Glacial Dispersal of Gold and Arsenic from an Unknown Source Near Wheatcroft Lake, Manitoba, Including Reference to Overlying Lake Agassiz Clay

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ABSTRACT

In 1986, a zone of high arsenic values in till was outlined south of Wheatcroft Lake in northwestern Manitoba. This zone was based on 8 anomalous samples taken over an area of approximately 800 km^2. As a follow-up to this study, 128 additional till samples were collected in the same area.

Dispersal patterns of gold and arsenic are parallel to sub-parallel to Wisconsinan ice-flow directions. No one source area or bedrock lithology has been outlined. Several sources probably contribute to anomalous gold and arsenic values.

Much of the study area is overlain by clay of glacial Lake Agassiz. Overlying clay was sampled in addition to till to determine whether clay geochemistry reflects the geochemistry of underlying till. For most trace elements, Lake Agassiz clay is unreliable for detecting the geochemical signal of underlying till. Uranium levels in overlying clay may reflect uranium concentrations in till.

RÉSUMÉ

En 1986, de hautes teneurs en arsenic furent observées dans une région de till au sud du Lac Wheatcroft, dans le nord-ouest du Manitoba. Cette région de till fut délimité par 8 échantillons à teneurs anomaliques et couvre une superficie d'environ 800 km^2. Pour faire suite à cette étude, 128 échantillons additionnels de till furent prélevés dans cette même region.

Les trains de dispersion des éleménts de l'or et de l'arsenic sont orientés parallèle à sub-parallèle avec l'orientation d'écoulement glaciaire du Wisconsin. Aucune région ou unité lithologique qui serait la source de ces éléments n'a èté trouvè. Il est probable que plusieurs sources ont contribué à la formation de ces teneurs anomaliques en or et en arsenic.

Une bonne partie de la région étudiée est recouverte par une argile glaciare du Lac Agassiz. Cette argile fut aussi échantillonnée, en plus du till, pour tenter d'identifier les mêmes variations géochimiques que celles du till sous-jacent. Il semble que la majorité des éléments traces, de l'argile du Lac Agassiz, ne permettent pas de caractériser la signature géochimique du till sous-jacent. Cependant les teneurs en uranium de l'argile pourraient reflêter celles du till.

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CHAPTER 1 - INTRODUCTION

BACKGROUND AND PURPOSE OF STUDY

In 1984, till sampling in the area covered by the Granville Lake map sheet (NTS 64C) revealed a zone of high arsenic values (>40 ppm) south of Granville Lake, Manitoba (Kaszycki and Dilabio, 1986) (Fig. 1). The area of anomalously high arsenic concentration was approximately 800 km^2 and was represented by samples taken at 8 sites. Kaszycki and DiLabio (1986, p. 255) proposed that the dispersal pattern formed by this arsenic anomaly "may reflect large scale glacial dispersal (<25 km) from a zone of sulphide mineralization along the south shore of Granville Lake".

Because of arsenic's potential as a pathfinder for gold (Levinson, 1980, p. 54), more detailed sampling was planned to more clearly outline the anomaly. Gold concentrations were also determined. This thesis is the result of the more detailed sampling.

The denser sample pattern incorporates an additional 128 till samples taken in an area of approximately 1200 km^2, including the original anomaly. At six of these sites, Lake Agassiz clay, which overlay the till, was also sampled.

The purpose of this thesis is: 1) to more clearly define the shape and dispersal pattern of arsenic in till; 2) to clearly define the shape and dispersal pattern of gold in till; 3) to define any possible source areas for gold and arsenic in till; 4) to define any possible source lithologies for gold and arsenic in till; and 5) to determine the extent to which Lake Agassiz clay reflects underlying till geochemistry.

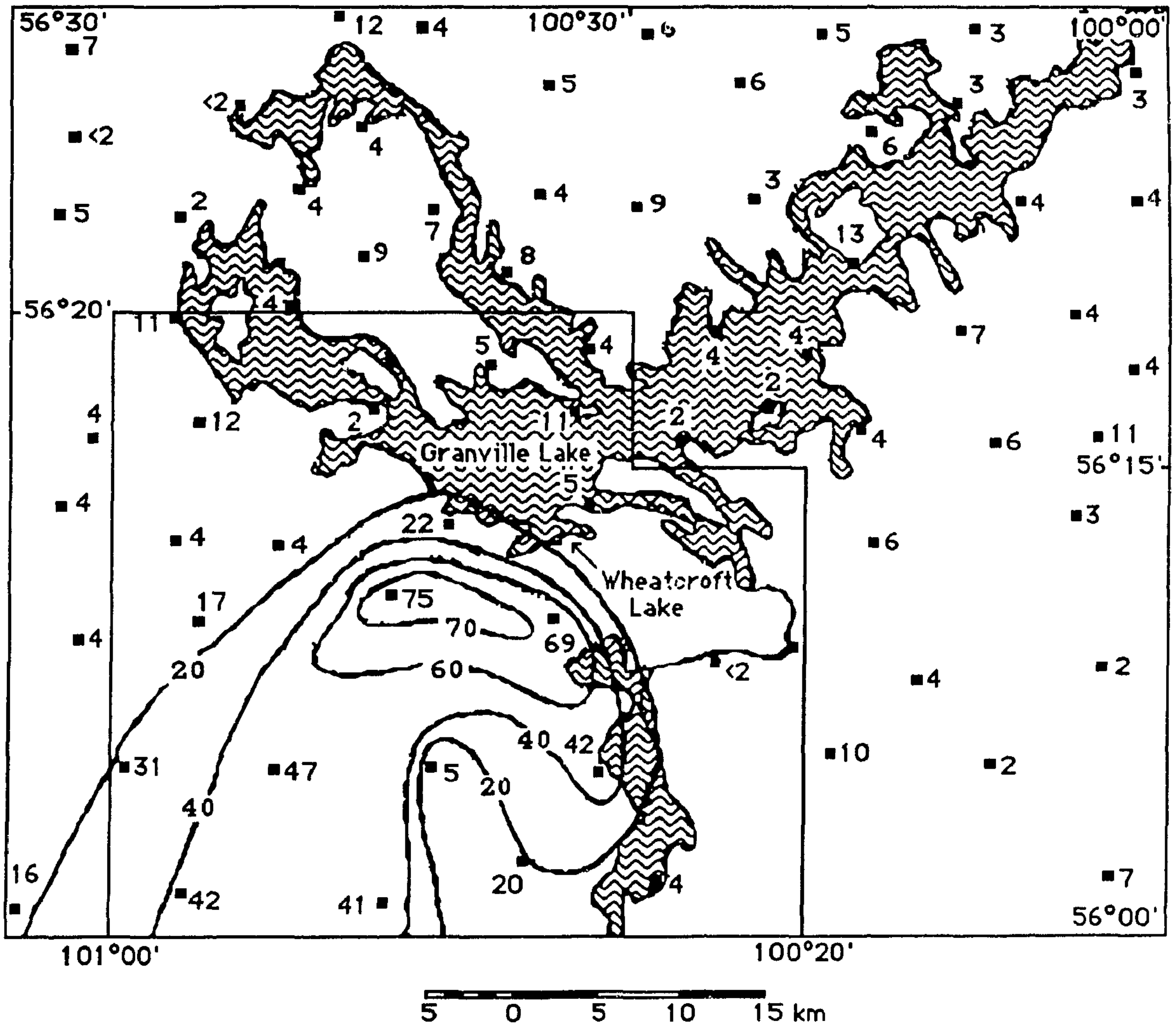


Figure 1. Original anomaly. Numbers represent arsenic values (ppm). Present study area is also outlined (modified from Kaszycki and DiLabio, 1986).

PRINCIPLES OF DRIFT PROSPECTING

The goal of geochemical prospecting is to locate economic deposits of minerals by the measurement of concentrations of chemical elements or compounds which normally occur in only small amounts in nature. The media in which the measured elements or compounds are found include rocks, stream sediments, soils, water, vegetation, glacial drift or even snow or air.

A geochemical survey of an area of unknown mineral and economic potential has two primary goals: 1) to allow the selection of areas with potential in the earliest stages of exploration at minimum cost; and 2) to outline areas of considerably higher trace element content than regional background in order that they may be investigated in more detail using geology, more geochemistry, and geophysics to determine whether an area shows enough potential for drilling (Allan et al., 1972).

The principle behind mineral exploration by drift prospecting is to trace back to an original source, glacially transported bedrock or sediment. The reasons for using till in mineral exploration were put forward clearly by W.W. Shilts in 1975; "There are many cogent reasons for using till (in mineral exploration), the most important of which are: 1) its widespread distribution; 2) the ease of relating till sheets to specific directions of ice movement as indicated by striations, drumlins, etc.; 3) the fact that unweathered till usually represents ground-up, fresh bedrock; 4) the ease of recognizing till; and 5) the fact that dispersal trains are a larger target than the source of the trains" (Shilts, 1975, p. 2).

A number of factors determine the concentration of the various components of till. "The relative contributions of various bedrock lithologies to till composition are most strongly controlled by the type and abundance of minerals in the rock and their size and resistance to crushing and shearing, the physical and chemical nature of the load of foreign debris in the glacier at the point of erosion, and the area, topographic position, and resistance to erosion of the source rock" (Klassen and Shilts, 1977, p. 81).

The form of a dispersal train is determined by the size and resistance of the source, the orientation of the source relative to the direction of ice-flow, and by the topography of both the source area and the dispersal area (DiLabio and Coker, 1987). Typical dispersal trains are often finger shaped or fan shaped. Fan shapes can result from changing directions of ice flow, or from radial spreading in lowlands or near an ice front (Shilts, 1976). Glacial dispersal trains range from a few metres to hundreds of kilometres in length (DiLabio and Coker, 1987).

The shape of a dispersal train can also depend on the choice of anomaly threshold for a component. Dispersal trains are mapped out by contouring an area or zone of anomalous values. The lowest value that is considered to be anomalous is the anomaly threshold. Values below this concentration are considered to be "background." The threshold value that is chosen depends on the author, but usually represents a value such as the mean plus one or two standard deviations, or the median or a cumulative frequency value such as 80 or 90 percent.

The abundance of the element, mineral or grain that defines a dispersal train has been found to be at a maximum close to the source (the "head" of the train) and to decrease exponentially in the direction of ice-flow (the "tail" of the train) (Gillberg, 1968; DiLabio and Coker, 1987). The pattern of decrease is influenced by: a) the topography of the area; b) the grain size and physical properties of the transported material; and c) the mechanism of glacial flow (Nichol and Bjorklund, 1973).

Shilts (1976) has classified dispersal trains into three main types, which in turn can be of three main plan shapes. The main types are: 1) anomalies that consist of one or two adjacent samples with values just above the regional background; 2) anomalies that cover several square kilometres and have values ranging from just above background to several times background; and 3) anomalies that comprise of one or two adjacent sample sites whose concentrations are five or more times background levels. The possible areal shapes of the three types of anomalies are: a) "ameboid"; b) strongly elongated in the direction of glacial movement; and c) strongly elongated in the direction of structural trend.

Shilts' interpretation of the combination of these types and shapes are as follows: 1a) sampling-analytical mistake, or tail of a small train; 1b and 1c) difficult to interpret; 2a) area of several small indicator trains and mineralized outcroppings, or a large rockmass with disseminated mineralization; 2b) indicator train, mineralization is likely at or near up-ice end; 2c) tail of broad indicator train trending down-ice from strata-bound mineralization or mineralization concentrated along a fault or other structural feature; 3a) steep part of dispersal curve, mineralization is probably within a few hundred metres, or hydromorphic anomaly with mineralization close by, or the sample contains debris of weathered mineralized boulder making the site of mineralization indeterminate; and 3b and 3c) same as 3a, but contamination from a weathered boulder is unlikely.

The importance of till in mineral exploration can perhaps only be appreciated with the realization that over 70% of Canada's land surface has been glaciated, and this area accounts for 75% of the nation's mineral production (Bradshaw et al., 1971). Mineral exploration in the past has been carried out primarily by prospectors and geologists who largely concentrated on outcrops or other "macro" expressions of mineralization. However, the time of exploration by visual observation is nearing an end as most of the world's obvious mineral deposits have already been located (Levinson, 1980, p. 2). As sources of economic mineral deposits become more difficult to locate by conventional methods, more intense, "micro" methods such as drift prospecting will become increasingly important.

LOCATION AND REGIONAL SETTING

The area studied is in the northern coniferous section of the boreal forest in northwestern Manitoba, between latitudes 56°0' and 56°20' and longitudes 100° 20' and 101° 0' (Fig. 2, back pocket).

The study area is approximately 1200 km^2 and is roughly centred around Wheatcroft Lake, south of Granville Lake. Drainage is part of the Churchill River system and includes, in addition to Wheatcroft and Granville Lakes, Trophy Lake, Onion River, Laurie River and Churchill River itself. Granville Lake is a local expansion of Churchill River, as is Wheatcroft Lake of Laurie River.

Altitudes range from less than 275 m A.S.L. in the central part of the study area, to over 400 m A.S.L. in the extreme southwest (Fig. 3). Local relief is rarely more than 30 m. The rivers of the area are predominantly at an altitude of less than 275 m A.S.L. In general, drainage is poor and much of the area is covered by swamp.

Permafrost in the region is discontinuous. Several sample sites were abandoned when permafrost rendered sampling impossible.

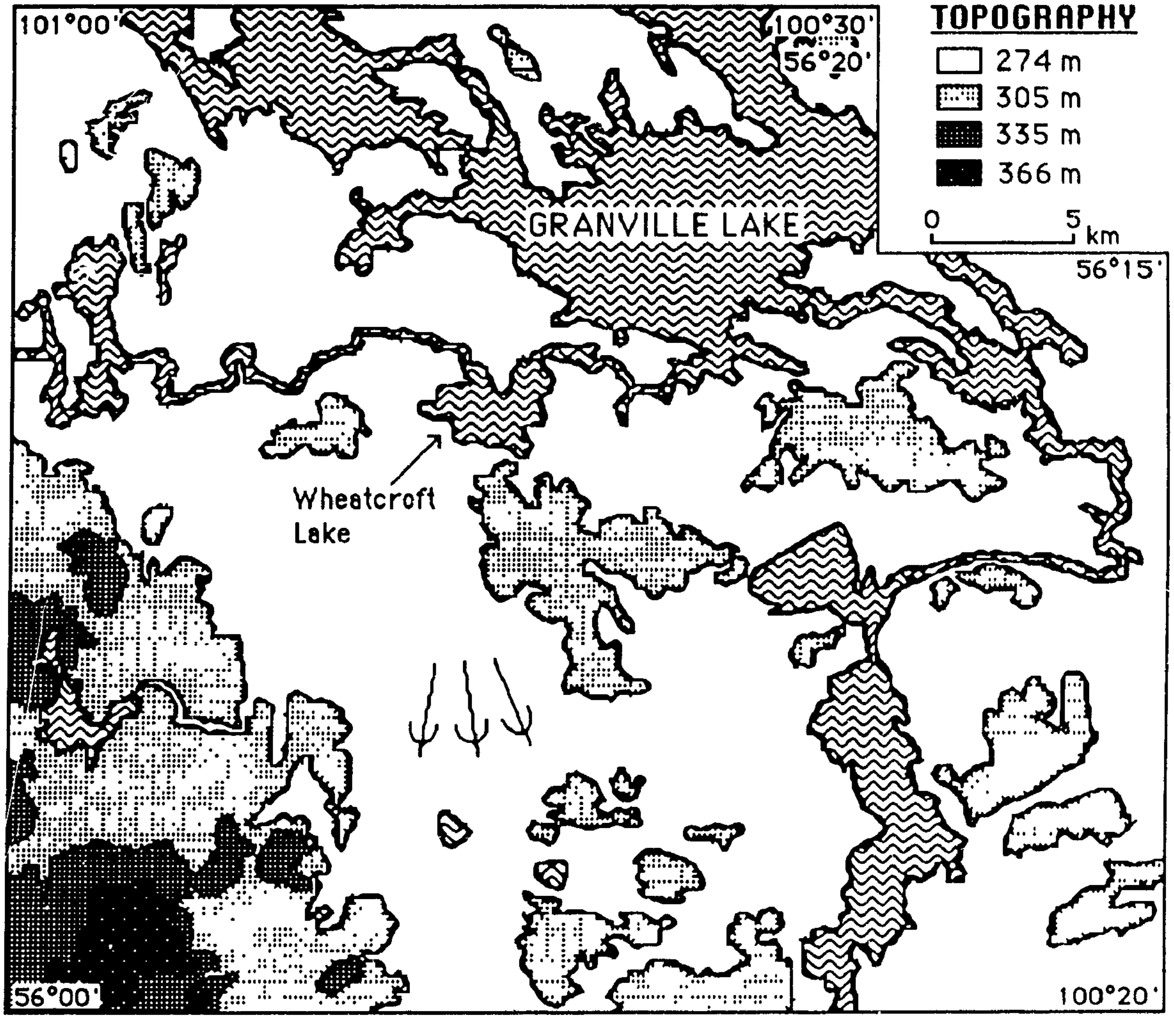


Figure 3. Topography (modified from Surveys and Mapping Branch, 1981). Prominent striation directions at 157°, 175°, and 192° also shown.

BEDROCK GEOLOGY

The rocks in the area around Wheatcroft Lake are part of the Kissinew Sedimentary Gneiss Belt (KSGB) of the Churchill Structural Province of the Canadian Shield (Gale et al., 1980, p. 5). The KSGB trends east-west and measures approximately 240 km x 140 km. It is bounded by the Lynn Lake greenstone belt in the north and the Flin Flon greenstone belt to the south. Wheatcroft Lake is situated near the northern flank of the KSGB. The rocks of this belt were regionally metamorphosed during the Hudsonian Orogeny (about 1700 m.y. B.P.) and are believed to be Aphebian in age (Baldwin, 1980, p. 1).

Most rocks of the KSBG have been metamorphosed to middle and upper amphibolite facies (Baldwin, 1980, p. 1; Richardson and Ostry, 1987, p. 72) with highest grades of metamorphism in the centre of the belt.

The area around Wheatcroft Lake is primarily made up of 5 rock subdivisions. From oldest to youngest they are: the Burntwood River Metamorphic Suite transition zone (BRMS) (formerly Wasekwan Series); pre-Sickle intrusions; the Sickle Series; derivatives of Wasekwan and Sickle rocks; and post-Sickle intrusions (Baldwin, 1980, p. 1; Barry, 1965; Pollack, 1966) (Fig. 2).

The Burntwood River Metamorphic Suite transition zone (BRMS) comprises metavolcanic and metasedimentary rocks. In the Wheatcroft Lake area, the metasediments of this series are grouped into 3 subunits. Two subunits of metavolcanics are recognized (Barry, 1965; Pollack, 1966).

The pre-Sickle intrusive group comprises hornblende gabbro, amphibolite and diorite. These rocks occur primarily as sills but some form dikes or small irregular bodies. These intrusions are probably related to Wasekwan volcanic action (Barry, 1965). On the southern flank of the KSGB, thin discontinuous layers and lenses of amphibolite occur within quartzo-feldspathic gneisses (Richardson and Ostry, 1987, p. 72).

Derivatives of Wasekwan and Sickle rocks comprise metamorphosed greywackes, psammites and mudstones that are interpreted to have been turbidites (Baldwin, 1980, p. 1). In the area around Wheatcroft Lake, these rocks result from high grade metamorphism of Wasekwan rocks (Barry, 1965), however, in other areas the main source of these rocks has been interpreted to have been rocks of the Sickle series (Davies et al., 1962).

Rocks of the Sickle series are made up of conglomerate and quartzo-feldspathic (greywacke and arkose) metasediments interbedded with metavolcanics (Barry and Gait, 1966; Godard, 1966).

Post-Sickle intrusive rocks, including gabbro, peridotite, granodiorite, granite, diorite, tonalite, aplite and pegmatite are youngest and cut all the other rocks of the region. Most intrusive rocks of the KSGB are considered to be anatectic (Richardson and Ostry, 1987, p. 71).

MINERALIZATION

The area under study is classified as having moderate potential for massive sulphide mineralization (Gale et al., 1980). BRMS transition zone metasediments and metavolcanics have gold and Cu-Zn mineralization at several locations (Gilbert et al., 1980). Copper and Ni are associated with gabbro intrusions in these metasediments and metavolcanics. Sulphide mineralization in the area usually occurs as thin stratiform deposits (Baldwin, 1980, p. 7).

Several occurrences of sulphides are located on the south shore of Laurie River, north of the amphibolitic schist (unit 3, Fig. 2). They include lenses of massive sphalerite, pyrite, chalcopyrite and galena (Barry, 1965). Disseminated pyrrhotite has also been found in the metavolcanics (unit 2b) of the BRMS transition zone (Barry, 1965; Pollack, 1966; Baldwin, 1980, p. 1). This mineralization is found in zones of gossan and rusty material, and Barry (1965) suggests that the mineralization occurs along the whole length of the unit.

In 1950, gold was discovered north of Wheatcroft Lake. Barry (1965) sampled a zone several feet wide which contained disseminated arsenopyrite and gold values of up to 0.15 oz/ton in a metasediment. On the north flank of the KSGB, Hunter (1953, *in* Richardson and Ostry, 1987, p. 74) found minor occurrences of gold in pyrite-quartz stringers associated with intrusive rocks, and Milligan (1960, *in* Richardson and Ostry, 1987, p. 74) reported a quartz vein containing a gold-copper showing within amphibolites near the Lynn Lake greenstone belt - KSGB boundary. At the McLellen deposit at Lynn Lake, gold is found in fine grained pyrite (DiLabio, 1985).

South of Wheatcroft Lake, the deposit at Puffy Lake went into production in 1987. The deposit zone at Puffy Lake is made up of gold-bearing arsenopyrite mineralization found in undeformed quartz veins that occur within biotite-rich pelitic gneiss (Richardson and Ostry, 1987, p. 75).

GEOMORPHOLOGY

The study area is within a physiographic zone known as the Kazan Upland (Klassen, 1986, p. 2) which is part of the Kazan Region which makes up the northwestern part of the Canadian Shield (Bostock, 1970). The terrane is "expressionless" and consists of a "wide expanse of rolling lake-spattered country" (Bostock, 1970, p. 13).

Alcock (1920, *in* Dredge et al., 1986, p. 3.) reported that the surface topography of this general area reflects the relief of the Precambrian bedrock surface. Alcock concluded that the Precambrian surface was not significantly altered by Pleistocene glaciation but rather is a pre-Paleozoic erosion surface that was buried by Paleozoic rocks which were later eroded away.

GLACIAL HISTORY

Glacial striations in this region trend from about 100° to 200°, with the most prominent directions being at around 175°, 157° and 192° (Fig. 2). The oldest ice-flow directions are toward the south-southwest at about 190°–210° (Kaszycki and DiLabio, 1986). There was, however a direction shift late in the history of ice flow in this region (Kaszycki and DiLabio, 1986) and this is reflected by younger striations trending southeast, with a prominent direction of about 165° (Fig. 2). In The Pas–Flin Flon region to the southwest, Groom and Nielsen (1987) report a dominant ice–flow direction of 210°.

During the last (Wisconsinan) glaciation, Manitoba was affected by two major ice domains (Fig. 4). One of these was centered in the district of Keewatin and flowed in a southerly direction over crystalline Precambrian bedrock, producing a sandy and bouldery till (Dredge et al., 1986, p. 23) (Fig. 5). The other ice mass originated in the south of Hudson Bay or in Nouveau Quebec and flowed in a southwesterly direction over Paleozoic carbonate terrain (Shilts, 1980; Dredge and Nixon, 1982; Klassen, 1986, p. 25) and Precambrian bedrock of the Churchill and Superior Provinces, producing a calcareous silty till (Dredge, 1983).

Kaszycki and DiLabio (1986) determined that a north-south trending ridge in the Leaf Rapids area, composed of ice-contact stratified drift, marks a zone of convergence between Keewatin Lobe ice and Hudson Lobe ice. This ridge, representing convergent ice flow has been named the Leaf Rapids interlobate moraine (Kaszycki and DiLabio, 1986).

Dredge et al. (1986, p. 23) suggest that the zone of convergence between the two ice lobes shifted across a 100 km wide zone. According to Shilts (1980) the northernmost contact between the two ice masses was along Seal River. Dredge (1988) also notes that the northern boundary of the Hudsonian Ice Lobe was Seal River.

Klassen (1986, p. 20) noted lithologic, geochemical and textural differences between the tills east and west of the margin between the two ice lobes. He noted a sharp drop in the carbonate content directly west of the boundary in northcentral Manitoba. The abrupt change led Klassen to conclude that the differences could not merely be the result of dilution caused by an increasing distance from the source of carbonate.

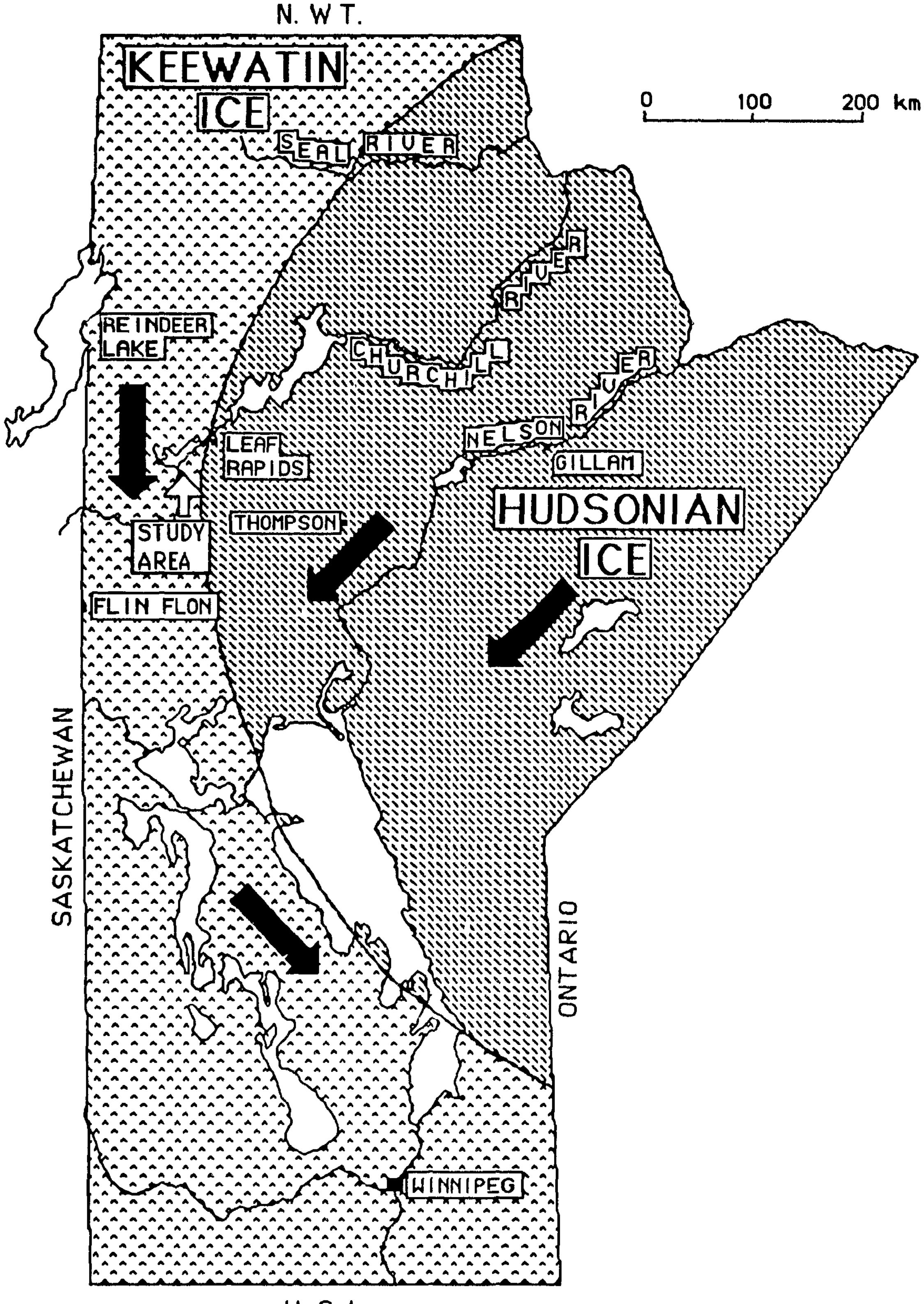


Figure 4. Laurentide ice masses in Manitoba (Modified from Klassen,1983) (arrows represent simplified ice-flow directions).

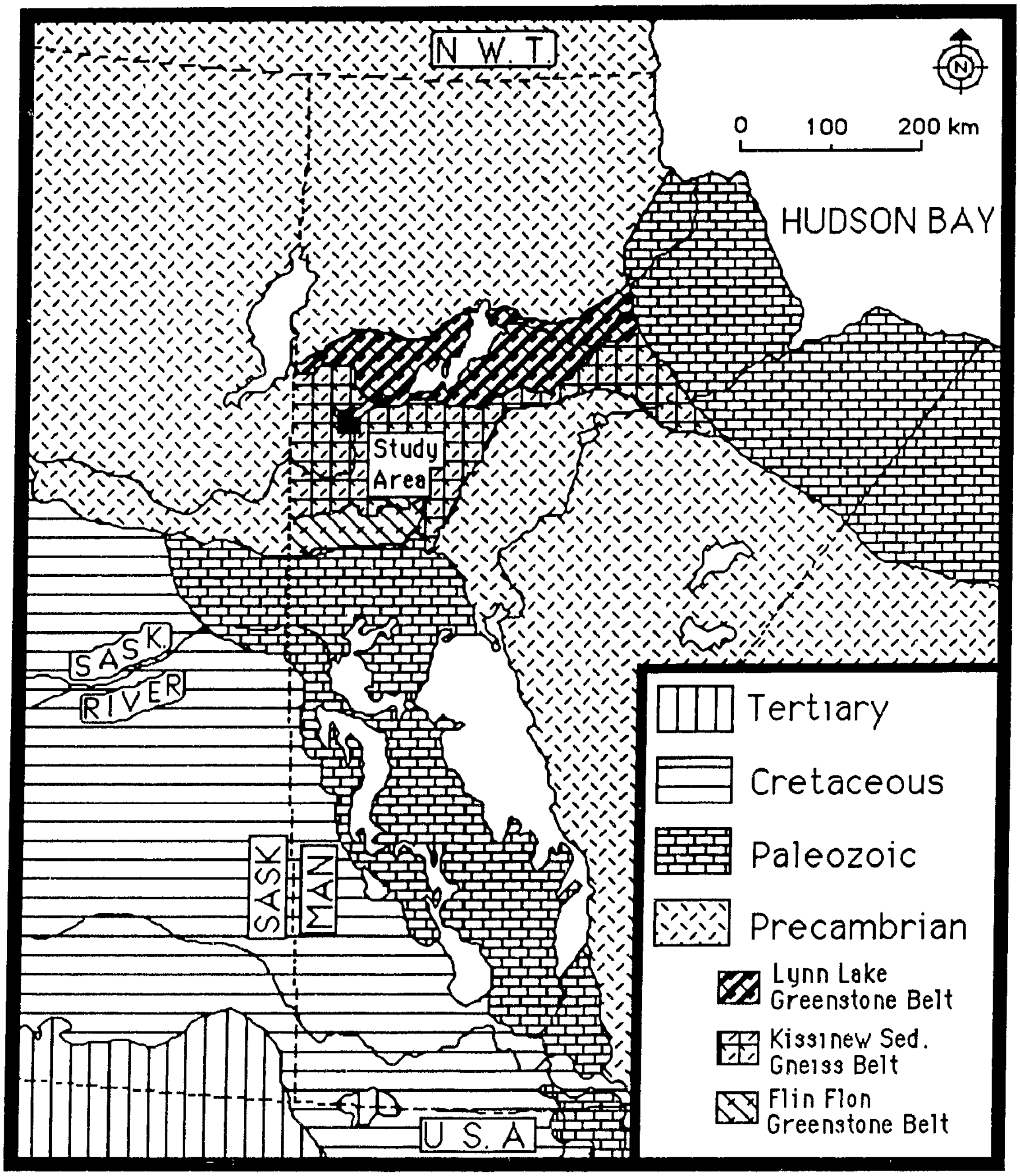


Figure 5. Bedrock sources of till and Lake Agassiz clay (Modified from Teller and Bluemle, 1983).

Dredge et al. (1986, p. 23) have suggested that in northwestern Manitoba, Keewatin Lobe ice extended only as far south as Churchill River, at which point it was overridden by Hudson Lobe ice. The area around Wheatcroft

Lake borders Churchill River and has predominantly south oriented striae, and a complete absence of carbonate pebbles in the till indicating that the area was not directly affected by Hudson Lobe ice. However, the southwest orientation of many striae does suggest that Keewatin Lobe ice was deflected toward the west by Hudson Lobe ice.

The youngest ice flow directions in the study area are toward south-southeast. This may indicate that Hudson Lobe ice retreated before Keewatin Lobe ice, releasing pressure from the Keewatin Lobe's eastern flank, allowing it to flow toward the southeast (Kaszycki, pers. comm.). Klassen (1986, p. 25) however states that at least in northcentral Manitoba, Hudson Lobe ice was the last to retreat.

Deglaciation of the region occurred between 9500 B.P. and 7500 B.P. (Klassen, 1986, p. 20). Lake Agassiz was formed as a result of the northward retreat of the late Wisconsinan Laurentide Ice Sheet (Fig. 6). As it continued to recede, sediment was deposited into Lake Agassiz via glacial runoff. Sediment also entered the lake at deltas along its western shore, primarily from Saskatchewan River (Teller et al., 1983).

Over its total life span, Lake Agassiz covered over 950,000 km^2, although its maximum size at any one time was 350,000 km^2 (Teller and Clayton, 1983). The Lake Agassiz drainage basin extended as far as the Rocky Mountains to the west, the Lake Superior basin to the east and stretched from South Dakota in the south to the edge of the Laurentide Ice Sheet in the north (Teller and Clayton, 1983).

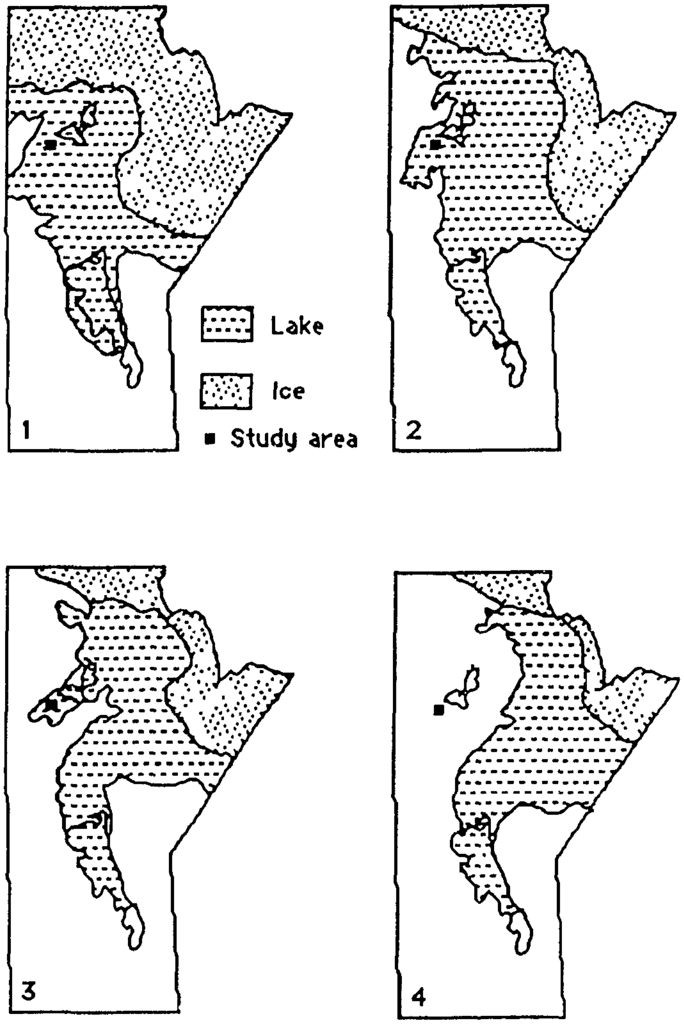


Figure 6. Late stages of Lake Agassiz and Laurentide Ice Sheet in Manitoba (Modified from Dredge, 1983). Approximate ages are Stage 1: 8800 BP; Stage 2: 8310 +/- 180 BP; Stages 3 and 4: <7750 BP.

SURFICIAL GEOLOGY

Although much the topography of the region was formed during pre-Paleozoic times, the finer details of the landscape are the product of Pleistocene glacial and glacio-lacustrine events.

The amount of bedrock exposed at the surface is shown in figure 7. Except for the southwest corner of the mapsheet, where the exposure is extensive, very little bedrock is found at the surface. This of course is the reason why the investigation of surficial geochemistry is a vital tool in mineral exploration in this area.

Till is rarely exposed at the surface and is usually under a cover of peat and mire (Fig. 8). At lower elevations the till is usually beneath Lake Agassiz clay.

Till cover in the study area is thin. At more than 25% of sample sites, bedrock was found at depths of less than 40 cm and in 30% of sample sites, at less than 50 cm. The mean thickness of till in the area is estimated to be 1.4 m. This figure was arrived at by assigning a depth of 2 m at all sample sites where bedrock was not struck at the bottom of sample holes. As this represents over 50% of sample sites, the average till thickness is probably underestimated.

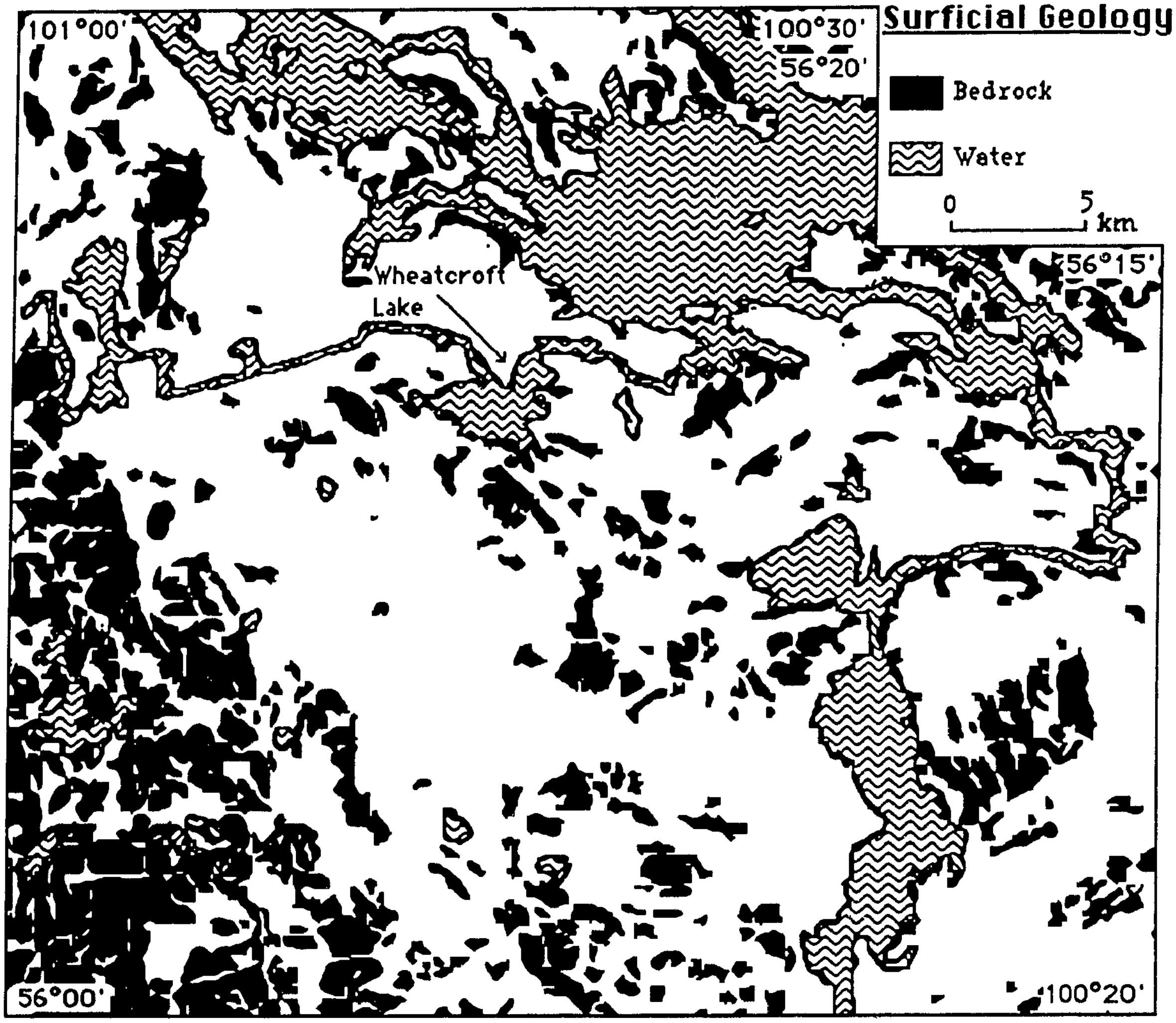


Figure 7. Surficial geology - bedrock exposure (modified from Kaszycki et al., 1986).

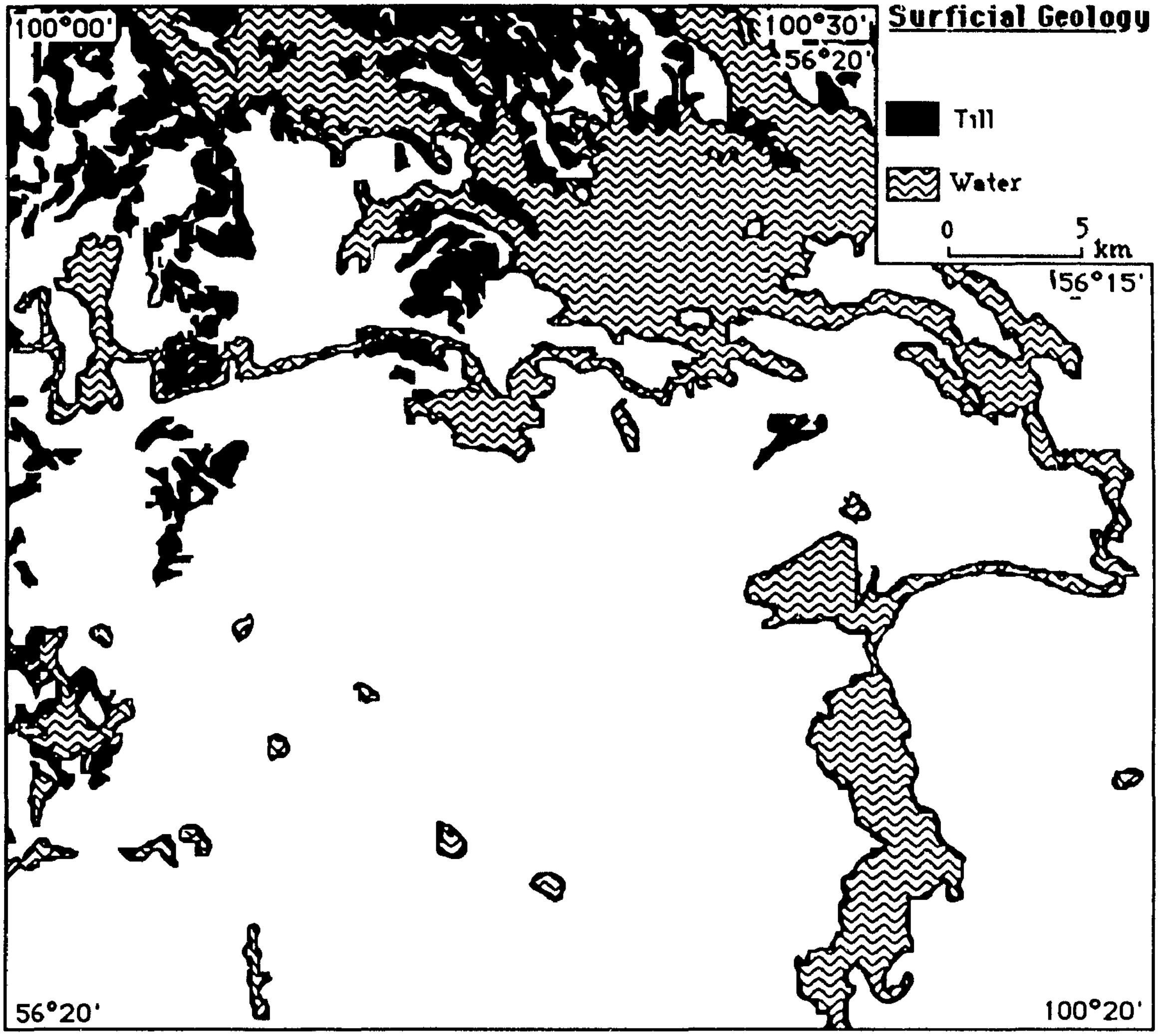


Figure 8. Surficial geology - till exposure (modified from Kaszycki et al., 1986).

If the average till thickness is in fact close to 1.4 m, then the volume of till over the entire study area can be approximated at 1.68 x 10^9 cubic metres.

Klassen (1986, p. 7) determined that in general the thickness of till in north–central Manitoba was less than 3 m, except in depressions oriented perpendicular to ice flow directions, where thicknesses ranged from 6 to over 15 m.

The composition of the till in the study area is significantly different from that of till found only a few kilometres to the east. Till to the east of the Leaf Rapids interlobate moraine has a silty matrix, was transported by Hudson Lobe ice, and contains erratics such as Paleozoic carbonates originating in the Hudson Bay basin, and greywackes of the Proterozoic Omarolluk Formation from the southeastern shores of Hudson Bay (Dredge, 1988).

West of the moraine, such as in the Wheatcroft Lake area, the till has a sandy matrix as a result of transportation over shield terrane by southward-flowing Keewatin ice. The shield terrane in this region comprises predominantly medium grained granitic and metasedimentary rocks that comminute to sand-sized till by breaking up along grain boundaries. Finer fractions of the till are formed by glacial abrasion of pelitic schists, gneisses and mineral grains (Dredge et. al., 1986, p. 8).

The <2 μm fraction of the Hudson Lobe till, east of the Leaf Rapids Interlobate moraine, is distinguished by expandable <14 Å clays, interpreted by Kaszycki and DiLabio (1986) as vermiculite, illite, minor chlorite and/or kaolinite, as well as dolomite and calcite. This differs from the clay mineralogy of tills from west of the moraine which is predominantly illite/muscovite and chlorite and/or kaolinite.

The area under study was completely submerged by glacial Lake Agassiz and much of the surface is covered by Lake Agassiz clay (Fig. 9), which ranges in thickness from nil to several metres.

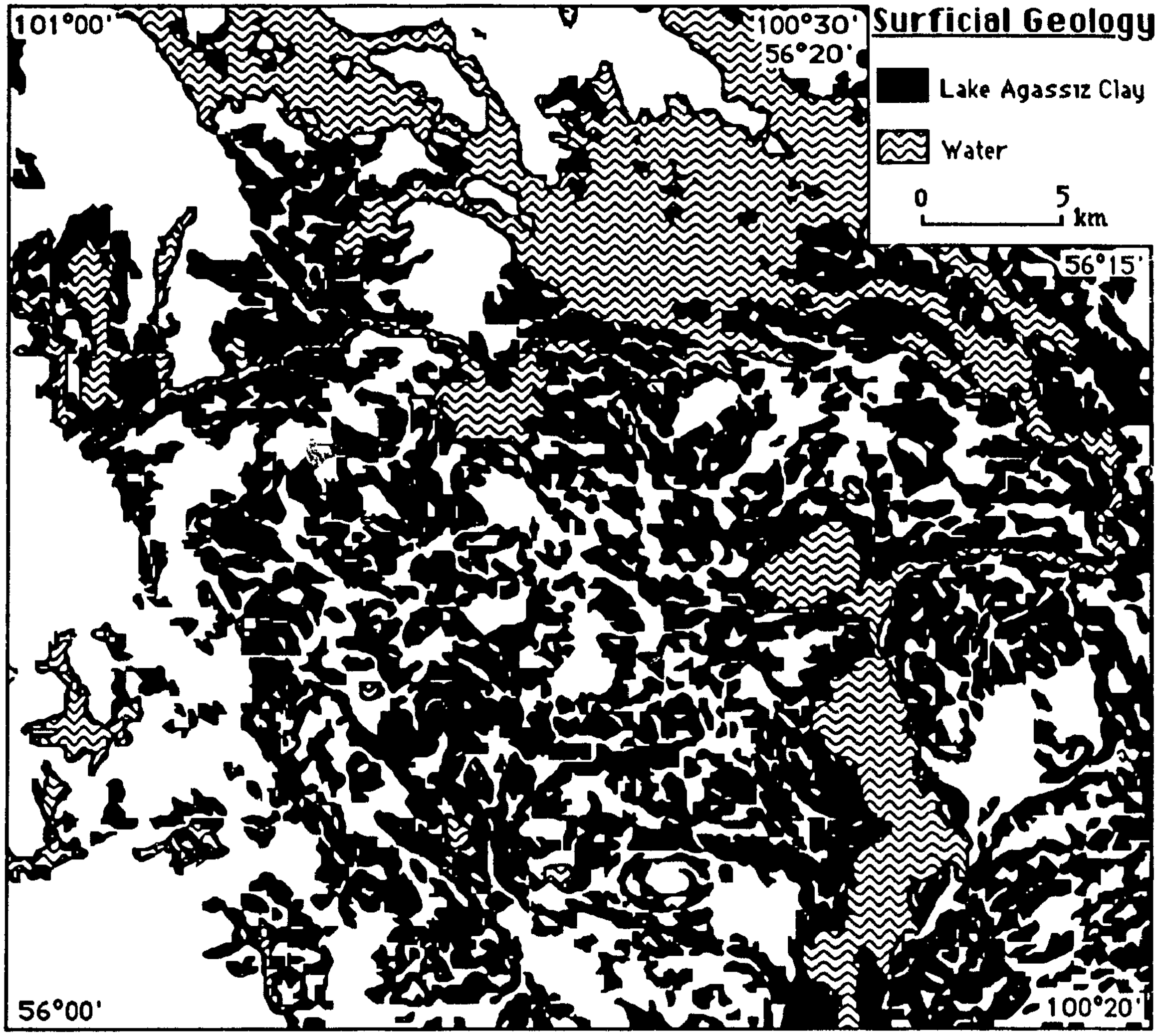


Figure 9. Surficial geology - Lake Agassiz clay (modified from Kaszycki et al., 1986).

The composition of Lake Agassiz clay differs significantly from the clay fraction of till in the area, due to the distance and variety of its source areas (Kaszycki and DiLabio, 1986; Suttner, 1986). The clay mineralogy of Lake Agassiz clay is dominated by smectite/illite, chlorite and/or kaolinite, with minor amounts of carbonate and quartz (Kaszycki and DiLabio, 1986; Suttner, 1986). The clay mineralogy of the till reflects primarily a local source and is predominantly illite/muscovite and chlorite and/or kaolinite, a mineralogy which indicates a source in Precambrian crystalline rocks (Kaszycki and DiLabio, 1986).

The source of the smectite in Lake Agassiz clay is shales of the Cretaceous Basin of Alberta and Saskatchewan (Langford, 1977) (Fig. 5). Smectite was brought into the Lake Agassiz Basin primarily by North Saskatchewan River (Teller, 1976). Due to the distal source areas of much of the Lake Agassiz clays, these clays would not be expected to reflect local bedrock geochemistry.

CHAPTER 2 - PREVIOUS WORK

Drift prospecting in northern Manitoba began in the early 1980's, however there is at least one report on the geochemistry of tills in the region from the 1970's (O'Donnell, 1976, *in* Nielsen and Graham, 1985).

Shilts (1980) reported on the geochemistry of a small number of till samples taken near Hudson Bay. These samples were collected as part of a larger project investigating till geochemistry from Longlac, Ontario to Somerset Island, N.W.T.

Dredge (1981) reported on the geochemistry and dispersal patterns of till from the Jackfish Lake area. She determined that the sand-sized fraction of tills in that area was transported in the direction of glacial movement for normally no more than several hundred metres, and concluded that trace elements in the clay-sized fraction would have a higher concentration than the coarser sand-sized fraction.

Dredge (1982) released data collected in the Caribou River area in 1977. Forty-three samples were taken in an area of 8,200 km^2. Aside from a few anomalous samples, most till geochemistry values were considered background values.

Nielsen (1982, 1983) reported on detailed till sampling carried out in the area around the McLellen Mine near Lynn Lake. The purpose of the project was to ascertain the feasibility of using till for inexpensive geochemical prospecting. Sixty-five samples were collected at thirty-eight sites in an area measuring approximately 28,000 m^2, directly down ice from the ore zone. Geochemical results were not published in this report.

Dredge (1983) reported on the collection and analysis of 400 samples of till taken in an area of 125,000 km^2 in northern Manitoba. This study reported on the geochemical differences and similarities between Hudson Lobe till and Keewatin Lobe till. Multiple-element anomaly areas were found near Hudson Bay, north of Caribou River. Arsenic anomalies were found close to the Great Island group of volcanics.

Nielsen and Graham (1984) reported on till sampling around known sources of mineralization at Dot Lake, Farley Lake, and Laurie Lake. Dot Lake is situated directly west of the McLellen gold-silver deposit, and Farley Lake is to the east, on the Agassiz Metallotect. The Agassiz Metallotect is a series of rock units which host the McLellan mineralization (Nielsen, 1985) and is characterized by a near linear zone of coincident magnetic and electromagnetic anomalies (Fedikow, 1984, *in* Nielsen, 1985). Sampling was undertaken around Laurie Lake to investigate dispersal from the Lar copper-zinc deposit located north of the Lake. Geochemical results were not published.

Nielsen et al. (1985) reported on field work at Nickel Lake, and between Minton and Farley Lakes, in a further effort to trace zones of mineralization along the Agassiz Metallotect. Nielsen (1985) reported further on till sampling in the area around Dot Lake, in addition to discussing till sampling around Gold Lake, Leclair Lake, and the Ruttan Mine. In the Dot Lake area, Nielsen identified a dispersal fan of anomalously high concentrations of arsenic in the <2 µm fraction and gold in the heavy mineral fraction (63 µm-2 mm). Gold values in the heavy mineral fraction from samples collected approximately 1.5 km south of the Dot Lake mineralization included concentrations of 8340, 50, and 180 ppb.

Nielsen and Graham (1985) released data primarily concerned with the petrology of pebbles from till sampled at Farley Lake, including petrographical analyses of heavy minerals.

Nielsen and Fedikow (1986) published geochemical data from till samples taken in the area of the Agassiz Metallotect, around Minton and Nickel lakes. Their interpretations were kept to a minimum because there was much laboratory work still to be completed at the time of printing, however one of their conclusions was that topography in this area plays a large role in determining the extent of glacial dispersal. They found that mineralization near the crest of a hill is dispersed in the direction of glacial flow much further than mineralization which is protected from the ice in the lee side of a hill. Arsenic values in the <2 μm fraction of these samples ranged from 2-98 ppm with a mean of 4.9 ppm, and gold values from the heavy mineral fraction ranged from 1-1220 ppb with a mean value of 20.6 ppm.

Dredge and Nielsen (1986) reported on the results of till sampling carried out by Dredge in the Great Island area. An anomalous zone was defined which included a sample with an arsenic concentration of 252 ppm in the <2 μm fraction, and a gold value of 87 ppb in the <63 μm fraction. Nielsen (1987) did additional sampling and was able to define well developed glacial dispersal fans for both arsenic and gold. These fans are approximately 1.3 km long and 0.5 km wide and were defined by determining trace element concentrations in the <2 μm, <63 μm, and heavy mineral fraction. Values as high as >2000 ppm arsenic were found in both the clay and heavy mineral fraction. Gold concentrations in the heavy mineral fraction peaked at 16380 ppb.

Kaszycki and DiLabio (1986) published a report on which the present study is based. Several multiple and single element anomalies are described in this report, based on the geochemistry of the <2 μm fraction of till samples. These anomalies are represented by samples with trace element concentrations higher than the 90th percentile values. The anomalies include: an arsenic anomaly (>11 ppm) along the greenstone belt west of Lynn Lake, with some sites also showing high Ni, Zn and/or Cr values; Cr anomalies located west and southwest of Granville Lake, on the western edge of map NTS 64 C and a Zn anomaly located to the east of Lynn Lake. In general, these areas of anomalously high trace element values in the till reflect known sites of mineralization and the Lynn Lake metavolcanic belt.

The arsenic anomaly southwest of Wheatcroft Lake is also outlined in this study (Kaszycki and DiLabio, 1986) (Fig. 1). This anomaly was first delineated as having arsenic concentrations over 20 ppm, over an area of about 200 km^2. At several of these sample sites there were also relatively high values of Cr, Ni and Zn which appeared to coincide with sulphide mineralization in the upper amphibolitic schist of the Burntwood River Metamorphic Suite transition zone.

Kaszycki and DiLabio (1986) suggested that this arsenic anomaly may have resulted from glacial dispersal from zones of sulphide mineralization located on the south shore of Granville Lake. The plan of this anomaly also appeared to reflect both the oldest (190°) and the youngest (165°) directions of ice flow. If this pattern represented a single source, then the distance of dispersal to the south west would be 25 km, at which point arsenic values still exceed 40 ppm. Dispersal to the southeast would be 20 km, where arsenic values return to background levels of 11 ppm.

The sampling density used by Kaszycki and DiLabio (1986) was approximately one sample per 30-50 km^2. According to Nielsen (pers. comm. *in* Kaszycki and DiLabio, 1986), the maximum distance that material from areas of known mineralization can be traced down-ice in the Lynn Lake area is 1-2 km. The sampling density used by Kaszycki and DiLabio was much too low to ascertain the short distance dispersal of sulphide material. It thus became apparent that further work was necessary to determine whether the extent of this anomaly is due to one large single source, several small sources, or to generally high level background values throughout the area.

CHAPTER 3 - METHODS

SAMPLING

A total of 128 till samples and 21 Lake Agassiz clay samples were taken at 120 sites in an area of approximately 1200 km^2. Almost without exception, samples were collected from local high altitude ground (Fig. 3). This was necessary because of the vast amount of swamp cover in the area that occupies lower ground.

Sampling was difficult below 305 m altitude. Glacial Lake Agassiz clay cover was thickest below this level. Sopuck et al. (1986) noted that in the southeastern Shield of Saskatchewan, extensive Lake Agassiz clay cover has led to a minimum elevation of 425 m for discovered gold prospects.

Sample holes were hand dug to a depth between 15 and 120 cm, with an average depth of about 40-50 cm. As much as was possible, samples were taken below the depth of leaching in order to maintain a consistency in the sampled material. Shilts (1984) and others have clearly demonstrated the effects of post depositional weathering on the geochemistry of tills (Rencz and Shilts, 1980; Nikkarinen, et al., 1984).

Although the majority of samples showed little or no physical evidence of weathering, the relatively shallow sample depths (Shilts, 1975, 1976; Dredge, 1988) indicate that most must be considered to be B horizon samples rather than true C horizon material. The exception to this rule would be samples taken below Lake Agassiz clay.

Sampling density was approximately 1 sample per 9 km^2. DiLabio and Coker (1987) have defined "local" scale sampling to be of a density of one sample per square km and "reconnaissance" scale sampling to represent one sample per 100 km^2.

At 6 sites, samples were taken in vertical sections, including both till and overlying Lake Agassiz clay. Samples were placed in numbered 2 litre bags. Most samples were taken by moving from site to site by helicopter, however a powerline crossing the map area from east to west from the Churchill River to the south end of Trophy Lake, at about Lat. 56° 10' N, was used to collect samples on several traverses.

ANALYSES

Three size fractions of the samples were analysed for their trace element geochemistry. In the clay-sized fraction, analyses for Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, Ag, Cd and Pb were by atomic absorption spectroscopy after a hot HCl-HNO_3 (1:3) leach. Arsenic analysis in this fraction was by colourimetry after a HNO_3-$HClO_4$ leach. The clay-sized (<2 μm) fraction was analysed because it normally contains the highest concentration of metals. The metallic ions are held within the structure of phyllosilicates or scavenged by secondary oxides and phyllosilicates (Shilts, 1984).

In the silt-sized (<63 μm) fraction arsenic and gold were analyzed by neutron activation. Gold values were not determined in the clay fraction. DiLabio (1985) has shown that gold is preferentially enriched in the fine fractions of oxidized till and the <63 μm fraction permits recovery of a sample that is large enough (>10g) for a reproducible analysis.

Gold values were also determined by atomic absorption in the heavy mineral concentrate (s.g. = 3.3) of the 0.063-0.25 mm fraction. Analysis of the heavy mineral concentrate was performed by Chemex Labs Ltd. Gold grain counts were done by Overburden Drilling Management Ltd.

"Pebble" counts were done by binocular microscope with representative samples from the 2.0–5.6 mm fraction. This fraction was chosen for consistency as all samples contained a large number of grains of this size.

In addition to till and Lake Agassiz clay, 43 rock samples were collected, crushed and analyzed by neutron activation. The rock types sampled were metavolcanics, amphibolites, metasediments, granites, paragneisses, granulites and gneisses. Some samples were collected from areas of, or close to, known mineralization while others were collected from bedrock at random locations.

All geochemical analyses, except those of the heavy mineral concentrate were done by Bondar-Clegg and Co. Ltd., Ottawa.

CHAPTER 4 - RESULTS AND DISCUSSION

CHAPTER 4A - BEDROCK GEOCHEMISTRY

The geochemical analyses of all 43 bedrock samples are shown in appendix 1, and sample locations are shown on figure 2. Geochemical mean values for the most common bedrock unit samples are shown in table 1. Most of the samples are from south of Granville Lake. The samples represent 9 lithological units. The following short summary deals with five rock samples which have anomalous trace element values.

Table 1. Geometric mean values of main bedrock units.

	Unit 1 Metasediment		Unit 2 Metavolcanic		Unit 7 Granulite Schist		Unit 14a Migmatite	
	Mean	std dev	Mean	std dev	Mean	std dev	Mean	std dev
Cr ppm	36	3.4	9	3.9	37	3.8	19	6.3
Mn ppm	234	1.6	214	2.3	193	1.7	165	2.7
Fe %	3.1	1.7	3.5	1.7	2.0	1.6	1.7	2.4
Co ppm	8	2.8	12	4.3	2.8	2.8	3.4	3.5
Ni ppm	22	3.1	10	9.8	9	4.0	7	5.4
Cu ppm	22	3.7	33	3.4	10	2.5	8	1.7
Zn ppm	106	1.7	62	1.5	80	1.4	67	2.2
Mo ppm	1.4	2.3	1.9	2.9	1	0	1	0
Ag ppm	0.2	2.6	0.2	3.3	0.1	1.3	0.2	2.2
Cd ppm	0.13	2.3	0.1	0	0.1	0	0.1	0
Pb ppm	10	2.5	6.4	1.4	6	1.3	7.4	1.5
As ppm	11	3.2	14	3.6	1.8	2.2	4.7	4.2
Au ppb	8	3.2	7.3	2.1	5.3	1.5	8	2.8
samples	12		10		7		5	

Rock sample #1 is a BRMS transition zone metasediment belonging to unit 1b, and has a gold concentration of 150 ppb. This sample is from just north of the Laurie River, approximately 4.5 km east of Wheatcroft Lake. This rock exhibited no mineralization.

Rock sample #8 is very rusty and has an iron concentration of 10%, a Co value of 67 ppm and a Ni concentration of 259 ppm. It is a BRMS transition zone metavolcanic of unit 2b. The sample was taken about 3.5 km north of the mouth of Laurie River, about 250 m northeast of the Wheatcroft Lake gold showing.

Sample #11 has the highest trace element concentrations and the greatest number of anomalous values. These include Cu 11600 ppm, Zn >20000 ppm, Ag >100 ppm, Cd 399 ppm, Pb 18100 ppm, As 8760 ppm, Fe 9.3% and gold 1860 ppb. Barry (1965) recorded sphalerite and chalcopyrite mineralization at this site and also presented a geochemical analysis of a sample taken here. He reported only trace amounts of gold (0.0302 oz/ton) whereas the gold value of sample #11 is almost 0.0602 oz/ton. Sample #11 is an amphibolite of unit 3 and contains sphalerite, galena and colliform pyrite.

Sample #12 was taken within a few metres of sample #11. It is the same rock type as sample #11 but was not rusty and showed no mineralization. It was collected in order to determine background values for the amphibolite of unit 3 in this area. Some of its trace element values are still relatively high while others represent much lower concentrations. Copper is 60 ppm, Zn 810 ppm, Ag 2.3 ppm, Cd 1.8 ppm, Pb 176 ppm, As 396 ppm, and gold 8 ppb.

Rock sample #13 is a BRMS transition zone metasediment showing pyrite mineralization. It was collected from the north shore of Wheatcroft Lake. The anomalous values for this sample are 10% Fe, 55 ppm Co and 208 ppm Ni.

CHAPTER 4B - TILL GEOCHEMISTRY

The geochemical analyses of all till samples are listed in appendices 2, 3, and 4. Appendix 2 presents the geochemical data from the <2 μm fraction of the tills, except for gold which is listed for the <63 μm fraction and the heavy mineral fraction.

Arsenic Analysis

Clay fraction

As shown in figure 10 and table 2 , the modal value of arsenic in the <2 μm fraction is 6 ppm, with a mean value of 47 ppm. Dredge et al. (1986, p.36) determined the mean arsenic level in northwestern Manitoba to be 8 ppm.

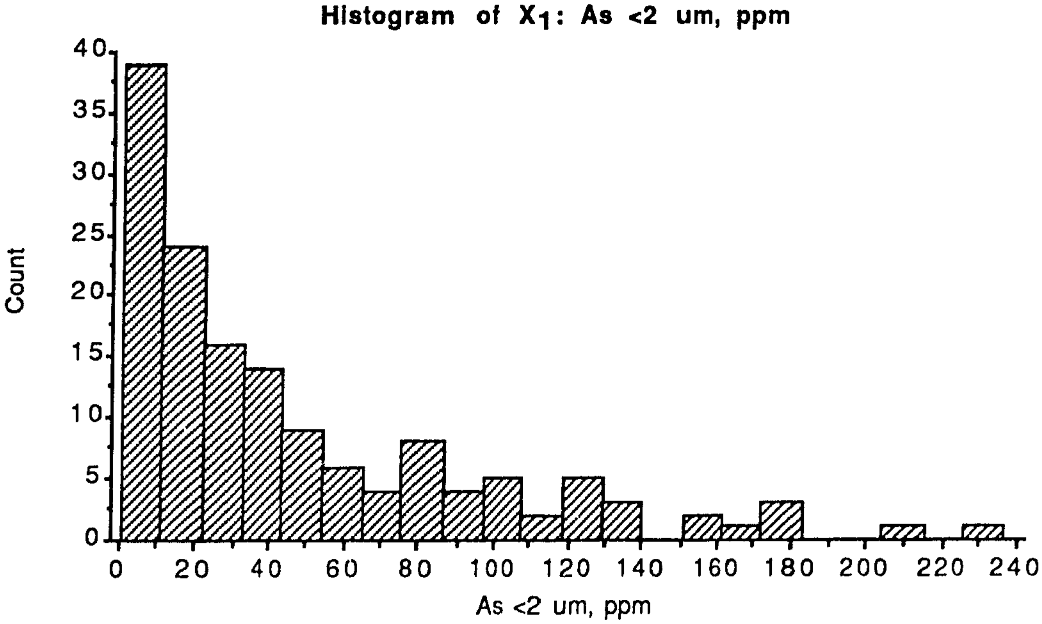


Figure 10. Frequency distribution of As <2 μm

Table 2. Arsenic <2 µm Statistics

X_1: As <2 um, ppm

Mean.	Std Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
47 333	48.321	3 985	2334.895	102.086	147
Minimum	Maximum:	Range:	Sum:	Sum Squared:	# Missing:
1	236	235	6958	670240	4
# < 10th %:	10th %	25th %:	50th %:	75th %.	90th %:
8	5	11	29	72	119 8
# > 90th %.	Mode:	Geo. Mean:	Har Mean:	Kurtosis:	Skewness:
15	6	26.707	13.486	1.818	1.476

Threshold values

There are several methods by which a background threshold value could have been chosen (Sinclair, 1976). In this study, the 75th percentile value was chosen as the lowest contour value. This was done in order to delineate anomalous zones as much as possible, in a relatively large area, with a relatively small sampling density. Dredge et al (1986, p. 36) used a 95th percentile value of 16 ppm as background.

The pattern of arsenic distribution in the <2 µm fraction in the map area is shown in figures 11 and 12, superimposed on bedrock maps outlining the Burntwood River Metamorphic Suite transition zone; and unit 2 and other metavolcanic units.

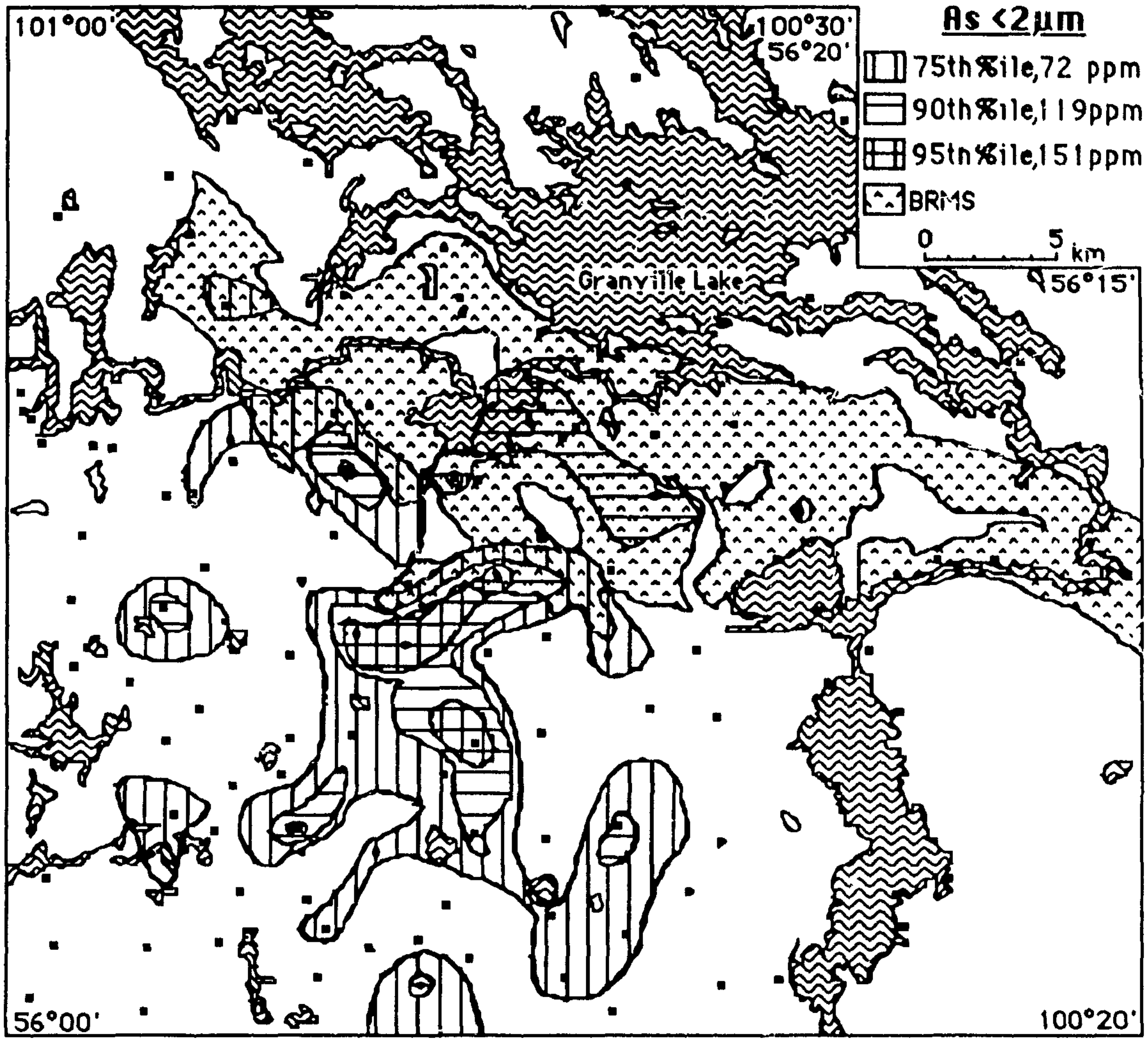


Figure 11. Dispersal pattern of As <2 µm fraction in relation to BRMS transition zone rock.

In general, the main area of high arsenic concentration is in the central part of the map sheet, south and southwest of Granville Lake. Although it would have been convenient to combine the main anomalous region with the smaller anomalous zone to the northwest, this would not have been justified because the two are separated by samples of relatively low arsenic concentration.

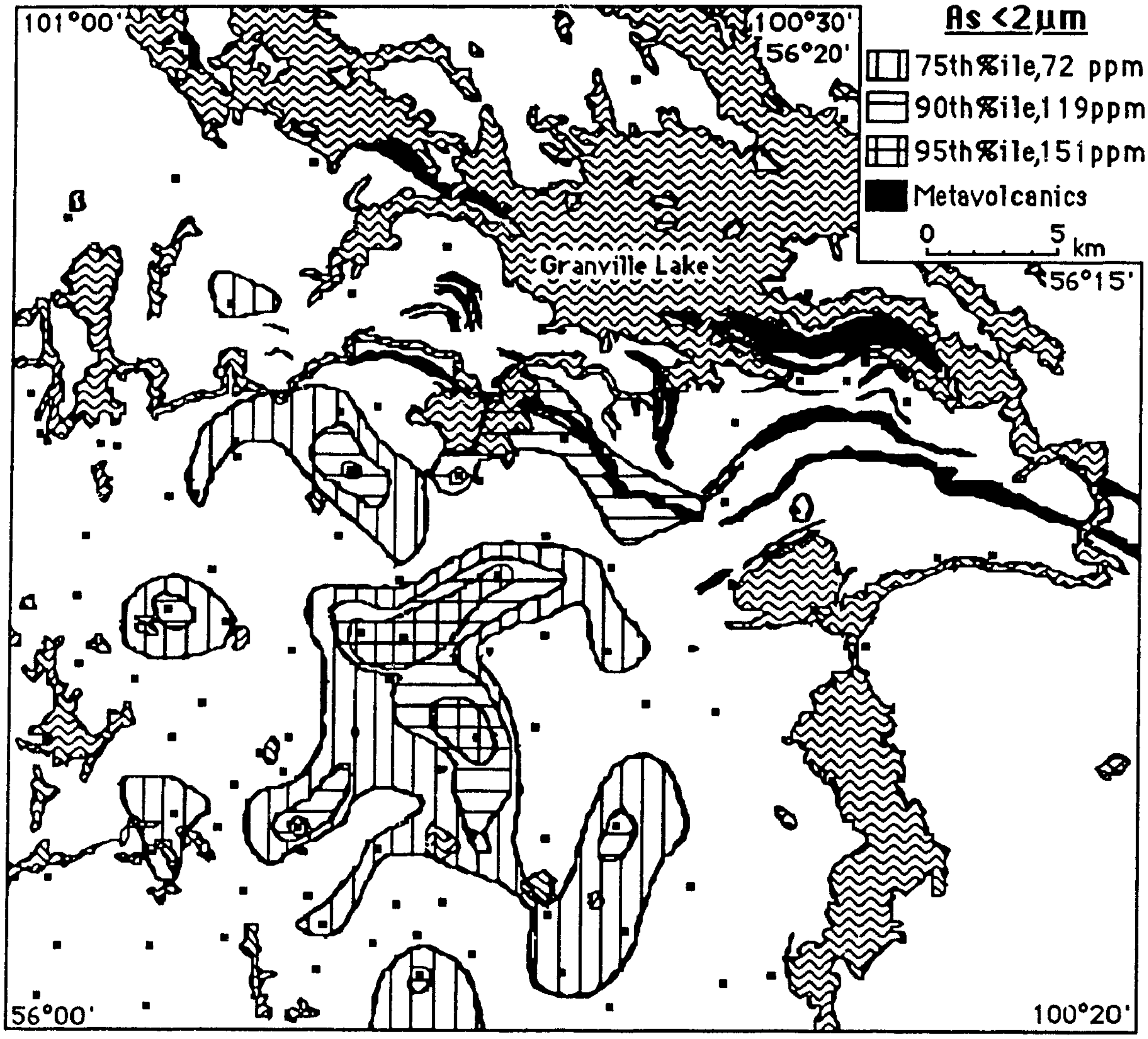


Figure 12. Dispersal pattern of As <2 µm fraction in relation to metavolcanic rock.

Within the main, central body of anomalous values (>72 ppm), an area of approximately 34 km^2 is outlined by values above the 90th percentile value

(<120 ppm). According to Shilts' classification scheme this zone represents a 2b type anomaly. Shilts (1976) assigned a relatively high follow-up priority to this type of anomaly.

Within this zone are four relatively close samples with values above the 95th percentile value (<151 ppm). The three northern sample sites above this level trend sub-parallel to the strike of bedrock in the region, making this a 2c type anomaly, which Shilts assigned only a moderate follow up priority.

If the WSW-ENE trending zone of 95th percentile values was considered to be the "head" of the 90th percentile dispersal pattern, then the transport distance to the "tail" would be some 8 kms. This is a considerably greater distance than has been previously determined in this part of Manitoba (Dredge, 1981; Dredge and Nielsen, 1986). However, Kaszycki et al. (1988) demonstrated that arsenic dispersal in this region may extend for >60 km.

Although the main central zone of 90th percentile values does trend northwest-southeast, corresponding to a later direction of glacial flow in the area, it is difficult to make a case for a definitive dispersal direction. This main body of 90th percentile values could have been contoured to include the smaller 90th percentile zone just to the southwest of it, within the central anomaly. If this were the case, the dispersal direction could also be northeast-southwest. However, neither pattern represents a classic dispersal train (Nichol and Bjorklund,1973; Shilts,1976; Klassen and Shilts, 1977; DiLabio, 1979; DiLabio and Coker, 1987) as values do not simply decrease exponentially and locally increase in a down ice direction.

There does not appear to be any direct relationship between arsenic concentrations in the <2 µm fraction and any one particular bedrock lithology at the density of sampling (1 per 9 km^2). Figure 11 shows that all anomalous zones are either within or down-ice from unit 1 of the BRMS transition zone. The rocks of this zone did not exhibit high arsenic values however, the average being 19 ppm, even lower than the average for till. However, individual samples of this unit did exhibit As values as high as 72 ppm (appendix 1).

Figure 12 also shows the bulk of the anomalous areas as being within or down-ice of the metavolcanic units (Units 2a, 2b and 6). The anomalous zone furthest to the northeast outlines a segment of unit 2. The anomalies may be related to this rock unit, however several low concentration samples exist in a down-ice direction. The average arsenic concentration for unit 2 rocks was found to be only 24 ppm, still well below the average for till.

Figure 3 coarsely illustrates the topography of the study area. A comparison between this diagram and that of dispersal of arsenic in the <2 μm fraction illustrates that topography has played a role, if not a major role in glacial dispersal in the region. The main central anomaly (75th percentile) is predominantly below the 305 m level, and the central 90th percentile contour, except for one site, is entirely below this altitude. This indicates that the transport of arsenic-rich till from source to deposition area was basal in nature. Debris that is carried at the base of a glacier can be blocked or diverted by hills and ridges in the area of dispersal (Shilts, 1975). In this nunatak-free area (Fig. 3), topography would have had little or no effect on the deposition of material that was transported englacially.

It must be pointed out that an anomaly in low ground indicates that the anomaly may be hydromorphic in nature. The distribution of trace elements within till can result from the movement of cations in ground water whose flow is regulated by topography (Wennervirta, 1968, p. 13). Three factors however, lend no support to this being the case in this area: 1) the dispersal pattern is for the most part at least sub–parallel to the direction of ice–flow; 2) the extent of Lake Agassiz clay would effectively retard or block the penetration of meteoric water into underlying ground moraine; and 3) slower chemical migration would result from the ground being frozen for much of the year (Bradshaw et al., 1971). Lee (1971, p. 35) pointed out that "in sealed environments, usually under clay, the diagnostic indicators remain today in the Shield with only moderate alteration."

Silt fraction

In the <63 µm fraction of the analysed till samples the mean arsenic value is 10.6 ppm. This is considerably smaller than in the <2 µm fraction. This reflects the dilution of trace metals by inert minerals (primarily quartz and feldspar) in the coarser <63 µm, and the abundance of trace metal scavengers in the <2 µm fraction (Shilts, 1975).

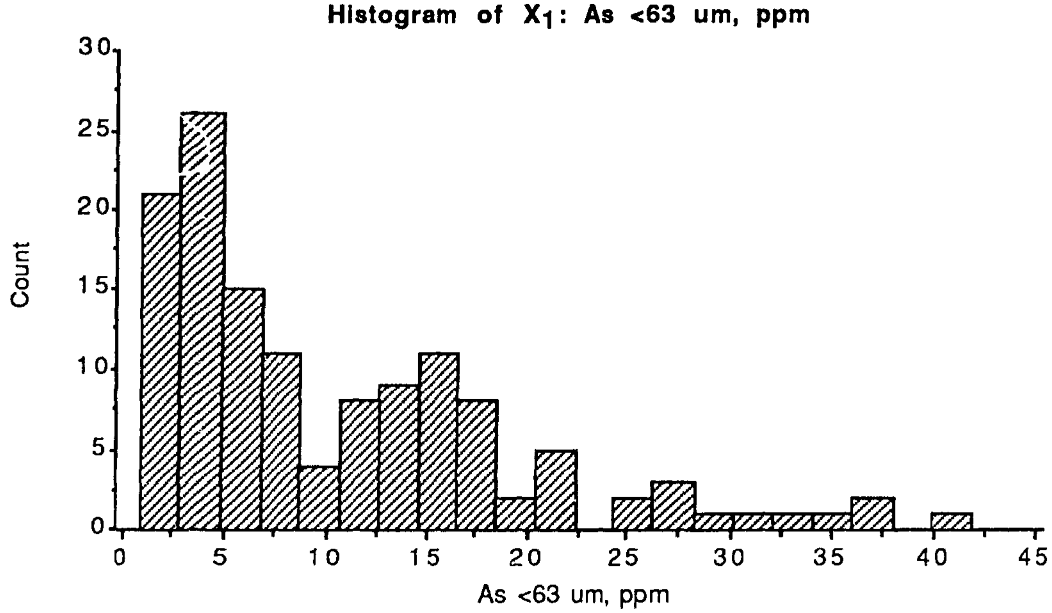


Figure 13. Frequency distribution of As <63 µm

Table 3. Arsenic <63 µm Statistics

X_1: As <63 um ppm

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
10.609	8.776	.764	77.01	82.717	132
Minimum:	Maximum:	Range	Sum	Sum Squared:	# Missing
.9	41	40 1	1400 4	24945.3	19
# < 10th %	10th %:	25th %:	50th %	75th %	90th %
12	2.2	3 6	7 75	15	22
# > 90th %:	Mode	Geo. Mean	Har Mean:	Kurtosis	Skewness
12	•	7.438	5 027	1 289	1 283

Once again using the 75th percentile value (15 ppm) as a contour threshold, an area of anomalous values is found in the south central part of the map sheet (figures 14 and 15). This contoured area is type a 2b anomaly, with high follow up priority (Shilts, 1976). As with the <2 µm fraction, some of the highest values occur from samples located south of Wheatcroft Lake, forming a pattern with a southwest trend, corresponding to an early ice-flow direction, as opposed to the <2 µm fraction, which displayed a northwest-southeast trend in this area. Neither pattern displays a definitive dispersal direction. The area of values within the main 90th percentile contour is approximately 50 km^2 and is a type 2b anomaly. The distance from the "head" of this anomaly to the "tail" is more than 10 kms. As with arsenic in the clay fraction, a "classic" dispersal train has not been demonstrated here.

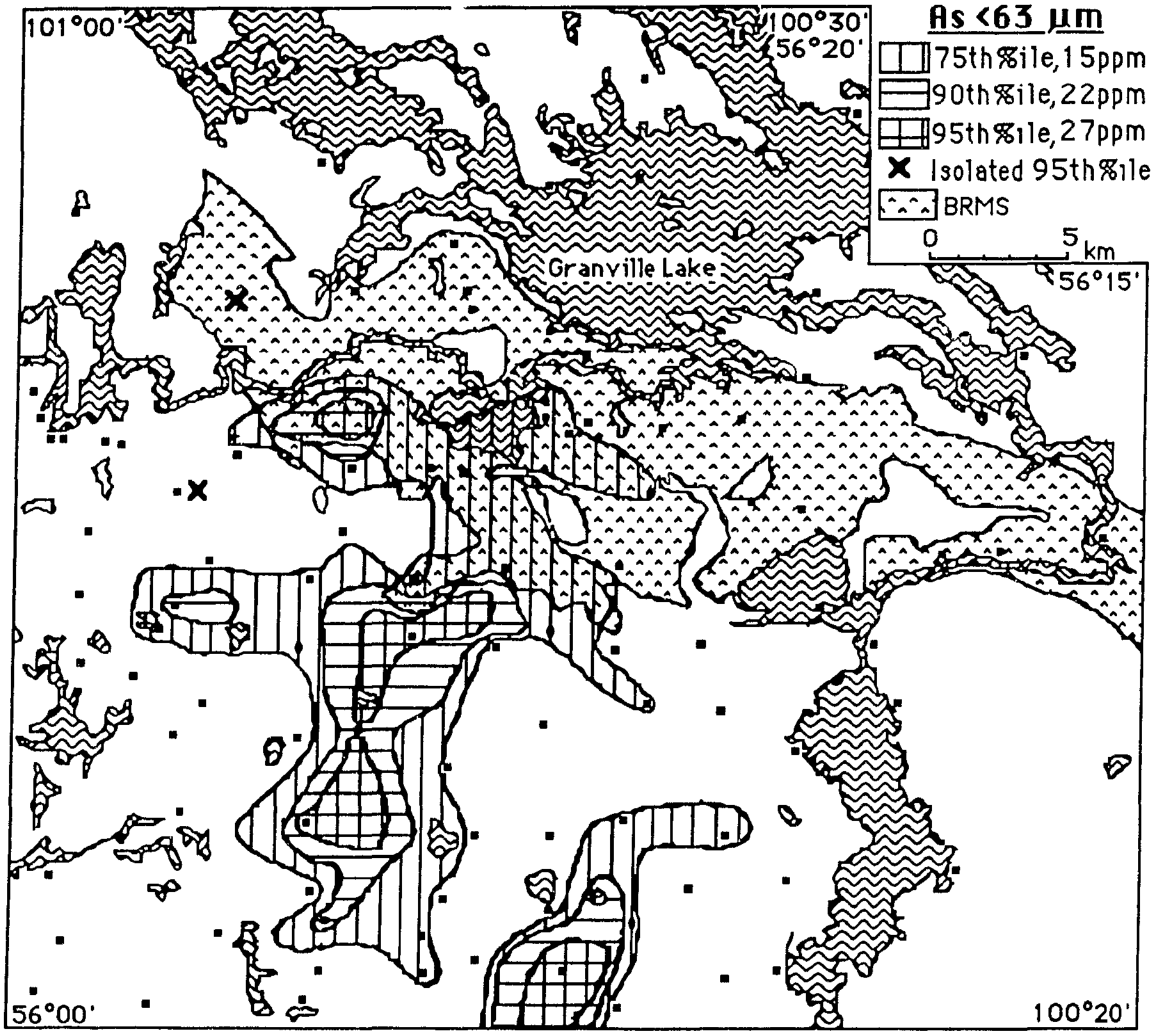


Figure 14. Dispersal pattern of As <63 µm fraction in relation to BRMS transition zone rock.

The relationships between arsenic in the <2 µm fraction and different bedrock lithologies also apply for arsenic in the coarser fraction. Especially worth noting is the outlining of the metavolcanic unit at the northeast of the anomaly (Fig. 15).

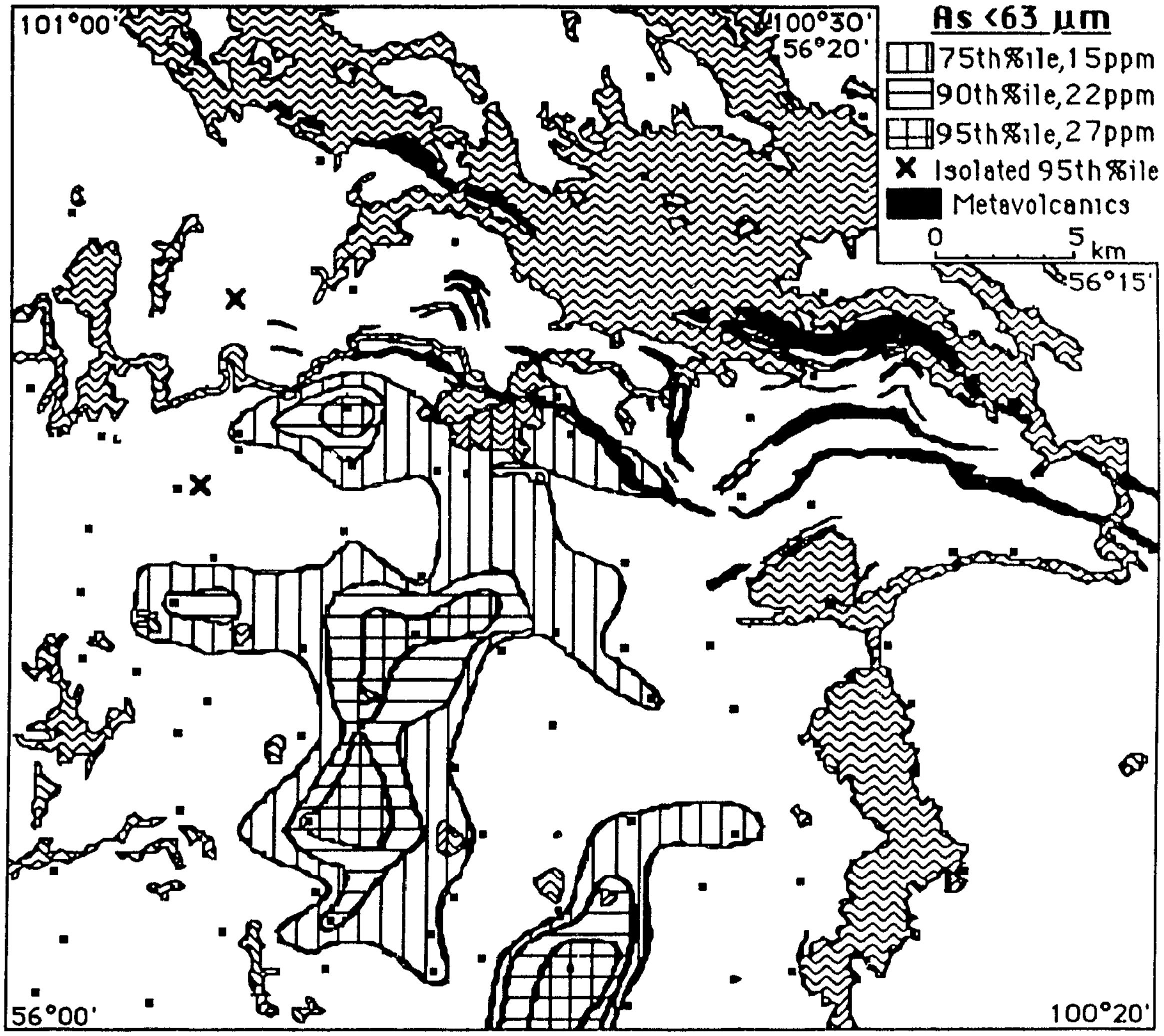


Figure 15. Dispersal pattern of As <63 µm fraction in relation to metavolcanic rock.

The dispersal of arsenic in the coarser fraction also exhibits the effects of topography.

Although the actual shapes of the anomaly patterns of arsenic in the clay and silt fractions are dissimilar, the actual areas that are outlined are almost identical. Figure 16 indicates that the correlation of arsenic in both fractions is relatively strong.

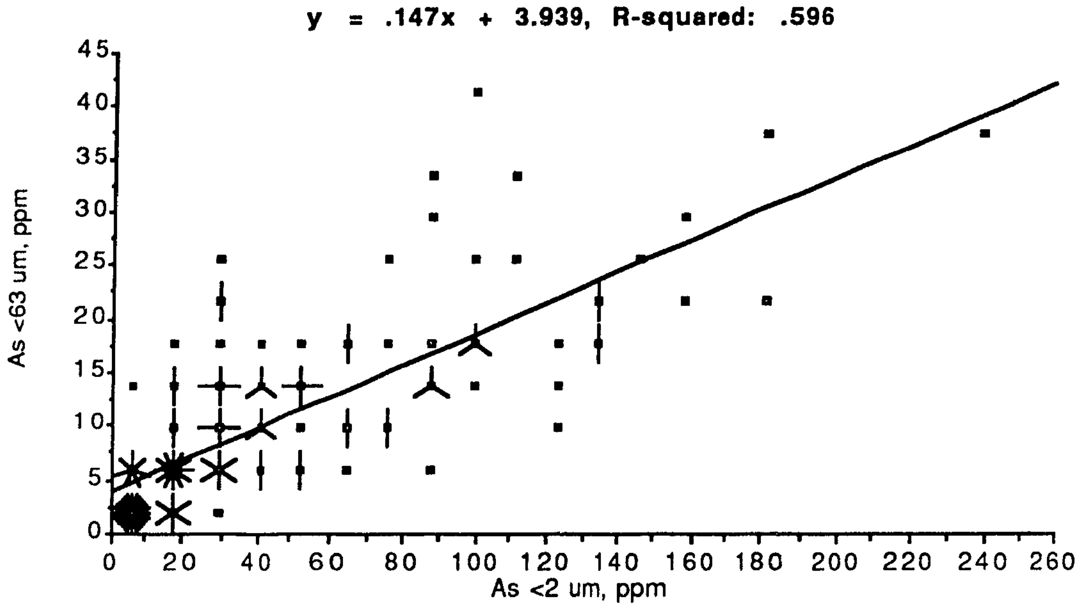


Figure 16. As <2 µm vs As <63 µm (clusters of data represented by increasingly dense symbols).

In both size fractions, "classic" dispersal trains have not been exhibited. Although there is in each case one relatively large area of anomalous values, locations of highest arsenic values are relatively spread out. This indicates that there are probably multiple source areas of arsenic in this region, as opposed to generally high background levels, or a single source.

Gold Analysis

Silt fraction

The mean value for gold in the <63 µm fraction is 6.6 ppb and the mode is 1 ppb (see table 4 and figure 17). The 75th percentile used as a threshold value in contouring the dispersal pattern is 7 ppb. This is slightly lower than the level of >10 ppb that DiLabio (1982) has considered as being anomalous for gold in the <63 µm fraction of oxidized till derived from mineralization at Onaman River, Ontario and Oldham, Nova Scotia.

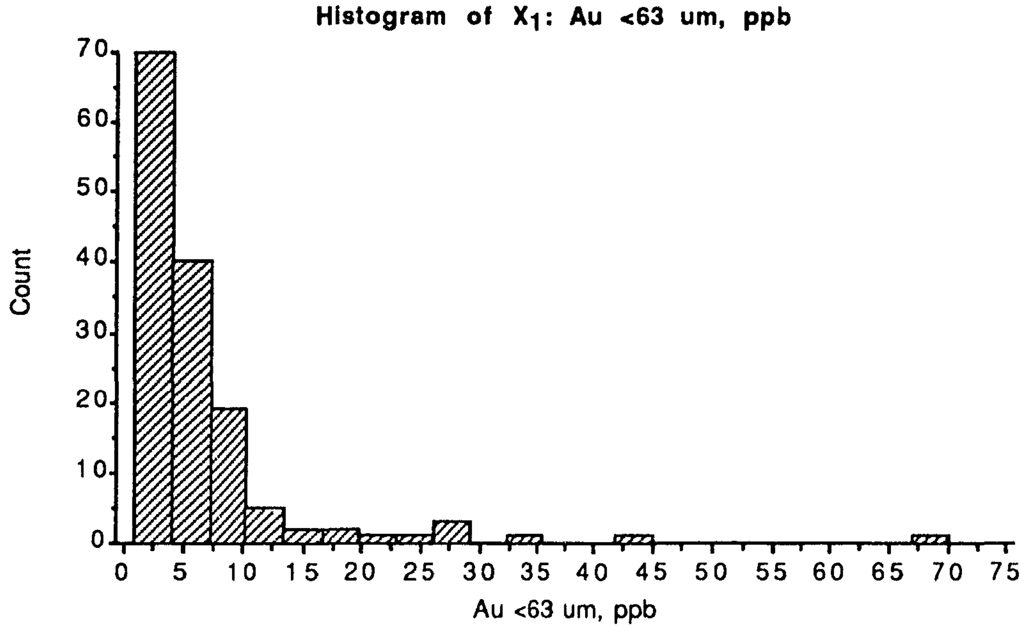


Figure 17. Frequency distribution of gold <63 µm

Table 4. Gold <63 μm Statistics

X_1: Au <63 um, ppb

Mean:	Std. Dev.:	Std Error:	Variance:	Coef. Var.:	Count:
6 575	8 307	687	69 005	126.334	146
Minimum	Maximum	Range:	Sum	Sum Squared:	# Missing:
1	69	68	960	16318	5
# < 10th %	10th %	25th %:	50th %	75th %:	90th %.
0	1	3	5	7	11
# > 90th %	Mode:	Geo Mean:	Har. Mean	Kurtosis	Skewness:
14	1	4 205	2 774	24 146	4 276

As with the pattern developed using arsenic concentrations, the area of highest gold values is south of Wheatcroft Lake and Laurie River (Figs. 18, 19, and 20). The main, central 90th percentile anomaly is approximately 56 km^2 and forms a type 2a anomaly (large ameboid, low follow-up priority). It was not possible to join up 95th percentile concentration sites while contouring the anomalous area. Areas of such high concentration are isolated from each other and form individual type 3a anomalies (high follow-up priority). It is not really possible to establish any clear dispersal direction from either the 90th or 95th percentile contours, however the main 75th percentile contour does exhibit a pattern that is at least sub–parallel to the direction of ice–flow.

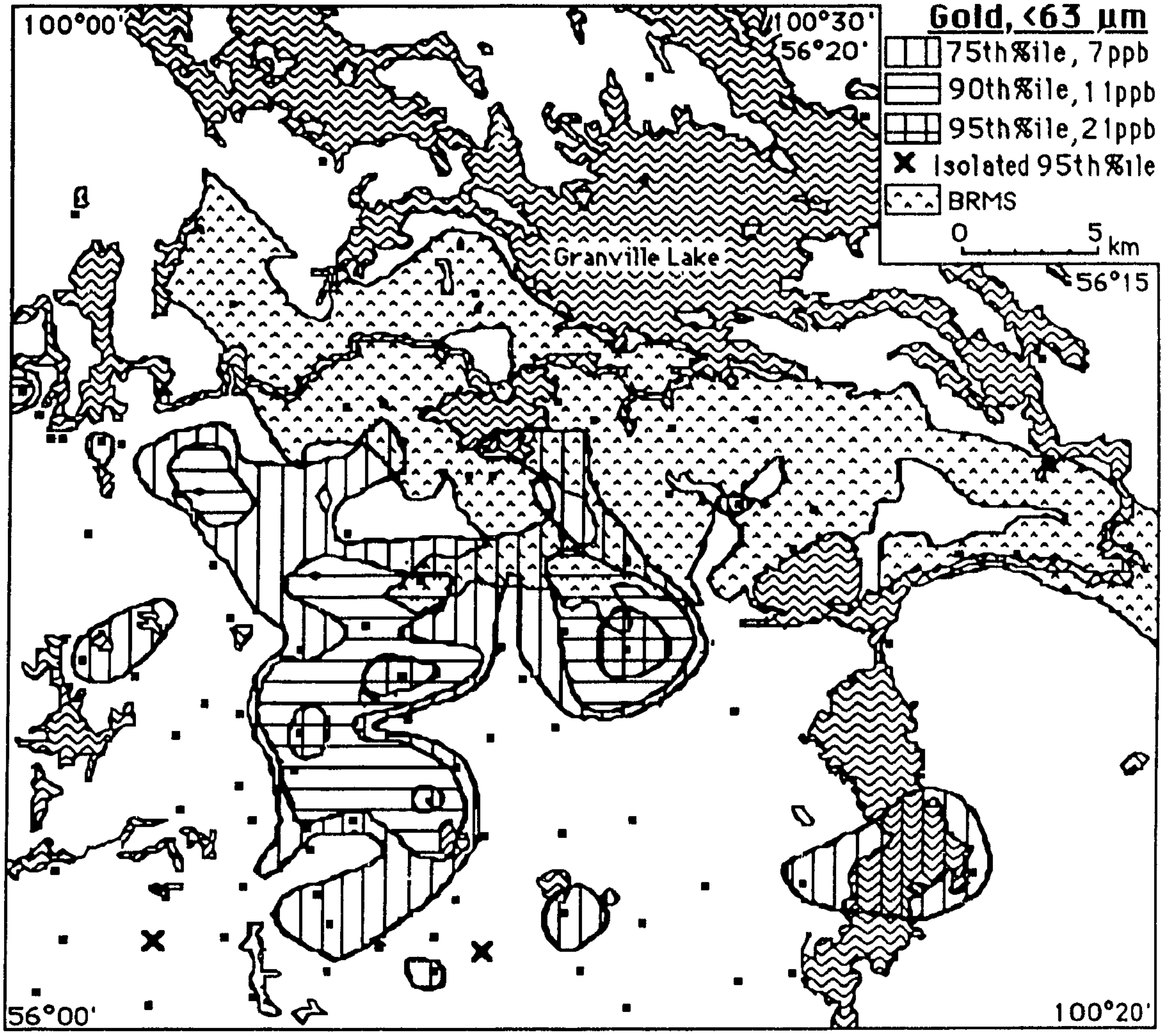


Figure 18. Dispersal pattern of gold <63 µm fraction in relation to BRMS transition zone rock.

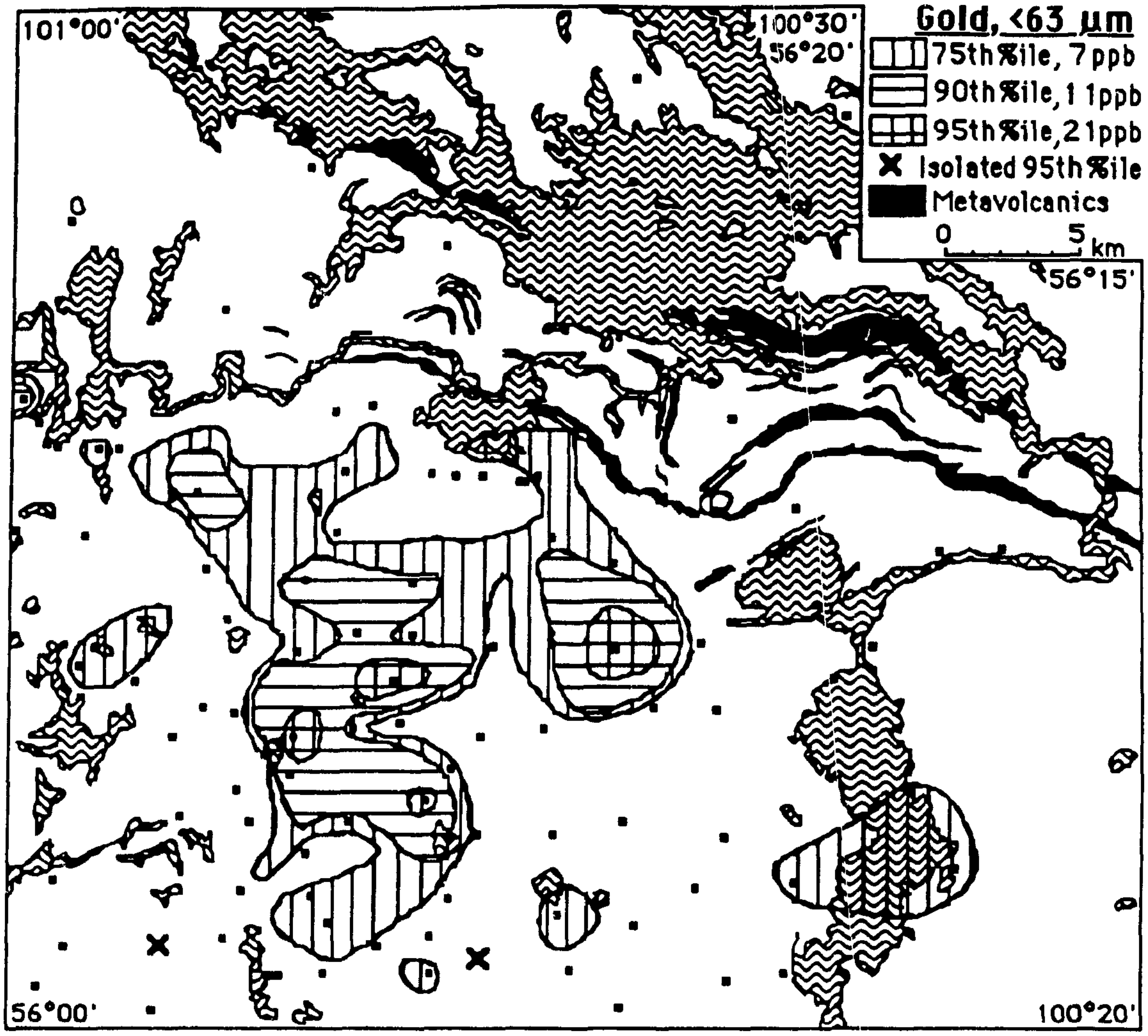


Figure 19. Dispersal pattern of gold <63 µm fraction in relation to metavolcanic rock.

MacEachern and Stea (1985, p. 20) working in Nova Scotia found that peak gold abundances in the silt fraction were less than 300 m from source veins. If the most southerly 95th percentile value were to be considered at or very close to a source, then the dispersal pattern to the most southerly point in the main 75th percentile anomaly would be 7 km to the southwest. At the

Williams gold deposit in Ontario, glacial dispersal of gold in till was found to be limited to less than 200 m (Sheehan and Gleeson, 1984, *in* MacEachern and Stea, 1985, p. 23). At Oldham, Nova Scotia, Dilabio (1982) determined that gold values remained above threshold value up to 1900 m down–ice from source.

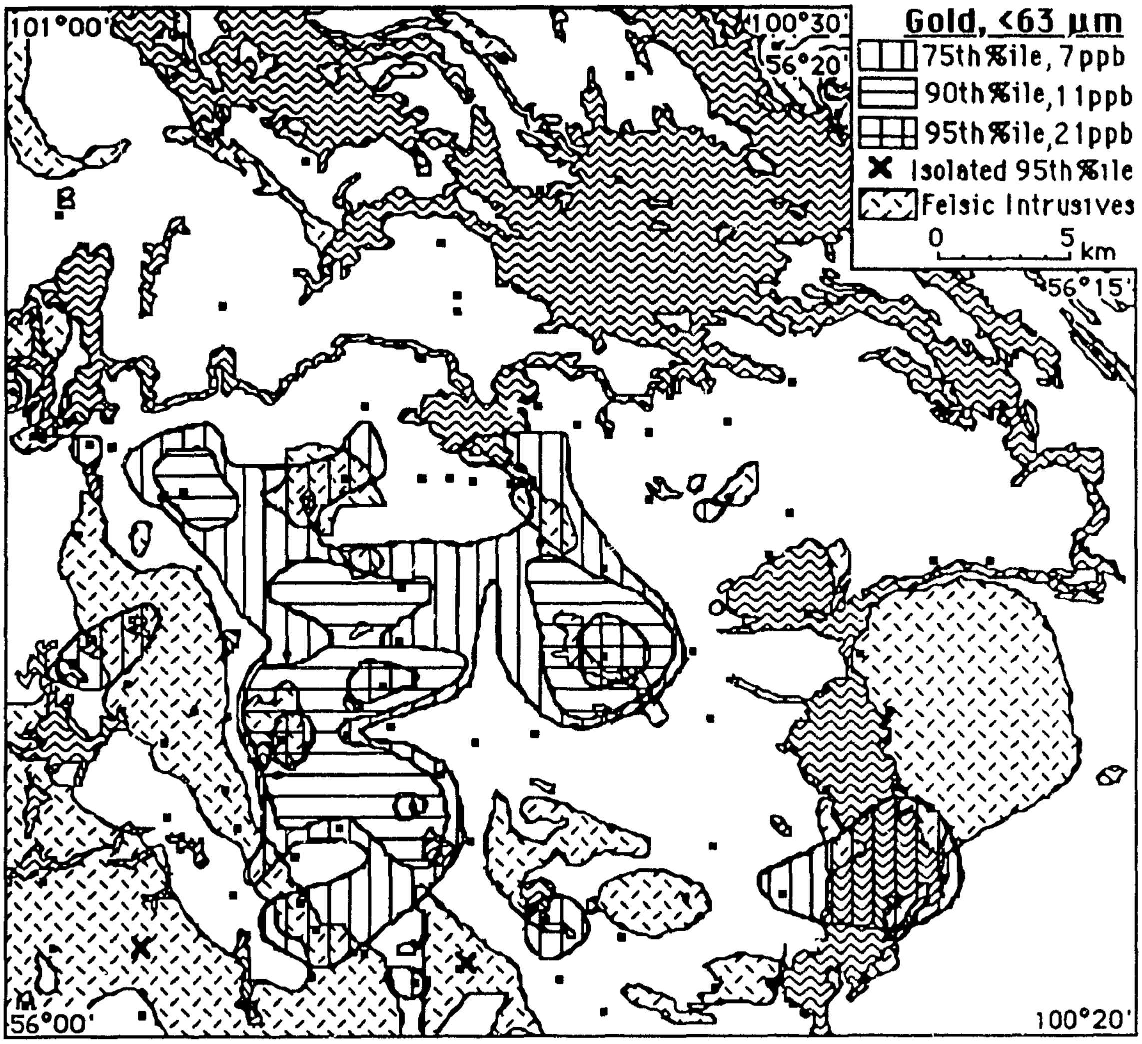


Figure 20. Dispersal pattern of gold <63 µm fraction in relation to felsic intrusive rock.

In the Wheatcroft Lake area, either the eroding power of continental glaciation was much stronger, or the source(s) of gold are much larger or more easily eroded than in other study areas.

As with arsenic, it is not easy to correlate areas of high gold values with bedrock lithology. The outlined 75th percentile anomaly is mostly down–ice of both the BRMS transition zone and the metavolcanics within that unit (Figs. 18 and 19).

Several of the sample sites with gold values in the 95th percentile range, are within 100 m of granitic intrusions (Fig. 20). This may indicate that gold mineralization is associated with quartz veins, as has been determined in other studies (Nielsen, 1987; Gleeson and Rampton, 1987; Gleeson et al., 1984). However, there are numerous sites where samples taken near granitic intrusions exhibit gold values that are well below anomalous values.

Like arsenic, the dispersal of gold in the silt fraction of till exhibits the effects of topography. The bulk of the anomalous zone is below the 305 m level except for the eastern portion of the main anomaly, indicating that gold rich till may have been dispersed around hills and ridges.

Heavy mineral fraction

Gold concentrations in the heavy mineral concentrate are considerably higher than in the silt fraction. This is due primarily to removal of diluting minerals such as quartz and feldspars before analysis.

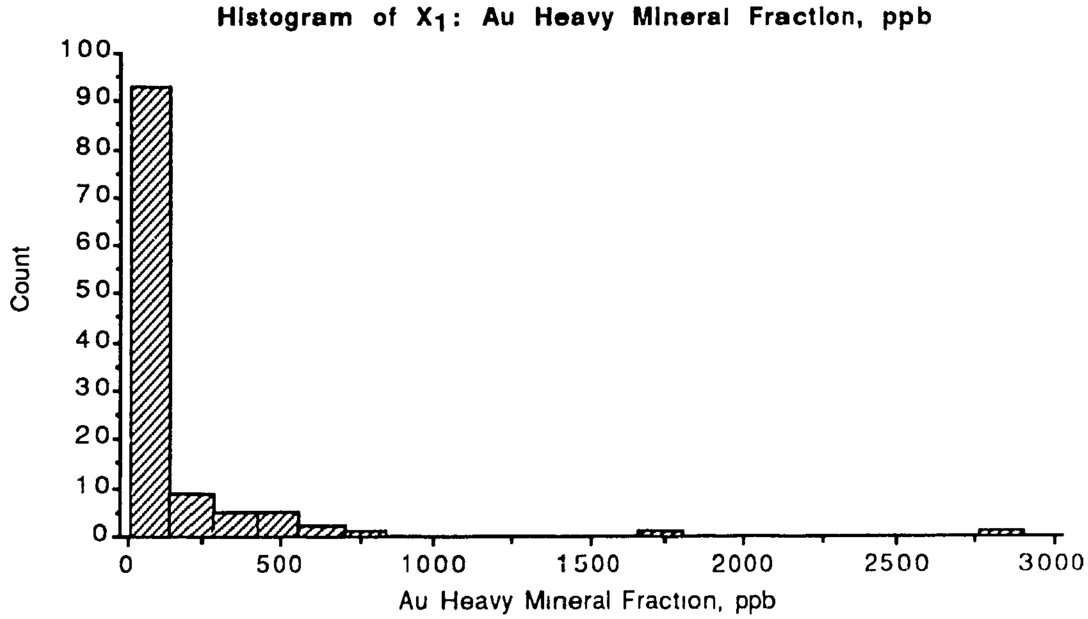


Figure 21. Frequency distribution of gold in heavy mineral fraction

Table 5. Statistics for gold in the heavy mineral fraction.

X_1: Au Heavies, ppb

Mean	Std Dev	Std Error	Variance.	Coef Var	Count
132 957	334 372	30.913	111804.507	251 488	117
Minimum	Maximum	Range	Sum	Sum Squared:	# Missing
5	2900	2895	15556	15037606	34
# < 10th %	10th %	25th %	50th %	75th %	90th %
0	5	5	20	112 5	358
# > 90th %	Mode	Geo Mean	Har Mean	Kurtosis	Skewness
12	5	29 179	11 097	42 411	5 958

The dispersal pattern of gold in this fraction is illustrated in figures 22, 23, and 24. The numbers on figure 22 refer to the number of visible gold grains per sample.

The dispersal pattern displayed in these figures is fundamentally the same as for gold in the finer fraction and covers an area similar to arsenic in both fractions. Most of the 90th and 95th percentile anomalies are type 2 anomalies with either a [illegible]boid shape or are subparallel to ice-flow direction. The two southern 90th percentile anomalies within the main anomaly are well aligned with striation directions (Fig. 2).

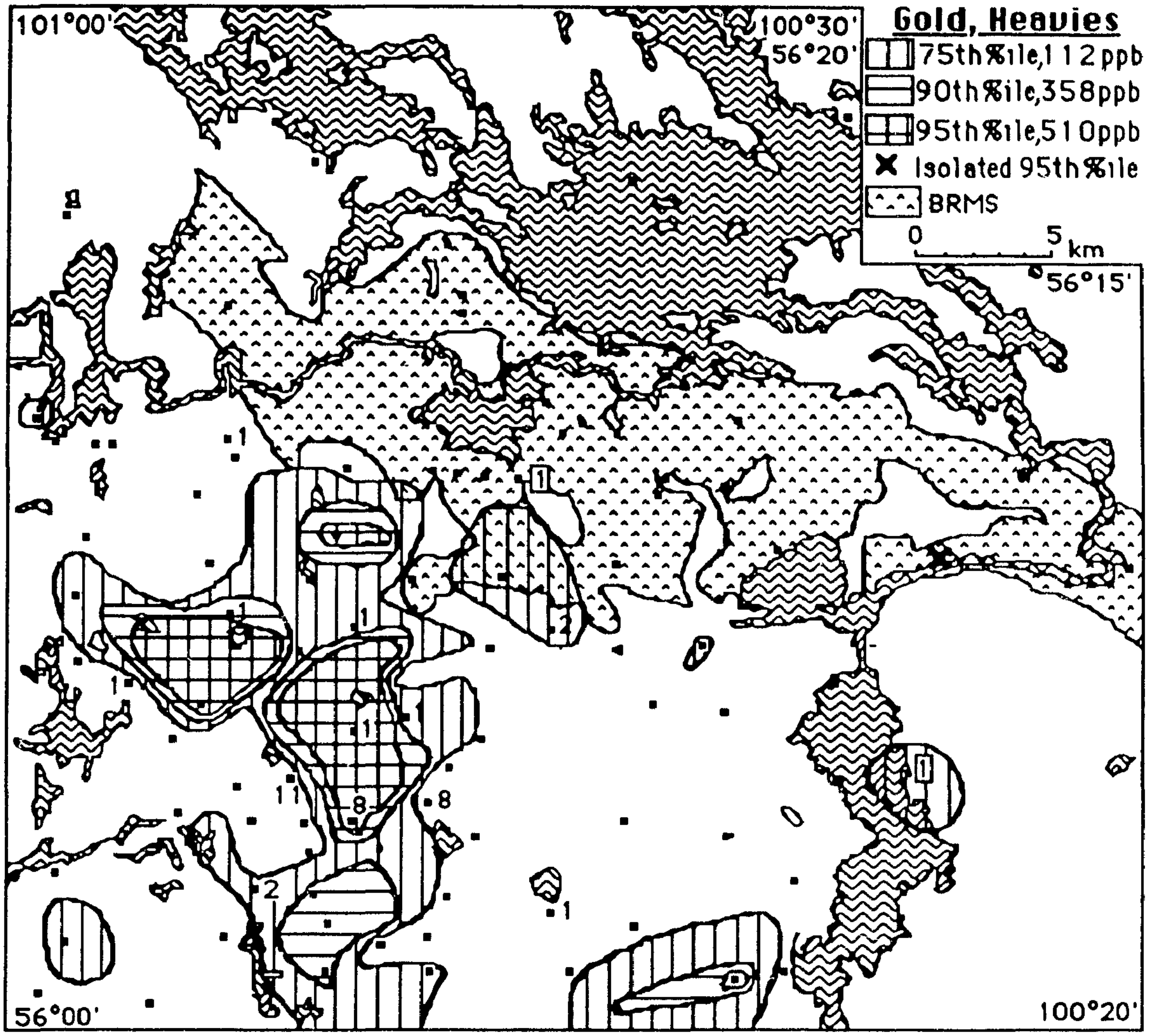


Figure 22. Dispersal pattern of gold in heavy mineral fraction in relation to BRMS rock. Numbers represent number of gold grains.

Sopuck et al. (1986) found poor correlation between dispersal patterns defined by gold in the heavy mineral fraction and in the -80 mesh fraction of tills in Saskatchewan. They determined that gold anomalies in the finer fraction were limited to the immediate area of mineralization and were only useful in detailed follow–up studies.

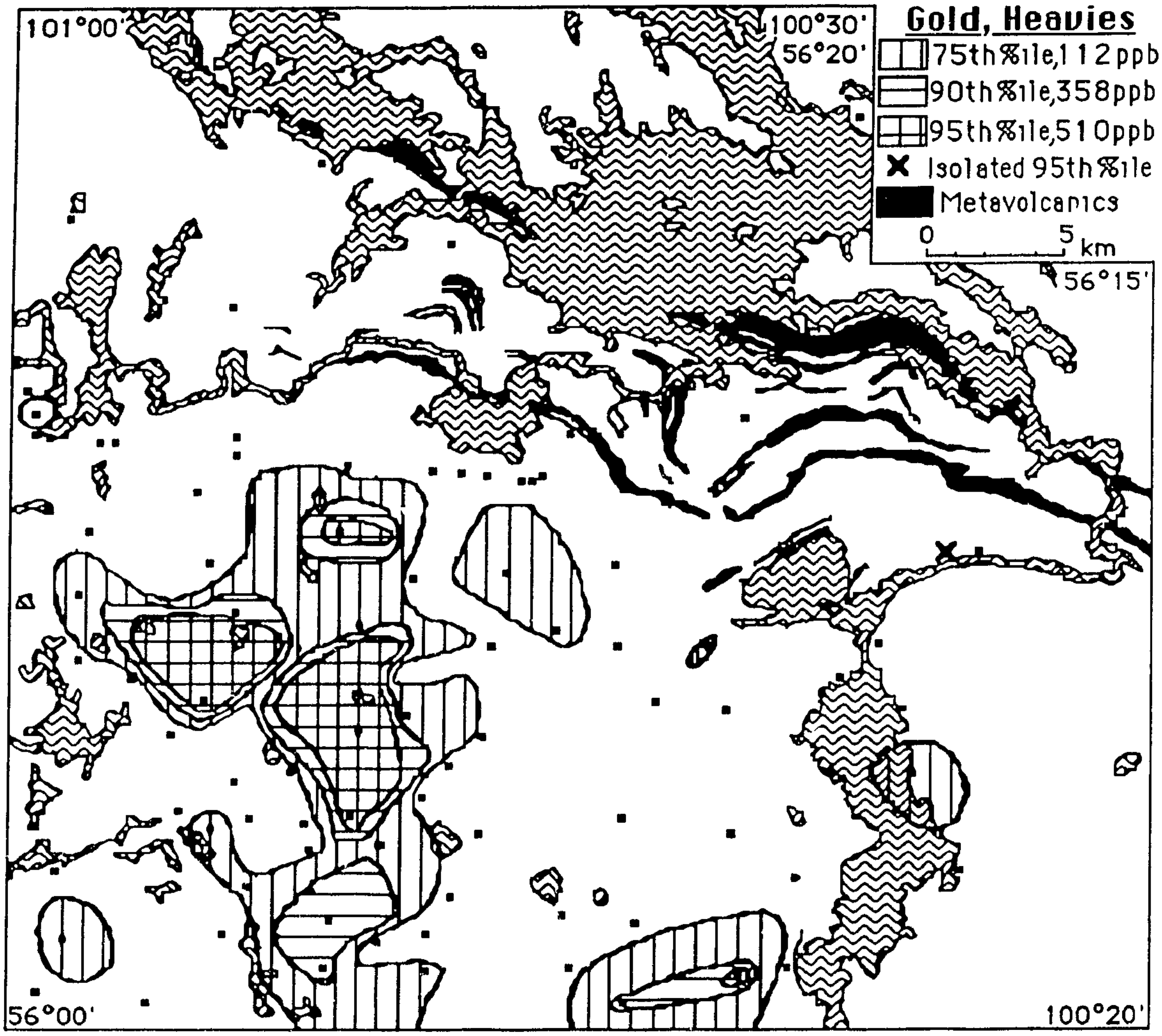


Figure 23. Dispersal pattern of gold in heavy mineral fraction in relation to metavolcanic rock.

In the present study, table 6 does indeed indicate a poor correlation between gold in the heavy mineral fraction and in the silt fraction. However, a clear similarity does exist for the two dispersal patterns. Both patterns show overall dispersal in the direction of ice–flow (Fig. 2), and both patterns show the effects of topography on glacial dispersal.

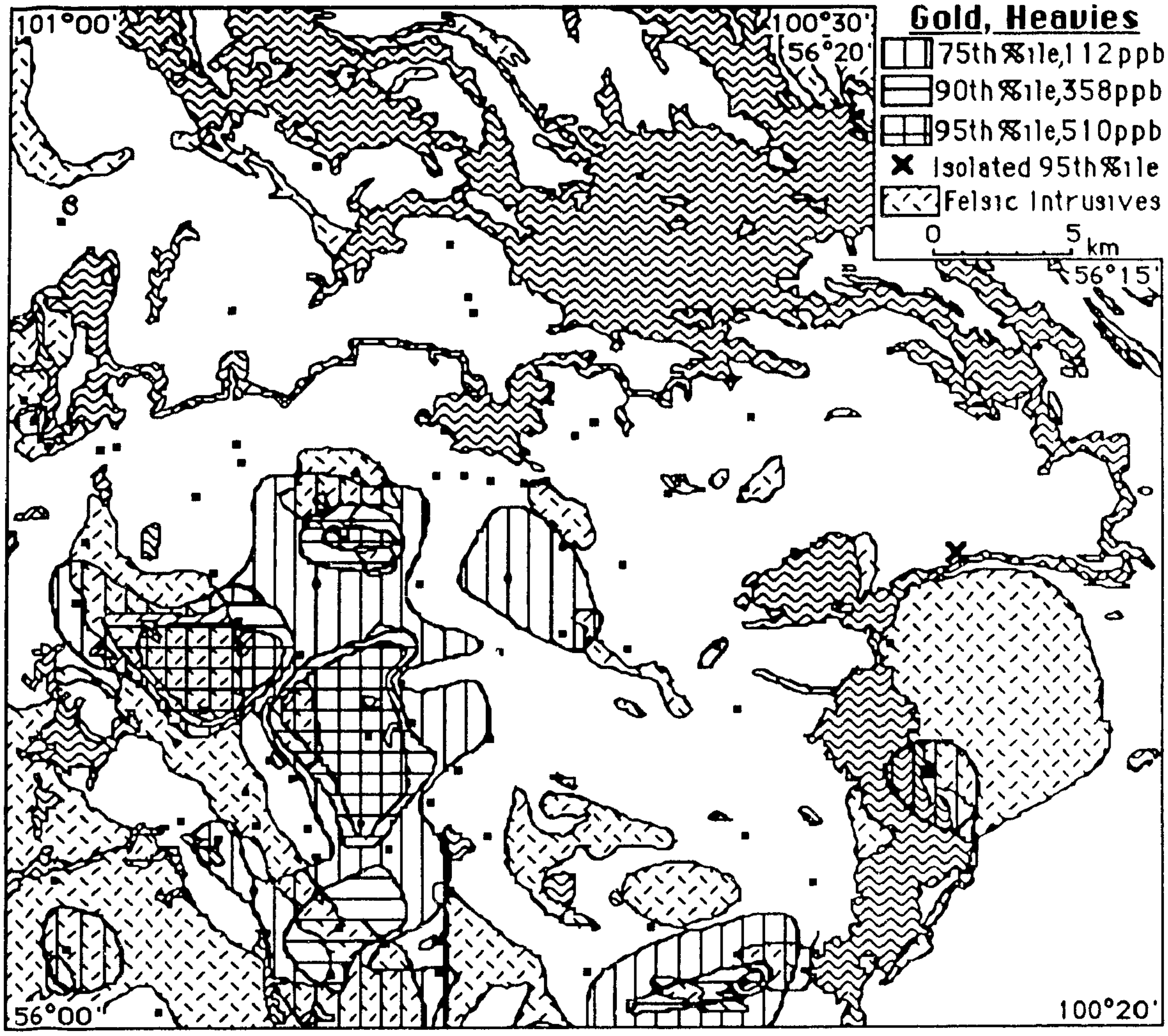


Figure 24. Dispersal pattern of gold in heavy mineral fraction in relation to felsic intrusive rock.

As with arsenic, there does not appear to be any one source for both fractions of gold in this region. Anomalous gold values below the 90th or 95th percentile level are probably due to glacial dispersal from several sources, rather than to generally high background concentrations.

CHAPTER 4C - ARSENIC AS A PATHFINDER FOR GOLD

It has been demonstrated above that the dispersal patterns for gold and arsenic are very similar in all fractions. Figures 25 to 28 illustrate regression curves of gold with arsenic. None of the curves display significant correlations.

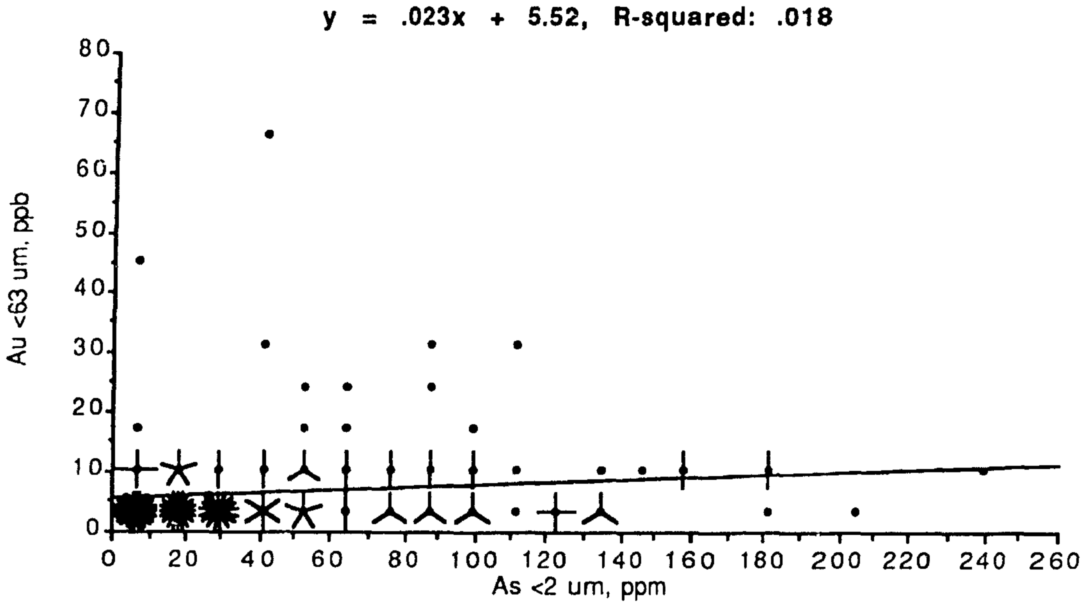


Figure 25. As <2 μm vs gold <63 μm (clusters of data represented by increasingly dense symbols).

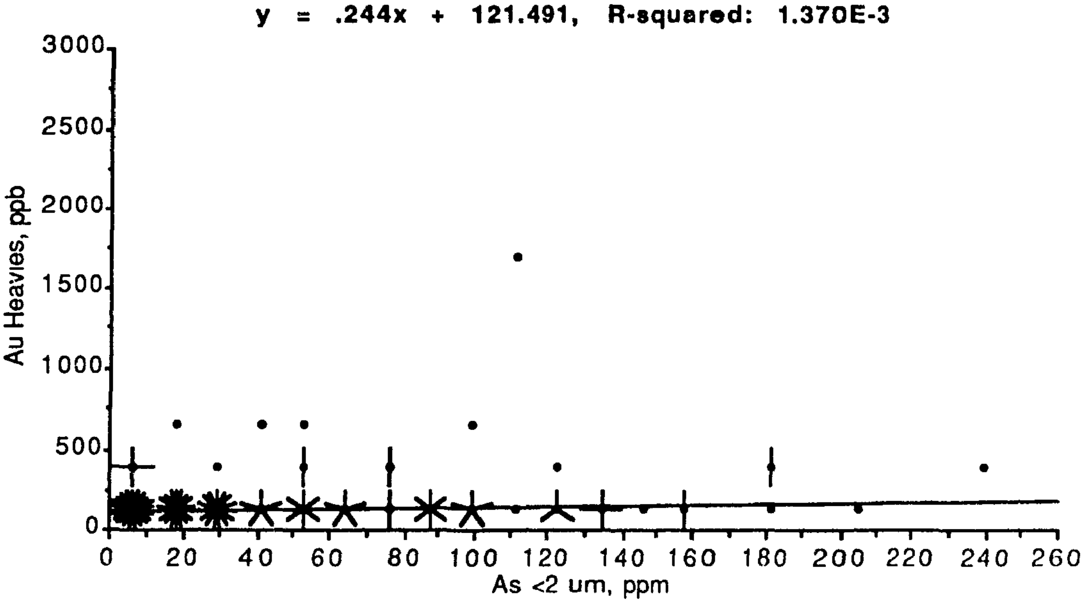


Figure 26. As <2 µm vs gold heavy mineral fraction

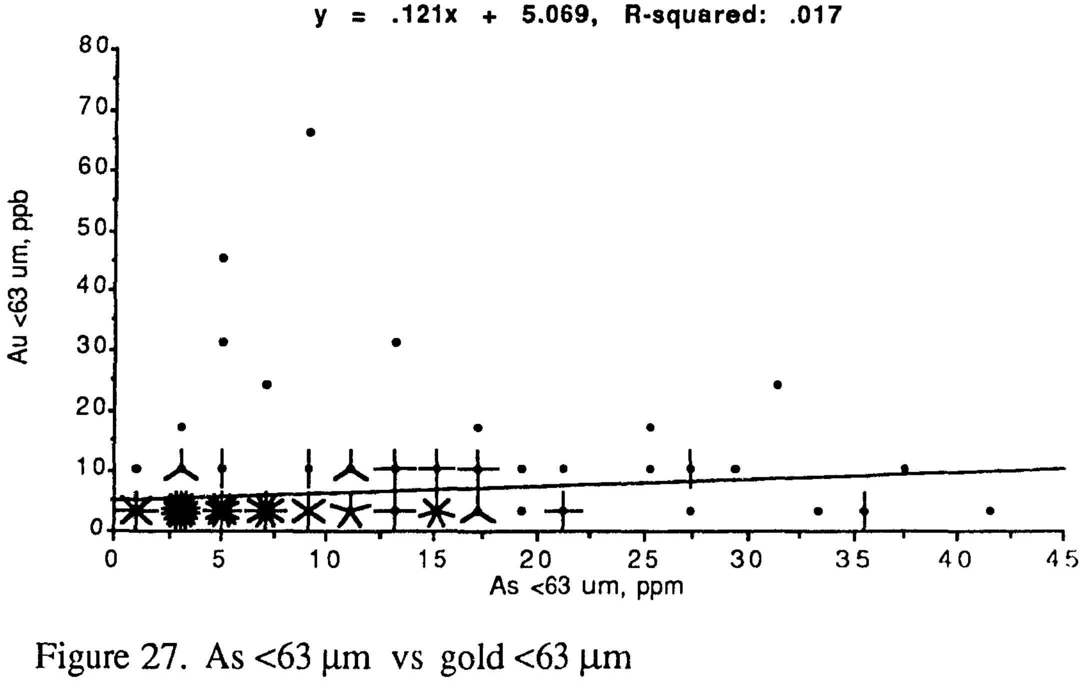


Figure 27. As <63 µm vs gold <63 µm

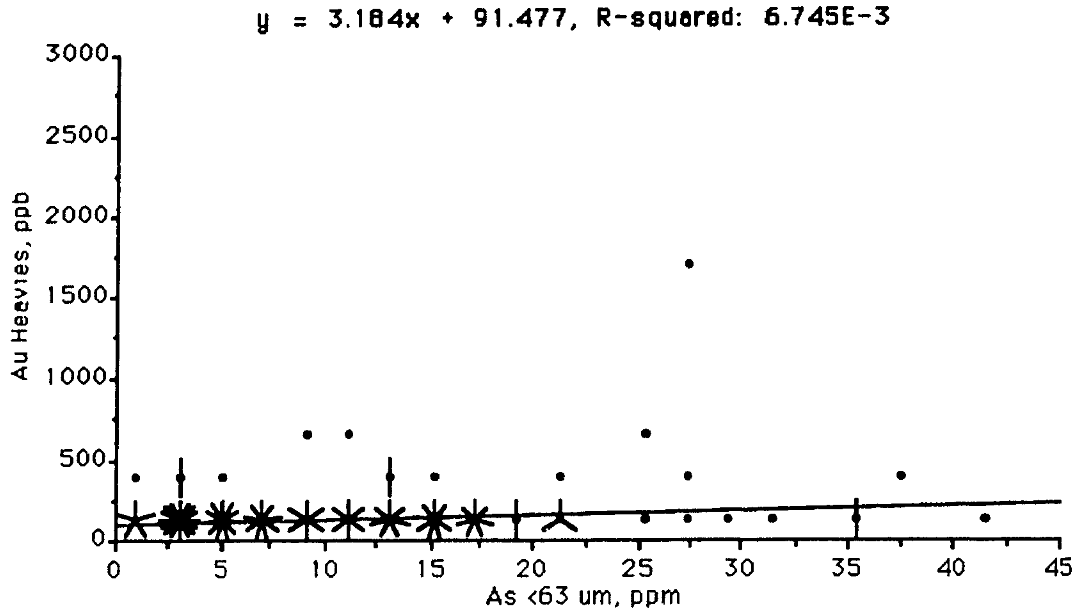


Figure 28. As <63 μm vs gold heavy mineral fraction

Tables 6a and 6b list Pearson correlation coefficients for ten elements. Although the correlation between arsenic and gold concentrations are not significant, on average, arsenic values reflect gold concentrations better than other trace elements. An exception to this is the correlation between Fe and gold in the silt fraction, which is slightly better than that of arsenic in the clay fraction and gold in the silt fraction. However, overall, arsenic is the best pathfinder element for gold in this region. The correlation between arsenic and iron is relatively good, indicating that arsenic may derive from arsenopyrite. The correlation between all elements and gold in the heavy mineral fraction is especially poor, probably a factor of variable fraction analysis.

Table 6a. Gold, Ni, Cu, Zn, Pb, As correlation matrix (101 samples)

Correlation Matrix for Variables: X_1 ... X_8

	Ni	Cu	Zn	Pb	As <2 um	As <63	Au <63	Au H
Ni	1							
Cu	384	1						
Zn	499	475	1					
Pb	.115	279	278	1				
As <2 um	.528	443	411	149	1			
As <63 um	.372	259	293	225	777	1		
Au <63 um	051	068	- 086	094	152	192	1	
Au H	01	- 069	-4.16E-3	.071	016	082	-5 30E-3	1

Table 6b. Gold, Cr, Mn, Fe, Co, As correlation matrix (101 samples)

Correlation Matrix for Variables: X_1 ... X_8

	Cr	Mn	Fe	Co	As <2 um	As <63	Au <63	Au H
Cr	1							
Mn	- 105	1						
Fe	331	.17	1					
Co	074	562	025	1				
As <2 um	388	018	224	155	1			
As <63 um	263	- 043	235	034	777	1		
Au <63 um	097	- 181	165	02	152	192	1	
Au H	03	- 053	023	043	016	082	-5 30E-3	1

CHAPTER 4D - VISIBLE GOLD

The great majority (76%) of gold grains are abraded (appendix 5), indicating that they have been transported a distance of at least 1 km (Averill and Zimmerman, 1984). Twelve percent are irregular in shape and 13% are delicate, indicating relatively short transport distances of less than 500 m (Sopuck et al., 1986). Averill and Zimmerman (1984) considered a distance of less than 100 m to represent transport distance of delicate gold grains at Waddy Lake, Saskatchewan. Sopuck et al. (1986) noted at Rush Lake, Saskatchewan that gold grains remained delicate up to 75 m from source.

Delicate gold grains are here defined as extremely thin, fresh, shiny grains or flakes exhibiting numerous primary crystal edges, elongated protrusions , and pitted surfaces. Abraded gold grains are flattened, rounded grains that are finely scaly, with microporous surfaces. Irregular gold grains are transitional between delicate and abraded grains, exhibiting folded over protuberances and the development of scaly surfaces (DiLabio, pers. comm., 1989).

The highest concentration of gold grains is located in the southwest corner of the study area (Fig. 29). One sample contains 2 delicate, 1 irregular and 5 abraded gold grains. Two hundred and fifty metres NEE is a sample with 1 delicate and 7 abraded grains. To the northwest (300 m), a sample contains 4 irregular and 7 abraded grains. Together, these three samples account for 60% of all gold grains found in the region. Glacially transported grains become progressively finer away from their source area (Nichol and

Bjorklund, 1973), indicating that the abraded and delicate grains from the same sample originate from different sources.

Most of the grains are relatively small. The average grain size is 58 x 90 x 16 µm. Grain size averages for abraded, irregular and delicate gold grains are 64 x 99 x 16 µm, 25 x 35 x 6 µm, and 54 x 83 x 24 µm respectively. DiLabio (1985) has determined that the grain size of gold in oxidized till is predominantly silt sized or finer and in unoxidized till is at or finer than the grain size of the gold bearing mineral in the source deposit.

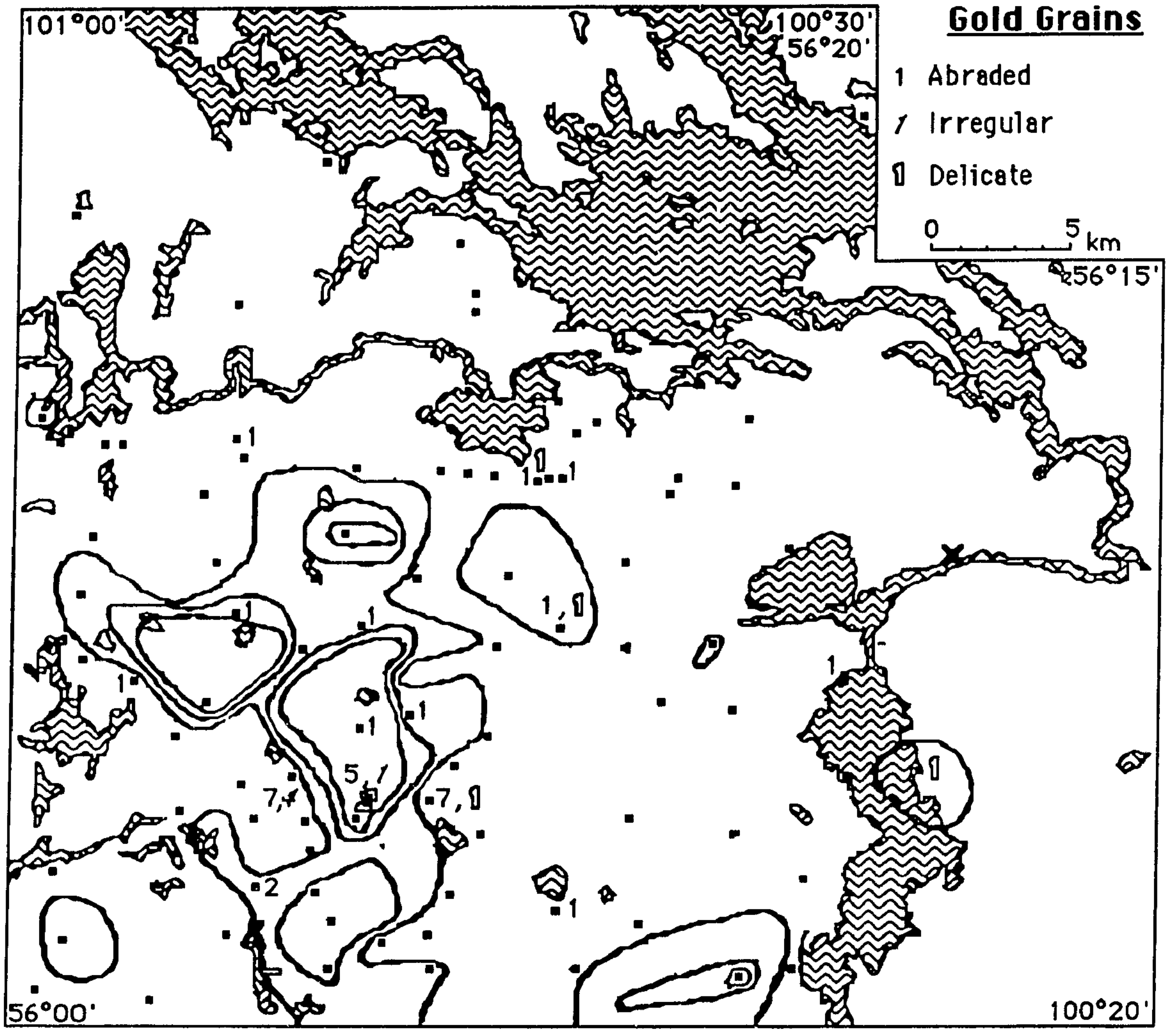


Figure 29. Abraded (normal print), irregular (italicized) and delicate (outline) gold grains. The dispersal pattern of gold in the heavy mineral fraction is also displayed.

The following information on the visible gold grains of the samples was provided to the author in February, 1989 (pers. comm., R.N.W. DiLabio): Only 13 grains survived laboratory polishing. Of these, the majority are very pure. Grains that have gold contents >98% have possibly been leached of silver by postglacial weathering. The exception is an angular, wedge shaped electrum grain with a silver content of 34% from the sample location with 2 delicate grains. This grain was the only polished grain that was fresh and pristine. The texture and geochemistry of this grain indicate that it may originate from a different source than the others.

It is difficult to correlate gold grain abundances with geochemical gold concentrations in the heavy mineral fraction. Figure 22 illustrates that some samples containing 8 or 11 grains are not even above threshold geochemically, while most samples above the 95th percentile contain no gold grains at all. This could be a factor of postglacial weathering, but it probably has more to do with the nugget effect and sample size. Steele et al. (1986), found a clear relationship between gold grain counts and heavy mineral geochemistry. However, Steele et al. (1986) used bulk samples of 7-10 kg, while the samples in the present study were usually around 1 kg.

CHAPTER 4E - PEBBLE DISTRIBUTION

Three pebble lithologies were identified and separated out from the total "pebble fraction" (2-5.6 mm). Approximately 100 pebbles were counted in each of the studied samples. The lithological fractions were then weighed to determine weight percents for the three lithologies. The size fraction used was chosen for consistency and because each sample had a large number of pebbles of this grain size. Only three lithologies were separated because others were not present in large enough quantities or because of difficulty in positive identification. The three rock types that were identified were; a) metasediments of Unit 1; b) Granulite schists of Unit 7, and; c) felsic intrusive pebbles.

Figure 30 illustrates the dispersal of Unit 1 pebbles in the study area. Unit 1 of the BRMS transition zone was chosen because of its central location and its orientation perpendicular to ice-flow direction. In general, the direction of dispersal is subparallel to striae in the region, similar to the dispersal of gold and arsenic in the region. One important difference between the dispersal patterns of the trace elements and pebbles of Unit 1, is that the pebble percentages are below threshold in the low lying central part of the map, exactly the opposite to the trace elements. This may be because this area is directly down-ice from Wheatcroft Lake and a relatively narrow region of the BRMS transition zone.

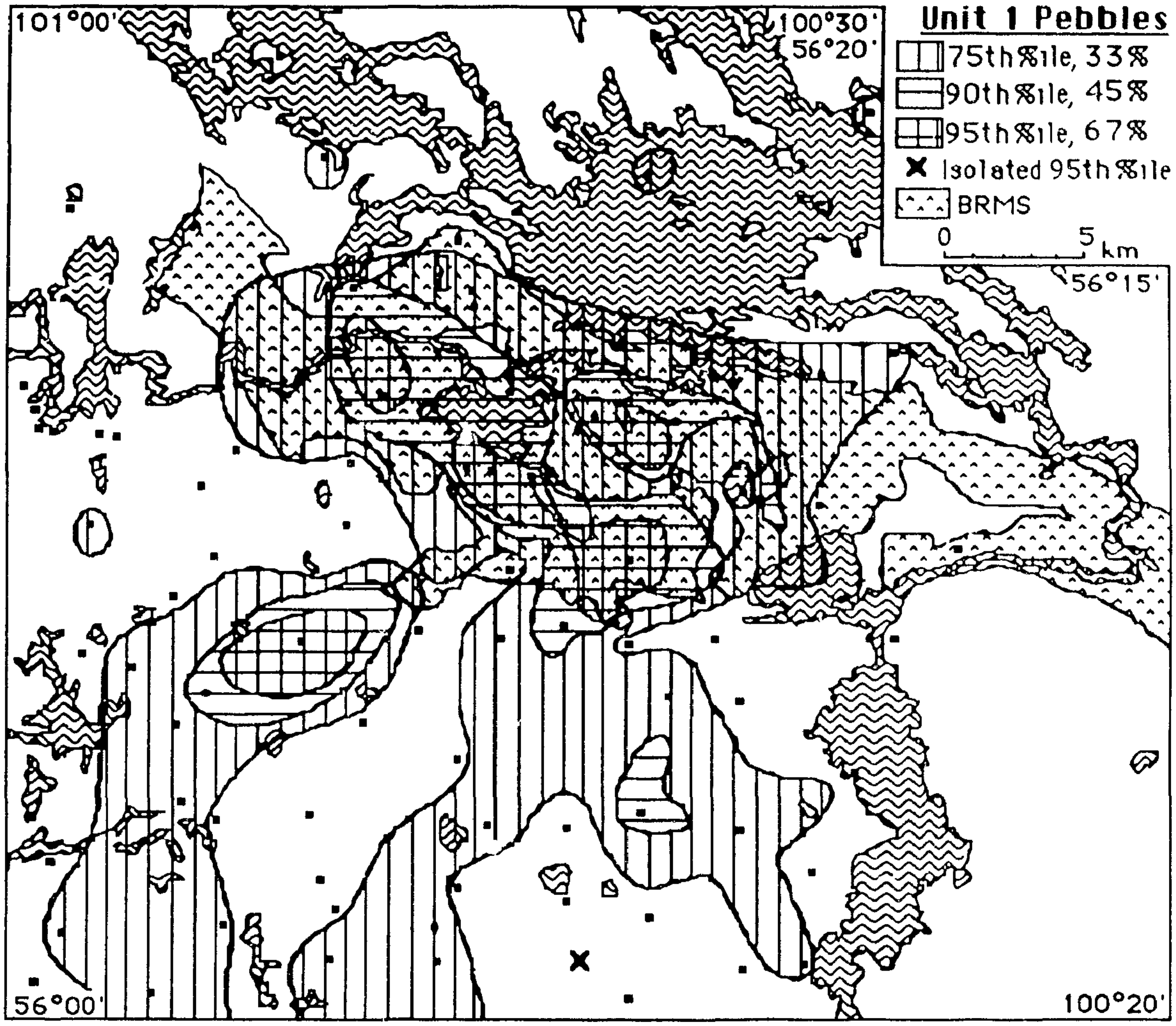


Figure 30. Distribution pattern of Unit 1 pebbles in relation to BRMS transition zone rock. Percentages refer to percent of total pebble fraction.

Unit 1 pebbles above the 95th percentile value are found approximately 3 km down-ice from their source. Concentrations above the 75th percentile value are found more than 15 km down-ice.

Table 7 illustrates the correlation between the pebble lithologies and gold concentrations in the silt and heavy mineral fractions. Although the correlation between Unit 7 pebbles and gold in the heavy mineral fraction is weak, it is better than gold in the heavy mineral fraction and arsenic in either size fraction. However, table 1 shows that the average gold concentration of Unit 7 bedrock is relatively low and there is no real indication that Unit 7 is a source for gold in this region.

Table 7. Pebble - gold correlation matrix (97 samples)

Correlation Matrix for Variables: X_1 ... X_5

	Unit 7	Fels Intr	Unit 1	Au<63um	Au H
Unit 7	1				
Fels Intr	-.264	1			
Unit 1	- 261	- 508	1		
Au<63um	063	- 183	- 218	1	
Au H	208	- 017	- 046	026	1

CHAPTER 4F - CLAY MASKING OF TILL GEOCHEMISTRY

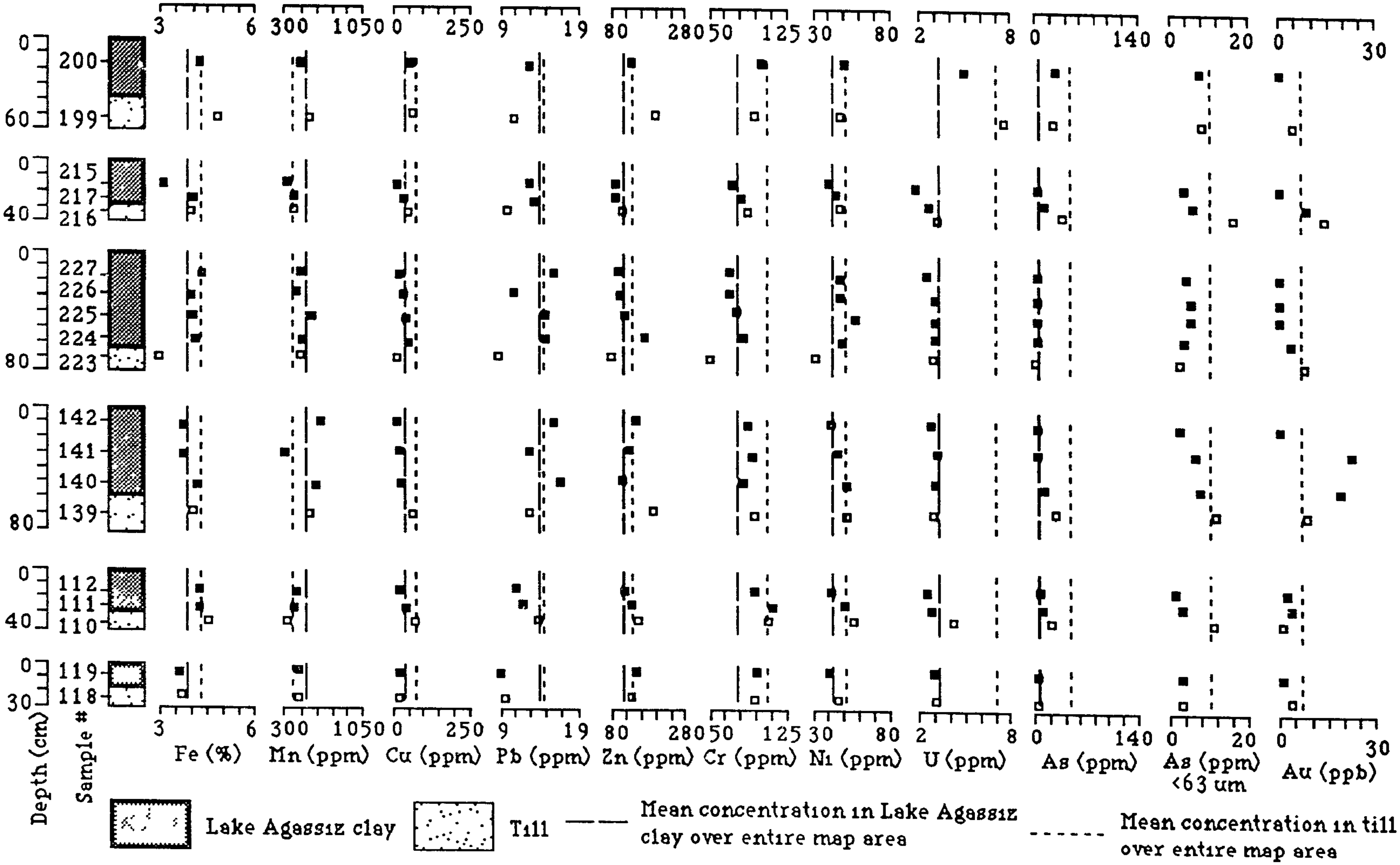
Lake Agassiz clay in the area around Wheatcroft Lake is an impediment to till sampling that cannot be ignored. Many potential sample sites were abandoned after determining that clay thickness was greater than 1 m. This part of the study investigates the usefulness of clay geochemistry as a guide to underlying till geochemistry. Few studies have attempted this. Most other studies involving the upward mobility of ions in clay have dealt with clay that directly overlies ore deposits (Bolviken and Gleeson, 1979; Dreimanis, 1960).

At 6 different sites, both till and glaciolacustrine Lake Agassiz clays overlying it were sampled (Fig. 31). The geochemical concentrations as well as the mean values of both sediment types are shown. Mean till values are from this report and mean Lake Agassiz clay values are supported by additional data provided by Kaszycki and DiLabio (pers. comm., 1987).

As the tills of this area are derived mainly from local sources, it can be expected that the geochemistry of the clay and till will differ. However, post depositional processes may contribute to narrowing these differences.

In the present study, comparisons were made to determine whether the geochemistry of till and clay in a section were together above or below their respective mean values. Ten different elements; Mn, Cu, Pb, Zn, Cr, Ni, U, Fe, As (<2, <63 μm) and gold were measured, from 6 sections, for a total of 60 examples (Fig.31).

Figure 31. Clay and till geochemical profiles



Correlations between till and clay samples from the same profiles can be made by determining whether both the till and clay from individual profiles are together above or together below the mean concentrations for till and clay respectively. Sample numbers 119 and 200 are considered as upper clay samples.

Some elements displayed a very good correlation between till and overlying clay. On average, there was better correlation between till and upper clay than with till and clay that was lying immediately on top of it.

In the till-upper clay correlations, Cu, Zn, Fe and U exhibited relatively strong correlation. Arsenic showed no correlation and Cr very little. Upper clay samples in the A1 horizon all contained organic matter which could have affected geochemical values (discussed below).

In the till-lower clay sequences, uranium levels are consistently below mean in both the till and clay. Arsenic shows no correlation, and manganese and Zn show relatively good correlation.

There are four profiles with lower and upper clay samples. Manganese, Zn and especially U are usually together above or below mean values throughout the four profiles. This has implications for determining whether till-upper clay correlations are due to upward transfer from till, or from surface contamination: the relatively strong till--upper clay correlation for Cu could be due to surface contamination, while that of Mn, Zn, and U make strong cases for upward transfer from till. Uranium and Zn both are highly mobile in oxidizing environments, while Mn is immobile under acidic environmental conditions (Levinson, 1980, p. 143).

There are several post-depositional mechanisms by which the geochemical signal in the till could be transferred to the overlying clay, all of which depend on the mobility of trace element ions. If fractures existed in the overlying clay, then one possible mechanism for the upward migration of ions could be capillary action (Lalonde and Beaumier, 1984). This involves evapo-transpiration of soluble ions and would thus be more effective within well drained areas of thinner clay cover.

Hydrostatic (artesian) pressure is another factor (Lalonde and Beaumier, 1984) which would be greatly enhanced by fracturing (Grisak and Cherry, 1975), especially in the clay. Fracturing is a requisite condition because of the impermeable nature of glaciolacustrine clays (Smee and Sinha, 1979).

The intergranular hydraulic conductivity of till and glaciolacustrine clay is normally very small, however if there are interconnected fractures, the hydraulic conductivity of these sediments will be greatly increased (Grisak and Cherry, 1975). Grisak and Cherry (1975) noted an example of Lake Agassiz clay in southern Manitoba in which fracturing increased the hydraulic conductivity from about 3×10^{-9} to 2×10^{-7} cm/sec. However, fracturing has not been demonstrated at moist sites or below the water table, only at dessicated sites. Clay sampling sites in the Wheatcroft Lake area did not show signs of dessication and were normally above the water table, although fracturing by freezing has probably occurred.

Another mechanism for the upward transport of ions is diffusion. Chemical diffusion involves diffusion down a concentration gradient. Smee (1979) predicted that cations of Zn^{2+}, Cu^{2+} and Na^{+} diffuse down a gradient a distance of about 200 cm in lacustrine sediments in 8000 years, however

Colville (1980) disputes Smee's calculations and estimates much lower rates of diffusion. Once the diffused ions reach the ground surface, they may accumulate in organic matter and thus be removed from the system, enhancing the concentration gradient. If the ions at the surface remain in solution, the concentration gradient will be destroyed and diffusion will halt (Smee, 1979).

Electrochemical migration occurs when two environments of differing Eh are connected by a natural conductor, causing a flow of electrons from the area of lower Eh to the area of higher Eh (Smee, 1983). If clay and till were directly overlying a sulphide ore body, then the sulphide ore conducts electrons from an area of low Eh at depth to an area of relatively higher Eh in the surficial environment. However, the Wheatcroft Lake samples are not known to directly overlie any ore zones.

One other method of upward ionic migration from till to overlying clay involves plants forcing their roots into the clay and even into the till. Roots have extremely high cation exchange capacities (Rose, et al., 1979, p. 459), and could not only transport ions to the surface but keep them there as well. This would be easier if the clay cover was relatively thin.

If trace elements in tills could be transported to the overlying glaciolacustrine sediments, then the possibility would exist for using glaciolacustrine sediments as a sampling medium for geochemical exploration. A survey of the literature reveals differences of opinion on this matter. Dreimanis (1960), and Lalonde and Beaumier (1984) have had some success using the overlying clay, while Gleeson and Hornbrook (1974) totally discount its use in at least one study area. Several factors may determine whether or not lacustrine sediments become geochemically enriched from below after deposition.

Lalonde and Beaumier (1984) found anomalous geochemical values in samples taken from the A1 horizon in soils on glaciolacustrine sediments. They suggested these anomalies may be attributable to the same sources which caused similar anomalous values in local groundwaters and till. They proposed that 70-90% of mineral targets found by geochemical sampling at depth could also by found by sampling the A1 soil horizon developed on glaciolacustrine clay. Suttner (1986) found sharp increases in the concentrations of Mn, Zn, Pb, Ni and Cu in this horizon in a section of Lake Agassiz clay. This horizon of the section contained 6-7 times the amount of organic carbon in lower parts of the section. This indicates that plants and other organic material cause the increased ion concentrations. Weathering and oxidation processes are strongest in this part of the section and break down mineral grains, releasing their trace elements. These ions are then scavenged onto the surfaces of roots and organic colloids. Root surfaces can have higher cation exchange capacities than clay minerals (Rose et al., 1979, p.197, Cation exchange capacities for humus and other soil organisms are also higher than for any phyllosilicate (Rose et al., 1979, p.197). These high exchange capacities prevent leaching of these trace elements, allowing for increased trace element concentrations in the clay fractions of this horizon.

In the present study, there are too few examples to make any firm conclusions about the usefulness of sampling Lake Agassiz clay as a guide to determining underlying till geochemistry. It appears that uranium and possibly zinc levels in till could be determined in this way, but a much larger survey would have to be carried out to be conclusive.

CHAPTER 5 - CONCLUSIONS

Grab samples of Wasekwan metasediments and metavolcanics, as well as pre-Sickle amphibolites, exhibit some relatively high trace element concentrations. These include values of gold at 1860 ppb, arsenic >8700 ppm, Fe 9.5%, Pb 181100 ppm, Cd 399 ppm, Ni at 259 ppm, Co 67 ppm and Ag 100 ppm. The rock sample with the greatest anomalous values was taken from a known mineral showing on the south shore of the Laurie River, east of Wheatcroft Lake.

From the <2 µm fraction of till, an area of high arsenic values is defined south of Wheatcroft Lake and Laurie River. Within the main, central anomalous zone, an area of approximately 34 km^2 is outlined by values above the 90th percentile value (<120 ppm).

For arsenic in the <63 µm fraction, a 50 km^2 zone of 90th percentile values has been outlined in the same area.

Dispersal trains for arsenic of approximately 8 km (<2 µm) and 10 km (<63 µm) are displayed within the larger anomalous region. These are considerably greater dispersal distances than have been previously determined for this part of Manitoba. Dispersal patterns for arsenic in both size fractions are parallel to sub-parallel to ice-flow direction. However, neither pattern represents a classic dispersal train as values do not simply decrease exponentially and actually sometimes increase in a down ice direction. The relatively large areas of anomalous values probably reflect the cumulative effect of a number of dispersal trains from a number of sources.

Topography has probably affected glacial dispersal in the area. Most anomalous zones are found below the 305 m level.

There does not appear to be any direct relationship between arsenic concentrations and any of the examined bedrock lithologies. Most anomalous zones are either within or down-ice from the BRMS transition zone. The rocks of this zone did not exhibit high arsenic values however, with the average being 19 ppm, even lower than the average for till.

The bulk of the anomalous areas are also within or down-ice of the metavolcanic units. The anomalies may be related to this rock type, however the average arsenic concentration for unit 2 rocks was found to be only 14 ppm, still well below the average for till.

Arsenic values in the coarser fraction are considerably lower than in the clay fraction. This reflects the dilution of trace elements by inert minerals such as quartz and feldspar in the silt fraction and the abundance of trace metal scavengers in the <2 μm fraction.

An area of high gold values in the silt fraction of till has also been outlined southwest of Wheatcroft Lake. In particular, a 56 km^2 zone within this area contains values above the 90th percentile value (11 ppb) and even the 95th percentile value (21 ppb). A dispersal train 7 km long is exhibited within the anomalous area.

The dispersal pattern for gold in the heavy mineral fraction is similar to that of gold in the finer fraction. In both cases, the overall dispersal is in the direction of ice–flow, and both patterns exhibit the effects of topography on glacial dispersal.

These anomalous gold values may be related to quartz veins as several of the sites within the 90th percentile range are located very close to granitic intrusions.

The scattered locations of highest concentration values for both gold and arsenic indicate that there are probably several source areas, as opposed to a single source or generally high background levels.

Gold dispersal in till is generally well reflected by arsenic dispersal in till. This is evidenced by the similarity of their respective dispersal patterns but not by correlation within individual samples.

Most gold grains are abraded, indicating transport distances of greater than 1 km. Some samples contain both abraded and delicate gold grains indicating possible different sources for gold.

Pebbles of the BRMS transition zone are found in relatively great abundance some 15 km from their source area.

Lake Agassiz clay is not an effective sampling medium for use as an exploration tool for trace elements in northwestern Manitoba. It may be that till trace element concentrations are reflected in the trace element concentration of overlying Lake Agassiz clay, by upward transport of ions from the till to the clay. However, uranium is the only element for which values in overlying Lake Agassiz clay appeared to reflect values in underlying till.

In conclusion, the pattern of gold and arsenic dispersal in the Wheatcroft Lake area does not indicate either a single source area or even a single lithological source. The patterns probably reflect multiple sources in a confined area. Areas of high concentration have been outlined, which may be used as a guide to further exploration. Gold mineralization may be associated with quartz veins as high gold values are often found close to granitic intrusions.

Hundreds of drift prospecting studies have been carried out and reported on in Scandinavia and Canada. However, many of these are on an experimental basis, defining glacial dispersal patterns from known source areas, usually to determine the effectiveness of this exploration technique in other local areas (DiLabio, 1979, 1982; Dreimanis, 1960; DiLabio and Shilts, 1977; MacEachern and Stea, 1985).

Many of these studies have enabled geologists to determine which component or size fraction of till displayed the most reliable glacial dispersal pattern for tracing back to source for a particular area. In this thesis, no knowledge of a known source was available beforehand. The effectiveness of this study will be more clearly established when the actual gold or arsenic source(s) is (are) located.

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APPENDICES

Appendix 1- Bedrock geochemistry

Atomic Adsorption, except where marked (C) colourimetry, and (NA) Neutron Activation. Units are ppm, except Fe (%), and Au (ppb).

Sample #	Rusty?	Rock Type	Unit	Cr	Mn	Fe	Co	Ni
	Y or N							
86 SDA 1R	N	Metasediment	1b	3	260	4.2	15	10
Duplicate				4	300	4.2	18	10
86 SDA 2R	N	Metasediment	1b	6	120	1.7	6	6
86 SDA 3R	N	Amphibole Schist	2a	48	430	4.6	11	16
86 SDA 4R	N	Amphibole Schist	2a	2	300	4.4	12	1
86 SDA 5R	Y	Amphibole Schist	2a	2	400	4.1	10	1
86 SDA 6R	Y	Amphibole Schist	2a	38	330	3.2	1	5
86 SDA 7R	Y	Amphibole Schist	2a	3	420	2.2	9	1
86 SDA 8R	N	Metavolcanic	2b	4	100	10	67	259
86 SDA 9R	N	Metavolcanic	2b	22	260	2.3	35	74
86 SDA 10R	N	Metavolcanic	2b	30	210	3.8	31	80
Duplicate				30	220	3.8	32	79
86 SDA 11R	Y	Amphibolite	3	6	150	9.3	12	14
86 SDA 12R	N	Amphibolite	3	90	310	3.6	16	33
86 SDA 13R	Y	Metasediment	1b	12	130	10	55	208
86 SDA 14R	N	Metavolcanic	2b	24	160	4	45	119
86 SDA 15R	N	Metasediment	1c	32	360	2.3	7	26
86 SDA 16R	N	Migmatite	14a	92	370	3.9	13	46
86 SDA 17R	N	Migmatite	14a	4	40	0.6	1	2
86 SDA 18R	N	Migmatite	14a	2	100	0.8	1	1
Duplicate				2	90	0.8	1	1
86 SDA 19R	N	Migmatite	14a	28	185	2	3	7
86 SDA 20R	N	Metasediment	1c	84	320	4	9	47
86 SDA 21R	N	Metasediment	1c	26	180	2	1	7
86 SDA 22R	N	Metasediment	1b	20	120	1.7	2	5
86 SDA 23R	N	Metasediment	1b	148	320	4	14	53
86 SDA 24R	N	Greywacke	1a	80	400	3.8	9	28
86 SDA 25R	N	Metasediment	1b	146	170	3.2	13	50
86 SDA 26R	N	Granulite Schist	7	3	70	0.8	1	1
86 SDA 27R	N	Granulite Schist	7	116	210	3.1	9	35
86 SDA 28R	N	Granulite Schist	7	29	140	1.7	3	8

Sample #	Rusty?	Rock Type	Unit	**Cr**	**Mn**	**Fe**	**Co**	**Ni**
	Y or N							
86 SDA 29R	Y	Granulite Schist	7	144	320	3.4	9	45
86 SDA 30R	Y	Granulite Schist	7	94	330	2.9	6	23
86 SDA 32R	N	Migmatite	14a	124	445	3.7	11	33
86 SDA 33R	N	Granulite Schist	7	28	230	2.1	1	6
86 SDA 35R	N	Granulite Schist	7	24	200	1.7	1	3
86 SDA 36R	N	Pegmatite	21	22	240	2	2	8
86 SDA 37R	N	Metasediment	1b	48	270	2.2	3	8
Duplicate				48	280	2.2	5	9
86 SDA 38R	Y	Metavolcanic	2b	2	30	1.2	1	1
86 SDA 39R	N	Granitoid Gneiss	9	144	315	3.5	11	37
86 SDA 40R	N	Amph-Plag Schist	8a	20	280	1.9	12	16
86 SDA 41R	Y	Amph-Plag Schist	8a	48	400	7.8	50	47
86 SDA 43R	N	Metasediment	1c	130	380	3.7	13	48
86 SDA 44R	N	Metasediment	5a	38	400	1.9	12	39

Sample #	Rusty?	Rock Type	Unit	**Cu**	**Zn**	**Mo**	**Ag**	**Cd**
	Y or N							
86 SDA 1R	N	Metasediment	1b	24	198	1	0.1	0.1
Duplicate				26	230	1	0.1	0.1
86 SDA 2R	N	Metasediment	1b	26	190	1	0.2	0.1
86 SDA 3R	N	Amphibole Schist	2a	46	74	1	0.1	0.1
86 SDA 4R	N	Amphibole Schist	2a	6	96	1	0.1	0.1
86 SDA 5R	Y	Amphibole Schist	2a	10	78	1	0.1	0.1
86 SDA 6R	Y	Amphibole Schist	2a	36	84	12	0.1	0.1
86 SDA 7R	Y	Amphibole Schist	2a	12	50	1	0.1	0.1
86 SDA 8R	N	Metavolcanic	2b	290	44	12	4.6	0.1
86 SDA 9R	N	Metavolcanic	2b	56	50	1	0.1	0.1
86 SDA 10R	N	Metavolcanic	2b	88	92	1	0.1	0.1
Duplicate				90	88	1	0.2	0.1
86 SDA 11R	Y	Amphibolite	3	11600	20000	10	100	399
86 SDA 12R	N	Amphibolite	3	60	810	4	2.3	1.8
86 SDA 13R	Y	Metasediment	1b	310	340	14	1.4	1.9
86 SDA 14R	N	Metavolcanic	2b	82	70	4	0.2	0.1
86 SDA 15R	N	Metasediment	1c	6	120	1	0.1	0.1
86 SDA 16R	N	Migmatite	14a	14	150	1	0.6	0.1
86 SDA 17R	N	Migmatite	14a	4	26	1	0.1	0.1
86 SDA 18R	N	Migmatite	14a	8	38	1	0.4	0.1

Sample #	Rusty?	Rock Type	Unit	Cu	Zn	Mo	Ag	Cd
	Y or N							
Duplicate				8	36	1	0.1	0.1
86 SDA 19R	N	Migmatite	14a	6	70	1	0.1	0.1
86 SDA 20R	N	Metasediment	1c	28	92	1	0.8	0.1
86 SDA 21R	N	Metasediment	1c	6	56	1	0.1	0.1
86 SDA 22R	N	Metasediment	1b	4	58	1	0.1	0.1
86 SDA 23R	N	Metasediment	1b	96	92	1	0.5	0.1
86 SDA 24R	N	Greywacke	1a	84	96	1	0.1	0.1
86 SDA 25R	N	Metasediment	1b	18	70	1	0.1	0.1
86 SDA 26R	N	Granulite Schist	7	2	48	1	0.1	0.1
86 SDA 27R	N	Granulite Schist	7	20	100	1	0.1	0.1
86 SDA 28R	N	Granulite Schist	7	10	50	1	0.1	0.1
86 SDA 29R	Y	Granulite Schist	7	12	88	1	0.1	0.1
86 SDA 30R	Y	Granulite Schist	7	38	104	1	0.1	0.1
86 SDA 32R	N	Migmatite	14a	12	134	1	0.2	0.1
86 SDA 33R	N	Granulite Schist	7	8	96	1	0.1	0.1
86 SDA 35R	N	Granulite Schist	7	6	98	1	0.2	0.1
86 SDA 36R	N	Pegmatite	21	20	156	6	0.1	0.1
86 SDA 37R	N	Metasediment	1b	12	84	1	0.1	0.1
Duplicate				12	80	1	0.1	0.1
86 SDA 38R	Y	Metavolcanic	2b	12	24	1	0.1	0.1
86 SDA 39R	N	Granitoid Gneiss	9	24	88	1	0.1	0.1
86 SDA 40R	N	Amph-Plag Schist	8a	26	32	1	0.1	0.1
86 SDA 41R	Y	Amph-Plag Schist	8a	530	112	2	0.1	0.1
86 SDA 43R	N	Metasediment	1c	8	74	1	0.1	0.1
86 SDA 44R	N	Metasediment	5a	12	108	1	0.1	0.1

					C	NA	NA
Sample #	Rusty?	Rock Type	Unit	Pb	As	Au	As
	Y or N						
86 SDA 1R	N	Metasediment	1b	32	20	150	20
Duplicate				34	17		
86 SDA 2R	N	Metasediment	1b	29	28	12	30
86 SDA 3R	N	Amphibole Schist	2a	4	2	4	2
86 SDA 4R	N	Amphibole Schist	2a	7	3	4	3
86 SDA 5R	Y	Amphibole Schist	2a	6	29	4	34
86 SDA 6R	Y	Amphibole Schist	2a	5	4	12	5
86 SDA 7R	Y	Amphibole Schist	2a	4	57	24	45

					C	NA	NA
Sample #	Rusty?	Rock Type	Unit	**Pb**	**As**	**Au**	**As**
	Y or N						
86 SDA 8R	N	Metavolcanic	2b	13	28	18	22
86 SDA 9R	N	Metavolcanic	2b	7	51	4	48
86 SDA 10R	N	Metavolcanic	2b	6	15	4	17
Duplicate				5	14		
86 SDA 11R	Y	Amphibolite	3	18100	2000	1860	8760
86 SDA 12R	N	Amphibolite	3	176	396	8	356
86 SDA 13R	Y	Metasediment	1b	47	22	32	18
86 SDA 14R	N	Metavolcanic	2b	9	6	7	5
86 SDA 15R	N	Metasediment	1c	7	10	4	8
86 SDA 16R	N	Migmatite	14a	12	6	41	7
86 SDA 17R	N	Migmatite	14a	6	45	4	43
86 SDA 18R	N	Migmatite	14a	10	3	4	4
Duplicate				7	4		
86 SDA 19R	N	Migmatite	14a	5	1	13	2
86 SDA 20R	N	Metasediment	1c	6	5	4	7
86 SDA 21R	N	Metasediment	1c	7	12	4	15
86 SDA 22R	N	Metasediment	1b	3	2	12	2
86 SDA 23R	N	Metasediment	1b	4	9	4	6
86 SDA 24R	N	Greywacke	1a	6	72	4	67
86 SDA 25R	N	Metasediment	1b	5	10	4	15
86 SDA 26R	N	Granulite Schist	7	8	4	4	6
86 SDA 27R	N	Granulite Schist	7	5	1	4	1
86 SDA 28R	N	Granulite Schist	7	5	1	11	1
86 SDA 29R	Y	Granulite Schist	7	9	1	4	1
86 SDA 30R	Y	Granulite Schist	7	6	1	5	2
86 SDA 32R	N	Migmatite	14a	6	1	4	1
86 SDA 33R	N	Granulite Schist	7	5	2	8	5
86 SDA 35R	N	Granulite Schist	7	5	2	4	1
86 SDA 36R	N	Pegmatite	21	8	2	4	2
86 SDA 37R	N	Metasediment	1b	14	26	4	27
Duplicate				19	26		
86 SDA 38R	Y	Metavolcanic	2b	7	55	18	72
86 SDA 39R	N	Granitoid Gneiss	9	4	65	5	54
86 SDA 40R	N	Amph-Plag Schist	8a	5	3	4	2
86 SDA 41R	Y	Amph-Plag Schist	8a	6	4	4	1
86 SDA 43R	N	Metasediment	1c	6	2	4	1
86 SDA 44R	N	Metasediment	5a	82	4	26	5

Appendix 2- Till geochemistry, <2 µm fraction

Atomic Adsorption, except As (colourimetry) and U (NA)

Sample #	Cr ppm	Mn ppm	Fe %	Co ppm	Ni ppm	Cu ppm
86 SDA 100	76	290	5.0	12	42	96
Duplicate	76	322	5.5	16	36	90
86 SDA 101	152	548	6.2	4	50	126
86 SDA 102	94	235	4.1	9	70	23
86 SDA 104	108	205	3.1	16	70	50
86 SDA 105	100	240	3.2	11	29	28
86 SDA 106	110	692	4.8	9	52	84
86 SDA 107	136	210	3.8	38	64	50
86 SDA 108	92	350	3.5	8	39	25
86 SDA 109	104	260	3.2	11	31	45
86 SDA 110	108	315	4.4	7	53	75
Duplicate	112	334	4.8	10	58	71
86 SDA 113	86	300	4.3	14	41	35
86 SDA 114	154	248	4.8	15	48	76
86 SDA 115	122	209	3.6	12	46	85
86 SDA 116	104	393	4.6	9	41	39
86 SDA 117	134	399	4.3	14	40	29
86 SDA 118	100	404	3.4	13	45	24
Duplicate	96	477	4.1	17	46	25
86 SDA 120	120	1010	5.8	23	64	125
86 SDA 121	88	314	4.2	15	42	48
86 SDA 122	122	667	4.9	19	66	206
86 SDA 123	96	285	4.1	13	40	36
86 SDA 132	108	319	3.8	12	54	35
86 SDA 133	134	279	4.3	9	69	50
86 SDA 134	132	384	4.4	18	70	73
86 SDA 135	94	606	4.4	16	63	116
Duplicate	88	635	4.4	20	65	117
86 SDA 136	98	889	4.8	34	71	205
86 SDA 137	92	581	5	20	54	82
86 SDA 139	94	548	4	16	49	69
86 SDA 143	112	217	4.7	8	35	67
86 SDA 144	68	444	4.8	18	49	82
86 SDA 145	82	480	6.7	13	43	42

Sample #	Cr ppm	Mn ppm	Fe %	Co ppm	Ni ppm	Cu ppm
Duplicate	84	509	6.7	13	47	44
86 SDA 146	78	308	3.6	10	43	22
86 SDA 147	60	650	3.1	20	39	52
86 SDA 148	128	280	5	15	47	99
86 SDA 149	118	297	4.1	6	42	103
86 SDA 150	136	314	4.1	10	41	94
86 SDA 151	110	220	4.1	12	42	61
86 SDA 152	64	223	3.2	19	36	28
86 SDA 153	110	158	6.8	7	37	75
Duplicate	104	173	7.2	11	40	79
86 SDA 154	80	272	3.2	13	40	37
86 SDA 155	152	267	4.2	7	52	106
86 SDA 156	130	134	9.5	1	23	172
86 SDA 157	76	273	3.7	11	48	94
86 SDA 158	104	373	5	7	73	225
86 SDA 159	92	265	4.4	13	70	276
86 SDA 160	94	311	4.4	16	63	177
86 SDA 162	100	339	3.2	14	46	41
86 SDA 163	84	283	2.9	10	41	28
86 SDA 164	104	280	3.5	11	51	94
86 SDA 165	84	278	3.4	16	42	27
86 SDA 166	100	266	3.4	17	73	55
86 SDA 167	92	275	3	5	39	24
86 SDA 168	116	289	4.4	12	53	80
86 SDA 169	230	319	5	13	79	61
86 SDA 170	160	197	4.1	16	78	173
Duplicate	164	201	4.1	12	77	177
86 SDA 171	80	364	3.4	18	41	18
86 SDA 172	128	324	8	12	51	68
86 SDA 173	156	379	4.2	17	66	113
86 SDA 174	92	346	3.7	14	42	23
86 SDA 175	176	179	4.8	11	53	75
86 SDA 176	200	315	4.7	22	99	98
86 SDA 177	52	152	1.2	8	24	36
86 SDA 178	126	499	4.1	21	66	48
86 SDA 179	130	679	5.3	28	72	97
Duplicate	134	672	5.2	25	74	96
86 SDA 180	92	428	4.1	14	57	51
86 SDA 181	112	242	3.4	18	43	77

Sample #	Cr ppm	Mn ppm	Fe %	Co ppm	Ni ppm	Cu ppm
86 SDA 182	98	277	3.1	10	44	36
86 SDA 183	112	312	3.6	15	46	82
86 SDA 184	112	304	4.2	15	47	70
86 SDA 185	134	372	4.9	17	59	87
86 SDA 186	90	334	6.4	12	38	29
86 SDA 187	162	389	4.8	19	69	119
Duplicate	158	452	5	18	73	123
86 SDA 188	116	338	4.3	11	45	63
86 SDA 189	180	238	4.4	8	69	122
86 SDA 190	148	382	4.4	13	87	110
86 SDA 191	142	397	4.3	12	63	99
86 SDA 192	118	393	3.8	12	52	57
86 SDA 193	128	415	3.8	12	56	21
86 SDA 194	116	289	3.6	16	48	65
86 SDA 195	106	327	4	13	46	54
86 SDA 196	98	233	2.9	4	43	84
86 SDA 197	120	333	2.9	12	52	106
86 SDA 198	146	299	3.7	16	46	85
86 SDA 199	100	553	4.9	14	48	60
86 SDA 201	148	284	3.5	16	59	89
86 SDA 202	100	280	3.8	13	51	64
86 SDA 203	134	478	5.3	22	68	82
86 SDA 204	164	487	4.9	20	89	187
Duplicate	164	460	5	22	86	185
86 SDA 205	98	374	3.8	15	57	66
86 SDA 206	120	259	4.2	16	58	154
86 SDA 207	120	478	3.6	20	55	62
86 SDA 208	112	297	4.3	17	47	85
86 SDA 209	128	236	4	18	44	55
86 SDA 210	130	454	4.9	25	65	82
86 SDA 211	76	324	3.4	14	44	27
86 SDA 212	112	312	4.8	16	66	129
86 SDA 213	98	357	3.6	16	49	51
Duplicate	88	261	3.7	16	52	53
86 SDA 214	134	242	4	13	64	112
86 SDA 216	92	387	4	12	49	43
86 SDA 218	96	552	4.4	18	57	61
86 SDA 219	72	599	3.1	18	60	73
86 SDA 220	84	219	4.7	12	44	69

Sample #	Cr ppm	Mn ppm	Fe %	Co ppm	Ni ppm	Cu ppm
86 SDA 221	70	709	4	19	44	440
Duplicate	66	767	4.3	19	46	414
86 SDA 222	72	335	3.8	16	38	32
86 SDA 223	56	469	3	11	33	24
86 SDA 228	90	1606	4.4	35	70	72
86 SDA 229	60	203	3.1	3	21	41
86 SDA 230	102	555	3.7	23	63	200
86 SDA 231	106	392	4.6	16	44	65
86 SDA 232	144	409	5.4	22	56	115
86 SDA 233	90	220	4.6	15	43	35
86 SDA 234	72	365	4.4	12	33	43
86 SDA 235	128	650	5.1	22	66	95
84 DDA 327	82	388	4.1		49	35
84 DDA 328	56	215	3		24	20
84 DDA 352	110	337	4.9		47	133
84 DDA 353	75	382	3.5		39	25
84 DDA 354	57	138	3.2		16	17
84 DDA 362	75	435	4.2		53	37
84 DDA 363	84	895	4		66	74
84 DDA 364	102	1467	4.2		83	91
84 DDA 365	88	397	3.8		55	36
84 DDA 366	70	292	4		29	18
84 DDA 382	90	185	4.5		42	50
84 DDA 383	122	600	4.6		78	107
84 DDA 384	72	215	2.8		34	40
84 DDA 385	78	300	3.6		38	13
84 DDA 386	74	530	4.4		50	66
84 DDA 393	70	300	3.3		36	39
84 DDA 394	98	975	5		57	63
84 DDA 395	144	600	5.7		56	62
84 DDA 396	170	480	4.7		98	170
84 DDA 409	127	335	5.4		66	58
84 DDA 410	101	269	5.6		41	54
84 DDA 411	92	390	6		40	47
84 DDA 412	110	725	4.7		55	54
87 SDA 1000	102	680	6.1	20	58	79
87 SDA 1001	56	130	2.1	6	29	33
87 SDA 1002	72	250	3.6	7	36	63
87 SDA 1003	42	110	2.1	4	18	46

Sample #	Cr ppm	Mn ppm	Fe %	Co ppm	Ni ppm	Cu ppm
87 SDA 1004	68	400	4.3	13	36	49
87 SDA 1005	60	140	2.5	4	19	45
87 SDA 1006	120	510	6.9	20	77	123
87 SDA 1007	84	270	5	19	61	70
87 SDA 1008	78	340	5.8	21	59	50
87 SDA 1009	70	270	4.6	15	52	90
87 SDA 1010	72	300	5	13	39	68
87 SDA 1011	72	280	4	12	44	60
87 SDA 1012	86	250	4.4	10	35	64
87 SDA 1013	78	300	4.3	12	42	88

Sample #	Zn ppm	Mo ppm	Ag ppm	Cd ppm	Pb ppm	As ppm	U ppm
86 SDA 100	128	1	0.2	0.1	16	28	3.3
Duplicate	138	2	0.1	0.1	14	28	3.3
86 SDA 101	154	2	0.1	0.1	8	34	7.0
86 SDA 102	93	1	0.1	0.1	12	27	2.5
86 SDA 104	87	1	0.1	0.1	9	24	3.5
86 SDA 105	99	2	0.1	0.1	15	6	3.1
86 SDA 106	167	0.5	0.1	0.1	12	33	3.0
86 SDA 107	60	2	0.1	0.1	10	14	4.0
86 SDA 108	101	1	0.1	0.1	13	5	3.7
86 SDA 109	83	2	0.1	0.1	12	6	6.4
86 SDA 110	155	0.5	0.1	0.1	13	20	4.3
Duplicate	155	0.5	0.1	0.1	15	21	
86 SDA 113	134	1	0.1	0.1	18	10	3.2
86 SDA 114	121	2	0.1	0.1	15	23	7.7
86 SDA 115	93	4	0.1	0.1	15	28	6.3
86 SDA 116	129	0.5	0.1	0.1	15	16	3.7
86 SDA 117	116	1	0.1	0.1	12	11	4.9
86 SDA 118	129	0.5	0.1	0.1	10	7	3.3
Duplicate	138	0.5	0.1	0.1	10	7	
86 SDA 120	269	1	0.1	0.3	9	81	3.7
86 SDA 121	115	1	0.1	0.1	19	33	23.5
86 SDA 122	338	3	0.1	0.1	21	178	13.1
86 SDA 123	118	1	0.1	0.1	16	40	2.8
86 SDA 132	106	1	0.1	0.1	9	34	3.7
86 SDA 133	145	4	0.2	0.1	14	130	3.3
86 SDA 134	145	1	0.1	0.1	16	125	3.5
86 SDA 135	188	0.5	0.3	0.1	17	58	3.9

Sample #	Zn ppm	Mo ppm	Ag ppm	Cd ppm	Pb ppm	As ppm	U ppm
Duplicate	191	0.5	0.1	0.1	21	62	
86 SDA 136	258	2	0.1	0.1	19	136	3.8
86 SDA 137	203	1	0.1	0.1	14	43	3.4
Duplicate							3.4
86 SDA 139	196	1	0.1	0.1	13	26	2.8
86 SDA 143	142	5	0.2	0.1	12	100	4.3
86 SDA 144	167	3	0.1	0.1	11	79	5.8
86 SDA 145	155	1	0.1	0.1	22	33	4.6
Duplicate	165	1	0.1	0.1	26	34	
86 SDA 146	100	1	0.1	0.1	13	11	3.3
86 SDA 147	120	6	0.1	0.1	9	20	4.0
86 SDA 148	98	4	0.1	0.1	13	95	5.1
86 SDA 149	134	4	0.1	0.1	16	7	13.0
86 SDA 150	131	4	0.1	0.1	15	5	13.0
86 SDA 151	113	3	0.1	0.1	18	14	10.7
86 SDA 152	92	1	0.3	0.1	15	9	3.1
86 SDA 153	107	6	0.1	0.1	20	110	5.3
Duplicate	118	6	0.2	0.1	20	104	
86 SDA 154	97	0.5	0.1	0.1	6	89	3.1
86 SDA 155	183	13	0.1	0.1	25	104	9.0
86 SDA 156	210	21	0.1	0.1	41	85	13.1
Duplicate							12.2
86 SDA 157	93	1	0.1	0.1	22	19	6.5
86 SDA 158	240	6	0.1	0.1	27	62	13.3
86 SDA 159	231	6	0.1	0.1	20	158	29.6
86 SDA 160	140	4	0.1	0.1	18	99	23.7
86 SDA 162	105	0.5	0.1	0.1	14	24	5.4
86 SDA 163	108	0.5	0.1	0.1	11	6	6.2
86 SDA 164	123	3	0.1	0.1	15	82	5.4
86 SDA 165	103	2	0.1	0.1	10	11	2.6
86 SDA 166	109	1	0.1	0.1	20	19	3.2
86 SDA 167	127	0.5	0.3	0.1	10	5	2.7
86 SDA 168	105	4	0.2	0.1	14	16	5.5
86 SDA 169	198	0.5	0.1	0.1	13	4	3.2
86 SDA 170	94	3	0.5	0.1	21	18	14.1
Duplicate	97	3	0.5	0.1	17	19	
86 SDA 171	158	0.5	0.2	0.1	12	6	2.7
86 SDA 172	147	6	0.1	0.1	19	29	12.7
86 SDA 173	191	4	0.1	0.1	16	119	4.5

Sample #	Zn ppm	Mo ppm	Ag ppm	Cd ppm	Pb ppm	As ppm	U ppm
86 SDA 174	118	0.5	0.1	0.1	15	17	2.5
Duplicate							2.7
86 SDA 175	130	4	0.4	<0.2	18	37	6.0
86 SDA 176	244	8	0.3	<0.2	22	151	5.1
86 SDA 177	92	0.5	0.1	<0.2	3	5	4.4
86 SDA 178	196	1	0.1	<0.2	18	6	34.9
86 SDA 179	219	1	0.1	<0.2	17	24	34.8
Duplicate	228	1	0.1	<0.2	18	25	
86 SDA 180	109	1	0.1	<0.2	20	23	3.3
86 SDA 181	118	2	0.1	<0.2	13	49	6.8
86 SDA 182	125	1	0.3	<0.2	21	9	4.2
86 SDA 183	103	2	0.1	<0.2	17	34	5.6
86 SDA 184	128	5	0.1	<0.2	27	18	4.3
86 SDA 185	148	3	0.1	<0.2	18	62	4.5
86 SDA 186	130	8	1.4	<0.2	40	15	2.9
86 SDA 187	146	1	0.1	<0.2	15	159	5.7
Duplicate	159	3	0.1	<0.2	18	163	
86 SDA 188	162	0.5	0.3	<0.2	14	56	3.8
86 SDA 189	113	2	0.1	<0.2	16	129	5.8
86 SDA 190	152	2	0.1	<0.2	20	100	5.0
86 SDA 191	132	1	0.1	<0.2	15	51	5.9
86 SDA 192	94	2	0.2	<0.2	15	57	4.6
Duplicate							4.7
86 SDA 193	122	1	0.1	0.1	15	14	2.7
86 SDA 194	113	1	0.1	0.1	14	17	5.0
86 SDA 195	104	0.5	0.1	0.1	13	43	4.8
86 SDA 196	80	2	0.7	0.1	15	51	6.0
86 SDA 197	143	2	0.2	0.1	14	83	5.9
86 SDA 198	116	2	0.1	0.1	12	83	5.9
86 SDA 199	204	0.5	0.1	0.1	11	22	7.6
86 SDA 201	132	2	0.2	0.1	17	95	6.3
86 SDA 202	97	1	0.1	0.1	17	78	3.8
86 SDA 203	160	1	0.1	0.1	14	106	3.1
86 SDA 204	182	4	0.4	0.1	20	227	5.7
Duplicate	184	4	0.1	0.1	19	236	
86 SDA 205	123	2	0.1	0.1	13	52	9.2
86 SDA 206	129	3	0.1	0.1	12	182	5.6
86 SDA 207	164	1	0.1	0.1	8	28	5.0
86 SDA 208	123	2	0.1	0.1	13	85	4.6

Sample #	Zn ppm	Mo ppm	Ag ppm	Cd ppm	Pb ppm	As ppm	U ppm
86 SDA 209	91	1	0.1	0.1	7	48	2.9
86 SDA 210	159	6	0.1	0.1	15	128	13.3
Duplicate							13.1
86 SDA 211	102	1	0.1	0.1	15	14	2.8
86 SDA 212	133	2	0.1	0.1	12	135	6.6
86 SDA 213	103	2	0.1	0.1	19	31	4.5
Duplicate	105	1	0.1	0.1	17	30	
86 SDA 214	109	2	0.1	0.1	8	90	6.1
86 SDA 216	116	0.5	0.1	0.1	10	38	3.3
86 SDA 218	115	1	0.1	0.1	13	45	5.2
86 SDA 219	128	2	0.1	0.1	12	65	4.3
86 SDA 220	74	3	0.3	0.1	14	21	6.9
86 SDA 221	149	1	0.1	0.1	15	6	7.0
Duplicate	157	1	0.1	0.1	18	6	
86 SDA 222	97	1	0.1	0.1	16	6	3.7
86 SDA 223	85	1	0.1	0.1	9	3	2.8
86 SDA 228	228	1	0.1	0.1	9	7	6.5
Duplicate				0.1			6.5
86 SDA 229	55	5	0.1	0.1	18	11	18.5
86 SDA 230	145	1	0.1	0.1	12	5	9.0
86 SDA 231	120	1	0.1	0.1	13	29	18.8
86 SDA 232	147	2	0.1	0.1	15	34	5.4
86 SDA 233	80	1	0.1	0.1	12	10	2.4
86 SDA 234	112	3	0.1	0.1	10	9	12.8
86 SDA 235	202	2	0.3	0.1	18	7	25.9
84 DDA 327	111				5	4	
84 DDA 328	69				5	5	
84 DDA 352	112				12	12	
84 DDA 353	94				7	2	
84 DDA 354	49				19	11	
84 DDA 362	125				9	3	
84 DDA 363	165				9	5	
84 DDA 364	248				8	22	
84 DDA 365	134				11	4	
84 DDA 366	102				14	4	
84 DDA 382	76				20	17	
84 DDA 383	210				14	75	
84 DDA 384	76				10	69	
84 DDA 385	96				14	1	

Sample #	Zn ppm	Mo ppm	Ag ppm	Cd ppm	Pb ppm	As ppm	U ppm
84 DDA 386	180				12	13	
84 DDA 393	76				16	42	
84 DDA 394	184				17	5	
84 DDA 395	148				14	47	
84 DDA 396	152				20	31	
84 DDA 409	112				21	42	
84 DDA 410	96				15	41	
84 DDA 411	105				20	20	
84 DDA 412	195				14	6	
87 SDA1000	175	1	0.1	0.1	13	12	
87 SDA1001	63	1	0.1	0.1	5	6	
87 SDA1002	90	1	0.1	0.1	14	53	
87 SDA1003	45	1	0.1	0.1	4	53	
87 SDA1004	105	1	0.1	0.1	19	15	
87 SDA1005	47	1	0.1	0.1	17	69	
87 SDA1006	218	1	0.1	0.1	20	120	
87 SDA1007	125	2	0.1	0.1	12	175	
87 SDA1008	133	2	0.1	0.1	27	115	
87 SDA1009	100	1	0.1	0.1	13	205	
87 SDA1010	100	2	0.1	0.1	18		
87 SDA1011	92	1	0.1	0.1	8		
87 SDA1012	90	2	0.1	0.1	10	73	
87 SDA1013	100	1	0.1	0.1	6	36	

Appendix 3- Till geochemistry, <63 μm fraction

Neutron Activation

Sample #	As ppm	Au ppb	Sample #	As ppm	Au ppb
86 SDA 100	5.5	3	86 SDA 191	13.0	5
86 SDA 101	8.5	1	86 SDA 192	6.5	1
86 SDA 102	15.0	4	86 SDA 193	4.5	8
86 SDA 104	22.0	6	86 SDA 194	7.6	4
86 SDA 105	2.0	5	86 SDA 195	11.0	5
86 SDA 106	8.5	1	86 SDA 196	10.0	6
86 SDA 107	1.8	10	86 SDA 197	16.0	4
86 SDA 108	1.9	3	86 SDA 198	14.0	8
86 SDA 109	2.2	4	86 SDA 199	8.5	5
86 SDA 110	13.0	2	86 SDA 201	26.0	17
86 SDA 113	4.5	1	86 SDA 202	27.0	7
86 SDA 114	3.5	6	86 SDA 203	27.0	10
86 SDA 115	6.7	6	86 SDA 204	37.0	10
86 SDA 116	6.1	6	86 SDA 205	14.0	12
86 SDA 117	4.5	1	86 SDA 206	22.0	7
86 SDA 118	3.5	4	86 SDA 207	13.0	4
86 SDA 120	10.0	3	86 SDA 208	13.0	8
86 SDA 121	27.0	6	86 SDA 209	16.0	4
86 SDA 122	36.0	4	86 SDA 210	13.0	6
86 SDA 123	15.0	1	86 SDA 211	7.6	1
86 SDA 132	22.0	6	86 SDA 212	21.0	5
86 SDA 133	21.0	3	86 SDA 213	15.0	6
86 SDA 134	18.0	1	86 SDA 214	14.0	34
86 SDA 135	16.0	5	86 SDA 216	16.0	11
86 SDA 136	19.0	3	86 SDA 218	15.0	8
86 SDA 137	12.0	1	86 SDA 219	10.0	8
			86 SDA 220	3.0	6
86 SDA 139	12.0	8	86 SDA 221	3.2	5
86 SDA 143	17.0	1	86 SDA 222	4.4	4
86 SDA 144	11.0	4	86 SDA 223	2.5	7
86 SDA 145	4.8	4	86 SDA 228	3.4	4
86 SDA 146	3.7	4	86 SDA 229	3.0	1
86 SDA 147	4.8	1	86 SDA 230	2.7	1
86 SDA 148	17.0	8	86 SDA 231	6.2	4

Sample #	As ppm	Au ppb	Sample #	As ppm	Au ppb
86 SDA 149	1.5	3	86 SDA 232	5.0	6
86 SDA 150	1.0	1	86 SDA 233	4.3	44
86 SDA 151	1.8	1	86 SDA 234	1.8	1
86 SDA 152	2.5	15	86 SDA 235	2.8	11
86 SDA 153	34.0	4	84 DDA 327	4.7	3
86 SDA 154	35.0	3	84 DDA 328	3.6	4
86 SDA 155	16.0	7	84 DDA 352		
86 SDA 156	31.0	21	84 DDA 353		
86 SDA 157	4.1	5	84 DDA 354		
86 SDA 158	11.0	7	84 DDA 362	4.2	3
86 SDA 159	20.0	9	84 DDA 363	3.3	1
86 SDA 160	15.0	5	84 DDA 364	6.0	1
86 SDA 162	8.4	8	84 DDA 365	3.6	3
86 SDA 163	2.8	6	84 DDA 366	2.1	5
86 SDA 164	4.6	1	84 DDA 382	12.0	8
86 SDA 165	15.0	7	84 DDA 383	17.0	8
86 SDA 166	3.3	3	84 DDA 384	6.6	1
86 SDA 167	2.2	4	84 DDA 385	1.1	1
86 SDA 168	4.4	9	84 DDA 386	4.3	4
86 SDA 169	0.9	1	84 DDA 393	7.9	2
86 SDA 170	2.5	5	84 DDA 394	2.3	1
86 SDA 171	1.4	3	84 DDA 395	7.2	27
86 SDA 172	8.0	5	84 DDA 396	3.6	1
86 SDA 173	11.0	5	84 DDA 409	5.2	29
86 SDA 174	6.1	1	84 DDA 410	9.4	69
86 SDA 175	6.4	6	84 DDA 411	5.8	1
86 SDA 176	25.0	7	84 DDA 412	3.0	7
86 SDA 177	2.1	1	87 SDA 1000		4
86 SDA 178	3.5	1	87 SDA 1001		6
86 SDA 179	5.9	4	87 SDA 1002		16
86 SDA 180	7.2	1	87 SDA 1003		9
86 SDA 181	12.0	5	87 SDA 1004		6
86 SDA 182	4.0	2	87 SDA 1005		24
86 SDA 183	18.0	5	87 SDA 1006		1
86 SDA 184	8.4	5	87 SDA 1007		12
86 SDA 185	18.0	19	87 SDA 1008		29
86 SDA 186	17.0	8	87 SDA 1009		4
86 SDA 187	29.0	11	87 SDA 1010		2
86 SDA 188	13.0	8	87 SDA 1011		3

Sample #	**As ppm**	**Au ppb**	**Sample #**	**As ppm**	**Au ppb**
86 SDA 189	18.0	8	87 SDA 1012		3
86 SDA 190	41.0	6	87 SDA 1013		2

Appendix 4- Gold in heavy mineral fraction

Neutron Activation, NA = Not Analysed

Sample #	Au ppb	Sample #	Au ppb	Sample #	Au ppb
86 SDA 100	5	86 SDA 167	270	86 SDA 220	90
86 SDA 101	5	86 SDA 168	60	86 SDA 221	10
86 SDA 102	5	86 SDA 169	40	86 SDA 222	10
86 SDA 104		86 SDA 170	240	86 SDA 223	5
86 SDA 105	20	86 SDA 171	10	86 SDA 228	10
86 SDA 106	5	86 SDA 172	10	86 SDA 229	5
86 SDA 107	5	86 SDA 173	40	86 SDA 230	5
86 SDA 108	80	86 SDA 174	5	86 SDA 231	5
86 SDA 109	10	86 SDA 175	5	86 SDA 232	280
86 SDA 110	10	86 SDA 176	110	86 SDA 233	5
86 SDA 113	2900	86 SDA 177	60	86 SDA 234	
86 SDA 114	5	86 SDA 178	205	86 SDA 235	10
86 SDA 115	190	86 SDA 179	120	84 DDA 327	NA
86 SDA 116	5	86 SDA 180	20	84 DDA 328	NA
86 SDA 117	5	86 SDA 181	120	84 DDA 352	NA
86 SDA 118	420	86 SDA 182	5	84 DDA 353	NA
86 SDA 120	40	86 SDA 183	60	84 DDA 354	NA
86 SDA 121	10	86 SDA 184	640	84 DDA 362	NA
86 SDA 122	50	86 SDA 185	120	84 DDA 363	NA
86 SDA 123	50	86 SDA 186	250	84 DDA 364	NA
86 SDA 132	90	86 SDA 187	5	84 DDA 365	NA
86 SDA 133	5	86 SDA 188	430	84 DDA 366	NA
86 SDA 134	5	86 SDA 189	120	84 DDA 382	NA
86 SDA 135	5	86 SDA 190	80	84 DDA 383	NA
86 SDA 136	40	86 SDA 191	360	84 DDA 384	NA
86 SDA 137	30	86 SDA 192	5	84 DDA 385	NA
86 SDA 139	5	86 SDA 193	20	84 DDA 386	NA
86 SDA 143	5	86 SDA 194	10	84 DDA 393	NA
86 SDA 144	5	86 SDA 195	520	84 DDA 394	NA
86 SDA 145	5	86 SDA 196	5	84 DDA 395	NA
86 SDA 146	5	86 SDA 197	5	84 DDA 396	NA
86 SDA 147	5	86 SDA 198	5	84 DDA 409	NA
86 SDA 148	5	86 SDA 199	25	84 DDA 410	NA
86 SDA 149	80	86 SDA 201	700	84 DDA 411	NA

Sample #	Au ppb	Sample #	Au ppb	Sample #	Au ppb
86 SDA 150	300	86 SDA 202	270	84 DDA 412	NA
86 SDA 151		86 SDA 203	1720	87 SDA 1000	40
86 SDA 152	5	86 SDA 204	420	87 SDA 1001	140
86 SDA 153		86 SDA 205	80	87 SDA 1002	30
86 SDA 154	80	86 SDA 206	270	87 SDA 1003	620
86 SDA 155	5	86 SDA 207	5	87 SDA 1004	60
86 SDA 156	10	86 SDA 208	10	87 SDA 1005	20
86 SDA 157	5	86 SDA 209	5	87 SDA 1006	295
86 SDA 158	50	86 SDA 210	5	87 SDA 1007	350
86 SDA 159	50	86 SDA 211		87 SDA 1008	70
86 SDA 160	5	86 SDA 212	5	87 SDA 1009	110
86 SDA 162		86 SDA 213	100	87 SDA 1010	65
86 SDA 163		86 SDA 214	5	87 SDA 1011	20
86 SDA 164		86 SDA 216	180	87 SDA 1012	510
86 SDA 165	390	86 SDA 218		87 SDA 1013	16
86 SDA 166	5	86 SDA 219	5		

Appendix 5- Visible gold

Sample #	Diameter (µm)	Thickness (µm)	Abr.	Irr.	Del.	Total
86 SDA 100	No Visible Gold		0	0	0	0
86 SDA 101	No Visible Gold		0	0	0	0
86 SDA 102	No Visible Gold		0	0	0	0
86 SDA 105	No Visible Gold		0	0	0	0
86 SDA 106	No Visible Gold		0	0	0	0
86 SDA 107	No Visible Gold		0	0	0	0
86 SDA 108	No Visible Gold		0	0	0	0
86 SDA 109	No Visible Gold		0	0	0	0
86 SDA 110	No Visible Gold		0	0	0	0
86 SDA 113	No Visible Gold		0	0	0	0
86 SDA 114	No Visible Gold		0	0	0	0
86 SDA 115	No Visible Gold		0	0	0	0
86 SDA 116	No Visible Gold		0	0	0	0
86 SDA 117	No Visible Gold		0	0	0	0
86 SDA 118	No Visible Gold		0	0	0	0
86 SDA 120	No Visible Gold		0	0	0	0
86 SDA 121	No Visible Gold		0	0	0	0
86 SDA 122	No Visible Gold		0	0	0	0
86 SDA 123	50 x 50	10	1	0	0	1
86 SDA 132	No Visible Gold		0	0	0	0
86 SDA 133	No Visible Gold		0	0	0	0
86 SDA 134	25 x 100	13	0	0	1	
86 SDA 134	100 x 150	25	1	0	0	2
86 SDA 135	No Visible Gold		0	0	0	0
86 SDA 136	No Visible Gold		0	0	0	0
86 SDA 137	No Visible Gold		0	0	0	0
86 SDA 139	No Visible Gold		0	0	0	0
86 SDA 143	No Visible Gold		0	0	0	0
86 SDA 144	No Visible Gold		0	0	0	0
86 SDA 145	No Visible Gold		0	0	0	0
86 SDA 146	No Visible Gold		0	0	0	0
86 SDA 147	No Visible Gold		0	0	0	0
86 SDA 148	No Visible Gold		0	0	0	0
86 SDA 150	No Visible Gold		0	0	0	0
86 SDA 151	No Visible Gold		0	0	0	0

Sample #	Diameter (µm)	Thickness (µm)	Abr.	Irr.	Del.	Total
86 SDA 149	No Visible Gold		0	0	0	0
86 SDA 152	No Visible Gold		0	0	0	0
86 SDA 153	No Visible Gold		0	0	0	0
86 SDA 154	No Visible Gold		0	0	0	0
86 SDA 155	125 x 150	27	1	0	0	1
86 SDA 156	No Visible Gold		0	0	0	0
86 SDA 157	No Visible Gold		0	0	0	0
86 SDA 158	No Visible Gold		0	0	0	0
86 SDA 159	No Visible Gold		0	0	0	0
86 SDA 160	No Visible Gold		0	0	0	0
86 SDA 165	No Visible Gold		0	0	0	0
86 SDA 166	No Visible Gold		0	0	0	0
86 SDA 167	No Visible Gold		0	0	0	0
86 SDA 168	No Visible Gold		0	0	0	0
86 SDA 169	No Visible Gold		0	0	0	0
86 SDA 170	No Visible Gold		0	0	0	0
86 SDA 171	No Visible Gold		0	0	0	0
86 SDA 172	No Visible Gold		0	0	0	0
86 SDA 173	No Visible Gold		0	0	0	0
86 SDA 174	No Visible Gold		0	0	0	0
86 SDA 175	75 x 75	15	1	0	0	1
86 SDA 176	No Visible Gold		0	0	0	0
86 SDA 177	No Visible Gold		0	0	0	0
86 SDA 178	No Visible Gold		0	0	0	0
86 SDA 179	75 x 100	18	1	0	0	1
86 SDA 180	No Visible Gold		0	0	0	0
86 SDA 181	No Visible Gold		0	0	0	0
86 SDA 182	No Visible Gold		0	0	0	0
86 SDA 183	No Visible Gold		0	0	0	0
86 SDA 184	No Visible Gold		0	0	0	0
86 SDA 185	200 x 325	48	1	0	0	1
86 SDA 186	No Visible Gold		0	0	0	0
86 SDA 187	No Visible Gold		0	0	0	0
86 SDA 188	No Visible Gold		0	0	0	0
86 SDA 189	No Visible Gold		0	0	0	0
86 SDA 190	No Visible Gold		0	0	0	0
86 SDA 191	No Visible Gold		0	0	0	0
86 SDA 192	No Visible Gold		0	0	0	0
86 SDA 193	No Visible Gold		0	0	0	0

Sample #	Diameter (µm)	Thickness (µm)	Abr.	Irr.	Del.	Total
86 SDA 194	No Visible Gold		0	0	0	0
86 SDA 195	No Visible Gold		0	0	0	0
86 SDA 196	No Visible Gold		0	0	0	0
86 SDA 197	No Visible Gold		0	0	0	0
86 SDA 198	100 x 150	25	1	0	0	1
86 SDA 199	No Visible Gold		0	0	0	0
86 SDA 201	No Visible Gold		0	0	0	0
86 SDA 202	No Visible Gold		0	0	0	0
86 SDA 203	75 x 250	31	1	0	0	1
86 SDA 204	No Visible Gold		0	0	0	0
86 SDA 205	No Visible Gold		0	0	0	0
86 SDA 206	No Visible Gold		0	0	0	0
86 SDA 207	No Visible Gold		0	0	0	0
86 SDA 208	No Visible Gold		0	0	0	0
86 SDA 209	No Visible Gold		0	0	0	0
86 SDA 210	No Visible Gold		0	0	0	0
86 SDA 212	No Visible Gold		0	0	0	0
86 SDA 213	No Visible Gold		0	0	0	0
86 SDA 214	100 x 125	22	1	0	0	1
86 SDA 216	25 x 150	8	1	0	0	
86 SDA 216	75 x 125	20	0	0	1	2
86 SDA 218	No Visible Gold		0	0	0	0
86 SDA 219	No Visible Gold		0	0	0	0
86 SDA 220	No Visible Gold		0	0	0	0
86 SDA 221	No Visible Gold		0	0	0	0
86 SDA 222	No Visible Gold		0	0	0	0
86 SDA 223	No Visible Gold		0	0	0	0
86 SDA 228	No Visible Gold		0	0	0	0
86 SDA 229	No Visible Gold		0	0	0	0
86 SDA 230	No Visible Gold		0	0	0	0
86 SDA 231	No Visible Gold		0	0	0	0
86 SDA 232	75 x 125	18	0	0	1	1
86 SDA 233	No Visible Gold		0	0	0	0
86 SDA 234	No Visible Gold		0	0	0	0
86 SDA 235	No Visible Gold		0	0	0	0
87 SDA 1000	No Visible Gold		0	0	0	0
87 SDA 1001	25 x 75	10	1	0	0	
87 SDA 1001	75 x 125	20	1	0	0	2
87 SDA 1002	25 x 25	5	2	3	0	

Sample #	Diameter (µm)	Thickness (µm)	Abr.	Irr.	Del.	Total
7 SDA 1002	50 x 50	10	2	0	0	
87 SDA 1002	50 x 75	13	2	0	0	
87 SDA 1002	25 x 75	10	1	1	0	11
87 SDA 1003	25 x 25	5	2	1	1	
87 SDA 1003	75 x 125	20	1	0	0	
87 SDA 1003	100 x 150	25	2	0	0	
87 SDA 1003	75 x 75	75	0	0	1	8
87 SDA 1004	No Visible Gold		0	0	0	0
87 SDA 1005	50 x 100	15	1	0	0	
87 SDA 1005	50 x 50	10	0	0	1	
87 SDA 1005	50 x 75	13	1	0	0	
87 SDA 1005	125 x 150	27	1	0	0	
87 SDA 1005	25 x 25	5	4	0	0	8
87 SDA 1006	75 x 75	15	1	0	0	1
87 SDA 1007	75 x 150	22	1	0	0	1
87 SDA 1008	No Visible Gold		0	0	0	0
87 SDA 1009	No Visible Gold		0	0	0	0
87 SDA 1010	No Visible Gold		0	0	0	0
87 SDA 1011	No Visible Gold		0	0	0	0
87 SDA 1012	75 x 150	22	1	0	0	1
Totals			34	5	6	45

Appendix 6- Lake Agassiz clay geochemistry

Atomic Adsorption except (C) colourimetry, and (NA) Neutron Activation

Sample #	Cr ppm	Mn ppm	Fe %	Co ppm	Ni ppm
86 SDA 111	116	401	4.2	11	50
86 SDA 112	96	417	4.2	13	42
86 SDA 119	100	434	3.6	13	40
86 SDA 124	76	677	4.6	15	42
86 SDA 125	64	733	4	14	40
86 SDA 126	76	529	4.1	15	46
86 SDA 127	88	376	4.6	10	42
86 SDA 128	78	304	3.4	10	37
86 SDA 129	92	377	3.2	10	38
86 SDA 130	88	383	3.7	10	41
86 SDA 131	90	533	3.6	12	21
86 SDA 140	82	606	4.2	13	50
86 SDA 141	90	333	3.7	12	43
86 SDA 142	84	645	3.7	21	40
86 SDA 200	114	470	4.3	7	51
86 SDA 215	76	347	3.2	17	41
86 SDA 217	84	399	84	15	46
86 SDA 224	88	502	4.2	16	52
86 SDA 225	84	572	4.1	16	59
86 SDA 226	76	439	4	16	48
86 SDA 227	76	466	4.3	18	47
86 SDA 111	35	131	1	0.1	0.1
86 SDA 112	24	116	1	0.1	0.2
86 SDA 119	20	146	1	0.1	0.1
86 SDA 124	36	134	1	0.1	0.1
86 SDA 125	32	106	1	0.1	0.1
86 SDA 126	36	112	1	0.1	0.1
86 SDA 127	35	100	1	0.2	0.1
86 SDA 128	30	89	1	0.1	0.1
86 SDA 129	30	100	1	0.1	0.1
86 SDA 130	27	97	1	0.1	0.1
86 SDA 131	20	106	3	0.1	0.1
86 SDA 141	30	128	1	0.2	0.1
86 SDA 142	21	151	1	0.3	0.1

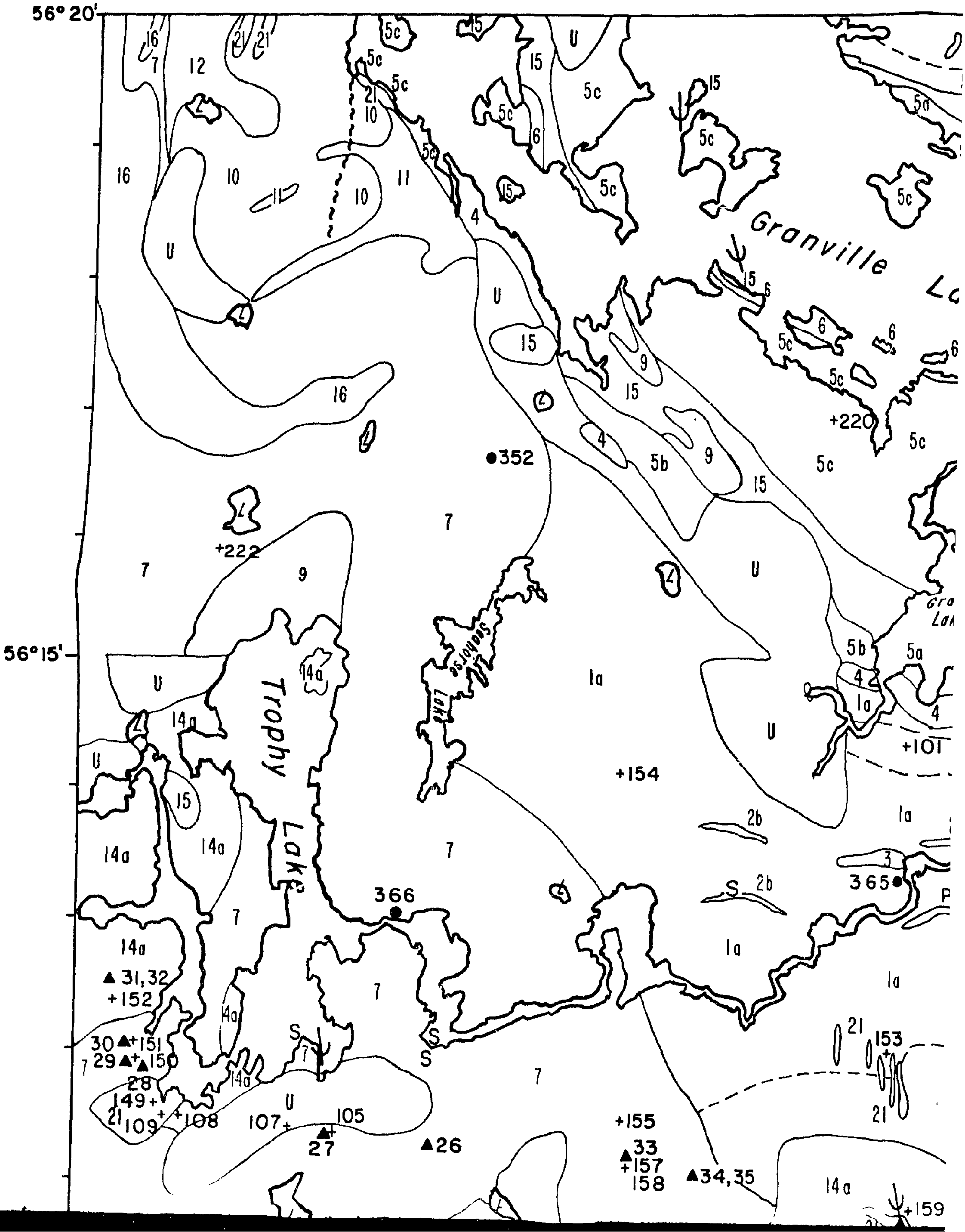
Sample #	**Cu ppm**	**Zn ppm**	**Mo ppm**	**Ag ppm**	**Cd ppm**
86 SDA 140	39	115	1	0.1	0.1
86 SDA 200	54	143	1	0.1	0.1
86 SDA 215	21	102	1	0.1	0.1
86 SDA 217	28	100	1	0.1	0.1
86 SDA 224	50	177	1	0.1	0.1
86 SDA 225	40	127	1	0.1	0.1
86 SDA 226	36	109	1	0.1	0.1
86 SDA 227	29	116	1	0.2	0.1
		C	NA	NA	NA
Sample #	**Pb ppm**	**As ppm**	**U ppm**	**As ppm**	**Au ppb**
86 SDA 111	12	8	2.8	3.5	4
86 SDA 112	11	5	2.5	2.1	3
86 SDA 119	9	7	3.1	3.2	2
86 SDA 124	14	6	2.9	4.3	21.3
86 SDA 125	14	7	2.4	5.3	24.5
86 SDA 126	13	6	2.7	5.2	25.6
86 SDA 127	12	6	2.8	5.6	27.3
86 SDA 128	12	4	3.3	5.7	30.1
86 SDA 129	13	4	3.6	5.8	31.3
86 SDA 130	12	4	3.2	4	25
86 SDA 131	12	4	3	3.7	22.7
86 SDA 140	17	9	3.2	7.9	23.8
86 SDA 141	13	7	3.3	6.4	27.6
86 SDA 142	16	5	2.7	2.8	1
86 SDA 200	13	23	4.9	8.1	1
86 SDA 215	13	6	1.9	4	1
86 SDA 217	14	9	2.7	6.1	8
86 SDA 224	15	6	3.1	3.7	4
86 SDA 225	15	6	2.9	5.6	1
86 SDA 226	11	6	2.9	5.6	1
86 SDA 227	16	6	2.5	4.8	1

Appendix 7- Pebble counts

Sample #	Unit 1 %	Unit 7 %	Fels. Intr. %	Other %
86 SDA 100	29.05	0	22.93	48.02
86 SDA 101	40.96	8.31	20.22	30.5
86 SDA 102	36.45	3.74	32.3	27.51
86 SDA 104	57.13	0	27.72	15.15
86 SDA 105	0	0	80.9	19.1
86 SDA 106	26.22	8.34	31.29	34.16
86 SDA 107	0.64	1	62.27	36.09
86 SDA 108	4.89	1.6	74.96	18.55
86 SDA 109	10.09	3.27	74.39	12.26
86 SDA 110	4.24	4.89	61.09	29.77
86 SDA 113	37.54	8.16	38.07	16.23
86 SDA 114	15.66	10.65	37.95	35.74
86 SDA 115	11.61	22.29	46.11	20
86 SDA 116	18.13	0	50.76	31.1
86 SDA 117	5.34	14.22	41.07	39.37
86 SDA 118	31.25	14.1	36.53	18.12
86 SDA 120	33.17	4.75	26.8	35.28
86 SDA 121	34.34	0	44.36	21.31
86 SDA 122	77.6	1.94	4.99	15.46
86 SDA 123	67.1	0.92	7.54	24.44
86 SDA 132	53.04	0	36.07	10.89
86 SDA 133	68.53	0.75	20.05	10.66
86 SDA 134	45.79	3.11	26.18	24.92
86 SDA 135	35.05	0	33.33	31.63
86 SDA 136	75.75	0	7.08	17.17
86 SDA 137	42.97	0	14.96	42.07
86 SDA 139	16.86	4.71	39.73	38.69
86 SDA 143	33.81	0	15.81	50.39
86 SDA 144	89.58	0	3.7	6.72
86 SDA 145	28.42	0	31.23	40.35
86 SDA 146	33.61	0	26.94	39.45
86 SDA 147	40.29	0	26.66	33.05
86 SDA 148	23.86	14.64	10.64	50.85
86 SDA 150	3.76	76.89	12.74	6.61
86 SDA 151	0	2.62	65.35	32.04

Sample #	**Unit 1 %**	**Unit 7 %**	**Fels. Intr. %**	**Other %**
86 SDA 152	5.02	1.73	50.78	42.47
86 SDA 153	34.97	0	48.15	16.88
86 SDA 154	16.15	4.97	25.64	53.23
86 SDA 155	16.43	9.51	34.92	39.15
86 SDA 156	2.75	0	42.38	54.87
86 SDA 157	14.6	0	43.66	41.74
86 SDA 158	5.86	14.99	34.2	44.95
86 SDA 159	8.27	0	43.48	48.24
86 SDA 160	28.2	3.67	22.83	45.3
86 SDA 162	0	0	22.3	77.7
86 SDA 163	41.06	0	20.68	38.26
86 SDA 164	8.49	7.64	29.66	54.22
86 SDA 165	0	11.47	29.31	59.22
86 SDA 166	25.7	15.17	36.02	23.11
86 SDA 168	3.67	0.86	49.98	45.49
86 SDA 169	6.3	6.28	86.58	0.85
86 SDA 170	27.47	0.91	57.63	13.99
86 SDA 171	4.83	3.36	61.21	30.61
86 SDA 172	33.96	0	36.15	29.9
86 SDA 173	23.95	39.62	21.9	14.53
86 SDA 174	28.86	6.89	28.26	35.99
86 SDA 175	28.53	10.12	50.58	10.78
86 SDA 176	1.82	52.15	18.98	27.04
86 SDA 177	28.03	7.49	37.84	26.63
86 SDA 178	7.26	0	81.62	11.13
86 SDA 179	4.6	5.21	47.43	42.76
86 SDA 180	19.23	0.93	50.45	29.38
86 SDA 181	4.56	12.29	49.44	33.7
86 SDA 182	8.71	5.78	57.39	28.12
86 SDA 183	24.84	0	41.9	33.26
86 SDA 184	2.36	8.29	76	13.35
86 SDA 185	6.72	7.09	24.37	61.82
86 SDA 186	77.39	0	22.61	0
86 SDA 187	13.26	53.97	6.94	25.83
86 SDA 188	2.03	11.11	39.02	47.84
86 SDA 189	22.08	31.67	15.37	30.89
86 SDA 190	44.75	0	40.63	14.61
86 SDA 191	9.04	6.53	41.47	42.97
86 SDA 192	12.69	8.3	64.62	14.4

Sample #	Unit 1 %	Unit 7 %	Fels. Intr. %	Other %
86 SDA 193	5.18	15.52	30.82	48.47
86 SDA 194	20.6	4.44	59.35	15.61
86 SDA 195	12.57	22.74	52.08	12.61
86 SDA 196	9.03	1.23	66.31	23.43
86 SDA 197	8.32	18.21	59.32	14.15
86 SDA 198	7.94	8.95	23.05	60.08
86 SDA 199	5.64	0	89.56	4.8
86 SDA 201	13.5	4.64	21.37	60.49
86 SDA 202	15.62	33.57	19.62	31.19
86 SDA 203	9.25	36.92	23.22	30.61
86 SDA 204	5.16	30.89	22.5	41.46
86 SDA 205	15.76	7.89	28.41	47.94
86 SDA 206	14.78	3.43	13.65	68.14
86 SDA 207	27.47	0.91	57.63	13.99
86 SDA 208	15.2	3.68	28.06	53.04
86 SDA 209	35.34	26.66	19.9	18.1
86 SDA 210	33.73	15.31	22.94	28.02
86 SDA 211	2.45	0	97.55	0
86 SDA 212	41.1	0	32.03	26.88
86 SDA 213	31.65	9.45	33.29	25.61
86 SDA 214	14.01	5.19	11.89	68.91
86 SDA 216	38.42	10.36	19.69	31.53
86 SDA 218	45.61	3.22	41.95	9.23
86 SDA 219	66.94	0	6.11	26.95
86 SDA 220	20.11	0	45.83	34.06
86 SDA 221	5.43	2.05	10.01	82.5
86 SDA 222	9.68	0	66.85	23.47
86 SDA 223	7.97	0	28.74	63.29
86 SDA 228	24.71	1.14	23.05	51.1
86 SDA 229	17.34	0	58.99	23.68
86 SDA 230	16.98	0	17.29	65.73
86 SDA 231	4.52	5.78	46.02	43.68
86 SDA 232	0	16.53	51.95	31.52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Trophy Lake
Seahorse Lake
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+222
●366
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+220
+154
+101
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+152
30▲+151
29▲+▲150
28
149+
109+
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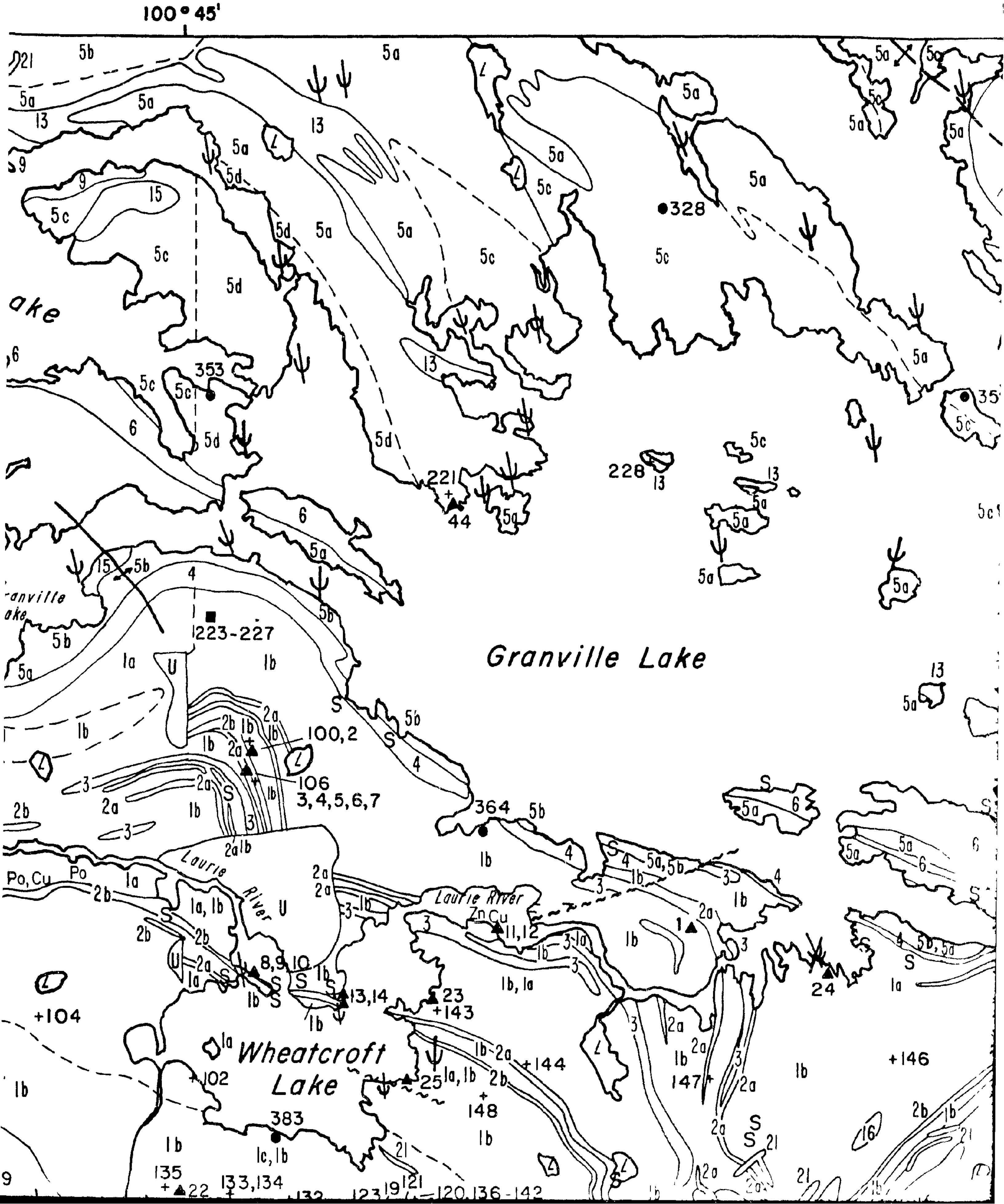
+159



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Laurie River
Laurie River
Wheatcroft Lake
Zn Cu
Po, Cu
Po
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4
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21
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328
353
221
44
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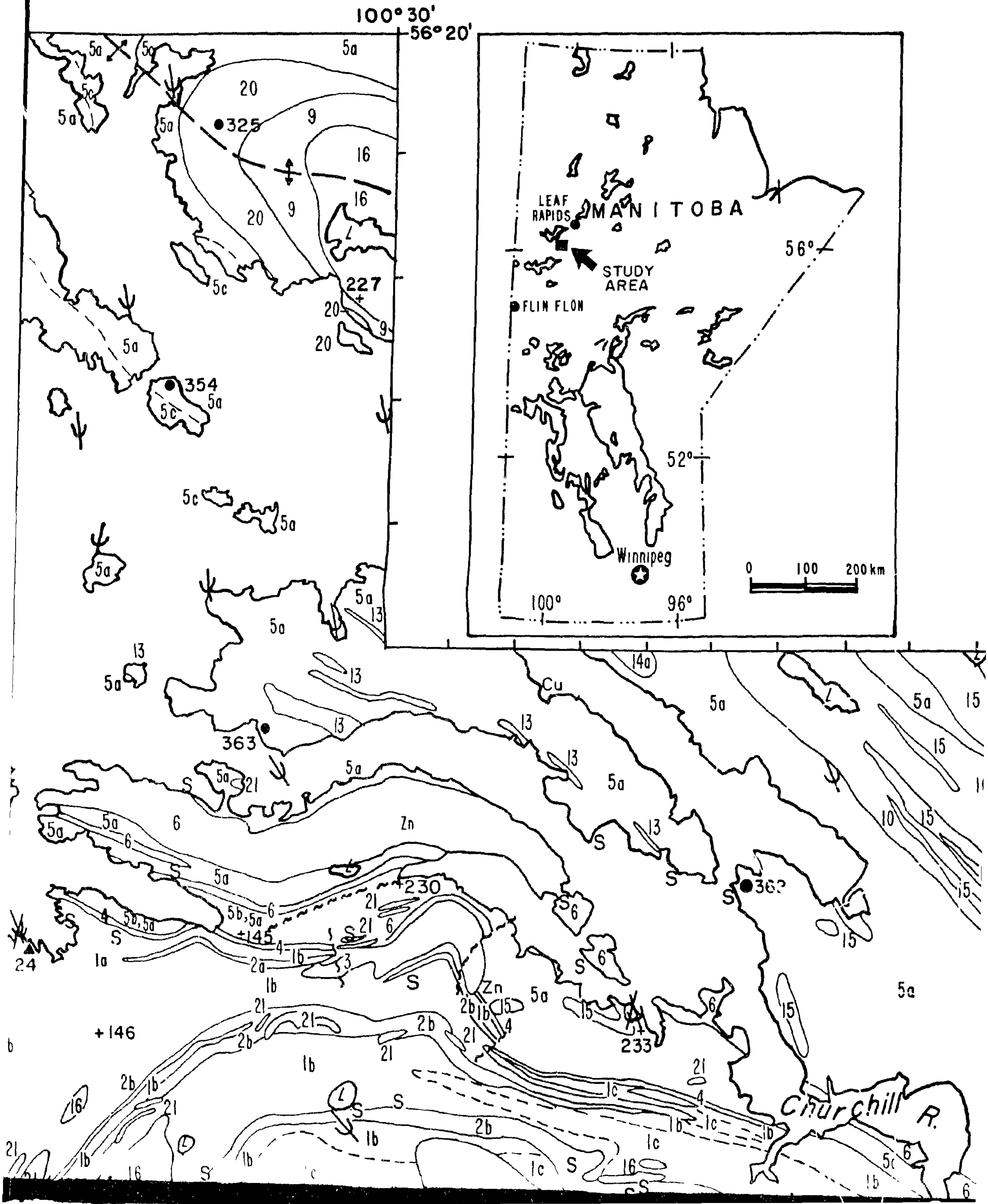
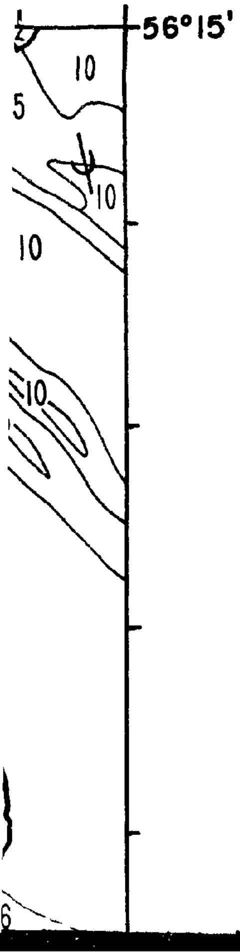
120
136-142


100° 30'
56° 20'
MANITOBA
LEAF RAPIDS
STUDY AREA
FLIN FLON
Winnipeg
56°
52°
100°
96°
0
100
200 km
325
227
354
363
230
+145
24
+146
233
362
Cu
Zn
Churchill R.
5a
5b, 5a
5c
6
9
13
14a
15
16
20
21
1a
1b
1c
2a
2b
3
4
10
S

Symbols

— ----	Geological boundary (approximate between subunits)
∿∿ ∿	Fault
┼ ╪	Fold axes (anticline, syncline)
Au, Po, Cu, Zn	Gold, pyrrhotite, chalcopyrite, sphalerite
S	Sulfides
↓	Glacial striae
U	Unmapped
L	Lake

+	*1986 till*	■	*clay and till*
●	*1984 till*	▲	*rock*

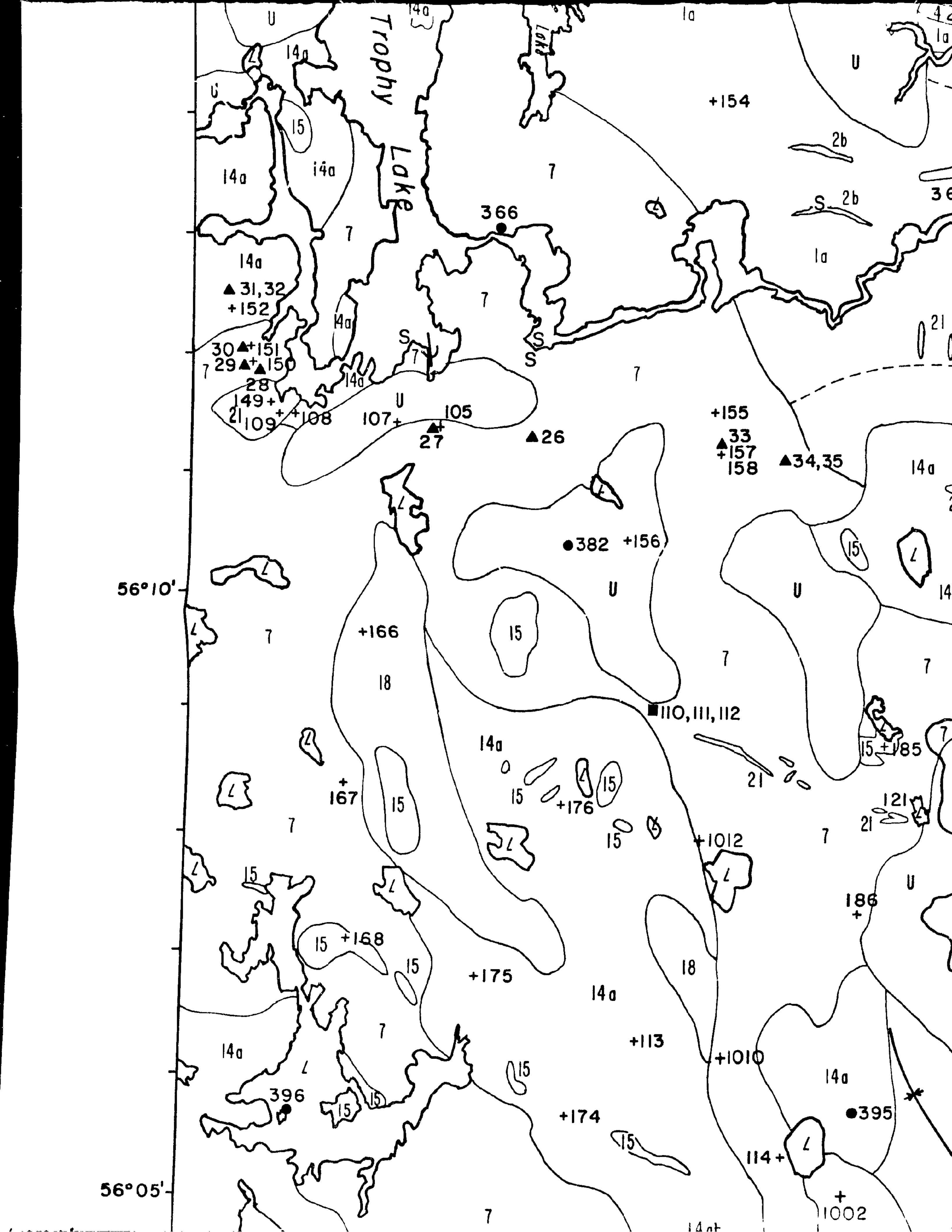


LEGEND

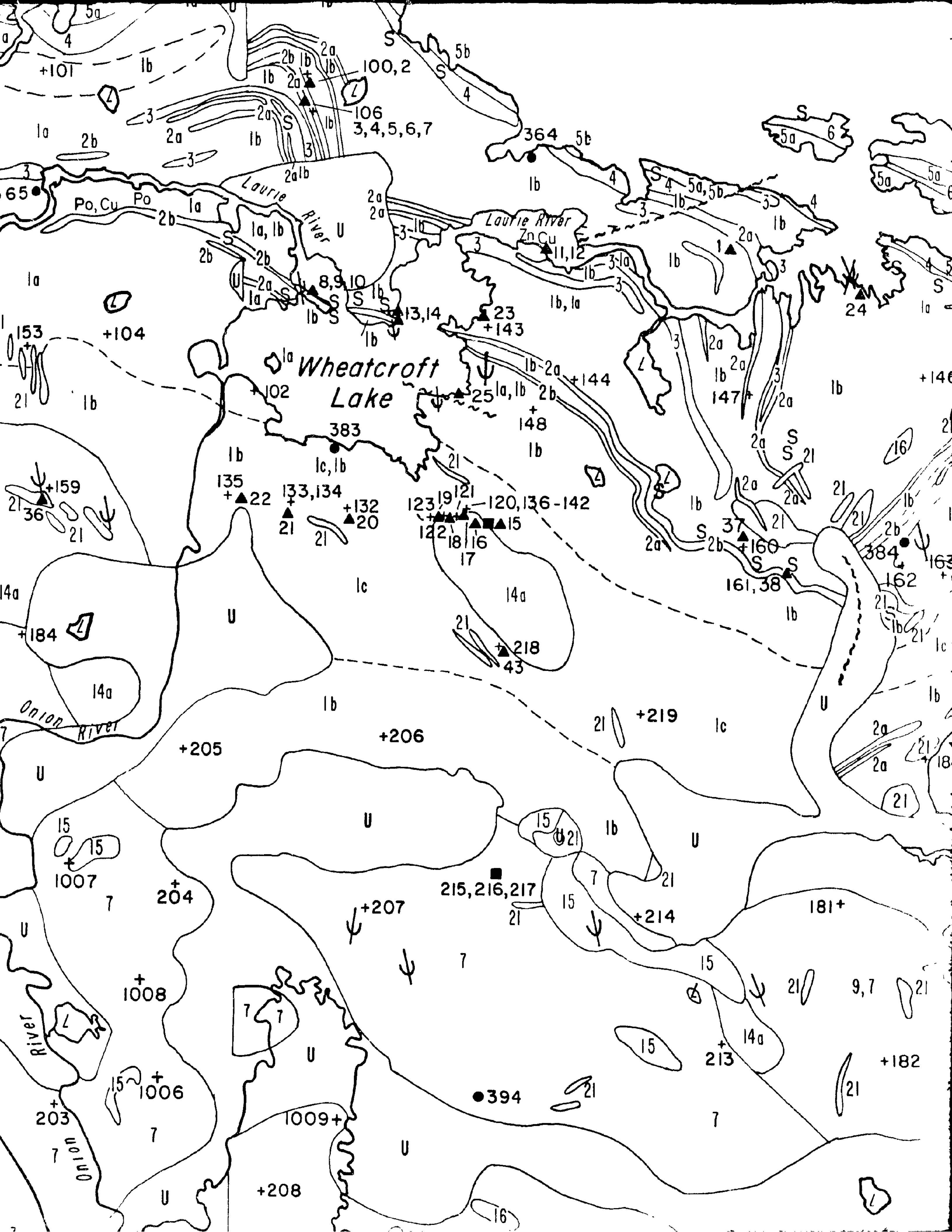
PRECAMBRIAN

Intrusive Rocks

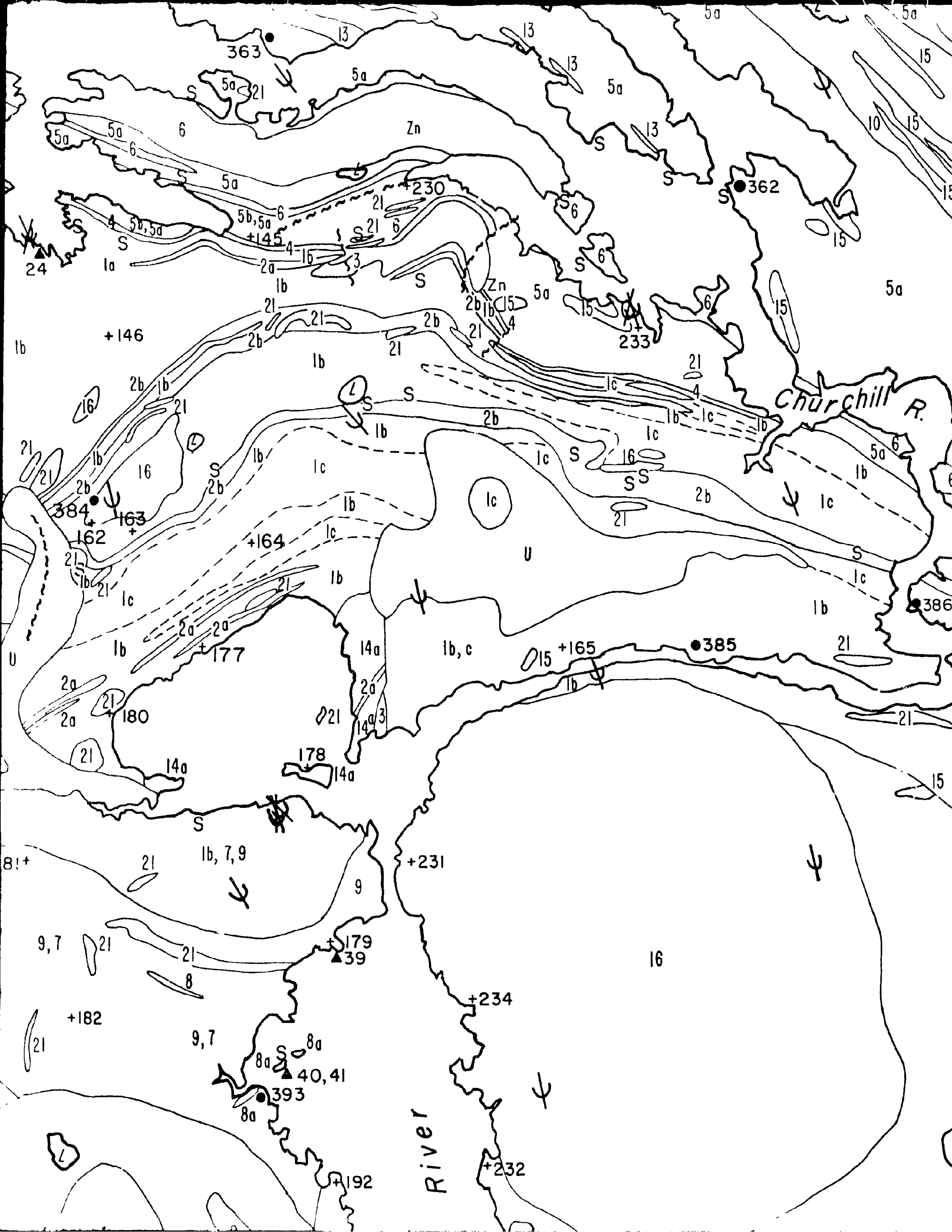
21	Pegmatite
20	Pegmatite with remnant inclusions of Sickle meta-arenites
19	Foliated granodiorite-tonalite
18	Granitoid migmatite
17	Pyroxene hornblende granite
16	Massive grey granodiorite
15	Grey and pink granite and granodiorite, chiefly massive
14a	Migmatite (schists and gneisses with more than 30% granitic inclusions
14b	Migmatite containing pyroxene-hornblende granite



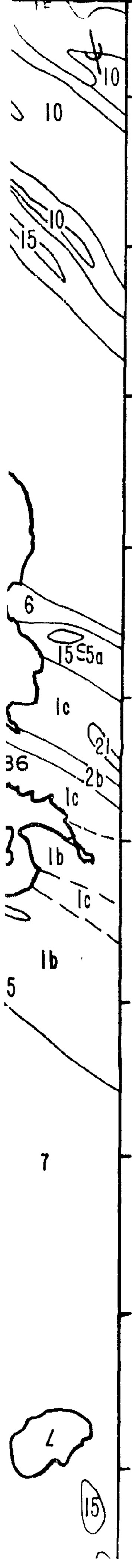
Trophy Lake
Lake
56°10'
56°05'
U
14a
1a
2b
7
15
18
21
S
+154
366
▲31,32
+152
30▲+151
29▲+▲150
28
149+
109
+108
107+
105
▲27
▲26
+155
▲33
+157
158
▲34,35
●382
+156
+166
■110,111,112
+185
121
+167
+176
+1012
186
+168
+175
+113
+1010
●395
396
+174
114+
+1002



Wheatcroft Lake
Laurie River
Laurie River
Onion River
Onion River
Po, Cu
Po
Zn Cu
100,2
106
3,4,5,6,7
364
+101
65
8,9,10
13,14
23
+143
11,12
1
24
153
+104
+102
25
+144
148
147
+146
383
Ic, Ib
+159
36
135
22
133,134
21
+132
20
123
19
121
120,136-142
122
18
16
17
15
37
+160
161,38
384
162
163
+184
218
43
+219
+205
+206
15
1007
204
215,216,217
+207
+214
181+
1008
9,7
213
+182
1006
203
394
1009+
+208
Ia
Ib
Ic
2a
2b
3
4
5a
5b
6
S
U
7
14a
15
16
21



363
13
5a
5a
21
S
6
Zn
5a
6
S
5a
5b, 5a
6
+230
21
6
S
21
4
5b, 5a
S
+145
4
1b
3
1a
2a
1b
S
24
2b
1b
15
5a
4
Zn
15
233
5a
13
13
13
5a
S
S
S
362
6
S
6
S
6
15
10
15
15
15
15
5a
+146
1b
21
21
2b
21
2b
21
1b
2b
1b
21
16
16
21
21
1b
S
S
1b
2b
1c
1b
1c
S
16
S
S
21
2b
1c
1b
1c
1b
5a
6
Churchill R.
21
4
2b
S
2b
384
163
162
1c
+164
1b
1c
1c
U
21
1b
21
1c
21
1b
1b
1c
S
386
1b
2a
2a
1b
177
U
14a
1b, c
15
+165
385
21
1b
2a
2a
21
180
2a
21
14a
3
21
21
15
21
178
14a
14a
S
81+
21
1b, 7, 9
9
+231
9, 7
21
21
179
39
8
16
+234
+182
9, 7
21
8a
S
8a
40, 41
393
8a
River
+232
+192



PRECAMBRIAN

Intrusive Rocks

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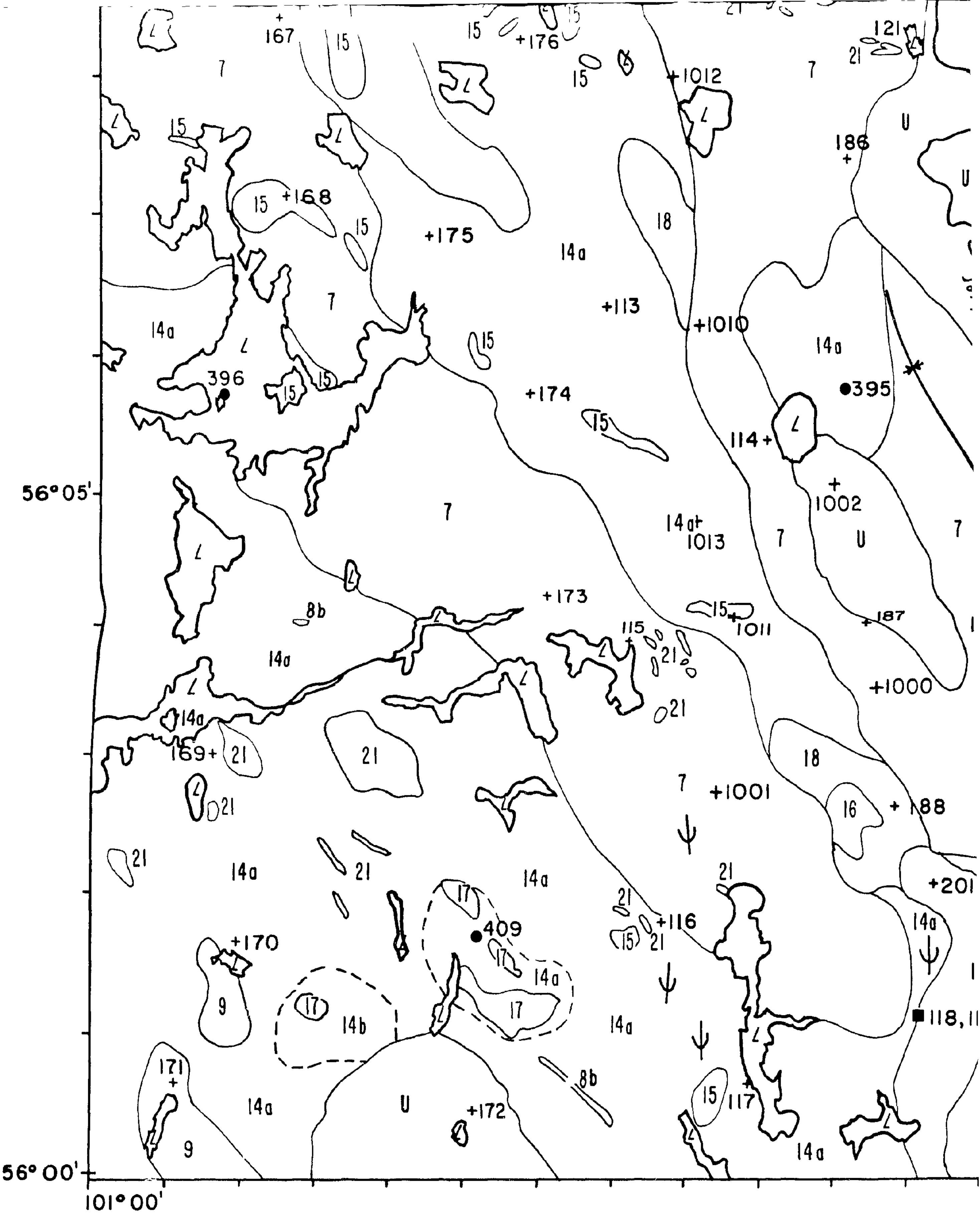
15	Grey and pink granite and granodiorite, chiefly massive
14a	Migmatite (schists and gneisses with more than 30% granitic inclusions
14b	Migmatite containing pyroxene-hornblende granite
13	Hornblende gabbro, Black Trout diorite

Schists, Gneisses, and Granulites derived from Wasekwan and Sickle Rocks

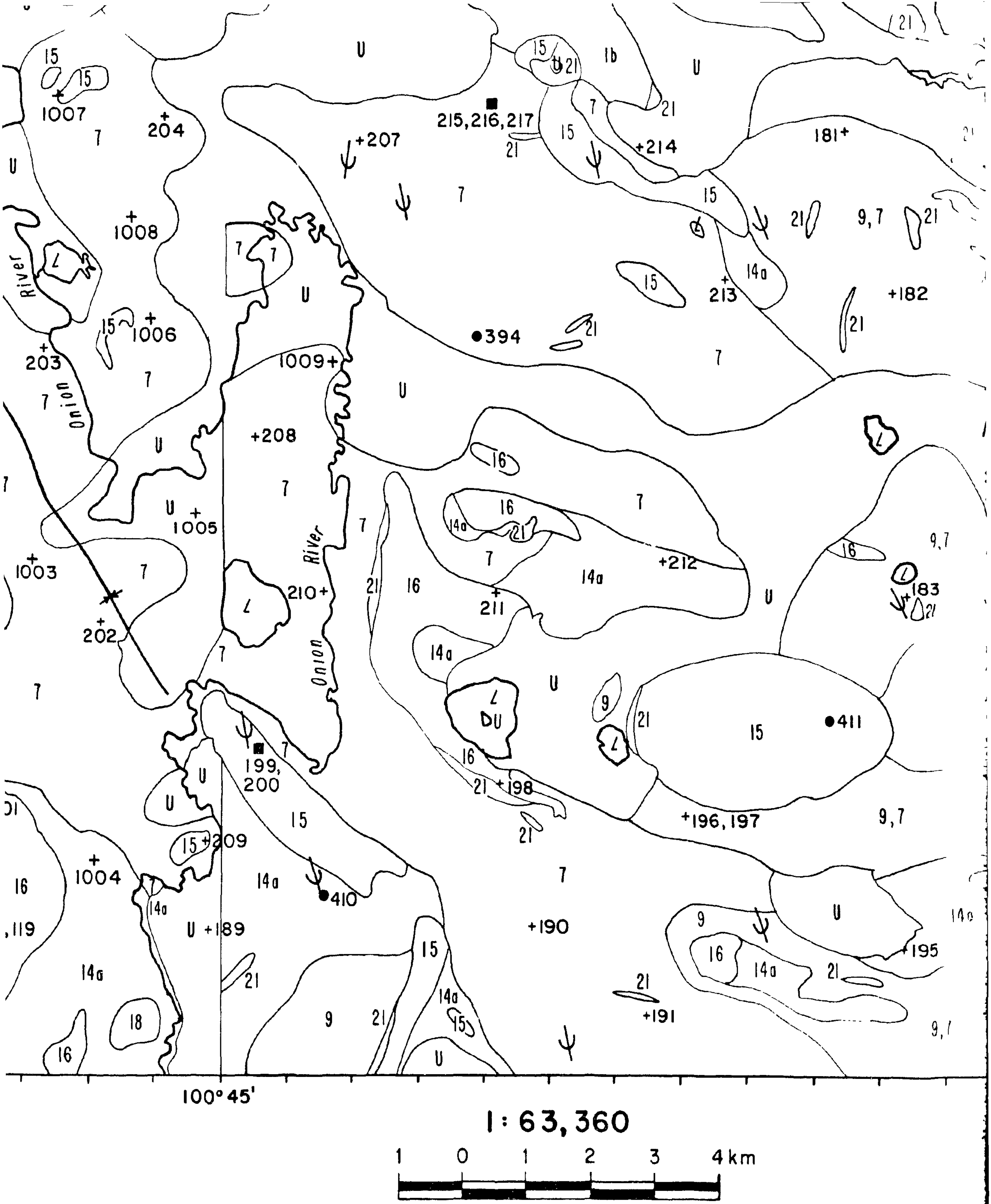
12	Quartzo-feldspathic paragneiss, *in part granitized*
11	Fragmental schists probably derived from sickle conglomerate
10	Granulite, schist, and paragneiss derived from Sickle meta-sediments
9	Granitoid gneiss, lit-par-lit gneiss
8a	Amphibole plagioclase schist and gneiss
8b	Amphibolite, pyroxene amphibolite derived from 2b and 3
7	Granulite schist derived from Wasekwan rocks

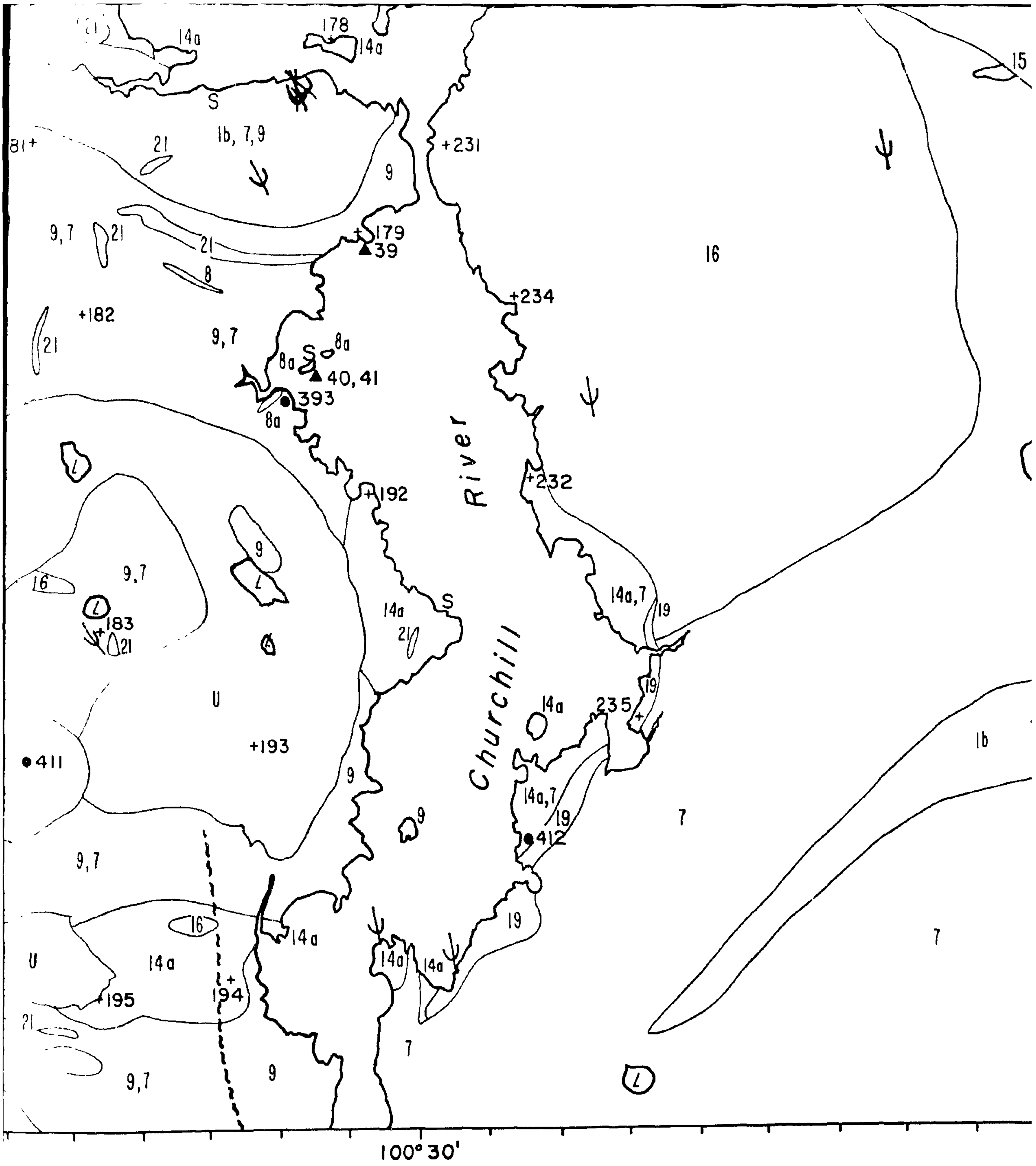
Sickle Series

6	Meta-Volcanics: hornblende-plagioclase schists
5a	Quartzo-feldspathic meta-sediments (mainly arkosic, locally arenitic), schists
5b	Quartzo-feldspathic meta-sediments, with calc-silicate material

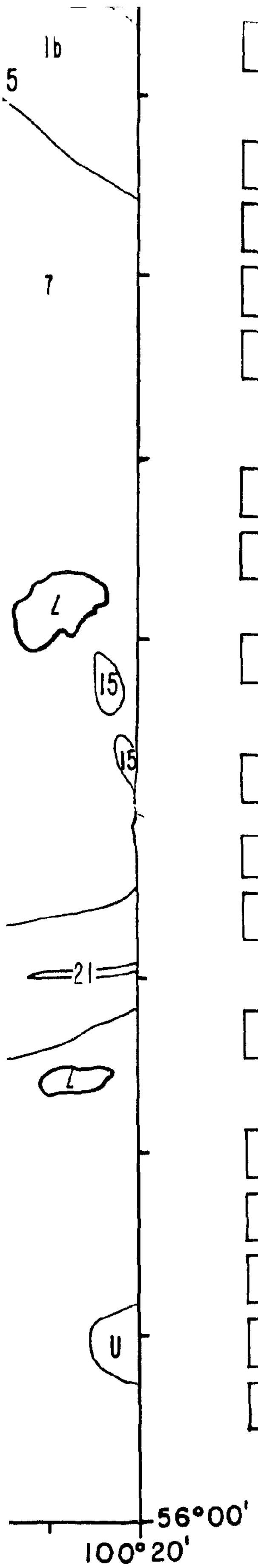


Compiled from: Barry and Gait; Pollock; Godard; Cranstone; Barry; and Baldwin.


Onion River
Onion River
100°45'
1:63,360
1 0 1 2 3 4 km
U
7
15
14a
16
18
9
9,7
21
1b
L
DU
215,216,217
199, 200
394
410
411
1007
204
1008
1006
203
1009
208
1005
1003
202
210
211
212
207
214
181
213
182
183
198
196,197
209
1004
189
190
191
195
119



21
14a
178
14a
15
S
1b, 7, 9
81+
21
+231
9
9,7
21
21
+179
39
16
8
+182
+234
9,7
21
S
8a
8a
40, 41
393
8a
River
L
+232
+192
9
9,7
16
L
L
183
21
14a
S
14a,7
19
21
Churchill
U
19
14a
235
1b
411
+193
9
14a,7
9
19
7
412
9,7
19
7
16
14a
U
14a
14a
14a
+
194
+195
21
7
9,7
9
L
100°30'



10	Granulite, schist, and paragneiss derived from Sickle meta-sediments
9	Granitoid gneiss, lit-par-lit gneiss
8a	Amphibole plagioclase schist and gneiss
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	Sickle Series
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5a	Quartzo-feldspathic meta-sediments (mainly arkosic, locally arenitic), schists
5b	Quartzo-feldspathic meta-sediments, with calc-silicate material
5c	Arkosic meta-sediments and schists containing quartz-muscovite and sillimonite knots
5d	Meta-arkose, granitoid meta-arkose
4	Conglomerate
	Pre-Sickle Intrusive Rocks
3	Hornblende gabbro, amphibolite, diorite
	BRMS Transition Zone Rocks
2a	Well banded amphibolitic schists (probably tuffs)
2b	Meta-volcanics, amphibole-plagioclase rocks and schists
1a	Greywacke
1b	Fine grained, micaceous meta-sediments
1c	Fine grained, mica poor quartzo-feldspathic meta-sediments

Fig 2. Bedrock geology, striations, and sample locations.