure 3.6 Flow chart outlining various procedures and analyses applied to samples collected for this study

Element	Lower Detection Limit
Au	2.0 PPB
Ag	5.0 PPM
As	0.5 PPM
Ba	50.0 PPM
Br	0.5 PPM
Ce	3.0 PPM
Ca	0.01%
Co	1.0 PPM
Cr	5.0 PPM
Cs	1.0 PPM
Eu	0.2 PPM
Fe	0.01%
Hf	1.0 PPM
Hg	1.0 PPM
Ir	5.0 PPB
La	0.5 PPM
Lu	0.05 PPM
Mo	1.0 PPM
Na	0.01%
Nd	5.0 PPM
Ni	20.0 PPM
Rb	5.0 PPM
Sb	0.1 PPM
Sc	0.1 PPM
Se	5.0 PPM
Sm	0.1 PPM
Sn	100.0 PPM
Sr	500.0 PPM
Ta	0.5 PPM
Tb	0.5 PPM
Th	0.2 PPM
U	0.5 PPM
W	1.0 PPM
Yb	0.2 PPM
Zn	50.0 PPM

Table 3.1 Lower detection limits for till geochemical analyses using INAA.

Clast Lithology Study

The purpose of the clast lithology study was to evaluate till provenance by comparing the lithologies present in the till with those lithologies which represent bedrock in the study area. For each sample, at least 100 clasts were separated by sieving (4-16 mm grain size range) and then classified in the following categories: granite, granodiorite, gneiss, pegmatite, schist, slate/phyllite, argillite, siltstone, sandstone, limestone/marble, volcanic, and unknown. The number of clasts in each category was then counted and the percentages of each lithology were tabulated.

The clast lithology study reflects a two-year study of till clasts collected from the 4-16 mm size fraction, including the above mentioned local clast lithology study conducted for the purposes of evaluating local provenance areas, and a broader, more regional clast lithology study conducted in 1991 (Plouffe, 1995) which reflected major provenance areas. In Plouffe (1995), at least 100 clasts were collected from the 4-16 mm size fraction and identified using seven broad lithological categories: igneous (plutonic), metamorphic, volcanic, calcareous, ultramafic, clastic and unknown. The data presented in this thesis have been included with Plouffe (1995) data to compare local versus regional provenance variations.

Plouffe (1995) Clast Categories	Clast Categories (This study)
Igneous (plutonic)	Granite Granodiorite Gneiss Pegmatite
Metamorphic	Schist Slate/Phyllite
Clastic	Argillite Siltstone Sandstone
Carbonate	Limestone/marble
Volcanic (fine-grained igneous)	Volcanic
Ultramafic	
Unknown	Unknown

Table 3.2 Comparison of clast lithological categories

REE Partitioning Study

The REE partitioning study involved the separation of bulk till samples into different grain size fractions, in order to study the residence sites of the REE and other elements in till. In all, 5 till samples were chosen on the basis of REE concentrations resulting from the first round of INAA till geochemical analyses. These 5 samples range from approximately background to highly anomalous geochemical values, to evaluate the relationship between residence sites and elemental concentrations.

To separate the till samples into various grain size fractions, 500 gram samples of bulk till was used. Each sample was freeze dried for approximately 24 hours to remove all moisture content. At this point the >4 mm fraction was removed from the sample by dry sieving. Next, approximately 350 grams of the <4mm fraction was measured, 20 grams of which were set aside in a separate vial. The remaining <4mm fraction was then mixed with a solution of Na-hexametaphosphate (5g/l) which acts as a deflocculant solution used in the separation of the silt and clay-sized fraction (<0.063mm) from the coarser material. Any visible organic matter in the till sample was removed by flotation. The <0.063mm fraction was then removed by wet sieving, and centrifuged to separate the silt-sized fraction from the clay-sized fraction, following standard procedures of the sedimentology laboratory at the Geological Survey of Canada in Ottawa (Lindsay and Shilts, 1995).

The >0.063mm fraction was allowed to dry at room temperature and was dry sieved to the following grain sizes: 4-2mm, 2-0.25mm, 0.25-0.125mm, 0.125-0.063mm. Dry sieving was done using a set of stainless steel sieves to avoid contamination from

brass. All grain size fractions were then weighed and recorded, and then crushed (if needed) to a <0.1mm powder for geochemical analysis using a ceramic ball mill.

The geochemical analyses performed on the partitioned grain size fractions were conducted by Activation Laboratories LTD., in Ancaster, Ontario, following the same procedures as for the regional till samples. The partitioned grain size fractions belonging to 5 till samples were analyzed, with 2 blind duplicates to ensure accuracy of geochemical results.

Heavy Mineral Study

To correlate the geochemical anomalies in till with mineralogic assemblages from possible bedrock sources, heavy mineral identification and counting was conducted on selected till samples. Heavy mineral separations were prepared by Overburden Drilling Management Ltd. in Nepean, Ontario, according to the methods described by Averill *et al.* (1986). The heavy mineral separations were completed using a shaker table, methylene iodide (>3.3 S.G.) and a hand-held magnet to produce a non-magnetic heavy mineral concentrate in the 0.063-0.250mm size fraction (figure 3.6).

The heavy mineral concentrates were then counted using the line traverse method. With this method, a thoroughly mixed sample is spread out evenly on to lined paper (lines are 0.2 mm wide). Each heavy mineral particle which falls on a line is recorded until 100 grains are counted along that line. Residual quartz and feldspar grains, rock chips and magnetite are counted but considered foreign materials and are

not included in the final 100 grain count which therefore represents the heavy mineral fraction of the clean concentrate (Averill, 1986). The resulting heavy mineral percentages were then tabulated. Although the optical identifications were not confirmed by other techniques such as x-ray analysis, the writer is confident that the identifications have provided reliable results.

Bedrock Geochemical Analysis

Selected bedrock samples were analyzed by INAA by Activation Laboratories Ltd., in Ancaster, Ontario following the same procedures as for the till samples. Twenty grams of crushed bedrock (<0.1mm) was utilized for analysis.

CHAPTER 4: *Results and Interpretations*

4.1 *Introduction*

To help reconstruct glacial ice flow history in the study area, and to evaluate geochemical anomalies in the till, their source, and the glacial dispersal patterns which they exhibit, the glacial macro- and micro- land forms in the study area indicative of local ice flow directions, augmented by regional observations provided by Plouffe (1996), have been compiled (figure 4.1).

Results from the geochemical analyses and the till pebble lithology study have been plotted as proportional symbol maps to illustrate relative distributions based on the symbol area. Anomaly thresholds used as guidelines to evaluate these data are based on a selected statistical range of percentile ranks for each element or pebble lithology analyzed (Plouffe *et al*, 1993; McClenaghan, 1992). The thresholds more or less correspond with values equal to or greater than the 50th, 75th, 90th, 95th, and 98th percentiles, and were chosen from a sample set which included samples collected for this study in 1993, and samples collected by Plouffe in 1991.

Both elemental and lithological concentrations in till are considered to be anomalous when they exceed the lower background levels (<50th percentile) of the concentrations in the rest of the study area. However, for the purposes of this study, and to better determine possible sources, minor anomalies are defined as values greater than or equal to the 95th percentile, while major anomalies are those values greater than or equal to the 98th percentile.

Figure 4.1
Pattern of ice flow direction deduced from flutings, drumlins, striations and till pebble fabric analyses.

When comparing concentrations in the study area to those of the regional study performed by Plouffe in 1991, it is apparent that the magnitudes of anomalies in the study area are greater when compared to concentrations for the entire region, which has much lower background concentrations. When only the results of the study area are considered, the magnitude of the anomalies is reduced, and therefore only highly anomalous values are seen, allowing their sources to be pin pointed with confidence.

For example, as stated in the introduction, REE concentrations in till within the study area are high compared to the regional REE background levels. An example of this is shown with Lanthanum in figure 4.2 (Plouffe, 1995). Consequently, if only the study area is depicted in a map using the same percentile thresholds employed by Plouffe (1995), the sources of the REE cannot be pin pointed. To increase the contrast between anomalies and background REE concentrations within the study area, thresholds were re-calculated using only the samples that fall within the study area (figure 4.3).

4.2 Till Geochemistry

Results from the till geochemical analyses using INAA are tabulated in Appendix II. The distribution of Au, Ag, As, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ir, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Th, U, W, Yb, and Zn are plotted as proportional symbol maps in Appendix IV. For summary statistics of the elemental sample set used to produce the proportional symbol maps, refer to Table 4.1.

Figure 4.3 Proportional symbol map illustrating the distribution of Lanthanum (ppm) within the study area.

Element	Mean	Standard Deviation	Minimum value	Maximum value
AS PPM	11.49	15.10	0.5	110.0
AU PPB	5.91	5.01	2.0	28.0
BA PPM	1137.74	282.04	630.0	2400.0
BR PPM	1.11	1.20	0.5	6.7
CE PPM	109.89	39.51	20.0	280.0
CO PPM	17.62	6.93	10.0	49.0
CR PPM	145.89	49.37	68.0	370.0
CS PPM	4.09	2.39	1.0	16.0
EU PPM	1.85	0.38	1.2	3.1
FE %	4.71	1.28	3.1	12.6
HF PPM	8.50	2.67	3.0	17.0
LA PPM	54.74	18.82	17.0	121.0
LU PPM	0.60	0.13	0.3	1.0
MO PPM	1.24	0.89	1.0	6.0
NA %	1.29	0.30	0.5	2.3
ND PPM	40.05	13.07	15.0	83.0
NI PPM	58.84	59.76	20.0	290.0
RB PPM	92.30	39.00	15.0	230.0
SB PPM	1.67	1.57	0.3	9.7
SC PPM	17.90	4.39	11.0	38.0
SM PPM	7.80	2.04	3.8	15.0
TA PPM	1.25	0.87	0.5	3.8
TB PPM	0.97	0.45	0.5	2.6
TH PPM	16.41	6.76	4.3	40.0
U PPM	4.24	1.57	0.5	9.2
W PPM	1.30	0.78	1.0	5.0
YB PPM	3.80	0.75	2.4	5.6
ZN PPM	145.74	60.23	50.0	380.0

Table 4.1 Summary statistics for elements in <0.063mm till fraction

Regional Dispersal Configuration

Examination of the geochemical results has revealed that there are several locations where elemental concentrations are much higher than background values in the study area. These local geochemical patterns in till can be illustrated by the following four distinct multi-element geochemical anomalies which have been identified from the proportional symbol maps. By linking the extent of these anomalies with ice flow direction, the local geochemical patterns can be linked to the bedrock geology in the study area (figure 4.4):

Anomaly 1. This anomaly is located along the northwest end of the forestry access road just southeast of Granite Creek. It shows eleven major anomalous values: Ce, Cs, Eu, La, Nd, Sm, Lu, Th, Yb, Tb, Br, Hf, Na; and four minor anomalous values for U, Rb, Ta, Fe. This multi-element anomalies likely derived from the shear zone and related carbonatite dikes at Granite Creek. The dispersal of these elements has a distance of transport reaching approximately 46 km. Concentrations decrease from the northwest to the southeast. The dispersal is difficult to determine due to the lack of samples, but the trend concurs with regional ice flow indicators measured in the area.

Anomaly 2. Located north of Munroe Creek, this anomaly is parallel to the eastern margin of Manson River. It appears to be a multi-element anomaly with highest concentrations along the margin of a calc-silicate division of the

Wolverine Complex. This anomaly is most likely mineralogically associated with intrusions of pegmatitic syenite and monzonite dikes within the Wolverine Complex. The anomaly shows major anomalous values of Ce, Eu, La, Nd, Sm, Ta, Tb, Th, Br, Na, U, Yb, Zn; minor values of Cs, Hf, Lu, Ni, Rb have been detected. The source and distance of transport for each elemental anomaly are difficult to identify, because many small intrusions may be concealed and some may have been eroded by the glacier. The dispersal likely represents a general transport of anomalous rocks from south to north along the Manson River valley, which parallels the regional ice flow direction.

Anomaly 3. The south central portion of the study area (south of Manson River) is characterized by a multi-element anomaly with major anomalous values of Au, Ba, Zn, Cr, As, U, Ba, Sb, Sc, Mo, and minor anomalous values of Cs, Co, Fe, Ni, Ta, Na, Br. The highest concentrations are in the graphitic sediment division (SM6) of the Slide Mountain Group, from which they most likely were derived. The dispersal of these elements appears to be to the north, with a distance of transport of 4 to 6 km.

Anomaly 4. North of Manson River, in the north central portion of the study area, there is a multi-element anomaly with major anomalous values of Cs, Hf, Lu, Rb, W, Yb, and minor anomalous values of Th, Ni. All of these values are

located over Ingenika sediments and schists (I2). The source and distance of transport are indeterminate due to a lack of sufficient sample locations in this area. These anomalies may be derived from an unknown source. However, due to the high concentrations of Cs and Th, as seen in anomalous pegmatitic monzonites in the area, a hidden intrusion in the vicinity may be the source for these anomalous values.

Along with the dispersive nature of the elements found to be anomalous in the till, examination of the geochemical results and the compositional characteristics of the till suggest several geochemical relationships. To examine these till geochemical relationships, a Pearson linear correlation matrix was prepared (Table 4.2) such that at the 98% confidence interval, $r=0.50$ is significant, where r is the value of the correlation coefficient (Koch and Link, 1971).

The elements contained in the till geochemistry matrix hold common associations and thus Table 4.2 strongly reflects known bedrock geochemical compositions in the study area. For example, Anomaly 1 is located just southeast of Granite Creek, where there is a known shear zone and related carbonatite dikes. Bedrock geochemical analyses of these carbonatite dikes by Pell (1987) show anomalous values of La, Sr, Th, and Yb. The till geochemistry matrix shows very strong positive correlation coefficients for all of these elements, along with high values for these elements. Consequently, the location of Anomaly 1, along with the strong correlation coefficients presented here,

<u>AUPB</u>		<u>AS</u>	
<u>AO</u>	<u>PPM</u>	<u>PPM</u>	<u>PPM</u>
<u>AU</u>		<u>AU</u>	
<u>AS</u>	<u>PPM</u>	<u>PPM</u>	<u>PPM</u>
<u>BA</u>		<u>BA</u>	
<u>CA</u>	<u>%</u>	<u>CA</u>	<u>%</u>
<u>CE</u>		<u>CE</u>	
<u>CO</u>	<u>PPM</u>	<u>CO</u>	<u>PPM</u>
<u>CR</u>		<u>CR</u>	
<u>CU</u>	<u>PPM</u>	<u>CU</u>	<u>PPM</u>
<u>EU</u>		<u>EU</u>	
<u>FE</u>	<u>%</u>	<u>FE</u>	<u>%</u>
<u>LA</u>		<u>LA</u>	
<u>LU</u>	<u>PPM</u>	<u>LU</u>	<u>PPM</u>
<u>MA</u>		<u>MA</u>	
<u>MO</u>	<u>PPM</u>	<u>MO</u>	<u>PPM</u>
<u>NA</u>		<u>NA</u>	
<u>NO</u>	<u>PPM</u>	<u>NO</u>	<u>PPM</u>
<u>PP</u>		<u>PP</u>	
<u>SR</u>	<u>PPM</u>	<u>SR</u>	<u>PPM</u>
<u>TA</u>		<u>TA</u>	
<u>TI</u>	<u>PPM</u>	<u>TI</u>	<u>PPM</u>
<u>U</u>		<u>U</u>	
<u>W</u>	<u>PPM</u>	<u>W</u>	<u>PPM</u>
<u>YB</u>		<u>YB</u>	
<u>Zn</u>	<u>PPM</u>	<u>Zn</u>	<u>PPM</u>

Table 4.2 Correlation coefficients of elements analyzed using INAA

suggest that the source of Anomaly 1 are the carbonatite dikes.

Similarly, Anomaly 2 is located near known occurrences of pegmatitic monzonite dikes. Geochemical analyses of these dikes by Halleran (1988) show anomalous values of La, Ce, Nd, Th, Zr, and Y. The till geochemistry matrix shows very strong positive correlation coefficients for La, Ce, Nd, and Th. Therefore, the location of Anomaly 2 and the correlation coefficients point to the pegmatite dikes as the source of Anomaly 2.

Statistically, the till geochemical relationships shown by these elements closely correspond to the mineralogical findings in the areas of Anomalies 1 and 2. The statistical relationship presented for anomalies 1 and 2 could not be repeated for anomalies 3 and 4 because no bedrock geochemical data are available for the Slide Mountain Group (anomaly 3) and Ingenika Group (anomaly 4) in the study area.

4.3 *Bedrock Geochemistry*

The results from the whole rock geochemical analyses using INAA are tabulated in Appendix II. These values have been used in the Till Section Study to test geochemical or lithological vertical mixing and variability within the till. The pertinent bedrock geochemistry has been plotted in conjunction with till geochemical data vertically versus the total depth of each section as geochemical profiles. These profiles are shown in Appendix VI.

4.4 Clast Lithology Study

Both the 1991/1993 and the 1993 pebble lithology results are tabulated in Appendix III. The distribution of 1991 and 1993 pebble lithologies are plotted as proportional symbol maps in Appendix V. For summary statistics of the sample set used to produce the proportional symbol maps, refer to Table 4.3. The sample set includes pebble samples collected for this study in 1993, and pebble samples collected by Plouffe in 1991.

Regional Dispersal Configuration

Upon examination of the till-clast lithology, the distribution of four broad lithological groups reveal information about ice flow direction. These four distinct lithologic anomalies have been identified from the proportional symbol maps:

1. Carbonate rocks: Major anomalous values for limestone/marble clasts cluster over the northwest end of the forestry access road, just southeast of Granite Creek. Here, a small dispersal train of limestone/marble clasts can be seen with highest concentrations overlying the limestone unit of the upper division of the Ingenika Group, the potential source of these carbonate clasts. Distally (2 km), concentrations begin to decrease toward the adjacent non-carbonate-bearing middle division of the Ingenika Group. This suggests a northwest to southeast direction of transport which parallels the regional ice flow direction.

	Clast Type	Mean	Standard Deviation	Minimum value	Maximum value
This study (1993)	Granite	6.35	12.08	0.00	53.50
	Granodiorite	6.44	12.21	0.00	69.20
	Gneissic granite	2.42	6.52	0.00	54.50
	Diorite	1.35	3.26	0.00	24.70
	Pegmatite	14.69	22.79	0.00	90.50
	Total volcs	19.21	20.47	0.00	98.50
	Ultramafic volcs	0.31	1.15	0.00	7.90
	Conglomerate	0.11	1.08	0.00	11.30
	Sandstone	3.78	6.67	0.00	35.90
	siltstone	15.65	15.86	0.00	72.70
	Limestone/ marble	3.73	10.21	0.00	71.30
	Argillite/ Greywacke	2.14	6.35	0.00	58.20
	Slate/ phyllite	7.91	15.81	0.00	95.80
	Schist	10.23	17.49	0.00	87.70
Plouffe (1991)	Igneous (plutonic)%	30.52	28.26	0.00	90.00
	Metamorph%	14.89	12.57	0.00	48.00
	Volcanic%	26.33	24.45	2.00	90.00
	Calc%	1.33	2.00	0.00	8.00
	clastic%	26.81	27.37	0.00	82.00

Table 4.3 Summary lithology statistics for the 4-16mm clast fraction from 1991/1993

Furthermore, volcanic clasts in till samples of this area resemble the volcanic rocks derived from the Slide Mountain Group 2km to the northwest, suggesting a similar ice flow direction.

2. Intrusive rocks: In the eastern part of the study area ,along the Manson River valley and Munroe Creek, there are major anomalous values for granite, granodiorite and pegmatite clasts. These anomalous clasts probably were derived from igneous intrusive bodies in the Wolverine Complex. The distribution of these anomalous clasts indicates that ice flowed north along the valleys of Munroe Creek, and northeast along the Manson River valley.

3. Clastic and Volcanic rocks: In the south central portion of the study area (south of Manson River) major anomalous values for clastic and volcanic clasts fall in a wide band parallel to the trend of the sedimentary and volcanic rocks belonging to the Slide Mountain Group which is their potential source. Argillite, siltstone, sandstone, slate/phyllite and volcanic clast dispersal trends in this area all show a similar wide train extending up to 5 km to the north. Furthermore, all of these clast types occur as much as 15 km to the northeast along the Manson River valley. These trends parallel regional ice direction, indicating that to the south of Manson River ice flowed to the north and northeast, along the Manson River valley.

4. Schist: North of Manson River, in the north central portion of the study area, there are major anomalous abundances of schist clasts. The source of these clasts is likely the Ingenika Group sediments and schists (12) which underlie the anomalous tills and occur slightly to the northwest and southeast. The ice flow direction and distance of transport, however, is difficult to ascertain due to a lack of sufficient and viable sample locations in this area, and to the fact that all anomalous abundances are directly above their bedrock source.

4.5 *Till Section Study: Vertical Variability within the Till*

A total of 17 till sections were sampled in detail within the study area (figure 3.3). To document the relationship between till geochemistry and till thickness, and to gain a better understanding of local variations in Quaternary stratigraphy and ice flow directions, only the till sections where fabric analyses and B-horizon sampling were conducted (plus the detailed stratigraphic study carried out north of the Manson River) are included in the till section study .

Each section was sampled vertically at different depths in each site. Sample depths were chosen to best suit the total thickness of each particular section, and any physical variation seen within it. This served to reveal any vertical geochemical or lithological variability within the till .

Geochemical analyses were completed on all samples collected from the till sections in this study, including the B-horizon samples. The geochemical results of these analyses have been individually plotted vertically versus the total depth of

each section as geochemical profiles. These profiles are shown in Appendix VI.

The 4-16mm clasts from each till samples collected for this study were counted to establish any variation with depth of the relative concentrations of different pebble lithologies. The results of the clast lithology counts have also been plotted vertically versus the total depth of each section. These profiles are Shown in Appendix VII.

Till fabrics were analyzed at four till section sites to document the ice flow patterns in the study area. The results from till fabric analyses are plotted on rose diagrams and are presented with corresponding geochemical and lithology profiles (Appendix VI and VII).

Vertical Geochemical Variations in Sections

Upon examination of the till geochemistry, clast lithology, and till fabrics in the till sections, vertical variability has been identified and can be related to local dispersal patterns and glacial ice flow directions. Descriptions of relevant sections characterized by this variability are presented below:

Section 93PMA1094

A detailed stratigraphic study was carried out on this section of glacial sediments exposed 50m north of Manson River at the centre of the study area (figure 3.3).

Samples of various sediment types were obtained at intervals corresponding to specific stratigraphic intervals, including detailed sampling of the till units, and a till fabric analysis (figure 4.5).

In total, this Manson River section is 66m thick. The lowest exposed unit comprises horizontally stratified glaciofluvial sediments approximately 15m thick mainly composed of oxidized coarse sand with minor layers of oxidized gravel. The unit coarsens upwards and is moderately mature and moderately sorted. This lowermost unit represents the oldest sediments found in the study area whose origin until now was not certain and which underlie the Fraser Glaciation succession.

The glaciofluvial sands and gravels are overlain by a unit composed of clay layers interbedded with gravels and fine sand. The unit is horizontally stratified and approximately 5 m thick. The contact between the lower glaciofluvial unit and this clay-rich unit is erosional. The top of this unit (the contact of which is covered) is overlain by another thick (24m) glaciofluvial unit which is composed of massive gravel that is both poorly sorted and immature. The top of the gravel unit is capped by 1.5-2m of coarse sand and minor gravel. All sediments above the oxidized gravel and below the overlying diamicton thought to be a product of the onset of the Fraser glaciation, deposited in front of an advancing glacier.

A 12m-thick massive dark grey brown diamicton unit with a few striated clasts and has a sandy silt texture overlies the glaciofluvial sediments. The contact

Figure 4.5
Composite stratigraphic column of the Manson River section 93PMA1094

between the gravel unit and this diamicton appears to be erosional. The diamicton is sharply overlain by a massive brown diamicton which is 7m thick and marks the top of the section. This diamicton unit contains minor sandy layers and lenses. It also has a few striated clasts and a silty clay texture.

The lowermost glaciofluvial sand and gravel unit appears to be confined to the Manson river valley, and shows high values for schist clasts most probably derived from the Wolverine Metamorphic complex located just to the north (Appendix VII). This suggests an earlier ice flow direction in the study area, illustrating that ice flowed initially down from the northern Wolverine Ranges to the south in tributary valleys of the Manson River. This unit coarsens upwards, and is inferred to represent advance-phase glaciofluvial sediments, providing evidence for sediments deposited during a glacial event at the onset of the Fraser Glaciation. The abundance of schist clasts is drastically reduced at the top of the section in the upper till unit, however, where till fabrics indicate a southwesterly direction of ice flow. Thus, the previous ice flow direction is only reflected in glaciofluvial sediments within the Manson River valley.

The overlying unit of clays, sands and gravels is predominantly clay-rich, suggesting a period of quiescence. This might be due to ice damming and the development of a glacial lake during the advance of ice in the Manson River valley. Furthermore, the massive glaciofluvial gravel unit is confined to the valley, and may represent outwash from the advancing glaciation in the Manson river valley.

The diamicton unit(s) at the top of the section show little compositional variation, both lithologically and geochemically. These units may simply represent the same till unit deposited during the Fraser Glaciation which presents a slight textural change near its top, with the increase of sandy lenses possibly due to reworking by glacial meltwaters. The abrupt colour variation may be a product of post-glacial weathering (ie. oxidation by the water table).

The predominant lithologies throughout both unit 1 and 2 are : volcanic (20-60%), siltstone (10-50%), slate (5-17%), and sandstone (5-12%). This suggests a provenance to the northwest, which corresponds to results of till fabric measurements in unit 2 that show clast orientations parallel to this northwest to southeast ice flow trend. This trend is also reflected by the till fabric completed in unit 1, although not so strongly, and this fabric appears to be bimodal. This can be explained by the fact that the two modes are perpendicular, a common phenomenon whereby clasts are aligned both parallel and perpendicular to the ice flow direction (Ryder, 1994).

Section 93PMA1003

Section 93 PMA 1003 illustrates lithological variation within a single till unit. Geochemically though, vertical variability is too subtle to show discernable trends. The section here can be described as having a basal unit comprised of an 8m diamicton with sandy lenses and layers which grades upwards into a 1 m layer of sandy gravel overlain by 5m of massive diamicton.

This section is thought to represent one till unit deposited during the Fraser Glaciation which has undergone reworking prior to deposition due either to subaqueous deposition at the front of the glacier, or subglacial melting.

Regional ice flow indicators show that ice in the vicinity of section 93 PMA 1003 flowed northward. This is reflected in the pebble lithology seen in the section. The predominant lithologies at the base of the section are gneiss (30%) and pegmatite (20%) with minor carbonate (5%), which are most likely derived locally from the gneissic division of the Wolverine Metamorphic complex. This reflects the incorporation of local bedrock sources near the base of the exposure. The abundance of these lithologies diminishes upwards in the section where there is enrichment of distal lithologies such as siltstone (20%), slate (18%) and volcanic clasts (10%). These distal lithologies were likely derived mostly from the Ingenika Group and Upper Slide Mountain Group sediments located 1-5km to the south, which is in accord with the regional ice flow direction.

Section 93 PMA 1020

This section also illustrates variation lithologically within a single till unit. The section is described as a massive 13m diamicton with minor sandy lenses and a few thin sandy layers near the top, which is interpreted to be till deposited during the Fraser Glaciation that has undergone minor reworking possible by outwash streams.

Geochemically, the variability is indistinguishable, but lithologically, vertical trends can be seen. Section 93 PMA 1020 is located over Ingenika Group sandstones, which represents the predominant lithology at the base of the section (35%). The abundance of this lithology diminishes upwards in the section where there is enrichment of distal lithology slate (70%). This distal lithology is most likely derived from the Upper Slide Mountain Group graphitic sediments located primarily 1-4km to the south, which concurs with the regional ice flow direction.

Section 1090

Section 93 PMA 1090 illustrates variation geochemically and lithologically within a single till unit. This section can be described as a 6.5m massive diamicton interpreted to be till deposited during the Fraser Glaciation, with highly sheared siltstone at its base. Two till fabrics were conducted in this section, the results of which conclude that ice flowed in one direction (east) in the vicinity of section 93 PMA 1090. This concurs with regional ice flow indicators which prove that ice flows to the east-southeast. The slight angle between the till fabric and the regional ice flow direction might be explained by the fact that the till fabric was measured on a steep incline of a valley wall and that subglacial topography influenced clast orientations.

The clast lithologies seen in the section reflect an easterly direction of transport. The predominant lithologies near the base of the section are siltstone (35%) and carbonate (10%), which most likely were derived locally from upper Ingenika Group

sediments. The abundance of these lithologies diminishes upwards in the section where there is enrichment of distal lithologies such as slate (45%), and sandstone (39%). The slate is also a part of the upper Ingenika Group sediments and crops out less than 300m to the north. The sandstone most likely was derived from the middle division of the Ingenika group, which crops out just to the northwest.

Geochemically, the easterly direction of transport is reflected in elevated La, U and Th concentrations seen in the upper portion of the section where the distal lithologies are concentrated. These high concentrations maybe the result of transport from the Lonnie carbonatite complex just to the north.

Both pebble lithologies and till geochemistry thus support an east-southeast direction of ice flow in the vicinity of section 93 PMA 1090.

Section 93 PMA 1095 does not show substantial vertical variability. It is worth mentioning, however, that the till fabric measured in this section revealed a local northward ice flow. This finding is further supported by the presence of sandstone, siltstone and volcanic clasts most likely derived from the Ingenka and Slide Mountain Groups to the south.

Section 93 PMA 1016 does not show substantial vertical variability. This section represents a thin, massive, relatively homogeneous till which is highly enriched in pegmatite clasts derived from the bedrock source which it has at its base. Because this section is very thin, there is not much chance for the incorporation of distal lithologies.

From the above findings, till in the study area generally displays one of two types of variability in depth and composition :

- (1) No variation geochemically and/or lithologically within a single till unit. This was the case for sections 93 PMA 1094, 93 PMA 1016 and 93 PMA 1095.
- (2) Variation geochemically and/or lithologically within a single till unit. Till samples collected at different depths in sections show high elemental and/or lithological values reflecting the incorporation of local bedrock sources near the base of an exposure. These high values tend to decrease upwards in the section, making way for more distal geochemical values and lithologies. This was seen in section 93 PMA 1003 and 93 PMA 1020.

Moreover, a relationship between till geochemistry and clast lithology is present, though very subtle in most sections.

Postglacial Weathering

Till samples were collected from the B-horizon in sections 93 PMA 1003, 93 PMA 1016 and 93 PMA 1090 to assess any post-glacial weathering of the till. Geochemically, variations between the B and C horizons can be seen in 93 PMA 1090. In this section, all elements analyzed show higher concentrations in the B-horizon than in the C-horizon. To a lesser extent, 93 PMA 1016 is seen to have higher values in the B-horizon of Th, U, La, Cr, Co and Zn.

Many studies have been conducted regarding the geochemical behaviour of elements in the B-horizon which have shown that the oxidation and weathering processes within this horizon cause the breakdown of minerals such as sulfides (Shilts, 1975, 1984, 1994; DiLabio, 1979, 1985, 1994).

The metal enrichment found in the B-horizon in 93 PMA 1016 and 93 PMA 1090 may reflect a concentration effect where metals are present in stable mineral phase that is not easily broken down by post-glacial weathering which destroyed such minerals as sulphides. This may explain the higher concentrations seen in the B-horizon.

Section 93 PMA 1003 on the other hand, shows lower values in the B-horizon for all elements analyzed except for Au. This might be explained by the fact that this section rests on the slope of a mountain, and that groundwater percolation may have transported mobilized elements in the B-horizon away (downhill) from the section towards Munroe Creek.

To fully understand the reasons for the increased and decreased concentrations in the B-horizon, more detailed sampling of the B-horizon in the study area is required, along with the application a partitioning study to determine the residence sites of B-horizon elements, and possibly a ground water geochemical study. Unfortunately, these are both beyond the scope of this thesis.

4.6 Heavy Mineral Study

The results from the heavy mineral study are tabulated in **Appendix IX**. The location of heavy samples used in this study are shown in figure 4.6. The most abundant heavy minerals in all samples analyzed are garnet, epidote, pyroxene, hematite and geothite. Hornblende, zircon, and kyanite/sillimanite represent local major constituents (figure 4.7a, 4.7b).

The high garnet concentrations occur throughout the suite of heavy mineral samples analyzed. These and local high concentrations of kyanite/sillimanite are derived primarily from the Wolverine Complex and Ingenika Group metamorphic rocks. The high concentrations of pyroxenes, and locally hornblende, could be derived in part from the Slide Mountain pyroxene-hornblende-bearing volcanic rocks. Another major contributor might be the calc-silicate units belonging to the Wolverine Complex which is both diopside and epidote bearing. However, high concentrations of epidote probably reflect contact metamorphism and local alteration due to regional metamorphism of the Slide Mountain and Ingenika Groups.

The pegmatites in the Munroe Creek area are known to contain heterogeneous clusters of mafic minerals including: allanite, titanite, apatite, zircon, and thorite found within small pegmatitic bodies of aegerine-augite monzonite and monzodiorite (Halleran *et al*, 1993). This could explain the presence of local concentrations and trace quantities of barite, titanite, zircon, apatite, allanite and monazite seen in samples located in proximity to Munroe Creek pegmatite intrusions (figure 4.7b).

Figure 4.7a Heavy mineral count results of the western portion of the study area.

Figure 4.7b Heavy mineral count results of the eastern portion of the study area.

The Lonnie carbonatite complex located in the Granite Creek area is not strongly reflected by the results of the heavy mineral study. However, high zircon and pyroxene concentrations along with trace allanite seen in samples located in proximity to Granite Creek could be derived from the carbonatite complex (figure 4.7a).

Throughout this study, the heavy mineral results from each sample reflect mainly local heavy mineral constituents and gives little evidence of detrital heavy mineral glacial transport.

4.7 REE Partitioning Study

The results from the REE partitioning study geochemical analyses are tabulated in Appendix II. These results have been plotted versus grain size to determine the partitioning of REE in the selected till samples. These graphs are tabulated in Appendix VIII.

The distributions of REE concentrations in till samples collected from the study area follow a similar pattern from sample to sample in that they show similarly shaped curves of metal abundance versus the analyzed grain size range (figure 4.8). This is true for La, Ce, Nd, U, Sm, Y, and Lu, which all show peak abundances within the range of fine sand to silt (between 0.125-0.063mm and 0.063-0.002mm).

In determining the residence sites of rare-earth elements in till, consideration must be given to the original form of those elements. Consideration must also be given to the possibility of remobilization and reprecipitation of these elements during

Figure 4.8 Profile of element concentrations in six size-fractions of till taken from 1993 till samples showing a range from background to anomalous concentrations.

weathering (DiLabio, 1994). The heavy mineral study indicated that the sand-sized heavy minerals contain trace amounts of the REE-bearing minerals allanite and monazite, which both occur in outcrops of carbonatite and pegmatitic monzonite in the study area. This (and the fact that the only other slightly enriched grain size fraction is the 4-2mm fraction) suggests that the residence sites for these elements in till are occupied by primary mineral grains, and that remobilization and reprecipitation of these elements are not factors affecting the REE residence sites in the till taken from the study area. This also concurs with the fact that the terminal mode for hard, poorly cleaved minerals such as allanite (REE-bearing silicate) and well-cleaved minerals such as monazite, which is known to form monazite "sands" (stubby prismatic REE phosphate) dominate the fine sand size fraction of glacial sediments (Mottana *et al*, 1988).

Contrary to the findings of this study, a trace-element residence site study conducted by DiLabio (1994) revealed that the residence sites for base metals, lithophile and platinum group elements (taken from till samples from a variety of locations) lie in the finest fractions (<0.063mm) in both primary and secondary mineral phases. This is due to the adsorption of metals in the clay fraction and the production of secondary clays, along with milling of the primary minerals to augment the clay-size fraction.

Furthermore, a till geochemical partitioning study performed by Shilts (1994) concluded that for most trace elements in till, the lowest concentrations are shown by the quartz-dominated sand to fine silt-size fractions, whereas the fine silt/clay fractions show the highest.

CHAPTER 5: *Conclusions and Implications for Future Exploration*

5.1 *Conclusions*

Based on the results of this study, several conclusions can be made regarding the extent, shape and source of the four main geochemical anomalies with respect to regional ice flow directions in the study area, and the partitioning of REE in different grain-size fractions of till.

The extent, shape and source of the geochemical anomalies in the study area have been defined by till geochemistry and abundance of clast lithologies. Four distinct anomalous areas in the study area have been identified from the proportional symbol maps, and are based on local geochemical and lithological dispersal patterns. Furthermore, it has been deduced that these dispersal patterns are linked to the bedrock geology in the study area, and concur with ice flow indicators measured within the study area. The following is a summary of the four distinct anomalous areas:

1. **Area along the northwest end of the forestry access road, just southeast of Granite Creek.** Geochemically, the area is enriched in Ce, Cs, Eu, La, Sm, Lu, Th, Yb, Tb, Br, Hf, Na, and has anomalous abundances of limestone/marble and volcanic clasts. This area is linked to a shear zone, and to related REE-enriched Lonnie Creek carbonatite dikes. Dispersal trains are characterized by an average distance of transport ranging from 4-6km for <0.063mm materials, and 2km for 4-16mm materials which have created trains

extending from the highest concentrations in the northwest to the lowest concentrations in the southeast.

2. Area located north of Munroe Creek, parallel to the eastern margin of Manson River. This anomalous area shows the highest geochemical concentrations of Ce, Eu, La, Sm, Ta, Tb, Th, Br, Na, U, Yb, Zn along the margin of the Wolverine Complex calc-silicate division, along with anomalous values for granite, granodiorite and pegmatite clasts. This anomalous area is most likely associated with igneous intrusions of pegmatitic syenite and monzonite within the Wolverine Complex. The source and distance of transport that produced these anomalies is difficult to identify, because many small intrusions may have been eroded by glacial action. However, it is likely that the dispersal represents a general transport of anomalous rocks from south to north along the Manson River valley, which parallels the regional ice flow direction.

3. South-central part of the study area (south of Manson River). This is an area characterized by anomalous values of Au, Ba, Zn, Cr, As, U, Ba, Sb, Sc, Mo. Dispersal of these elements appears to be to the north, with a distance of transport of 4 to 6 km. The highest elemental concentrations are in the graphitic sediment division (SM6) of the Slide Mountain Group. These

high concentrations correspond to anomalous values for argillite, siltstone, sandstone, slate/phyllite and volcanic clasts, which all show similar dispersal trends marked by wide trains extending up to 5 km to the north. Furthermore, each of these clast types can be found up to 15 km to the northeast along the Manson River valley. These trends parallel regional ice direction.

4. **Area north of Manson River, in the north central portion of the study area.** This area displays anomalous values of Cs, Hf, Lu, Rb, W, Yb and anomalous abundances of schist clasts. The source of these anomalies (both geochemical and lithological) is likely the Ingenika Group sediments and schists (12) which underlie the anomalous tills and crop out slightly to the northwest and southeast. The direction and distance of transport is difficult to ascertain, due to lack of sufficient and viable sample locations in this area, and to the fact that the anomalous values are directly above their bedrock source. These anomalies may be due to an unknown source, or may simply be the geochemical signature of the bedrock.

Where till samples were collected from sections at different localities, generally one of two types of variability in depth and composition were observed:

(1) No variation geochemically and/or lithologically within a single till unit.

This was the case for sections 93 PMA 1016, 93 PMA 1094, and 93 PMA 1095.

(2) Variation geochemically and/or lithologically within a single till unit. Till samples collected at different depths in sections show high elemental and/or lithological values, reflecting the incorporation of local bedrock sources near the base of an exposure. These high values tend to decrease upwards in the section, making way for more distal geochemical values and lithologies. This was seen in section 93 PMA 1003 and 93 PMA 1020.

With respect to ice flow directions in the study area, the above mentioned glacial dispersal patterns along with the variability in depth and composition of till and other surficial sediments seen in the study area illustrate that it is likely that glacier ice in the study area flowed initially down from the northern Wolverine Ranges in tributary valleys of the Manson River. This however, is no longer reflected in the till but is seen in the glaciofluvial sediments found beneath the till in the Manson River valley.

Ice flow then changed direction to flow eastward, parallel to the Manson River in the western portion of the study area, and from south to north in the eastern portion of the study area. Fabric analyses showed a preferred clast fabric similar to ice flow patterns determined locally. The data from till fabric analyses and bedrock striae was useful in aiding in the identification of the subtle deviations in the local ice flow regime. However, it is not clear whether this noted change in ice flow direction represents differing ice flow events or only a deviation in one event.

Application of the partitioning study to determine the residence sites of the REE

has been useful in concluding that, based on this study, REEs are most likely primary minerals in the fine sand to silt-size fraction, and analysis of this size fractions of till, is recommended for exploration purposes. The partitioning study along with the heavy mineral analysis aided in the determination that the REE enrichment of these size fractions were from primary mineral grains, and not that of secondary adsorption. Therefore, analysis of REE in this size fraction range should be adequate to map the shape of dispersal halos in till and link the shape to the ice flow directions.

5.2 Implications and Recommendations for Future Exploration

From the results of the work performed in the study area, an exploration strategy for similar related deposits like the Lonnie Creek carbonatite complex and the Munroe Creek Pegmatite, in similarly glaciated terrain can be suggested:

At the reconnaissance level, till sampling at a density of 1 sample per 2 km² is adequate to detect relevant elemental dispersal trains. By their nature, the mineral deposits seen in the study area are multi-element and thus produce dispersal trains as such. The elements analyzed in till which provide the best contrast of the Lonnie Creek carbonatite dispersal relative to background values are: Ce, Cs, Eu, La, Lu, Sm, Th, Yb, Tb, Br, Hf, Na; Also effective, but providing less contrast, are: U, Rb, Ta, Fe. The elements analyzed in till which provide the best contrast of the Munroe Creek pegmatitic syenite and monzonite dispersal relative to background values are: Ce, Eu, La, Sm, Ta, Tb, Th, Br, Na, U, Yb, Zn. Also effective, but providing less contrast, are

Cs, Hf, Lu, Ni, Rb. Therefore, till geochemistry is a useful technique for delineating mineralization associated with REE-bearing carbonatite and pegmatite bodies.

Analysis of the fine sand to silt size fractions of till is recommended for detecting substantial REE concentrations for exploration purposes.

REFERENCES

- Armstrong, J.E. 1949. Fort St. James map-area Cassiar and Coast District, British Columbia. Geological Survey of Canada, Memoir 252, 204p.
- Armstrong, J.E. and Tipper, H.W. 1948. Glaciation in north central British Columbia. *American Journal of Science*, v.246, p.283-310.
- Averill S.A., MacNeil, K.A., Huneault, R.G. and Baker C.L. 1986. Rotasonic drilling operations (1984) and overburden heavy mineral studies, Matheson area, District of Cochrane. Ontario Geological Survey Open File 5569, 57p.
- Coker, W.B. and DiLabio, R.N.W. 1989. Geochemical exploration in glaciated terrain: geochemical responses. *In* Proceedings of Exploration '87. *Edited by* G.D. Garland, Ontario Geological Survey, Special Volume 3, p.336-383.
- Dawson, G.M. 1878. On the superficial geology of British Columbia. *Quarterly Journal of the Geological Society of London*, v. 34, p.89-123.
- Dawson, G.M. 1881. Additional observations on the superficial geology of British Columbia and adjacent regions. *Quarterly Journal of the Geological Society of London*, v. 37, p.272-285.
- Dawson, G.M. 1888. Recent observations on the glaciation of British Columbia and adjacent regions. *Geological Magazine, New Series*, v.5, p.347-350.
- Dawson, G.M. 1889. Glaciation of high points in the southern interior of British Columbia. *Geological Magazine, New Series*, v.6, p.350-352.
- DiLabio, R.N.W. 1985. Gold abundances vs. grain size in weathered and unweathered till. *In* Current Research, Part A. Geological Survey of Canada, Paper 85-1A, p.117-122.

- DiLabio, R.N.W. 1988. Residence sites of gold, PGE and rare lithophile elements in till. *In* Prospecting in areas of glaciated terrain - 1988. *Edited by* D.R. Macdonald and K.A. Mills, The Canadian Institute of Mining and Metallurgy, p.121-140.
- DiLabio, R.N.W. 1994. Residence sites of trace elements in oxidized till. *In* Drift exploration in glaciated and mountainous terrain. *Edited by* P.T. Bobrowsky, S. Sibbick, and P.F. Matyssek. British Columbia British Columbia Ministry of Energy, Mines and Petroleum Resources short course, 23p.
- Dreimanis, A., and Vagners, U.J. 1971. Bimodal distribution of rock and mineral fragments in basal tills. *In* Till - a symposium. *Edited by* R.P. Goldthwait, Ohio State University Press, Columbus, Ohio, p.237-250.
- Dreimanis, A., and Vagners, U.J. 1972. The effect of lithology on the texture of till. *In* Research methods in Pleistocene geomorphology. *Edited by* E. Yatsu and A. Falconer, 2nd Guelph Symposium on Geomorphology, Guelph, Ontario, p.66-82.
- Dreimanis, A. 1982. Work Group 1 - Genetic classifications of tills and criteria for their differentiation: Progress report on activities 1977-1982, and definitions on glacial terms. *In* INQUA Commission on genesis and lithology of Quaternary deposits, Report on activities 1977-1982. *Edited by* Schluchter, C. ETH, Zurich, p.12-31.
- Ferri, F. and Melville, D. M. 1988. Manson Creek mapping project (93N/09). British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork 1987, Paper 1988-1, p.169-180.
- Ferri, F. and Melville, D. M. 1989. Geology of Germanson Landing area, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork 1988, Paper 1989-1, p.209-220.

- Ferri, F. and Melville, D. M. 1990. Geology between Nina Lake and Osilinka River, north-central British Columbia (93 N/15, north half and 94 C/2, south half). British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork 1988, Paper 1989-1, p.209-220.
- Ferri, F. and Melville, D. M. 1994. Bedrock geology of the Germanson Landing - Manson Creek area, British Columbia (94 N/9, 10, 15; 94 C/2). British Columbia Ministry of Energy, Mines and Petroleum Resources, 147p.
- Flint, R. F. 1971. Glacial and Pleistocene Geology. J. Wiley and Sons, New York, 468p.
- Govett, G.J.W. 1973. Geochemical exploration studies in glaciated terrain, New Brunswick, Canada. *In* Prospecting in areas of glaciated terrain - 1973. *Edited by* M.J.Jones, Institution of Mining and Metallurgy, London, p.11-24.
- Halleran, A.A.D. 1980. Petrology, mineralogy, and origin of the Lonnie Carbonatite Complex of the Manson Creek area. British Columbia British Columbia Ministry of Energy, Mines and Petroleum Resources, Assessment Report 14545.
- Halleran, A.A.D. 1988. Geology, geochemistry, geophysics; Ursa Property. British Columbia British Columbia Ministry of Energy, Mines and Petroleum Resources, Assessment Report 17872.
- Halleran, A.A.D. and Russell, J.K. 1993. Rare-earth element bearing pegmatites in the Wolverine Metamorphic Complex: a new exploration target. British Columbia British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork 1992, Paper 1993-1, p.301-306.
- Hawkes, H.E. and Webb, J.S. 1962. Geochemistry in Mineral Exploration. Harper and Row, New York, 415p.
- Hirvas, H. and Nenonen, K. 1990. Field methods for glacial indicator tracing. *In* Glacial Indicator Tracing. *Edited by* R. Kujansuu and M. Saarnisto. Balkema, Rotterdam, p.217-248.

- Kerr, F.A. 1934. Glaciation in northern British Columbia. Transaction of the Royal Society of Canada, v.28, sec.IV, p.17-32.
- Koch, G.S. and Link, R.F. 1971. Statistical Analysis of Geological Data. Dover Publications Inc., New York, 523p.
- Lindsay, P.J. and Shilts W.W. 1995. A standard laboratory procedure for separating clay-sized detritus from unconsolidated glacial sediments and their derivatives. *In* Drift Exploration in the Canadian Cordillera. Edited by P.T. Bobrowsky, S.J. Sibbick, J.M. Newell, and P.F. Matyssek. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1995-2, p.165-166.
- Mathews, W.H. 1986. Physiography of the Canadian Cordillera. Geological Survey Canada, Map 1701A, scale 1: 5 000 000.
- McClenaghan, M.B. 1992. Surface till geochemistry and implications for exploration, Black River - Matheson Area, Northeast Ontario. Canadian Institute of Mining, Metallurgy and Petroleum, v.1, no.4, p.327-337.
- Melville, D.M. 1990. Carbonate-hosted Lead-Zinc Occurrences in the Germansen Landing and End Lake Areas (94 C/2, 93 N/15). *In* Exploration in British Columbia 1990, Part B, British Columbia Ministry of Energy, Mines and Petroleum Resources, p.193-196.
- Melville, D.M., Nelles, D.M., Payie, G.J., Bellefontaine, K., and Ferri, F. 1993. Minfile NTS 093N - Manson River. British Columbia Ministry of Energy, Mines and Petroleum Resources, 13p.
- Monger, J.W.H. 1984. Cordilleran Tectonics: A Canadian Perspective. Bulletin Societe Geologie de France, v.26, No.2, p.255-278.
- Mottana, A., Crespi, R. and Liborio G. 1988. Guide to Rocks and Minerals. Simon and Schuster Inc., Toronto, 607p.

- Pell, J. 1987. Alkaline ultrabasic rocks in British Columbia: carbonatites, nepheline syenites, kimberlites, ultramafic lamprophyres and related rocks. British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File 1987-17, 109p.
- Plouffe, A. 1991. Preliminary study of the Quaternary geology of the northern interior of British Columbia. *In* Current Research, Part A. Geological Survey of Canada, Paper 91-1A, p. 7-13.
- Plouffe, A. 1992. Quaternary stratigraphy and history of central British Columbia. *In* Current Research, Part A. Geological Survey of Canada, Paper 92-1A, p.189-193.
- Plouffe, A. 1995. Geochemistry, lithology, mineralogy and visible gold grain content of till in the Manson River and Fort Fraser map areas, central British Columbia (NTS 93K and N). Geological Survey of Canada, Open File 3194, 119p.
- Plouffe, A. 1996. Surficial Geology, Germansen Lake, British Columbia (NTS 93N/NE). Geological Survey of Canada, Open File 3312, scale 1:100 000.
- Plouffe, A. 1997. Ice Flow and late glacial lakes of the Fraser Glaciation, central British Columbia. *In* Current Research 1997-A. Geological Survey of Canada, Paper 97-1A, p. 1-11.
- Plouffe, A. and Ballantyne, S.B. 1993. Regional till geochemistry, Manson River and Fort Fraser area, British Columbia (93K,93N), silt plus clay and clay size fractions. Geological Survey of Canada, Open File 2593, 210p.
- Ryder, J.M. 1994. Recognition and interpretation of flow direction indicators for former glaciers and meltwater streams. In Drift exploration in glaciated and mountainous terrain. *Edited by* P.T. Bobrowsky, S. Sibbick, and P.F. Matyssek. British Columbia British Columbia Ministry of Energy, Mines and Petroleum Resources short course, 23p.
- Ryder, J.M. and Maynard D. 1991. The Cordilleran Ice Sheet in northern British Columbia. *Geographie physique et Quaternaire*, v.45, p.355-363.

- Ryder, J.M., Fulton R.J. and Clague J.J. 1991. The Cordilleran Ice Sheet and the glacial geomorphology of southern and central British Columbia. *Geographie physique et Quaternaire*, v.45, p.365-377. Shilts, W.W. 1975. Principles of geochemical exploration for sulphide deposits using shallow samples of glacial drift. *Canadian Institute of Mining and Metallurgy Bulletin*, Volume 68, Number 757, p.73-80.
- Shilts, W.W. 1976. Glacial till and mineral exploration. *In* *Glacial till: An interdisciplinary study*. Edited by R.F. Legget. Royal Society of Canada, Special Publication Number 12.
- Shilts, W.W. 1984. Till geochemistry in Finland and Canada. *Journal of Exploration Geochemistry*, v.21, p.95-117.
- Shilts, W.W. 1991. Principles of glacial dispersal and sedimentation. *In* *Exploration Geochemistry workshop*. Edited by W.B. Coker. Geological Survey of Canada, Open File 2390, pages 2-1 to 2-42.
- Shilts, W.W. 1994. Geochemical partitioning in till. *In* *Drift exploration in glaciated and mountainous terrain*. Edited by P.T. Bobrowsky, S. Sibbick, and P.F. Matysek. British Columbia British Columbia Ministry of Energy, Mines and Petroleum Resources short course, 23p.
- Shilts, W.W. and Kettles, L.M. 1990. Geochemical/mineralogical profiles through fresh and weathered till. *In* *Handbook of glacial indicator tracing*. Edited by R. Kujansuu and M. Saarnisto. Balkema, Rotterdam, p.187-216.
- Souther, J.G. 1991. Volcanic Regimes. *In* *Geology of the Cordilleran Orogen in Canada*. Edited by H. Gabrielse and C.J. Yorath, Geological Survey of Canada, Geology of Canada, No. 4, p.457-490.
- Struik, L.C. 1985. Pre-Cretaceous Terranes and their thrust and strike-slip Contacts, Prince George (east half) and McBride (west half) map areas, British Columbia. *In* *Current Research, Part A*. Geological Survey of Canada, Paper 85-1A, p.267-272.

- Taylor, S.R. and McLennnon, S.M. 1981. The composition and evolution of the continental crust: rare earth element evidence from sedimentary rocks. *Phil. Trans. Roy. Soc.*, v.A301, p.381.
- Tipper, H.W. 1971a. Multiple glaciation in central British Columbia. *Canadian Journal of Earth Science*, v.8, p.743-752.
- Tipper, H.W. 1971b. Glacial geomorphology and Pleistocene history of central British Columbia. *Geological Survey of Canada, Bulletin 196*, 89p.
- Whiting, K.S. and Faure, G. 1991. Transport of magnetite and ilmenite by glaciers in the Adirondack Mountains of New York. *Journal of Geology*, v. 99, p.482-492.

Appendix I
Field Station Locations

Field Station #:	Type of sample:	Sample #	East	North	Lat.	Long.
93 PMA 1000	none		434005	6155230	55.54	-124.05
93 PMA 1001	till	93-PMA-1001-1	434021	6155265	55.54	-124.05
	till	93-PMA-1001-2	434021	6155265	55.54	-124.05
93 PMA 1002	till	93-PMA-1002	435169	6155598	55.54	-124.03
93 PMA 1003	till	93-PMA-1003-1	433800	6154182	55.53	-124.05
	till	93-PMA-1003-2	433800	6154182	55.53	-124.05
	till	93-PMA-1003-3	433800	6154182	55.53	-124.05
	till	93-PMA-1003-4	433800	6154182	55.53	-124.05
93 PMA 1004	till	93-PMA-1004	435150	6153412	55.52	-124.03
93 PMA 1005	till	93-PMA-1005	436631	6153805	55.53	-124.00
93 PMA 1006	till	93-PMA-1006-1	436815	6154673	55.54	-124.00
	till	93-PMA-1006-2	436815	6154673	55.54	-124.00
93 PMA 1007	none		436631	6153805	55.53	-124.00
93 PMA 1008	bedrock	93-PMA-1008	436815	6154673	55.54	-124.00
93 PMA 1009	till	93-PMA-1009	436815	6154673	55.54	-124.00
93 PMA 1010	bedrock	93-PMA-1010-1	437680	6153970	55.53	-123.99
	bedrock	93-PMA-1010-2	437680	6153970	55.53	-123.99
	bedrock	93-PMA-1010-3	437680	6153970	55.53	-123.99
93 PMA 1011	till	93-PMA-1011	437680	6153970	55.53	-123.99
93 PMA 1012	till	93-PMA-1012	437290	6151790	55.51	-123.99
93 PMA 1013	bedrock	93 PMA 1013	438830	6152000	55.51	-123.97
93 PMA 1014	till	93-PMA-1014-1	438100	6150500	55.51	-123.95
	till	93-PMA-1014-2	438100	6150500	55.51	-123.95
93 PMA 1015	bedrock	93 PMA 1015	438100	6150500	55.51	-123.95
93 PMA 1016	bedrock	93-PMA-1016-1	440300	6150400	55.51	-123.94
	till	93-PMA-1016-2	440300	6150400	55.51	-123.94
	till	93-PMA-1016-3	440300	6150400	55.51	-123.94
93 PMA 1017	till	93-PMA-1017	441450	6150800	55.50	-123.93
93 PMA 1018	till	93-PMA-1018	439300	6150000	55.52	-123.92
93 PMA 1019	till	93-PMA-1019	433138	6154165	55.53	-124.06
93 PMA 1020	till	93-PMA-1020-1	433002	6153194	55.52	-124.06
	till	93-PMA-1020-2	433002	6153194	55.52	-124.06
	till	93-PMA-1020-3	433002	6153194	55.52	-124.06
	till	93-PMA-1020-4	433002	6153194	55.52	-124.06
	till	93-PMA-1020-5	433002	6153194	55.52	-124.06
93 PMA 1021	till	93-PMA-1021	432166	6151023	55.50	-124.07
93 PMA 1022	till	93-PMA-1022-1	433590	6151460	55.51	-124.05
	till	93-PMA-1022-2	433590	6151460	55.51	-124.05
93 PMA 1023	till	93-PMA-1023	434133	6149760	55.49	-124.04
93 PMA 1024	till	93-PMA-1024	430887	6150941	55.50	-124.09
93 PMA 1025	bedrock	93 PMA 1025	430956	6151023	55.50	-124.07
93 PMA 1026	till	93-PMA-1026	431238	6149404	55.49	-124.09
93 PMA 1027	till	93-PMA-1027	432053	6148137	55.48	-124.07
93 PMA 1028	till	93-PMA-1028	432848	6146939	55.47	-124.06
93 PMA 1029	till	93-PMA-1029	434286	6146767	55.46	-124.04
93 PMA 1030	1029 duplicate	93-PMA-1030	434286	6146767	55.46	-124.04
93 PMA 1031	till	93-PMA-1031	430984	6147210	55.47	-124.09
93 PMA 1032	till	93-PMA-1032	430520	6151822	55.51	-124.10
93 PMA 1033	till	93-PMA-1033	428370	6153107	55.52	-124.13
93 PMA 1034	till	93-PMA-1034	431751	6152878	55.52	-124.08
93 PMA 1035	bedrock	93 PMA 1035	432966	6165680	55.63	-124.18
93 PMA 1036	bedrock	93 PMA 1036	432966	6165680	55.63	-124.18
93 PMA 1037	till	93-PMA-1037	432732	6163574	55.62	-124.07
93 PMA 1038	till	93-PMA-1038	436556	6166923	55.65	-124.01
93 PMA 1039	till	93-PMA-1039-1	438400	6167325	55.65	-123.98
	till	93-PMA-1039-2	438400	6167325	55.65	-123.98
93 PMA 1040	till	93-PMA-1040	437825	6165300	55.63	-123.97
93 PMA 1041	till	93-PMA-1041	438900	6165700	55.64	-123.90
93 PMA 1042	none		443200	6167400	55.65	-123.94
93 PMA 1043	till	93-PMA-1043	443200	6167400	55.65	-123.94
93 PMA 1044	till	93-PMA-1044	440800	6164950	55.63	-123.94
93 PMA 1045	till	93-PMA-1045	440625	6167300	55.65	-124.08
93 PMA 1046	till	93-PMA-1046-1	432053	6156014	55.55	-124.08
	till	93-PMA-1046-2	432053	6156014	55.55	-124.11
93 PMA 1047	till	93-PMA-1047-1	429948	6155404	55.54	-124.15

Field Station #:	Type of sample:	Sample #	East	North	Lat.	Long.
93 PMA 1048	till	93-PMA-1047-2	427233	6156782	55.55	-124.15
93 PMA 1049	till	93-PMA-1048	427233	6156782	55.55	-124.15
93 PMA 1050	1048 duplicate	93-PMA-1049	427233	6156782	55.55	-124.15
93 PMA 1051	none		435352	6160050	55.59	-124.02
93 PMA 1052	none		435375	6160250	55.59	-124.02
93 PMA 1053	till	93-PMA-1052	435352	6160378	55.59	-124.02
93 PMA 1054	none		435301	6162073	55.60	-124.03
93 PMA 1055	none		435301	6162073	55.60	-124.03
93 PMA 1056	till	93-PMA-1055	435797	6160983	55.59	-124.01
93 PMA 1057	none		435797	6160983	55.59	-124.01
93 PMA 1058	till	93-PMA-1057	436404	6159564	55.58	-123.98
93 PMA 1059	till	93-PMA-1058	437900	6159025	55.58	-124.00
93 PMA 1060	till	93-PMA-1059	437200	6161600	55.60	-123.98
93 PMA 1061	till	93-PMA-1060	438200	6162000	55.60	-124.00
93 PMA 1062	till	93-PMA-1061	438847	6162785	55.61	-124.03
93 PMA 1063	none		438620	6162950	55.61	-124.03
93 PMA 1064	till	93-PMA-1063	435380	6163362	55.61	-124.03
93 PMA 1065	till	93-PMA-1064	435301	6162073	55.60	-124.03
93 PMA 1066	till	93 PMA 1065	434133	6149760	55.49	-124.04
93 PMA 1067	till	93-PMA-1066	435182	6147919	55.48	-124.38
	till	93-PMA-1067-1	413450	6171525	55.68	-124.38
	till	93-PMA-1067-2	413450	6171525	55.68	-124.38
93 PMA 1068	till	93-PMA-1068	412979	6171017	55.68	-124.20
93 PMA 1069	till	93-PMA-1069	424515	6158056	55.56	-124.17
93 PMA 1070	till	93-PMA-1070	425944	6160545	55.59	-124.16
93 PMA 1071	till	93-PMA-1071	427070	6161830	55.60	-124.15
93 PMA 1072	till	93-PMA-1072	427660	6163637	55.62	-124.22
93 PMA 1073	none		427660	6163637	55.62	-124.22
93 PMA 1074	till	93-PMA-1074	423207	6162064	55.60	-124.21
93 PMA 1075	till	93-PMA-1075	423796	6163638	55.61	-124.24
93 PMA 1076	till	93-PMA-1076	422134	6163851	55.62	-124.26
93 PMA 1077	till	93-PMA-1077	420977	6165328	55.63	-124.35
93 PMA 1078	till	93-PMA-1078	415014	6170288	55.67	-124.35
93 PMA 1079	till	93-PMA-1079	415251	6168970	55.67	-124.34
93 PMA 1080	till	93-PMA-1080	415497	6169603	55.67	-124.34
93 PMA 1081	till	93-PMA-1081	415780	6169256	55.66	-124.33
93 PMA 1082	till	93-PMA-1082	416157	6168914	55.66	-124.33
93 PMA 1083	till	93-PMA-1083-1	416574	6168604	55.66	-124.32
	till	93-PMA-1083-2	416574	6168604	55.66	-124.31
93 PMA 1084	till	93-PMA-1084	416966	6168294	55.66	-124.27
93 PMA 1085	till	93-PMA-1085	417397	6167913	55.65	-124.39
93 PMA 1086	none		420036	6166374	55.64	-124.39
93 PMA 1087	till	93-PMA-1087	420036	6166374	55.64	-124.39
93 PMA 1088	bedrock	93-PMA-1088-1	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-2	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-3	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-4	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-5	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-6	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-7	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-8	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-9	412528	6170349	55.67	-124.39
	bedrock	93-PMA-1088-10	412528	6170349	55.67	-124.39
93 PMA 1089	till	93 PMA 1089	412528	6170349	55.67	-124.39
93 PMA 1090	till	93-PMA-1090-1	412528	6170349	55.67	-124.39
	till	93-PMA-1090-2	412528	6170349	55.67	-124.39
	till	93-PMA-1090-3	412528	6170349	55.67	-124.39
	till	93-PMA-1090-4	412528	6170349	55.67	-124.39
93 PMA 1091	bedrock	93 PMA 1091	412528	6170349	55.67	-124.39
93 PMA 1092	till	93-PMA-1092-1	412338	6170035	55.67	-124.39
	till	93-PMA-1092-2	412338	6170035	55.67	-124.39
93 PMA 1093	till	93-PMA-1093-1	412350	6169892	55.67	-124.19
	till	93-PMA-1093-2	412350	6169892	55.67	-124.19
93 PMA 1094	till	93-PMA-1094-1	425021	6157431	55.56	-124.19
	till	93-PMA-1094-2	425021	6157431	55.56	-124.19

Field Station #:	Type of sample:	Sample #	East.	North.	Lat.	Long.
93 PMA 1095	til	93-PMA-1094-3	425021	6157431	55.56	-124.06
	til	93-PMA-1094-4	425021	6157431	55.56	-124.06
	til	93-PMA-1094-6	425021	6157431	55.56	-124.06
	til	93-PMA-1094-8	425021	6157431	55.56	-124.06
	til	93-PMA-1094-10	425021	6157431	55.56	-124.06
	til	93-PMA-1094-12	425021	6157431	55.56	-124.06
	til	93-PMA-1094-14	425021	6157431	55.56	-124.06
	til	93-PMA-1095-1	432966	6165680	55.63	-124.18
	til	93-PMA-1095-2	432966	6165680	55.63	-124.21
	til	93-PMA-1096	425368	6154458	55.53	-124.23
	til	93-PMA-1097	423463	6154137	55.53	-124.42
	til	93-PMA-1098	422426	6159171	55.57	-124.24
	bedrock	93 PMA 1099	422426	6159171	55.57	-124.24
	til	93-PMA-1100	410668	6170668	55.68	-124.48

Appendix II
Till Geochemistry

1992 Till Geochemistry Results

Sample #	Est.	North	Lat	Long	AG PPM	AS PPM	AU PPB	BA PPM	BR PPM	CD	CE PPM	CO PPM	CR PPM	CS PPM	EU PPM	FE %	HF PPM	IR PPB	LA PPM
Detection Limit					5	0.5	2	50	0.5	5	3	1	5	1	0.2	0	1	5	0.5
91-PMA-336	425425	6152025	55.52	-124.18	<2	25	12	1500	<0.5	<5	57	29	220	42	1	5.3	4	<50	32
91-PMA-339	425425	6152025	55.52	-124.18	<2	26	11	1500	<0.5	<5	52	31	190	4	<1	5.9	5	<50	33
91-PMA-340	422060	6155738	55.54	-124.24	<2	25	19	1600	1.3	<5	72	31	330	46	2	5.9	7	<50	40
91-PMA-342	418675	6159934	55.58	-124.29	<2	17	7	1600	1.6	<5	39	46	220	47	1	7.1	4	<50	26
91-PMA-344-1	417047	6161159	55.59	-124.32	<2	16	9	840	<0.5	<5	24	66	410	3.6	<1	5.6	2	<50	15
91-PMA-344-2	417047	6161159	55.59	-124.32	<2	19	14	1000	0.9	<5	24	69	430	3.8	1	6.3	3	<50	17
91-PMA-344-3	417047	6161159	55.59	-124.32	<2	21	8	810	0.9	<5	24	76	510	3.2	<1	6.3	2	<50	15
91-PMA-345	417047	6161159	55.59	-124.32	<2	20	6	780	1.3	<5	20	84	470	3.6	<1	6	2	<50	14
91-PMA-346-1	414972	6163813	55.61	-124.35	<2	24	12	1400	<0.5	<5	43	30	160	4.3	1	5.2	3	<50	28
91-PMA-346-2	414972	6163813	55.61	-124.35	<2	19	17	1400	1.7	<5	38	39	210	3.2	1	5.8	3	<50	24
91-PMA-347	414972	6163813	55.61	-124.35	<2	22	12	1400	<0.5	<5	47	30	170	4.5	1	5.1	4	<50	26
91-PMA-348-1	424932	6157242	55.56	-124.19	<2	12	11	1100	<0.5	<5	69	20	170	2.8	<1	4.2	7	<50	41
91-PMA-348-2	424932	6157242	55.56	-124.19	<2	11	13	1100	<0.5	<5	81	24	160	3	2	4.5	9	<50	50
91-PMA-348-3	424932	6157242	55.56	-124.19	<2	17	6	1400	0.5	<5	69	34	190	6	1	5.9	4	<50	43
91-PMA-348-4	424932	6157242	55.56	-124.19	<2	15	22	1300	<0.5	<5	78	29	160	4.9	2	5	5	<50	45
91-PMA-348-5	424932	6157242	55.56	-124.19	<2	13	6	1300	0.7	<5	90	29	160	4.6	1	5	7	<50	55
91-PMA-348-6	424932	6157242	55.56	-124.19	<2	18	5	1400	<0.5	<5	100	32	140	6.8	2	6.5	7	<50	65
91-PMA-349-1	425638	6153185	55.52	-124.18	<2	23	12	1600	<0.5	<5	54	30	230	5.2	1	4.8	4	<50	35
91-PMA-349-2	425638	6153185	55.52	-124.18	<2	29	15	1900	<0.5	<5	56	34	200	5.6	<1	4.4	5	<50	39
91-PMA-349-3	425638	6153185	55.52	-124.18	<2	31	17	1400	<0.5	<5	68	34	200	4	1	5.6	6	<50	41
91-PMA-352	429012	6159277	55.57	-124.13	<2	3.9	4	1100	<0.5	<5	72	23	85	6	2	4.8	10	<50	45
91-PMA-353	429012	6159277	55.57	-124.13	<2	3.1	2	930	<0.5	<5	67	20	86	5.8	1	4.1	10	<50	41
91-PMA-354	433152	6155236	55.54	-124.06	<2	14	7	1500	<0.5	<5	89	26	170	3.1	2	4.6	8	<50	52
91-PMA-355	433152	6155236	55.54	-124.06	<2	13	6	1200	0.7	<5	97	24	190	3.2	3	4.8	10	<50	57
91-PMA-358	412383	6170153	55.67	-124.39	<2	11	8	1000	<0.5	<5	90	27	150	3.6	1	4.8	7	<50	49
91-PMA-359	412383	6170153	55.67	-124.39	<2	8.4	5	940	<0.5	<5	85	27	160	4.2	1	4.6	8	<50	48
91-PMA-362	406965	6173284	55.70	-124.48	<2	11	7	1100	<0.5	<5	33	27	190	2.6	<1	5.3	3	<50	21
91-PMA-363	406965	6173284	55.70	-124.48	<2	12	7	1200	<0.5	<5	30	31	170	3.2	2	5.4	3	<50	21
91-PMA-370-1	432370	6152552	55.52	-124.07	<2	14	6	1600	<0.5	<5	58	22	130	4.9	1	4.3	4	<50	38
91-PMA-370-2	432370	6152552	55.52	-124.07	<2	15	7	1700	<0.5	<5	66	20	130	4.7	1	4.3	5	<50	39
91-PMA-370-3	432370	6152552	55.52	-124.07	<2	14	5	1600	<0.5	<5	61	20	120	4.1	1	4.1	5	<50	37
91-PMA-371	434035	6148207	55.48	-124.04	<2	17	6	1400	0.6	<5	48	28	170	4	1	5.5	5	<50	29
91-PMA-375-1	429047	6151802	55.51	-124.12	<2	22	17	1200	<0.5	<5	38	34	190	4.5	1	5.5	3	<50	24

1992 Till Geochemistry Results

Sample #	East.	North.	Lat.	Long.	AG PPM	AS PPM	AU PPB	BA PPM	BR PPM	CD	CE PPM	CO PPM	CR PPM	CS PPM	EU PPM	FE %	HF PPM	IR PPB	LA PPM
Detection Limit					5	0.5	2	50	0.5	5	3	1	5	1	0.2	0	1	5	0.5
91-PMA-375-2	429047	6151802	55.51	-124.12	<2	21	13	1000	<0.5	<5	38	30	220	3.5	1	6.5	3	<50	24
91-PMA-376	429047	6151802	55.51	-124.12	<2	25	18	1200	0.5	<5	38	29	210	3.9	1	5.7	3	<50	25
91-PMA-377	428928	6149065	55.48	-124.12	<2	32	15	1800	<0.5	<5	72	28	140	4.7	2	5.2	5	<50	40
91-PMA-378	430003	6147054	55.47	-124.09	<2	21	19	1500	<0.5	<5	51	20	150	2.2	<1	4.1	5	<50	34
91-PMA-383	439211	6159071	55.58	-124.01	<2	7.3	4	1500	<0.5	<5	98	22	100	4	1	5	7	<50	61
91-PMA-384	439211	6159071	55.58	-124.01	<2	7.7	2	1400	0.7	<5	90	23	120	4.3	2	4.9	7	<50	58
91-PMA-394	433018	6162529	55.61	-124.06	<2	11	5	1400	<0.5	<5	78	22	140	5.4	1	4.8	6	<50	40
91-PMA-395-1	433078	6165999	55.64	-124.08	<2	7.9	2	890	<0.5	<5	60	13	75	5.6	1	3.7	6	<50	41
91-PMA-395-2	433078	6165999	55.64	-124.08	<2	12	5	1200	<0.5	<5	53	22	120	8.5	1	4.5	4	<50	38
91-PMA-396	425373	6163318	55.61	-124.18	<2	1.9	6	1200	<0.5	<5	89	18	110	8.4	1	5.1	10	<50	58
91-PMA-399	416900	6168756	55.66	-124.33	<2	3.3	2	1000	<0.5	<5	110	19	110	8.4	2	4.4	10	<50	67
91-PMA-400	420425	6168323	55.64	-124.26	<2	6.2	3	1400	<0.5	<5	59	24	120	6.1	<1	4.9	5	<50	35
91-PMA-401	420425	6168323	55.64	-124.26	<2	6.8	2	1400	<0.5	<5	58	24	110	6	1	5	5	<50	35
91-PMA-402	424241	6168382	55.61	-124.23	<2	2.5	18	1000	<0.5	<5	81	19	81	6	1	4.3	10	<50	48
91-PMA-403	424716	6159787	55.58	-124.19	<2	10	3	1300	<0.5	<5	65	26	120	6	2	5.2	5	<50	43
91-PMA-404	427432	6161007	55.59	-124.15	<2	1.9	2	820	<0.5	<5	69	21	86	11	1	4.8	8	<50	44

1992 Till Geochemistry Results

Sample #	LI PPM	HO PPM	NA %	NI PPM	RB PPM	SB PPM	SC PPM	SE PPM	SM PPM	SN PPM	TA PPM	TB PPM	TE PPM	TH PPM	U PPM	W PPM	YB PPM	ZN PPM	ZR PPM	MASS g
Detection Limit	0.05	1	0	20	5	0.1	0.1	5	0.1	100	0.5	0.5	10	0.2	0.5	1	0.2	50	200	0
91-PMA-338	0.3	4	1.1	95	74	43	18	<5	6.4	<100	1.1	0.8	<10	10	3.6	1	2	230	<200	33.19
91-PMA-339	0.2	7	1	120	71	47	18	<5	6	<100	1	0.9	<10	10	3.4	2	2	260	<200	27.72
91-PMA-340	<0.2	1	1.8	170	87	3.1	19	<5	8.1	<100	1.6	1.3	<10	14	4.4	2	2	180	<200	32.87
91-PMA-341	0.4	<1	1.3	84	61	2.8	32.1	<5	6.1	<100	0.8	1.2	<10	7.2	2.2	<1	2	110	<200	32.35
91-PMA-342	0.3	<1	0.9	450	28	1.8	25	<5	3.5	<100	0.5	0.8	<10	4.4	1.2	1	1	<100	<200	20.48
91-PMA-343	<0.2	<1	0.9	460	35	1.8	28.9	<5	3.9	<100	0.5	0.7	<10	4.7	1.8	<1	1	190	<200	24.77
91-PMA-344	0.3	<1	0.8	660	25	1.9	28	<5	3.7	<100	0.6	0.8	<10	4.1	1.5	<1	1	<100	<200	19.28
91-PMA-345	0.3	<1	0.8	640	27	1.9	24.8	<5	3.5	<100	0.6	0.8	<10	4.2	1.6	<1	<1	<100	<200	21.87
91-PMA-346	0.3	<1	1.3	100	75	3	18	<5	5.7	<100	0.9	0.9	<10	9.4	2.7	1	1	110	<200	27.34
91-PMA-347	0.3	<1	1.3	130	72	3	18	<5	5.6	<100	1	0.9	<10	9.2	2.6	<1	1	<100	<200	26.85
91-PMA-348	0.3	<1	1.3	130	72	3	18	<5	5.6	<100	1	0.9	<10	9.2	2.6	<1	1	<100	<200	25.04
91-PMA-349	0.3	<1	1.7	69	74	1.4	15	<5	6.7	<100	1.3	0.9	<10	12	2.9	2	2	<100	<200	37.17
91-PMA-349-1	0.3	<1	1.7	69	74	1.4	16	<5	8	<100	1.9	1.2	<10	14	3.8	2	1	130	<200	29.6
91-PMA-349-2	0.2	<1	1.5	83	100	2	19	<5	7	<100	1.8	0.9	<10	14	3.4	2	2	110	<200	31.99
91-PMA-349-3	0.3	<1	1.5	83	110	1.7	16	<5	7.6	<100	1.8	0.9	<10	15	3.6	3	2	170	280	39.68
91-PMA-349-4	0.3	<1	1.5	86	85	1.7	17	<5	8.6	<100	1.9	1.3	<10	17	4.4	2	2	100	<200	31.81
91-PMA-349-5	0.4	<1	1.5	86	85	1.7	17	<5	9.3	<100	1.9	1.4	<10	21.5	4.2	2	2	100	<200	29.86
91-PMA-349-6	0.4	<1	1.4	82	140	1.8	17	<5	7	<100	1.1	1.2	<10	11	4.7	3	2	230	300	29.15
91-PMA-349-1	0.2	6	1.1	140	84	4.6	17	<5	7.4	<100	1.3	0.9	<10	13	4	2	2	220	<200	39.55
91-PMA-349-2	<0.2	8	0.9	110	91	6.5	16	<5	8	<100	1.3	1.1	<10	13	4	2	2	<100	250	30.18
91-PMA-349-3	0.3	3	1	110	61	5.3	18	<5	8.4	<100	1.5	1.3	<10	16	3.7	3	2	<100	250	23.39
91-PMA-352	0.5	<1	0.8	23	130	0.8	15	<5	8.4	<100	1.7	1	<10	15	3.5	3	2	150	330	35.38
91-PMA-353	0.5	<1	0.8	39	120	0.7	13	<5	8	<100	1.4	1.2	<10	17	4.5	1	2	140	230	33
91-PMA-354	0.5	<1	1.3	41	77	2	18	<5	9.2	<100	1.5	1.2	<10	17	4.5	<1	2	<100	230	34.45
91-PMA-355	0.4	<1	1.5	44	69	1.9	17	<5	9.1	<100	1.4	1.4	<10	17	3.8	<1	2	<100	230	34.45
91-PMA-358	0.4	<1	1.6	21	96	2.2	17	<5	9.1	<100	1.3	1.2	<10	16	3.7	1	2	<100	<200	25.11
91-PMA-359	0.3	<1	1.5	54	100	1.7	17	<5	8.6	<100	0.7	0.8	<10	5	1.9	<1	1	<100	<200	25.09
91-PMA-362	<0.2	<1	1.9	74	36	1.7	19	<5	4.5	<100	0.8	0.8	<10	5.1	2	1	1	<100	220	21.64
91-PMA-363	0.3	<1	1.8	120	45	1.8	19	<5	4.5	<100	1.5	0.9	<10	13	3.8	2	1	140	<200	32.74
91-PMA-370-1	0.3	<1	1	69	90	2.5	14	<5	6.9	<100	1.4	1.1	<10	14	4.3	1	1	120	210	32.58
91-PMA-370-2	0.3	1	1	43	100	2.5	15	<5	7.3	<100	1.3	1	<10	12	3.9	<1	1	160	<200	30.19
91-PMA-370-3	0.3	1	1	41	79	2.4	14	<5	6.7	<100	1.3	1	<10	12	3.9	<1	2	150	250	33.63
91-PMA-371	<0.2	<1	1.1	50	53	3.1	20	<5	5.5	<100	1	0.9	<10	7.7	2.7	1	1	150	200	25.41
91-PMA-375-1	0.3	6	1.1	82	50	5.1	20.3	<5	5.4	<100	0.8	0.8	<10	6.7	3.5	1	1	150	200	25.41

1992 Till Geochemistry Results

Sample #	LU PPM	MO PPM	NA %	NI PPM	RB PPM	SB PPM	SC PPM	SE PPM	SM PPM	SN PPM	TA PPM	TB PPM	TE PPM	TH PPM	U PPM	W PPM	YB PPM	ZN PPM	ZR PPM	MASS g
Detection Limit	0.05	1	0	20	5	0.1	0.1	5	0.1	100	0.5	0.5	10	0.2	0.5	1	0.2	50	200	0
91-PMA-375-2	0.3	2	1.2	81	44	4.4	22.9	<5	5.5	<100	0.9	1.1	<10	6.6	2.9	<1	1	140	<200	35.86
91-PMA-376	0.3	4	1.2	87	54	5	22.5	<5	5.6	<100	0.9	0.9	<10	6.7	3	<1	1	170	210	34.09
91-PMA-377	<0.2	12	0.8	87	97	7.3	15	<5	9	<100	1.1	1.3	<10	13	5.7	1	2	430	200	33.01
91-PMA-378	0.4	<1	1.4	53	47	3.7	15	<5	6.9	<100	1	1.1	<10	10	3.4	<1	2	130	230	47.54
91-PMA-383	0.3	<1	1.5	53	130	1.1	16	<5	10	<100	1.6	1.1	<10	23.2	5	1	2	110	<200	32.13
91-PMA-384	0.4	<1	1.4	20	120	1	16	<5	9.5	<100	1.4	1.3	<10	21.9	4.8	2	1	<100	<200	30.39
91-PMA-394	0.2	<1	1.2	67	130	1.4	15	<5	8.8	<100	1.5	0.8	<10	14	3.9	1	2	100	<200	32.99
91-PMA-395-1	<0.2	<1	1.4	-10	140	1.1	11	<5	6.8	<100	2	0.8	<10	16	4.9	1	1	<100	300	35.4
91-PMA-395-2	<0.2	<1	1.2	58	160	1.8	15	<5	6.7	<100	2.3	1.1	<10	15	4.2	1	1	150	<200	27.12
91-PMA-398	0.3	<1	0.9	25	160	0.4	16	<5	10	<100	1.8	1.4	<10	24.7	5.9	2	2	120	450	26.21
91-PMA-399	0.4	<1	1.3	46	150	0.5	16	<5	11	<100	2.1	1.7	<10	23.4	5.2	2	2	<100	450	37.09
91-PMA-400	0.4	<1	1.2	23	96	0.7	17	<5	8.8	<100	1.3	1.2	<10	12	2.8	2	1	130	<200	33.94
91-PMA-401	0.3	<1	1.2	50	99	0.7	17	<5	6.9	<100	1.1	0.9	<10	12	3	1	2	100	<200	26.92
91-PMA-402	0.3	<1	1.1	23	140	0.4	14	<5	8.5	<100	1.7	1.4	<10	20	4.9	2	2	110	270	29.94
91-PMA-403	0.3	<1	1.3	59	110	1.5	16	<5	8.2	<100	1.5	1.2	<10	16	4	1	2	<100	320	27.97
91-PMA-404	<0.2	<1	1	22	160	0.3	14	<5	7.3	<100	1.7	1	<10	19	4.5	7	2	120	<200	25.65

1993 Td Geochemistry Results

Sample #	Estid	Idorth	Lat	Long	AG	AS	AU	BA	BR	CA	CE	CO	CR	CS	EU	FE	IF	MD	IR	LA	LU	MO	NA
					PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
03 PMA-1001-1	434011	6155265	55.54	-124.05	5	7.4	6	920	2.9	2	160	15	100	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1001-2	434012	6155265	55.54	-124.05	5	7.4	6	920	2.9	2	160	15	100	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1002	434069	6155268	55.54	-124.05	5	7.8	6	920	2.9	2	160	15	100	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1003-1	434069	6154187	55.53	-124.05	5	8.8	6	1000	-0.5	2	110	17	130	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1003-2	434069	6154187	55.53	-124.05	5	8.9	7	1100	-0.5	3	120	16	140	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1003-3	434069	6154187	55.53	-124.05	5	10	6	1200	-0.5	3	130	19	150	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1003-4	434069	6154187	55.53	-124.05	5	6.6	11	600	-0.5	1	70	13	130	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1004	435102	6153412	55.52	-124.05	5	6.5	12	600	-0.5	3	130	14	110	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1005	435631	6153005	55.53	-124.05	5	5.3	9	1000	1.3	1	130	13	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1005-1	435631	6154073	55.54	-124.05	5	5.6	9	1000	1.3	1	130	13	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1005-2	435631	6154073	55.54	-124.05	5	5.6	9	1000	1.3	1	130	13	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1009	437690	6155970	55.51	-123.99	5	5.8	9	1000	1.3	1	130	13	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1011	437690	6151700	55.51	-123.99	5	8.6	9	1000	1.3	1	130	13	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1012	438930	6155000	55.51	-123.97	5	4.5	9	1000	-0.5	4	180	15	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1014-1	438100	6150000	55.51	-123.95	5	3.2	9	1100	-0.5	6	180	15	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1014-2	438100	6150000	55.51	-123.95	5	4.7	8	1000	-0.5	6	180	15	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1015-2	440300	6150400	55.51	-123.94	5	4.6	7	1000	-0.5	5	170	17	130	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1015-3	440300	6150400	55.51	-123.94	5	9.1	7	1000	-0.5	3	170	17	130	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1017	441650	6150000	55.52	-123.92	5	2.5	9	1000	-0.5	4	180	15	120	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1018	433000	6150000	55.52	-123.92	5	8.9	9	1000	-0.5	2	140	18	130	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1019	433136	6154185	55.52	-124.06	5	7.8	8	1000	-0.5	3	170	16	150	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1020-1	433002	6151194	55.52	-124.06	5	7.8	8	1000	-0.5	3	170	16	150	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1020-2	433002	6151194	55.52	-124.06	5	11	9	1000	-0.5	3	170	16	150	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1020-3	433002	6151194	55.52	-124.06	5	11	9	1000	-0.5	3	170	16	150	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1020-4	433002	6151194	55.52	-124.06	5	12	8	1000	-0.5	5	170	14	150	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1020-5	433002	6151194	55.52	-124.06	5	13	6	1000	-0.5	4	175	16	160	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1021	431068	6151073	55.50	-124.07	5	10	6	1000	-0.5	4	180	15	170	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1021-1	433560	6154450	55.51	-124.05	5	18	2	1000	-0.5	5	100	20	160	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1021-2	433560	6154450	55.51	-124.05	5	18	2	1000	-0.5	5	100	20	160	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1022-1	434133	6149700	55.49	-124.04	5	9	2	1100	-0.5	3	97	19	160	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1023	434133	6149700	55.49	-124.04	5	9	2	1100	-0.5	3	97	19	160	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1024	430687	6150241	55.50	-124.03	5	15	2	1200	-0.5	4	67	19	200	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1024-1	431758	6149404	55.49	-124.03	5	24	2	1200	-0.5	4	55	26	200	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1024-2	431758	6149404	55.49	-124.03	5	11	2	1200	-0.5	4	55	26	200	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1026	432053	6148137	55.47	-124.05	5	11	2	1200	-0.5	4	55	26	200	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1028	432648	6146239	55.47	-124.05	5	8.7	2	1200	-0.5	4	39	40	300	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1029	434168	6146767	55.46	-124.04	5	13	2	1200	-0.5	4	44	42	310	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1030	434168	6146767	55.46	-124.04	5	20	2	1200	-0.5	4	44	42	310	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1031	430744	6147210	55.47	-124.03	5	7	2	1200	-0.5	4	39	40	300	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1032	430744	6147210	55.47	-124.03	5	20	2	1200	-0.5	4	39	40	300	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1033	436570	6151872	55.51	-124.13	5	7	2	1200	-0.5	4	39	40	300	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1034	431751	6159816	55.52	-124.06	5	15	16	1600	1.2	2	82	16	180	3	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1037	432132	6163574	55.62	-124.07	5	74	1	930	-0.5	2	150	11	94	0	1	0.2	0	1	1	5	0.3	0.5	1
03 PMA-1038	435558	6162218	55.65	-124.01	5	5.7	9	1000	-0.5	4	150	17	110	6	1	0.2	0	1	1	5	0.3	0.5	1

1993 TIM Geochemistry Results

Sample #	EnH	North	Lat	Long	AG	AS	BA	BR	CA	CE	CO	GR	GS	EU	TE	WF	WD	VB	LA	PU	PM	MO	WA
					5	05	2	50	05	1	3	1	5	1	02	0	1	5	25	05	1	0	
Directional Lind	435656	616692	55.65	-124.01	-5	52	6	1000	-22	-41	120	11	120	7	2.9	5.4	9	-41	-5	78	080	-1	135
93 PMA-1030XP	438400	616725	55.63	-123.96	-5	33	-2	1000	-05	4	120	11	97	2	1.7	3.72	10	-41	-5	56	041	-1	131
93 PMA-1036-1	438400	616725	55.65	-123.96	-5	67	-2	1100	-05	2	130	12	120	3	2.3	4.07	9	-41	-5	65	073	-1	147
93 PMA-1036-2	438400	616725	55.65	-123.96	-5	67	-2	1100	-05	4	130	13	110	3	2.3	3.6	10	-41	-5	65	070	-1	143
93 PMA-1039-TOP	437825	616520	55.63	-123.97	-5	64	16	1000	-05	4	130	12	110	2	1.9	3.97	11	-41	-5	67	063	-1	141
93 PMA-1040	438000	616510	55.64	-123.90	-5	38	-2	1100	21	-41	140	12	110	3	1.9	3.97	11	-41	-5	65	061	-1	150
93 PMA-1041	437200	616740	55.65	-123.94	-5	66	-2	1100	-05	6	94	12	97	3	1.6	3.63	8	-41	-5	64	046	-1	145
93 PMA-1043	440000	616490	55.63	-123.94	-5	22	-2	1200	-05	4	160	13	100	4	2.5	4.75	13	-41	-5	66	074	-1	145
93 PMA-1044	438000	616730	55.65	-124.00	-5	5	10	1100	21	-41	150	12	110	3	2.3	3.65	11	-41	-5	75	069	-1	149
93 PMA-1045	440625	616730	55.65	-124.06	-5	5	10	1100	21	-41	150	12	110	3	2.3	3.65	11	-41	-5	75	069	-1	149
93 PMA-1046-1	437063	6156014	55.55	-124.11	-5	10	-2	1100	-05	3	4	19	140	2	1.2	4.27	3	-41	-5	70	040	-1	167
93 PMA-1046-2	437063	6156014	55.55	-124.11	-5	10	-2	1100	-05	3	4	19	140	2	1.2	4.27	3	-41	-5	70	040	-1	167
93 PMA-1046-TOP	429948	6155404	55.54	-124.15	-5	75	7	1100	-05	4	96	16	150	3	1.5	4.01	8	-41	-5	41	057	-1	111
93 PMA-1047-1	427133	6156182	55.54	-124.15	-5	95	-2	1100	-05	4	100	16	170	5	1.7	4.61	8	-41	-5	41	057	-1	093
93 PMA-1047-2	427133	6156182	55.54	-124.15	-5	95	-2	1100	-05	4	100	16	170	5	1.7	4.61	8	-41	-5	41	057	-1	093
93 PMA-1048	427233	6156182	55.55	-124.03	-5	66	21	1000	-05	2	100	11	170	3	1.7	3.64	8	-41	-5	49	051	-1	142
93 PMA-1049	427233	6156182	55.55	-124.03	-5	66	21	1000	-05	2	100	11	170	3	1.7	3.64	8	-41	-5	49	051	-1	142
93 PMA-1052	435352	6160776	55.56	-124.07	-5	77	6	1200	-05	3	92	14	100	2	1.6	3.61	7	-41	-5	43	054	-1	126
93 PMA-1053	435352	6160776	55.56	-124.07	-5	92	10	1300	-05	21	110	14	100	3	1.9	4.18	9	-41	-5	51	063	-1	101
93 PMA-1055	435797	6160935	55.56	-124.01	-5	12	12	1000	-05	3	71	19	200	4	1.5	4.73	5	-41	-5	32	052	-1	160
93 PMA-1056	436004	6159954	55.56	-123.94	-5	52	-2	1400	-05	3	160	14	93	3	2.2	4.69	11	-41	-5	76	040	-1	225
93 PMA-1056	437000	6160006	55.56	-123.94	-5	76	-2	1600	-05	4	160	14	93	3	2.2	4.69	11	-41	-5	76	040	-1	225
93 PMA-1059	437000	6160006	55.56	-123.94	-5	76	-2	1600	-05	4	160	14	93	3	2.2	4.69	11	-41	-5	76	040	-1	225
93 PMA-1060	436700	6160700	55.60	-123.96	-5	42	6	1200	-05	4	150	10	110	2	2.1	3.72	12	-41	-5	55	055	-1	117
93 PMA-1060	436700	6160700	55.60	-123.96	-5	42	6	1200	-05	4	150	10	110	2	2.1	3.72	12	-41	-5	55	055	-1	117
93 PMA-1060	436700	6160700	55.60	-123.96	-5	42	6	1200	-05	4	150	10	110	2	2.1	3.72	12	-41	-5	55	055	-1	117
93 PMA-1061	436487	6162765	55.61	-124.03	-5	83	860	-05	4	150	10	110	2	2.1	3.72	12	-41	-5	55	055	-1	117	
93 PMA-1061	436487	6162765	55.61	-124.03	-5	83	860	-05	4	150	10	110	2	2.1	3.72	12	-41	-5	55	055	-1	117	
93 PMA-1061	436487	6162765	55.61	-124.03	-5	83	860	-05	4	150	10	110	2	2.1	3.72	12	-41	-5	55	055	-1	117	
93 PMA-1063	435300	6163367	55.61	-124.03	-5	73	9	1100	-05	2	130	10	130	2	2	3.48	11	-41	-5	43	037	-1	112
93 PMA-1063	435300	6163367	55.61	-124.03	-5	73	9	1100	-05	2	130	10	130	2	2	3.48	11	-41	-5	43	037	-1	112
93 PMA-1064	435301	6162919	55.60	-124.03	-5	48	7	1300	-05	2	130	13	120	4	1.6	4.33	6	-41	-5	65	037	-1	115
93 PMA-1064	435301	6162919	55.60	-124.03	-5	48	7	1300	-05	2	130	13	120	4	1.6	4.33	6	-41	-5	65	037	-1	115
93 PMA-1066	435182	6161910	55.64	-124.36	-5	18	-2	1100	-05	4	96	16	150	6	1.8	4.73	6	-41	-5	54	051	-1	063
93 PMA-1066	435182	6161910	55.64	-124.36	-5	18	-2	1100	-05	4	96	16	150	6	1.8	4.73	6	-41	-5	54	051	-1	063
93 PMA-1067-1	413450	617525	55.66	-124.36	-5	11	5	860	29	4	120	17	140	2	2.1	4.68	10	-41	-5	58	011	-1	127
93 PMA-1067-2	413450	617525	55.66	-124.36	-5	11	5	860	29	4	120	17	140	2	2.1	4.68	10	-41	-5	58	011	-1	127
93 PMA-1067-3	413450	617525	55.66	-124.36	-5	11	5	860	29	4	120	17	140	2	2.1	4.68	10	-41	-5	58	011	-1	127
93 PMA-1068	412978	6170117	55.66	-124.36	-5	14	4	840	59	4	100	19	140	2	2.6	5.31	9	-41	-5	68	045	-1	113
93 PMA-1068	412978	6170117	55.66	-124.36	-5	14	4	840	59	4	100	19	140	2	2.6	5.31	9	-41	-5	68	045	-1	113
93 PMA-1068	412978	6170117	55.66	-124.36	-5	14	4	840	59	4	100	19	140	2	2.6	5.31	9	-41	-5	68	045	-1	113
93 PMA-1069	415415	6150094	55.56	-124.17	-5	5	6	910	16	4	100	19	150	4	1.6	4.84	5	-41	-5	75	011	-1	137
93 PMA-1069	415415	6150094	55.56	-124.17	-5	5	6	910	16	4	100	19	150	4	1.6	4.84	5	-41	-5	75	011	-1	137
93 PMA-1069	415415	6150094	55.56	-124.17	-5	5	6	910	16	4	100	19	150	4	1.6	4.84	5	-41	-5	75	011	-1	137
93 PMA-1070	425944	6160845	55.56	-124.16	-5	74	7	860	-05	2	150	16	120	10	2.4	5.37	14	-41	-5	63	060	-1	1
93 PMA-1070	425944	6160845	55.56	-124.16	-5	74	7	860	-05	2	150	16	120	10	2.4	5.37	14	-41	-5	63	060	-1	1
93 PMA-1070	425944	6160845	55.56	-124.16	-5	74	7	860	-05	2	150	16	120	10	2.4	5.37	14	-41	-5	63	060	-1	1
93 PMA-1071	427660	6163604	55.62	-124.22	-5	5	-2	1100	-05	4	120	13	100	4	1.7	3.71	14	-41	-5	58	073	-1	171
93 PMA-1071	427660	6163604	55.62	-124.22	-5	5	-2	1100	-05	4	120	13	100	4	1.7	3.71	14	-41	-5	58	073	-1	171
93 PMA-1071	427660	6163604	55.62	-124.22	-5	5	-2	1100	-05	4	120	13	100	4	1.7	3.71	14	-41	-5	58	073	-1	171
93 PMA-1074	423207	6160704	55.62	-124.21	-5	35	7	910	-05	4	120	11	100	4	2	4.11	11	-41	-5	64	073	-1	171
93 PMA-1074	423207	6160704	55.62	-124.21	-5	35	7	910	-05	4	120	11	100	4	2	4.11	11	-41	-5	64	073	-1	171
93 PMA-1075	423134	6163585	55.61	-124.26	-5	45	-2	1200	-05	4	120	14	110	5	2	4.19	12	-41	-5	64	073	-1	168
93 PMA-1075	423134	6163585	55.61	-124.26	-5	45	-2	1200	-05	4	120	14	110	5	2	4.19	12	-41	-5	64	073	-1	168
93 PMA-1075	423134	6163585	55.61	-124.26	-5	45	-2	1200	-05	4	120	14	110	5	2	4.19	12	-41	-5	64	073	-1	168
93 PMA-1076	420917	6165238	55.63	-124.35	-5	37	7	1100	-05	4	120	15	110	4	2	4.75	5	-41	-5	64	050	-1	159
93 PMA-1076	420917	6165238	55.63	-124.35	-5	37	7	1100	-05	4	120	15	110	4	2	4.75	5	-41	-5	64	050	-1	159
93 PMA-1077	4170786	6170178	55.67	-124.35	-5	1	-2	1100	-05	4	120	15	110	4	2	4.75	5	-41	-5	64	050	-1	159
93 PMA-1077	4170786	6170178	55.67	-124.35	-5	1	-2	1100	-05	4	120	15	110	4	2	4.75	5	-41	-5	64	050	-1	159
93 PMA-1078	415251	6169870	55.67	-124.34	-5	2	-2	1200	-05	4	120	15	110	4	2	4.75	5	-41	-5	64	050	-1	159
93 PMA-1078	415251	6169870	55.67	-124.34	-5	2	-2	1200	-05	4	120	15	110	4	2	4.75	5	-41	-5	64	050	-1	159
93 PMA-1079	415497	6160203	55.67	-124.34	-5	27	-2	1100	-05	2	160	19											

1993 TIA Geochemistry Results

Sample #	East	North	Lat	Long	AG PPM	AS PPM	AU PPM	BA PPM	BR PPM	CA %	CE PPM	CO PPM	CR PPM	CS PPM	EU PPM	FE PPM	IF PPM	IG PPM	IR PPM	LA PPM	LU PPM	MO PPM	NA %
Detection Limit					5	5	5	50	0.5	1	3	1	5	1	0.7	0	1	1	5	0.5	0.05	1	0
93 PMA-10020P	418157	6162014	55.65	-124.33	<5	2.9	<2	800	<0.5	<1	170	14	110	4	2.4	4.01	11	<1	<5	81	0.73	<1	1.53
93 PMA-10031P	418514	6162014	55.65	-124.33	<5	3.5	<2	800	<0.5	4	140	11	96	5	1.9	4.01	10	<1	<5	70	0.73	<1	1.79
93 PMA-10031	418514	6162004	55.65	-124.31	<5	4.7	<2	833	1.4	4	140	16	130	4	2	4.22	10	<1	<5	68	0.68	<1	1.35
93 PMA-10032	418514	6162004	55.65	-124.31	<5	3.7	3	810	<0.5	<1	150	12	96	4	2.1	3.83	13	<1	<5	75	0.81	<1	1.4
93 PMA-1004	418626	6162004	55.65	-124.27	<5	3.0	5	800	<0.5	10	150	12	92	3	2.2	4	12	<1	<5	76	0.77	<1	1.47
93 PMA-1004P	418626	6162004	55.65	-124.27	<5	3.0	5	800	<0.5	10	150	12	92	3	2.2	4	12	<1	<5	76	0.77	<1	1.47
93 PMA-1005	417397	6167313	55.65	-124.36	<5	2.1	<2	930	<0.5	4	110	13	94	5	1.4	3.45	7	<1	<5	45	0.50	<1	0.84
93 PMA-1007	420036	6165714	55.64	-124.36	<5	2.1	<2	930	<0.5	4	110	13	94	5	1.4	3.45	7	<1	<5	45	0.50	<1	0.84
93 PMA-1004.1	417578	6170749	55.67	-124.36	<5	13	<2	1000	<0.5	3	74	16	170	2	1.6	4.63	5	<1	<5	36	0.52	<1	1.07
93 PMA-1004.2	417578	6170749	55.67	-124.36	<5	10	2	1070	<0.5	6	83	17	150	3	1.5	4.75	7	<1	<5	40	0.54	<1	1.46
93 PMA-1004.3	417578	6170749	55.67	-124.36	<5	7.6	<2	1000	<0.5	2	81	13	150	2	1.4	4.56	9	<1	<5	37	0.49	<1	1.71
93 PMA-1004.4	417578	6170749	55.67	-124.36	<5	9.6	<2	1000	<0.5	2	81	13	150	2	1.4	4.56	9	<1	<5	37	0.49	<1	1.71
93 PMA-1004.5	417336	6170035	55.67	-124.36	<5	15	<2	840	<0.5	3	77	16	170	3	1.4	4.31	6	<1	<5	47	0.54	<1	1.35
93 PMA-1007.1	417336	6170035	55.67	-124.36	<5	17	7	760	<0.5	4	75	27	210	4	1.3	4.51	5	<1	<5	40	0.32	<1	1.12
93 PMA-1007.2	417336	6170035	55.67	-124.36	<5	17	7	760	<0.5	4	75	27	210	4	1.3	4.51	5	<1	<5	40	0.32	<1	1.12
93 PMA-1003.1	417350	6162602	55.67	-124.19	<5	17	7	800	2.2	5	86	17	150	4	1.5	4.31	6	<1	<5	47	0.47	<1	0.87
93 PMA-1003.2	417350	6162602	55.67	-124.19	<5	22	9	1100	1.6	6	79	25	200	4	1.5	5.02	6	<1	<5	43	0.48	<1	1.15
93 PMA-1004.1	425011	6157431	55.56	-124.19	<5	10	12	1100	<0.5	3	73	18	180	3	1.4	3.6	6	<1	<5	43	0.45	<1	1.58
93 PMA-1004.2	425011	6157431	55.56	-124.19	<5	8.6	10	810	<0.5	3	67	15	160	2	1.4	3.6	6	<1	<5	41	0.45	<1	1.47
93 PMA-1004.3	425011	6157431	55.56	-124.05	<5	6.7	4	1000	<0.5	3	66	17	150	4	1.6	4.7	6	<1	<5	50	0.53	<1	1.76
93 PMA-1004.4	425011	6157431	55.56	-124.05	<5	11	<2	1200	1.2	2	78	19	100	5	1.5	4.56	7	<1	<5	48	0.48	<1	1.79
93 PMA-1004.6	425011	6157431	55.56	-124.05	<5	10	6	840	<0.5	4	66	16	160	4	1.7	4.09	8	<1	<5	61	0.56	<1	1.74
93 PMA-1004.8	425011	6157431	55.56	-124.05	<5	51	14	830	<0.5	2	150	39	190	4	2.7	8.74	17	<1	<5	60	0.63	<1	0.91
93 PMA-1004.10	425011	6157431	55.56	-124.05	<5	66	28	840	<0.5	2	120	36	150	4	2.2	8.75	17	<1	<5	74	0.79	<1	0.97
93 PMA-1004.12	425011	6157431	55.56	-124.05	<5	87	13	740	<0.5	4	120	37	150	3	2.2	8.49	17	<1	<5	71	0.79	<1	0.97
93 PMA-1004.120P	425011	6157431	55.56	-124.05	<5	110	16	700	<0.5	3	120	49	150	6	2.1	17.6	9	<1	<5	67	0.73	<1	0.86
93 PMA-1004.14	425011	6157431	55.56	-124.05	<5	15	5	780	<0.5	3	78	10	170	5	1.3	3.98	8	<1	<5	43	0.43	<1	1.46
93 PMA-1005.1	437926	6165260	55.63	-124.18	<5	15	5	780	<0.5	3	78	10	170	5	1.3	3.98	8	<1	<5	43	0.43	<1	1.46
93 PMA-1005.2	437926	6165260	55.63	-124.18	<5	20	11	810	1.4	1	65	10	100	6	1.4	3.61	8	<1	<5	44	0.50	<1	1.52
93 PMA-1006	425368	6154158	55.53	-124.23	<5	10	19	1400	<0.5	2	69	18	250	3	1.6	4.16	6	<1	<5	41	0.57	<1	1.44
93 PMA-1007	423463	6154137	55.53	-124.47	<5	17	16	1400	<0.5	<1	76	14	110	2	2.2	4.27	7	<1	<5	49	0.71	<1	1.34
93 PMA-1008	424276	6159171	55.57	-124.74	<5	21	6	1400	1.9	2	67	26	200	6	1.8	4.41	5	<1	<5	30	0.81	<1	1.1
93 PMA-1100	410968	6170268	55.68	-124.48	<5	14	5	1100	4.3	5	77	18	150	3	1.6	4.83	6	<1	<5	40	0.53	<1	1.32

1993 TB Geochemistry Results

Sample #	NO	RI	RB	SC	SE	SM	SN	SR	TA	TB	TH	U	W	YB	ZH	MASS 9	
Detection Limit	5	20	5	0.1	0.1	5	0.1	100	500	0.5	0.5	1	0.2	0.5	1	0	
93 PMA-1001-1	54	<20	75	0.8	14	3	10	<500	<0.5	1.6	23	3.9	<1	4.3	149	26.34	
93 PMA-1001-2	41	<20	110	0.6	17	3	7.8	<100	<500	<0.5	1.1	19	3.2	<1	3.6	321	24.20
93 PMA-1002	40	<20	100	1	16	<3	7.9	<100	<500	<0.5	<0.5	17	3	<1	3.6	108	28.18
93 PMA-1002.1	40	<20	91	14	17	<3	7.5	<100	<500	<0.5	1.6	23	<1	3.9	113	26.51	
93 PMA-1002.2	40	<24	110	14	19	<3	8	<100	<500	<0.5	1.7	17	3.8	<1	4	175	26.78
93 PMA-1002.3	46	<25	83	14	21	<3	8.9	<100	<500	<0.5	1.5	16	3.3	<1	4.4	189	25.58
93 PMA-1003.4	30	<22	81	1	15	<3	5	<100	<500	<0.5	1.1	9.9	3	<1	2.9	134	28.50
93 PMA-1003.5	42	<24	100	1	16	<3	8.5	<100	<500	1.4	<0.5	16	4.7	<1	3.8	132	25.05
93 PMA-1005	40	<27	96	0.6	17	<3	7.7	<100	<500	1.6	1.5	21	4.4	<1	4	164	23.78
93 PMA-1006.1	44	<20	150	0.7	21	<3	8.7	<100	<500	1.8	1.5	21	4.4	<1	4	164	23.78
93 PMA-1006.2	49	<24	110	0.5	16	<3	8.5	<100	<500	1.9	0.8	14	5.7	<1	5.5	172	23.91
93 PMA-1009	29	<25	110	1.2	19	<3	8.6	<100	<500	0.5	1.2	15	3.7	<1	4.3	137	29.65
93 PMA-1011	40	<23	63	1.3	17	<3	8.1	<100	<500	0.5	1.2	24	4.7	<1	4.1	182	26.92
93 PMA-1011.1	40	<25	96	0.5	17	<3	7.3	<100	<500	<0.5	1.4	19	4	<1	3	166	29.17
93 PMA-1014.1	38	<21	93	0.8	15	<3	7.2	<100	<500	<0.5	1.3	19	3.5	2	3	171	28.86
93 PMA-1014.2	42	<20	73	0.6	14	<3	8	<100	<500	<0.5	1.3	19	3.9	<1	3.4	90	27.45
93 PMA-1016.3	55	<50	120	0.8	20	<3	11	<100	<500	<0.5	1.6	27	6	<1	3.4	140	0.78
93 PMA-1016.5	42	<24	140	0.5	15	<3	8.7	<100	<500	2.4	<0.5	40	7.5	<1	3	85	24.58
93 PMA-1016	42	<24	100	0.9	18	<3	7.9	<100	<500	1.4	0.5	4.9	2.1	<1	3.3	141	20.55
93 PMA-1019	16	<20	37	1.5	20	<3	3.6	<100	<500	1.4	0.5	4.9	2.1	<1	2.7	123	34.21
93 PMA-1005.1	77	<20	76	1.8	16	<3	5.9	<100	<500	2.1	1	11	3.1	1	3.2	200	27.07
93 PMA-1020.2	26	<20	50	1.9	15	<3	5.7	<100	<500	<0.5	<0.5	10	3.3	<1	3.1	169	27.87
93 PMA-1005.3	27	<20	65	1.6	15	<3	5.7	<100	<500	<0.5	0.9	10	2.4	<1	3.4	226	26.10
93 PMA-1005.4	79	<20	64	1.6	16	<3	5.9	<100	<500	<0.5	0.9	10	3.2	<1	3.3	209	25.64
93 PMA-1020.5	25	<30	66	2.1	17	<3	5.7	<100	<500	<0.5	0.8	11	3.1	<1	3.6	195	26.73
93 PMA-1021	32	<20	64	1.6	17	<3	8.5	<100	<500	<0.5	<0.5	13	1.7	<1	3.6	240	27.36
93 PMA-1027.1	37	<44	<15	2.3	23	<3	8.4	<100	<500	2.8	1.7	12	3.7	<1	4	268	25.80
93 PMA-1027.2	38	<47	<15	2.5	23	<3	8.4	<100	<500	3	<0.5	23	8.7	3	4.7	90	27.40
93 PMA-1027.3	62	<47	130	1.4	18	<3	11	<100	<500	<0.5	<0.5	7.1	<0.5	<1	3.6	271	26.73
93 PMA-1026	17	200	<15	3.4	20	<3	6	<100	<500	<0.5	<0.5	7.4	2.8	<1	3.2	100	25.48
93 PMA-1074	35	<48	<15	4.8	26	<3	5.7	<100	<500	<0.5	<0.5	7.4	2.8	<1	3.2	100	25.48
93 PMA-1077	40	<45	<15	2.6	25	<3	7.4	<100	<500	<0.5	<0.5	7	2.4	2	4.3	136	30.26
93 PMA-1078	30	<43	<15	1.9	20	<3	6.3	<100	<500	1.6	1.4	6.7	2.6	<1	3.4	110	30.18
93 PMA-1079	15	<48	<15	2.1	36	<3	4	<100	<500	<0.5	<0.5	4.4	1.4	<1	2.4	217	24.67
93 PMA-1029	21	<53	73	2.5	37	<3	4.6	<100	<500	<0.5	<0.5	5.5	1.9	<1	3	149	21.76
93 PMA-1031	34	<44	75	3.1	20	<3	6.5	<100	<500	<0.5	<0.5	9.2	2.6	<1	3.7	254	30.36
93 PMA-1032	23	<48	97	4.7	24	<3	5.7	<100	<500	<0.5	<0.5	8.1	2.6	<1	3.6	303	24.32
93 PMA-1033	19	<35	39	1.7	31	<3	4.9	<100	<500	<0.5	0.8	4.3	1.4	<1	2.8	100	31.05
93 PMA-1034	34	190	110	2.7	19	<3	6.6	<100	<500	<0.5	<0.5	11	2.7	<1	3.5	252	25.04
93 PMA-1037	55	<37	230	2.4	17	<3	9.9	<100	<500	3.8	<0.5	23	6.6	<1	4.4	176	22.31
93 PMA-1038	50	<36	130	0.7	19	<3	11	<100	<500	<0.5	<0.5	25	8.3	<1	4.8	185	22.51

1993 TIE Geochemistry Results

Sample #	MD PPM	IN PPM	RI PPM	SO PPM	SE PPM	SM PPM	SV PPM	SR PPM	TA PPM	TH PPM	U PPM	W PPM	YD PPM	2H PPM	MASS 0		
Detection Limit	5	20	5	0.1	5	0.1	100	500	0.5	0.5	0.5	1	0.2	50	0		
93-PHA-10300UP	64	<36	140	0.7	20	<3	12	<100	<500	3.1	15	75	5	41	51	200	2180
93-PHA-1035-1	45	<33	95	0.6	13	<3	12	<100	<500	2.5	15	17	51	41	37	<250	2852
93-PHA-1035-2	53	<34	100	0.9	16	<3	10	<100	<500	1.8	15	20	61	41	48	183	2647
93-PHA-1035-TOUP	53	<34	95	0.9	15	<3	96	<100	<500	2.5	12	6	4	43	171	2674	
93-PHA-1040	47	<34	110	0.8	15	<3	87	<100	<500	3.1	30	53	41	34	131	2639	
93-PHA-1041	50	<34	82	0.7	14	<3	9	<100	<500	2	0.9	20	81	41	37	149	2179
93-PHA-1043	36	<29	55	0.8	13	<3	66	<100	<500	<0.5	14	66	41	27	<500	2861	
93-PHA-1044	67	<30	110	0.4	15	<3	17	<100	<500	2.6	18	46	41	41	300	2734	
93-PHA-1045-1	77	240	80	1.4	19	<3	11	<100	<500	1.6	15	74	61	41	45	<500	2861
93-PHA-1045-2	18	<24	33	1.5	19	<3	32	<100	<500	<0.5	13	36	41	3	180	2905	
93-PHA-1045-TOUP	35	<24	53	1.3	16	<3	66	<100	<500	<0.5	9.5	14	41	24	169	3564	
93-PHA-1047-1	35	190	120	1.3	18	<3	69	<100	<500	<0.5	14	34	41	35	144	2847	
93-PHA-1047-2	34	<17	32	1.2	15	<3	7	<100	<500	2.1	14	5	4	3	35	155	2435
93-PHA-1048	31	<15	44	1.2	16	<3	7	<100	<500	1.8	11	14	4	3	37	164	2631
93-PHA-1049	41	<19	81	1.4	17	<3	7	<100	<500	<0.5	13	36	41	36	62	2631	
93-PHA-1052	72	260	110	1.9	19	<3	54	<100	<500	<0.5	11	38	41	33	173	2663	
93-PHA-1054	65	237	100	0.9	17	<3	95	<100	<500	<0.5	8.9	37	3	26	100	2400	
93-PHA-1056	58	<29	140	0.4	17	<3	91	<100	<500	2.5	11	22	57	41	32	<500	2606
93-PHA-1059	53	<24	54	0.7	15	<3	99	<100	<500	1.8	<0.5	24	7	41	37	140	2526
93-PHA-1060	34	230	100	1	16	<3	76	<100	<500	1.9	<0.5	17	43	41	35	167	2432
93-PHA-1061	47	<24	56	0.7	14	<3	87	<100	<500	1.8	<0.5	16	49	41	39	60	3050
93-PHA-1061-1	31	<24	81	1.3	18	<3	69	<100	<500	<0.5	0.9	15	41	41	35	210	2241
93-PHA-1061-2	51	<26	93	0.9	18	<3	87	<100	<500	<0.5	11	25	5	41	33	160	2654
93-PHA-1064	30	110	83	3.5	17	<3	7	<100	<500	<0.5	13	36	41	34	166	2443	
93-PHA-1064-1	41	130	86	1.9	17	<3	86	<100	<500	<0.5	12	15	33	41	47	97	3460
93-PHA-1064-2	48	<26	74	2.7	20	<3	10	<100	<500	<0.5	1.5	17	47	41	55	<500	2704
93-PHA-1064-3	36	<23	130	1.8	19	<3	71	<100	<500	<0.5	0.8	14	31	41	34	132	2558
93-PHA-1069	18	<24	48	0.9	38	<3	6	<100	<500	<0.5	1.3	57	23	41	46	178	3097
93-PHA-1070	50	160	140	0.5	19	<3	10	<100	<500	<0.5	1.6	22	56	41	52	179	2237
93-PHA-1071	47	150	170	0.8	19	<3	10	<100	<500	<0.5	1.7	26	56	41	55	153	2113
93-PHA-1072	42	<22	110	0.8	18	<3	82	<100	<500	2.3	<0.5	17	62	41	46	151	2621
93-PHA-1074	46	110	110	0.5	18	<3	85	<100	<500	<0.5	2.1	17	47	41	46	137	2436
93-PHA-1075	41	130	160	0.3	17	<3	83	<100	<500	<0.5	<0.5	11	32	41	31	145	2298
93-PHA-1076	27	<24	74	1.2	17	<3	55	<100	<500	<0.5	<0.5	11	32	41	44	156	2260
93-PHA-1077	40	120	120	0.6	18	<3	67	<100	<500	<0.5	1.3	18	5	41	46	156	2260
93-PHA-1078	83	178	160	0.4	18	<3	15	<100	<500	2.5	1.6	31	74	41	54	152	2074
93-PHA-1079	55	<27	160	0.5	18	<3	10	<100	<500	2.1	1.4	25	49	3	44	174	2150
93-PHA-1080	70	<27	160	0.6	19	<3	11	<100	<500	2.3	1.6	22	82	41	47	137	2136
93-PHA-1081	75	<63	190	0.7	22	<3	15	<100	<500	2.8	2.6	29	63	41	53	210	648
93-PHA-1082	61	110	74	0.8	14	<3	10	<100	<500	1.8	1.6	20	45	41	47	136	2835

1993 TM Geochemistry Results

Sample #	NO	IN	RD	SB	SC	SE	SN	SR	TA	TB	TH	U	W	YB	ZN	MASS g
Location/line	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	
93 PMA-1020A.P	60	85	91	11	15	<3	0	<100	<500	21	14	21	46	<1	47	106
93 PMA-1023.1	50	<21	120	08	14	<3	0	<100	<500	<0.5	<0.5	19	35	<1	44	<50
93 PMA-1023.2	44	<22	84	07	15	3	87	<100	<500	19	13	18	46	<1	41	133
93 PMA-1024	51	110	110	04	14	<3	98	<100	<500	17	12	19	53	3	51	61
93 PMA-1024A.P	49	<22	87	04	14	<3	98	<100	<500	18	13	19	40	<1	5	93
93 PMA-1025	35	71	80	04	11	<3	66	<100	760	22	09	13	31	<1	31	66
93 PMA-1027	41	<20	130	04	14	<3	78	<100	<500	13	11	17	35	4	44	118
93 PMA-1029.1	37	<22	59	3	21	<3	61	<100	<500	<0.5	<0.5	91	25	<1	33	157
93 PMA-1029.2	34	<21	55	35	16	<3	84	<100	<500	15	11	10	27	<1	34	142
93 PMA-1029.3	29	<20	52	22	16	<3	58	<100	<500	17	09	93	31	<1	34	<50
93 PMA-1029.4	30	<22	100	16	15	<3	58	<100	<500	14	1	13	4	<1	3	90
93 PMA-1029.1	25	100	81	26	17	<3	59	<100	<500	<0.5	1	12	33	<1	29	182
93 PMA-1029.2	28	<23	100	23	16	<3	59	<100	<500	2	11	12	29	<1	28	99
93 PMA-1029.3	33	<20	110	22	17	<3	67	<100	<500	14	1	14	29	2	31	73
93 PMA-1029.4	26	73	83	97	19	<3	66	<100	<500	<0.5	12	11	29	1	29	161
93 PMA-1029.1	28	150	16	14	16	<3	58	<100	<500	<0.5	<0.5	12	35	2	29	90
93 PMA-1029.2	26	<20	27	11	14	<3	52	<100	<500	<0.5	<0.5	10	27	<1	26	177
93 PMA-1029.3	35	<22	84	12	16	<3	67	<100	<500	17	13	14	43	<1	36	123
93 PMA-1029.4	30	<23	85	14	17	<3	67	<100	<500	22	11	14	49	3	32	60
93 PMA-1029.1	37	<25	120	15	16	<3	71	<100	<500	<0.5	1	20	38	<1	35	135
93 PMA-1029.2	32	<22	70	11	16	<3	7	<100	<500	22	<0.5	16	46	<1	36	114
93 PMA-1029.3	54	<24	120	58	20	<3	11	<100	<500	32	2	35	69	5	56	195
93 PMA-1029.4	44	<24	97	33	16	<3	89	<100	<500	14	<0.5	27	48	<1	48	198
93 PMA-1029.102A.P	48	200	79	32	18	<3	86	<100	<500	26	16	27	65	2	48	209
93 PMA-1029.14	39	140	110	94	20	<3	83	<100	<500	22	<0.5	30	56	3	47	260
93 PMA-1029.5	27	<20	150	13	12	<3	63	<100	<500	17	1	15	58	<1	32	119
93 PMA-1029.2	32	83	160	17	13	<3	66	<100	800	25	12	17	92	<1	32	84
93 PMA-1029.4	30	<24	51	16	20	<3	67	<100	<500	<0.5	<0.5	10	39	<1	33	174
93 PMA-1029	35	120	83	35	18	<3	78	<100	<500	11	12	12	42	3	44	143
93 PMA-1029	28	150	81	41	29	<3	84	<100	<500	<0.5	11	98	27	<1	39	199
93 PMA-1100	79	<20	89	27	19	<3	65	<100	<500	<0.5	11	13	31	<1	34	91

1993 Bedrock Geochemical Results

Sample #	East.	North.	Lat.	Long.	AU PPB	AG PPM	AS PPM	BA PPM	BR PPM	CA %	CO PPM	CR PPM	CS PPM	FE %	HF PPM	HQ PPM	IR PPB	MO PPM	NA %
93-PMA-1008	437600	6153970	55.53	-123.09	<2	<5	0.8	560	<0.5	2	1	120	1	0.46	<1	<1	<5	<1	3.01
93-PMA-1010-1	437700	6151760	55.51	-123.09	<2	<5	0.8	840	<0.5	<1	1	230	<1	0.3	<1	<1	<5	<1	0.33
93-PMA-1010-2	437700	6151760	55.51	-123.09	<2	<5	<0.5	760	<0.5	<1	4	190	3	1.62	7	<1	<5	<1	1.20
93-PMA-1010-2A	437700	6151760	55.51	-123.09	<2	<5	<0.5	830	<0.5	<1	4	170	2	1.49	7	<1	<5	<1	1.17
93-PMA-1013	438000	6152000	55.51	-123.07	<2	<5	1.1	4100	<0.5	<1	1	100	2	0.63	1	<1	<5	<1	1.46
93-PMA-1015	440300	6150400	55.51	-123.94	<2	<5	1.9	770	<0.5	<1	1	160	1	0.44	<1	<1	<5	<1	2.22
93-PMA-1016-1	440300	6150400	55.51	-123.94	<2	<5	<0.5	90	<0.5	2	1	170	<1	0.76	6	<1	<5	<1	2.47
93-PMA-1068-1	420038	6166374	55.64	-124.39	<2	<5	5.8	240	<0.5	25	4	66	1	2.97	3	<1	<5	<1	0.12
93-PMA-1068-1A	420038	6166374	55.64	-124.39	3	<5	7.9	240	<0.5	27	4	92	1	3.33	4	<1	<5	<1	0.13
93-PMA-1068-2	420038	6166374	55.64	-124.39	<2	<5	9	190	<0.5	26	5	35	<1	2.52	1	<1	<5	<1	0.1
93-PMA-1068-4	420038	6166374	55.64	-124.39	4	<5	4	150	<0.5	16	8	96	2	9.63	<1	<1	<5	3	0.3
93-PMA-1068-5	420038	6166374	55.64	-124.39	4	<5	58	570	<0.5	18	13	160	3	4.41	12	<1	<5	<1	0.45
93-PMA-1068-9	420038	6166374	55.64	-124.39	6	<5	3.5	120	<0.5	29	2	97	<1	1.75	<1	<1	<5	<1	0.09
93-PMA-1090-5	420038	6166374	55.64	-124.39	6	<5	<0.5	290	<0.5	<1	6	230	<1	4.68	2	<1	<5	<1	0.05

1993 Bedrock Geochemical Results

Sample #	Ni	RB	SB	SC	SE	SN	SR	TA	TH	U	W	ZN	LA	CE	ND	SM	EU	TB	YB	LU
PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
93-PMA-1008	<20	110	<0.1	1.4	<3	<100	620	<0.5	1.6	1.8	<1	<50	6	12	6	1	1.3	<0.5	<0.2	<0.05
93-PMA-1010-1	<20	51	0.1	0.5	<3	<100	<500	<0.5	0.7	<0.5	<1	<50	1.9	6	<5	0.2	0.6	<0.5	0.4	<0.05
93-PMA-1010-2	<20	120	<0.1	5.6	<3	<100	<500	<0.5	1.7	4.4	<1	<50	29	62	24	4.4	0.9	<0.5	2.5	0.43
93-PMA-1010-2A	<20	98	<0.1	5.2	<3	<100	<500	1.6	1.4	3.5	<1	88	25	58	18	3.8	0.8	<0.5	2.3	0.39
93-PMA-1013	<20	240	<0.1	1.3	<3	<100	780	<0.5	3.9	<0.5	<1	<50	6.3	14	7	2.1	0.6	<0.5	0.9	0.14
93-PMA-1015	<20	97	0.2	1.2	<3	<100	<500	<0.5	6	1.1	<1	<50	15	31	9	2	1.2	<0.5	<0.2	<0.05
93-PMA-1016-1	<20	28	<0.1	0.4	<3	<100	<500	<0.5	3.3	0.9	<1	<50	9.5	19	6	1.2	0.8	<0.5	0.2	0.05
93-PMA-1088-1	<20	35	0.3	11	<3	<100	2200	1.1	12	2.5	<1	54	46	110	40	9.9	2.5	2.3	10.3	1.46
93-PMA-1088-1A	<20	37	0.2	12	<3	<100	2400	1.2	13	2.1	<1	81	50	120	45	11	2.8	2.6	11.4	1.55
93-PMA-1088-2	<20	46	0.2	4.4	<3	<100	1700	0.7	4.1	1	<1	<50	19	31	9	3.1	0.9	0.9	4.7	0.64
93-PMA-1088-4	<33	66	0.6	5.2	<3	<100	1720	<0.5	1.5	1.3	<1	<50	3.6	11	<5	0.6	0.7	<0.5	5.6	0.92
93-PMA-1088-5	<23	130	0.8	18	<3	<100	1500	3.6	34	6.9	10	63	78	170	57	12	2.7	2.2	12.1	1.87
93-PMA-1088-9	<21	27	<0.1	6.6	<3	<100	2600	<0.5	1.4	<0.5	<1	<50	4.7	17	8	2.1	0.8	<0.5	7.9	1.15
93-PMA-1090-5	<20	<15	<0.1	2.6	<3	<100	<500	<0.5	1.9	<0.5	<1	<50	13	39	11	2.2	0.8	<0.5	1	0.15

REE Partitioning Study Geochemical Results

Sample #	Size Fraction	AU PPB	AG PPM	AS PPM	BA PPM	BR PPM	CA %	CO PPM	CR PPM	CS PPM	FE %	HF PPM	HO PPM	IR PPB	MO PPM	NA %	NI PPM	RB PPM	SB PPM	SC PPM
93-PMA-1001-1	silt	<2	<5	6.8	1100	<0.5	1	14	100	3	4.15	9	<1	<5	3	1.67	<31	110	0.6	14
93-PMA-1001-2	silt	<2	<5	4.7	930	<0.5	1	18	140	10	5.49	7	<1	<5	<1	1.7	<33	190	0.6	19
93-PMA-1001-2	silt	<2	<5	4.7	930	<0.5	1	18	140	10	5.49	7	<1	<5	<1	1.7	<33	190	0.6	19
93-PMA-1012	silt	5	<5	3.6	1000	<0.5	2	12	81	3	3.47	7	<1	<5	<1	1.35	110	30	1.9	15
93-PMA-1027	silt	12	<5	6.2	760	<0.5	2	12	160	<1	3.1	6	<1	<5	<1	1.63	<28	68	0.8	14
93-PMA-1048	silt	<2	<5	6.3	1000	<0.5	1	11	150	2	3.35	7	<1	<5	<1	1.65	<28	68	1.1	13
93-PMA-1202	silt	<2	<5	7.4	700	<0.5	2	12	140	2	3.27	7	<1	<5	<1	1.65	<27	65	0.7	13
93-PMA-1203	silt	6	<5	3.3	1100	<0.5	1	11	77	2	3.34	6	<1	<5	<1	1.64	<100	<15	1.2	17
93-PMA-1001-1	clay	2	<5	20.0	610	<0.8	<1	15	65	8	3.01	<1	<5	<5	<1	1.41	<51	140	1.1	17
93-PMA-1001-2	clay	2	<5	10.0	940	7.1	<1	15	73	8	3.75	<1	<5	<5	<1	1.48	<48	89	0.7	16
93-PMA-1012	clay	0	<5	3.8	600	3.8	<1	15	61	4	3.68	<1	<5	<5	<1	1.48	<48	89	0.7	16
93-PMA-1027	clay	2	<5	24.0	1500	4.9	1	24	220	5	7.19	3	<1	<5	3	3.03	<44	80	4.5	44
93-PMA-1048	clay	2	<5	12.0	760	8	<1	20	120	5	4.09	<1	<5	<5	<1	1.58	<57	<15	1.5	32
93-PMA-1202	clay	6	<5	7.4	700	4.2	<1	14	75	5	2.83	<1	<5	<5	<1	1.69	<67	<18	1.2	14
93-PMA-1203	clay	2	<5	7.8	1100	5.9	1	20	120	8	6.65	2	<1	<5	<1	1.68	<67	<18	1.2	14
93-PMA-1001-1	bulk	5	<5	4.9	1100	<0.5	5	11	90	4	3.57	6	<1	<5	<1	1.48	<34	96	0.6	13
93-PMA-1001-2	bulk	2	<5	2.8	1300	<0.5	10	13	91	6	3.99	5	<1	<5	<1	1.57	<38	140	0.4	15
93-PMA-1012	bulk	2	<5	9.5	1000	<0.5	3	10	71	2	3.34	7	<1	<5	<1	1.55	<30	92	0.5	12
93-PMA-1027	bulk	0	<5	5.9	1100	<0.5	2	11	150	2	3.18	4	<1	<5	<1	1.63	<30	96	2	32
93-PMA-1048	bulk	<2	<5	5.0	980	<0.5	1	11	140	2	3	4	<1	<5	<1	1.63	<27	76	0.7	13
93-PMA-1202	bulk	<2	<5	4.4	1100	<0.5	1	14	70	3	3.49	6	<1	<5	<1	1.48	<27	76	0.5	12
93-PMA-1203	bulk	<2	<5	4.5	1300	<0.5	4	10	110	2	3.11	7	<1	<5	<1	1.57	<30	87	0.4	11
93-PMA-1001-1	125-63um	<2	<5	4.5	1300	<0.5	4	10	110	2	3.11	7	<1	<5	<1	1.57	<30	87	0.4	11
93-PMA-1001-2	125-63um	<2	<5	2.0	880	<0.5	6	12	95	6	3.93	3	<1	<5	<1	1.44	<28	130	0.3	13
93-PMA-1012	125-63um	<2	<5	1.1	930	<0.5	3	7	53	2	2.2	8	<1	<5	<1	1.87	<35	17	0.3	8.1
93-PMA-1027	125-63um	5	<5	5.0	780	<0.5	2	12	230	4	2.74	3	<1	<5	<1	1.55	<31	20	1	14
93-PMA-1048	125-63um	<2	<5	4.0	980	<0.5	3	8	100	1	2.15	2	<1	<5	<1	1.62	<34	38	0.7	8.9
93-PMA-1202	125-63um	<2	<5	3.5	780	<0.5	1	8	200	2	2.52	5	<1	<5	<1	2.12	<34	38	0.7	8.9
93-PMA-1203	125-63um	<2	<5	1.8	1000	<0.5	4	7	91	2	2.32	6	<1	<5	<1	1.84	<30	71	<0.1	9.3
93-PMA-1001-1	250-125um	<2	<5	1.1	880	<0.5	4	6	77	2	2.8	2	<1	<5	<1	1.4	<30	71	0.3	9.5
93-PMA-1001-2	250-125um	<2	<5	1.1	1000	<0.5	4	6	80	2	3.31	2	<1	<5	<1	1.45	<30	70	<0.1	8.6
93-PMA-1012	250-125um	2200	<5	4.9	1000	<0.5	2	6	43	2	2.75	2	<1	<5	<1	1.86	<20	59	0.6	8.9
93-PMA-1027	250-125um	6	<5	3.2	940	<0.5	1	7	130	2	2.85	2	<1	<5	<1	1.94	<100	50	0.6	7.4
93-PMA-1048	250-125um	3	<5	3.2	980	<0.5	1	7	160	1	2.07	3	<1	<5	2	1.34	<20	64	0.2	7.8
93-PMA-1202	250-125um	<2	<5	1.6	780	<0.5	3	5	36	1	1.91	3	<1	<5	<1	1.65	<25	75	0.6	11
93-PMA-1203	250-125um	<2	<5	1.8	1100	<0.5	4	10	160	2	3.26	5	<1	<5	<1	1.47	<28	32	1.4	22
93-PMA-1001-1	crushed	<2	<5	7.0	1000	<0.5	2	16	230	2	4.53	4	<1	<5	3	1.5	<28	33	0.7	16
93-PMA-1027	crushed	<2	<5	6.3	1100	<0.5	3	19	270	2	4.95	4	<1	<5	1	1.58	<27	71	0.6	70
93-PMA-1048	crushed	<2	<5	5.5	1100	<0.5	3	7	160	2	2.62	5	<1	<5	<1	1.87	<24	150	0.4	8.8
93-PMA-1202	crushed	<2	<5	2.1	1500	<0.5	3	8	65	2	2.7	3	<1	<5	5	1.34	77	75	0.4	9.3
93-PMA-1001-1	2000-250um	<2	<5	3.7	1300	<0.5	3	8	65	2	2.7	3	<1	<5	5	1.34	77	75	0.4	9.3

REE Partitioning Study Geochemical Results

Sample #	Size Fraction	AU PPB	AG PPM	AS PPM	BA PPM	BR PPM	CA %	CO PPM	CR PPM	CS PPM	FE %	HF PPM	HQ PPM	IR PPB	MO PPM	UA %	IN PPM	RB PPM	SB PPM	SC PPM
93-PMA-1001-2	2000-250um	<2	<5	1.4	890	<0.5	10	6	46	3	227	3	<1	<5	2	1.52	<20	81	0.2	6.5
93-PMA-1012	2000-250um	5	<5	<0.5	1200	<0.5	4	6	47	1	224	3	<1	<5	<1	1.39	<20	93	0.2	7.9
93-PMA-1027	2000-250um	<2	<5	6.6	890	<0.5	2	14	140	<1	3.65	3	<1	<5	<1	1.44	<20	44	1.1	18
93-PMA-1048	2000-250um	<2	<5	2.8	850	<0.5	2	8	100	1	2.41	3	<1	<5	<1	1.36	<20	47	0.5	6.6
93-PMA-1202	2000-250um	<2	<5	3.8	890	<0.5	2	8	110	<1	2.46	3	<1	<5	3	1.35	<20	43	0.6	6.7
93-PMA-1203	2000-250um	<2	<5	<0.5	1100	<0.5	2	6	47	2	222	4	<1	<5	<1	1.36	<20	60	0.2	6.1
93-PMA-1001-1	2-4mm	<2	<5	<0.5	1200	<0.5	13	7	61	3	2.61	3	<1	<5	<1	1.81	<28	87	<0.1	11
93-PMA-1001-2	2-4mm	2	<5	3.8	1200	<0.5	10	12	91	6	3.99	5	<1	<5	6	1.57	<36	140	0.4	15
93-PMA-1012	2-4mm	6	<5	2.5	1500	<0.5	3	7	68	2	3.32	4	<1	<5	6	1.6	<29	97	0.3	12
93-PMA-1027	2-4mm	<2	<5	7.0	1000	<0.5	2	18	190	1	5.17	3	<1	<5	<1	1.47	<26	32	1.4	22
93-PMA-1048	2-4mm	<2	<5	5.5	1200	<0.5	3	18	230	2	4.53	4	<1	<5	3	1.5	<26	33	0.7	18
93-PMA-1203	2-4mm	<2	<5	6.3	1100	<0.5	3	19	270	2	4.95	4	<1	<5	1	1.56	<27	71	0.6	20
93-PMA-1203	2-4mm	<2	<5	2.1	1500	<0.5	3	7	160	2	2.62	5	<1	<5	<1	1.87	<24	150	0.4	9.6

REE Partitioning Study Geochemical Results

Sample #	Size Fraction	SE PPM	SI PPM	SR PPM	TA PPM	TH PPM	U PP M	W PP M	Zn PPM	LA PPM	CE PPM	HD PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
93-PHA-1001-1	sl	<3	<100	<500	<0.5	20	3.8	<1	134	69	150	48	8.6	1.8	<0.5	3.6	0.59
93-PHA-1001-2	sl	<3	<100	<500	2.6	16	1.9	<1	479	53	110	39	6.5	1.8	<0.5	3.2	0.51
93-PHA-1002	sl	<3	<100	<500	0.5	18	4.2	<1	116	58	110	40	8.0	1.5	<0.5	2.8	0.45
93-PHA-1007	sl	<3	<100	<500	<0.5	5.8	2.3	<1	103	28	57	24	4.9	1.4	1	3.1	0.49
93-PHA-1048	sl	<3	<100	<500	<0.5	10	2.9	<1	90	38	67	29	5.4	1.6	<0.5	3	0.5
93-PHA-1002	sl	<3	<100	<500	1.1	11	2.5	<1	100	39	83	25	5.5	1.3	1.2	3.1	0.5
93-PHA-1003	sl	<3	<100	<500	<0.5	17	3	<1	122	54	100	36	8.6	1.5	<0.5	3	0.48
93-PHA-1001-1	clay	<5	<100	<500	<1.1	15	<0.7	<2	<54	65	67	20	8.3	2.8	<0.5	2.9	0.48
93-PHA-1001-2	clay	<3	<100	<500	<0.5	10	<0.5	<1	260	35	35	16	5	1.8	<0.5	2.9	0.48
93-PHA-1007	clay	<3	<100	<500	<0.5	10	<0.5	<1	130	30	35	14	3.5	1	<0.5	1.8	0.18
93-PHA-1002	clay	<3	<100	<500	0.8	7.2	3.6	<1	250	29	45	27	7.5	2.5	1.7	4.4	0.87
93-PHA-1048	clay	<3	<100	<500	<0.5	8.3	<0.5	<1	<50	39	54	31	5.7	1.3	2.3	2.2	0.28
93-PHA-1002	clay	<3	<100	<500	2.8	8.3	<0.5	<1	<50	24	22	<5	3.4	1	<0.5	1.4	0.23
93-PHA-1003	clay	<3	<100	<500	1	15	<0.5	<1	207	43	69	32	6.5	2.1	<0.5	2.8	0.48
93-PHA-1001-1	bulk	<3	<100	<500	<0.5	20	3.9	<1	158	49	95	37	6.3	1.6	<0.5	2.8	0.42
93-PHA-1001-2	bulk	<3	<100	<500	<0.5	18	<0.5	<1	222	51	110	31	6.2	1.6	<0.5	2.3	0.42
93-PHA-1007	bulk	<3	<100	<500	<0.5	17	3.7	<1	169	50	100	34	6.4	1.6	<0.5	2.9	0.42
93-PHA-1002	bulk	<3	<100	<500	1.9	6	2.2	<1	98	28	57	22	5.3	1.5	0.8	3.4	0.48
93-PHA-1048	bulk	<3	<100	<500	<0.5	7.2	1	3	<50	30	62	20	4.3	1.2	<0.5	2.5	0.39
93-PHA-1003	bulk	<3	<100	<500	<0.5	6	2.6	<1	<50	28	57	13	4	1.2	<0.5	2.5	0.39
93-PHA-1001-1	bulk	<3	<100	<500	<0.5	15	3.6	<1	<50	48	98	34	6.1	1.4	<0.5	2.5	0.4
93-PHA-1001-2	125-63um	<3	<100	<500	<0.5	22	4.2	<1	<50	68	140	50	8.6	1.9	<0.5	3	0.52
93-PHA-1007	125-63um	<3	<100	<500	<0.5	19	2.6	<1	220	59	120	43	8.8	1.1	<0.5	2.2	0.39
93-PHA-1002	125-63um	<3	<100	<500	<0.5	21	3.6	<1	<50	61	120	46	7.5	1.7	<0.5	2.4	0.39
93-PHA-1007	125-63um	<3	<100	<500	<0.5	3.7	<0.5	<1	<50	19	42	19	3.3	1	<0.5	2	0.28
93-PHA-1048	125-63um	<3	<100	<500	1.3	2.1	1.4	<1	52	27	55	15	3.7	1	<0.5	2	0.31
93-PHA-1002	125-63um	<3	<100	<500	<0.5	8.5	2.2	<1	<50	32	66	21	4.5	1.3	<0.5	2.3	0.33
93-PHA-1003	125-63um	<3	<100	<500	<0.5	20	3.6	<1	<50	62	120	46	7.3	1.6	<0.5	2.6	0.41
93-PHA-1001-1	250-125um	<3	<100	<500	1.2	12	2.1	<1	80	36	72	25	4.5	1.3	<0.5	2.2	0.35
93-PHA-1001-2	250-125um	<3	<100	<500	<0.5	13	1.8	<1	188	45	87	32	5.1	1.1	<0.5	1.6	0.3
93-PHA-1007	250-125um	<3	<100	<500	1.2	11	2.3	<1	<50	38	71	26	4.8	1.2	0.9	1.8	0.32
93-PHA-1027	250-125um	<3	<100	<500	<0.5	3.3	0.9	<1	81	15	35	15	2.9	1	<0.5	1.9	0.29
93-PHA-1048	250-125um	<3	<100	<500	<0.5	4.5	<0.5	<1	<50	19	37	13	2.9	0.7	<0.5	1.4	0.19
93-PHA-1002	250-125um	<3	<100	<500	<0.5	4.8	<0.5	<1	<50	20	41	15	2.7	0.9	1.2	1.8	0.29
93-PHA-1007	250-125um	<3	<100	<500	<0.5	9.5	1.8	<1	68	31	60	20	3.6	1.1	<0.5	1.8	0.22
93-PHA-1001-1	crushed	<3	<100	<500	<0.5	14	1.8	<1	102	39	78	19	4.6	1.2	0.7	1.9	0.31
93-PHA-1002	crushed	<3	<100	<500	<0.5	3.4	<0.5	<1	111	17	35	17	4.1	1.3	0.6	2.7	0.47
93-PHA-1048	crushed	<3	<100	<500	<0.5	5.3	1.2	<1	<50	20	41	18	3.6	1.2	<0.5	2.6	0.45
93-PHA-1007	crushed	<3	<100	<500	<0.5	4.4	1.5	<1	<50	16	36	16	3.6	1.1	<0.5	2.8	0.47
93-PHA-1002	crushed	<3	<100	<500	<0.5	14	3.2	<1	115	33	66	25	4.4	1.5	<0.5	1.9	0.3
93-PHA-1001-1	2000-750um	<3	<100	<500	<0.5	9.9	1.2	<1	103	26	54	20	3.3	1.1	<0.5	1.8	0.25

REE Partitioning Study Geochemical Results

Sample #	Size Fraction	SE PPM	SN PPM	SR PPM	TA PPM	TH PPM	U PPM	W PPM	Zn PPM	LA PPM	CE PPM	HD PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
93 PMA-1001-2	2000-2500µm	<3	<100	<500	<0.5	10	2.8	<1	111	34	67	20	3.8	1	<0.5	1.5	0.2
93 PMA-1017	2000-2500µm	<3	<100	730	<0.5	83	1.8	<1	<50	26	53	21	3.2	1.1	<0.5	1.3	0.2
93 PMA-1027	2000-2500µm	<3	<100	<500	<0.5	32	1.1	<1	<50	14	29	15	3.1	1	0.5	2.1	0.33
93 PMA-1046	2000-2500µm	<3	<100	<500	1.3	3.6	0.9	4	<50	14	25	9	2.2	0.7	<0.5	1.4	0.25
93 PMA-1702	2000-2500µm	<3	<100	<500	1.1	3.6	1.4	3	<50	13	28	10	2.2	0.6	<0.5	1.3	<0.05
93 PMA-1703	2000-2500µm	<3	<100	<500	<0.5	6.0	1.4	<1	64	27	54	19	33	1.1	<0.5	1.4	0.23
93 PMA-1001-1	2-4mm	<3	<100	850	<0.5	14	2.5	4	181	44	88	33	4.9	1.1	<0.5	1.6	0.33
93 PMA-1001-2	2-4mm	<3	<100	<500	2	8.9	<0.5	<1	222	51	110	31	82	1.8	<0.5	2.3	0.42
93 PMA-1027	2-4mm	<3	<100	<500	<0.5	3.4	1.5	6	103	27	58	22	3.9	1.2	<0.5	1.9	0.32
93 PMA-1046	2-4mm	<3	<100	<500	<0.5	5.3	1.2	<1	<50	20	41	16	3.8	1.2	<0.5	2.6	0.45
93 PMA-1702	2-4mm	<3	<100	<500	<0.5	4.4	1.5	<1	<50	16	36	16	3.6	1.1	<0.5	2.8	0.42
93 PMA-1703	2-4mm	<3	<100	<500	<0.5	14	3.2	<1	115	33	68	25	4.4	1.3	<0.5	1.9	0.3

Appendix III
Clast Lithology Abundances

1992 Clast Lithology Results (Count%)

SAMPLE #	igneous%	Metamorph%	Volcanic%	Calc%	clastic%
91-PMA-344-1	72	15	0	4	0
91-PMA-344-2	62	16	22	0	0
91-PMA-346-1	10	0	29	0	60
91-PMA-346-2	30	0	30	0	40
91-PMA-348-1	10	17	16	5	52
91-PMA-348-2	23	23	18	2	33
91-PMA-348-3	21	15	30	3	30
91-PMA-348-4	14	22	5	8	51
91-PMA-348-5	11	14	28	3	45
91-PMA-348-6	16	26	24	1	33
91-PMA-349-1	27	2	7	0	65
91-PMA-349-2	2	6	0	0	82
91-PMA-349-3	16	2	4	0	78
91-PMA-367-2	71	23	6	0	0
91-PMA-370-1	18	0	24	2	47
91-PMA-370-2	14	18	33	0	35
91-PMA-370-3	14	28	29	1	28
91-PMA-371	0	47	42	3	0
91-PMA-375-1	8	2	60	0	0
91-PMA-375-2	6	6	83	3	0
91-PMA-377	0	17	83	0	0
91-PMA-378	6	2	47	0	45
91-PMA-383	70	10	20	0	0
91-PMA-392	71	20	8	0	0
91-PMA-395-1	82	8	9	1	0
91-PMA-395-2	90	4	5	0	0
91-PMA-404	50	48	2	0	0

1993 Clast Lithology Abundances (Count%)

[illegible]

1893 Clast Lithology Abundances (Count%)

SAMPLE#	Grande	Granodiorite	Gneissic	Diorite	Peg-	Felsic/Int	Mafic	Ultramafic	Conglom-	Sand-	Silt-	Time-	Argillite	Slate/phyllite	Schist	Other	Total	Description	
					malite	volcs	vols		erate	stone	stone	stone	maile				of		
93PMA1032	8.2	2.1	3.1	2.1	59.8	7.2	1.0	0.0	0.0	4.1	2.1	0.0	0.0	3.1	7.2	0.0	100.0	Qz/fels	
93PMA1033	0.6	0.0	0.0	0.0	0.0	0.0	98.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.1	Qz/fels	
93PMA1034	0.0	0.0	0.0	0.0	0.0	23.4	14.9	0.0	0.0	4.3	27.7	0.0	0.0	25.5	0.0	4.3	100.1	Qz/fels	
93PMA1037	0.0	0.0	0.0	0.0	0.0	69.5	1.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	100.0	Qz/fels	
93PMA1038	0.0	13.5	2.8	1.0	51.9	1.0	6.7	0.0	0.0	1.9	1.9	0.0	2.9	0.0	9.8	6.7	100.0	Qz/fels	
93PMA1039-1	1.2	8.9	0.0	4.8	54.3	0.0	3.8	0.0	0.0	2.4	7.1	0.0	0.8	0.0	1.2	11.9	100.0	Qz/fels/CHERT	
93PMA1039-2	0.0	2.1	1.5	0.0	81.4	3.1	2.8	0.0	0.0	0.0	2.6	0.0	3.1	1.0	0.0	2.8	100.0	Qz/fels/CHERT	
93PMA1040	2.9	51.8	0.0	2.2	24.1	0.0	6.8	0.0	0.0	1.5	5.1	0.0	0.7	5.1	0.0	0.0	100.0	Qz/fels	
93PMA1041	1.2	10.7	0.0	1.2	38.1	25.0	3.8	0.0	0.0	1.2	2.5	0.0	0.0	0.0	0.0	4.1	100.1	Qz/fels	
93PMA1042	0.8	0.0	0.0	2.5	0.0	69.4	19.5	0.0	0.0	3.3	2.5	0.0	0.0	0.0	3.9	0.0	100.1	Qz/fels	
93PMA1043	9.1	0.0	0.0	0.0	35.1	0.0	98.7	0.0	0.0	2.6	1.3	9.1	0.0	0.0	0.0	0.0	100.1	Qz/fels	
93PMA1044	3.0	0.0	0.0	0.0	60.5	0.0	3.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	100.1	Qz/fels	
93PMA1045	4.8	6.2	2.1	0.0	67.1	0.0	4.8	0.0	0.0	2.7	4.8	0.0	4.8	0.0	2.7	0.0	100.0	Qz/fels	
93PMA1046-1	0.0	33.7	0.0	0.0	0.0	14.5	12.3	21.0	0.0	5.1	11.6	7.2	17.4	2.9	0.0	0.0	99.9	Qz/fels	
93PMA1046-2	2.2	5.8	0.0	0.0	0.0	0.0	3.2	3.2	0.0	1.6	4.8	12.9	6.1	3.2	69.7	0.0	99.9	Qz/fels	
93PMA1047-1	3.2	0.0	0.0	0.0	0.0	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	100.1	Qz/fels	
93PMA1047-2	13.6	0.0	54.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	10.7	0.0	15.5	7.3	100.1	Qz/fels	
93PMA1048	4.9	2.9	0.0	0.0	2.4	35.4	10.2	1.0	0.0	0.0	8.8	17.3	5.8	0.0	13.5	0.0	100.0	Qz/fels	
93PMA1049	15.4	0.0	3.8	0.0	5.8	0.0	9.8	19.2	0.0	0.0	8.8	0.0	12.1	3.0	8.3	0.0	99.9	Qz/fels	
93PMA1052	0.0	30.3	0.0	0.0	19.7	6.8	12.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	Qz/fels	
93PMA1055	0.0	5.8	0.0	0.0	24.4	0.0	28.9	0.0	0.0	8.7	13.3	0.0	0.0	8.7	13.3	0.0	100.0	Qz/fels	
93PMA1057	0.0	8.7	0.0	0.0	3.9	87.8	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	100.1	Qz/fels	
93PMA1058	2.7	42.8	20.3	3.4	12.8	0.0	15.5	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	100.0	Qz/fels	
93PMA1059	12.9	52.9	0.0	0.0	9.4	0.0	12.9	0.0	0.0	0.0	3.5	2.4	2.4	2.4	0.0	1.2	100.0	Qz/fels	
93PMA1060	2.8	18.4	0.0	0.0	71.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	1.4	3.5	0.0	100.0	Qz/fels
93PMA1061	0.0	34.5	0.0	24.7	16.1	9.8	6.3	0.0	0.0	0.0	2.8	0.0	5.7	0.0	0.0	0.0	100.0	Qz/fels	
93PMA1063	0.0	18.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	4.0	20.0	20.0	0.0	0.0	8.0	24.0	0.0	100.0	Qz/fels
93PMA1064	0.0	69.2	0.0	0.0	9.0	5.1	7.6	0.0	0.0	2.6	0.0	0.0	6.4	0.0	0.0	5.1	100.0	Qz/fels	
93PMA1065	0.0	0.0	0.0	0.0	3.8	3.3	84.7	0.0	0.0	0.0	1.8	0.0	1.8	2.2	1.1	1.8	99.8	Qz/fels	
93PMA1066	0.0	0.0	0.0	0.0	5.7	12.3	4.7	0.0	0.0	2.8	3.8	0.0	0.0	65.1	0.0	5.7	100.1	Qz/fels	
93PMA1067-1	0.0	0.0	0.0	0.0	0.0	7.5	6.3	28.3	0.0	0.0	1.3	3.8	46.3	3.8	5.0	0.0	100.3	Qz/fels	
93PMA1067-2	0.0	0.0	0.0	0.0	0.0	3.0	65.2	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	25.8	3.0	100.1	Qz/fels
93PMA1068	0.0	0.9	1.7	0.0	5.2	11.2	4.3	0.0	0.0	0.0	4.3	50.9	0.0	0.0	19.8	1.7	100.0	Qz/fels	
93PMA1069	0.0	0.0	0.0	0.0	0.0	81.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	Qz/fels	
93PMA1070	0.0	5.9	0.0	0.0	0.0	96	15.7	9.8	0.0	2.0	2.0	0.0	0.0	0.0	37.3	17.8	100.1	Qz/fels	
93PMA1071	1.0	30.8	10.2	0.0	2.0	5.1	9.8	0.0	0.0	0.0	0.0	0.0	1.0	0.0	29.6	14.3	99.9	Qz/fels	
93PMA1072	2.4	4.7	21.2	1.2	21.2	5.9	2.4	0.0	0.0	0.0	1.2	0.0	0.0	0.0	40.0	0.0	100.2	Qz/fels	

1993 Clast Lithology Abundances (Count%)

SAMPLE#	Grande	Granodiorite	Gneissic	Diorite	Peg-	Felsic/mf	Mafic	Ultr-	Concom-	Sand-	Sr-	Lin-	Argill-	Silt-	Other	Total	Description
					mites	vol%	vol%	mic	ite	stone	stone	stone	stone	stone	stone	stone	
93PMA1074	00	23	53	00	61	15	214	00	00	00	31	00	53	08	469	53	1000
93PMA1075	00	00	00	00	41	82	00	00	00	00	00	00	00	00	00	00	00
93PMA1076	00	00	61	00	45	76	45	00	00	30	00	00	00	00	662	61	1000
93PMA1077	00	04	00	00	28	13	34	00	00	00	00	00	21	00	677	28	1001
93PMA1078	00	06	24	00	00	289	157	00	00	98	217	00	00	24	72	99	00
93PMA1079	29	72	00	00	116	130	522	00	00	00	00	00	00	43	43	998	00
93PMA1080	24	407	12	00	162	00	48	00	00	00	00	00	06	00	335	00	1000
93PMA1081	00	29	29	00	98	255	304	00	00	39	39	00	00	10	176	20	999
93PMA1082	00	00	10	00	120	100	340	00	00	00	00	30	00	00	320	00	1000
93PMA1083	00	00	00	00	19	96	00	00	00	00	26	90	00	51	199	13	1000
93PMA1083.1	08	00	00	00	00	126	100	00	00	00	00	38	317	10	00	38	135
93PMA1083.2	00	19	173	00	00	48	125	77	00	00	19	59	176	00	40	176	00
93PMA1084	00	00	00	00	00	109	00	00	00	19	59	176	00	17	26	35	1000
93PMA1085	00	00	00	00	00	09	122	09	00	00	17	43	713	49	24	329	61
93PMA1087	00	37	73	00	61	185	12	00	00	61	24	73	00	00	00	00	00
93PMA1089	12	00	00	00	00	00	24	00	00	00	00	00	00	00	00	00	00
93PMA1090.1	61	00	20	00	61	204	216	00	00	44	71	115	00	00	00	00	00
93PMA1090.2	53	00	00	00	27	369	115	00	00	27	135	00	00	00	00	00	00
93PMA1090.3	63	00	00	00	36	27	106	342	00	00	00	00	00	00	00	00	00
93PMA1090.4	14	00	00	00	00	41	378	16	00	00	50	00	00	00	446	14	32
93PMA1092.1	07	14	00	00	00	117	172	207	00	00	14	00	103	00	168	159	14
93PMA1092.2	16	39	39	00	24	94	126	00	00	39	110	47	31	06	370	55	998
93PMA1093	22	00	00	00	130	152	261	00	00	00	33	43	00	00	67	272	00
93PMA1094.1	00	42	10	31	00	446	125	00	00	73	187	10	00	10	00	63	999
93PMA1094.2	00	32	00	32	16	564	60	00	00	64	46	64	00	08	32	40	1000
93PMA1094.3	30	00	00	00	30	127	627	00	00	37	37	15	30	07	52	00	999
93PMA1094.4	38	30	00	15	30	96	561	00	00	23	38	00	00	63	30	53	999
93PMA1094.6	00	36	00	00	54	54	213	00	00	62	154	23	136	08	154	92	1000
93PMA1094.87	00	00	00	00	55	119	264	00	00	00	37	101	165	18	183	26	1000
93PMA1094.12	06	00	00	00	16	53	534	00	00	27	169	44	47	00	65	36	1000
93PMA1094.14	00	15	37	00	15	111	69	00	00	62	141	00	86	37	296	111	1000
93PMA1095-1	00	21	55	00	622	00	07	00	00	14	27	14	00	00	00	00	00
93PMA1095-2	24	12	12	00	905	24	24	00	00	00	00	00	00	00	00	00	00
93PMA1096	00	00	00	00	36	57	283	00	00	00	123	28	66	311	75	00	1000
93PMA1097	00	00	00	00	24	00	30	00	00	12	36	00	00	898	00	00	1000
93PMA1098	00	00	00	00	13	94	657	00	00	00	00	00	16	04	00	09	999
93PMA1100	21	00	00	00	52	177	73	00	10	31	63	104	31	73	323	42	1000

Appendix IV
Till Geochemistry
Proportional Symbol Maps

Appendix V
Clast Lithology
Proportional Symbol Maps

Appendix VI
Till-Section
Geochemical Profiles

Munroe Creek
section
93PMA1016

Munroe Creek
section
93PMA1016

Munroe Creek
section
93PMA1016

Munroe Creek
section
93PMA1016

Munroe Creek

Section

Depth 93PMA1020
(m)

Legend

Interstratified diamicton
with fine silt and sand
lenses

Five sand

Silt

Munroe Creek

Section

93PMA1020

Depth (m)

Munroe Creek

Section

Depth 93PMA1020
(m)

Munroe Creek

Section

93PMA1020

Depth (m)

0 2 4 6 8 10 12

93PMA1020-5
93PMA1020-4
93PMA1020-3
93PMA1020-2
93PMA1020-1

U (ppm)

2 3 4

Zn (ppm)

150 200 250

La (ppm)

35 36 37 38 39 40

Ce (ppm)

75 76 77 78 79 80

Nd (ppm)

25 26 27 28 29 30

0 1 2 3 4 5 6 7 8 9 10 11 12 13

Munroe Creek

Section

93PMA1020

Depth (m)

**Appendix VII
Till-Section
Clast Lithology Profiles**

Munroe Creek

Section

93PMA1003

Depth (m)

0 2 4 6 8 10 12 14

93PMA1003-4

93PMA1003-3

93PMA1003-2

93PMA1003-1

Legend

Till unit 1: grey-brown sandy till

Till unit 2: Interstratified sand and gravel lenses

Coarse sand

Sandy gravel

Munroe Creek

Section

Munroe Creek

Section

Munroe Creek

section

93PMA1016

Munroe Creek
section
93PMA1016

Munroa Creek
section
93PMA1016

Munroe Creek

Section

Depth (m)

Munroa Creek

Section

Depth 93PMA1020

Granite Creek
section

Appendix VIII
Partitioning Study Results:
Grainsize vs. Concentration

Profile of Lanthanum concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Cerium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Neodymium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Uranium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Samarium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Zinc

Profile of Zinc concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Chromium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Cesium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Cobalt concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Arsenic

Profile of Arsenic concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Gold

Profile of Gold concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Barium

Profile of Barium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

232

Rubidium

Profile of Rubidium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Scandium

Profile of Scandium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Ytterbium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Profile of Lutetium concentrations in six size-fractions of till collected from 1993 till samples showing a range from background to anomalous concentrations.

Appendix IX
Heavy Mineral Count Results

Sample Number	Garnet	Staurolite	Kyanite/ Sillimanite	Epidote	Proterose	Hornblende	Ilmenite	Hematite	Goethite	Pyrite	Barite	Rutile	Titanite	Zircon	Other
93 PMA 1001-1	35	7	10	17	22	3	2	4	3	0	3	0	1	6	1% Qtz/Fld
93 PMA 1001-2	45	0	7	22	24	5	TR	2	5	0	2	0	4	14	1% Qtz/Fld; 1% monazite
93 PMA 1018-2	42	0	2	19	29	2	0	5	0	0	0	TR	3	0	2% epid
93 PMA 1018-3	10	TR	4	12	9	38	0	7	2	0	0	0	1	5	0
93 PMA 1017	9	4	1	15	16	33	3	3	3	0	3	0	9	7	0
93 PMA 1020-1	20	4	1	15	16	33	3	3	3	0	3	0	9	7	0
93 PMA 1020-3	14	1	5	25	25	TR	1	9	14	3	4	0	1	3	1% Qtz/Fld, 1% chromite
93 PMA 1037	53	0	1	5	6	TR	0	7	30	TR	2	TR	1	1	0
93 PMA 1078	51	1	2	13	13	TR	2	14	21	0	0	3	2	6	3% Qtz/Fld
93 PMA 1078	29	7	10	34	34	3	1	7	4	0	0	4	2	2	2% Qtz/Fld; TR epid; 1% allanite
93 PMA 1081	35	1	0	3	3	5	4	12	4	0	0	0	0	31	1% Qtz/Fld
93 PMA 1084-1	25	6	3	22	22	3	2	10	8	0	0	0	0	0	1% Qtz/Fld; TR monazite
93 PMA 1084-3	21	4	3	24	24	5	TR	5	8	0	0	0	1	17	2% Qtz/Fld; TR allanite
93 PMA 1085-1	72	TR	3	6	6	TR	1	4	7	0	0	0	1	3	2% Qtz/Fld; TR epid
93 PMA 1085-2	70	TR	4	13	13	2	0	1	5	0	0	0	1	TR	0

Abbreviations Table:

Qtz/Fld: Quartz/Feldspar

TR: Trace amount of
minerals observed beside

HVMINRESULT.xls

Appendix I Duplicate Analyses

Quality Control: Precision and Accuracy of analytical methods

For geochemical analyses on the <0.063mm size fraction of till to be reliable, standard and duplicate samples were inserted at random within each sample set analyzed by INAA. These results are included with the <0.063mm analysis presented in Appendix II, and show consistent metal concentrations with precision to within +/-20%.

Furthermore, X-Y plots have been drawn to verify the precision and accuracy of the analytical methods employed by INAA. These results are presented in the following pages.

Analytical results of these quality control measures do not reflect large differences between original and duplicate samples, and therefore do not influence the discrimination between anomalous and background sites (Plouffe, 1995).

Duplicate analyses: <63µm sized fraction by INAA

Duplicate analyses: <63um sized fraction by INAA

Duplicate analyses: <63um sized fraction by INAA

Duplicate analyses: <63 μ m sized fraction by INAA

Duplicate analyses: <63 μ m sized fraction by INAA