THE MINERAL DEPOSITS POTENTIAL OF THE MARGUERITE RIVER AND FORT McKAY AREAS, NORTHEAST ALBERTA (NTS 74E)

MDA PROJECT M93-04-038

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THE MINERAL DEPOSITS POTENTIAL OF THE MARGUERITE RIVER AND FORT McKAY AREAS, NORTHEAST ALBERTA (NTS 74E)

SUMMARY

This report provides a preliminary assessment of the potential for metallic mineral deposits in the Precambrian, Devonian and Cretaceous rocks in the Marguerite River and Fort McKay areas of northeastern Alberta. The field portion of this study focused on the geological examination and geochemical sampling of selected bedrock exposures. However, in order to supplement the poor bedrock exposure and to test for a possible relationship between gold and discharging brines in the Bitumount map area, selected core from coal exploration drillholes was also examined and sampled. As well, nine till and three fluvial sediment samples were collected for geochemical analysis and diamond indicator mineral analysis in order to assess the viability of sampling surficial materials to aid exploration. Lastly, a study of the till stratigraphy in the Bitumount area was undertaken. This till study incorporates unpublished field data obtained by the Alberta Geological Survey during the middle 1980's along the Firebag River.

Several new sulphide and radioactive occurrences were discovered in the Marguerite River area. Elevated concentrations of up to 191 parts per million (ppm) copper, 343 ppm zinc, 44 ppm cobalt, 210 ppm nickel, 500 ppm chromium and 163 ppm vanadium were obtained from samples that were collected from pyrite and pyrrhotite occurrences in a 2 to 4 km wide mylonite zone in Precambrian rocks. Radioactive occurrences in peraluminous megacrystic syenites to granitoids yield up to 3,000 counts per second with a SRAT SPP2N scintillometer, and assays of up to 350 ppm uranium, 1,900 ppm thorium, 3,300 ppm cerium, 1,900 ppm lanthanum and 1,200 ppm neodymium, along with elevated contents of other rare earth elements and base metals such as lead, zinc, bismuth and molybdenum.

Samples collected from recent carbonate material associated with a springwater discharge site in the Fort McKay area yielded 0.5 ppm silver, 54 ppm lead, 16 ppm arsenic, 120 ppm chromium, 1.2 ppm antimony, 9 ppm vanadium, 39 ppm boron, 18 ppm bromine, and 472 ppm strontium. A sample of Devonian Waterways Formation carbonate yielded 118 ppm lead and 32 ppm antimony. Anomalous concentrations of gold up to 837 parts per billion (ppb) were detected in oil stained or impregnated Cretaceous coal, shale and sandstone in core from five coal exploration drillholes in the Firebag River area. A positive correlation exists between elevated concentrations of gold and elevated values for chromium (up to 553 ppm) and, to a lesser extent, silver (up to 1.1 ppm) and vanadium (up to 39 ppm). Other anomalous elements associated with elevated concentrations of gold include up to 61 ppm copper, 97 ppm lead, 211 ppm zinc, 58 ppm nickel, 35 ppm cobalt, 14 ppm arsenic, 951 ppm strontium, 4 ppm antimony, 6 ppm bismuth and 257 ppm boron.

Geochemical results for the till samples include up to 9 ppb gold, 0.7 ppm silver, 14 ppm arsenic, 97 ppm zinc, 32 ppm copper, 12 ppm bromine and 570 ppm fluorine. Based on the microprobe results of potential diamond indicator minerals, there are no grains indicative of either kimberlite, lamproite or peridotitic source rocks, with the possible exception of four chrome diopsides. However, five G3 and twenty-two G5 eclogitic garnets were identified by microprobe analysis, several of which have favourable chemistry plotting within the diamond inclusion field for eclogitic garnets on scatter plots of total iron versus magnesium and titanium versus calcium. In addition, several of the eclogitic garnets contain sufficiently high amounts of sodium and titanium such that they border on the diamond inclusion field for eclogitic garnets on a plot of titanium versus sodium.

The results from the 1993 fieldwork at the Marguerite River to Fort McKay area, plus the ongoing work by the Geological Survey of Canada and recent exploration results announced by industry, indicate that the potential for the discovery of metallic mineral deposits in the Bitumount map area north of Fort McMurray is much higher than previously believed. Potential deposit types to explore for include: (a) brine- and/or hydrocarbon-related gold deposits, (b) Archean shear zone hosted gold deposits; (c) Mississippi Valley type lead-zinc deposits; (d) sediment hosted base metal deposits with one or more of zinc, lead, copper, nickel, silver and gold; (e) granitoid-related uranium and/or rare earth element, precious metal or base metal deposits; (f) unconformity-related, sandstone-hosted or vein-type uranium deposits, (g) diamondiferous kimberlite or lamproite diatremes; and (h) various types of placer or paleoplacer deposits, with the important metals/minerals being gold, diamonds, titanium or other 'heavy minerals'.

INTRODUCTION

This report documents the results of project M93-04-038, which was funded under the Canada-Alberta Partnership Agreement On Mineral Development (MDA) and represents a preliminary assessment of the potential for metallic mineral deposits in the Marguerite River and Fort McKay areas, of northeastern Alberta. The need for this and other continuing geological studies in the area is based on: (a) the presence of favourable host rocks for several different types of mineral deposits, (b) the many past and recent reports of gold bearing zones, and (c) prior geological examinations and exploration focused towards metallic minerals has been insignificant in comparison to the extensive geological and geotechnical work that has been focused on the Athabasca Oil Sands in the vicinity of Fort McKay. The primary objectives of this study were to provide preliminary data on the geology and geochemistry of the Precambrian and Phanerozoic rocks, and the surficial deposits in National Topographic System (NTS) 74E, Bitumount map area, in order to provide geological information to assist industry in their future mineral exploration endeavours in this area.

The Marguerite River area is a potentially important focus for mineral deposits because it contains the largest exposure of Precambrian Shield rocks south of Lake Athabasca. These ancient rocks host a multitude of metallic mineral occurrences north of Lake Athabasca in Alberta, and large number of diverse metallic mineral deposits where they are exposed elsewhere in Canada. Therefore, potential exists for important metallic mineral deposits to be present in the Marguerite River area. Prior geological mapping by Godfrey (1970) documented the existence of gossans, radioactivity and bedrock alteration associated with shear zones, brecciation and mylonites in the Marguerite River area. These features are all indicators of potential metallic mineral deposits.

Phanerozoic rocks in the study area are primarily exposed in the Athabasca River valley and in some tributary rivers, such as the Muskeg and Firebag Rivers. Several accounts have been documented, between the early 1900's and today, of significant gold anomalies in subsurface and, more recently, surface rocks from the Fort McKay area. Initially, it was reported that Precambrian granite underlying the Phanerozoic succession contains anomalous gold values (Allan 1920), but more recently exploration and geological investigations have been focused on the precious metal potential of the Upper Devonian carbonates. Several junior mining companies, as well as government scientists, have reported significant gold concentrations in the carbonates.

The Alberta Geological Survey (AGS) contracted with APEX Geoscience Ltd. (formerly R.A. Olson Consulting Ltd.) and the Environmental Research and Engineering Division of the Alberta Research Council (ARC) in order to complete the required fiscal 1993-1994 field and office geological studies. Fieldwork for the project took place between August 23 and September 11, 1993 with approximately 12 days spent at the Marguerite River area and 8 days spent at the Fort McKay area. The field portion of the study comprised geological mapping, prospecting and sampling of rocks in the Marguerite River and Fort McKay areas and was conducted by Mr. M.B. Dufresne of APEX Geoscience Ltd. and Mr. A. Turner, then of the Alberta Research Council. In addition, Mr. J.G. Pawlowicz of the Alberta Research Council assisted in conducting a till and fluvial sediment sampling survey in the Marguerite River and Fort McKay areas, and along the Firebag River. With respect to prior work on the surficial geology, a team led by Dr. M.M. Fenton of the Alberta Research Council had conducted geological examinations during the mid 1980's along the Firebag River. The unpublished results of this work have been interpreted and incorporated into this report. The office portion of this study consisted of petrographic and laboratory analyses, examination of an extensive coal database donated by Shell Canada Ltd., and examination and sampling of coal exploration core at the Energy Resources Conservation Board (ERCB) in Calgary.

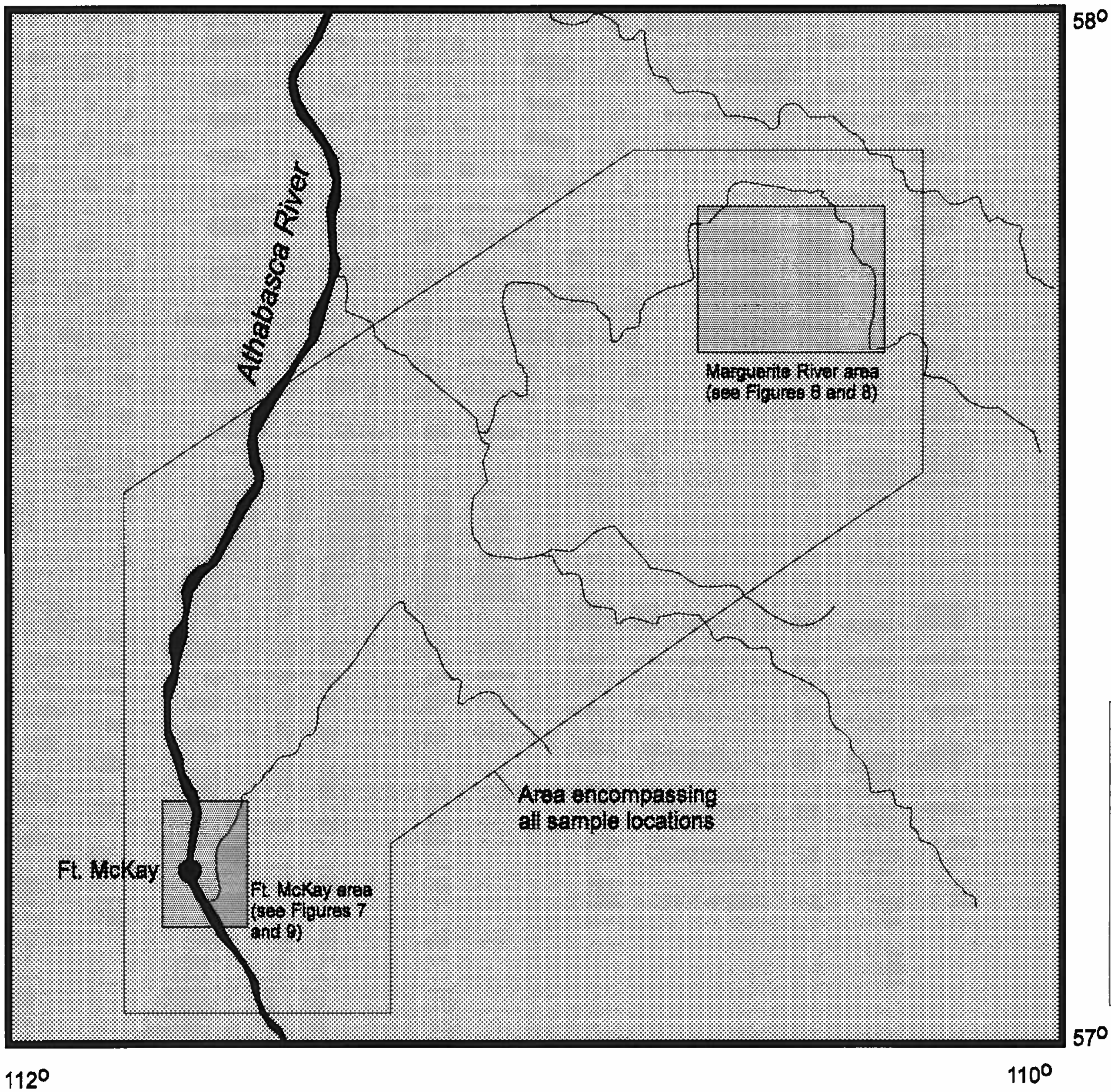
Location

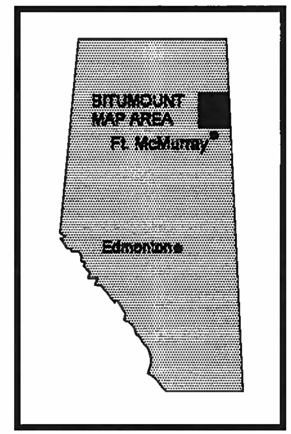
The area encompassed by this study comprises most of the 1:250,000 scale Bitumount map sheet (NTS 74E), in northeastern Alberta, with the fieldwork focused in the vicinity of Marguerite River and Fort McKay (Figure 1). This area is bordered by latitudes 57° and 58°, longitudes 110° and 112°, and extends from the north half of Township 92 to the south edge of Township 104 and from the east edge of Range 1 to the east edge of Range 13 west of the 4th Meridian. Geologically, the study area is south of the mid-Proterozoic Athabasca Basin, but includes the northern part of the Athabasca Oil Sands.

Access and Infrastructure

The study area encompasses the village of Fort McKay, which has a population of less than 300. Fort McMurray, with a population of about 35,000, lies approximately 50 kilometres to the south and is 375 km northeast of Edmonton. Fort McMurray is served by regularly scheduled airline flights from Edmonton and is the northeastern terminus of the Canadian National Railway. Access to the area is by Highway 63 to Fort McMurray and Provincial Trunk Road 963 to Fort McKay. The Fort McKay bridge provides easy access to both sides of the Athabasca River in the vicinity of Fort McKay. A winter road exists on the east side of the Athabasca River and connects the McKay bridge to Fort Chipewyan on the north shore of Lake Athabasca. Several all-weather gravel roads allow access to the McMurray Oil Sands area in the vicinity of Fort McKay. There are many unpaved truck trails and seismic lines that transect most parts of the study area, but these trails and seismic lines are mostly impassable during the summer months. Therefore access to off road portions of the study area during the summer months is mostly restricted to helicopter, or locally by boat from Fort McMurray .

Most services, including accommodation, expediting, and air support can be obtained in Fort McMurray, with only minor services available in Fort McKay.





Scale approximately 1:750,000

Figure 1

LOCATION OF THE BITUMOUNT MAP AREA WITH THE MARGUERITE RIVER AND FT. McKAY STUDY AREAS HIGHLIGHTED

Final report on The mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038

Regional Physiography

The Marguerite River to Fort McKay region consists of a north- to northeasterly-trending low-lying area, formed by the Athabasca River. This low-lying area, with an average elevation of approximately 320 m above sea level, is flanked by the Birch Mountains to the northwest, with an elevation of approximately 900 m above sea level, and Muskeg Mountain to the southeast, with an elevation of approximately 700 m above sea level. The region is drained by the Athabasca River, and by several smaller rivers and streams (Figure 1). Boreal forest, consisting of aspen, pine and spruce trees, covers most of the study area, although bogs are common in low-lying areas.

Outcrop exposure in the study area is poor, with most outcrop consisting of Precambrian basement exposures in the Marguerite River area, and carbonates and oil sands in and near the Athabasca River and other tributary rivers. Most of the area is covered by surficial deposits of preglacial, glacial and postglacial sediments that range in thickness from less than 1 m locally, to over 180 m at Muskeg Mountain (McPherson and Kathol 1977).

Previous Mineral Exploration

Previous mineral exploration within the Bitumount map area (NTS 74E) has largely focused on two commodities: uranium and gold. Exploration for these metals was most active during the 1960's and 1970's, although there has been a recent resurgence in exploration for gold and diamonds in the area. Olson *et al.* (*In Press*) have summarized the history of mineral exploration for northeast Alberta north and south of Lake Athabasca, based on a detailed review of all the assessment reports presently on file and publically available at the AGS.

Exploration Prior to the Early 1990's

Previous gold exploration within the Bitumount map area has been primarily confined to the Fort McKay area. Gold exploration was initially sparked by a report by Allan (1920) in which a drill hole, known as Athabasca Oils Ltd. No. 1, was drilled to a depth of 344.4 m between 1911 and 1912, approximately 8 m into the Precambrian basement. Allan (1920) reported that a sample of this basement granite carried $13.00 per ton gold, equivalent to 0.63 ounces per ton (opT) based on the price of gold at that time, or 21.6 grams gold per tonne (g Au/t). Halferdahl (1986), however, after reviewing the data in Allan (1920), Ells (1926) and a sworn statement provided by one of the drillers of the Athabasca Oils Ltd. No. 1 well, concluded that the reported two auriferous quartz veins were intersected at a depth of 276.5 m in limestone of the Devonian Methy Formation rather than in the underlying Precambrian basement. In the 1962 to 1963 period, four holes were drilled by Scurry-Rainbow Oil Ltd. near the approximate location of the Athabasca Oils Ltd. No. 1 hole (Elstone 1963). Three of the four drillholes reached the Precambrian basement, but only trace amounts of gold were found in the samples collected. However, comments by Elstone (1963) give the first hint at the potential for gold in the limestones of the area; "*The possibility of finding gold in the limestones above the Precambrian surface has been an unexplainable enigma to the writer since the first examination of the property. This is not considered any unsurmountable obstacle from finding ore, however, for ore has been found many times in places that have been "firsts" either in types or localities.*"

During 1986, Halferdahl and Associates Ltd. (Halferdahl 1986) drilled two holes on behalf of Kenneth Richardson, on the east side of the Athabasca River south of the Fort McKay bridge, approximately 35 km south of the reported location for the Athabasca Oils Ltd. No. 1 well. A sample assaying 0.063 opT gold (2.16 g Au/t) was obtained from Methy Formation carbonates at a depth of 241 m (Ibid.). Pyrite with a few specks of chalcopyrite and malachite were noted in argillaceous dolomite immediately above the interval with anomalous gold. Chalcopyrite and malachite were also noted in the Precambrian basement in one of the two drillholes, with assays of up to 60 ppb gold and 2.6 g/t silver in the granitic rocks (Ibid.). Also in 1986, Tanner Arctic Oil Ltd. drilled one hole approximately 1.3 km south of the site of the Athabasca Oils Ltd. No. 1 well, but all five of the samples that were collected from this drillhole returned low gold results. Lastly, records on file at the Alberta Geological Survey indicate that a drillhole, Ells Gold 1, was drilled during 1988 by a numbered Alberta company, near the site of the Athabasca Oils Ltd. No. 1 well. A brief log indicates that the Ells Gold 1 drillhole penetrated the Precambrian at about 272.8 m and ended in quartz with abundant pyrite at about 280 m. Assay certificates from Loring Laboratories Ltd. indicate that nine samples were assayed for gold and silver. One sample assayed 0.032 opT gold (1.10 g Au/t) and 0.22 opT silver (7.54 g Ag/t), two other samples assayed 0.006 opT gold (0.21 g Au/t). The downhole locations of these samples is not provided. However, other than the sample with 1.10 g Au/t, the remaining eight samples were likely collected from Devonian dolomitic carbonates based on the high concentrations of calcium (15.94 to 23.63 wt%) and magnesium (up to 9.75 wt%) that are given in the accompanying geochemical results from Induction Coupled Plasma (ICP) analysis for all eight samples. The sample with 1.10 g Au/t also contains 2,677 ppm As, 215 ppm Cu, 8 ppm Sb and 5.64 wt% Fe with low values for calcium and magnesium. Although silica is not reported, the low calcium and magnesium values may indicate that this sample was collected from the quartz-rich zone at the bottom of the drillhole or perhaps a quartz-sulphide rich zone within the carbonates. Two of the eight carbonate samples also contain other elevated metals, including up to 56 ppm As, 72 ppm Cu, 406 ppm Pb, 142 ppm Zn, 52 ppm Ni, 17 ppm Co, 12 ppm V, 54 ppm B and 131 ppm W, which are all associated with elevated iron (up to 3.38 wt%).

Numerous unconformity-related uranium deposits have been discovered within and near the Athabasca Basin in Saskatchewan. The Bitumount map area, which is just south of the Alberta portion of the Athabasca Basin, and which contains, in places, sub-surface drillhole intersections of Athabasca Group sandstones that are known to host uranium deposits in Saskatchewan, has been the focus of uranium exploration by several companies. The economic geology of the Athabasca Group and the underlying basement rocks south of Lake Athabasca is well summarized by Wilson (1985a,b, 1986, 1987a,b). In the northeast part of the Bitumount map area, Eldorado Nuclear Ltd. drilled 16 holes during 1976, 15 holes during 1978 and 1979, and conducted a lake water and sediment sampling survey to test for geochemical anomalies possibly related to buried uranium mineralization (Laanela 1977; Mitchell and Fortuna 1978; Fortuna 1979). The geochemical survey outlined several areas with anomalous concentrations of Ni, Co and Cu near the north boundary of the Bitumount map sheet in the vicinity of the Richardson River, and up to 123 ppm U in lake sediment samples and up to 0.9 ppm U in lake water samples (Laanela 1977). Eldorado Nuclear Ltd. also reported the intersection of a deep east-west trending alteration zone during the 1976 drilling program, in which a small stringer of pitchblende was intersected (Mitchell and Fortuna 1978). Follow-up drilling, in combination with magnetometer and resistivity surveys, confirmed that the alteration zone is of considerable width and that it is likely related to a prominent magnetic low that is interpreted to be a fault zone. No other significant mineralized zones were intersected in the 1978 or 1979 drilling programs (Mitchell and Fortuna 1978; Fortuna 1979). Carl *et al.* (1992) show the existence of an "*epigenetic uranium deposit*" at the Maybelle River area, which may be the same uranium occurrence reported by Eldorado Nuclear Ltd. No other important radioactive anomalies were discovered by Eldorado Nuclear Ltd. Norcen Energy Resources Ltd. conducted airborne and ground geophysical surveys in conjunction with small drilling programs from 1977 to 1979 along the Maybelle and Richardson Rivers in order to follow-up a reconnaissance boulder and lake sediment sampling survey that they had conducted during 1976 (McWilliams 1977; McWilliams and Sawyer 1977; McWilliams and Cool 1979; McWilliams *et al.* 1979). In total, Norcen drilled twenty holes south of Lake Athabasca, with hole #3 drilled during 1977 in the Bitumount map area (McWilliams 1977). Athabasca Sandstone was not intersected in hole #3, but, 32.3 m of Devonian carbonates and mudstones were intersected above Precambrian granite. No important anomalous results were reported from any of the Norcen drillholes, although lake sediment sampling yielded assays of up to 18.8 ppm U within NTS 74 L/1 and up to 7.2 ppm U from a sample collected within NTS 74 E/16 (McWilliams and Sawyer 1976).

A few other small uranium or base metal exploration projects have been conducted within the Bitumount map area. These include: (1) a 1967 to 1968 IP survey by C.C. Huston and Associates as well as a muskeg and soil sampling survey in an area that is approximately 8 km north of the Firebag River near the Athabasca River. This work identified a weakly anomalous zone with soil samples that assayed up to 10 ppm Pb, 150 ppm Zn and 22 ppm Hg, but these results were interpreted as being due to overburden variations (Sproule and Stuart-Smith 1966; Goettler 1969); (2) a 1969 airborne radiometric survey by Radex Minerals Ltd. which identified two weak radiometric anomalies north of Johnson Lake (Paterson 1969); and (3) a 1977 lake sediment geochemical survey combined with a review of previously drilled oil sands drillholes conducted by Taiga Consultants Ltd. on behalf of E. & B. Explorations Ltd. The Taiga program identified a radioactivity anomaly in oil-stained McMurray sandstone unconformably overlying Precambrian basement, and a few lake sediment samples with up to 200 ppm zinc and up to 17 ppm lead (Allan 1977). A few other anomalies have been reported in oils sands drilling, including reports of chalcopyrite in the McMurray Formation in three separate drillholes in the vicinity of Fort McKay (Table 1). Metallic mineral occurrences have also been noted south of the Bitumount map area along the Clearwater River east of Fort McMurray. Carrigy (1959), for example, reported the presence of galena associated with a dolomitized zone in the Methy Formation at Whitemud Falls near the Saskatchewan border, and La Casse and Roebuck (1978) reported the presence of enargite and malachite at one location and enargite at two other locations west of Whitemud Falls and east of Fort McMurray.

Table 1. Metallic Mineral Anomalies In Oil Sands And Coal Drilling

Hole Name	Location (Lsd/S/T/R&Mer)	TD[1] (m)	Depth To Dev.[2] (m)	Remarks
Shell 406	5/31/95/9W4	88.4	Not Given	Cpy[3] in McMurray Fm. 74.7 to 82.3 m
Shell 408	11/31/95/9W4	83.8	78.6	Minor Cpy[3] in McMurray Fm. at 71.6 m
Shell 472	1/36/95/10W4	94.5	86	Cpy[3] in McMurray Fm. at 70.1 m
Unnamed	11/36/97/11W4	?	?	"Mineralization is prominent" (Devonian)
Unnamed	13/16/86/25W3	328.9	208.5	Fluorite in Oil Sand (In Saskatchewan)

TD[1] is total hole depth.
Dev[2] is Devonian.
Cpy[3] is chalcopyrite.

Recent Exploration

Intensive gold exploration has recently been renewed in the Bitumount map area due to the reported discovery of gold, silver and platinum group elements (PGE's) in surface carbonates in the vicinity of Fort McKay. During 1993, Focal Resources Ltd. (1993) reportedly drilled 14 holes, most of which were less than 30 m in length, and collected surface samples from Devonian Waterways Formation limestone on their Bradley property near Fort McKay. They reported up to 68.6 g Au/t, 40.8 g Pt/t and 44.6 g Rh/t from surface samples, and 13.7 g Au/t, 78.5 g Pt/t and 18.5 g Rh/t from drill core samples (Northern Miner 1993a). These results were obtained using **'non-traditional'** assaying techniques (Northern Miner 1993b), although they report that standard fire assaying techniques "*provided by a Certified Canadian Laboratory*" were used to obtain values of up to 45.1 g Au/t, 180.3 g Ag/t and 2.5 g Pt/t in surface samples from their South Bradley property (Focal Resources Ltd. 1993). In addition, they report that fire assays provided by Asarco Inc. yielded up to 46.3 g Au/t across 1.5 m in drill core samples (Focal Resources Ltd. 1993). The high values for gold, silver and PGE's reportedly came from "*Devonian limestone with high silica and commercial values of gold and platinum group metals in salt form*" (Northern Miner 1993a).

In addition to the exploration conducted by Focal Resources, gold exploration was also carried out in the Fort McKay area by a joint venture between Tintina Mines Ltd. and NSR Resources Inc. during 1993. Tintina collected 85 surface samples from Devonian Waterways Formation carbonates and an overlying, well-indurated, siliceous, sandstone named the Beaver River sandstone (Fenton and Ives 1990) along the east bank of the Athabasca River (Tintina Mines Ltd. 1993). Twenty-two of the samples were submitted for gold, silver and PGE analysis. Values of up to 19.38 g Au/t and 18.97 g Ag/t were reported for these samples (Tintina Mines Ltd. 1993). The company also drilled four holes totalling approximately 600 m on their Fort McKay property. Two of these holes were abandoned in major fault zones, and two holes encountered disseminated sulphides, sulphide pods, spheroids and sulphide-healed fractures in collapse breccia zones. Gold exploration is continuing presently in the Fort McKay area. The GSC reports values of up to 3.71 g Au/t in Waterways Formation carbonates and up to 1.08 g Au/t in the Beaver River sandstone using laser ablation coupled with ICP and mass spectrometry (Abercrombie *pers comm.* 1994; Abercrombie and Feng 1994). Surface and core samples for the analyses were provided to the GSC by HMS Properties, Focal Resources Ltd. and the Tintina Mines Ltd./NSR Resources Inc. joint venture.

REGIONAL GEOLOGY

The Bitumount map area contains the Athabasca North Tar Sands area, and the only significant exposure of Precambrian basement south of Lake Athabasca, and has been mapped in whole or in part by numerous workers since the late 1800's. The earliest geologic reports on the area were by Bell (1884) and McConnell (1893), who published comprehensive documents on the geology of the area. Since that time, government agencies, including the Alberta Research Council and the Geological Survey of Canada, and private companies, have contributed, through published and unpublished data, to the geological knowledge of the Bitumount map area. These include reports on various aspects of the bedrock geology by Carrigy (1959, 1966, 1973), Norris (1963, 1973), Langenberg and Nielsen (1982) and Wilson (1985a,b, 1986); reports on the surficial geology by McPherson and Kathol (1977), and Horne and Seve (1991); bedrock geology maps of the Marguerite River area by Tremblay (1961) and Godfrey (1970); and a surficial geology map of the Bitumount map area by Bayrock (1971). Numerous unpublished geological reports, primarily based on well log information, have been provided by oil, coal and uranium exploration companies and have greatly enhanced the knowledge of the subsurface of the Bitumount area. This well log information is on file with various government agencies, such as the ERCB and the AGS. For this project, extensive use was made of a large unpublished geological database that was the result of coal exploration in the vicinity of the Firebag River by Shell Canada Ltd. during the 1970's. This database was recently donated to the AGS by Shell.

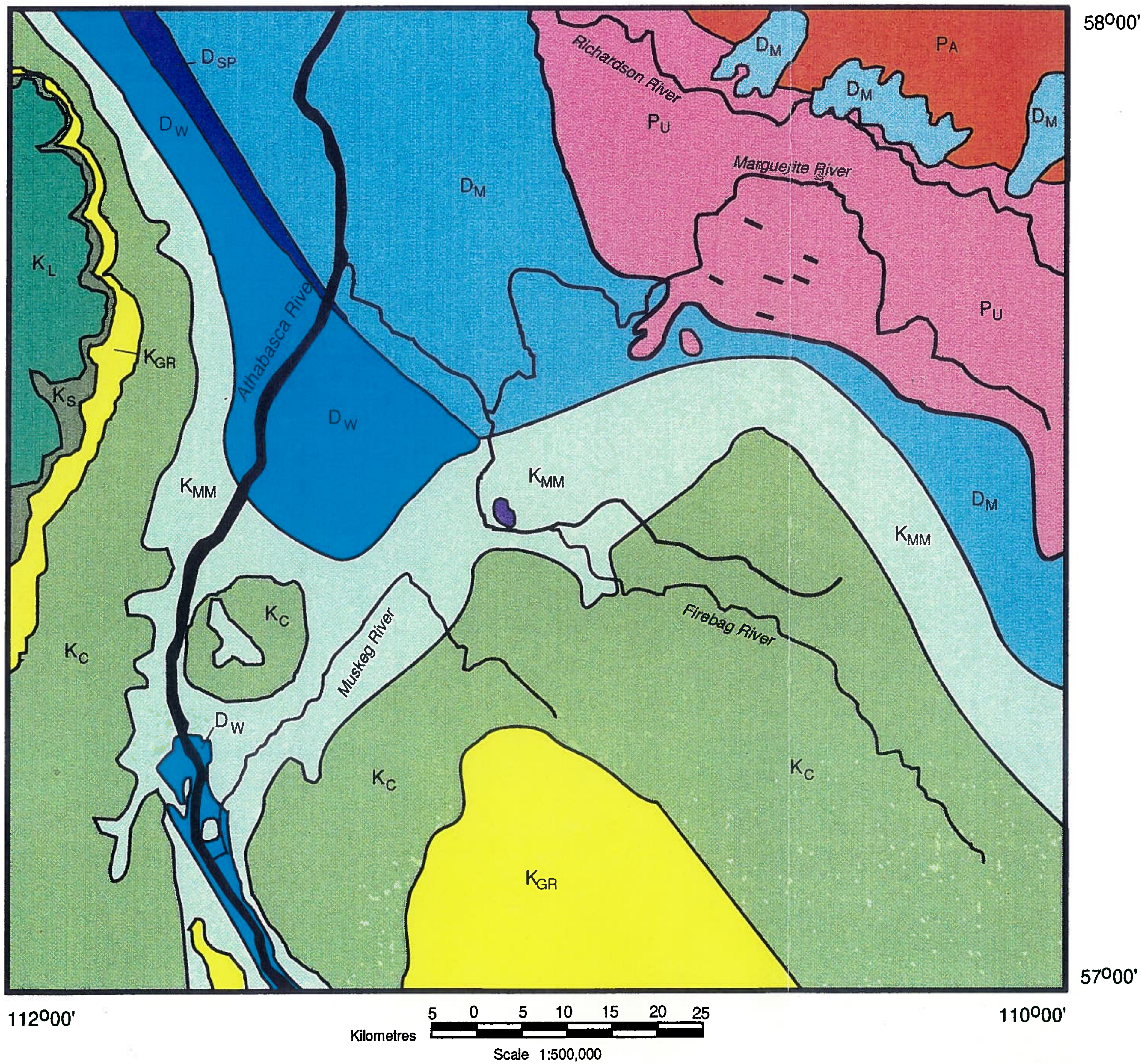
Bedrock Geology Of The Bitumount Map Area

Outcrop in the Bitumount map area is generally poor, and is limited to the main river valleys and an isolated outlier of Precambrian Shield in the vicinity of the Marguerite River. A simplified compilation of the published bedrock geology maps is presented in Figure 2. A brief descriptive summary of the exposed bedrock and of information obtained from drill holes for the Bitumount area follows.

Precambrian

The Precambrian Shield which is exposed in the northeast corner of the Bitumount map area in the vicinity of the Marguerite River, is considered to be part of the Churchill Province (Rae Sub-province) of Hoffman (1988), an Archean micro-continent that was welded to the Superior Province during the Early Proterozoic. As a result of this collision, the Churchill Province has recorded a strong Proterozoic orogenic event that has thermally reset most isotope systems used for dating of the basement rocks. The Bitumount map area can be divided into two distinct magnetic terranes based on government aeromagnetic data (Geological Survey of Canada 1983; Sprenke *et al.* 1986; Wilson 1986). Ross and Stephenson (1989), Ross *et al.* (1989, 1991, 1993), Ross (1991, 1992) and Villeneuve *et al.* (1993) have suggested that the eastern half of the Bitumount map area, with a relatively low background magnetic signature, is probably part of the Archean Rae subprovince, and the western half of the area, with a strong background magnetic signature, is part of the Proterozoic Taltson Arc. The Taltson Arc, which has been dated between 1,932 Ma and 1,975 Ma from outcrops north of Lake Athabasca and from oil well drill core to the south (Ross *et al.* 1989; McNicholl *et al.* 1993; Villeneuve *et al.* 1993), is a north-south trending magmatic belt that originates near Great Slave Lake, as part of Thelon Tectonic Zone, and is truncated in east-central Alberta by the Snowbird Tectonic Zone. Precambrian rocks in the Marguerite River area have not been dated as of yet.

The Shield exposure in the Marguerite River area is the largest Precambrian basement exposure that exists south of Lake Athabasca in Alberta. In addition, since the Marguerite River area includes relatively abundant outcrop exposures, in contrast to the paucity of outcrop in most of the Bitumount map area, it has perhaps received more geological attention than most other parts of the map area (Tremblay 1961; Godfrey 1970). The Precambrian rocks in the Marguerite River area comprise Archean granite, gneiss,



LEGEND

CRETACEOUS

- K_L Labiche Fm.
- K_S Shaftesbury Fm.
- K_{GR} Grand Rapids Fm.
- K_C Clearwater Fm.
- K_{MM} McMurray Fm.

DEVONIAN

- D_W Waterways Fm.
- D_{SP} Slave Point Fm.
- D_M Methy Fm.

PRECAMBRIAN

- P_A Athabasca Fm.
- Mafic dykes/amphibolite
- P_U Undivided granite, gneiss and mylonitic rocks

Geology compiled from Godfrey (1970), Bayrock (1971), Tremblay (1961), Green et al. (1970), Wilson (1985a,b) and McPherson and Kathol (1977)

Figure 2
BEDROCK GEOLOGY OF THE BITUMOUNT MAP AREA

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038

mafic igneous rocks, mylonite and Proterozoic Athabasca Group, which is known from uranium exploration drilling only. Carrigy (1959) describes the Marguerite River area as consisting of northwesterly-striking metasedimentary rocks intruded by granite and granite gneiss, and later by pegmatite, aplite and diabase dykes. Tremblay (1961) does not unequivocally document metasedimentary rocks in the area, but did suggest that the granite and gneiss were likely of a sedimentary origin. That is, possibly greywackes and quartzites were metamorphosed and partially melted to form granite and granite gneiss. Such metasedimentary rocks and paragneiss have been documented within similar granite-gneiss complexes north of Lake Athabasca (Green *et al.* 1970; Nielson *et al.* 1981; Langenberg and Nielsen 1982; McDonough *et al.* 1993a,b). The various granites and gneisses of the Marguerite River area are shown as undivided on Figure 2, although some workers have proposed varying degrees of subdivision. Tremblay (1961), for example, suggested two subdivisions for the granitoids at Marguerite River: an older granitoid gneiss and a younger garnetiferous granite. Green *et al.* (1970) suggested four subdivisions: an older porphyroblastic granite, followed by undivided granitoids, granite and granite gneiss. Godfrey (1970) mapped 10 different granite, granitoid and gneissic varieties in the Marguerite River area. Therefore, it seems that the following subdivisions at least are warranted: (a) a porphyroblastic granitoid phase, (b) a granitoid phase and (c) a gneissic phase. These rocks are weakly to strongly foliated (Godfrey 1970; Tremblay 1961), and in the southern part of the exposed area, mylonitic rocks predominate (Godfrey 1970; Langenberg and Nielsen 1982).

In addition to the Precambrian basement granite-gneiss complex which is preserved in the Marguerite River area, numerous workers report the presence of mafic dykes, although the true nature of these rocks is as yet undetermined. Tremblay (1961) reported basaltic dykes and sills which cut the granitoids, and are generally less than 2 metres wide and 300 metres or less in strike length. Godfrey (1970) mapped these mafic rocks as amphibolite. The age and origin of these mafic rocks is not well constrained and they may be either Archean or Proterozoic.

Proterozoic rocks occur northeast of the Richardson River in the northeast corner of the Bitumount map area. Their presence is known only from drilling associated with uranium exploration during the 1970's, and their geology is well summarized by Wilson (1985a, 1987a,b). Tremblay (1961) visited one outcrop just outside the Bitumount map area in Saskatchewan and described the rock as a fine-grained white, faintly bedded and crossbedded clastic sediment, with minor colour-banding. Green *et al.* (1970) and Wilson (1985a, 1986, 1987a,b) have attempted to define the extent of Athabasca Group rocks in the northeast corner of the Bitumount map area on their regional maps.

Phanerozoic

The majority of the Bitumount map area is underlain by rocks of Devonian and Cretaceous ages. However, these units are poorly exposed except in the valley of the

Athabasca River and along a few other rivers such as the Firebag, Muskeg and McKay Rivers. Most of the information about the distribution and character of these units was obtained from well log data and the work of other people. Brief descriptions of the Phanerozoic units which underlie the Bitumount map area, as shown in Figure 2, follow.

Based on drilling, the Devonian succession in the Bitumount map area overlies the Precambrian basement by an erosional unconformity. Above the unconformity, there is a thin veneer of about 2 m (up to 6 m in places) of basal sandstone or conglomerate of the LaLoche Formation, which is commonly referred to as 'arkosic sandstone', 'basal red beds' or 'granite wash' (Table 2, modified after Carrigy 1959, 1973; Norris 1963, 1973; Hamilton 1971). For the most part, the LaLoche Formation is overlain by Middle Devonian Elk Point Group rocks consisting of McLean River Formation shale, siltstone and dolomite, Methy Formation dolomites with minor reefal units, and Prairie Evaporite Formation comprised of salt and anhydrite beds, with minor shale and dolomite (Norris 1963, 1973). Middle Devonian Methy Formation crops out along the Firebag and Marguerite Rivers in the Bitumount map area. Salt beds within the Prairie Evaporite Formation occur only in the subsurface and mostly west of the Athabasca River because they have been predominantly removed by groundwater dissolution east of the Athabasca River. Subsurface salt beds do exist east of the Athabasca River in the northwest portion of the Bitumount map area in the vicinity of Bitumount, but they are part of the Cold Lake and Lotsberg Formations (Table 2). Dissolution of these Lower Elk Point salt units is likely responsible for the karsting and related collapse structures that presently exist in the overlying Cretaceous and surficial deposits in the vicinity of the Athabasca River north of Fort McKay (Hamilton *pers comm.* 1994).

The Slave Point Formation consists of limestone, siltstone and dolomitic limestone. This unit does not crop out in the Bitumount map area, but has been noted in the subsurface, although it is relatively thin (approximately 3 m thick) in the area of the Birch Mountains. The age of this unit is debatable; Carrigy (1973) placed the unit in the Upper Devonian, whereas Norris (1973) placed it at the end of the Middle Devonian. The unit is bounded on its lower and upper contacts by paraconformities (Carrigy 1973).

The Waterways Formation consists of calcareous shale and argillaceous limestone alternating with clastic limestone, and is between 200 m and 230 m thick (Green *et al.* 1970). This unit underlies a large part of the Bitumount map area, and is exposed locally near McClelland Lake, along the Athabasca River from Fort McKay to the southern boundary of the map area, and along the lower portions of the McKay, Muskeg and Steepbank Rivers. The Waterways Formation is the uppermost Devonian unit exposed in the Bitumount map area.

The Devonian units are separated from the overlying Lower Cretaceous units by an erosional unconformity (Carrigy 1959, 1973). This unconformity represents a marked change in lithology and a fairly long interval of time. It has been postulated that

Table 2. Generalized Stratigraphy For The Bitumount Area [1]

SYSTEM	GROUP	FORMATION	MEMBER	DOMINANT LITHOLOGY
Upper Cretaceous	La Biche	La Biche		Shale
		Dunvegan		Sandstone & siltstone
		Shaftesbury		Shale, bentonites, fish-scale horizon
Lower Cretaceous		Pelican		Sands
		Joli Fou		Shale
	Mannville	Grand Rapids		Lithic sands
		Clearwater		Shale & glauconitic sands
		McMurray		Quartzose sands, heavy oil
Jurassic?		Beaver River		Quartzose sandstone
Upper Devonian	Beaverhill Lk.	Waterways	Mildred	Argillaceous limestone
			Moberly	Limestone & shale
			Christina	Shale & limestone
			Calumet	Limestone & shale
			Firebag	Shale, minor limestone
Middle Devonian		Slave Point		Limestone, local breccia
	Upper Elk Point	Prairie Evapoite		Salt, anhydrite (gypsum), shale & dolomite
		Methy		Dolomite, minor reefs
	Lower Elk Point	McLean River		Shale, siltstone & dolomite
		Cold Lake		Salt, minor shale
		Ernestina		Shale, limestone & Anhydrite
		Lotsberg		Salt, minor shale
		LaLoche		Arkosic sand & conglomerate
Precambrian				Granitic basement

[1]Modified after Carrigy (1959, 1973), Norris (1963, 1973) and Hamilton (1971).

the pre-Cretaceous units underwent several periods of subaerial erosion and karsting, and that the erosional surfaces resulting from these processes greatly affected the sedimentation of the lowermost Mesozoic units to be deposited (Carrigy 1973). A coarse grained and well indurated quartzose sandstone exists east of Fort McKay between the Athabasca and Muskeg Rivers (Carrigy 1973). This silica- and goethite-cemented sandstone appears to unconformably underlie the McMurray Formation, and as such, likely represents a remnant of a once more regionally continuous early Cretaceous (or possibly Jurassic) sandstone (Carrigy 1973). More recent work by Fenton and Ives (1982, 1990) and Ives and Fenton (1983), who have named the unit the Beaver River sandstone (Table 2), has shown it to have a lateral extent of at least 13 km. Fenton and Ives (1990) also suggested that the Beaver River sandstone exists near the top of the lower member of the McMurray Formation based on the work of Flach (1984).

The McMurray Formation is the oldest Lower Cretaceous unit to be preserved in the Bitumount map area. This unit consists mainly of deltaic sediments that include thick crossbedded oil-impregnated quartz sands, with interbeds of silt and shale. McMurray Formation constitutes the famous Athabasca Tar Sands deposits and is exposed within the Athabasca River valley, although it underlies a considerable portion of the Bitumount map area (Green *et al.* 1970). Carrigy (1966; 1973) subdivided the McMurray Formation into (a) pre-McMurray, (b) lower, (c) middle and (d) upper units. The pre-McMurray unit is equivalent to the Beaver River sandstone. Carrigy (1973) suggested that the lower McMurray Formation was predominantly of fluviatile origin, the middle McMurray of fluviatile to deltaic origin, and the upper McMurray of delta platform to brackish water origin. Extensive geological studies related to heavy oil have since been conducted on the McMurray Formation by numerous authors including Stewart (1963, 1981), Mossop (1980), Mossop and Flach (1983), Flach (1984), Flach and Mossop (1985), and Anderson *et al.* (1993).

The McMurray Formation oil sands are conformably overlain by marine shale, laminated siltstone and cherty sandstone of the Clearwater Formation. This unit is exposed locally along the Athabasca River and its tributaries, although it underlies much of the southern part of the map area, and is approximately 100 m thick (Green *et al.* 1970). The age of this unit has been established as Early Cretaceous (Carrigy 1973).

The Grand Rapids Formation underlies much of the thick drift covered region in the southeast corner of the map area in the vicinity of Muskeg Mountain. This unit is approximately 100 m thick, and is exposed northwest of Fort McKay on the eastern flank of the Birch Mountains. The Grand Rapids Formation consists of salt and pepper sandstone, laminated siltstone and shale with thin coal beds (Green *et al.* 1970). The overlying Joli Fou and Pelican Formations are present southwest of Fort McMurray (Carrigy 1973), but have not been mapped in the Bitumount map area. It is possible that these formations or their stratigraphic equivalents exist northwest of Fort McKay, as the geology is not well constrained for the Birch Mountains.

Shaftesbury Formation shales overlie the Grand Rapids Formation on the eastern flank of the Birch Mountains in the northwest corner of the Bitumount map area (Green *et al.* 1970). These shales are 250 m to 300 m thick and consist of dark marine, highly fissile shales with thin bentonite beds and abundant concretionary ironstone. The Shaftesbury also contains the well known Fish Scale marker horizon estimated to be about 96 Ma (Bloch *et al.* 1993).

The youngest bedrock stratum present in the Bitumount map area is that of the La Biche Formation, which is poorly exposed, but does crop out on the eastern edge and top of the Birch Mountains. This unit consists of dark shale with ironstone partings and concretions, and thin fish scale bearing silty beds (Green *et al.* 1970).

Surficial Geology Of The Bitumount Area

Existing Quaternary Information

The data on surficial geology (Figure 3) comes from mapping done by Bayrock (1971) on the Bitumount Map Sheet, Bayrock and Reimchen (1974) on the Waterways map sheet just to the south, and from more detailed investigations in the western portion of the area by McPherson and Kathol (1977). Fenton, one of the co-authors of this report, participated in the McPherson and Kathol (1977) study and led a team that did reconnaissance stratigraphy along the lower two-thirds of the Firebag River. Horne and Seve (1991) described a buried channel east of the Athabasca River, and Smith and Fisher (1993) discussed the development of the Athabasca River during the Late Wisconsin deglaciation.

Additional information on the bedrock topography and drift thickness in the Bitumount area comes from the logs of holes drilled for petroleum, coal or groundwater exploration (Figure 3).

Surficial Geology

The surficial geology, east of the Athabasca River, consists primarily of till and outwash, with less extensive outcrops of lacustrine and eolian sediment (Figure 4). Bedrock exists only in the northeast quadrant. The small scale map included as Figure 4 has simplified the units defined by Bayrock (1971), and the reader is directed to the 1:250,000 scale surficial geology map of the Bitumount map area for more detailed geologic information such as the distribution of the bedrock outcrops.

The till east of the Athabasca River was divided by Bayrock and Reimchen (1974) into the "Kinosis Till" and the "Gypsy Till" during their mapping of the Waterways map sheet, which adjoins the south margin of the Bitumount sheet. The Kinosis Till was correlated by Bayrock and Reimchen (1974) with Bayrock's (1971) unit 2 "ground moraine"

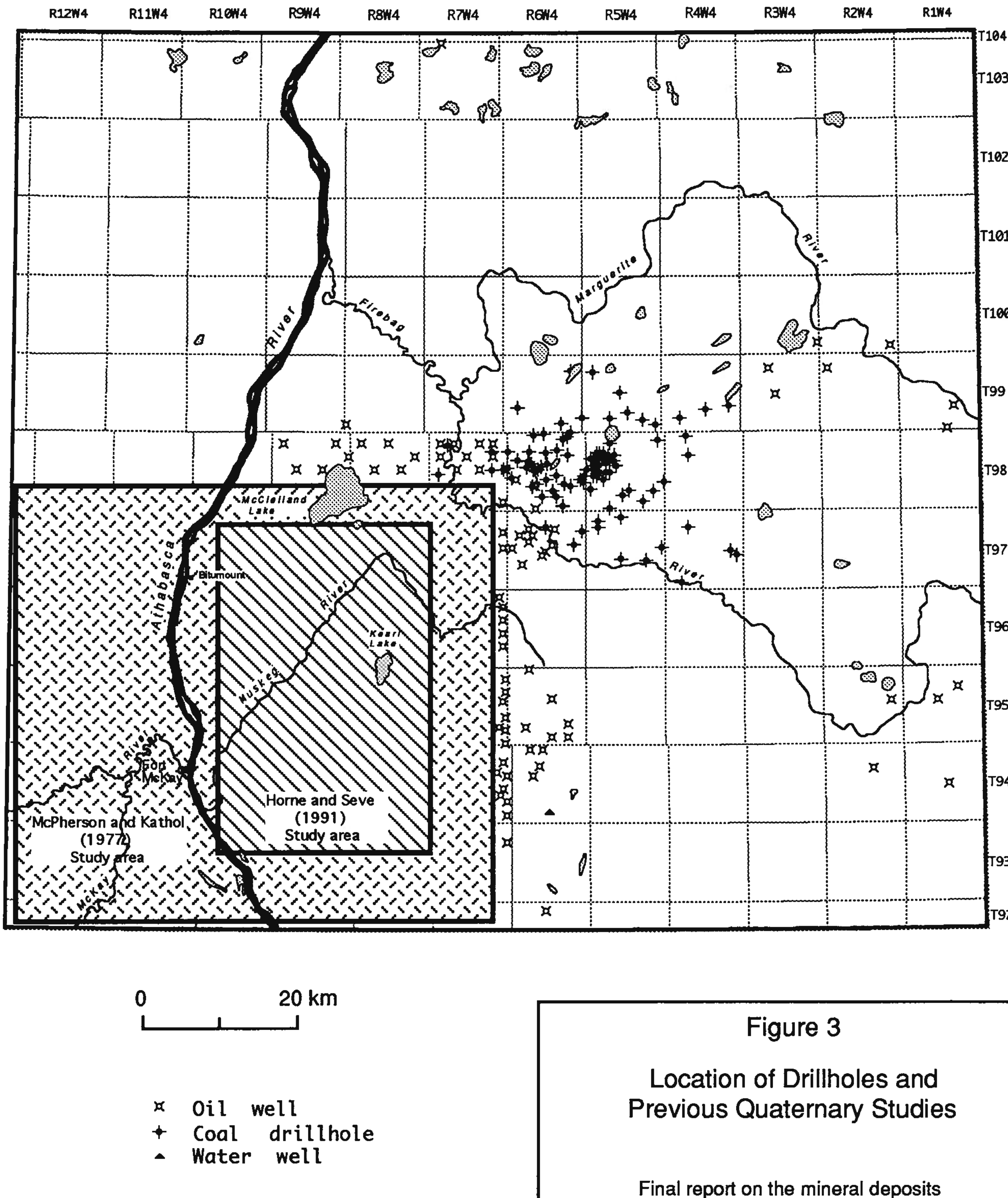


Figure 3

Location of Drillholes and Previous Quaternary Studies

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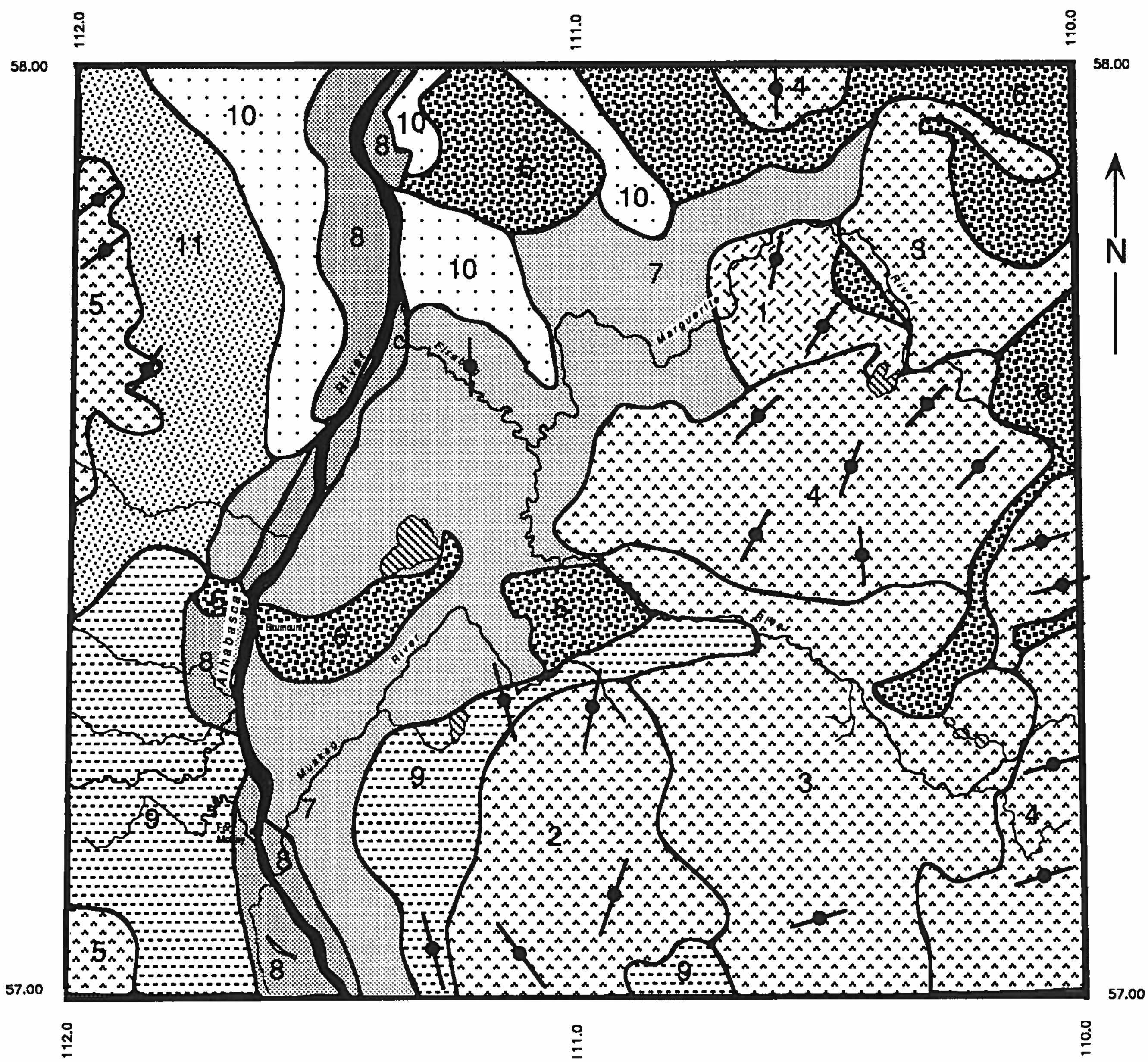

0 20 km

Legend

1 Bedrock
2 Kinosis Till
3 Gypsy Till
4 Gypsy till fluted
5 Till undifferentiated
6 Ice-contact sand & gravel
7 Outwash sand
8 Meltwater channel sand & gravel
9 Lacustrine silt, clay, sand & stratified diamicton
10 Eolian sand
11 Alluvial fan and slump sediment

Flute or drumlin

Figure 4

Surficial Geology
Simplified from Bayrock (1971), Bayrock & Reimchen (1974), and McPherson & Kathol (1977)

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on the Bitumount map sheet. The Kinosis Till has a loamy texture with equal amounts of sand, silt and clay.

The Gypsy Till was correlated by Bayrock and Reimchen (1974) with Unit 7, outwash, and Unit 6, overridden and fluted outwash, on the Bitumount map area. Bayrock and Reimchen (1974) stated that the Gypsy Till was interpreted as outwash on the earlier mapped Bitumount map area because this unit consists of sand and gravel with essentially no fines; that is till "*in which the grain size composition approximates outwash*". The Gypsy Till is composed of material eroded from the Athabasca Formation. The sand content exceeds 90% with the remainder being silt, pebbles and boulders.

Flutings on the Kinosis Till indicate ice flow from the north-northeast, and the north-northwest (Figure 4; and the larger scale map of Bayrock (1971) which is able to show many more fluting and drumlins). The eastern portion of the Gypsy Till has been strongly fluted and drumlinized by glacial flow from the northeast (Figure 4; unit 4). The only exception to this flow direction is in the northwestern part of the Gypsy Till (Figure 4; unit 3) where flow is from the north-northwest. This north-northwest flow is also evident from striations on the northern half of the large area of bedrock outcrop in the vicinity of the Marguerite River (Figure 4; unit 1). Striations on the southern portion of this outcrop record flow from the northeast.

Glaciofluvial sediment includes the ice contact sand and gravel (unit 6) and outwash sand (Unit 7). The ice contact sediment has a rolling topography with individual hills exceeding 30 m (Bayrock 1971). The ice contact sediment forming the Fort Hills immediately east of Bitumount is also known to include finer grained sediment at depth.

The lacustrine sediment is predominantly silt and clay with minor sand and stratified diamicton. Pink fragments and laminae are present in some areas. The eolian deposits consist of medium to coarse grained sand sheets and dunes (Bayrock 1971). The alluvial fan and slump sediment is located on the lower slopes of the Birch Mountains, west of the Athabasca River, and consists of sediment eroded from that highland.

Structural Geology of the Bitumount area

Little is known about the structural geology in the Bitumount map area; mainly because of the poor outcrop exposure. Most of the work on the structural geology has come from interpretations of the aeromagnetic data, lineament analysis and structure contour surfaces created from drillhole information by such workers as Sproule (1938), Hume (1949), Kidd (1951), Carrigy (1959), Garland and Bower (1959), Martin and Jamin (1963), Norris (1963, 1973), Stewart (1963), Martin (1966), Godfrey (1970), Babcock and Sheldon (1976), Langenberg and Nielson (1982), Wilson (1985b) and Sprenke *et al.* (1986).

In general, the Precambrian and the Devonian erosional surfaces slope gently to the southwest in the Bitumount map area (Carrigy 1959). However, the topography of the Precambrian surface is poorly constrained due to the limited number of drillholes that have penetrated to the basement. The Marguerite River area is the main, possibly only, Precambrian basement exposure south of Lake Athabasca in Alberta. Wilson (1985a) and Ramaekers (1979) suggested that the Marguerite River basement exposures are remnants of a once active basement high, the Paterson High, that controlled sedimentation at the southwest end of the Athabasca Basin during the Proterozoic. Perhaps this paleohigh was related to Proterozoic uplift associated with the Peace River Arch. Stelck *et al.* (1978), O'Connell *et al.* (1990) and Ross (1990), for example, have suggested that the Peace River Arch exhibited uplift during Late Proterozoic. Past uranium exploration has identified northwest trending fault structures in the basement rocks below the Athabasca succession of sediments in the vicinity of the Richardson and Maybelle Rivers (Mitchell and Fortuna 1978; McWilliams *et al.* 1979). Wilson (1985b) identified several prominent northwest and northeast trending structures, one of which is the Richardson River Fault, in the northeast corner of the Bitumount map area. Based on the aeromagnetic data, a prominent northeast trending fault, herein named the Johnson Lake Fault, exists from the centre of Tp. 100, R. 2W4 to at least as far southwest as the northwest corner of Tp. 98, R. 4W4 (Geological Survey of Canada 1983; Wilson 1985b; Sprenke *et al.* 1986). The Johnson Lake Fault appears to offset the magnetic high in the Marguerite River area that corresponds to the 2 to 4 km wide north-northwest trending mylonitic zone (Godfrey 1970; Wilson 1985b) a minimum of 5 km and perhaps as far as 13 km. Based on structure contours for the top of the Devonian from unpublished data provided by Shell Canada Ltd., and the work of Martin and Jamin (1963), the Johnson Lake Fault probably exists as far southwest as the Muskeg River as a prominent northeast trending scarp on the Devonian surface between the Firebag and Muskeg Rivers.

Carbonates along the Athabasca and Clearwater Rivers exhibit noticeable flexures with dips up to about 15°. This gentle warping has usually been attributed to gradual removal of Elk Point Group salts. Martin and Jamin (1963) describe a "*major Devonian fault zone*" that extends from as far south as the Athabasca River south of Pelican Mountain (northeast corner Tp. 70, R.27W4) and trends northeasterly through the Fort McKay area. This fault lines up fairly well with the southwest extension of the Deranger Creek Fault that is extrapolated as far southwest as the Richardson River (Wilson 1985b). Hackbarth and Nastasa (1979) described a major northwest to north trending basement fault, the Sewetakun Fault, that generally has a similar trace to that of the present day salt dissolution edge of the Prairie Evaporite. Hackbarth and Nastasa (1979) give evidence for its reactivation during the Devonian. Structure contour maps on the Devonian surface by Martin and Jamin (1963), and Hackbarth and Nastasa (1979) show that the Devonian erosional surface in the vicinity of Fort McKay is extremely complex with substantive relief and, in fact, has the appearance of being a highly dissected paleo-landscape, particularly in the area of Tps. 94 to 97 and Rs. 9 to 11 west of the 4th Meridian. Martin and Jamin (1963) have suggested that this landscape is due to faulting. Perhaps the north, northeasterly and northwesterly trending paleo-valleys and paleo-ridges are a product of reactivation of basement faults, such as the Sewetakun, Deranger Creek and Johnson Lake Faults described above, associated with uplift of the east-trending Peace River Arch. Other evidence of the periodic uplift of the Peace River Arch in the Fort McKay area is the non-deposition of the Middle Devonian Lower Elk Point salt and associated units (Hamilton 1971, *pers comm.* 1994). The area of non-deposition is east-trending and is on strike with the Peace River Arch to the west as defined by the margin of the Elk Point Basin. The Peace River Arch was a positive feature from Late Proterozoic to Late Devonian, and from Late Cretaceous to Early Tertiary (O'Connell *et al.* 1990; Hart and Plint 1990; Leckie 1989). Burwash (1990) suggested that the effects of the Peace River Arch can be seen as far east as the Marguerite River area, and that its persistence to the present is evidenced by present day positive relief and high heat generation in the basement rocks underlying the Arch (Burwash and Burwash 1989; Bachu and Burwash 1991). If the dissected erosional Devonian surface described above was a result of uplift related to the Peace River Arch, it is likely to have happened during the Late Devonian because the Peace River Arch was in fact a negative feature (a graben) in the Peace River area from Mississippian to Late Cretaceous (O'Connell *et al.* 1990; Cant 1988).

Exploration by Shell Canada Ltd. in the Bitumount map area identified five partially linked basins, each containing coal and developed on the Devonian erosional surface. Each basin is 2 to 3 km in diameter and tends to be elongated to the northwest. The five basins line up along a northwest lineament that is more or less parallel to and near the trend of the Firebag River. Unidentified coal geologists from Shell Canada Ltd. interpreted this structure as a fault, herein named the Firebag River Fault.

The Pre-Cretaceous topography, which developed on a highly dissected Devonian erosional surface (Martin and Jamin 1963; Hackbarth and Nastasa 1979), played a major role in controlling the thickness and extent of the McMurray Formation (Stewart 1963). Evidence of tectonic deformation affecting the post-Devonian units is limited, and is difficult to distinguish from deformation brought about by collapse due to salt dissolution. Stewart (1963) suggested that the McMurray and Clearwater Formations are anomalously topographically high in the vicinity of Telegraph Creek (Tp. 84, R. 12W4) due to reactivation of an underlying Precambrian fault. Kidd (1951) presented evidence that movement took place during the Lower Cretaceous along a northwesterly trending fault that cuts across the Clearwater River east of Fort McMurray, and suggested that the western block was downthrown. Hume (1949) suggested that post-Cretaceous folding, possibly unrelated to salt dissolution, affected Lower Cretaceous units in the Mildred-Ruth Lakes area. Babcock and Sheldon (1976) documented the existence of many lineaments in the Bitumount map area. They suggested that the vast majority of these lineaments are related to the dominant trend of joints and fracture sets in the McMurray and Waterways Formation. However, they also stated that fault related lineaments cannot be ruled out.

PROJECT RESULTS

The objectives of the project were (a) to supplement the existing data on the bedrock geology, surficial geology and the geochemistry of Precambrian to Phanerozoic rocks and the surficial materials in the Marguerite River and Fort McKay areas within the Bitumount map area (NTS 74E), and (b) to provide a preliminary assessment of the economic mineral potential of these areas. Implementation of these objectives involved five basic aspects: (1) geological examination and sampling in the Marguerite River area to assess the Precambrian rocks exposed there, (2) geological examination and sampling in the Fort McKay area to assess the Phanerozoic rocks exposed there, (3) examination of a coal database donated by Shell Canada Ltd. and available core from the Energy Resources Conservation Board (ERCB), (4) a study of the till stratigraphy in the Bitumount map area incorporating unpublished field data obtained during the middle 1980's along the Firebag River, and (5) providing results from sampling of tills and fluvial sediments which was done during 1992 and 1993, for trace element geochemistry and diamond indicator minerals.

Methodology

Fieldwork during 1993 was conducted in both the Marguerite River and Fort McKay areas with the use of a helicopter, and by foot traverse. Results from fieldwork along the Firebag River were supplemented by unpublished data obtained during the middle 1980's by Fenton from a study which was conducted by boat. A total of 71 surface rock samples were collected for geochemical analysis, fire assay and/or thin section: 43 are from the Marguerite River area and 28 are from the Fort McKay area. In addition, five drill holes from a 1970's coal exploration program, which are stored at the ERCB facility in Calgary, were sampled for geochemical analysis and fire assay for gold. All traverse routes, bedrock outcrops and the core examined at the ERCB facility were tested for anomalous radioactivity using a SPP2N SRAT scintillometer. Due to the extensive drift cover in the Bitumount area, nine till and three fluvial sediment samples were collected for geochemical analysis and diamond indicator mineral analysis in order to assess the viability of using the sampling of surficial materials to aid exploration. Two of the nine till samples were collected by Fenton and Pawlowicz during 1992, the remaining seven samples were collected during the field portion of the 1993 program. Brief sample descriptions along with the location and analytical techniques employed for all the samples are in Appendix 1. Sample location maps for the Bitumount, Marguerite River and Fort McKay areas are at the end of the report (Figures 5 to 7, respectively).

The geochemical analyses and fire assaying was completed by Loring Laboratories Ltd. of Calgary, Alberta. Geochemical analysis, using standard '30element Induction Coupled Plasma spectrometry (ICP)' analysis with an aqua regia digestion, and 'gold+34 element Instrumental Neutron Activation Analysis (INAA)' using a 30 gram aliquot, were conducted on all 71 surface rock samples. Fire assay for gold, using a 30 gram aliquot with standard fusion techniques coupled with Atomic Absorption Spectrophotometry (AAS) with a 5 ppb detection limit, was conducted on 24 selected surface samples of Phanerozoic carbonate and clastic rocks, and 23 selected samples from the ERCB drill core. Standard ICP analysis was also conducted on the ERCB drill core samples. Geochemical analysis of the till sample clay fraction was completed using INAA, coupled with AAS analysis utilizing the same sample preparation and techniques as those reported in the Prairie till sampling program of Thorliefson and Garrett (1993). A summary of the geochemical and fire assay results for all the samples is in Appendix 2. The geochemical results for the rock and core samples are summarized geographically on Figure 8 at the end of the report, and Figures 9 and 10 within the body of the report. In addition, sulphide and radioactive occurrences are identified on Figures 8 to 10. The assay certificates for the 71 surface rock samples and the 23 drill core samples are attached as Appendix 3.

Grain size distribution and carbonate content was estimated for all tills encountered along the Firebag River. The two till samples collected during 1992, NAT92-24 and NAT92-25, were processed for diamond indicator minerals at the Saskatchewan Research Council (SRC). Microprobe analysis of potential indicator minerals from these two samples was completed at Canmet during 1993 (Appendix 4; Fenton and Pawlowicz 1993). Three of the seven till samples and the three river sediment samples that were collected during 1993, were processed at the SRC for potential diamond indicator minerals. Selected grains from these six samples were subsequently submitted for microprobe analysis at the University of Saskatchewan during 1994 (Appendix 4). As well, additional potential diamond indicator minerals from samples NAT92-24 and NAT92-25 were submitted for microprobe analysis during 1994 (Appendix 4). The diamond indicator results are presented on X-Y scatter plots and are summarized geographically on Figure 8. The remaining four till samples will be processed along with other samples from northern Alberta during 1994-95 under ongoing MDA project M92-04-006.

A total of 33 surface rock samples were cut into 15 standard and 21 polished thin sections, and were examined under polarized and reflected light on a Zeiss microscope at the Alberta Research Council. Sample mineralogy and descriptions are included as Appendix 5. The results of the fieldwork and geochemical/mineralogical analyses for the Marguerite River area, Fort McKay area and along the Firebag River are presented below.

<u>Marguerite River Area</u>

Fieldwork in the Marguerite River area consisted primarily of foot traverses to examine and sample gossans, radioactivity and bedrock alteration associated with shear zones, brecciation and mylonites in weakly foliated to mylonitic granitoids, and mafic igneous rocks identified by Godfrey (1970). Figures 5 and 6 show sample locations for the Marguerite River area. Brief sample descriptions, including details with respect to sulphides, radioactivity and alteration, are given in Appendix 1. Although the area was not mapped, geological notes were taken at each outcrop examined along traverses during the course of the fieldwork, and selected samples were collected for thin section study. As a result, a better understanding of the geology of the area was obtained, which builds upon previous geological reports for the area.

Compositionally, the Marguerite River area mainly comprises: (a) three types of granitoid rocks, (b) a mafic meta-igneous rock of unknown origin and (c) strongly mylonitic rocks. The granitoids include: (1) a granite to granite gneiss unit, which is generally leucocratic and quartz- and plagioclase-rich, (2) a megacrystic alkali feldspar granite to syenite unit, with abundant K-feldspar, from <20% to often <10% quartz, 15 to 30% mafic minerals and minor amounts of corundum. The presence of primary corundum is indicative of the peraluminous nature of this unit and indicates that it is likely derived from a sedimentary protolith, (3) an alkali feldspar granite to alkali feldspar granite gneiss unit, which is similar to the peraluminous megacrystic unit, but is less coarse grained, is more quartz- and plagioclase-rich, and locally contains garnet and pyrophyllite. This unit may be compositionally related to the megacrystic unit in light of its peraluminous nature and relative abundance of potassium. Foliation in these granitoid units tends to be variable, grading from unfoliated to mylonitic, but in the northern part of the area the foliation generally trends north to northwest, is weak to gneissic, with rare discrete mylonite to ultramylonite zones up to 10 m wide. In the southern part of the area, foliation predominantly trends easterly and is moderate to strong, with mylonite predominating in a 2 to 4 km wide belt. This is in keeping with observations of Tremblay (1961), Godfrey (1970), Langenberg and Nielsen (1982) and Wilson (1985b, 1986).

In addition to the granitoid units, a mafic meta-igneous unit exists in places. This unit is generally 3 to 10 m wide and is weakly to strongly foliated. The unit consists of abundant clinopyroxene that has readily altered to uralitic hornblende, plus or minus chlorite, quartz and plagioclase. The mafic unit crops out on the limb and nose of a regional west plunging antiform which was defined by Godfrey (1970), and acts as a marker horizon defining the fold. As this unit generally is foliated, it is herein named a mafic meta-igneous augite-bearing schist. The protolith of this unit is unknown, but it probably is either a mafic volcanic or a mafic dyke. In general, the mafic unit corresponds to the amphibolite cited by Godfrey (1970), and the basaltic dykes and sills of Tremblay (1961).

Eight sulphide and four radioactive occurrences were found during the course of the fieldwork in the Marguerite River area, and these anomalies are shown on Figures 8 and 9. The sulphide occurrences consist of areas with greater than 2 volume % total sulphides with locally up to 10% pyrite with or without pyrrhotite. The vast majority of the sulphide occurrences exist in the southern half of the Marguerite River area in the 2 to 4 km wide mylonite-dominated region. In addition, a number of sulphide occurrences, particularly those with high sulphide content, occur in the mafic schist or are spatially near the mafic schist in the surrounding mylonitic granitoids and are locally associated with quartz-rich gneisses. This assemblage of mafic schists, quartz-rich gneisses and increased sulphides

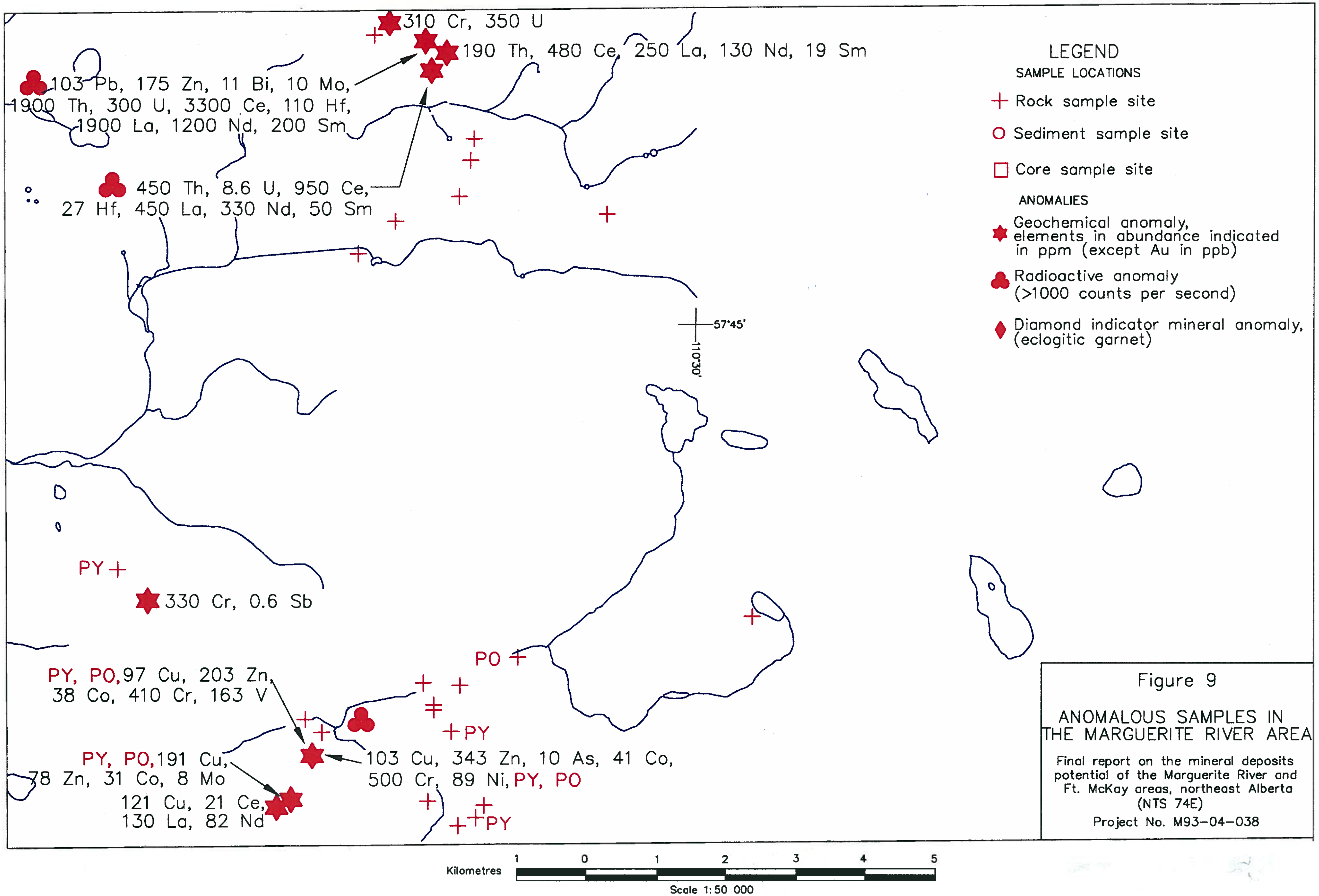


Figure 9

ANOMALOUS SAMPLES IN THE MARGUERITE RIVER AREA

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038

within the 2 to 4 km east-west trending mylonite zone might be indicative of remnant supracrustal rocks within the mylonite belt. This belt is also associated with a strong east trending linear aeromagnetic high that further west becomes more northerly trending (Geological Survey of Canada 1983; Sprenke *et al.* 1986). The four radioactive occurrences range from spot highs of 1,000 counts per second (cps) up to 3,000 cps, as measured with a SPP2N SRAT scintillometer, and are mostly associated with the megacrystic peraluminous syenite (Figures 8 and 9). Secondary yellow uranium oxide stain or hematitization or both exist at a few of these radioactive occurrences.

Highlights of the results from ICP and INAA analyses of rock samples from the Marguerite River area are presented in Table 3, and on Figure 9. The complete table of ICP and INAA results is given in Appendix 2. In total, 37 samples of Precambrian granitoids, and 6 samples of the mafic schist were submitted for analysis. In general, low gold and silver values were obtained from all the samples of the granitoids and the mafic schist, with the highest value being 14 ppb Au. The most anomalous results are from samples that were collected from the radioactive occurrences in the granitoids (Figure 9). In these samples, up to 350 ppm U, 1,900 ppm Th, 3,300 ppm Ce, 1,900 ppm La and

Table 3. Highlights Of ICP And INAA Analyses For Marguerite River Area Samples

Sample #	Lithology	Anomalous Trace Elements (ppm)
Marguerite R.	**(Granitoids)**	
MD93082701	Hematite-stained (675 cps)	190 Th, 480 Ce, 250 La, 130 Nd, 19 Sm
MD93082703	Megacrystic (1,500 cps)	450 Th, 8.6 U, 950 Ce, 27 Hf, 450 La, 330 Nd, 50 Sm
MD93082704	Megacrystic (3,000 cps)	103 Pb, 175 Zn, 11 Bi, 10 Mo, 1900 Th, 300 U, 3300 Ce, 4.5 Eu, 110 Hf, 1900 La, 1200 Nd, 200 Sm, 15 Tb
MD93083002B	Rusty with yellow stain	310 Cr, 350 U
MD93090306B	Garnet bearing quartzose gneiss (1-2% Po+Py)	191 Cu, 78 Zn, 31 Co, 210 Cr, 58 Ni, 8 Mo
MD93090601A	Quartzose gneiss (up to 10% Py)	108 Cu, 2200 Ba
MD93090801	Mylonitic	330 Cr, 0.6 Sb
Marguerite R.	**(Mafic Schists)**	
MD93090303A	Foliated (1% Py+Po)	97 Cu, 203 Zn, 38 Co, 410 Cr, 163 V
MD93090303B	Foliated (1-2% Py+Po)	103 Cu, 343 Zn, 10 As, 41 Co, 500 Cr, 89 Ni
MD93090307	Rusty	121 Cu, 210 Ce, 130 La, 82 Nd

1,200 ppm Nd were obtained, along with elevated values of other rare earth elements (REE's) in a few samples. Sample MD93082704, which yielded the highest REE values for all the rock samples also contains 300 ppm U and anomalous base metal elements such as Pb, Zn, Bi and Mo (Table 3). Base metal elements were locally anomalous in samples from the 2 to 4 km wide mylonite zone, with results of up to 191 ppm Cu, 78 ppm Zn and 330 ppm Cr associated with pyrite and pyrrhotite in quartz-rich gneiss. Mafic schist within the 2 to 4 km wide mylonite zone also yielded anomalous base metal concentrations, with up to 121 ppm Cu, 343 ppm Zn, 41 ppm Co, 500 pm Cr, 89 ppm Ni and 163 ppm V (Table 3 and Appendix 2).

Fort McKay Area

The Fort McKay area was included in this study because there has been a high level of exploration interest in the area, both historically and recently. As mentioned previously, surface sampling and drilling during 1992 and 1993 along the east side of the Athabasca River by the Tintina Mines Ltd./NSR Resources Inc. joint venture, and by Focal Resources Ltd. has indicated the presence of anomalous concentrations of gold, silver and PGE's in Upper Devonian Waterways Formation carbonates. During 1993, MDA-related fieldwork in the Fort McKay area consisted primarily of sampling those outcrops that are readily accessible by road or boat, and reconnaissance prospecting for mineral occurrences and indications of alteration. Sample locations in the vicinity of the Fort McKay area are shown on Figures 5 and 7.

The following units were examined and sampled for gold and other selected metals in the Fort McKay area: (a) Upper Devonian carbonates, (b) well-indurated pre-Cretaceous (?) Beaver River sandstone, (c) McMurray Formation oil sands, and (d) a presently forming salt mound at the southeast corner of Saline Lake. Four sulphide occurrences were discovered as a result of the fieldwork in the Fort McKay area and along the Athabasca River (Figures 8 and 10). Two of the sulphide occurrences consist of fracture-controlled pyrite concentrations in limestone of the Moberly Member along the west shore of the Athabasca River at the townsite of Fort McKay (MD93090503B), and in the Calumet Member along the west shore of the Athabasca River immediately down river from Pierre Creek (MD93090901A). Both units are limestone-rich members of the Upper Devonian Waterways Formation (Table 2) as illustrated on Figure 2 and in Norris (1963). The other two sulphide occurrences consist of pyrite associated with nodules or concretions in the McMurray Formation oil sands in borrow pits along the main north-trending gravel road north of Fort McKay. The Beaver River sandstone differs from the McMurray Formation sandstones in that it is quartz-rich and appears to be well cemented by quartz and minor carbonate, hence it is well indurated. Only trace amounts of pyrite were observed within the Beaver River sandstone, even though outcrops of the unit are quite rusty in places. Petrographic descriptions of selected Phanerozoic rocks are included in Appendix 5.

A total of 15 rock samples from Waterways Formation carbonates, 4 rock samples of carbonate or salt crusts from a salt mound associated with springwater discharge at Saline Lake, which is probably underlain by Waterways Formation carbonate, and 9 rock samples of either Beaver River sandstone or McMurray Formation sandstone/siltstone were collected and submitted for ICP and INAA analysis. In addition, the 24 rock samples from Waterways Formation carbonates and Beaver River sandstone, were all reanalysed for gold by fire assay with an AAS finish. Highlights of the results of these analyses are presented in Table 4, and complete results for all samples are given in Appendices 2 and 3.

Table 4. Highlights Of ICP And INAA Analyses For Fort McKay Area Samples

Sample #	Lithology	Anomalous Trace Elements (ppm)
Fort McKay	**(Clastic Rocks)**	
MD93082401B	Hematitic siliceous sandstone	0.6 Cd, 220 Cr, 460 Ba
MD93090503C	Rusty McMurray Fm. sandstone	144 Zn, 42 V
MD93090707	McMurray Fm. sandstone (15% Py)	82 Zn, 0.5 Sb
Fort McKay	**(Carbonates)**	
MD93091001B	Limonitic carbonate crust near salt mound at Saline Lake	0.5 Ag, 54 Pb, 16 As, 120 Cr, 1.2 Sb, 9 V, 39 B, 18 Br, 472 Sr
MD93091102A	Rubbly limestone	118 Pb, 32 Sb

Low gold values (up to 9 ppb) were obtained by both INAA and fire assay methods for all the Phanerozoic rock samples submitted for geochemical analysis. However, sample MD93091102A (Table 4; Figures 8 and 10), which is from nodular to brecciated argillaceous limestone from the Moberly Member of the Waterways Formation, yielded anomalous concentrations of 32 ppm Sb and 118 ppm Pb. In addition, one sample of material from a salt mound at an active spring water discharge site at Saline Lake (MD93091001B) yielded anomalous concentrations of Ag, Pb, As, Cr, Sb, V, B, Br and Sr (Table 4; Figures 8 and 10). It is not clear whether these anomalous metal concentrations are derived directly from the saline spring waters or are related to possible Waterways Formation carbonates that underlie the salt mound. Geochemical analyses of the five samples from the Beaver River sandstone yielded no geochemically anomalous elements other than chromium in four of the samples (260 to 340 ppm; Appendix 2). The fifth sample, which is from a boulder of possible hematite-stained Beaver River sandstone, yielded 0.6 ppm Cd, 220 ppm Cr and 460 ppm Ba (Table 4 and Appendix 2). Recently, mineral exploration companies have reported that they have found high gold and silver concentrations in Waterways Formation carbonates in the vicinity of Fort McKay (Focal Resources Ltd. 1993; Northern Miner 1993a). Some controversy has arisen over these reported results due to the use of non-traditional methods of gold assaying because the more traditional methods such as fire assay have been reported to be ineffective in evaluating the gold content in comparison to the non-traditional methods (Northern Miner 1993a,b). However, both Focal Resources Ltd. (1993) and Tintina Mines Ltd. (1993) have since reported anomalous gold values using traditional fire assay methods. As well, Dr. H. Abercrombie (*pers comm.* 1994) of the GSC has reported some difficulties in obtaining gold values by traditional assaying methods on surface and core samples from Waterways Formation carbonates and the Beaver River sandstone that were supplied to him by HMS Properties, Focal Resources Ltd. and the Tintina Mines Ltd./NSR Resources Inc. joint venture. Abercrombie and Feng (1994) reported analytical results of up to 3.71 g Au/t in Waterways Formation carbonates and up to 1.08 g Au/t in the Beaver River sandstone using laser ablation coupled with ICP and mass spectrometry.

ERCB Core Firebag River

Although the gold assays obtained from surface rock samples in this study were low, others, including industry (Focal Resources Ltd, 1993; Tintina Mines Ltd. 1993) and the GSC (Abercrombie and Feng 1994), have reported anomalous gold results for samples of Devonian carbonates as well as the overlying pre-McMurray Formation Beaver River sandstone. Some of these reports by others have alluded to the possibility of the gold being in "salt form" (Focal Resources Ltd. 1993) or possibly being halogen associated (Abercrombie and Feng 1994). If these forms of gold exist, it might indicate a possible relationship between elevated gold, along with other metals, in subsurface brines (Barnes 1979) that are discharging in the Bitumount map area or have discharged in the past. Therefore, if such auriferous brines exist or existed, then it is possible that other rock units or lithologies may have been mineralized in addition to the Devonian carbonates. It was decided to test this possible relationship by examining core from the Cretaceous units in the Firebag coal basins. The Firebag coal basins were chosen as they represent five partially connected Cretaceous depositional basins that line up along a possible northwest trending fault, the Firebag River Fault, that affects Devonian carbonates (Unpublished Shell Canada Ltd. data donated to the AGS). This Firebag River Fault could have provided the necessary conduit to focus fluid flow. In addition, the oil saturated coal and carbonaceous shales which are on top of the Devonian unconformity, as well as the underlying carbonates, might have served to reduce any gold-bearing brines that may have infiltrated the basins, a process which would result in gold deposition. For this reason, during January 1994, core from five drillholes stored at the ERCB facility in Calgary, were examined and sampled. These five drillholes are representative of the many holes that were drilled by Shell Canada Ltd. during their coal exploration program in the Firebag River area during the mid 1970's. The location of the drillholes is shown on Figure 5.

A total of 23 core samples from the five drillholes were selected and submitted for standard fire assay for gold and for ICP analysis. Brief descriptions along with assay results and the calculated gold content of the samples are given in Table 5. A complete list of the samples submitted for analysis and their respective gold assay values and ICP results, are presented in Appendix 2. All the intersections examined were in Tp. 98, R. 5 and consist of post-Devonian coal, shale, siltstone and sandstone, most of which was oil stained or oil impregnated. Logs for most of the drillholes indicate that intercepts into the Devonian carbonates were common, but little if any core was recovered below the targeted coal horizons. No visible signs of alteration were visually observed in the core, but pyrite or marcasite is present in a few places. Eleven of the 23 samples are anomalously auriferous, assaying >100 ppb gold, with **four samples** containing **>500 ppb gold**. The highest assay obtained was **1,040 ppb gold** (Table 5). However, several of the reported assays are for samples in which bitumen and/or coal were present and these constituents had to be burned off prior to fire assaying. As a result, sample weight loss ranges from 4.3% to as high as 63.3%, but for most of the samples the weight loss was less than 20%. Using the original core weights, the calculated gold content of the burned samples ranges from 55 ppb to 837 ppb, with 8 samples yielding gold values >100 ppb (Table 5). Interestingly, those samples with bitumen and/or coal consistently yielded the highest gold values, especially those samples which also contained pyrite (or marcasite). Samples from all five drillholes yielded anomalous concentrations of gold. The ICP results indicate there are other anomalous trace elements present and that there is a positive correlation between elevated Au and elevated values for Cr (up to 553 ppm) and, to a lesser extent, Ag (up to 1.1 ppm) and V (up to 39 ppm). Other elements that are also anomalous in several samples in various cores include up to 61 ppm Cu, 97 ppm Pb, 211 ppm Zn, 58 ppm Ni, 35 ppm Co, 14 ppm As, 951 ppm Sr, 4 ppm Sb, 6 ppm Bi and 257 ppm B (Appendix 2). The concentration of these elements is elevated in comparison to the oil sands analyzed by Gulf Canada Resources Ltd. for co-product metals, except for a few bitumen poor horizons below the oil sands where elevated concentrations of Au and high levels of W were encountered (Gulf Canada Resources Ltd. 1993). Of particular interest is the high levels of B, as seven samples yielded concentrations between 96 ppm and 257 ppm. In most cases, high levels of B are accompanied by increased Sr and Na. In some samples, such as B+148C-3, high B is associated with elevated Au, Ag, Cu, Pb, V and Cr (Table 5, Appendix 2). In other samples, high B is occasionally associated with elevated As, Sb and Bi. The presence of elevated concentrations of B, Sr and Na in these samples may possibly support the premise that brine solutions have carried and deposited a diverse suite of trace metals, and that these processes may still be operating today in the Bitumount area. As well, a genetic relationship between the bitumen and these trace elements cannot be ruled out, nor can the possibility of paleoplacer concentrations. However, work by Trevoy *et al.* (1978) indicates that the McMurray Formation oil sands carry a limited suite of elevated trace metals, such as Ti and Zr, which are mainly related to original heavy mineral concentrations rather than the bitumen content. Placer concentrations are considered only a remote possibility due to the fact that anomalous gold concentrations were found in each hole across a wide variety of lithologies including coal and shale. Recent work by Gulf Canada Resources Ltd. (1993) indicate that Ni and V (and other associated trace metals) increase in concentration in the fine-grained to clay-rich sediments, which they suggest raises questions about theories that link Ni, V and other trace metal concentrations to the contained bitumen.

Table 5. Assays And Calculated Gold Content For ERCB Core Samples

Sample #	Description	Weight (gm)	Weight After LOI (gm)	Weight Loss (%)	Gold Assay (ppb)	Calculated Gold (ppb) Content
SL27C-1	Grey mottled shale secondary fibrous mineral present	NA	NA	NA	24	24
SL27C-2	Dull coal with trace py	NA	NA	NA	14	14
SL27C1-1	Grey to black oil sands	113	101.86	9.9	677	610
SL27C1-2	Pebbly sand & oil sand contact	168.67	161.44	4.3	168	161
SL27C1-3	Maroon shale, minor white crust	NA	NA	NA	<5	<5
SL27C2-1	Dull coal with secondary fibrous alteration of py or cbnt	NA	NA	NA	13	13
SL27C2-2	Typical coal	NA	NA	NA	<5	<5
SL27C2-3	Sandy unit with minor white-yellow crust	NA	NA	NA	11	11
SL27C2-4	Mssv py & qtz nodule in oil sand	130.58	105.03	19.6	1040	837
SL27C2-5	Shaley lens in oil sand	49.96	44.23	11.5	647	573
SL27C2-6	Tan to maroon shale	NA	NA	NA	<5	<5
SL27C2-7	Shale with cbnt clasts, regolith?	NA	NA	NA	16	16
B+148C-1	Oil sand with thin shale lenses	81.94	69.87	14.7	109	93
B+148C-2	Mssv py & qtz nodule in oil sand	73.22	58.5	20.1	69	55
B+148C-3	Typical coal chips	57.44	21.06	63.3	218	78
B+148C-4	Maroon shale and sand contact	101.6	95.21	6.3	297	278
E+8C-1	Grey silt clasts at top of silt interval in oil sand	42.13	36.1	14.3	455	390
E+8C-2	Oil sand with secondary white fibrous crust	96.22	77.47	19.5	717	577
E+8C-3	Py nodule in oil sand	71.62	57.56	19.6	107	86
E+8C-4	White fibrous mineral & sulphur clots in coal	NA	NA	NA	17	17
E+8C-5	Dull coal chips	NA	NA	NA	5	5
E+8C-6	White-yellow crust on coal	NA	NA	NA	17	17
E+8C-7	Sulphur stain in coal chips in oil sand	122.95	105.85	13.9	277	238

NA = Samples that were not ashed

The results from the 1993 work have important implications for gold exploration in the Bitumount map area, because the drillhole locations of the core used in this study are about 60 km northeast of Fort McKay. In addition, all five drillholes exhibited some anomalous concentrations of gold from what was essentially a random sampling of the available core. Two of the drillholes are more than 4 km apart. This study has demonstrated that gold, possibly in subsurface brines, was mobile throughout the area, and was probably deposited under reducing conditions associated with the oil sands or carbonaceous units such as coal.

Surficial Geology Along The Firebag River And Sampling Results

The only reasonable exposures of the Quaternary sediments within the map area are along the Firebag River. A reconnaissance survey was made during the mid 1980's by Fenton as part of a project on the Quaternary stratigraphy of the Athabasca surface mineable oil sands area. At that time, about 8 days were spent examining 34 poor to medium quality sections along the Firebag River or adjacent areas. The project was suspended after preliminary lab analyses due to a change in research direction. These data were retrieved and used in conjunction with data from 1993 fieldwork in the preparation of this report.

Physiography

The Firebag River lies within the boundaries of the Bitumount map area, Alberta and the Lloyd Lake map area, Saskatchewan (NTS 74E and 74F; Figure 1), and flows northwest to join the Athabasca River. The eastern quarter of the river flows through locally high relief, rolling, drumlinized terrain (Figure 4; Bayrock, 1971). The central portion flows through low relief, gently undulating terrain, originally called outwash (Bayrock 1971), but later reclassified as moraine (Bayrock and Reimchen 1974). The western quarter is situated in low relief, gently undulating glaciofluvial sand and gravel. The vegetation consists of a narrow band of 25 to 30 m tall spruce adjacent to the river beyond which are highlands covered by predominantly jackpine and minor poplar alternating with muskeg filled lowlands. Much of the terrain has been repeatedly burned by forest fires.

Bedrock Observations

Within Alberta, the Firebag River flows first over subcrops of the Clearwater Formation and, downstream, over subcrops of the McMurray and Methy Formations (Figure 2). The easternmost outcrop of the McMurray Formation is at section MF82-11 in NE LSD. 9, S. 34, Tp. 97, R. 7W4.

The present day surface of the Methy Formation is cut by a number of sinkholes throughout the Waterways and Bitumount map areas. These have been noted by a number of researchers, including Hume (1947), Bayrock (1971), Norris (1973), McPherson and Kathol (1977), Hackbarth and Nastasa (1979), and Ozoray *et al.* (1978). The author (Fenton) examined a number of these sinkholes at sections on the Firebag River (center of Tp. 99, R. 7) and is impressed by the frequency and the amount of relief of these features. At site MFFB83-2 (LSD. 4, S. 10, Tp. 99, R. 7W4), for example, a 3 m high outcrop of the Methy Formation contains at least three sinkholes in a distance of about 100 metres. The sinkholes are three to five metres across and filled to a depth of at least 3 metres by rubble consisting of about 60% oil sand and 40% limestone. A few of the blocks of the McMurray Formation exceed 2m in height and width. The bedding in the Methy Formation dips toward the margin of the sinkhole but appears to have been truncated by collapse at the edge of the depression. There was no clear evidence whether Quaternary sediment had been included in the collapse of the sinkholes because they are situated at the base of the Quaternary section where there is an abundance of colluvium. However, at section MFFB83-2 there is some evidence that till may be included in the collapse rubble. The sinkholes shown on the Bitumount surficial map (Bayrock 1971) also indicate postglacial collapse occurred in some areas, particularly in the northwest quarter of the Bitumount map area. One sinkhole at the Muskeg River (about S. 8, Tp. 94, R. 10W4) is about 7 m across and 10 m deep, and is filled with limestone and oil sand debris. The dimensions of the area in which these closely spaced sinkholes exist is uncertain, but within that area the topography on the Devonian erosional surface must be highly irregular, and porosity and permeability is likely high.

Quaternary Stratigraphy

The stratigraphy of the Quaternary sequence is exposed in a number of geologic sections as far upstream as Tp. 96 R. 3W4. Samples were analysed for matrix texture in the field by hand (% 1-2 mm fraction, sand, silt and clay), and for total carbonate and the calcite to dolomite ratio using hydrochloric acid. The analyses were difficult to perform on some of the till samples because of their high bitumen content. This may have affected the analyses for clay and carbonate content.

The field data, together with the geochemical data (Appendix 2), indicate a preliminary stratigraphy consisting of seven units (Table 6, Figure 11). Four diamicton units are interpreted to be till. The lowest unit is a black, silty-sand till, that is exposed at only two locations along the central portion of the Firebag river and is not illustrated on the schematic cross section (Figure 11). Little is known about this unit because it is inaccessible at the first geologic section due to its exposure occurring in a near vertical face, and it is almost inaccessible in the second section because of a thick cover of colluvium. In the first section, where this unit is well exposed, albeit inaccessible, the contacts with the underlying McMurray Formation and with the overlying bituminous till (T4) are both sharp. The Unit 1 "Black Till" is less than 1.5 m thick.

Table 6. Preliminary Surficial Stratigraphy Firebag River

Unit	Lithology	Lithological Description	Thickness & Distribution
Unit 7	Uppermost sand unit	Sand with minor gravelly sand layers and reworked oil sand fragments.	Unit is < 2 m thick in its upstream half; 10 to 15 m thick in the downstream third of the river
Unit 6	Clay unit	Gray sediment with pink layers: Pink layers are confined to the upper 5% of the sequence Generally clay to silty clay.	Thick, along the lower third of the Firebag River
Unit 5	Medium to fine grained sand unit	The sand is clean (free of silt and clay), well sorted, and clast free except for a boulder lag at the base. The upper contact, with the overlying sediment of Unit 6, is sharp.	Unit thickness varies from 0 to 2 m
Unit 4	Till T5	Sandy till; dark grayish brown to grayish brown on a fresh surface. Slightly less sand than till T4.	
Unit 3	Till T4	Sandy till; dark grayish brown to olive brown. This till is characterized by a high proportion of total sand and very coarse sand, and total matrix carbonate.	This is the most widespread till
Unit 2	Till T2	Silty sand till ; grayish brown to olive brown on a fresh surface. This till is characterized by a relatively low proportion of sand, very coarse sand and carbonate.	A discontinuous stratified layer that overlies the till is included in this unit
Unit 1	'Black Till'	Silty sand till; black. Little is known about this unit because the only two exposures are inaccessible.	Crops out only in the central portion of the river

The grain size and carbonate content analyses (Figures 12 and 13) indicate the presence of three till units that overlie the Black Till along the central portion of the Firebag River. These units are informally called tills T5, T4 and T2, from the uppermost to the lowermost till (Figure 11). The analyses are from till units that are thick enough that there are no signs of contamination from the sediment above or below the till and the till was not strongly weathered. The means and standard deviations were determined for the sections with two or more samples within each unit. Most of the stratigraphic sections are comparatively short, with only five sections containing two of the three till units. Till T2 contains less sand, less of the 1-2 mm fraction, and less carbonate than tills T4 and T5 (Figures 12 and 13). Till T4 generally contains more 1-2 mm sediment, more sand, and slightly less clay than till T5.

Till T2 was recognized in three sections and in one was overlain by till T4.

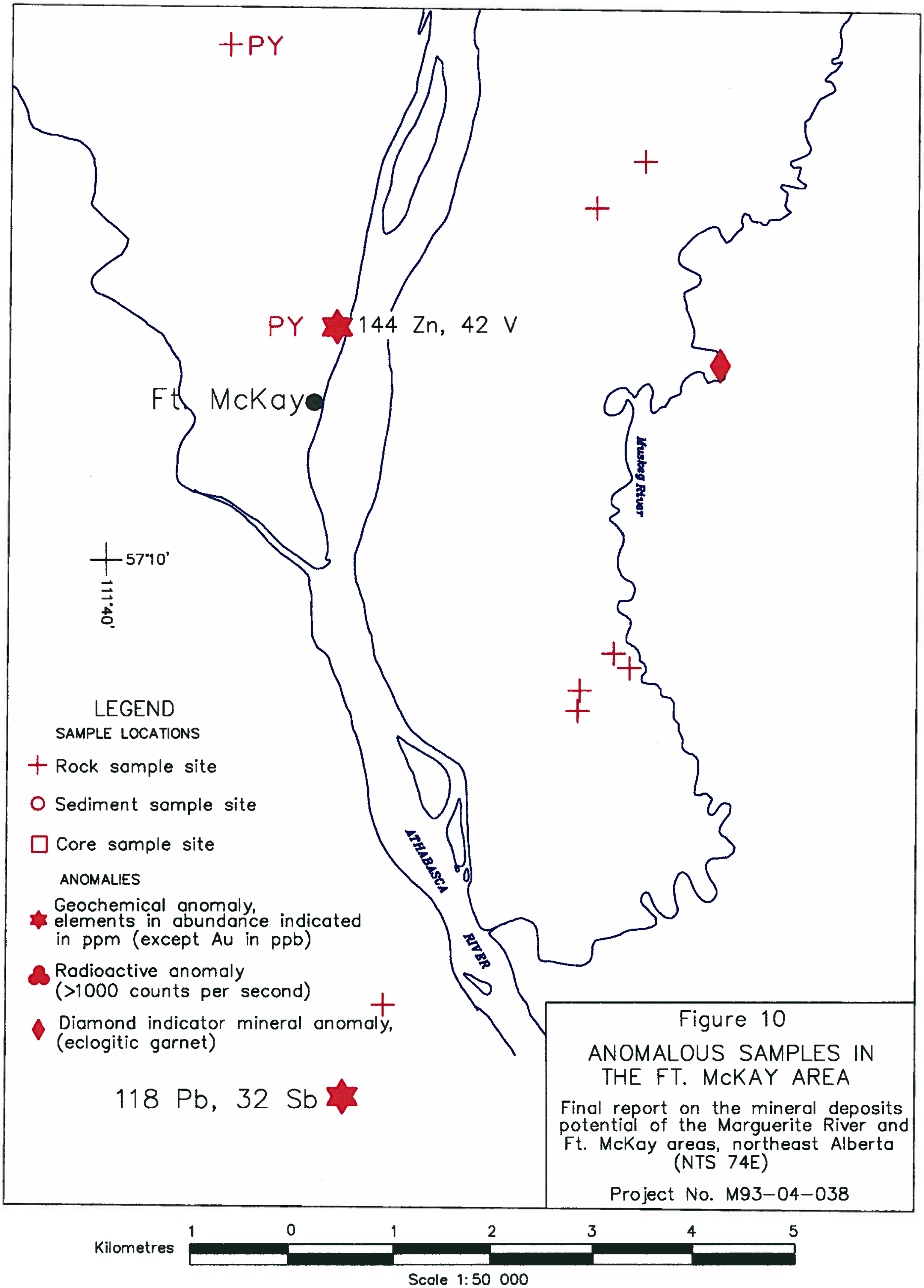


Figure 10

ANOMALOUS SAMPLES IN THE FT. McKAY AREA

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038

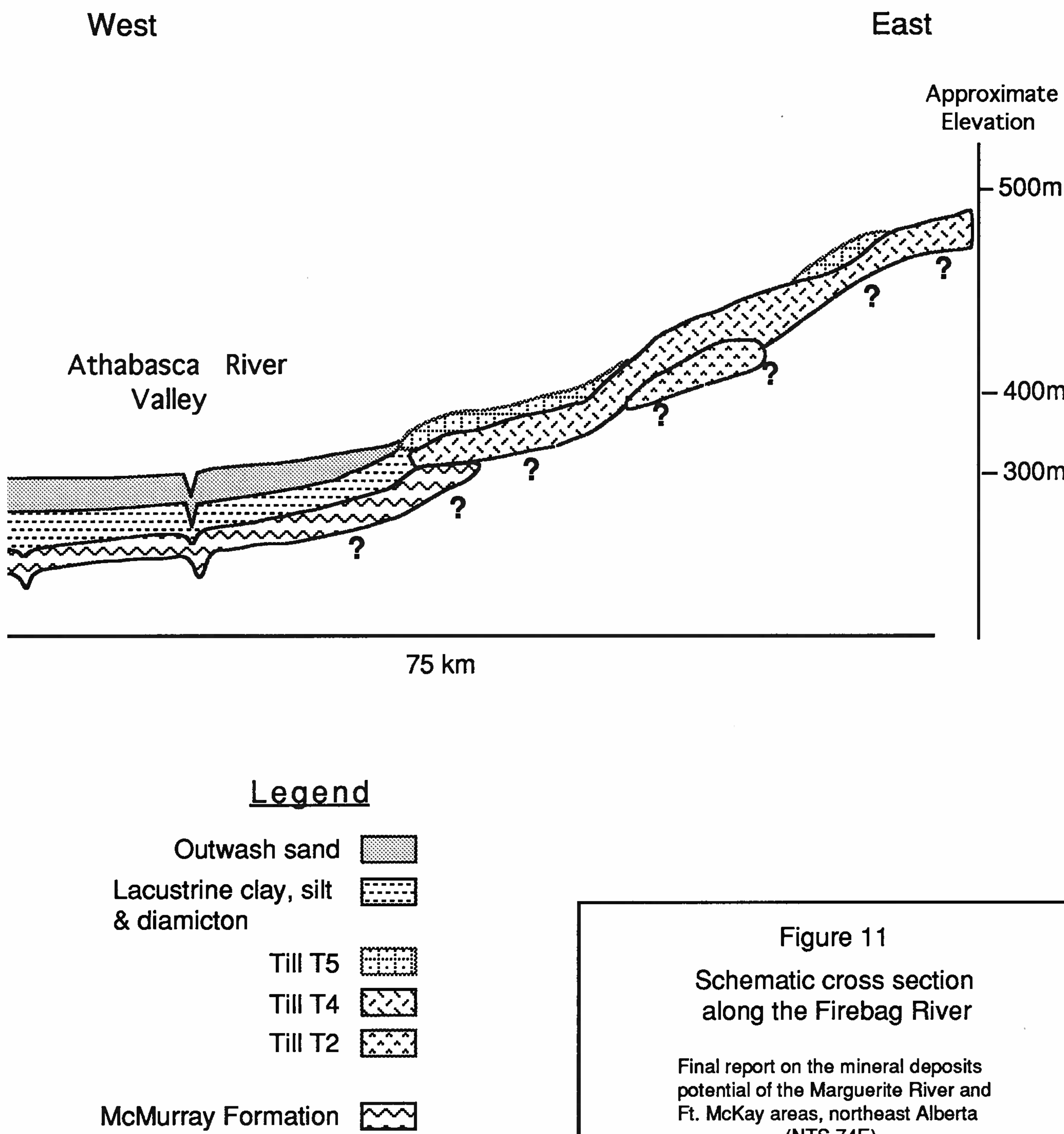


Figure 11

Schematic cross section along the Firebag River

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038

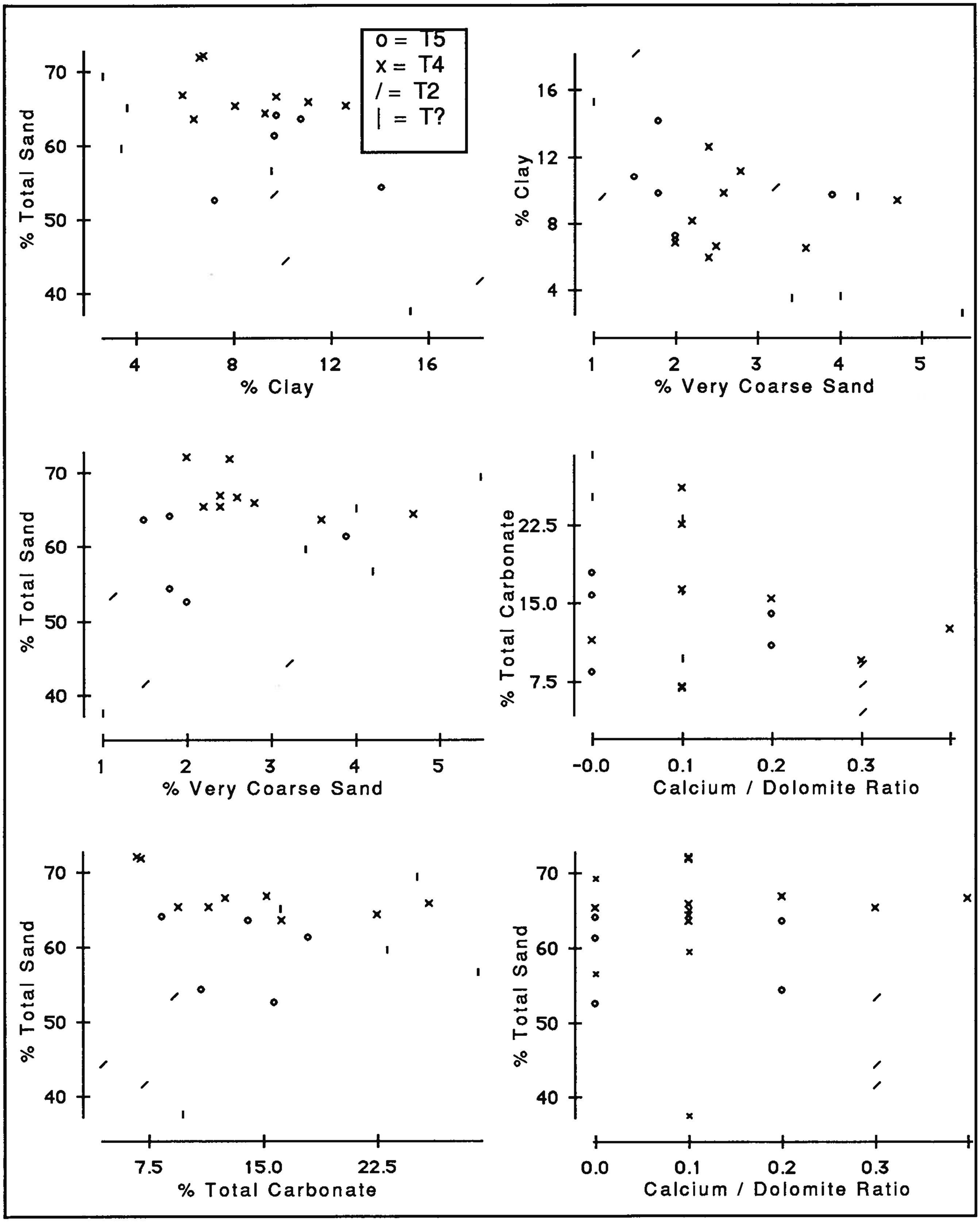


Figure 12. Scatter plots of the mean values for each till at each site for tills T2, T4, T5, and unknowns (T?).

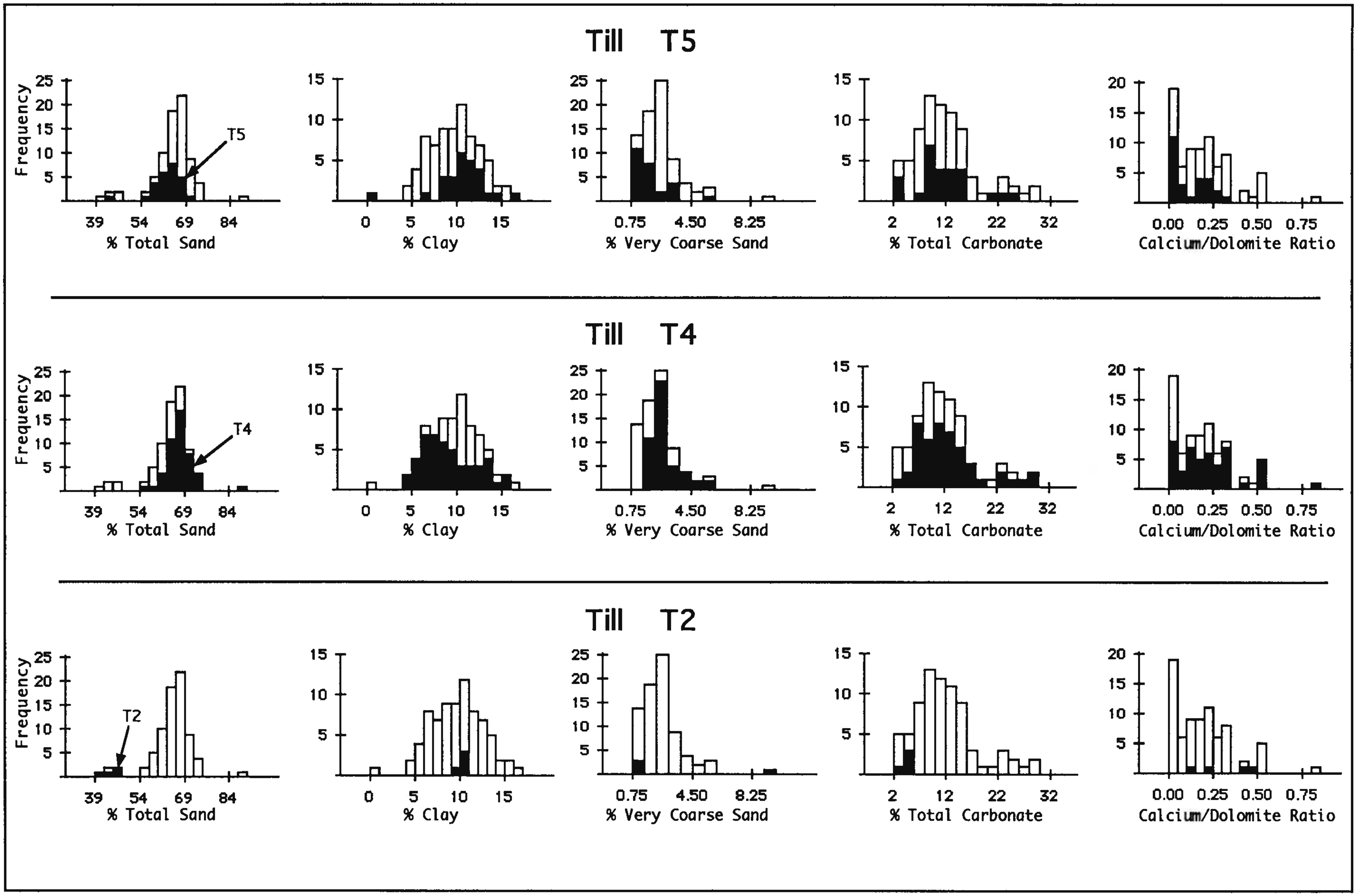


Figure 13. Histograms showing variation in properties of all samples from till units T2, T4 and T5. Black bars in each plot represents the designated till. (Note: these plots are disproportionately influenced by the multiple samples from the few thick geologic sections).

Till T5 was recognized in five sections and overlies till T4 in four of these sections. There were five sections in which the till could not be identified as one of the above and these samples are shown as "T?" in Figure 12. The reason for this may be that in four of the sections the till was so thin that only one sample was obtained and that the composition was not typical of tills T2, T4 or T5. Alternatively, one or more of these sites may contain an entirely different till.

When sampling the sections, some of the till units emitted a distinctive bitumen odour. This was originally considered to be indicative of a particular till layer. However, the subdivisions of the tills into T2, T4 and T5 based on the texture and matrix carbonate does not support this hypothesis. Within each till type there are sections with and without the bitumen odor. The presence of the bitumen is probably the result of local incorporation of oil sands.

There is a greater difference between till T2 and the two tills T4 and T5, than between T4 and T5. Tills T4 and T5 are much sandier and have a higher carbonate content than T2. This may indicate that tills T4 and T5 are similar and perhaps genetically related to the sandy Gypsy Till recognized by Bayrock and Reimchen (1974), and that the less sandy till, T2, is related to the Kinosis Till. In addition, till T2 was recognized in the central portion of the Firebag River (Figure 11), which is spatially near the outcropping Kinosis Till (Unit 2 on Figure 4). However, the spatial relationship may just be coincidental. The stratigraphy of the buried channel described by Horne and Seve (1991) was examined by Fenton during a groundwater investigation by excavating with a backhoe at a number of sites. The channel contained a till composed almost entirely of sand, overlying a till with more silt and clay. These two tills may correspond to till T2 overlain by till T4.

Unit 6 is a gray clay to silty clay unit with pink layers confined to the upper 5% of the unit. The unit is 5 to 10 m thick along the lower third of the river and decreases to less than 2 m thick along the upstream half of the river, where pink sediment predominates. In many sections the gray sediment is a massive diamicton with a few small fragments of pink sediment. At some sites the pink sediment appears to fill fractures in the gray sediment.

Unit 7, the uppermost unit, consists of sand with minor gravelly sand layers. The sand is generally medium grained and clean. In downstream sections, cross beds of reworked oil sand fragments are present. These fragments could make this unit difficult to distinguish from relatively bitumen free portions of the McMurray Formation when looking at well cuttings. This unit is less than 2 m thick in the upstream half of the area and 10 to 15 m thick in the downstream one third of the river. This unit has been mapped as outwash sands (Bayrock 1971, and Unit 7 on Figure 4).

Units 6 and 7 are associated with the deglaciation of the region. They were effected by the paleoflood described by Smith and Fisher (1993). The bitumen fragments included in Unit 7 may be rip-up clasts eroded during the flood.

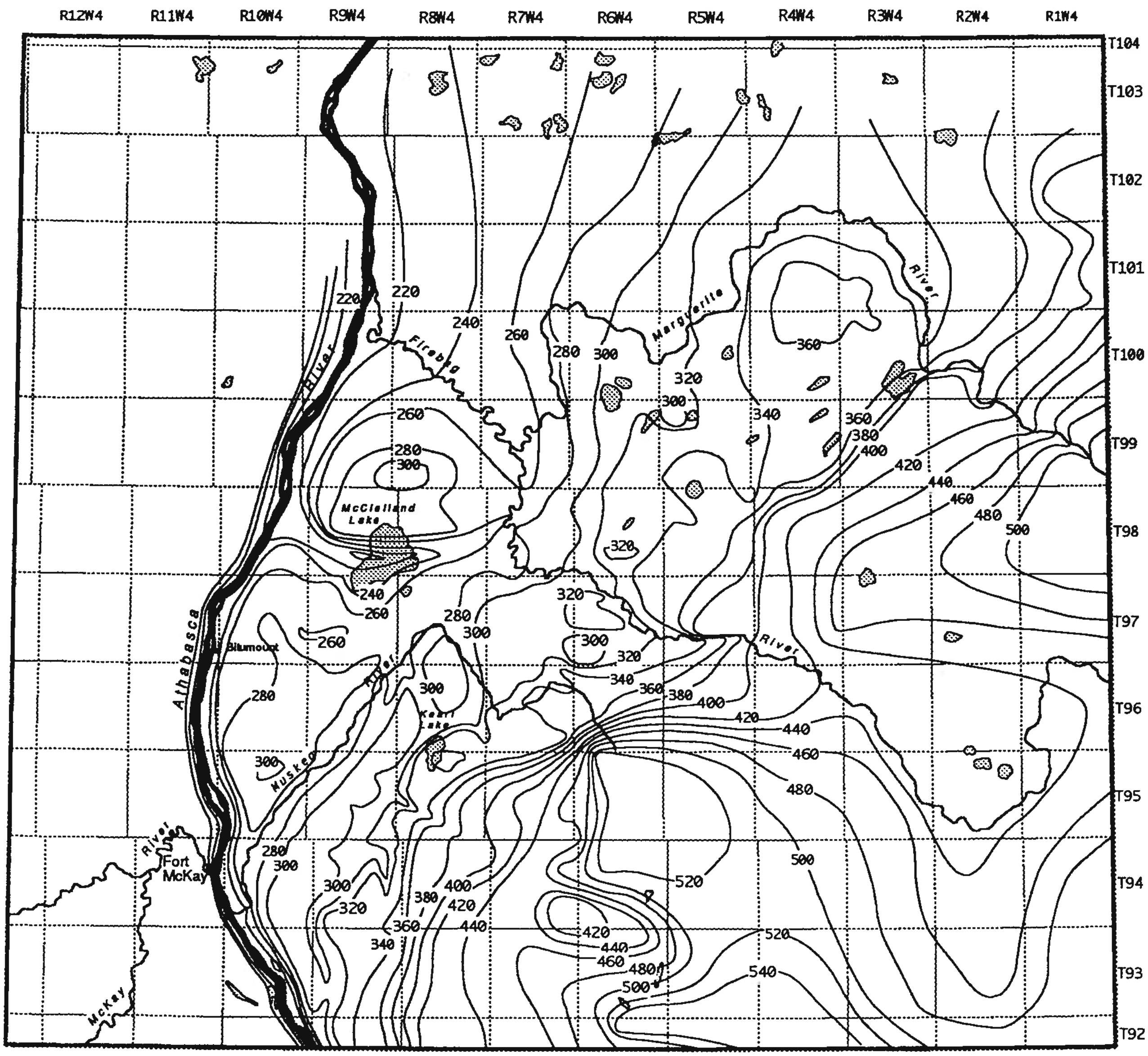
Bedrock Topography and Drift Thickness

The data used to construct the bedrock topography and drift thickness maps comes from existing holes that were drilled for coal, petroleum, and groundwater. The maps produced by McPherson and Kathol (1977) together with a local investigation by Horne and Seve (1991) were used to provide the contours in the southwestern quadrant of the Bitumount map area (Figure 3). The data are very sparse throughout much of the area, with the exception of the central portion where Shell Canada Ltd. drilled a number of holes for coal, and the southwest quadrant where hundreds of holes have been drilled as part of the mining of the Athabasca North Tar Sands Deposit.

The regional bedrock surface slopes toward the Athabasca River from highs in the Birch Mountains to the west and the Muskeg Mountain to the southeast. The bedrock surface east of the Athabasca River slopes to the northwest toward the river valley and ranges from about 525 m above sea level (asl) in the vicinity of Tp. 95, Rg. 6, to 205 m asl along the northern portion of the Athabasca River (Figure 14). There is a broad southwesterly trending low that extends from the Marguerite River area to the southwest corner of Bitumount map area in the vicinity of the Athabasca River. The highland to the east rises to about 505 m asl in Tp. 98 Rg. 1. A narrow north-northeast trending buried channel which extends from at least Tp. 93 Rg. 9 to Tp. 96 Rg. 8, has been documented by Horne and Seve (1991).

McPherson and Kathol (1977) defined a narrow channel that underlies McClelland Lake and slopes westward to the Athabasca River. This channel may connect with that described by Horne and Seve (1991) but the data are insufficient to be certain. Based on the known geological setting in other areas of northern Alberta, it is probable that similar channels can be expected elsewhere in the Bitumount map area, particularly in the eastern half of the area, although the existing poor well control has precluded their recognition.

The drift thickness ranges from 0 m in the Marguerite River area where the Precambrian crops out, to about 185 m in the south central portion of the area (Figure 15). Thick drift is present east to southeast and south of McClelland Lake and this is likely due to the presence of thick ice contact sediment as has been mapped by Bayrock (1971). The thick drift which underlies McClelland Lake is the infilling of the buried channel in that area. There is no surface expression (eg. a topographic high) of this thick drift. The large area of thick drift in the vicinity of Tp. 93, R. 4 and 5 in part corresponds to the same location as a bedrock high (Figures 14 and 15). This shows that Muskeg Mountain, which is the topographic high in this region, is a composite feature formed by the deposition of thick drift on a bedrock high.



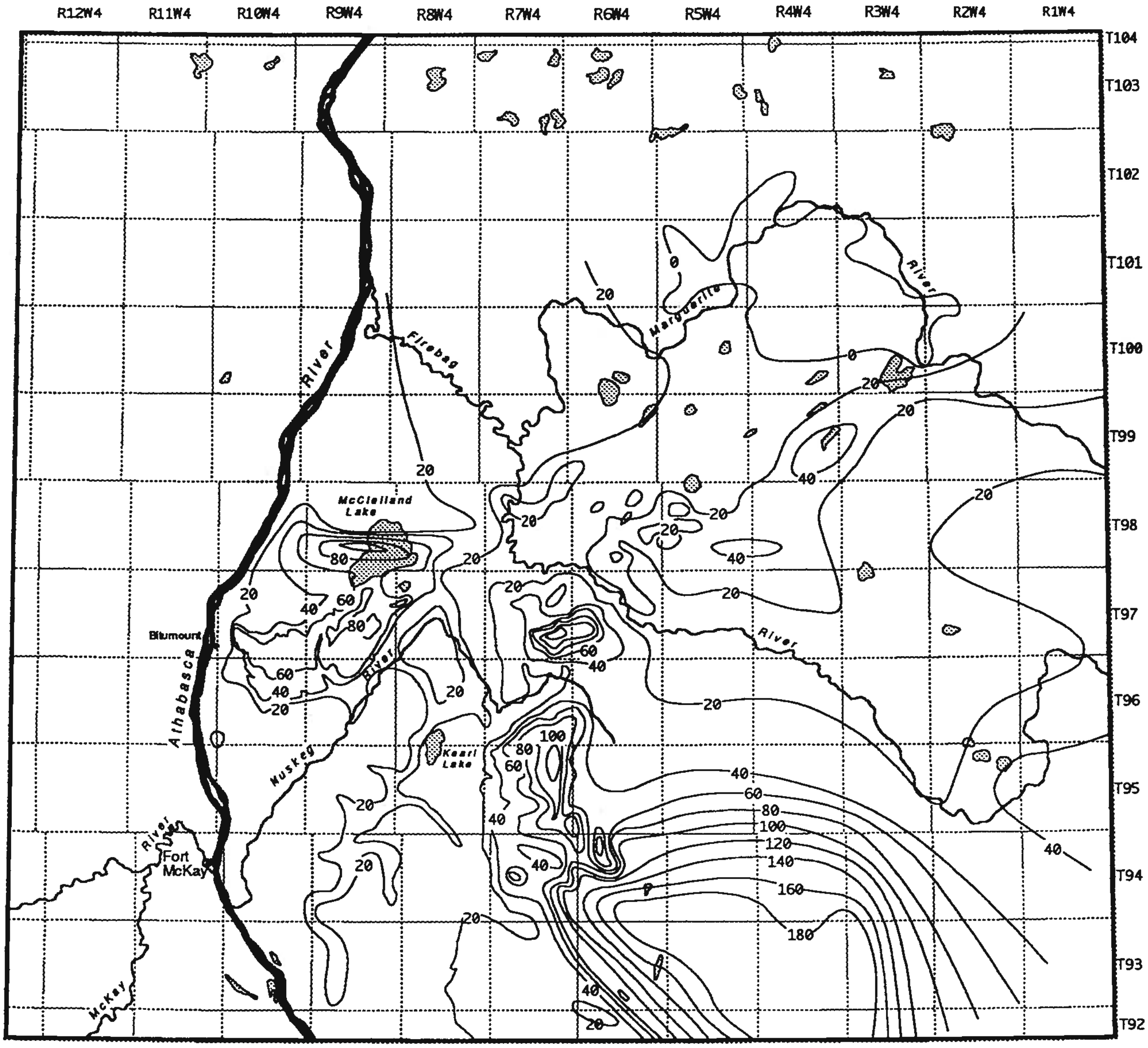
0 20 km

Figure 14

Bedrock Topography
(elevation above sea level)
Contour Interval = 20 m

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038



0 20 km

Figure 15

Drift Thickness map of Study Area
Contour Interval = 20 m

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

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In general, the present day surface topography reflects the topography of the bedrock surface, that is, the broad north-south low along the Athabasca River and the highlands to the southeast (Muskeg Mountain) and east of the Firebag River, are both bedrock and topographic lows and highs. This also is likely the case for the Birch Mountains, which are northwest of the Athabasca River, but there is little data available to confirm this.

Till and Fluvial Sediment Sampling

A total of nine till samples and three fluvial sediment samples were collected during 1992 and 1993, and comprise the diamond indicator mineral and till geochemistry data included in this report. The locations of these samples are shown on Figure 5. All the till samples have been geochemically analyzed for selected elements and the results are in Appendix 2. The fluvial samples were not geochemically analyzed. However, three of the fluvial samples and five of the till samples have been analysed for diamond indicator minerals. The remaining four till samples will be processed for diamond indicator minerals during 1994-95 under ongoing MDA project M92-04-006.

The results of the till geochemistry were interpreted by comparing the values obtained for this study versus the 95th percentile values reported by Thorliefson and Garrett (1993) for their Prairie till survey. Potentially anomalous tills include NAT92-24 with up to 0.7 ppm Ag, 97 ppm Zn, 32 ppm Cu and 570 ppm F, and NAT93-88 with 9 ppb Au, 14 ppm As and 12 ppm Br (Appendix 2). Interestingly, sample NAT93-88 is from till situated close to the salt mound at the southeast end of Saline Lake (Figures 5 and 8), where a rock sample is anomalous in Ag, Pb, As, Cr, Sb, V, B and Br.

In an attempt to evaluate the diamond indicator mineral content of the tills and fluvial sediments, the samples were first processed into certain magnetic, size and specific gravity fractions by the Saskatchewan Research Council (SRC), and were then hand-picked by the SRC for potential diamond indicator minerals, including garnets, pyroxenes, chromites and ilmenites (Table 7). Swanson and Gent (1993) have summarized the processing and microprobe procedures at the SRC and the University of Saskatchewan, respectively. These potential diamond indicator grains were then sent for microprobe analysis. Hand-picking of the eight samples by the SRC yielded no '**probable**' pyrope garnets or chrome diopsides. However, a number of '**possible**' indicator minerals were identified by the SRC, including 5 possible pyropic garnets, 37 possible eclogitic garnets and 7 possible Cr-diopsides. The complete results of the processing and hand-picking are given in Table 7. The grains picked by the SRC were supplemented by additional hand-picking for some of the samples prior to sending the selected grains off for microprobe analysis.

The results of the microprobe analysis for all eight samples are in Appendix 4. All of the microprobe data in Appendix 4 was processed using mineral identification

Table 7. Results Of SRC Processing Of Till And Fluvial Samples From The Bitumount Map Area

Sample Number	Type*	Sample Weight (kg)	+1.7 mm Weight (kg)	Mid Fraction (g)	Heavy Fraction (g)	Probable Pyrope Garnets	Probable Chrome Diopsides	Possible Pyrope Garnets	Possible Chrome Diopsides	Possible Eclogitic Garnets	Opaques
NAT92-24	(T?)	26.85	0.60	2.89	2.03	0	0	2 (2)**	0	7 (7)	26 (8)
NAT92-25	(T?)	27.35	0.53	2.13	2.08	0	0	2 (2)	1 (1)	12 (12)	25 (16)
NAT93-80	(Fl)	11.45	0.05	6.62	27.17	0	0	1 (1)	0	1 (1)	2 (2)
NAT93-81	(T4)	Not analysed until 1994									
NAT93-82	(T5)	30.75	1.85	2.06	7.10	0	0	0	3 (3)	0	4 (4)
NAT93-83	(T4)	25.65	2.65	1.05	3.69	0	0	0	1 (1)	1 (1)	2 (2)
NAT93-84	(T?)	Not analysed until 1994									
NAT93-85	(Fl)	14.00	0.05	11.57	15.67	0	0	0	1 (1)	4 (4)	15+ (15)
NAT93-86	(T?)	Not analysed until 1994									
NAT93-87	(Fl)	11.95	0.05	11.74	36.47	0	0	0	1 (1)	12 (12)	2 (2)
NAT93-88	(T?)	Not analysed until 1994									
NAT93-89	(T?)	30.85	3.35	8.26	5.96	0	0	0	0 (3)	0 (16)	0

*Sample types = Tills T? (Unknown Till), T2, T4 and T5, or Fluvial Sands (Fl)
**(2) Number of selected grains sent for microprobe analysis (oxides from 1993 samples were screened for MgO and Cr2O3)

programs written in QBASIC and provided by the SRC (Quirt 1992a,b; Gent 1993). The results were evaluated using major and minor element X-Y scatter plots of the sample data versus those for known diamond inclusion compositions given in Fipke (1990), and the diamond inclusion fields illustrated by numerous authors including McCandless and Gurney (1989), Fipke (1990) and Gurney and Moore (1993) (Figures 16 to 18). Because diamonds are regarded as fragments of disaggregated upper mantle peridotite or eclogite incorporated into kimberlite or lamproite magmas as xenocrysts, there are essentially three types of indicator minerals that may have meaning in low density regional surveys: (1) those that are indicative of kimberlites or lamproites, (2) those that are indicative of peridotite or eclogite, and (3) those that are indicative of diamondiferous peridotite or eclogite source rocks. Indicator minerals that are probably indicative of kimberlites or lamproites include: (a) high titanium G1 or G2 pyrope garnets and high magnesium ilmenites (picroilmenites) for kimberlites, and (b) high magnesium (variable chromium) P3 and P4 chromites for lamproites. Indicator minerals indicative of peridotite include G7, G9, G10 and G11 pyrope garnets, chrome diopsides (>0.5 wt% Cr_2O_3) and P1 chromites. Indicator minerals indicative of eclogite include: (a) low iron (<25 wt% total Fe as FeO), high magnesium (>6 wt% MgO) G3, G4, G5 and G6 almandine garnets (referred to as eclogitic garnets), (b) low chromium, high sodium and high aluminum diopsides, and (c) jadeite, corundum and kyanite. Indicator minerals indicative of diamondiferous peridotite include: (a) subcalcic, high chromium, G10 pyrope garnets, and (b) high magnesium, high chromium (>61 wt% Cr_2O_3) P1 chromites. Indicator minerals used to identify diamondiferous eclogite include: (a) high sodium (>0.07 wt% Na_2O) and high titanium in low iron, high magnesium G3, G4, G5 and G6 eclogitic garnets, and (b) high potassium (>0.1 wt% K_2O) clinopyroxenes.

Based on the results of the grains probed to date, there are no grains indicative of either kimberlite, lamproite or peridotitic source rocks, with the possible exception of four chrome diopsides in samples NAT93-82, -83 and -87. However, five G3 and twenty-two G5 eclogitic garnets were identified by microprobe analysis using the computer program MIN-ID.ASC (Gent 1993), several of which have favourable chemistry because they plot within the diamond inclusion field (DIF) for eclogitic garnets on X-Y scatter plots of FeO (total Fe) versus MgO (Figure 16) and TiO_2 versus CaO (Figure 17). Several of the ecologitic garnets have sufficient amounts of Na and Ti, such that they border on the diamond inclusion field for eclogitic garnets on a plot of TiO_2 versus Na_2O (Figure 18). The lack of kimberlitic indicators in the samples which contain the eclogitic garnets indicates that they are not likely derived from kimberlites. The lack of lamproitic indicators, such as chromite, does not preclude the possibility for eclogite-bearing lamproites because lamproites tend to yield few diagnostic indicator minerals (Fipke 1990). The most interesting grain is grain 55 from till sample NAT93-83 along the Firebag River, which plots well within the DIF for FeO versus MgO, TiO_2 versus CaO and borders on the DIF for TiO_2 versus Na_2O with 0.05 wt% Na_2O (Figures 8, 16 to 18 and Appendix 4). Indicators of paleo-ice flow direction suggest that the last glacial event had a southwesterly trend, hence the eclogitic garnet and associated chrome diopside may have been derived

Figure 16. MgO vs FeO For Eclogitic Garnets

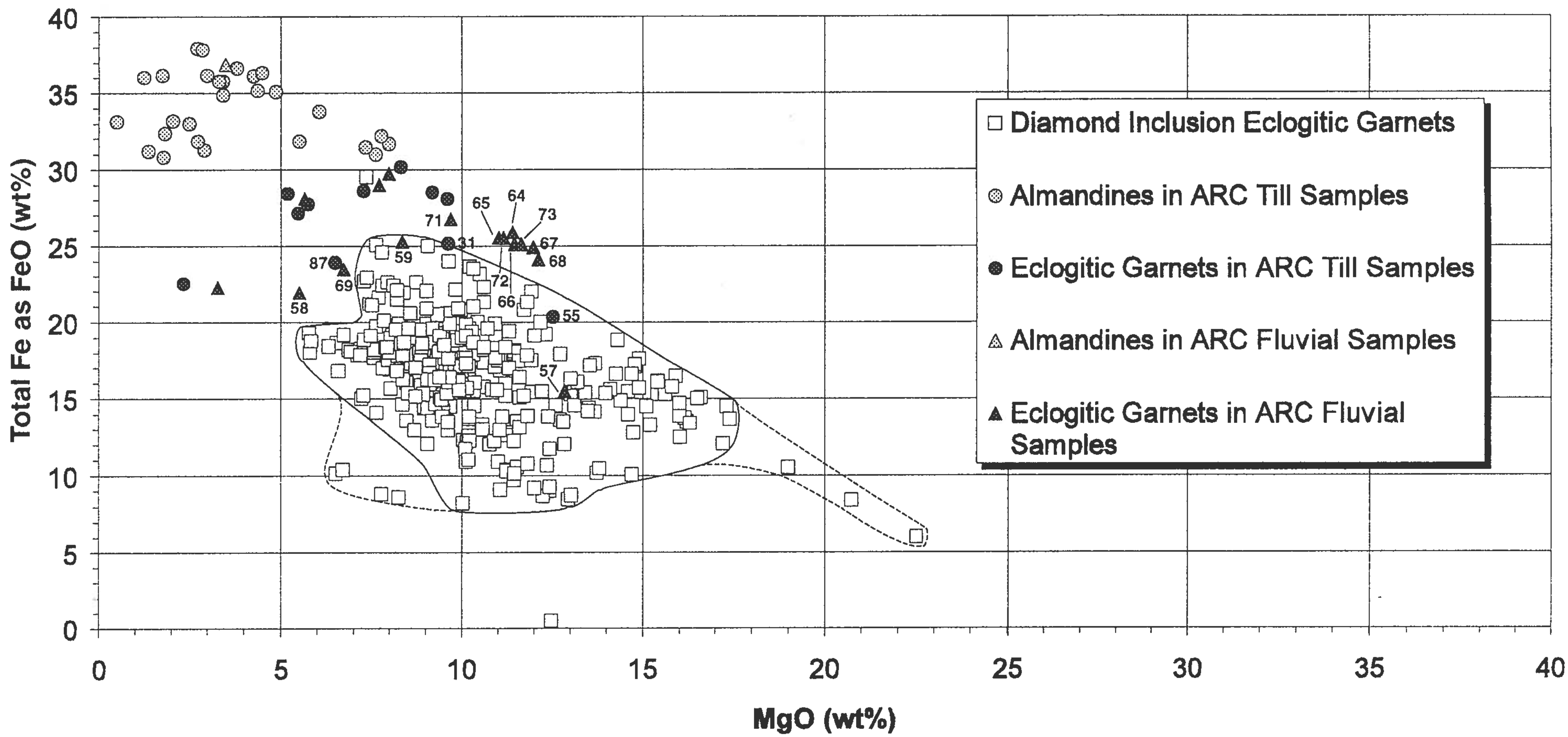


Figure 17. CaO vs TiO2 For Eclogitic Garnets

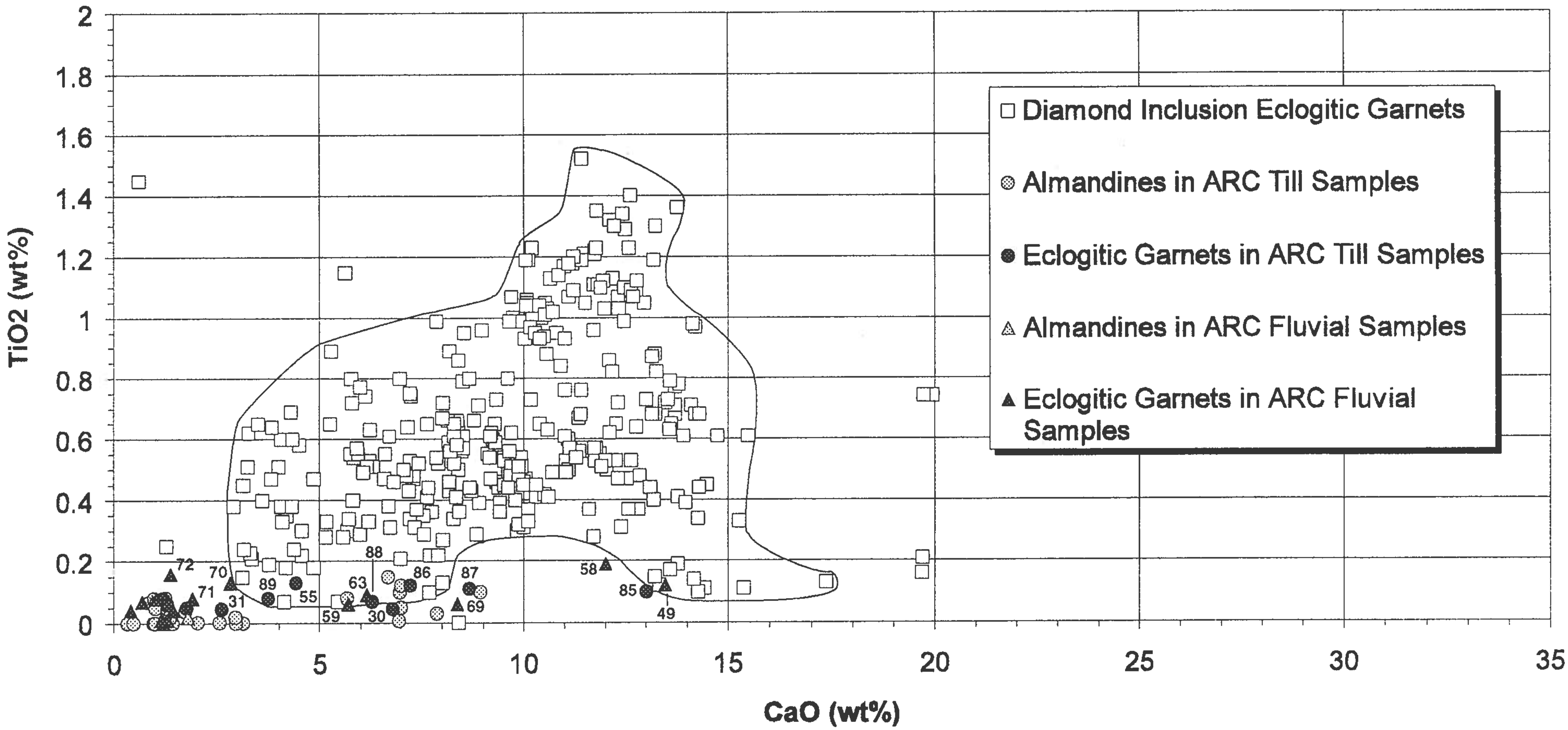
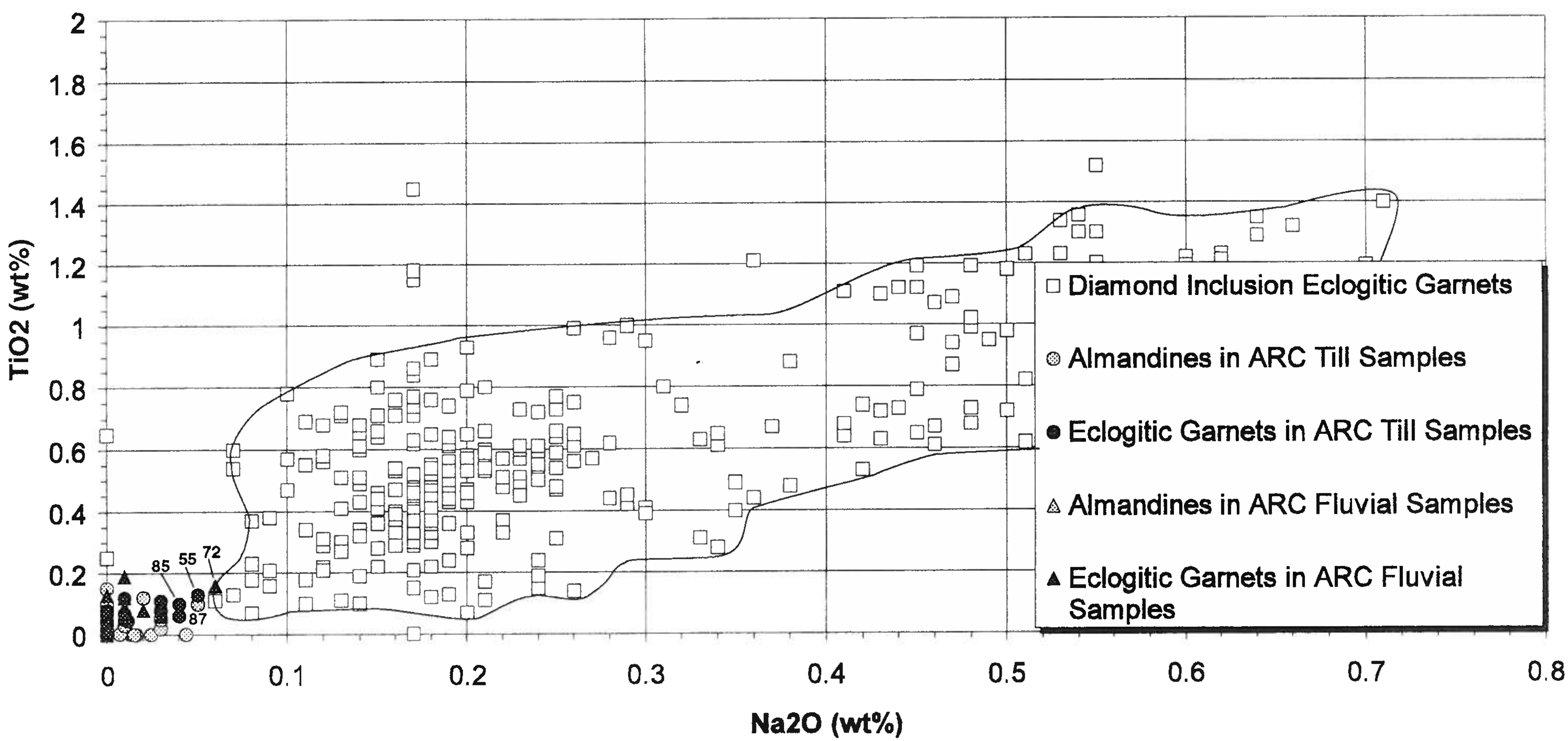


Figure 18. Na2O vs TiO2 For Eclogitic Garnets



from the northeast. Other eclogitic garnets of interest include: (a) grain 87 from till sample NAT93-89 and grains 57 and 59 from fluvial sediment sample NAT93-85, both of which were collected along the Marguerite River, (b) grain 31 from till sample NAT92-25 east of the Muskeg River, and (c) eleven G5 eclogitic garnets with high MgO and, in particular, grain 72 with 0.06 wt% Na_2O, in fluvial sediment sample NAT93-87 from the Muskeg River (Figures 8, 16 to 18 and Appendix 4). For those grains derived from tills, the interpretation of the point of origin is somewhat straight forward, but is dependant on which till was sampled. For those grains derived from the fluvial samples, however, the interpretation is much more complicated because the indicator minerals could be derived from tills, glaciofluvial sediments or Cretaceous sedimentary strata in subcrop. Determining the point of origin for these grains is beyond the scope of this study, but, several of the eclogitic garnets have encouraging chemistry and should be followed up by industry.

DISCUSSION

Potential Mineral Deposit Types in the Bitumount Area

Based on the geology of the Bitumount map area, and the geochemical results obtained for samples from Marguerite River, Fort McKay and from drill core in the vicinity of the Firebag River, there is definite potential for: (a) precious and base metal deposits in both the Precambrian basement and overlying Phanerozoic strata, (b) uranium deposits associated with the Precambrian Athabasca Group, and possibly for (c) rare earth element deposits in some Precambrian basement rocks. In addition, there is potential for diamond-bearing kimberlite or lamproite pipes to exist, based on the presence of several eclogitic garnets with chemistry comparable to diamond inclusion eclogitic garnets .

The most encouraging results obtained in this study involve rock samples from the Phanerozoic succession, including Devonian carbonates and Cretaceous sands, shales and coal, in the vicinity of the sub-Cretaceous unconformity. Potential deposit types in the Phanerozoic stata are discussed below, as well as an evaluation of the sub-Cretaceous unconformity as an exploration target. The two most prospective types of deposits in the Phanerozoic strata are epithermal (or brine related) gold deposits and Mississippi Valley-type Pb-Zn deposits.

Brine Related and Carlin-type Epithermal Gold Deposits

Epithermal, disseminated gold-silver deposits are large producers of gold and, in places, silver throughout California, Nevada and Utah. Characteristics of epithermal Au-Ag deposits include the following: (a) they occur in a variety of host rocks, but 'dirty' or 'carbonaceous' silty carbonates are a common host, (b) typically the deposits are low-grade, but with large tonnages, and (c) they generally display near-surface enrichments of Sb, Hg, As, Tl, B, F, and Ba. Epithermal Au-Ag deposits are commonly referred to as "No-see-um gold deposits" because of their fine-grained, disseminated nature, or "Carlin type" after the Carlin trend in northeast Nevada. The formation of Carlin type deposits has usually been attributed to epithermal hydrothermal processes associated with the emplacement of high-level felsic intrusions and rhyolitic volcanism (Bagby and Berger 1985; Romberger 1986; Berger and Henley 1989). Because such felsic igneous activity is largely lacking in the Alberta Plains, the potential for Carlin type deposits in Alberta has long been regarded as significantly lower than that for British Columbia or the Yukon Territory. However, recent work on Carlin type deposits has indicated that the assumed genetic relationship to felsic igneous activity may not be universally valid. For example, at the Carlin type Mercur gold district in north-central Utah, the gold deposits are hosted by the Mississippian Great Blue Limestone below the Long Trail Shale. The Mercur deposits are characterized by replacement of carbonate and silty carbonate by silica, phyllosilicates, pyrite, barite, various arsenic, mercury, antimony and thallium minerals, and by disseminated micrometre-sized gold (Jewell and Parry 1987, 1988). At Mercur, there are spatially-associated Tertiary felsic stocks and rhyolites. Recently, however, Wilson and Parry (1990) have dated alteration associated with the gold mineralized zones at between 122 Ma and 193 Ma, hence the Mercur gold deposits are much older than the Tertiary felsic igneous rocks. Wilson and Parry (1990) concluded that the gold-bearing hydrothermal activity is related to Rocky Mountain-style thrust faulting along the Manning Canyon detachment during the Mesozoic, because there are no igneous rocks older than 40 Ma in the Mercur gold district.

With respect to possible brine and/or hydrocarbon-related Au-Ag deposits, such deposits have been reported elsewhere (e.g, Ballantyne 1993, Green and Hulen 1993, Hulen and Nielson 1993, Pinnell 1993). Ballantyne (1993), for example, noted that "*deposition of gold in sufficient quantities to produce an ore deposit requires sustained flow of hydrothermal fluid through a narrow zone that coincides with a stable physico-chemical interface. Hydrocarbon-enriched rocks provide such an interface, at which thermal cracking of hydrocarbons can generate an oxidizing environment by depleting hydrogen. Gold complexes are destabilized, depositing gold on available pyrite and other minerals surfaces*". Hulen and Nielson stated that some of the hydrocarbon fields in Nevada "*share a surprisingly long list of essential attributes with the Carlin-type, low-grade, sediment-hosted gold deposits*". Pinnell (1983) suggested that some hydrothermal systems "*given favourable host rocks, traps, seals, and migratory pathways, might well have formed not only gold deposits, but also rich, spatially coincident oil reservoirs*". Bogashova (1991) described a relationship between Phanerozoic sedimentary rocks and brines; "*Comparison of maps of the distribution of stratiform polymetallic ore deposits with hydrochemical and salt maps shows the almost universal confinement of such deposits both directly to salt-generating basins and to their marginal parts, where subsurface thermal brines were discharged in zones of paleouplifts. Study of fluid inclusions in minerals from these ore deposits has shown that ore-forming solutions were brines with high contents of Cl, Na, Ca and often K, and a low content of* SO_4." An extensive brine system has been discharging in the Bitumount area for a long period of time. In addition, the central portion of the Bitumount map area has been a paleohigh during the Proterozoic, post deposition of

Devonian carbonates, and perhaps as recently as the Cretaceous. Extensive hydrocarbon and locally, coal deposits exist throughout much of the area and may have served has a depositional locus for precious metals given the right conditions.

Exploration for brine related or Carlin type epithermal gold deposits is difficult because (a) gold and silver grades are generally low, (b) the deposits rarely contain visible gold, (c) even where the Au-Ag deposits are eroded they typically are not geographically associated with important placer gold accumulations, and (d) an extensive zone of associated alteration to act as a guide to ore is not always present (Bagby and Berger 1985). In general, most of the Carlin type Au-Ag deposits in Nevada and other parts of the western United States of America which have been discovered since the early 1970's, have been found by systematic geochemical rock or surficial sampling methods, followed by drilling of selected targets.

Highly anomalous gold values have been reported by Tintina Mines Ltd., Focal Resources Ltd., and by the Geological Survey of Canada from samples of Devonian carbonates and the pre-Cretaceous (?) Beaver River sandstone of the Fort McKay area. Anomalous gold values obtained in this study along with a variety of trace elements such as Ag, Cr, V, B and other metals from drill core of post Devonian carbonaceous sedimentary rocks in the vicinity of the Firebag River, point toward a possible genetic relationship between gold, brines and hydrocarbons. It is clear that large volumes of brines have moved through the Phanerozoic succession in the Bitumount area. The geochemical associations in the core samples from the Firebag River area provide preliminary evidence for deposition of gold from these brines. This hypothesis is relatively new, and has only been tested in this study by the geochemical analysis of 23 core samples. Clearly further work is required and is highly warranted given the positive results obtained to date. Perhaps a new exploration target for gold deposits in the Phanerozoic succession of northeastern Alberta has been identified.

Mississippi Valley Type Pb-Zn deposits

Worldwide, Mississippi Valley Type (MVT) Pb-Zn deposits occur in carbonate rocks of several diverse ages that range from Proterozoic to at least the Mesozoic, although most of the economically important deposits are hosted by Paleozoic strata. In North America, carbonates of either Cambrian-Ordovician or Carboniferous age host the majority of the important MVT deposits (Anderson and Macqueen 1988). However, in the Western Canada Sedimentary Basin, the most important MVT lead-zinc deposits are in Devonian strata at Pine Point, N.W.T. and at Robb Lake, British Columbia.

MVT deposits might also be found in near-surface Devonian carbonates in the Bitumount map area. Geological features that are considered favourable for the presence of MVT Pb-Zn deposits include: (a) dolomitization or silicification fronts, (b) porosity and permeability associated with karstification, (c) faulting or fracturing to channel the large volumes of saline fluids required to deposit Pb, Zn, Ag, Fe, Mg, F and Ba, (d) the presence of reefal masses, (e) regional transitions from platformal carbonates to basinal shales, (f) several unconformities and disconformities in the stratigraphic sequence, and (g) structural complexities such as folds and faults (Anderson and Macqueen 1988). It should be noted that strong evidence exists for the movement of saline fluids through the Phanerozoic succession in the Fort McKay area, including extensive karst features and the presence of salt mounds, which currently are forming from groundwater emerging at the present day surface. In addition, many MVT deposits are associated with hydrocarbons, and are spatially related to petroleum fields. These features are all present in the Devonian rocks of the Bitumount area, and therefore, the potential for MVT deposits should not be ignored.

Other Potential Deposit Types In The Bitumount Area

The results from this study, ongoing work by the Geological Survey of Canada and the recent exploration results announced by industry, indicate that good potential exists for the discovery of metallic mineral deposits in the Bitumount map area north of Fort McMurray. In addition to the potential for brine related (or Carlin type) gold deposits and MVT lead-zinc deposits in the Bitumount area, other deposit types to explore for include: (a) Archean shear zone hosted gold deposits, (b) sediment hosted base metal deposits with one or more of zinc, lead, copper, nickel, silver and gold, (c) granitoid-related uranium and/or rare earth element, precious metal or base metal deposits, (d) unconformity-related, sandstone-hosted or vein-type uranium deposits, (e) diamondiferous kimberlite or lamproite diatremes, and (f) various types of placer or paleoplacer deposits with the important metals/minerals being gold, diamonds, titanium or other 'heavy minerals'. More details with respect to these deposit types and their potential existence in northeast Alberta are discussed in Olson *et al. (In Press).*

The Sub-Cretaceous Unconformity

As discussed above, Devonian carbonate strata and the overlying Cretaceous clastic units in the Bitumount map area represent a prospective target for both gold and base metal deposits. The exposure of the sub-Cretaceous unconformity, however, is apparently limited to thin strips of outcrop on the flanks of the Athabasca River in the vicinity of Fort McKay, a fact which may seem daunting to exploration in the area. Figure 19 shows a structural contour map for the top of the Devonian in the Bitumount map area. From this figure, it is clear that the Devonian surface slopes gently to the southwest. The sub-Cretaceous unconformity is well below the ground surface in the southwest corner of the map area and beneath topographic highs such as the Birch Mountains in the northwest portion of the map area and Muskeg Mountain in the south-central portion of the map area. Figure 20, an isopach map of the rock and overburden between the present ground surface and the sub-Cretaceous unconformity, shows that in approximately one-third of the map area, the Devonian is within 100 m of the ground surface, and is easily within reach

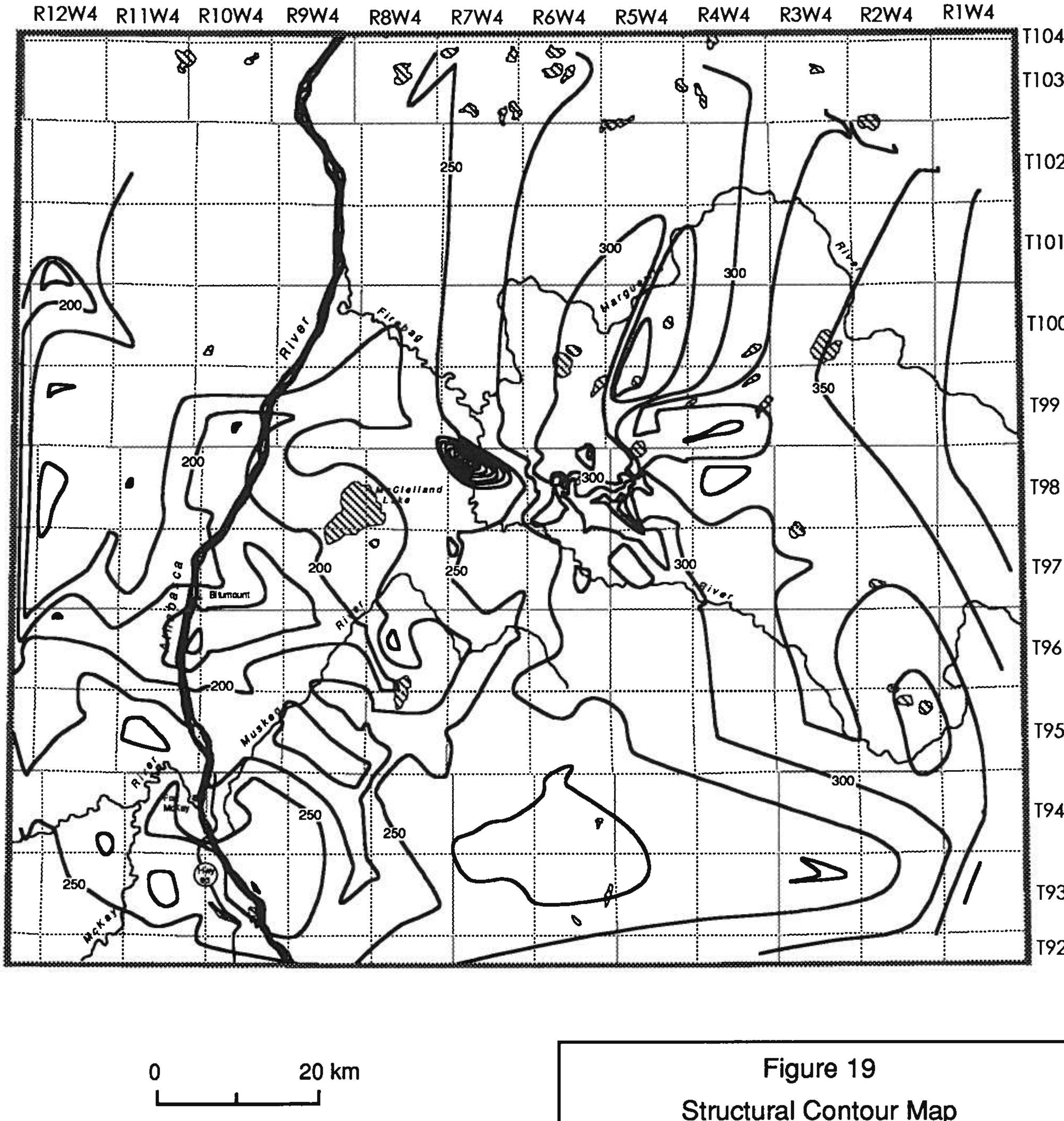


Figure 19

Structural Contour Map
for the Top of the Devonian
(elevation above sea level)
Contour Interval = 25 m

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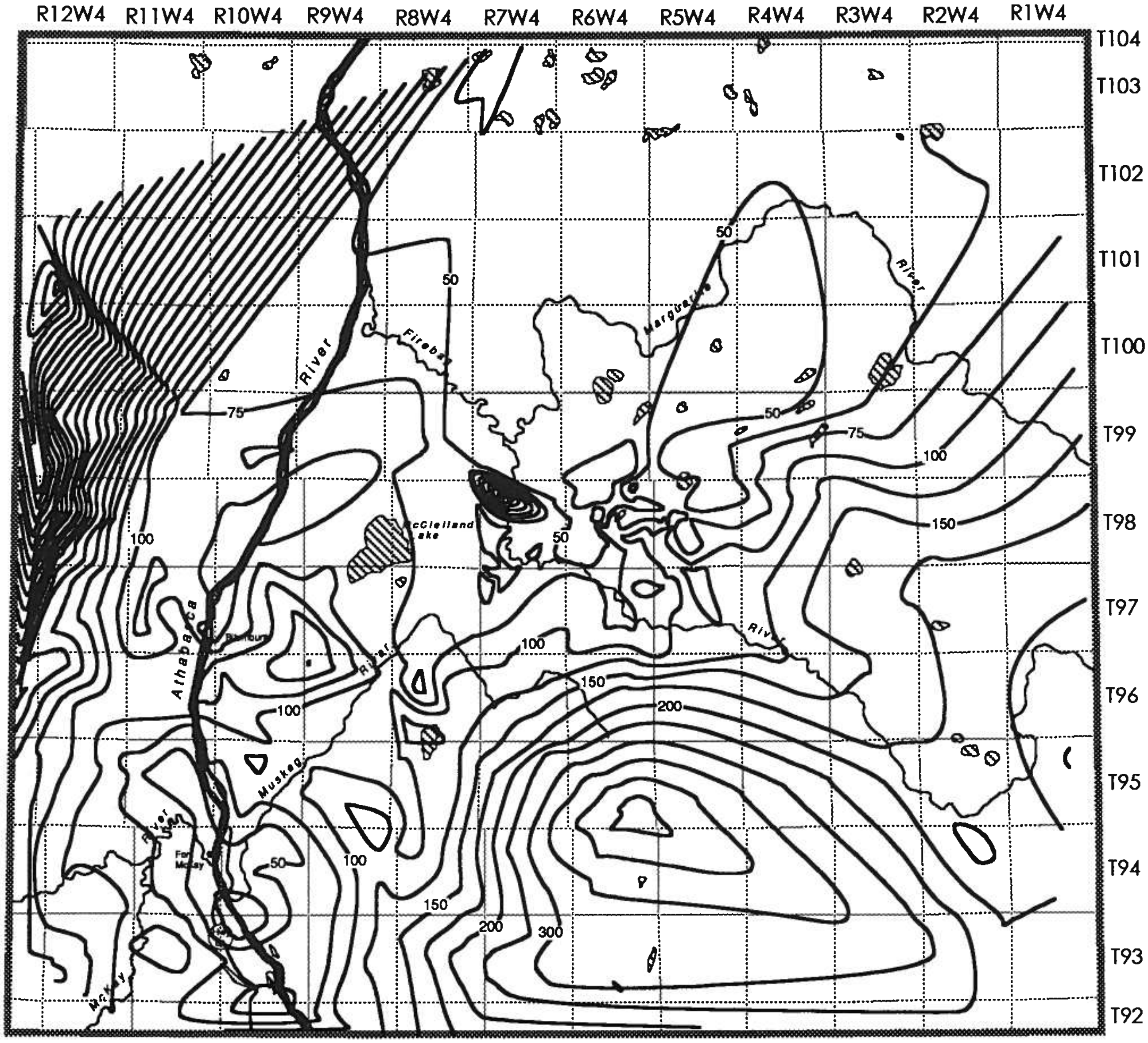
Ft. McKay areas, northeast Alberta
(NTS 74E)

Project No. M93-04-038



0 20 km

Figure 20

Isopach of Surface to the Sub-Cretaceous Unconformity Contour Interval = 25 m

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of exploration methods such as geophysics (e.g. induced polarization and some electromagnetic methods) and drilling. For this reason, the Devonian remains a prospective target horizon for base and precious metal deposits over a large part of the Bitumount map area.

CONCLUSIONS

The Bitumount map area contains a wide diversity of rock types, including exposures of Precambrian Shield, Paleozoic carbonates, and Cretaceous clastic sedimentary rocks, and is situated on the edge of a significant subsurface brine basin. To date, with the possible exception of uranium, little exploration for metals or diamondiferous deposits has been conducted in the area due to the relatively poor outcrop exposure, and the perception of a lack of favourable host rocks for mineral deposits. This study has shown that favourable host rocks for precious and base metal deposits do exist in the Bitumount area, and that although exposure is poor, the favourable horizons occur well within reach of several standard exploration techniques. Therefore, the Bitumount map area has the potential to contain significant metallic mineral and diamondiferous deposits and to date, the area has been grossly underexplored for such deposits.

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APPENDIX 1

SAMPLE LOCATIONS, DESCRIPTION AND TYPES OF ANALYSES

SAMPLE LOCATION, DESCRIPTION AND TYPES OF ANALYSES

SAMPLE NUMBER	TYPE	UTM EASTING	UTM NORTHING	SAMPLE DESCRIPTION	TYPE OF ANALYSIS: GEOCHEM	FIRE ASSAY	INDICATOR MINERAL	THIN SECTION
NAT92-24	Till	496697	6344769	Till from Kearl Lake East	X		X	
NAT92-25	Till	475804	6345243	Till from Kearl Lake West	X		X	
NAT93-80	Fluvial	494204	6376344	Fluvial sand (<2mm) from Firebag River			X	
NAT93-81	Till	498249	6368649	Till from Firebag River (T4)	X			
NAT93-82	Till	532833	6355018	Till from Firebag River (T5)	X		X	
NAT93-83	Till	515307	6362201	Till from Firebag River (T4)	X		X	
NAT93-84	Till	487895	6389309	Till from Firebag River (Grey diamicton)	X			
NAT93-85	Fluvial	499709	6386458	Fluvial Sand (<2mm) from Marguerite River			X	
NAT93-86	Till	470310	6380091	Till from Ft. McKay	X			
NAT93-87	Fluvial	466022	6337621	Fluvial sand (<2mm) from Muskeg River			X	
NAT93-88	Till	469579	6325855	Till from Saline Lake	X			
NAT93-89	Till	519272	6387314	Till from Johnson Lake	X		X	
082401A	Rock	469125	6325625	Salt crust from spring near Saline Lake	X			
082401B	Rock	469125	6325625	Sulfurous mud from Saline Lake area	X			
082401C	Rock	469125	6325625	Beaver River sandstone float from Saline Lake area	X			
082701	Rock	526170	6404585	Hematite-stained granitoid with 675 cps	X			
082703	Rock	526084	6404391	Megacrystic granitoid with 1500 cps	X			X
082704	Rock	526519	6402948	Banded megacrystic granitoid with 3000 cps	X			X
082705	Rock	526519	6402948	Red hematite-stained granitoid with garnet	X			
082707	Rock	526408	6402379	Red granitoid with quartz vein	X			
082803A	Rock	528485	6402166	Black mylonite in leucocratic granitoid	X			X
082803B	Rock	528485	6402166	Leucocratic granitoid with quartz vein	X			
082804	Rock	526045	6404780	Quartz vein in sheared granitoid	X			
082901A	Rock	525437	6402068	Chlorite-rich mafic rock	X			X
082901B	Rock	525437	6402068	Syenite-looking rock	X			X
082903A	Rock	524850	6401680	Megacrystic granitoid - has syenitic appearance	X			X
082903B	Rock	524850	6401680	Mafic dyke	X			X
083002A	Rock	525422	6404880	Rusty saussertized granitoid	X			
083002B	Rock	525422	6404880	Rusty granitoid with yellow stain	X			
083003A	Rock	525128	6404752	Rusty mylonitized shear zone	X			X
083003B	Rock	525128	6404752	Rusty sheared granite with trace pyrite	X			X
090101	Rock	526990	6395100	Quartz vein with granitic wall rock	X			
090102	Rock	526990	6395070	Mylonitic zone in granitoid	X			

SAMPLE NUMBER	TYPE	UTM EASTING	UTM NORTHING	SAMPLE DESCRIPTION	TYPE OF ANALYSIS GEOCHEM	FIRE ASSAY		THIN SECTION
090103	Rock	526166	6394779	Foliated melanocratic rusty granite with 1-2% pyrite	X			X
090104	Rock	526729	6393653	2-3% magnetite, trace pyrite in mylonitized granitoid	X			X
090105A	Rock	526550	6393550	Sheared quartz-chlorite rock with up to 5% pyrite	X			X
090105B	Rock	526550	6393550	Glassy mylonite with garnet and 1-2% pyrite	X			X
090106A	Rock	526353	6393359	Intensely mylonitized quartz-rich rock with garnet	X			
090106B	Rock	526353	6393359	Mylonitized pink quartz-feldspar-garnet rock	X			
090202	Rock	525851	6395415	Glassy silica- and chlorite-rich mylonite	X			
090203A	Rock	526380	6395380	Glassy gray mylonitized rock with minor chlorite	X			
090203B	Rock	526380	6395380	Felsic mylonite with chlorite partings and garnet	X			
090203C	Rock	526380	6395380	Leucocratic gneiss to mylonite with trace sulfides	X			
090206	Rock	527250	6295650	Dark quartz-chlorite mylonite with 2-3% pyrrhotite	X			X
090301	Rock	524385	6394703	Mylonitic feldspar-quartz-chlorite gneissic rock	X			
090303A	Rock	524190	6294335	Mafic meta-igneous schist with 1% pyrite + pyrrhotite	X			X
090303B	Rock	524190	6294335	Mafic meta-igneous schist with 1-2% pyrite + pyrrhotite	X			X
090304	Rock	524146	6294892	Quartz-feldspar-amphibole-chlorite-garnet gneiss	X			
090305	Rock	525917	6293712	Rusty gneiss with chlorite, quartz and garnet	X			
090306A	Rock	523797	6393656	Weakly foliated amphibolite with 1% pyrite + pyrrhotite	X			
090306B	Rock	523797	6393656	Garnet-rich paragneiss with 1-2% pyrrhotite + pyrite	X			X
090307	Rock	523695	6393644	Rusty quartz-amphibole rock	X			X
090501	Rock	460920	6340811	McMurray siltstone with 2-3% framboidal pyrite	X	X		X
090503A	Rock	461950	6337989	Sideritic vein in Waterways Fm.	X	X		X
090503B	Rock	461950	6337989	Fossiliferous Waterways Fm. with pyrite in fractures	X	X		
090503C	Rock	461950	6337989	Float of rusty McMurray Fm.	X	X		
090601A	Rock	538850	6393303	Quartz-rich granitoid with chlorite, and up to 10% pyrite	X			X
090601B	Rock	538850	6393303	Quartz-chlorite-garnet granitoid with 3-5% pyrite	X			X
090603	Rock	538366	6392679	Leucocratic granitoid with up to 1,100 cps	X			X
090605	Rock	530588	6396369	Rusty leucocratic gneiss	X			
090701	Rock	462380	6331051	Silica sandstone (Beaver River) with plant material	X	X		X
090703A	Rock	465051	6339637	Beaver River sandstone	X	X		X
090703B	Rock	465051	6339637	Beaver River sandstone with some carbonate	X	X		X
090705	Rock	464564	6339170	Beaver River sandstone	X	X		
090706A	Rock	464721	6334676	Waterways Fm. carbonate	X	X		X
090706B	Rock	464721	6334676	Waterways Fm. carbonate	X	X		
090707	Rock	460086	6344470	McMurray Fm. oil sands with up to 15% pyrite	X	X		X
090801	Rock	521887	6396662	Mylonitic pink granitoid	X			
090802	Rock	521450	6397050	Chlorite-quartz gneiss to mylonite with 1% pyrite	X			X
090803	Rock	498249	6368649	Pyrite nodule in McMurray Fm.	X	X		X

SAMPLE NUMBER	TYPE	UTM EASTING	UTM NORTHING	SAMPLE DESCRIPTION	TYPE OF ANALYSIS GEOCHEM	FIRE ASSAY		THIN SECTION
090901A	Rock	462664	6367443	Waterways Fm. limestone with 2-3% pyrite	X	X		
090901B	Rock	462664	6367443	Limestone with trace pyrite	X	X		
091001A	Rock	469125	6325625	Rusty carbonate boulder	X	X		
091001B	Rock	469125	6325625	Limonitic mud with sulfurous carbonate crust	X	X		
091001C	Rock	469125	6325625	Limonitic mud with sulfurous carbonate crust	X	X		
091101A	Rock	464721	6334676	Rubbly limestone	X	X		
091101B	Rock	464721	6334676	Nodular to brecciated limestone	X	X		
091101C	Rock	464721	6334676	Nodular to brecciated limestone	X	X		
091101D	Rock	464721	6334676	Nodular to brecciated limestone	X	X		X
091101E	Rock	464721	6334676	Nodular to brecciated limestone	X	X		X
091101F	Rock	464721	6334676	Nodular to brecciated limestone	X	X		X
091102A	Rock	462063	6330265	Rubbly limestone	X	X		
091102B	Rock	462063	6330265	Rusty rubbly limestone	X	X		
SL27C-1	Core	511219	6375144	Gray mottled shale with secondary fibrous alteration	X	X		
SL27C-2	Core	511219	6375144	Dull coal with trace pyrite	X	X		
SL27C2-1	Core	511219	6375156	Dull coal with white alteration of pyrite or carbonate	X	X		
SL27C2-2	Core	511219	6375156	Typical coal	X	X		
SL27C2-3	Core	511219	6375156	White to yellow crusty alteration of brown sandy unit	X	X		
SL27C2-4	Core	511219	6375156	Massive pyrite and quartz in oil sand	X	X		
SL27C2-5	Core	511219	6375156	Shaley lens in oil sand - some white alteration	X	X		
SL27C2-6	Core	511219	6375156	Tan to maroon shale with poker chip cleavage	X	X		
SL27C2-7	Core	511219	6375156	Shale with carbonate clasts - possibly regolith	X	X		
E+8C-1	Core	511217	6372306	Gray silt clasts at top of silt interval in oil sands	X	X		
E+8C-2	Core	511217	6372306	Black oil sand with white secondary crust	X	X		
E+8C-3	Core	511217	6372306	Pyrite nodule in black oil sand	X	X		
E+8C-4	Core	511217	6372306	White fibrous alteration and yellow sulfur clots in coal	X	X		
E+8C-5	Core	511217	6372306	Dull coal chips	X	X		
E+8C-6	Core	511217	6372306	White and yellow alteration crust in coal	X	X		
E+8C-7	Core	511217	6372306	Sulfur stain in coal chips in oil sand	X	X		
SL27C1-1	Core	511219	6374140	Gray to black oil sands	X	X		
SL27C1-2	Core	511219	6374140	Contact of pebbly sand and dark oil sand	X	X		
SL27C1-3	Core	511219	6374140	Maroon shale with minor white alteration crust	X	X		
B+148C-1	Core	513235	6375970	Brown to black oil sand with thin shale lens	X	X		
B+148C-2	Core	513235	6375970	Massive pyrite and quartz nodule in oil sand	X	X		
B+148C-3	Core	513235	6375970	Typical coal chips	X	X		
B+148C-4	Core	513235	6375970	Contact of maroon shale and tan sand	X	X		

APPENDIX 2

HIGHLIGHTS* OF GEOCHEMICAL ANALYSES

FOR ROCK, CORE AND TILL SAMPLES

*Duplicate analyses and analyses for standards and certain major elements omitted, refer to certificates of analysis in Appendix 3 for complete results.

SAMPLE #	TYPE	Au ppb INAA	Au ppm ICP	Au ppb FA/AA	Ag ppm ICP	Ag ppm INAA	Cu ppm ICP	Pb ppm ICP	Zn ppm ICP	Zn ppm INAA	As ppm INAA	As ppm ICP	Bi ppm ICP	Cd ppm ICP	Co ppm ICP	Co ppm INAA	Cr ppm ICP	Cr ppm INAA	Hg ppm INAA	Ir ppb INAA	Mo ppm INAA	Mo ppm ICP
SHIELD GRANITOIDS																						
MD93082701	Rock	<5	<2		0.3	<5	7	11	10	<50	<2	<2	4	<0.2	3	<5	111	160	<1	<5	<5	2
MD93082703	Rock	<5	<2		0.1	<5	2	20	29	<50	<2	<2	4	<0.2	5	<5	68	100	<1	<5	6	1
MD93082704	Rock	<5	<2		0.2	<5	5	103	175	<50	<2	<2	11	0.2	13	15	52	48	<1	<5	<5	10
MD93082705	Rock	<5	<2		0.2	<5	5	9	13	<50	<2	<2	<2	<0.2	2	<5	132	180	<1	<5	<5	1
MD93082707	Rock	<5	<2		0.1	<5	8	5	17	<50	<2	2	<2	<0.2	2	<5	163	220	<1	<5	<5	3
MD93082803A	Rock	<5	<2		0.1	<5	2	11	25	<50	<2	<2	<2	<0.2	1	<5	94	150	<1	<5	<5	1
MD93082803B	Rock	<5	<2		0.2	<5	2	2	17	132	<2	<2	<2	<0.2	1	<5	194	240	<1	<5	<5	3
MD93082804	Rock	<5	<2		0.2	<5	3	6	19	<50	<2	<2	<2	<0.2	2	<5	117	170	<1	<5	<5	1
MD93082901B	Rock	<5	<2		0.1	<5	2	3	16	<50	<2	<2	<2	<0.2	2	<5	104	140	<1	<5	<5	1
MD93082903A	Rock	<5	<2		0.1	<5	3	12	28	<50	<2	<2	<2	<0.2	2	<5	117	150	<1	<5	<5	3
MD93083002A	Rock	<5	<2		0.3	<5	23	9	49	<50	<2	<2	<2	0.2	6	6	108	180	<1	<5	<5	2
MD93083002B	Rock	<5	<2		0.1	<5	2	13	21	<50	<2	<2	<2	<0.2	2	<5	199	310	<1	<5	<5	3
MD93083003A	Rock	<5	<2		0.6	<5	32	16	49	<50	<2	<2	<2	<0.2	5	5	73	110	<1	<5	6	1
MD93083003B	Rock	<5	<2		0.4	<5	10	13	54	<50	3	<2	2	0.2	4	<5	112	140	<1	<5	<5	2
MD93090101	Rock	<5	<2		0.2	<5	3	3	38	<50	<2	<2	<2	<0.2	5	6	197	260	<1	<5	<5	4
MD93090102	Rock	<5	<2		0.1	<5	2	4	12	<50	<2	<2	<2	<0.2	1	<5	112	170	<1	<5	<5	1
MD9390103	Rock	<5	<2		0.2	<5	6	6	26	<50	<2	<2	<2	<0.2	4	5	126	170	<1	<5	<5	2
MD93090104	Rock	<5	<2		0.1	<5	21	2	25	<50	<2	<2	<2	<0.2	9	16	94	170	<1	<5	<5	1
MD93090105A	Rock	<5	<2		0.2	<5	7	7	17	<50	<2	<2	<2	<0.2	5	5	85	130	<1	<5	<5	2
MD93090105B	Rock	<5	<2		0.1	<5	6	9	2	<50	<2	<2	<2	<0.2	1	<5	128	200	<1	<5	<5	1
MD93090106A	Rock	<5	<2		0.2	<5	3	7	27	<50	5	<2	<2	<0.2	2	<5	99	160	<1	<5	<5	2
MD93090106B	Rock	14	<2		0.3	<5	3	5	9	<50	<2	<2	<2	<0.2	1	<5	126	170	<1	<5	<5	1
MD93090202	Rock	<5	<2		0.1	<5	10	5	29	<50	<2	<2	<2	<0.2	4	<5	96	150	<1	<5	<5	4
MD93090203A	Rock	<5	<2		0.2	<5	4	2	4	<50	<2	<2	<2	<0.2	1	<5	194	290	<1	<5	<5	1
MD93090203B	Rock	<5	<2		0.2	<5	2	3	3	<50	<2	2	<2	<0.2	1	<5	117	180	<1	<5	<5	2
MD93090203C	Rock	<5	<2		0.2	<5	6	7	31	<50	<2	<2	<2	<0.2	6	<5	88	150	<1	<5	10	12
MD93090206	Rock	<5	<2		0.2	<5	10	4	57	<50	<2	<2	<2	<0.2	7	10	128	210	<1	<5	<5	1
MD93090301	Rock	<5	<2		0.2	<5	3	8	25	<50	<2	<2	<2	<0.2	6	5	95	140	<1	<5	<5	2
MD93090304	Rock	<5	<2		0.3	<5	6	2	34	<50	<2	<2	<2	<0.2	3	<5	82	120	<1	<5	<5	1
MD93090305	Rock	<5	<2		0.2	<5	7	3	29	<50	<2	4	<2	<0.2	4	<5	103	160	<1	<5	<5	3
MD93090306B	Rock	<5	<2		0.3	<5	191	10	78	<50	<2	<2	3	<0.2	31	27	172	210	<1	<5	8	8
MD93090601A	Rock	8	<2		0.3	<5	108	19	18	<50	<2	3	2	<0.2	5	<5	122	190	<1	<5	<5	2
MD93090601B	Rock	8	<2		0.3	<5	41	14	36	<50	<2	<2	2	<0.2	4	<5	123	170	<1	<5	<5	2
MD93090603	Rock	<5	<2		0.1	<5	3	23	35	<50	<2	<2	3	<0.2	4	5	79	81	<1	<5	<5	3
MD93090605	Rock	<5	<2		0.2	<5	24	17	20	<50	<2	2	<2	<0.2	2	<5	128	170	<1	<5	<5	3
MD93090801	Rock	<5	<2		0.2	<5	5	7	11	<50	<2	<2	<2	<0.2	2	<5	248	330	<1	<5	<5	1
MD93090802	Rock	5	<2		0.1	<5	8	2	47	<50	<2	<2	2	<0.2	7	5	131	170	<1	<5	<5	2
MAFIC GNEISS																						
MD93082901A	Rock	<5	<2		0.4	<5	5	5	69	<50	<2	<2	<2	0.3	12	15	65	110	<1	<5	<5	1
MD93082903B	Rock	<5	<2		0.3	<5	3	4	144	<50	<2	<2	<2	<0.2	21	22	113	180	<1	<5	<5	1
MD93090303A	Rock	<5	<2		0.2	<5	97	3	29	203	<2	<2	<2	<0.2	10	38	220	410	<1	<5	<5	2
MD93090303B	Rock	<5	<2		0.2	<5	103	2	87	343	<2	10	<2	0.3	15	41	196	500	<1	<5	<5	2
MD93090306A	Rock	<5	<2		0.3	<5	31	2	34	<50	<2	<2	<2	0.2	22	44	95	200	<1	<5	<5	2
MD93090307	Rock	7	<2		0.3	<5	121	2	32	<50	<2	<2	<2	0.2	7	8	90	130	<1	<5	<5	1

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion; box indicates possible anomalous values.

SAMPLE #	TYPE	Mn ppm ICP	Ni ppm ICP	Ni ppm INAA	Sb ppm INAA	Sb ppm ICP	Sc ppm INAA	Sn % INAA	W ppm ICP	W ppm INAA	V ppm ICP	B ppm ICP	Ba ppm INAA	Ba ppm ICP	Br ppm INAA	P % ICP	Se ppm INAA	Sr ppm ICP	Sr % INAA	Rb ppm INAA	Th ppm ICP	Th ppm INAA
SHIELD GRANITOIDS																						
MD93082701	Rock	41	3	<50	<0.2	2	1.4	<0.01	1	<4	8	8	1500	49	<1	0.024	<5	26	<0.05	230	185	190
MD93082703	Rock	88	23	<50	<0.2	<2	3.8	<0.01	<1	<4	15	11	910	47	<1	0.147	<5	44	<0.05	210	330	450
MD93082704	Rock	78	9	<50	<0.2	<2	8.5	<0.01	<1	<4	66	12	1200	235	<1	0.107	<5	29	<0.05	320	1153	1900
MD93082705	Rock	72	3	<50	<0.2	3	2.7	<0.01	1	<4	2	11	500	27	<1	0.011	<5	6	<0.05	120	51	61
MD93082707	Rock	77	4	<50	<0.2	<2	0.9	<0.01	1	<4	4	2	<100	8	<1	0.004	<5	2	<0.05	<30	8	8.1
MD93082803A	Rock	81	3	<50	<0.2	<2	2.9	<0.01	1	<4	3	3	<100	25	<1	0.02	<5	5	<0.05	240	37	39
MD93082803B	Rock	78	2	<50	<0.2	<2	1.2	<0.01	1	<4	3	3	370	17	<1	0.009	<5	3	<0.05	140	16	20
MD93082804	Rock	94	4	<50	<0.2	2	2.6	<0.01	1	<4	4	13	1100	60	<1	0.013	<5	6	<0.05	150	34	34
MD93082901B	Rock	121	5	<50	<0.2	<2	2.4	<0.01	1	<4	5	6	1600	54	<1	0.007	<5	9	<0.05	100	5	6.2
MD93082903A	Rock	97	5	<50	<0.2	<2	3.4	<0.01	<1	<4	5	4	690	35	<1	0.019	<5	8	<0.05	170	82	89
MD93083002A	Rock	168	5	<50	<0.2	<2	8.7	<0.01	1	<4	38	2	1200	171	<1	0.033	<5	20	<0.05	73	17	20
MD93083002B	Rock	184	3	<50	<0.2	<2	4.3	<0.01	<1	<4	3	2	830	104	<1	0.011	<5	13	<0.05	180	15	18
MD93083003A	Rock	464	4	<50	<0.2	<2	16	<0.01	1	<4	25	4	1600	168	<1	0.037	<5	16	<0.05	150	10	11
MD93083003B	Rock	234	4	<50	0.3	2	6.8	<0.01	1	<4	35	2	1000	94	<1	0.038	<5	12	<0.05	160	35	38
MD93090101	Rock	246	11	<50	<0.2	<2	3.5	<0.01	1	<4	20	6	560	36	<1	0.053	<5	7	<0.05	<30	6	5.2
MD93090102	Rock	106	2	<50	<0.2	<2	1.7	<0.01	1	<4	2	3	310	16	<1	0.006	<5	4	<0.05	110	8	8.3
MD9390103	Rock	171	3	<50	<0.2	3	4	<0.01	1	<4	21	5	1400	50	<1	0.023	<5	21	<0.05	<30	6	5.8
MD93090104	Rock	218	7	<50	<0.2	<2	17	<0.01	<1	<4	86	6	1300	161	<1	0.056	<5	49	0.11	<30	2	2.2
MD93090105A	Rock	153	3	<50	<0.2	2	5.9	<0.01	<1	<4	25	12	1900	98	<1	0.036	<5	9	<0.05	160	25	37
MD93090105B	Rock	70	2	<50	<0.2	2	5.6	<0.01	<1	<4	2	4	560	19	<1	0.004	<5	4	<0.05	92	<2	0.7
MD93090106A	Rock	187	1	<50	<0.2	<2	4.9	<0.01	1	<4	10	3	860	57	3	0.011	<5	8	<0.05	61	10	12
MD93090106B	Rock	76	2	<50	<0.2	2	3.8	<0.01	1	<4	14	3	1400	51	<1	0.006	<5	8	<0.05	83	10	9.7
MD93090202	Rock	229	4	210	<0.2	<2	5.8	<0.01	1	<4	22	3	1000	101	<1	0.024	<5	11	0.09	140	10	13
MD93090203A	Rock	77	2	<50	<0.2	<2	1.3	<0.01	1	<4	2	6	450	20	<1	0.008	<5	3	<0.05	100	12	13
MD93090203B	Rock	65	1	<50	<0.2	<2	1.5	<0.01	1	<4	2	3	280	8	<1	0.009	<5	1	<0.05	110	2	1
MD93090203C	Rock	220	4	<50	0.3	<2	5.7	<0.01	1	<4	33	4	1300	97	<1	0.011	<5	10	<0.05	120	14	16
MD93090206	Rock	284	13	<50	<0.2	<2	8.2	<0.01	<1	<4	50	2	1000	301	<1	0.039	<5	20	<0.05	120	9	14
MD93090301	Rock	145	10	<50	<0.2	<2	5.4	<0.01	1	<4	29	8	1300	51	<1	0.045	<5	14	<0.05	130	27	26
MD93090304	Rock	211	3	<50	<0.2	<2	5.2	<0.01	<1	<4	21	4	1000	59	<1	0.008	<5	8	<0.05	96	10	11
MD93090305	Rock	205	3	<50	<0.2	<2	4.1	<0.01	<1	<4	16	4	860	58	<1	0.011	<5	10	<0.05	140	13	17
MD93090306B	Rock	151	58	<50	<0.2	<2	12	<0.01	<1	<4	68	6	490	154	<1	0.007	<5	21	<0.05	130	31	44
MD93090601A	Rock	120	3	<50	<0.2	2	1.9	<0.01	<1	<4	3	5	2200	69	<1	0.005	<5	12	<0.05	210	38	46
MD93090601B	Rock	240	3	<50	<0.2	<2	4.5	<0.01	<1	<4	19	8	1100	46	<1	0.014	<5	12	<0.05	100	68	71
MD93090603	Rock	307	2	<50	<0.2	<2	4.1	<0.01	<1	<4	12	2	1100	39	<1	0.042	<5	10	<0.05	130	238	220
MD93090605	Rock	162	3	<50	<0.2	<2	2.2	<0.01	<1	<4	10	5	1200	57	<1	0.044	<5	14	<0.05	180	21	19
MD93090801	Rock	103	6	<50	0.6	<2	1.1	<0.01	<1	<4	6	6	250	18	3	0.003	<5	5	<0.05	30	2	2
MD93090802	Rock	446	5	<50	<0.2	<2	6	<0.01	<1	<4	34	3	1400	164	<1	0.023	<5	16	<0.05	<30	10	14
MAFIC GNEISS																						
MD93082901A	Rock	764	9	<50	<0.2	2	25	<0.01	1	<4	68	16	670	214	<1	0.057	<5	27	<0.05	94	6	6.7
MD93082903B	Rock	626	19	<50	<0.2	<2	21	<0.01	1	<4	52	11	730	29	<1	0.234	<5	113	<0.05	75	23	28
MD93090303A	Rock	282	34	<50	<0.2	<2	45	<0.01	1	<4	163	4	<100	62	<1	0.02	<5	21	<0.05	<30	<2	0.6
MD93090303B	Rock	332	89	<50	<0.2	<2	38	<0.01	<1	<4	58	4	390	56	<1	0.018	<5	18	<0.05	<30	<2	<0.5
MD93090306A	Rock	275	49	<50	<0.2	<2	37	<0.01	<1	<4	60	6	<100	95	<1	0.042	<5	110	<0.05	<30	<2	<0.5
MD93090307	Rock	192	24	<50	<0.2	<2	4.8	<0.01	<1	<4	18	10	<100	39	<1	0.027	<5	49	<0.05	44	12	21

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion

SAMPLE #	TYPE	U ppm INAA	U ppm ICP	Ce ppm INAA	Cs ppm INAA	Eu ppm INAA	Hf ppm INAA	La ppm INAA	La ppm ICP	Lu ppm INAA	Nd ppm INAA	Sm ppm INAA	Ta ppm INAA	Tb ppm INAA	Yb ppm INAA
SHIELD GRANITOIDS															
MD93082701	Rock	3.9	<5	480	<2	1.6	13	250	217	<0.05	130	19	<1	<0.5	<0.2
MD93082703	Rock	8.6	<5	950	<2	<0.2	27	450	259	<0.05	330	50	<1	<0.5	<0.2
MD93082704	Rock	65	300	3300	<2	4.5	110	1900	1040	<0.05	1200	200	<1	15	<0.2
MD93082705	Rock	4	<5	170	<2	<0.2	8	90	78	0.06	62	9.4	<1	<0.5	1.3
MD93082707	Rock	<0.5	<5	28	<2	<0.2	<0.5	13	11	<0.05	18	1.6	<1	<0.5	0.3
MD93082803A	Rock	15	10	110	2	0.3	5	52	40	<0.05	36	6.7	<1	<0.5	1.3
MD93082803B	Rock	1.6	6	25	<2	<0.2	2	12	11	0.15	11	1.6	<1	<0.5	0.5
MD93082804	Rock	1.8	<5	77	<2	0.5	3	40	34	0.09	37	4.7	<1	<0.5	1
MD93082901B	Rock	1.8	<5	28	3	0.5	3	17	13	0.1	15	1.6	<1	<0.5	0.6
MD93082903A	Rock	4.9	<5	210	<2	0.7	8	100	86	0.14	82	14	<1	<0.5	<0.2
MD93083002A	Rock	3.4	<5	98	<2	1.4	5	53	30	0.47	28	6	<1	<0.5	3.1
MD93083002B	Rock	330	350	79	<2	1.1	<0.5	34	15	0.65	43	5.5	<1	<0.5	5
MD93083003A	Rock	2.4	<5	68	<2	0.9	4	37	29	0.39	17	3.5	<1	<0.5	2.3
MD93083003B	Rock	4.9	<5	150	<2	0.9	5	82	63	0.51	52	7.4	5	<0.5	3.3
MD93090101	Rock	<0.5	<5	37	<2	0.8	2	23	19	0.09	17	2.3	<1	<0.5	0.8
MD93090102	Rock	1	<5	21	<2	<0.2	2	11	8	<0.05	6	1.9	<1	<0.5	<0.2
MD9390103	Rock	<0.5	6	46	<2	<0.2	4	26	12	0.13	11	1.8	<1	<0.5	0.6
MD93090104	Rock	<0.5	<5	43	<2	1.3	3	25	8	0.35	16	3.9	<1	<0.5	2
MD93090105A	Rock	2.4	<5	140	<2	1.1	6	81	39	0.35	42	6.6	<1	<0.5	1.6
MD93090105B	Rock	1.9	<5	17	<2	0.4	<0.5	11	3	0.41	<5	0.7	<1	<0.5	2.7
MD93090106A	Rock	3	<5	62	<2	0.7	3	32	21	0.29	22	3.3	<1	<0.5	1.9
MD93090106B	Rock	<0.5	5	61	<2	0.7	3	35	12	0.15	13	3	<1	0.7	0.7
MD93090202	Rock	2	<5	61	<2	1	2	34	21	0.52	16	3.7	<1	<0.5	3.1
MD93090203A	Rock	1.2	<5	60	<2	<0.2	4	31	20	0.34	26	2.9	<1	<0.5	2
MD93090203B	Rock	1.4	8	5	<2	<0.2	<0.5	2	2	0.11	<5	0.4	<1	<0.5	0.5
MD93090203C	Rock	1.8	<5	86	2	1.1	5	54	29	0.13	30	4.2	<1	<0.5	0.9
MD93090206	Rock	2.5	<5	98	<2	1.4	5	64	26	0.18	40	5	<1	<0.5	1
MD93090301	Rock	1.4	<5	82	<2	1	5	53	30	0.23	18	3.6	<1	<0.5	1.1
MD93090304	Rock	<0.5	<5	56	<2	0.7	3	32	13	0.28	23	3.1	<1	<0.5	1.7
MD93090305	Rock	2.1	<5	75	<2	0.7	4	41	23	0.27	19	3.8	<1	<0.5	1.5
MD93090306B	Rock	<0.5	<5	170	<2	1.6	10	97	31	0.27	57	10	<1	<0.5	1.1
MD93090601A	Rock	6.2	8	150	<2	1.4	8	92	51	0.18	49	6.7	<1	<0.5	0.9
MD93090601B	Rock	7.1	7	170	3	1.3	13	98	72	0.14	52	7.9	4	<0.5	1.2
MD93090603	Rock	4	16	500	<2	0.9	15	260	233	0.15	170	25	<1	<0.5	1.8
MD93090605	Rock	4.9	6	56	<2	0.8	5	35	31	<0.05	17	2.5	<1	<0.5	0.7
MD93090801	Rock	0.5	<5	5	<2	<0.2	<0.5	3	2	0.07	<5	0.3	<1	<0.5	0.3
MD93090802	Rock	1.4	<5	68	<2	0.9	4	40	22	0.21	29	3.7	<1	<0.5	0.9
MAFIC GNEISS															
MD93082901A	Rock	3.8	<5	49	3	1.2	5	24	14	0.98	24	6.3	<1	0.7	6.3
MD93082903B	Rock	3.7	<5	88	<2	1.6	9	46	33	0.41	43	6.4	6	<0.5	2.6
MD93090303A	Rock	<0.5	<5	11	<2	0.6	<0.5	7	2	0.57	<5	1.4	<1	<0.5	3.2
MD93090303B	Rock	<0.5	<5	27	<2	0.9	2	10	2	0.78	13	4	<1	<0.5	4.4
MD93090306A	Rock	<0.5	<5	23	<2	1.2	<0.5	11	4	0.51	14	3.1	<1	0.6	2.7
MD93090307	Rock	<0.5	<5	210	<2	1.2	3	130	51	0.1	82	10	<1	<0.5	0.8

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion

SAMPLE #	TYPE	Au ppb INAA	Au ppm ICP	Au ppb FA/AA	Ag ppm ICP	Ag ppm INAA	Cu ppm ICP	Pb ppm ICP	Zn ppm ICP	Zn ppm INAA	As ppm INAA	As ppm ICP	Bi ppm ICP	Cd ppm ICP	Co ppm ICP	Co ppm INAA	Cr ppm ICP	Cr ppm INAA	Hg ppm INAA	Ir ppb INAA	Mo ppm INAA	Mo ppm ICP
PHANEROZOIC CLASTIC ROCKS																						
MD93082401B	Rock	7	<2		0.2	<5	10	6	10	<50	<2	3	<2	0.6	2	<5	91	220	<1	<5	<5	2
MD93090501	Rock	<5	<2	<5	0.1	<5	7	2	6	57	<2	<2	<2	<0.2	5	<5	42	82	<1	<5	<5	1
MD93090503C	Rock	<5	<2	<5	0.1	<5	4	4	77	144	3	7	2	<0.2	5	<5	97	170	<1	<5	<5	2
MD93090701	Rock	<5	<2	<5	0.1	<5	6	2	2	<50	<2	3	<2	<0.2	1	<5	256	340	<1	<5	6	4
MD93090703A	Rock	<5	<2	<5	0.1	<5	4	3	2	<50	<2	2	<2	<0.2	1	<5	253	330	<1	<5	<5	1
MD93090703B	Rock	<5	<2	<5	0.1	<5	4	2	3	<50	4	6	2	<0.2	1	<5	179	260	<1	<5	<5	4
MD93090705	Rock	<5	<2	<5	0.2	<5	3	2	1	<50	<2	<2	<2	<0.2	1	<5	224	340	<1	<5	<5	1
MD93090707	Rock	<5	<2	<5	0.2	<5	3	2	49	82	7	5	<2	<0.2	7	6	73	130	<1	<5	<5	3
MD93090803	Rock	<5	<2	<5	0.1	<5	5	3	6	<50	6	3	<2	<0.2	11	12	93	160	<1	<5	<5	1
PHANEROZOIC CARBONATES																						
MD93082401A	Rock	<5	<2		0.1	<5	2	12	10	<50	<2	2	<2	0.2	1	<5	2	<10	<1	<5	<5	1
MD93082401C	Rock	<5	<2		0.2	<5	1	2	1	<50	<2	2	<2	<0.2	1	<5	5	17	<1	<5	<5	1
MD93090503A	Rock	<5	<2	<5	0.4	<5	4	2	21	<50	<2	<2	<2	<0.2	11	11	7	22	<1	<5	<5	1
MD93090503B	Rock	<5	<2	<5	0.3	<5	3	2	5	<50	<2	6	<2	<0.2	4	<5	8	20	<1	<5	<5	1
MD93090706A	Rock	<5	<2	<5	0.2	<5	5	2	8	<50	<2	2	<2	<0.2	3	<5	9	20	<1	<5	<5	1
MD93090706B	Rock	<5	<2	<5	0.2	<5	5	2	7	<50	<2	2	<2	<0.2	2	<5	13	26	<1	<5	<5	1
MD93090901A	Rock	<5	<2	<5	0.3	<5	3	5	10	<50	<2	3	<2	<0.2	4	<5	5	17	<1	<5	<5	1
MD93090901B	Rock	<5	<2	9	0.1	<5	9	6	31	62	11	11	<2	<0.2	12	12	10	26	<1	<5	<5	1
MD93091001A	Rock	<5	<2	<5	0.1	<5	2	2	2	<50	<2	3	<2	<0.2	1	<5	2	<10	<1	<5	<5	1
MD93091001B	Rock	<5	<2	6	0.5	<5	7	54	14	<50	10	16	<2	<0.2	3	<5	85	120	<1	<5	<5	1
MD93091001C	Rock	<5	<2	<5	0.2	<5	2	8	3	<50	3	6	<2	<0.2	1	<5	27	47	<1	<5	<5	1
MD93091101A	Rock	<5	<2	<5	0.1	<5	4	5	5	<50	2	6	<2	<0.2	3	<5	7	17	<1	<5	<5	1
MD93091101B	Rock	<5	<2	<5	0.1	<5	3	2	3	<50	<2	7	<2	<0.2	1	<5	3	<10	<1	<5	<5	1
MD93091101C	Rock	<5	<2	<5	0.1	<5	2	3	3	<50	<2	6	<2	<0.2	2	<5	4	<10	<1	<5	<5	1
MD93091101D	Rock	<5	<2	<5	0.2	<5	3	2	2	<50	<2	5	<2	<0.2	1	<5	3	<10	<1	<5	<5	1
MD93091101E	Rock	<5	<2	<5	0.2	<5	3	5	6	<50	<2	<2	<2	<0.2	2	<5	6	14	<1	<5	<5	1
MD93091101F	Rock	<5	<2	<5	0.2	<5	10	3	16	<50	3	7	<2	<0.2	4	<5	10	28	<1	<5	<5	1
MD93091102A	Rock	<5	<2	<5	0.1	<5	9	118	15	<50	3	9	<2	<0.2	2	<5	6	15	<1	<5	<5	3
MD93091102B	Rock	<5	<2		0.1	<5	5	2	14	<50	3	<2	<2	<0.2	3	<5	6	14	<1	<5	<5	1

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion

SAMPLE #	TYPE	Mn ppm ICP	Ni ppm ICP	Ni ppm INAA	Sb ppm INAA	Sb ppm ICP	Sc ppm INAA	Sn % INAA	W ppm ICP	W ppm INAA	V ppm ICP	B ppm ICP	Ba ppm INAA	Ba ppm ICP	Br ppm INAA	P % ICP	Se ppm INAA	Sr ppm ICP	Sr % INAA	Rb ppm INAA	Th ppm ICP	Th ppm INAA
PHANEROZOIC CLASTIC ROCKS																						
MD93082401B	Rock	520	4	<50	<0.2	2	6	<0.01	<1	<4	10	9	460	90	<1	0.006	<5	142	<0.05	<30	3	4.7
MD93090501	Rock	3904	6	<50	0.2	<2	9.2	<0.01	1	<4	14	8	520	233	<1	0.062	<5	70	<0.05	32	2	3.5
MD93090503C	Rock	325	6	<50	<0.2	2	3.7	<0.01	<1	<4	42	8	<100	19	<1	0.041	<5	19	<0.05	<30	3	4.7
MD93090701	Rock	56	6	<50	<0.2	<2	1.2	<0.01	<1	<4	3	2	<100	4	<1	0.001	<5	1	<0.05	<30	<2	1.9
MD93090703A	Rock	58	5	<50	<0.2	<2	1.2	<0.01	<1	<4	4	2	<100	4	<1	0.001	<5	1	<0.05	<30	<2	1.1
MD93090703B	Rock	57	4	<50	0.3	<2	2.1	<0.01	<1	<4	11	2	<100	8	<1	0.018	<5	3	<0.05	<30	<2	2.6
MD93090705	Rock	41	5	<50	<0.2	<2	0.9	<0.01	<1	<4	3	3	<100	5	<1	0.001	<5	1	<0.05	<30	<2	0.7
MD93090707	Rock	1199	8	<50	0.5	<2	4.2	<0.01	1	<4	6	6	<100	101	2	0.009	<5	63	<0.05	<30	<2	3.7
MD93090803	Rock	63	32	<50	0.3	<2	2.1	<0.01	<1	<4	3	2	120	5	<1	0.004	<5	5	<0.05	<30	<2	3.6
PHANEROZOIC CARBONATES																						
MD93082401A	Rock	13	1	<50	0.3	<2	0.2	<0.01	1	<4	2	3	<100	2	9	0.005	<5	474	0.12	<30	<2	<0.5
MD93082401C	Rock	20	1	<50	<0.2	<2	0.3	<0.01	1	<4	2	9	<100	2	7	0.003	<5	1079	0.19	<30	<2	<0.5
MD93090503A	Rock	2079	13	<50	<0.2	<2	1.9	<0.01	<1	<4	3	2	<100	60	<1	0.094	<5	50	<0.05	<30	2	1.3
MD93090503B	Rock	176	16	<50	<0.2	<2	1.6	<0.01	1	<4	2	12	<100	11	3	0.01	<5	233	<0.05	<30	<2	1.2
MD93090706A	Rock	179	6	<50	0.3	<2	2.5	<0.01	1	<4	2	11	<100	15	3	0.01	<5	312	0.06	<30	<2	1.5
MD93090706B	Rock	213	7	<50	<0.2	2	2.5	<0.01	1	<4	3	13	150	14	3	0.01	<5	265	<0.05	<30	<2	1.7
MD93090901A	Rock	270	22	<50	<0.2	<2	1.4	<0.01	<1	<4	2	7	<100	8	5	0.004	<5	187	<0.05	<30	<2	1
MD93090901B	Rock	375	13	<50	0.4	<2	2.5	<0.01	1	<4	2	8	<100	11	3	0.012	<5	184	<0.05	<30	<2	1.9
MD93091001A	Rock	135	2	<50	<0.2	<2	0.6	<0.01	<1	<4	2	3	<100	8	2	0.004	<5	245	<0.05	<30	<2	<0.5
MD93091001B	Rock	221	9	<50	1.2	2	2.8	<0.01	1	<4	9	39	<100	19	18	0.019	<5	472	<0.05	<30	<2	2.1
MD93091001C	Rock	25	2	<50	0.6	2	0.4	<0.01	<1	<4	2	11	<100	8	9	0.003	<5	1002	0.17	<30	<2	<0.5
MD93091101A	Rock	217	6	<50	<0.2	2	1.9	<0.01	<1	<4	3	6	<100	12	4	0.011	<5	245	<0.05	<30	2	1.5
MD93091101B	Rock	178	3	<50	<0.2	<2	1.3	<0.01	<1	<4	2	3	100	11	3	0.008	<5	207	<0.05	<30	<2	0.8
MD93091101C	Rock	168	4	<50	<0.2	<2	1.7	<0.01	<1	<4	2	4	<100	11	3	0.009	<5	208	<0.05	<30	<2	1.1
MD93091101D	Rock	173	3	<50	<0.2	<2	0.9	<0.01	<1	<4	2	3	<100	9	3	0.004	<5	219	<0.05	<30	<2	<0.5
MD93091101E	Rock	119	4	<50	<0.2	<2	2.1	<0.01	<1	<4	2	10	<100	12	3	0.008	<5	272	<0.05	<30	<2	1.2
MD93091101F	Rock	1181	9	<50	0.4	<2	3.1	<0.01	1	<4	4	10	140	41	2	0.107	<5	242	<0.05	40	2	1.9
MD93091102A	Rock	377	5	<50	32	20	2.8	<0.01	<1	<4	2	3	<100	23	<1	0.014	<5	172	0.06	<30	<2	1.9
MD93091102B	Rock	378	5	<50	<0.2	<2	2.4	<0.01	1	<4	2	5	120	24	2	0.025	<5	180	<0.05	<30	<2	1.9

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion

SAMPLE #	TYPE	U ppm INAA	U ppm ICP	Ce ppm INAA	Cs ppm INAA	Eu ppm INAA	Hf ppm INAA	La ppm INAA	La ppm ICP	Lu ppm INAA	Nd ppm INAA	Sm ppm INAA	Ta ppm INAA	Tb ppm INAA	Yb ppm INAA
PHANEROZOIC CLASTIC ROCKS															
MD93082401B	Rock	1.8	<5	40	<2	<0.2	11	19	5	0.42	17	2.7	<1	<0.5	2.2
MD93090501	Rock	1.2	<5	33	<2	0.7	5	19	9	0.33	12	2.3	<1	<0.5	2
MD93090503C	Rock	0.9	<5	18	<2	0.4	5	11	5	0.19	10	1.3	<1	<0.5	1
MD93090701	Rock	1	<5	4	<2	<0.2	10	2	2	0.27	<5	0.3	<1	<0.5	1.5
MD93090703A	Rock	0.9	<5	<3	<2	<0.2	9	<1	2	0.24	<5	0.2	<1	<0.5	1.3
MD93090703B	Rock	1.4	<5	8	<2	0.3	11	4	2	0.38	<5	0.6	1	<0.5	2
MD93090705	Rock	0.6	<5	<3	<2	<0.2	10	<1	2	0.18	<5	0.2	<1	<0.5	1.1
MD93090707	Rock	1.1	<5	32	<2	0.6	9	17	5	0.33	12	2.1	<1	<0.5	2
MD93090803	Rock	1.6	<5	25	<2	0.4	7	13	2	0.2	<5	1.5	<1	<0.5	1.3
PHANEROZOIC CARBONATES															
MD93082401A	Rock	1.6	<5	<3	<2	<0.2	<0.5	<1	2	<0.05	<5	<0.1	<1	<0.5	<0.2
MD93082401C	Rock	<0.5	<5	<3	<2	<0.2	<0.5	2	2	<0.05	<5	0.2	<1	<0.5	<0.2
MD93090503A	Rock	<0.5	<5	12	<2	<0.2	<0.5	5	2	0.09	<5	0.6	<1	<0.5	0.5
MD93090503B	Rock	<0.5	<5	7	<2	0.3	<0.5	5	2	0.06	6	0.8	<1	<0.5	0.3
MD93090706A	Rock	0.8	<5	11	<2	0.3	<0.5	7	2	0.08	9	0.9	<1	<0.5	0.5
MD93090706B	Rock	<0.5	<5	16	<2	<0.2	<0.5	7	2	0.1	7	1.1	<1	<0.5	0.6
MD93090901A	Rock	0.7	<5	9	<2	0.2	<0.5	6	2	0.08	5	0.9	<1	<0.5	0.5
MD93090901B	Rock	1.4	<5	20	<2	0.3	<0.5	10	3	0.14	10	1.6	<1	<0.5	0.9
MD93091001A	Rock	<0.5	<5	6	<2	<0.2	<0.5	2	2	0.06	<5	0.4	<1	<0.5	0.2
MD93091001B	Rock	<0.5	<5	19	<2	<0.2	2	10	3	0.13	<5	1.3	<1	<0.5	0.7
MD93091001C	Rock	<0.5	7	<3	<2	<0.2	1	2	2	<0.05	<5	0.2	<1	<0.5	<0.2
MD93091101A	Rock	<0.5	<5	12	<2	0.2	<0.5	6	2	0.1	<5	0.9	<1	<0.5	0.5
MD93091101B	Rock	0.6	<5	9	<2	0.3	<0.5	5	2	0.06	7	0.8	<1	<0.5	0.4
MD93091101C	Rock	<0.5	<5	10	<2	0.2	<0.5	5	2	0.09	<5	0.9	<1	<0.5	0.5
MD93091101D	Rock	<0.5	<5	7	<2	0.3	<0.5	3	2	0.07	<5	0.5	<1	<0.5	0.3
MD93091101E	Rock	<0.5	<5	13	<2	<0.2	<0.5	6	2	0.07	<5	0.9	<1	<0.5	0.5
MD93091101F	Rock	0.7	<5	16	<2	<0.2	<0.5	8	2	0.06	<5	1	<1	<0.5	0.6
MD93091102A	Rock	<0.5	<5	16	<2	<0.2	<0.5	8	2	0.12	<5	1.2	<1	<0.5	0.7
MD93091102B	Rock	0.7	<5	15	<2	<0.2	<0.5	7	2	0.11	6	0.9	<1	<0.5	0.5

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion

SAMPLE #	TYPE	Au ppb INAA	Au ppm ICP	Au ppb FA/AA	Ag ppm ICP	Ag ppm INAA	Cu ppm ICP	Pb ppm ICP	Zn ppm ICP	Zn ppm INAA	As ppm INAA	As ppm ICP	Bi ppm ICP	Cd ppm ICP	Co ppm ICP	Co ppm INAA	Cr ppm ICP	Cr ppm INAA	Hg ppm INAA	Ir ppb INAA	Mo ppm INAA	Mo ppm ICP
HOLE SL27C																						
SL27C-1	Core		<2	24	<0.1		11	61	41			<2	<2	<0.2	12		104					2
SL27C-2	Core		<2	14	0.1		2	97	6			<2	<2	<0.2	1		17					1
HOLE SL27C2																						
SL27C2-1	Core		<2	13	0.1		2	70	5			<2	<2	<0.2	<1		20					1
SL27C2-2	Core		<2	<5	0.2		5	85	4			2	<2	<0.2	1		32					1
SL27C2-3	Core		<2	11	0.3		9	53	4			5	5	<0.2	1		279					5
SL27C2-4*	Core		<2	1040	0.9		34	9	15			<2	<2	<0.2	<1		124					1
SL27C2-5*	Core		<2	647	0.3		7	57	211			8	<2	0.3	35		398					3
SL27C2-6	Core		<2	<5	0.1		21	19	150			5	3	<0.2	15		28					1
SL27C2-7	Core		<2	16	0.3		12	24	43			14	<2	<0.2	9		63					2
HOLE E+8C																						
E+8C-1*	Core		<2	455	0.3		16	20	22			3	4	<0.2	6		223					2
E+8C-2*	Core		<2	717	0.5		5	4	13			4	6	<0.2	6		219					3
E+8C-3*	Core		<2	107	0.4		8	<2	8			<2	<2	<0.2	1		398					2
E+8C-4	Core		<2	17	0.1		7	4	3			14	5	<0.2	<1		14					1
E+8C-5	Core		<2	5	<0.1		1	20	2			<2	<2	<0.2	1		25					1
E+8C-6	Core		<2	17	1.1		46	17	4			7	6	<0.2	<1		33					3
E+8C-7*	Core		<2	277	0.3		3	9	1			2	<2	<0.2	1		172					1
HOLE SL27C1																						
SL27C1-1*	Core		<2	677	0.3		5	20	2			<2	<2	<0.2	1		256					2
SL27C1-2*	Core		<2	168	0.1		5	12	99			<2	<2	<0.2	5		184					1
SL27C1-3	Core		<2	<5	0.2		18	11	38			<2	<2	<0.2	10		104					1
HOLE B+148C																						
B+148C-1*	Core		<2	109	<0.1		6	9	8			<2	<2	<0.2	3		396					3
B+148C-2*	Core		<2	69	0.1		10	5	12			<2	<2	<0.2	<1		302					1
B+148C-3*	Core		<2	218	0.4		61	45	9			<2	4	<0.2	2		553					6
B+148C-4*	Core		<2	297	0.1		5	6	5			<2	<2	<0.2	1		165					1

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion
*FA/AA and ICP analyses performed on the ash residue after 16 hours at 800C

SAMPLE #	TYPE	Mn ppm ICP	Ni ppm ICP	Ni ppm INAA	Sb ppm INAA	Sb ppm ICP	Sc ppm INAA	Sn % INAA	W ppm ICP	W ppm INAA	V ppm ICP	B ppm ICP	Ba ppm INAA	Ba ppm ICP	Br ppm INAA	P % ICP	Se ppm INAA	Sr ppm ICP	Sr % INAA	Rb ppm INAA	Th ppm ICP	Th ppm INAA
HOLE SL27C																						
SL27C-1		171	35			2			1		16	14		34		0.010		33			6	
SL27C-2		53	3			4			<1		3	102		95		0.004		417			<2	
HOLE SL27C2																						
SL27C2-1		41	<1			<2			<1		2	110		7		<0.001		259			<2	
SL27C2-2		45	2			4			<1		4	141		49		0.001		354			<2	
SL27C2-3		50	5			4			<1		11	15		30		0.002		46			3	
SL27C2-4*		346	5			<2			<1		8	<2		38		0.002		13			2	
SL27C2-5*		55	54			2			<1		24	10		28		0.003		18			2	
SL27C2-6		20	37			2			<1		10	21		25		0.004		41			8	
SL27C2-7		77	47			<2			<1		6	2		15		0.015		76			3	
HOLE E+8C																						
E+8C-1*		206	22			2			<1		33	16		94		0.009		29			5	
E+8C-2*		1020	23			<2			<1		28	<2		29		0.003		10			3	
E+8C-3*		422	16			<2			<1		21	<2		30		0.004		8			6	
E+8C-4		62	4			<2			<1		4	147		12		0.001		193			2	
E+8C-5		70	3			3			1		5	122		92		0.001		372			4	
E+8C-6		55	3			3			<1		11	96		7		0.002		130			3	
E+8C-7*		33	8			3			<1		13	13		27		0.002		34			2	
HOLE SL27C1																						
SL27C1-1*		44	10			<2			<1		20	10		37		0.004		21			2	
SL27C1-2*		46	12			<2			1		10	4		19		0.003		10			2	
SL27C1-3		146	58			<2			<1		10	9		3		0.021		21			4	
HOLE B+148C																						
B+148C-1*		81	19			3			<1		28	8		51		0.006		12			7	
B+148C-2*		75	19			<2			<1		13	<2		42		0.002		8			3	
B+148C-3*		106	23			<2			<1		39	257		14		0.006		951			10	
B+148C-4*		32	7			<2			<1		24	17		54		0.003		33			2	

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion
*FA/AA and ICP analyses performed on the ash residue after 16 hours at 800C

SAMPLE #	TYPE	U ppm INAA	U ppm ICP	Ce ppm INAA	Cs ppm INAA	Eu ppm INAA	Hf ppm INAA	La ppm INAA	La ppm ICP	Lu ppm INAA	Nd ppm INAA	Sm ppm INAA	Ta ppm INAA	Tb ppm INAA	Yb ppm INAA
HOLE SL27C															
SL27C-1			<5						13						
SL27C-2			<5						<2						
HOLE SL27C2															
SL27C2-1			<5						<2						
SL27C2-2			<5						4						
SL27C2-3			<5						5						
SL27C2-4*			<5						5						
SL27C2-5*			<5						12						
SL27C2-6			<5						19						
SL27C2-7			<5						12						
HOLE E+8C															
E+8C-1*			<5						22						
E+8C-2*			<5						9						
E+8C-3*			<5						14						
E+8C-4			<5						2						
E+8C-5			<5						5						
E+8C-6			<5						<2						
E+8C-7*			<5						7						
HOLE SL27C1															
SL27C1-1*			<5						9						
SL27C1-2*			<5						6						
SL27C1-3			<5						6						
HOLE B+148C															
B+148C-1*			<5						22						
B+148C-2*			<5						7						
B+148C-3*			<5						24						
B+148C-4*			<5						14						

Methods: FA/AA & INAA analyses using 30 gm aliquots; ICP analysis with aqua regia partial digestion
*FA/AA and ICP analyses performed on the ash residue after 16 hours at 800C

SAMPLE #	TYPE	Au ppb FA	Au ppm ICP	Au ppb INAA	Ag ppm AA	Ag ppm ICP	Ag ppm INAA	Cu ppm AA	Cu ppm ICP	Pb ppm AA	Pb ppm ICP	Zn ppm AA	Zn ppm ICP	Zn ppm INAA	As ppm ICP	As ppm INAA	Bi ppm ICP	Cd ppm AA	Cd ppm ICP	Cd ppm INAA	Co ppm AA	Co ppm ICP	Co ppm INAA	Cr ppm ICP	Cr ppm INAA
NAT92-24 (1993)	Till		ND		0.2	0.7		32	25	13	12	89	92		9		<3	0.3	1		9	12		14	
NAT92-24 (1994)	Till				<0.2			28		19		97						<0.2			10				
NAT92-25 (1993)	Till		ND		0.2	0.2		12	12	6	5	14	18		2		<3	0.2	<1		3	3		7	
NAT92-25 (1994)	Till				<0.2			10		11		19						<0.2			5				
NAT93-81	Till			<2	0.2		<2	15		13		56		<100		3.9		<0.2		<5	7		9		49
NAT93-82	Till			<2	0.2		<2	11		10		37		<100		3.2		<0.2		<5	3		5		36
NAT93-83	Till			2	<0.2		<2	18		15		60		<100		6		<0.2		<5	9		11		40
NAT93-84	Till			3	0.3		<2	19		13		70		<100		7.6		<0.2		<5	7		9		49
NAT93-84G	Till			3	0.3		<2	18		12		62		<100		7.4		<0.2		<5	6		7		50
NAT93-84P	Till			<2	0.2		<2	11		12		31		<100		4.2		0.2		<5	3		<5		34
NAT93-86D1	Till			6	0.2		<2	18		20		88		<100		6.6		<0.2		<5	6		5		64
NAT93-86D2	Till			8	<0.2		<2	17		16		73		<100		6.3		<0.2		<5	7		8		68
NAT93-88	Till			9	0.4		<2	19		13		48		<100		14		0.2		<5	11		16		49
NAT93-89	Till			<2	<0.2		<2	15		14		41		<100		4.8		<0.2		<5	7		6		37

Methods: <0.063mm fraction; 1993 ICP & AA analyses with aqua regia partial digestion; 1994 AA & ICP analyses with multi acid full digestion

ND = Not Detected; N/A = Not Available

SAMPLE #	TYPE	F ppm AA	Fe % AA	Fe % ICP	Fe % INAA	Hg ppm AA	Hg ppm ICP	Ir ppb INAA	Mo ppm AA	Mo ppm ICP	Mo ppm INAA	Mn ppm AA	Mn ppm ICP	Ni ppm AA	Ni ppm ICP	Ni ppm INAA	Sb ppm ICP	Sb ppm INAA	Sc ppm INAA	Sn ppm INAA	W ppm ICP	W ppm INAA	V ppm AA	V ppm ICP
NAT92-24 (1993)	Till	570	2.2	2.3		70	ND		2	<1		286	348	26	24		<2				<2		26	18
NAT92-24 (1994)	Till		3.1						6			268		27									140	
NAT92-25 (1993)	Till	260	0.9	0.9		30	ND		<2	<1		125	147	10	8		<2				<2		17	12
NAT92-25 (1994)	Till		1.5						4			157		11									47	
NAT93-81	Till		1.8		1.5			<50	3		1	185		23		28		0.4	7.4	<100		<1	80	
NAT93-82	Till		1.8		1.4			<50	2		<1	169		11		<10		0.3	4.8	<100		<1	54	
NAT93-83	Till		2.3		2.2			<50	4		<1	460		24		21		0.6	9	<100		<1	84	
NAT93-84	Till		2.4		2			<50	4		<1	253		19		20		0.5	8.3	<100		<1	88	
NAT93-84G	Till		3		2.2			<50	2		<1	251		17		22		0.5	8.1	<100		<1	89	
NAT93-84P	Till		2.1		1.4			<50	3		<1	160		12		<10		0.4	5.1	<100		<1	54	
NAT93-86D1	Till		2		2.1			<50	2		<1	168		17		<10		0.6	8.4	<100		1	97	
NAT93-86D2	Till		2.5		2.5			<50	3		<1	174		19		19		0.5	10	<100		<1	100	
NAT93-88	Till		6.1		5.3			<50	4		<1	940		24		38		0.6	8.7	<100		1	88	
NAT93-89	Till		2.2		1.5			<50	6		1	167		28		34		0.3	6	<100		<1	94	

Methods: <0.063mm fraction; 1993 ICP & AA analyses with aqua regia partial digestion; 1994 AA & ICP analyses with multi acid full digestion
ND = Not Detected; N/A = Not Available

SAMPLE #	TYPE	B ppm ICP	Ba ppm ICP	Ba ppm INAA	Br ppm INAA	P % ICP	Se ppm INAA	Sr ppm ICP	Rb ppm INAA	Th ppm INAA	U ppm ICP	U ppm INAA	Ce ppm INAA	Cs ppm INAA	Eu ppm INAA	Hf ppm INAA	La ppm ICP	La ppm INAA	Lu ppm INAA	Sm ppm INAA	Ta ppm INAA	Te ppm INAA	Tb ppm INAA	Yb ppm INAA	Zr ppm INAA
NAT92-24 (1993)	Till	N/A	210			0.1		38			N/A						23								
NAT92-24 (1994)	Till																								
NAT92-25 (1993)	Till	N/A	39			0		27			N/A						11								
NAT92-25 (1994)	Till																								
NAT93-81	Till			320	1.4		<5		63	10		2.7	63	1.7	<1	13		31	<0.2	5.2	1.1	<10	0.6	3	530
NAT93-82	Till			300	2.2		<5		49	7.1		1.6	42	1.2	<1	8		22	<0.2	3.7	0.8	<10	<0.5	1	360
NAT93-83	Till			480	1		<5		82	11		2.8	72	2.8	1	9		38	<0.2	6.2	1.1	<10	0.8	3	440
NAT93-84	Till			430	0.9		<5		70	9.2		2.7	62	2.3	1	7		31	<0.2	5.4	0.8	<10	0.8	2	360
NAT93-84G	Till			390	0.8		<5		60	8.6		2.6	59	2.4	1	6		30	<0.2	5.2	1	<10	0.6	2	310
NAT93-84P	Till			240	0.7		<5		36	10		2	62	1.4	<1	6		33	0.2	5.2	0.6	<10	0.6	2	210
NAT93-86D1	Till			350	1.1		<5		83	11		2.6	67	3.5	1	8		37	<0.2	5.8	1	<10	0.6	2	310
NAT93-86D2	Till			300	1.1		<5		74	11		2.4	83	3.4	1	7		44	0.3	5.7	0.9	<10	0.8	3	310
NAT93-88	Till			350	12		<5		62	7.9		2.4	49	2.5	<1	10		26	<0.2	4.7	0.9	<10	0.7	2	280
NAT93-89	Till			340	2.5		<5		59	10		2.4	52	1.4	<1	7		29	<0.2	4.3	0.7	<10	0.5	2	320

Methods: <0.063mm fraction; 1993 ICP & AA analyses with aqua regia partial digestion; 1994 AA & ICP analyses with multi acid full digestion
ND = Not Detected; N/A = Not Available

APPENDIX 3

CERTIFICATES OF ANALYSES

To: ALBERTA RESEARCH COUNCIL,
P.O. Box 8330,
Postal Station "F",
Edmonton, Alberta T6H 5X2

ATTN: Mike Dufresne

File No. 36190-1
Date January 28, 1994
Samples Rock
P.O. # EC 94061286

Certificate of Assay
LORING LABORATORIES LTD.

SAMPLE NO.	PPB GOLD
Geochemical Analysis	
MD 9309 0501	<5
0503 A	<5
0503 B	<5
0503 C	<5
0701	<5
0703 A	<5
0703 B	<5
0705	<5
0706 A	<5
0706 B	<5
0707	<5
0803	<5
0901 A	<5
0901 B	9
1001 A	<5
1001 B	6
1001 C	<5
1101 A	<5
1101 B	<5
1101 C	<5
1101 D	<5
1101 E	<5
1101 F	<5
1102 A	<5
1102 B	<5

I Hereby Certify that the above results are those assays made by me upon the herein described samples....

Rejects retained one month.
Pulps retained one month
unless specific arrangements
are made in advance.

Assayer

GEOCHEMICAL ANALYSIS CERTIFICATE

Loring Laboratories Ltd. PROJECT 36190 File # 93-3328

629 Beaverdam Road N.E., Calgary AB T2K 4W7

SAMPLE#	Au PPB	Ag PPM	As PPM	Ba PPM	Br PPM	Ca %	Co PPM	Cr PPM	Cs PPM	Fe %	Hf PPM	Hg PPM	Ir PPB	Mo PPM	Na PPM	Ni PPM	Rb PPM	Sb PPM	Sc PPM	Se PPM	Sn %	Sr %	Ta PPM	Th PPM	U PPM	W PPM	Zn PPM	La PPM	Ce PPM	Nd PPM	Sm PPM	Eu PPM	Tb PPM	Yb PPM	Lu PPM
MD93082401A	<5	<5	<2	<100	9	13	<5	<10	<2	.23	<.5	<1	<5	<5	9410	<50	<30	.3	.2	<5	<.01	.12	<1	<.5	1.6	<4	<50	<1	<3	<5	<.1	<.2	<.5	<.2	<.05
MD93082401B	7	<5	<2	460	<1	4	<5	220	<2	12.00	11.0	<1	<5	<5	1560	<50	<30	<.2	6.0	<5	<.01	<.05	<1	4.7	1.8	<4	<50	19	40	17	2.7	<.2	<.5	2.2	.42
MD93082401C	<5	<5	<2	<100	7	22	<5	17	<2	.48	<.5	<1	<5	<5	8640	<50	<30	<.2	.3	<5	<.01	.19	<1	<.5	<.5	<4	<50	2	<3	<5	.2	<.2	<.5	<.2	<.05
MD93082701	<5	<5	<2	1500	<1	<1	<5	160	<2	1.37	13.0	<1	<5	<5	14300	<50	230	<.2	1.4	<5	<.01	<.05	<1	190.0	3.9	<4	<50	250	480	130	19.0	1.6	<.5	<.2	<.05
MD93082703	<5	<5	<2	910	<1	<1	<5	100	<2	1.98	27.0	<1	<5	6	18100	<50	210	<.2	3.8	<5	<.01	<.05	<1	450.0	8.6	<4	<50	450	950	330	50.0	<.2	<.5	<.2	<.05
MD93082704	<5	<5	<2	1200	<1	<1	15	48	<2	5.61	110.0	<1	<5	<5	23600	<50	320	<.2	8.5	<5	<.01	<.05	<1	1900.0	65.0	<4	<50	1900	3300	1200	200.0	4.5	15.0	<.2	<.05
MD93082705	<5	<5	<2	500	<1	<1	<5	180	<2	1.18	8.0	<1	<5	<5	8220	<50	120	<.2	2.7	<5	<.01	<.05	<1	61.0	4.0	<4	<50	90	170	62	9.4	<.2	<.5	1.3	.06
MD93082707	<5	<5	<2	<100	<1	<1	<5	220	<2	.60	<.5	<1	<5	<5	5170	<50	<30	<.2	.9	<5	<.01	<.05	<1	8.1	<.5	<4	<50	13	28	18	1.6	<.2	<.5	.3	<.05
MD93082803A	<5	<5	<2	<100	<1	<1	<5	150	2	1.09	5.0	<1	<5	<5	22200	<50	240	<.2	2.9	<5	<.01	<.05	<1	39.0	15.0	<4	<50	52	110	36	6.7	.3	<.5	1.3	<.05
MD93082803B	<5	<5	<2	370	<1	<1	<5	240	<2	.66	2.0	<1	<5	<5	11100	<50	140	<.2	1.2	<5	<.01	<.05	<1	20.0	1.6	<4	132	12	25	11	1.6	<.2	<.5	.5	.15
MD93082804	<5	<5	<2	1100	<1	<1	<5	170	<2	.92	3.0	<1	<5	<5	1850	<50	150	<.2	2.6	<5	<.01	<.05	<1	34.0	1.8	<4	<50	40	77	37	4.7	.5	<.5	1.0	.09
MD93082901A	<5	<5	<2	670	<1	4	15	110	3	4.83	5.0	<1	<5	<5	21300	<50	94	<.2	25.0	<5	<.01	<.05	<1	6.7	3.8	<4	<50	24	49	24	6.3	1.2	.7	6.3	.98
MD93082901B	<5	<5	<2	1600	<1	<1	<5	140	3	1.02	3.0	<1	<5	<5	31000	<50	100	<.2	2.4	<5	<.01	<.05	<1	6.2	1.8	<4	<50	17	28	15	1.6	.5	<.5	.6	.10
MD93082903A	<5	<5	<2	690	<1	<1	<5	150	<2	1.53	8.0	<1	<5	<5	21300	<50	170	<.2	3.4	<5	<.01	<.05	<1	89.0	4.9	<4	<50	100	210	82	14.0	.7	<.5	<.2	.14
MD93082903B	<5	<5	<2	730	<1	<1	22	180	<2	5.31	9.0	<1	<5	<5	11800	<50	75	<.2	21.0	<5	<.01	<.05	6	28.0	3.7	<4	<50	46	88	43	6.4	1.6	<.5	2.6	.41
MD93083002A	<5	<5	<2	1200	<1	<1	6	180	<2	2.26	5.0	<1	<5	<5	24800	<50	73	<.2	8.7	<5	<.01	<.05	<1	20.0	3.4	<4	<50	53	98	28	6.0	1.4	<.5	3.1	.47
MD93083002B	<5	<5	<2	830	<1	<1	<5	310	<2	1.00	<.5	<1	<5	<5	25300	<50	180	<.2	4.3	<5	<.01	<.05	<1	18.0	330.0	<4	<50	34	79	43	5.5	1.1	<.5	5.0	.65
MD93083003A	<5	<5	<2	1600	<1	<1	5	110	<2	2.74	4.0	<1	<5	6	24300	<50	150	<.2	16.0	<5	<.01	<.05	<1	11.0	2.4	<4	<50	37	68	17	3.5	.9	<.5	2.3	.39
MD93083003B	<5	<5	3	1000	<1	<1	<5	140	<2	2.57	5.0	<1	<5	<5	24400	<50	160	.3	6.8	<5	<.01	<.05	5	38.0	4.9	<4	<50	82	150	52	7.4	.9	<.5	3.3	.51
MD93090101	<5	<5	<2	560	<1	<1	6	260	<2	1.74	2.0	<1	<5	<5	15100	<50	<30	<.2	3.5	<5	<.01	<.05	<1	5.2	<.5	<4	<50	23	37	17	2.3	.8	<.5	.8	.09
MD93090102	<5	<5	<2	310	<1	<1	<5	170	<2	.48	2.0	<1	<5	<5	22400	<50	110	<.2	1.7	<5	<.01	<.05	<1	8.3	1.0	<4	<50	11	21	6	1.9	<.2	<.5	<.2	<.05
MD9390103	<5	<5	<2	1400	<1	4	5	170	<2	1.95	4.0	<1	<5	<5	40400	<50	<30	<.2	4.0	<5	<.01	<.05	<1	5.8	<.5	<4	<50	26	46	11	1.8	<.2	<.5	.6	.13
MD93090104	<5	<5	<2	1300	<1	<1	16	170	<2	5.42	3.0	<1	<5	<5	29500	<50	<30	<.2	17.0	<5	<.01	.11	<1	2.2	<.5	<4	<50	25	43	16	3.9	1.3	<.5	2.0	.35
MD93090105A	<5	<5	<2	1900	<1	<1	5	130	<2	2.15	6.0	<1	<5	<5	19800	<50	160	<.2	5.9	<5	<.01	<.05	<1	37.0	2.4	<4	<50	81	140	42	6.6	1.1	<.5	1.6	.35
MD93090105B	<5	<5	<2	560	<1	<1	<5	200	<2	.71	<.5	<1	<5	<5	31000	<50	92	<.2	5.6	<5	<.01	<.05	<1	.7	1.9	<4	<50	11	17	<5	.7	.4	<.5	2.7	.41
RE MD93090105B	<5	<5	<2	500	<1	<1	<5	210	<2	.69	<.5	<1	<5	6	31000	<50	65	<.2	5.3	<5	<.01	<.05	<1	1.1	1.5	<4	<50	10	14	<5	.8	.4	.6	2.4	.46
MD93090106A	<5	<5	5	860	<1	3	<5	160	<2	1.65	3.0	<1	<5	<5	30900	<50	61	<.2	4.9	<5	<.01	<.05	<1	12.0	3.0	<4	<50	32	62	22	3.3	.7	<.5	1.9	.29
MD93090106B	14	<5	<2	1400	<1	<1	<5	170	<2	1.01	3.0	<1	<5	<5	32500	<50	83	<.2	3.8	<5	<.01	<.05	<1	9.7	<.5	<4	<50	35	61	13	3.0	.7	.7	.7	.15
MD93090202	<5	<5	<2	1000	<1	<1	<5	150	<2	2.03	2.0	<1	<5	<5	27200	210	140	<.2	5.8	<5	<.01	.09	<1	13.0	2.0	<4	<50	34	61	16	3.7	1.0	<.5	3.1	.52
MD93090203A	<5	<5	<2	450	<1	<1	<5	290	<2	.55	4.0	<1	<5	<5	7250	<50	100	<.2	1.3	<5	<.01	<.05	<1	13.0	1.2	<4	<50	31	60	26	2.9	<.2	<.5	2.0	.34
MD93090203B	<5	<5	<2	280	<1	<1	<5	180	<2	.46	<.5	<1	<5	<5	22100	<50	110	<.2	1.5	<5	<.01	<.05	<1	1.0	1.4	<4	<50	2	5	<5	.4	<.2	<.5	.5	.11
MD93090203C	<5	<5	<2	1300	<1	<1	<5	150	2	2.39	5.0	<1	<5	10	34300	<50	120	.3	5.7	<5	<.01	<.05	<1	16.0	1.8	<4	<50	54	86	30	4.2	1.1	<.5	.9	.13
MD93090206	<5	<5	<2	1000	<1	<1	10	210	<2	3.15	5.0	<1	<5	<5	24900	<50	120	<.2	8.2	<5	<.01	<.05	<1	14.0	2.5	<4	<50	64	98	40	5.0	1.4	<.5	1.0	.18
MD93090301	<5	<5	<2	1300	<1	<1	5	140	<2	1.55	5.0	<1	<5	<5	25500	<50	130	<.2	5.4	<5	<.01	<.05	<1	26.0	1.4	<4	<50	53	82	18	3.6	1.0	<.5	1.1	.23
MD93090303A	<5	<5	<2	<100	<1	5	38	410	<2	14.50	<.5	<1	<5	<5	16500	<50	<30	<.2	45.0	<5	<.01	<.05	<1	.6	<.5	<4	203	7	11	<5	1.4	.6	<.5	3.2	.57
MD93090303B	<5	<5	<2	390	<1	11	41	500	<2	8.95	2.0	<1	<5	<5	18200	<50	<30	<.2	38.0	<5	<.01	<.05	<1	<.5	<.5	<4	343	10	27	13	4.0	.9	<.5	4.4	.78
MD93090304	<5	<5	<2	1000	<1	<1	<5	120	<2	1.73	3.0	<1	<5	<5	29900	<50	96	<.2	5.2	<5	<.01	<.05	<1	11.0	<.5	<4	<50	32	56	23	3.1	.7	<.5	1.7	.28
MD93090305	<5	<5	<2	860	<1	<1	<5	160	<2	1.64	4.0	<1	<5	<5	30400	<50	140	<.2	4.1	<5	<.01	<.05	<1	17.0	2.1	<4	<50	41	75	19	3.8	.7	<.5	1.5	.27

ANALYSED BY INAA.
- SAMPLE TYPE: PULP
Samples beginning 'RE' are duplicate samples.

SAMPLE#	Au PPB	Ag PPM	As PPM	Ba PPM	Br PPM	Ca %	Co PPM	Cr PPM	Cs PPM	Fe %	Hf PPM	Hg PPM	Ir PPB	Mo PPM	Na PPM	Ni PPM	Rb PPM	Sb PPM	Sc PPM	Se PPM	Sn %	Sr %	Ta PPM	Th PPM	U PPM	W PPM	Zn PPM	La PPM	Ce PPM	Nd PPM	Sm PPM	Eu PPM	Tb PPM	Yb PPM	Lu PPM
MD93090306A	<5	<5	<2	<100	<1	8	44	200	<2	9.02	<.5	<1	<5	<5	14700	<50	<30	<.2	37.0	<5	<.01	<.05	<1	<.5	<.5	<4	<50	11	23	14	3.1	1.2	.6	2.7	.51
MD93090306B	<5	<5	<2	490	<1	<1	27	210	<2	5.75	10.0	<1	<5	8	31500	<50	130	<.2	12.0	<5	<.01	<.05	<1	44.0	<.5	<4	<50	97	170	57	10.0	1.6	<.5	1.1	.27
MD93090307	7	<5	<2	<100	<1	4	8	130	<2	3.85	3.0	<1	<5	<5	14200	<50	44	<.2	4.8	<5	<.01	<.05	<1	21.0	<.5	<4	<50	130	210	82	10.0	1.2	<.5	.8	.10
MD93090501	<5	<5	<2	520	<1	3	<5	82	<2	25.40	5.0	<1	<5	<5	1200	<50	32	.2	9.2	<5	<.01	<.05	<1	3.5	1.2	<4	57	19	33	12	2.3	.7	<.5	2.0	.33
MD93090503A	<5	<5	<2	<100	<1	5	11	22	<2	36.90	<.5	<1	<5	<5	542	<50	<30	<.2	1.9	<5	<.01	<.05	<1	1.3	<.5	<4	<50	5	12	<5	.6	<.2	<.5	.5	.09
MD93090503B	<5	<5	<2	<100	3	32	<5	20	<2	5.10	<.5	<1	<5	<5	<.05	<50	<30	<.2	1.6	<5	<.01	<.05	<1	1.2	<.5	<4	<50	5	7	6	.8	.3	<.5	.3	.06
MD93090503C	<5	<5	3	<100	<1	<1	<5	170	<2	18.10	5.0	<1	<5	<5	<.05	<50	<30	<.2	3.7	<5	<.01	<.05	<1	4.7	.9	<4	144	11	18	10	1.3	.4	<.5	1.0	.19
MD93090601A	8	<5	<2	2200	<1	<1	<5	190	<2	1.99	8.0	<1	<5	<5	19000	<50	210	<.2	1.9	<5	<.01	<.05	<1	46.0	6.2	<4	<50	92	150	49	6.7	1.4	<.5	.9	.18
MD93090601B	8	<5	<2	1100	<1	<1	<5	170	3	2.59	13.0	<1	<5	<5	24400	<50	100	<.2	4.5	<5	<.01	<.05	4	71.0	7.1	<4	<50	98	170	52	7.9	1.3	<.5	1.2	.14
MD93090603	<5	<5	<2	1100	<1	<1	5	81	<2	1.82	15.0	<1	<5	<5	20600	<50	130	<.2	4.1	<5	<.01	<.05	<1	220.0	4.0	<4	<50	260	500	170	25.0	.9	<.5	1.8	.15
MD93090605	<5	<5	<2	1200	<1	2	<5	170	<2	1.33	5.0	<1	<5	<5	23900	<50	180	<.2	2.2	<5	<.01	<.05	<1	19.0	4.9	<4	<50	35	56	17	2.5	.8	<.5	.7	<.05
MD93090701	<5	<5	<2	<100	<1	<1	<5	340	<2	.34	10.0	<1	<5	6	<.05	<50	<30	<.2	1.2	<5	<.01	<.05	<1	1.9	1.0	<4	<50	2	4	<5	.3	<.2	<.5	1.5	.27
MD93090703A	<5	<5	<2	<100	<1	<1	<5	330	<2	.38	9.0	<1	<5	<5	<.05	<50	<30	<.2	1.2	<5	<.01	<.05	<1	1.1	.9	<4	<50	<1	<3	<5	.2	<.2	<.5	1.3	.24
MD93090703B	<5	<5	4	<100	<1	<1	<5	260	<2	4.12	11.0	<1	<5	<5	<.05	<50	<30	.3	2.1	<5	<.01	<.05	1	2.6	1.4	<4	<50	4	8	<5	.6	.3	<.5	2.0	.38
MD93090705	<5	<5	<2	<100	<1	<1	<5	340	<2	.32	10.0	<1	<5	<5	<.05	<50	<30	<.2	.9	<5	<.01	<.05	<1	.7	.6	<4	<50	<1	<3	<5	.2	<.2	<.5	1.1	.18
RE MD93090705	<5	<5	<2	<100	<1	<1	<5	350	<2	.33	10.0	<1	<5	<5	<.05	<50	<30	<.2	.9	<5	<.01	<.05	<1	.7	1.0	<4	<50	<1	<3	<5	.2	<.2	<.5	1.1	.19
MD93090706A	<5	<5	<2	<100	3	31	<5	20	<2	1.19	<.5	<1	<5	<5	<.05	<50	<30	.3	2.5	<5	<.01	.06	<1	1.5	.8	<4	<50	7	11	9	.9	.3	<.5	.5	.08
MD93090706B	<5	<5	<2	150	3	33	<5	26	<2	.82	<.5	<1	<5	<5	<.05	<50	<30	<.2	2.5	<5	<.01	<.05	<1	1.7	<.5	<4	<50	7	16	7	1.1	<.2	<.5	.6	.10
MD93090707	<5	<5	7	<100	2	3	6	130	<2	16.40	9.0	<1	<5	<5	1250	<50	<30	.5	4.2	<5	<.01	<.05	<1	3.7	1.1	<4	82	17	32	12	2.1	.6	<.5	2.0	.33
MD93090801	<5	<5	<2	250	3	<1	<5	330	<2	.68	<.5	<1	<5	<5	4530	<50	30	.6	1.1	<5	<.01	<.05	<1	2.0	.5	<4	<50	3	5	<5	.3	<.2	<.5	.3	.07
MD93090802	5	<5	<2	1400	<1	<1	5	170	<2	2.73	4.0	<1	<5	<5	26900	<50	<30	<.2	6.0	<5	<.01	<.05	<1	14.0	1.4	<4	<50	40	68	29	3.7	.9	<.5	.9	.21
MD93090803	<5	<5	6	120	<1	<1	12	160	<2	28.40	7.0	<1	<5	<5	<.05	<50	<30	.3	2.1	<5	<.01	<.05	<1	3.6	1.6	<4	<50	13	25	<5	1.5	.4	<.5	1.3	.20
MD93090901A	<5	<5	<2	<100	5	32	<5	17	<2	3.41	<.5	<1	<5	<5	<.05	<50	<30	<.2	1.4	<5	<.01	<.05	<1	1.0	.7	<4	<50	6	9	5	.9	.2	<.5	.5	.08
MD93090901B	<5	<5	11	<100	3	34	12	26	<2	1.34	<.5	<1	<5	<5	<.05	<50	<30	.4	2.5	<5	<.01	<.05	<1	1.9	1.4	<4	62	10	20	10	1.6	.3	<.5	.9	.14
MD93091001A	<5	<5	<2	<100	2	36	<5	<10	<2	.60	<.5	<1	<5	<5	<.05	<50	<30	<.2	.6	<5	<.01	<.05	<1	<.5	<.5	<4	<50	2	6	<5	.4	<.2	<.5	.2	.06
MD93091001B	<5	<5	10	<100	18	14	<5	120	<2	2.94	2.0	<1	<5	<5	19200	<50	<30	1.2	2.8	<5	<.01	<.05	<1	2.1	<.5	<4	<50	10	19	<5	1.3	<.2	<.5	.7	.13
MD93091001C	<5	<5	3	<100	9	20	<5	47	<2	.17	1.0	<1	<5	<5	11000	<50	<30	.6	.4	<5	<.01	.17	<1	<.5	<.5	<4	<50	2	<3	<5	.2	<.2	<.5	<.2	<.05
MD93091101A	<5	<5	2	<100	4	34	<5	17	<2	1.15	<.5	<1	<5	<5	<.05	<50	<30	<.2	1.9	<5	<.01	<.05	<1	1.5	<.5	<4	<50	6	12	<5	.9	.2	<.5	.5	.10
MD93091101B	<5	<5	<2	100	3	43	<5	<10	<2	.78	<.5	<1	<5	<5	<.05	<50	<30	<.2	1.3	<5	<.01	<.05	<1	.8	.6	<4	<50	5	9	7	.8	.3	<.5	.4	.06
MD93091101C	<5	<5	<2	<100	3	38	<5	<10	<2	.69	<.5	<1	<5	<5	<.05	<50	<30	<.2	1.7	<5	<.01	<.05	<1	1.1	<.5	<4	<50	5	10	<5	.9	.2	<.5	.5	.09
MD93091101D	<5	<5	<2	<100	3	41	<5	<10	<2	.92	<.5	<1	<5	<5	<.05	<50	<30	<.2	.9	<5	<.01	<.05	<1	<.5	<.5	<4	<50	3	7	<5	.5	.3	<.5	.3	.07
MD93091101E	<5	<5	<2	<100	3	38	<5	14	<2	.55	<.5	<1	<5	<5	<.05	<50	<30	<.2	2.1	<5	<.01	<.05	<1	1.2	<.5	<4	<50	6	13	<5	.9	<.2	<.5	.5	.07
MD93091101F	<5	<5	3	140	2	35	<5	28	<2	7.83	<.5	<1	<5	<5	744	<50	40	.4	3.1	<5	<.01	<.05	<1	1.9	.7	<4	<50	8	16	<5	1.0	<.2	<.5	.6	.06
MD93091102A	<5	<5	3	<100	<1	37	<5	15	<2	1.48	<.5	<1	<5	<5	<.05	<50	<30	32.0	2.8	<5	<.01	.06	<1	1.9	<.5	<4	<50	8	16	<5	1.2	<.2	<.5	.7	.12
MD93091102B	<5	<5	3	120	2	38	<5	14	<2	2.51	<.5	<1	<5	<5	512	<50	<30	<.2	2.4	<5	<.01	<.05	<1	1.9	.7	<4	<50	7	15	6	.9	<.2	<.5	.5	.11
RE MD93091102B	<5	<5	3	<100	2	36	<5	14	<2	2.57	<.5	<1	<5	<5	520	<50	<30	<.2	2.5	<5	<.01	<.05	<1	1.8	.8	<4	<50	7	15	<5	1.0	.3	<.5	.4	.14

Sample type: PULP. Samples beginning 'RE' are duplicate samples.

GEOCHEMICAL ANALYSIS CERTIFICATE

Loring Laboratories Ltd. PROJECT 36190 File # 93-3328 Page 1

629 Beaverdam Road N.E., Calgary AB T2K 4W7

SAMPLE#	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppm	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %	W ppm
MD93082401A	<1	2	12	10	.1	1	<1	13	.12	2	<5	<2	<2	474	.2	2	<2	<2	14.47	.005	<2	2	.04	<2	<.01	3	.02	.94	.02	1
MD93082401B	2	10	6	10	.2	4	2	520	9.59	3	<5	<2	3	142	.6	<2	<2	10	2.43	.006	5	91	1.91	90	.01	9	.19	.05	.06	<1
MD93082401C	<1	<1	2	1	.2	<1	<1	20	.29	2	<5	<2	<2	1079	<.2	<2	<2	<2	23.18	.003	<2	5	.07	2	<.01	9	.04	.66	.01	1
MD93082701	2	7	11	10	.3	3	3	41	1.11	<2	<5	<2	185	26	<.2	2	4	8	.19	.024	217	111	.55	49	.01	8	.80	.08	.28	1
MD93082703	1	2	20	29	<.1	23	5	88	2.19	<2	<5	<2	330	44	<.2	<2	4	15	.68	.147	259	68	.99	47	.04	11	1.44	.07	.31	<1
MD93082704	10	5	103	175	.2	9	13	78	5.04	<2	300	<2	1153	29	.2	<2	11	66	.13	.107	1040	52	1.82	235	.33	12	3.02	.12	2.37	<1
MD93082705	1	5	9	13	.2	3	2	72	.98	<2	<5	<2	51	6	<.2	3	<2	2	.03	.011	78	132	.40	27	.01	11	.84	.05	.34	1
MD93082707	3	8	5	17	.1	4	2	77	.52	2	<5	<2	8	2	<.2	<2	<2	4	.02	.004	11	163	.21	8	.01	2	.30	.03	.05	1
MD93082803A	1	2	11	25	.1	3	1	81	.85	<2	10	<2	37	5	<.2	<2	<2	3	.07	.020	40	94	.13	25	.04	3	.53	.09	.42	1
MD93082803B	3	2	2	17	.2	2	1	78	.62	<2	6	<2	16	3	<.2	<2	<2	3	.04	.009	11	194	.14	17	.01	3	.37	.07	.17	1
MD93082804	1	3	6	19	.2	4	2	94	.79	<2	<5	<2	34	6	<.2	2	<2	4	.07	.013	34	117	.55	60	.01	13	1.09	.01	.43	1
MD93082901A	1	5	5	69	.4	9	12	764	3.69	<2	<5	<2	6	27	.3	2	<2	68	.56	.057	14	65	1.58	214	.18	16	2.35	.13	.86	1
MD93082901B	<1	2	3	16	.1	5	2	121	.80	<2	<5	<2	5	9	<.2	<2	<2	5	.05	.007	13	104	.54	54	.01	6	.80	.12	.24	1
MD93082903A	3	3	12	28	<.1	5	2	97	1.34	<2	<5	<2	82	8	<.2	<2	<2	5	.13	.019	86	117	.33	35	.02	4	.72	.10	.30	<1
MD93082903B	1	3	4	144	.3	19	21	626	4.26	<2	<5	<2	23	113	<.2	<2	<2	52	1.36	.234	33	113	3.28	29	.11	11	3.19	.04	.06	1
MD93083002A	2	23	9	49	.3	5	6	168	1.88	<2	<5	<2	17	20	.2	<2	<2	38	.24	.033	30	108	.58	171	.19	2	1.16	.22	.76	1
MD93083002B	3	2	13	21	<.1	3	2	184	.60	<2	350	<2	15	13	<.2	<2	<2	3	.13	.011	15	199	.14	104	.01	2	.50	.13	.28	<1
MD93083003A	1	32	16	49	.6	4	5	464	2.21	<2	<5	<2	10	16	<.2	<2	<2	25	.26	.037	29	73	.61	168	.13	4	1.33	.15	.90	1
MD93083003B	2	10	13	54	.4	4	4	234	1.94	<2	<5	<2	35	12	.2	2	2	35	.19	.038	63	112	.57	94	.12	2	1.21	.17	.84	1
MD93090101	4	3	3	38	.2	11	5	246	1.62	<2	<5	<2	6	7	<.2	<2	<2	20	.20	.053	19	197	1.10	36	.01	6	.97	.10	.17	1
MD93090102	<1	2	4	12	.1	2	1	106	.41	<2	<5	<2	8	4	<.2	<2	<2	<2	.02	.006	8	112	.20	16	<.01	3	.38	.09	.17	1
MD93090103	2	6	6	26	.2	3	4	171	1.57	<2	6	<2	6	21	<.2	3	<2	21	.18	.023	12	126	.54	50	.03	5	.58	.14	.10	1
MD93090104	1	21	<2	25	.1	7	9	218	3.24	<2	<5	<2	2	49	<.2	<2	<2	86	.54	.056	8	94	.61	161	.09	6	.92	.27	.33	<1
MD93090105A	2	7	7	17	.2	3	5	153	1.78	<2	<5	<2	25	9	<.2	2	<2	25	.11	.036	39	85	.58	98	.04	12	.96	.07	.48	<1
MD93090105B	<1	6	9	2	<.1	2	1	70	.31	<2	<5	<2	<2	4	<.2	2	<2	<2	.04	.004	3	128	.05	19	<.01	4	.26	.08	.14	<1
RE MD93090105B	<1	6	7	1	.2	2	1	75	.31	<2	<5	<2	<2	4	<.2	<2	<2	<2	.03	.004	3	121	.05	19	<.01	5	.25	.10	.16	1
MD93090106A	2	3	7	27	.2	1	2	187	1.16	<2	<5	<2	10	8	<.2	<2	<2	10	.05	.011	21	99	.23	57	.04	3	.69	.13	.41	1
MD93090106B	<1	3	5	9	.3	2	1	76	.93	<2	5	<2	10	8	<.2	2	<2	14	.03	.006	12	126	.09	51	.03	3	.40	.11	.18	1
MD93090202	4	10	5	29	.1	4	4	229	1.74	<2	<5	<2	10	11	<.2	<2	<2	22	.13	.024	21	96	.72	101	.06	3	1.04	.12	.50	1
MD93090203A	1	4	2	4	.2	2	1	77	.39	<2	<5	<2	12	3	<.2	<2	<2	<2	.04	.008	20	194	.22	20	<.01	6	.50	.05	.23	1
MD93090203B	2	2	3	3	.2	1	1	65	.20	2	8	<2	2	1	<.2	<2	<2	<2	.03	.009	<2	117	.05	8	<.01	3	.34	.07	.22	1
MD93090203C	12	6	7	31	.2	4	6	220	2.05	<2	<5	<2	14	10	<.2	<2	<2	33	.06	.011	29	88	.90	97	.06	4	1.11	.13	.66	1
MD93090206	1	10	4	57	.2	13	7	284	2.49	<2	<5	<2	9	20	<.2	<2	<2	50	.29	.039	26	128	.80	301	.15	2	1.15	.14	.74	<1
MD93090301	2	3	8	25	.2	10	6	145	1.39	<2	<5	<2	27	14	<.2	<2	<2	29	.20	.045	30	95	.54	51	.03	8	.78	.09	.32	1
MD93090303A	2	97	3	29	.2	34	10	282	3.43	<2	<5	<2	<2	21	<.2	<2	<2	163	.67	.020	2	220	.60	62	.18	4	1.13	.27	.23	1
STANDARD C	19	62	37	127	6.8	69	32	1019	4.01	41	14	7	34	52	19.2	14	21	58	.50	.087	39	59	.94	183	.09	34	1.88	.08	.16	11

ICP - .500 GRAM SAMPLE IS DIGESTED WITH 3ML 3-1-2 HCL-HNO3-H2O AT 95 DEG. C FOR ONE HOUR AND IS DILUTED TO 10 ML WITH WATER.
THIS LEACH IS PARTIAL FOR MN FE SR CA P LA CR MG BA TI B W AND LIMITED FOR NA K AND AL.
- SAMPLE TYPE: PULP   Samples beginning 'RE' are duplicate samples.

Loring Laboratories Ltd. PROJECT 36190 FILE # 93-3328

SAMPLE#	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppm	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %	W ppm
MD93090303B	2	103	<2	87	.2	89	15	332	2.31	10	<5	<2	<2	18	.3	<2	<2	58	1.01	.018	2	196	.72	56	.13	4	1.30	.18	.22	<1
MD93090304	1	6	2	34	.3	3	3	211	1.41	<2	<5	<2	10	8	<.2	<2	<2	21	.04	.008	13	82	.45	59	.05	4	.87	.06	.36	<1
MD93090305	3	7	3	29	.2	3	4	205	1.42	4	<5	<2	13	10	<.2	<2	<2	16	.07	.011	23	103	.35	58	.03	4	.76	.08	.34	<1
MD93090306A	2	31	2	34	.3	49	22	275	3.05	<2	<5	<2	<2	110	.2	<2	<2	60	2.25	.042	4	95	1.24	95	.19	6	3.56	.46	.35	<1
MD93090306B	8	191	10	78	.3	58	31	151	4.14	<2	<5	<2	31	21	<.2	<2	3	68	.19	.007	31	172	1.70	154	.27	6	2.26	.11	1.54	<1
MD93090307	1	121	2	32	.3	24	7	192	2.33	<2	<5	<2	12	49	.2	<2	<2	18	1.44	.027	51	90	.72	39	.03	10	2.42	.26	.16	<1
MD93090501	<1	7	<2	6	.1	6	5	3904	24.85	<2	<5	<2	2	70	<.2	<2	<2	14	1.49	.062	9	42	1.31	233	.01	8	.36	.04	.08	1
MD93090503A	<1	4	<2	21	.4	13	11	2079	35.41	<2	<5	<2	2	50	<.2	<2	<2	3	2.72	.094	<2	7	.55	60	<.01	<2	.25	.03	.10	<1
MD93090503B	<1	3	<2	5	.3	16	4	176	4.54	6	<5	<2	<2	233	<.2	<2	<2	2	30.56	.010	<2	8	.66	11	<.01	12	.18	.01	.08	1
MD93090503C	2	4	4	77	<.1	6	5	325	18.11	7	<5	<2	3	19	<.2	2	2	42	.32	.041	5	97	.07	19	.02	8	.31	<.01	.02	<1
MD93090601A	2	108	19	18	.3	3	5	120	1.84	3	8	<2	38	12	<.2	2	2	3	.28	.005	51	122	.14	69	.01	5	.47	.04	.14	<1
MD93090601B	2	41	14	36	.3	3	4	240	2.15	<2	7	<2	68	12	<.2	<2	2	19	.20	.014	72	123	.26	46	.05	8	.81	.06	.11	<1
MD93090603	3	3	23	35	.1	2	4	307	1.72	<2	16	<2	238	10	<.2	<2	3	12	.22	.042	233	79	.49	39	.05	<2	1.04	.03	.21	<1
MD93090605	3	24	17	20	.2	3	2	162	1.27	2	6	<2	21	14	<.2	<2	<2	10	.13	.044	31	128	.16	57	.02	5	.64	.06	.15	<1
MD93090701	4	6	<2	2	.1	6	1	56	.30	3	<5	<2	<2	1	<.2	<2	<2	3	.02	.001	<2	256	<.01	4	.01	2	.02	.01	<.01	<1
MD93090703A	1	4	3	2	.1	5	1	58	.36	2	<5	<2	<2	1	<.2	<2	<2	4	<.01	.001	<2	253	<.01	4	.01	2	.01	<.01	<.01	<1
MD93090703B	4	4	2	3	<.1	4	1	57	4.04	6	<5	<2	<2	3	<.2	<2	2	11	.02	.018	2	179	.01	8	.01	<2	.11	<.01	.01	<1
MD93090705	1	3	<2	1	.2	5	1	41	.27	<2	<5	<2	<2	<1	<.2	<2	<2	3	<.01	.001	<2	224	<.01	5	.01	3	.01	<.01	<.01	<1
RE MD93090705	1	3	<2	1	.2	4	1	38	.26	3	<5	<2	<2	3	<.2	<2	<2	3	.03	.001	<2	238	<.01	6	.01	3	.01	<.01	<.01	<1
MD93090706A	<1	5	<2	8	.2	6	3	179	.85	2	<5	<2	<2	312	<.2	<2	<2	2	32.27	.010	2	9	.93	15	<.01	11	.29	.01	.13	1
MD93090706B	<1	5	<2	7	.2	7	2	213	.60	2	<5	<2	<2	265	<.2	2	<2	3	33.71	.010	2	13	.32	14	<.01	13	.30	.01	.12	1
MD93090707	3	3	<2	49	.2	8	7	1199	16.46	5	<5	<2	<2	63	<.2	<2	<2	6	1.72	.009	5	73	1.28	101	.01	6	.18	.01	.04	1
MD93090801	1	5	7	11	.2	6	2	103	.69	<2	<5	<2	2	5	<.2	<2	<2	6	.13	.003	2	248	.18	18	<.01	6	.27	.02	.05	<1
MD93090802	2	8	2	47	<.1	5	7	446	2.64	<2	<5	<2	10	16	<.2	<2	2	34	.19	.023	22	131	.91	164	.07	3	1.32	.06	.52	<1
MD93090803	<1	5	3	6	<.1	32	11	63	20.69	3	<5	<2	<2	5	<.2	<2	<2	3	.02	.004	2	93	.02	5	.01	<2	.13	<.01	.04	<1
MD93090901A	<1	3	5	10	.3	22	4	270	2.62	3	<5	<2	<2	187	<.2	<2	<2	<2	30.27	.004	2	5	.31	8	<.01	7	.12	.02	.05	<1
MD93090901B	<1	9	6	31	.1	13	12	375	1.08	11	<5	<2	<2	184	<.2	<2	<2	2	31.24	.012	3	10	.33	11	<.01	8	.21	.02	.09	1
MD93091001A	<1	2	2	2	.1	2	1	135	.52	3	<5	<2	<2	245	<.2	<2	<2	<2	37.24	.004	<2	2	.40	8	<.01	3	.07	.01	.03	<1
MD93091001B	1	7	54	14	.5	9	3	221	2.91	16	<5	<2	<2	472	<.2	2	<2	9	16.98	.019	3	85	.47	19	<.01	39	.30	1.54	.11	1
MD93091001C	<1	2	8	3	.2	2	1	25	.15	6	7	<2	<2	1002	<.2	2	<2	<2	22.78	.003	<2	27	.10	8	<.01	11	.04	.85	.02	<1
MD93091101A	<1	4	5	5	.1	6	3	217	1.01	6	<5	<2	2	245	<.2	2	<2	3	35.28	.011	2	7	.43	12	<.01	6	.24	.03	.10	<1
MD93091101B	<1	3	<2	3	.1	3	1	178	.54	7	<5	<2	<2	207	<.2	<2	<2	2	39.06	.008	2	3	.27	11	<.01	3	.11	.01	.04	<1
MD93091101C	<1	2	3	3	.1	4	2	168	.52	6	<5	<2	<2	208	<.2	<2	<2	2	38.78	.009	2	4	.31	11	<.01	4	.15	.01	.06	<1
MD93091101D	<1	3	<2	2	.2	3	1	173	.76	5	<5	<2	<2	219	<.2	<2	<2	<2	40.14	.004	<2	3	.27	9	<.01	3	.08	.01	.03	<1
MD93091101E	<1	3	5	6	.2	4	2	119	.37	<2	<5	<2	<2	272	<.2	<2	<2	2	34.81	.008	2	6	.39	12	<.01	10	.22	.01	.10	<1
STANDARD C	17	61	38	122	7.0	66	31	1079	4.03	43	14	7	36	52	18.7	14	19	56	.50	.086	38	62	.91	186	.08	33	1.92	.06	.14	10

Sample type: PULP. Samples beginning 'RE' are duplicate samples.

SAMPLE#	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppm	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %	W ppm
MD93091101F	<1	10	3	16	.2	9	4	1181	6.07	7	<5	<2	2	242	<.2	<2	<2	4	21.85	.107	2	10	.38	41	<.01	10	.39	.01	.13	1
MD93091102A	3	9	118	15	.1	5	2	377	1.17	9	<5	<2	<2	172	<.2	20	<2	2	25.68	.014	2	6	.27	23	<.01	3	.20	.01	.06	<1
MD93091102B	<1	5	2	14	<.1	5	3	378	1.78	<2	<5	<2	<2	180	<.2	<2	2	2	26.60	.025	2	6	.42	24	<.01	5	.24	.01	.07	1
RE MD93091102B	<1	4	4	14	<.1	5	3	360	1.67	5	<5	<2	2	176	<.2	<2	<2	2	26.29	.025	2	5	.42	23	<.01	4	.23	.01	.07	<1
STANDARD C	18	63	42	122	7.0	66	31	1070	4.05	41	14	6	36	52	18.1	14	20	56	.51	.086	38	61	.93	183	.08	33	1.92	.08	.16	11

Sample type: PULP. Samples beginning 'RE' are duplicate samples.

To :	ALBERTA RESEARCH COUNCIL,		File No	: 36416.00
	P.O. Box 8330,		Date	: April 6, 1994
	Postal Station "F",		Samples	: Core
	Edmonton, Alberta T6H 5X2		P.O. #	: ED 94062364

Certificate of Assay

Loring Laboratories Ltd.

Sample No.	ppb GOLD	Total Rec'd Wt grams	Total Wt After LOI @ 800 C /16 Hours grams
SL 27C-1	24		
SL 27C-2	14		
SL 27C2-1	13		
SL 27C2-2	<5		
SL 27C2-3	11		
SL 27C2-4	1040 *	130.58	105.03
SL 27C2-5	647 *	49.96	44.23
SL 27C2-6	<5		
SL 27C2-7	16		
E+86-1	455 *	42.13	36.10
E+86-2	717 *	96.22	77.47
E+86-3	107 *	71.62	57.56
E+86-4	17		
E+86-5	5		
E+86-6	17		
E+86-7	277 *	122.95	105.85
SL 27C1-1	677 *	113.00	101.86
SL 27C1-2	168 *	168.67	161.44

I Hereby Certify *that the above results are those assays made by me upon the herein described samples ....*

Rejects retained one month.
Pulps retained one month
unless specific arrangements
are made in advance.

Assayer

To : ALBERTA RESEARCH COUNCIL,
P.O. Box 8330,
Postal Station "F",
Edmonton, Alberta T6H 5X2

File No : 36416.00
Date : April 6, 1994
Samples : Core
P.O. # : ED 94062364

Certificate of Assay

Loring Laboratories Ltd.

Sample No.	ppb GOLD	Total Rec'd Wt grams	Total Wt After LOI @ 800 C /16 Hours grams
SL 27C1-3	<5		
B+148C-1	109 *	81.94	69.87
B+148C-2	69 *	73.22	58.50
B+148C-3	218 *	57.44	21.06
B+148C-4	297 *	101.60	95.21

* Asterisk indicates these particular samples were burned off due to Bitumen content.

I Hereby Certify that the above results are those assays made by me upon the herein described samples ....

Rejects retained one month.
Pulps retained one month
unless specific arrangements
are made in advance.

Assayer

GEOCHEMICAL ANALYSIS CERTIFICATE

Loring Laboratories Ltd. File # 94-0812

629 Beaverdam Road N.E., Calgary AB T2K 4W7

SAMPLE#	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppm	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %	W ppm
SL27C-1	2	11	61	41	<.1	25	12	171	3.19	<2	<5	<2	6	33	<.2	2	<2	16	.17	.010	13	104	.13	34	.01	14	.74	.01	.18	1
SL27C-2	1	2	97	6	.1	3	1	53	.23	<2	<5	<2	<2	417	<.2	4	<2	3	1.90	.004	<2	17	.40	95	.01	102	.25	.02	.01	<1
SL27C2-1	1	2	70	5	.1	<1	<1	41	4.91	<2	<5	<2	<2	259	<.2	<2	<2	2	1.26	<.001	<2	20	.25	7	.02	110	.19	.02	<.01	<1
SL27C2-2	1	5	85	4	.2	2	1	45	.52	2	<5	<2	<2	354	<.2	4	<2	4	1.77	.001	4	32	.35	49	.03	141	.23	.02	.01	<1
SL27C2-3	5	9	53	4	.3	5	1	50	3.60	5	<5	<2	3	46	<.2	4	5	11	.20	.002	5	279	.07	30	.01	15	.65	.01	.08	<1
SL27C2-4	1	34	9	15	.9	5	<1	346	25.70	<2	<5	<2	2	13	<.2	<2	<2	8	.05	.002	5	124	.02	38	.02	<2	.23	<.01	.03	<1
SL27C2-5	3	7	57	211	.3	54	35	55	2.53	8	<5	<2	2	18	.3	2	<2	24	.08	.003	12	398	.02	28	.02	10	1.09	.01	.04	<1
SL27C2-6	1	21	19	150	.1	37	15	20	2.10	5	<5	<2	8	41	<.2	2	3	10	.13	.004	19	28	.16	25	<.01	21	.94	.01	.36	<1
SL27C2-7	2	12	24	43	.3	47	9	77	14.36	14	<5	<2	3	76	<.2	<2	<2	6	7.35	.015	12	63	.15	15	<.01	2	.35	.01	.13	<1
E+8C-1	2	16	20	22	.3	22	6	206	3.59	3	<5	<2	5	29	<.2	2	4	33	.07	.009	22	223	.09	94	.03	16	1.85	.03	.39	<1
E+8C-2	3	5	4	13	.5	23	6	1020	8.57	4	<5	<2	3	10	<.2	<2	6	28	.19	.003	9	219	.01	29	.01	<2	.31	.01	.06	<1
E+8C-3	2	8	<2	8	.4	16	1	422	13.38	<2	<5	<2	6	8	<.2	<2	<2	21	.01	.004	14	398	.01	30	.02	<2	.28	.01	.06	<1
E+8C-4	1	7	4	3	.1	4	<1	62	5.20	14	<5	<2	2	193	<.2	<2	5	4	.98	.001	2	14	.13	12	.04	147	.32	.02	<.01	<1
E+8C-5	1	1	20	2	<.1	3	1	70	.07	<2	<5	<2	4	372	<.2	3	<2	5	1.84	.001	5	25	.33	92	.02	122	.19	.04	.01	1
E+8C-6	3	46	17	4	1.1	3	<1	55	10.08	7	<5	<2	3	130	<.2	3	6	11	.61	.002	<2	33	.11	7	.05	96	.48	.02	.02	<1
E+8C-7	1	3	9	1	.3	8	1	33	.75	2	<5	<2	2	34	<.2	3	<2	13	.14	.002	7	172	.02	27	.02	13	.18	.01	.02	<1
SL27C1-1	2	5	20	2	.3	10	1	44	.75	<2	<5	<2	2	21	<.2	<2	<2	20	.11	.004	9	256	.03	37	.01	10	.55	.01	.08	<1
RE SL27C1-1	2	5	22	1	.3	9	1	41	.76	<2	<5	<2	<2	22	<.2	<2	2	21	.12	.004	10	259	.03	39	.02	11	.56	.01	.09	<1
SL27C1-2	1	5	12	99	.1	12	5	46	.49	<2	<5	<2	2	10	<.2	<2	<2	10	.03	.003	6	184	.01	19	.01	4	.98	.01	.03	1
SL27C1-3	1	18	11	38	.2	58	10	146	20.14	<2	<5	<2	4	21	<.2	<2	<2	10	.11	.021	6	104	.19	3	<.01	9	.78	.01	.28	<1
B+148C-1	3	6	9	8	<.1	19	3	81	1.43	<2	<5	<2	7	12	<.2	3	<2	28	.03	.006	22	396	.02	51	.02	8	.90	.01	.15	<1
B+148C-2	1	10	5	12	.1	19	<1	75	26.64	<2	<5	<2	3	8	<.2	<2	<2	13	.01	.002	7	302	.01	42	.02	<2	.64	.01	.10	<1
B+148C-3	6	61	45	9	.4	23	2	106	2.80	<2	<5	<2	10	951	<.2	<2	4	39	3.53	.006	24	553	.75	14	.19	257	4.25	.02	.02	<1
B+148C-4	1	5	6	5	.1	7	1	32	.38	<2	<5	<2	2	33	<.2	<2	<2	24	.08	.003	14	165	.06	54	.01	17	1.42	.01	.21	<1
STANDARD C	19	61	37	132	7.2	72	31	1072	3.96	44	18	8	38	54	18.8	15	21	55	.51	.095	36	59	.91	190	.08	34	1.88	.07	.13	13

ICP - .500 GRAM SAMPLE IS DIGESTED WITH 3ML 3-1-2 HCL-HNO3-H2O AT 95 DEG. C FOR ONE HOUR AND IS DILUTED TO 10 ML WITH WATER.
THIS LEACH IS PARTIAL FOR MN FE SR CA P LA CR MG BA TI B W AND LIMITED FOR NA K AND AL.
- SAMPLE TYPE: PULP   Samples beginning 'RE' are duplicate samples.

APPENDIX 4

MICROPROBE ANALYSES AND MIN-ID.ASC RESULTS FOR SURFICIAL SAMPLES

RESULTS OF MICROPROBE ANALYSES AND MIN-ID.ASC FOR BITUMOUNT SURFICIAL SAMPLES

Sample	Grain	Year	Probe	TiO2	Cr2O3	FeO	MgO	CaO	SiO2	Al2O3	Na2O	MnO	K2O	Total	Classes			Mineral
NAT92-24	1	1994	U of S	0.00	0.08	31.66	7.99	0.95	37.78	21.31	0.02	0.50	0.00	100.29	5	0	5	ALMANDINE
NAT92-24	2	1994	U of S	0.00	0.16	34.87	3.42	3.13	37.24	20.48	0.00	0.46	0.00	99.76	5	0	5	ALMANDINE
NAT92-24	3	1994	U of S	0.00	0.09	30.97	7.63	1.04	38.04	21.64	0.00	1.47	0.00	100.88	5	0	5	ALMANDINE
NAT92-24	4	1994	U of S	0.00	0.04	37.93	2.70	2.03	36.90	20.85	0.01	0.25	0.00	100.71	5	0	5	ALMANDINE
NAT92-24	5	1994	U of S	0.07	0.03	35.10	4.86	0.85	38.11	20.90	0.00	0.75	0.00	100.64	5	0	5	ALMANDINE
NAT92-24	6	1994	U of S	0.00	0.00	37.86	2.85	1.42	37.61	20.53	0.02	0.88	0.00	101.17	5	0	5	ALMANDINE
NAT92-24	7	1994	U of S	0.04	0.00	35.16	4.36	1.73	37.71	21.17	0.00	0.61	0.00	100.78	5	0	5	ALMANDINE
NAT92-24	8	1994	U of S	0.08	0.00	36.16	2.97	1.24	37.39	20.42	0.00	1.97	0.00	100.24	5	0	5	ALMANDINE
NAT92-24	9	1994	U of S	0.00	0.00	36.10	4.24	0.33	37.81	21.21	0.00	2.13	0.00	101.82	5	0	5	ALMANDINE
NAT92-24	10	1993	Canmet	0.12	0.00	89.03	0.00	0.00	0.03	0.16	0.00	0.03	NA	89.37	0	0	0	Fe_OXIDE
NAT92-24	11	1993	Canmet	63.85	0.01	27.28	0.05	0.12	0.18	0.28	0.00	0.78	NA	92.54	1	0	0	ILMENITE
NAT92-24	12	1993	Canmet	57.74	0.01	33.34	0.18	0.04	0.22	0.28	0.00	0.81	NA	92.63	1	0	0	ILMENITE
NAT92-24	13	1993	Canmet	59.59	0.01	31.51	0.39	0.08	0.22	0.21	0.00	0.39	NA	92.41	1	0	0	ILMENITE
NAT92-24	14	1993	Canmet	64.10	0.32	26.66	1.26	0.09	0.19	0.73	0.00	0.42	NA	93.76	1	0	0	ILMENITE
NAT92-24	15	1993	Canmet	65.34	0.35	21.84	2.73	0.12	0.29	0.30	0.00	0.40	NA	91.36	0	0	0	UNKNOWN
NAT92-24	16	1993	Canmet	64.00	0.35	23.52	1.08	0.20	0.88	0.98	0.00	0.20	NA	91.21	0	0	0	UNKNOWN
NAT92-24	17	1993	Canmet	66.14	0.02	22.69	0.04	0.15	0.59	0.36	0.00	1.65	NA	91.65	0	0	0	UNKNOWN
NAT92-25	18	1994	U of S	0.00	0.09	35.79	3.41	2.95	37.15	20.72	0.02	0.21	0.00	100.33	5	0	5	ALMANDINE
NAT92-25	19	1994	U of S	0.08	0.06	36.65	3.79	0.97	37.48	20.99	0.00	0.70	0.00	100.71	5	0	5	ALMANDINE
NAT92-25	20	1994	U of S	0.00	0.14	33.14	0.49	0.48	36.36	20.70	0.04	8.91	0.00	100.27	5	0	5	ALMANDINE
NAT92-25	21	1994	U of S	0.02	0.11	31.84	5.51	2.94	37.67	20.85	0.00	0.30	0.00	99.23	5	0	5	ALMANDINE
NAT92-25	22	1994	U of S	0.01	0.10	31.29	2.90	6.95	37.76	20.83	0.01	0.86	0.00	100.71	5	0	5	ALMANDINE
NAT92-25	23	1994	U of S	0.00	0.08	36.32	4.48	1.00	37.44	21.02	0.00	0.22	0.00	100.55	5	0	5	ALMANDINE
NAT92-25	24	1994	U of S	0.00	0.05	35.79	3.30	2.56	37.53	20.24	0.01	0.48	0.00	99.97	5	0	5	ALMANDINE
NAT92-25	25	1994	U of S	0.10	0.00	31.21	1.36	8.93	37.18	20.69	0.05	0.90	0.00	100.41	5	0	5	ALMANDINE
NAT92-25	26	1994	U of S	0.07	0.00	32.18	7.77	1.04	38.67	21.84	0.01	0.76	0.00	102.35	5	0	5	ALMANDINE
NAT92-25	27	1994	U of S	0.02	0.00	31.44	7.34	1.36	38.81	21.90	0.03	0.48	0.00	101.38	5	0	5	ALMANDINE
NAT92-25	28	1994	U of S	0.02	0.16	5.85	15.53	22.75	53.69	0.80	0.75	0.23	0.00	99.77	2	4	0	CPX_02_UNKNOWN
NAT92-25	29	1993	Canmet	0.20	0.19	89.00	0.00	0.00	0.18	0.08	0.00	0.24	NA	89.88	0	0	0	Fe_OXIDE
NAT92-25	30	1994	U of S	0.05	0.13	28.43	5.19	6.79	38.35	20.66	0.01	0.59	0.00	100.18	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT92-25	31	1994	U of S	0.05	0.04	25.16	9.62	2.61	38.70	21.74	0.00	0.61	0.00	98.53	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT92-25	32	1994	U of S	0.05	0.02	30.18	8.32	1.76	38.57	22.16	0.01	0.41	0.00	101.48	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT92-25	33	1994	U of S	0.08	0.01	28.54	9.18	1.17	38.79	22.53	0.00	0.33	0.00	100.62	5	0	5	G_05_MAGNESIAN_ALMANDINE
NAT92-25	34	1993	Canmet	62.53	0.26	29.62	0.11	0.18	0.21	0.42	0.00	0.27	NA	93.59	1	0	0	ILMENITE
NAT92-25	35	1993	Canmet	60.52	0.41	27.38	1.82	0.12	0.37	0.25	0.00	0.27	NA	91.14	1	0	0	ILMENITE
NAT92-25	36	1993	Canmet	62.03	0.12	31.06	0.07	0.11	0.19	0.31	0.00	0.64	NA	94.51	1	0	0	ILMENITE
NAT92-25	37	1993	Canmet	59.68	0.07	33.42	0.04	0.02	0.17	0.17	0.00	0.36	NA	93.92	1	0	0	ILMENITE
NAT92-25	38	1993	Canmet	58.39	0.00	30.76	0.07	0.07	0.82	0.54	0.00	1.45	NA	92.11	1	0	0	ILMENITE
NAT92-25	39	1993	Canmet	59.05	0.02	32.12	0.07	0.07	0.13	0.21	0.00	0.89	NA	92.55	1	0	0	ILMENITE

Sample	Grain	Year	Probe	TiO2	Cr2O3	FeO	MgO	CaO	SiO2	Al2O3	Na2O	MnO	K2O	Total	Classes			Mineral
NAT92-25	40	1993	Canmet	59.59	0.02	31.52	0.13	0.06	0.11	0.26	0.00	0.93	NA	92.62	1	0	0	ILMENITE
NAT92-25	41	1993	Canmet	64.24	0.31	26.21	1.21	0.17	0.28	0.41	0.00	0.54	NA	93.37	1	0	0	ILMENITE
NAT92-25	42	1993	Canmet	56.40	0.00	37.14	0.03	0.02	0.12	0.00	0.00	1.43	NA	95.14	1	0	0	ILMENITE
NAT92-25	43	1993	Canmet	58.37	0.11	32.94	0.95	0.06	0.14	0.24	0.00	0.56	NA	93.36	1	0	0	ILMENITE
NAT92-25	44	1993	Canmet	58.53	0.00	31.06	0.00	0.07	0.08	0.09	0.00	1.55	NA	91.42	1	0	0	ILMENITE
NAT92-25	45	1993	Canmet	65.88	0.08	23.42	1.23	0.26	0.74	0.82	0.00	0.56	NA	92.99	0	0	0	UNKNOWN
NAT92-25	46	1993	Canmet	62.95	0.14	23.60	1.92	0.20	0.44	0.33	0.00	0.38	NA	89.96	0	0	0	UNKNOWN
NAT92-25	47	1993	Canmet	63.08	0.02	23.50	0.18	0.19	0.34	0.32	0.00	2.98	NA	90.59	0	0	0	UNKNOWN
NAT92-25	48	1993	Canmet	60.92	0.01	25.42	0.23	0.21	0.61	0.21	0.00	2.15	NA	89.76	0	0	0	UNKNOWN
NAT93-80	49	1994	U of S	0.12	0.00	22.28	3.26	13.46	38.74	21.12	0.01	0.74	0.00	99.72	3	6	3	G_03_CALCIC_PYROPE_ALMANDINE
NAT93-80	50	1994	U of S	0.02	0.04	4.90	24.15	0.02	0.00	67.17	0.02	0.11	0.00	96.44	0	0	0	SPINEL
NAT93-82	51	1994	U of S	0.05	0.65	4.11	15.87	22.90	53.58	1.55	0.59	0.10	0.00	99.39	2	5	0	CPX_02_UNKNOWN
NAT93-82	52	1994	U of S	0.01	0.17	4.53	15.83	23.00	53.91	0.76	0.84	0.28	0.00	99.34	2	5	0	CPX_02_UNKNOWN
NAT93-82	53	1994	U of S	0.10	0.58	3.93	16.48	22.66	53.75	1.65	0.60	0.13	0.00	99.88	2	5	0	CPX_02_UNKNOWN
NAT93-83	54	1994	U of S	0.11	0.77	8.17	15.71	18.01	52.39	2.65	0.77	0.04	0.00	98.63	4	2	0	CPX_04_UNKNOWN
NAT93-83	55	1994	U of S	0.13	0.22	20.32	12.50	4.43	39.71	21.62	0.05	0.70	0.00	99.69	3	5	3	G_03_CALCIC_PYROPE_ALMANDINE
NAT93-85	56	1994	U of S	0.04	0.02	5.12	15.92	23.29	53.48	1.17	0.46	0.27	0.00	99.77	2	5	0	CPX_02_UNKNOWN
NAT93-85	57	1994	U of S	0.04	0.00	15.51	12.83	0.42	40.39	21.43	0.00	8.96	0.00	99.58	3	9	3	G_03_CALCIC_PYROPE_ALMANDINE
NAT93-85	58	1994	U of S	0.19	0.00	21.91	5.51	12.01	38.48	21.00	0.01	0.69	0.00	99.80	3	5	3	G_03_CALCIC_PYROPE_ALMANDINE
NAT93-85	59	1994	U of S	0.06	0.00	25.30	8.35	5.70	39.78	21.19	0.01	0.49	0.00	100.88	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-85	60	1994	U of S	0.00	0.11	29.75	7.98	1.19	39.16	21.08	0.00	0.70	0.00	99.98	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	61	1994	U of S	0.02	0.00	36.90	3.48	1.79	38.25	20.47	0.00	0.71	0.00	101.62	5	0	5	ALMANDINE
NAT93-87	62	1994	U of S	0.04	0.47	6.84	16.00	21.49	53.53	1.36	0.52	0.27	0.00	100.52	2	4	0	CPX_02_UNKNOWN
NAT93-87	63	1994	U of S	0.09	0.00	28.10	5.66	6.15	37.89	21.19	0.01	0.67	0.00	99.76	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	64	1994	U of S	0.08	0.00	25.88	11.39	1.04	40.52	21.86	0.03	0.46	0.00	101.26	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	65	1994	U of S	0.04	0.00	25.56	11.02	1.44	40.17	21.66	0.00	0.86	0.00	100.75	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	66	1994	U of S	0.01	0.04	25.11	11.45	1.30	39.99	21.70	0.00	0.48	0.00	100.09	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	67	1994	U of S	0.07	0.00	24.88	11.96	1.32	40.15	21.55	0.01	0.52	0.00	100.47	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	68	1994	U of S	0.01	0.00	24.11	12.10	1.15	40.07	21.79	0.00	0.87	0.00	100.10	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	69	1994	U of S	0.06	0.00	23.49	6.73	8.37	39.52	21.17	0.03	0.67	0.00	100.03	5	3	3	G_05_MAGNESIAN_ALMANDINE
NAT93-87	70	1994	U of S	0.13	0.00	29.00	7.72	2.81	39.66	21.19	0.00	0.51	0.00	101.01	5	0	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	71	1994	U of S	0.08	0.00	26.75	9.69	1.90	39.83	21.39	0.02	1.06	0.00	100.72	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	72	1994	U of S	0.16	0.00	25.49	11.15	1.38	39.58	21.74	0.06	0.94	0.00	100.50	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-87	73	1994	U of S	0.07	0.00	25.10	11.63	0.68	40.73	21.51	0.01	1.42	0.00	101.14	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-89	74	1994	U of S	0.05	0.01	33.78	6.06	1.01	37.65	21.46	0.01	0.48	0.00	100.49	5	0	5	ALMANDINE
NAT93-89	75	1994	U of S	0.05	0.00	36.15	1.74	1.30	36.25	21.03	0.03	3.90	0.00	100.44	5	0	5	ALMANDINE
NAT93-89	76	1994	U of S	0.03	0.00	30.81	1.78	7.87	37.34	20.40	0.01	1.90	0.00	100.14	5	0	5	ALMANDINE
NAT93-89	77	1994	U of S	0.08	0.05	36.05	1.23	5.67	37.34	20.68	0.03	0.43	0.00	101.57	5	0	5	ALMANDINE
NAT93-89	78	1994	U of S	0.10	0.01	33.19	2.03	6.96	37.82	20.77	0.00	0.84	0.00	101.72	5	0	5	ALMANDINE
NAT93-89	79	1994	U of S	0.05	0.04	32.37	1.82	7.00	36.51	20.29	0.01	2.23	0.00	100.32	5	0	5	ALMANDINE
NAT93-89	80	1994	U of S	0.15	0.00	33.00	2.48	6.68	37.55	20.48	0.00	0.94	0.00	101.26	5	0	5	ALMANDINE
NAT93-89	81	1994	U of S	0.12	0.01	31.84	2.73	6.99	37.58	21.05	0.02	0.64	0.00	100.98	5	0	5	ALMANDINE

Sample	Grain	Year	Probe	TiO2	Cr2O3	FeO	MgO	CaO	SiO2	Al2O3	Na2O	MnO	K2O	Total	Classes			Mineral
NAT93-89	82	1994	U of S	0.09	0.03	8.93	13.63	22.56	53.19	0.43	0.98	0.34	0.00	100.17	4	2	0	CPX_04_UNKNOWN
NAT93-89	83	1994	U of S	0.08	0.04	8.36	13.07	22.86	52.03	1.52	1.02	0.33	0.00	99.29	4	2	0	CPX_04_UNKNOWN
NAT93-89	84	1994	U of S	0.16	0.01	11.30	11.36	23.05	50.28	1.78	0.41	0.63	0.02	98.99	0	0	0	CPX_04_UNKNOWN
NAT93-89	85	1994	U of S	0.10	0.00	22.51	2.33	12.99	38.40	21.20	0.04	2.68	0.00	100.26	3	6	3	G_03_CALCIC_PYROPE_ALMANDINE
NAT93-89	86	1994	U of S	0.12	0.00	27.13	5.48	7.22	37.60	21.44	0.01	0.72	0.00	99.72	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-89	87	1994	U of S	0.11	0.00	23.90	6.50	8.65	39.01	21.88	0.03	0.72	0.00	100.80	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-89	88	1994	U of S	0.07	0.02	27.73	5.75	6.27	38.38	21.43	0.00	0.55	0.00	100.19	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-89	89	1994	U of S	0.08	0.05	28.60	7.28	3.73	38.61	21.48	0.03	0.45	0.00	100.30	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-89	90	1994	U of S	0.06	0.00	28.09	9.60	1.30	38.37	21.85	0.04	0.52	0.00	99.81	5	3	5	G_05_MAGNESIAN_ALMANDINE
NAT93-89	91	1994	U of S	97.78	0.11	0.54	0.00	0.04	0.00	0.02	0.02	0.05	0.00	98.56	0	0	0	RUTILE
NAT93-89	92	1994	U of S	0.96	0.00	11.41	2.60	0.01	26.41	56.93	0.05	0.08	0.00	98.45	0	0	0	STAUROLITE

APPENDIX 5

PETROGRAPHIC DESCRIPTIONS AND SUMMARY

SUMMARY OF OBSERVATIONS OF THIN SECTIONS FROM THE MARGUERITE RIVER AREA

Rock samples were taken from both Precambrian and Phanerozoic rocks in the Marguerite River area. Of these, 36 were cut into regular or polished thin section. The thin sections were observed under transmitted light, and reflected light in the case of the polished sections. A summary of the observations made on both the Precambrian and Phanerozoic samples is given below.

PRECAMBRIAN SAMPLES

Precambrian rocks in the Marguerite River area consist of abundant granitoids, with minor mafic units described as amphibolite (Godfrey 1970) or basaltic dykes (Tremblay 1960).

Granitoids:

Three different varieties of granitoid rocks were defined in this study:

1. Megacrystic alkali feldspar granites to syenites. These rocks tend to be meso- to melanocratic in nature with 15 to 30% mafics, including chlorite, biotite +/- hornblende. They are also characterized by relatively low quartz values (less than 20% and often less than 10%), and the presence of minor amounts of corundum, indicating an excess of aluminum in the magma which gave rise to this unit. Two samples which are part of this group (MD93082704A and 2704B) had high radiation counts in the field (up to 5,000 cps), but no uranium-bearing minerals were observed in the thin sections of these samples. Additional samples which were part of this group include MD93082703 and 2901A.

2. Granites to granite gneisses. These rocks are generally leuco- to mesocratic, and are more quartz- and plagioclase-rich than unit 1. Mafic minerals include biotite and chlorite. This unit is distinguished from the above unit by its overall composition (especially the presence of plagioclase). In addition, intergrown hematite and magnetite were noted in all of the samples belonging to this unit, which include 93MD090103, 0104A, 0104B, and 0306.

3. Alkali feldspar granites to alkali feldspar granite gneisses. This unit comprises a majority of the granitoid rock samples observed in this study. The unit is typically leucocratic to mesocratic, with biotite and chlorite being the main mafic minerals. This unit is differentiated from the megacrystic alkali feldspar granitoids by being less mafic-rich, less coarse-grained and slightly more quartz-rich overall. It is distinguished from the granites by composition, especially the lack of plagioclase. Some samples of this unit also contain garnet and white mica (pyrophyllite) which are generally lacking in the other two units. Samples which belong to this unit include MD93082901B, 3003B, 090105A, 0105B, 0601A, 0601B, 0603, and 0802.

Mafic meta-igneous unit:

A mafic unit was defined in the field as an approximately 3 m wide unit which could be traced from the limb to the nose of a fold defined primarily by foliation directions. This unit apparently acts as a marker horizon and also defines this fold.

Thin sections of the mafic unit from the limb of this fold contain abundant clinopyroxene (augite), quartz, and lesser hornblende, uralitic hornblende, biotite, chlorite and plagioclase. The augite is readily altering to hornblende +/- chlorite in one sample, and in the sample from the nose of the fold, no augite exists. The fold nose sample, although slightly different in character than the limb samples, is believed to be a fairly highly altered equivalent of the latter, with abundant epidote and uralitic hornblende. The samples belonging to this group tend to have relatively high sulphide contents compared to the remaining samples in the study, although it has not been determined whether these sulfide are primary or secondary in the mafic unit. Although foliation is only vague in the thin sections, it is observed in the field, and this unit has been given the name 'mafic meta-igneous augite-bearing schist', the protolith of which is undetermined, but which is likely a mafic volcanic or mafic dyke. Samples of this unit include MD93090303A, 0303B, and 0307.

A mafic dyke was also observed in the field and one sample from this unit was examined in thin section (MD93082903B). From thin section observations, this sample is consistent with an altered mafic dyke (dioritic? not diabasic).

In addition to the above classification of thin section samples, the following general observations were made:

** Potassium feldspar (mainly orthoclase, with lesser local microcline), which is abundant in all three granitoids, was commonly altered to sericite. Also, epidote, clinozoisite, and pyrophyllite exist locally in close relation to K-spar. This indicates that hydrothermal alteration was fairly prevalent throughout the area. This contention is also supported by the alteration of augite to uralitic hornblende that exists in the mafic meta-igneous unit, and possibly by the presence of garnet locally.

** The garnet observed is commonly altered to chlorite along grain boundaries and fractures, which suggests it is almandine in composition.

** Metamorphic grade, as determined by thin section mineralogy, is likely upper greenschist to lower amphibolite. This is supported by the presence of chlorite, epidote, almandine garnet, and biotite in the granitoids, and clinopyroxene, hornblende, and plagioclase in the mafic meta-igneous unit. It should be noted, however, that the absence of pelitic rocks in this suite precludes a more precise constraint on metamorphic grade, as alumino-silicate minerals are not present, and many of the above listed minerals are commonly rock-forming, and therefore not a clear indication of metamorphic grade. The mineralogy observed in this study, however, does allow for a general statement about metamorphic grade, given the stability ranges of the above minerals.

** Numerous samples of mylonitized granitoids were studied, including MD93080203A, 2903A, 3003A, and 090206. These samples show definite indications of grain size reduction, including an overall fine-grained texture with strong foliation, and sub-grain development in, and recrystallization of, quartz. In addition, augen of recrystallized quartz are common. Feldspar grains are not augen-shaped, although there is local indication of rotation, where foliation wraps around the feldspars. These mylonite zones likely acted as fluid conduits, because minor carbonate exists in most of the samples.

** Minor sulfides and oxides (trace to 3%) exist in most samples, and consist of pyrite, pyrrhotite, hematite, magnetite, and hematite/magnetite intergrowths. In two samples (93MD090307 - a sample of the mafic unit from the fold nose and 090601B), there is marcasite. There does not appear to be a clear association between degree of alteration, and sulfide content. However, the mafic meta-igneous unit, and the alkali feldspar granites to alkali feldspar gneisses surrounding this unit tend to be higher in sulfide content. That is, they contain 1-3% sulfide as opposed to trace amounts in the other granitoids, and mylonitic zones.

PHANEROZOIC SAMPLES

Thin sections were studied of samples from the McMurray, Beaver River, and Waterways Formations.

McMurray Fm: siltstone, found to consist of sub-angular quartz and plagioclase clasts set in a fine-grained matrix of quartz +/- carbonate. A sideritic vein from this formation was also observed. Includes samples MD93090501, 0503A-A, 0503A-B, 0707 and 0803.

Beaver River Fm: sandstone, found to consist of sub-angular to sub-rounded quartz grains set in a finer grained matrix of primarily quartz +/- carbonate. Includes samples MD93090701, 0703A, and 0703B.

Waterways Fm: limestone, found to consist of fossiliferous, moderately vuggy, locally brecciated limestone, locally iron stained. Includes samples MD93090706A, 1101D, 1101E, and 1101F.

SAMPLE NUMBER: MD93082703			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	20		Megacrystic granite to alkali-feldspar granite to syenite. Quartz has sutured boundaries and undulose extinction. Clinozoisite grains are euhedral to subhedral. Corundum grains are subhedral to anhedral. Biotite exists in fractures in both quartz and feldspars. K-spar grains have altered to sericite.
biotite	15		
microcline	5		
orthoclase	45		
plagioclase	5		
chlorite	2		
clinozoisite	1		
corundum	3		*tr = trace
hematite	tr*		

SAMPLE NUMBER: MD93082704A			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	20	^10mm	Megacrystic alkali-feldspar granite. Garnet is highly fractured and cemented by chlorite +/- biotite. Quartz grains have sutured boundaries and undulose extinction.
garnet	35		
biotite	5		
chlorite	10		
microcline	tr		
orthoclase	25		
hematite	tr		

SAMPLE NUMBER: MD93082704B			
MINERAL	%	GRAIN SIZE	COMMENTS
K-spar	55	1-4mm	Megacrystic alkali-feldspar syenite. Hematite is primarily found alongside biotite grains. Deformation features such as undulose extinction and crenulation in biotite is fairly common. K-spar is often perthitic.
biotite	30		
quartz	3		
chlorite	5		
clinozoisite	3	0.3mm	
corundum	3	0.5mm	
hematite	tr		

SAMPLE NUMBER: MD93082803A			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	60		Mylonite with probable alkali-feldspar granite protolith. Fine-grained with alternating bands (foliation) of quartz and very fine-grained material (chlorite+biotite+quartz). Quartz occurs as fine-grained stringers which show definite grain size reduction. Quartz is often augen-shaped. *vfg = very fine grained
chlorite	5		
zircon?	tr		
vfg* material	20		
K-spar	15		
opaques	tr		

SAMPLE NUMBER: MD93082901A			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	18	0.1-2mm	Megacrystic quartz syenite. Orthoclase has altered to sericite in cores. Carbonate grains are interstitial to quartz. K-spar grains commonly contain inclusions of clinozoisite. Quartz has fairly straight grain boundaries, but undulose extinction. Hornblende is closely associated with siderite.
plagioclase	6	1-1.5mm	
biotite	7		
chlorite	10		
orthoclase	38	5mm	
microcline	3	1mm	
carbonate	1	0.5mm	
clinozoisite	2	0.05mm	
siderite	5	0.1mm	
hornblende	8		

SAMPLE NUMBER: MD93082901B			
MINERAL	%	GRAIN SIZE	COMMENTS
orthoclase	65	1-2.5mm	Leucocratic alkali-feldspar granite. Quartz grains have fairly sutured boundaries and undulose extinction. K-spar has altered to sericite, and also contains inclusions of a white mica?
quartz	25	0.1-1mm	
chlorite	5	0.1mm	
plagioclase	5	0.4mm	
opaques	tr		

SAMPLE NUMBER: MD93082903A			
MINERAL	%	GRAIN SIZE	COMMENTS
orthoclase	55		Mylonite with probable alkali-feldspar granite protolith. Orthoclase has commonly altered to sericite, and some grains are perthitic. Quartz and feldspar generally have undulose extinction. Carbonate is interstitial to quartz and feldspar.
microcline	7		
quartz	24		
carbonate	2		
chlorite	10		
apatite	tr		
biotite	tr		
hematite	tr		

SAMPLE NUMBER: MD93082903B			
MINERAL	%	GRAIN SIZE	COMMENTS
chlorite	30		Fine-grained mafic dyke. Clinozoisite grains found on edges of dark stringers in thin sectiom; these are well-formed crystals. Fine-grained mass on one end of slide is composed mainly of epidote. Epidote also exists as very fine stringers which were cut by thin quartz stringers.
quartz	35		
clinozoisite	2		
plagioclase	6		
Kspar	22		
epidote	5		

SAMPLE NUMBER: MD93083003A			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	8		Mylonite with unknown protolith. Rock is very fine-grained and highly sheared. Most minerals are unidentifiable. Quartz is as stringers and augen-shaped masses which show grain size reduction. K-spar is as rounded grains in which foliation wraps around. Vfg mass probably includes quartz, chlorite and possibly biotite and epidote.
K-spar	2		
vfg mass	90		
corundum?	tr		

SAMPLE NUMBER: MD93083003B			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	56		Leucocratic alkali-feldspar granite. K-spar is altered to sericite. Fine-grained epidote is scattered throughout quartz-feldspar-rich parts of slide (as small stringers interstitial to quartz and feldspar).
biotite	4		
chlorite	4		
epidote	16		
K-spar	20		
opaques	tr		

SAMPLE NUMBER: MD93090103

MINERAL	%	GRAIN	COMMENTS
quartz	55		Leucocratic granite gneiss. Most quartz has undulose extinction and very sutured grain boundaries. Gneissic textures prevail. Hematite as inclusions in, and contains inclusions of magnetite.
K-spar	30		
plagioclase	5		
biotite	3		
chlorite	5		
clinozoisite	2		
hematite	tr		
pyrite	tr		
magnetite	tr		

SAMPLE NUMBER: MD93090104A

MINERAL	%	GRAIN	COMMENTS
quartz	45		Leucocratic granite. Hematite as lamellae in, and contains lamellae of magnetite. Chlorite +/- biotite as corona around garnet. Rusty stringers throughout quartz common. Carbonate (probably siderite) usually associated with garnet +chlorite +biotite +opaques.
chlorite	10		
biotite	5		
plagioclase	25		
garnet	1		
carbonate	1		
K-spar	15		
magnetite	tr		
hematite	tr		
clinozoisite	1		

SAMPLE NUMBER: MD93090104B			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	60		Leucocratic granite. Quartz appears strained and shows evidence of grain size reduction. Similar to MD93090104A.
chlorite	7		
biotite	3		
garnet	1		
clinozoisite	2		
siderite	7		
plagioclase	7		
K-spar	8		
magnetite	0.5		
hematite	0.5		

SAMPLE NUMBER: MD93090105A			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	60		Leucocratic alkali-feldspar granite gneiss. Pyrite and pyrrhotite grains are small and anhedral, and are scattered throughout rock. Garnet often contains inclusions of quartz and biotite. Quartz shows evidence of grain size reduction. K-spar is locally perthitic. Gneissic textures common.
orthoclase	25		
microcline	<1		
garnet	7		
biotite	5		
chlorite	2		
pyrrhotite	tr		
pyrite	tr		

SAMPLE NUMBER: MD93090105B

MINERAL	%	GRAIN SIZE	COMMENTS
quartz	50	<0.05mm	Leucocratic alkali-feldspar granite gneiss. K-spar grains are large and partially altered to sericite. Quartz is greatly reduced in grain size. Thin section is basically a fine-grained groundmass of quartz and K-spar with larger grains of orthoclase, microcline and garnet, and small grains of pyrophyllite. Hydrothermal alteration may have affected this rock. Pyrophyllite associated with K-spar.
microcline	5		
orthoclase	40		
garnet	2		
pyrophyllite	3		
pyrite	tr		

SAMPLE NUMBER: MD93090206

MINERAL	%	GRAIN SIZE	COMMENTS
quartz	75		Mylonite with unknown granitoid protolith. Fe-carbonate occurs as wispy intergranular stringers. Large part of slide is as very fine-grained mass consisting of quartz, epidote, sericite, chlorite and biotite. Quartz has irregular boundaries and often shows sub-grain development.
biotite	3		
chlorite	4		
sericite	3		
Fe-carbonate	5		
K-spar	10		
pyrrhotite	tr		
hematite	tr		
magnetite	tr		

SAMPLE NUMBER: MD93090303A			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	25	0.05-2mm	Mafic meta-igneous schist. Protolith of this schist is a mafic volcanic or intrusive. Rock basically composed of quartz+plagioclase with larger grains of augite set in it. Tabular biotite and hornblende locally show vague preferred orientation. Augite is anhedral and altered to chlorite on grain edges. Cleavage of augite is indistinct.
plagioclase	10	0.05-2mm	
chlorite	8		
augite	50	0.8mm	
biotite	2	0.1mm	
hornblende	3	0.4mm	
pyrrhotite	1		
pyrite	tr		
chalcopyrite	tr		

SAMPLE NUMBER: MD93090303B			
MINERAL	%	GRAIN SIZE	COMMENTS
hornblende	15	0.3-1mm	Mafic meta-igneous schist. Same as MD93090303A. Augite noted with hornblende in center locally, and is often rimmed by vfg mass which may be uralitic hornblende.
augite	38	0.6mm	
chlorite	10		
quartz	19		
biotite	1		
plagioclase	6		
vfg mass	10		
pyrite	0.5		
pyrrhotite	0.5		
chalcopyrite	tr		

SAMPLE NUMBER: MD93090306B			
MINERAL	%	GRAIN SIZE	COMMENTS
biotite	18		Mesocratic granite gneiss. Garnet often with biotite and often contains inclusions of biotite or opaques. Vfg mass of sericite may include some epidote.
garnet	12		
sericite	17		
quartz	30	0.05-1mm	
plagioclase	4		
K-spar	15		
corundum?	tr		
pyrophyllite	tr		
pyrite+po	3		
chalcopyrite	tr		

SAMPLE NUMBER: MD93090307			
MINERAL	%	GRAIN SIZE	COMMENTS
plagioclase	25		Altered mafic meta-igneous unit. Similar to MD93090303A & B, but much more altered. Quartz has sutured edges. Vfg mass may be from alteration of augite (complete alteration) to uralitic hornblende. Vfg mass is similar to material rimming augite in MD93090303B. *cg = coarse grained *py = pyrite *cpy = chalcopyrite
epidote	8		
clinozoisite	2		
quartz	30		
biotite	3		
cg* epidote	10		
vfg mass	20		
marcasite	1.5		
pyrrhotite	0.5		
py* + cpy*	tr		

SAMPLE NUMBER: MD93090501			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	40	0.1mm	McMurray Fm. siltstone. Approximately 45 % clasts as above, in a matrix-supported clastic sediment. Matrix composition is quartz +/- carbonate.
plagioclase	3	0.1mm	
white mica	tr	0.1mm	

SAMPLE NUMBER: MD93090503A-A			
MINERAL	%	GRAIN SIZE	COMMENTS
siderite	98		Sideritic vein in McMurray Fm. Rock consists of equigranular carbonate grains with locally dark edges. Some intergranular spaces contain quartz or calcite, or are empty. Unit is very rusty and dark coloured adjacent to fractures.
calcite	2		
quartz	tr		

SAMPLE NUMBER: MD93090503A-B			
MINERAL	%	GRAIN SIZE	COMMENTS
siderite	100%		Same as MD93090503A-A. Rock is virtually all siderite.

SAMPLE NUMBER: MD93090601A			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	00		Leucocratic alkali-feldspar granite gneiss. Chlorite is locally as inclusions in opaque grains. Orthoclase is largely altered to sericite.
orthoclase	50		
microcline	3		
chlorite	7		
corundum?	tr		
muscovite	tr		
chalcopyrite	tr		
pyrite	1		
magnetite	1		

SAMPLE NUMBER: MD93090601B			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	50	0.05-1mm	Leucocratic alkali-feldspar granite gneiss. Quartz is largely sutured and has undulose extinction. Chlorite +/- biotite included in large K-spar grain in corner of slide.
K-spar	40	0.5-2mm	
chlorite	3		
biotite	2		
clinozoisite	tr	0.1mm	
plagioclase	2		
marcasite	0.25		
pyrite	0.25		
chalcopyrite	tr		

SAMPLE NUMBER: MD93090603			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	48		Leucocratic alkali-feldspar granite. -Kspar grains locally contain inclusions of quartz +/- chlorite. Smaller K-spar grains altering to sericite. Garnet is welded by chlorite. Pyrophyllite noted in K-spar grain.
microcline	4	0.5mm	
orthoclase	35	3mm	
plagioclase	2		
chlorite	3		
corundum?	0.5		
garnet	3		
pyrophyllite	tr		
magnetite	tr		
hematite	tr		

SAMPLE NUMBER: MD93090701			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	60	0.5mm	Beaver River sandstone. Matrix-supported sub-angular to sub-rounded quartz clasts. Matrix is comprised of finer-grained quartz +/- opaques. Clasts = 60% of rock, matrix = 40%.

SAMPLE NUMBER: MD93090703A			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	60%	0.2-3mm	Beaver River sandstone. Similar to MD93090701. Matrix may contain some very fine-grained carbonate.

SAMPLE NUMBER: MD93090703B			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	60	0.1-2mm	Beaver River sandstone. Similar to MD93090701 and MD93090703A. Sub-angular to rounded quartz clasts set in dirty and possibly rusty matrix. Possibly some siderite in matrix. Clasts = 60% and matrix = 40%.

SAMPLE NUMBER: MD93090706A			
MINERAL	%	GRAIN SIZE	COMMENTS
calcite	5	0.3mm	Waterways Fm. limestone. Rock consists of carbonate groundmass with local fossils replaced by, and cavities filled by more crystalline calcite. Glide twins exist locally in calcite. Groundmass becomes slightly darker adjacent to fractures. Groundmass may contain minor amounts of quartz as well as carbonate.
groundmass	95		

SAMPLE NUMBER: MD93090707			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	33		McMurray Fm. siltstone. Slide consists of clasts, as above, set in carbonate-rich matrix. Clasts = 35% and matrix = 65%.
chlorite	tr		
white mica	2		
calcite	tr		
pyrite	tr		
magnetite	tr		

SAMPLE NUMBER: MD93090802			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	65		Mesocratic alkali-feldspar granite gneiss. K-spar is locally altering to sericite. Cleavage also noted in some grains. Quartz is very strained and shows sub-grain development. Rock is basically quartz + K-spar with wispy stringers of chlorite +/- epidote +/- opaques. Epidote is euhedral to subhedral. Biotite has altered to chlorite.
K-spar	16		
epidote	2		
clinozoisite	2		
chlorite	12		
biotite	tr		
hematite	1		
magnetite	1		
pyrite	1		

SAMPLE NUMBER: MD93090803			
MINERAL	%	GRAIN SIZE	COMMENTS
quartz	34		Pyrite nodule in McMurray Fm. Rock is primarily pyrite with grains of biotite, quartz and K-spar (slightly altered to sericite). Silicate grains are angular to sub-angular.
biotite	tr		
K-spar	1		
pyrite	65		

SAMPLE NUMBER: MD93091101D			
MINERAL	%	GRAIN SIZE	COMMENTS
groundmass	99		Waterways Fm. limestone. Rock consists primarily of carbonate groundmass with local fossils replaced by, and vugs filled by crystalline calcite. Groundmass is locally darker and may contain minor amounts of Fe-carbonate. In one section of slide, groundmass appears brecciated, although fragments are rounded and are welded by a slightly darker carbonate. Possibly nodular.
calcite	1		

SAMPLE NUMBER: MD93091101E

MINERAL	%	GRAIN SIZE	COMMENTS
groundmass	99		Waterways Fm. limestone. Same as MD93091101D. Fossils fairly common. No brecciated zones.
calcite	1		

SAMPLE NUMBER: MD93091101F

MINERAL	%	GRAIN SIZE	COMMENTS
groundmass	99		Waterways Fm. limestone. Similar to MD93091101D & E. Darker orange brown stringers exist throughout slide - possibly hematite stained.
calcite	1		

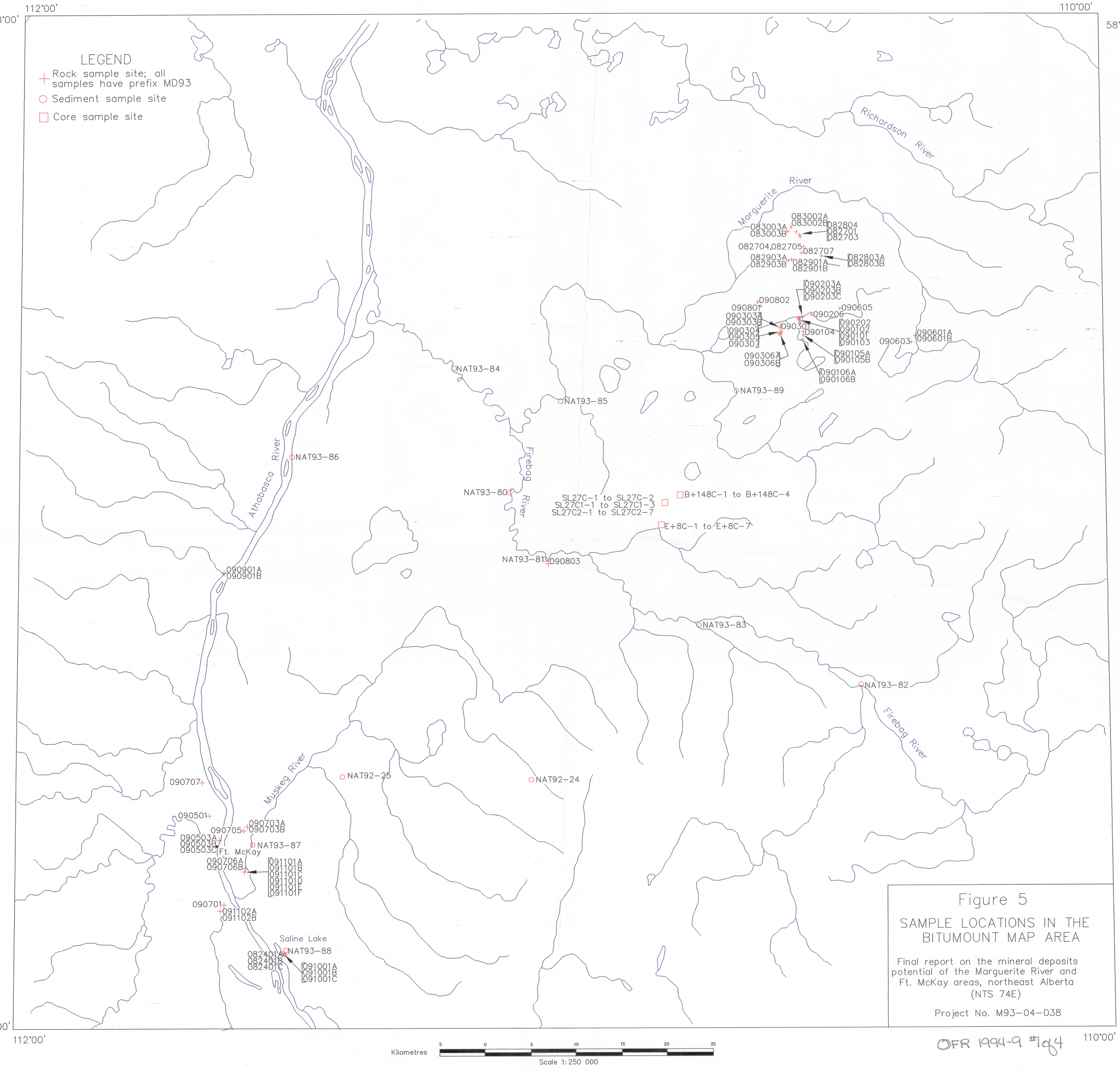

Figure 5

SAMPLE LOCATIONS IN THE BITUMOUNT MAP AREA

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038

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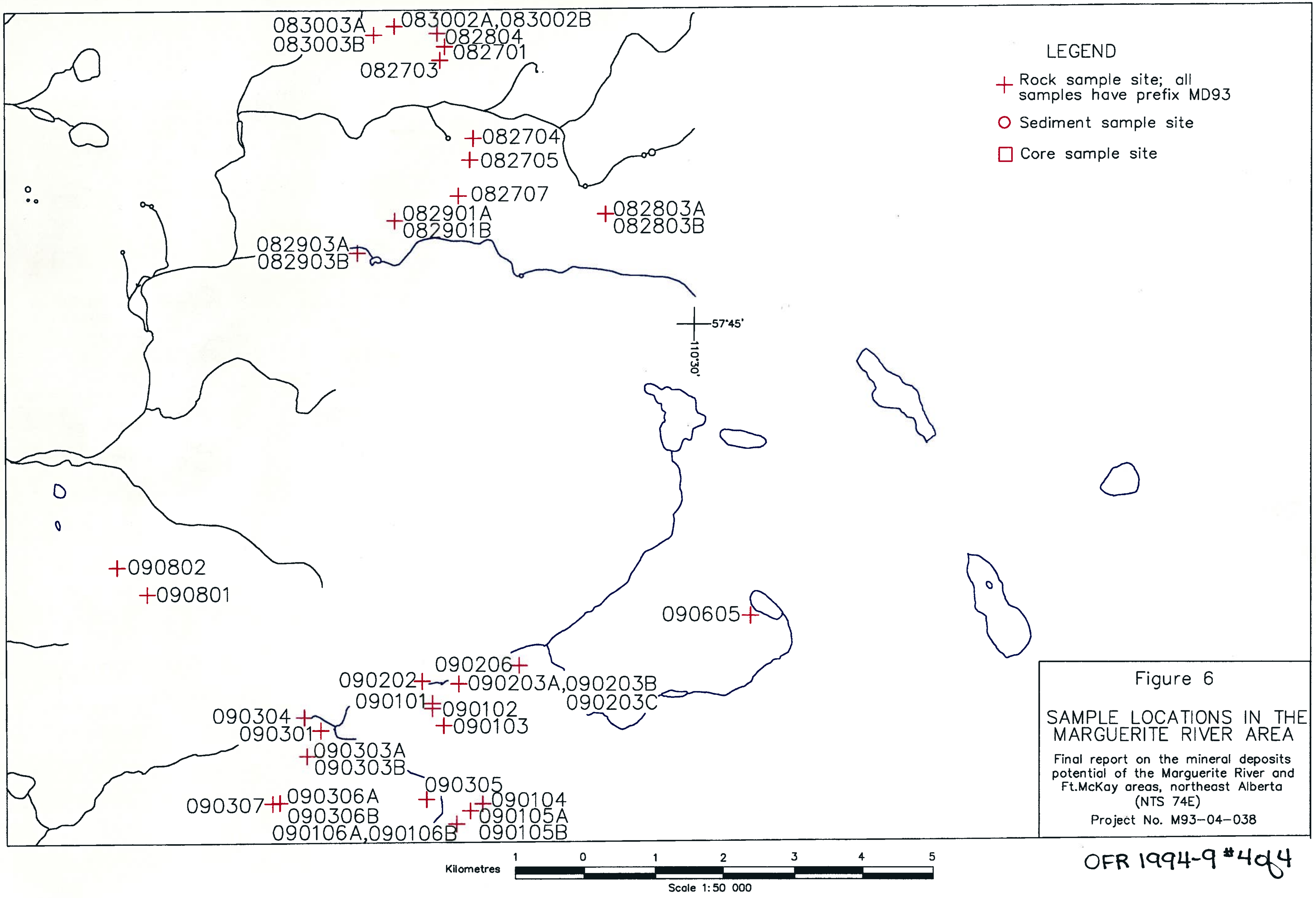

Figure 6

SAMPLE LOCATIONS IN THE MARGUERITE RIVER AREA

Final report on the mineral deposits potential of the Marguerite River and Ft.McKay areas, northeast Alberta (NTS 74E)

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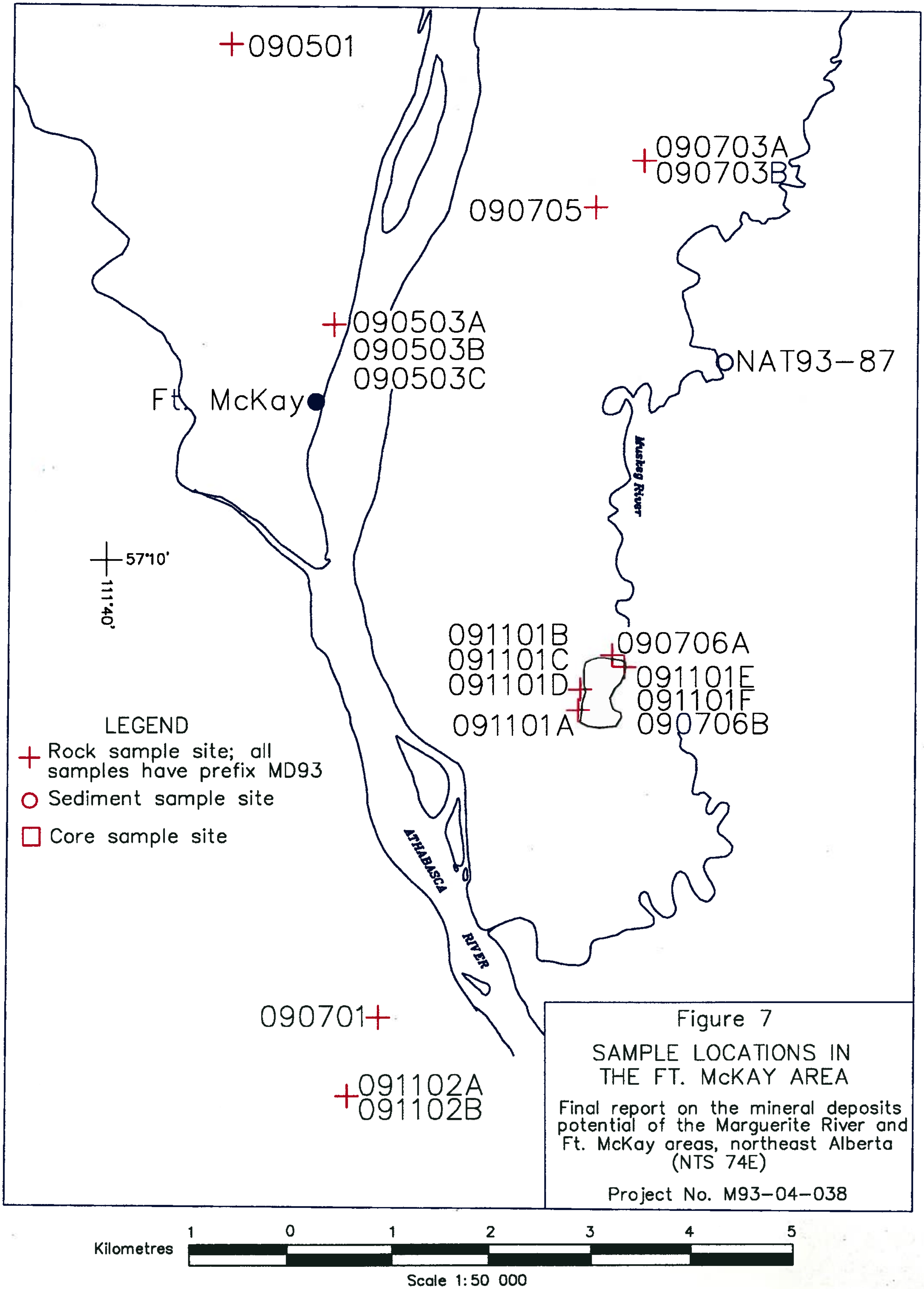

Figure 7

SAMPLE LOCATIONS IN THE FT. McKAY AREA

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038

Fig# 3 of 4.

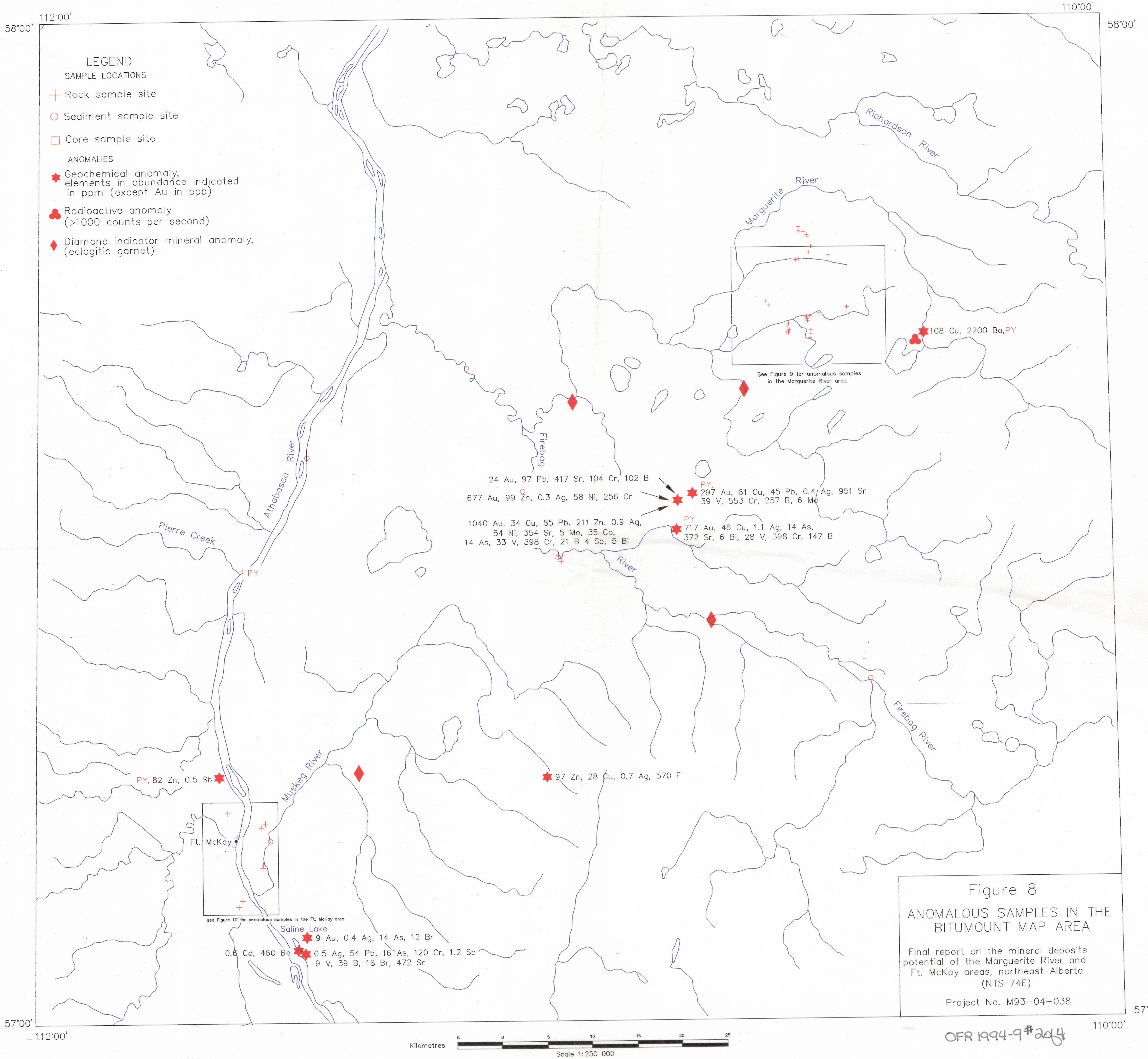

Figure 8

ANOMALOUS SAMPLES IN THE BITUMOUNT MAP AREA

Final report on the mineral deposits potential of the Marguerite River and Ft. McKay areas, northeast Alberta (NTS 74E)

Project No. M93-04-038

OFR 1994-9 #204