RECONNAISSANCE MINERAL AND GEOCHEMICAL SURVEY WITH EMPHASIS ON NORTHERN ALBERTA

REPORT FOR THE END FISCAL YEAR 1994-1995 TILL GEOCHEMISTRY NORTHEASTERN ALBERTA

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SUMMARY

The overall objectives of this reconnaissance project, which is partially funded under the Canada-Alberta Partnership Agreement on Mineral Development (MDA), are to determine the regional variations in the compositions (geochemistry, mineralogy, and texture) and the provenance of the tills in northern Alberta in order to assist exploration by industry for diamondiferous kimberlites or lamproites, gold placers, and other minerals of potential economic interest. This is the interim report for Phase 3 (1994-95) of a three year project and focuses on northeastern Alberta (north of 55° N and east of 115° W). The report is relatively brief because it will be superseded by the final project report which is in preparation for publication in the last quarter of 1997-98.

Ninety-five samples, which were collected for a suite of elements from both road and helicopter accessible sites, were analysed. The clay and silt fraction (<0.063 mm) was analysed using Flame Atomic Absorption Spectrophotometry (AA, following total sample digestion) and Instrumental Neutron Activation Analysis (NA) techniques. The collection and analytical procedures and the chemical elements being measured are the same as those selected by Drs. Garrett and Thorleifson for the complementary Geological Survey of Canada MDA project on till mineralogy and geochemistry in the southern half of Alberta.

This report discusses twenty-four elements: silver (Ag), arsenic (As), gold (Au), barium (Ba), bromine (Br), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), lithium (Li), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), lead (Pb), rubidium (Rb), antimony (Sb), thorium (Th), uranium (U), vanadium (V), tungsten (W), zinc (Zn), and zirconium (Zr).

Variations in the data are illustrated by a figure which shows the concentration range for each element in histogram format, and a series of bubble plot maps. Each plot is underlain by the bedrock geology to help

show the influence of the bedrock on the till geochemistry

The concentration of almost all the elements varies considerably throughout the study area. Many of the elements show high concentrations in samples from sites that are above or below glacier, the subcrop of the Shaftesbury Formation, particularly those samples from the northeast portion of the Buffalo Head Hills and the northwest and northeast portion of the Birch Mountains. The three sites having the highest concentrations of Co, Cr, Li, Zn, Sb, V and Zn are located along an imaginary line that passes through the northeast corner of the Buffalo Head Hills, and the northern margin of the Birch Mountains. This may just be a coincidence or it may indicate a possible structural control.

Geological sections which are exposed along the Firebag River, east of the Athabasca River, show multiple till units. Data from a section with three till units on the Firebag River reveal vertical variations in the geochemistry with depth; some elements decrease in concentration, others increase, and some are concentrated in the middle till unit.

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1. INTRODUCTION

The overall objectives of the project, which is partially funded under the Canada-Alberta Partnership Agreement on Mineral Development (MDA), are: (a) to determine the regional variations to be expected in the texture, indicator minerals and geochemistry of till in order to assist exploration by industry for diamondiferous kimberlites and lamproites, gold placers, and other minerals of potential economic interest, and (b) to determine the provenance of at least the surface till in northern Alberta. Phase 3 (1994-95) activities were focused primarily on northeastern Alberta.

This is the interim report for the last year of a three year project and focuses on the results of the geochemical analyses. The report is relatively brief because it will be superseded by the final project report which is in preparation (for publication early in 1998).

1.1 SAMPLE COLLECTION AND ANALYSIS

The 1994-1995 fieldwork focused principally on northeastern Alberta (north of 55° N latitude and east of 115° W longitude; Figure 1.1). Ninety-five samples were analysed from the area (Figures 1.1, 1.2a, and 1.2b). The samples were collected from both road accessible sites and for the more remote sites, by helicopter. The procedures used for sample collection and subsequent sample lab analysis were the same as those used for the complementary MDA project being done by staff of the Geological Survey of Canada (GSC) on the southern half of Alberta. Each site was assigned both a field number and a shorter site ID number that was easier to plot on a map. Figures 1.2a and 1.2b show the site ID number for each site and Table 5.1, in the appendix, lists the field number, and site ID number together with the location and geochemical data.

At each site the sample was taken from below the top of the C soil horizon; generally between a depth of 1 and 2 m to minimize the effects of weathering on the carbonate content of the till, and to maximize the

preservation of indicator mineral grains. Till samples of about 25 kg were collected for indicator minerals and as well as a 2-3 kg sample was collected for geochemical analysis. The small samples were placed in plastic bags, and the large till samples were placed in 5 gallon (~23 litre) plastic pails. The field data that were recorded at each site include information on the general sampling environment, and observations on the colour, texture, moisture content, and mineralogy of the till.

The samples were collected from road cuts, from naturally exposed sections or from hand-dug sample pits excavated into the land surface. Particularly during the helicopter-assisted sampling, emphasis was placed on visiting well-exposed sections. Where the sections included more than one unit, such as those along the Firebag River, samples were collected from each unit. A few samples were also collected from the exposed bedrock, and the Quaternary lacustrine and fluvial sediment.

1.2 PHYSIOGRAPHY

The area includes major highlands: the Caribou Mountains, Birch Mountains, Pelican Mountains, and Stoney Mountain (Figure 1.3). Areas of intermediate height and extent include Muskeg Mountain, Thickwood Hills, and the topographic high area southwest of the Birch Mountains which includes Peerless Lake near its center. The margins of the highlands are not uniform; there is generally one portion or side that is much steeper in slope than the others. These steep margins have a much greater proportion of geological sections because mass wasting, primarily slumping, is more active on these margins. The bedrock is well exposed in sections along the margins of the Birch and Caribou Mountains, although extensive slumping tends to complicate the exposures.

The Peace River has eroded into the lowland between the Caribou and Birch Mountains and the Athabasca River has cut into the lowland east of the Birch Mountains. The Firebag River, situated north of Muskeg Mountain, flows northwestward into the Athabasca River (Figure 1.3).

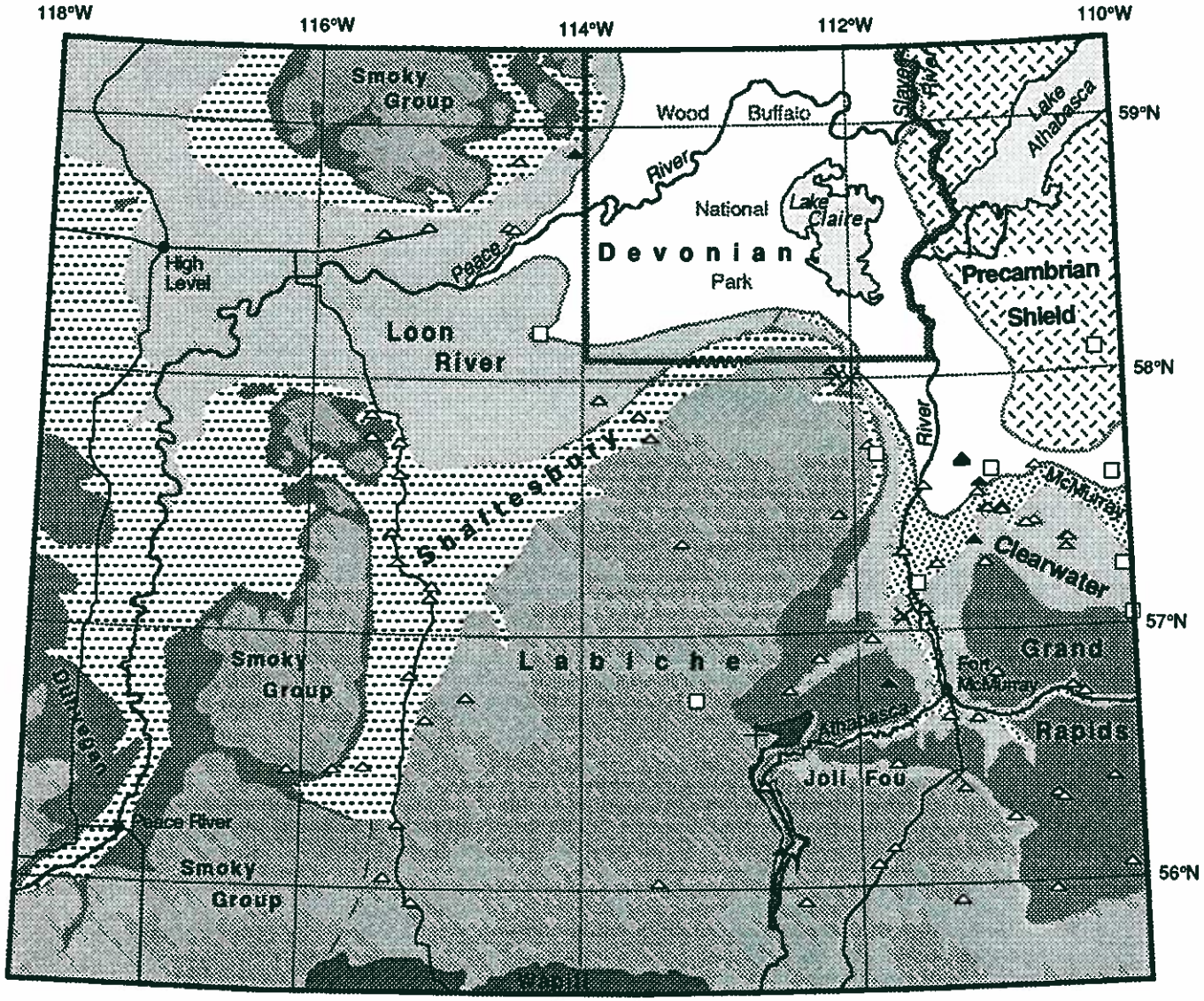

Figure 1.1. Location of sample sites and bedrock geology, northeastern Alberta (modified from Green, 1972).

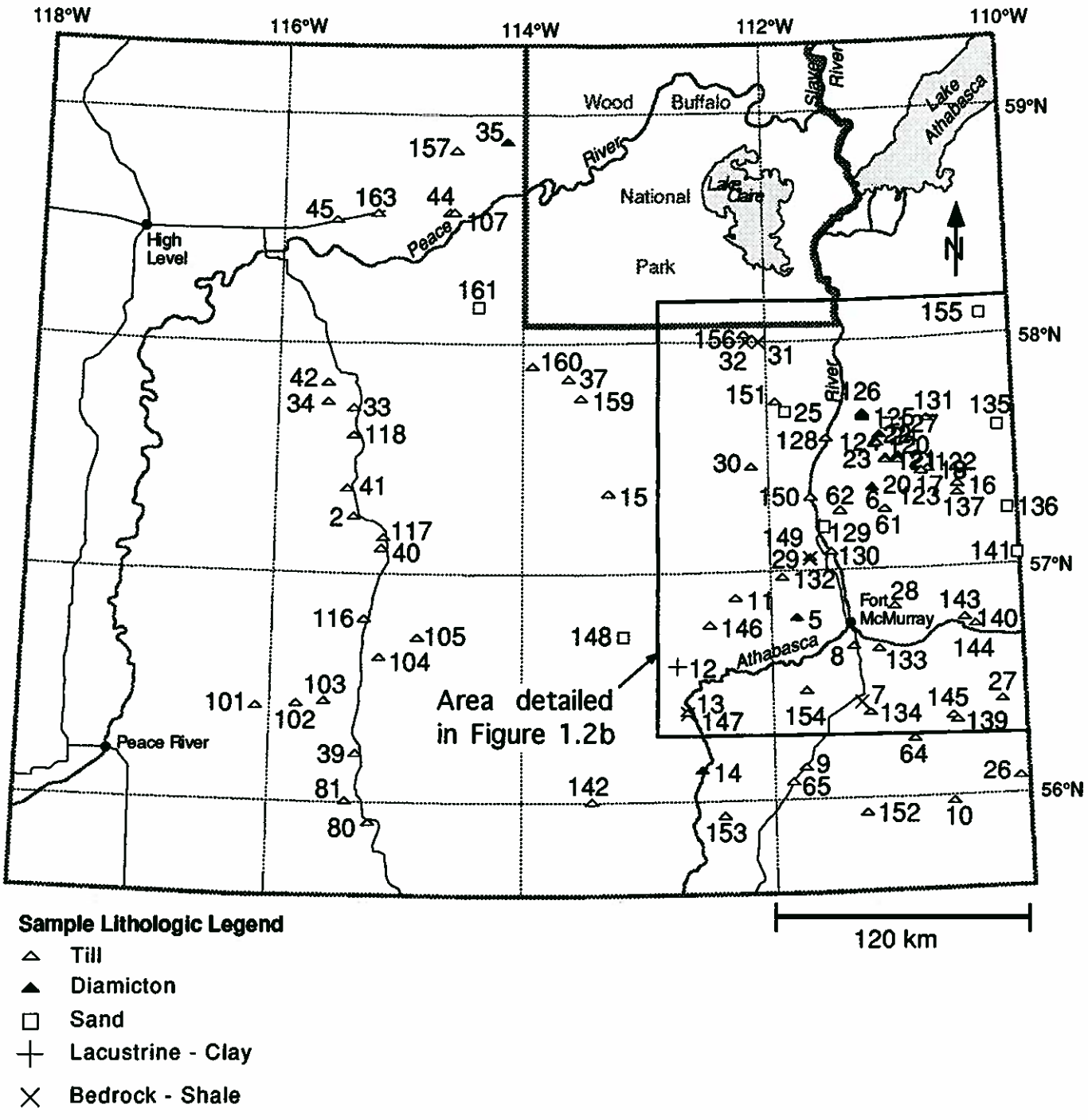

Figure 1.2a. Map showing the site ID number assigned to each sample.

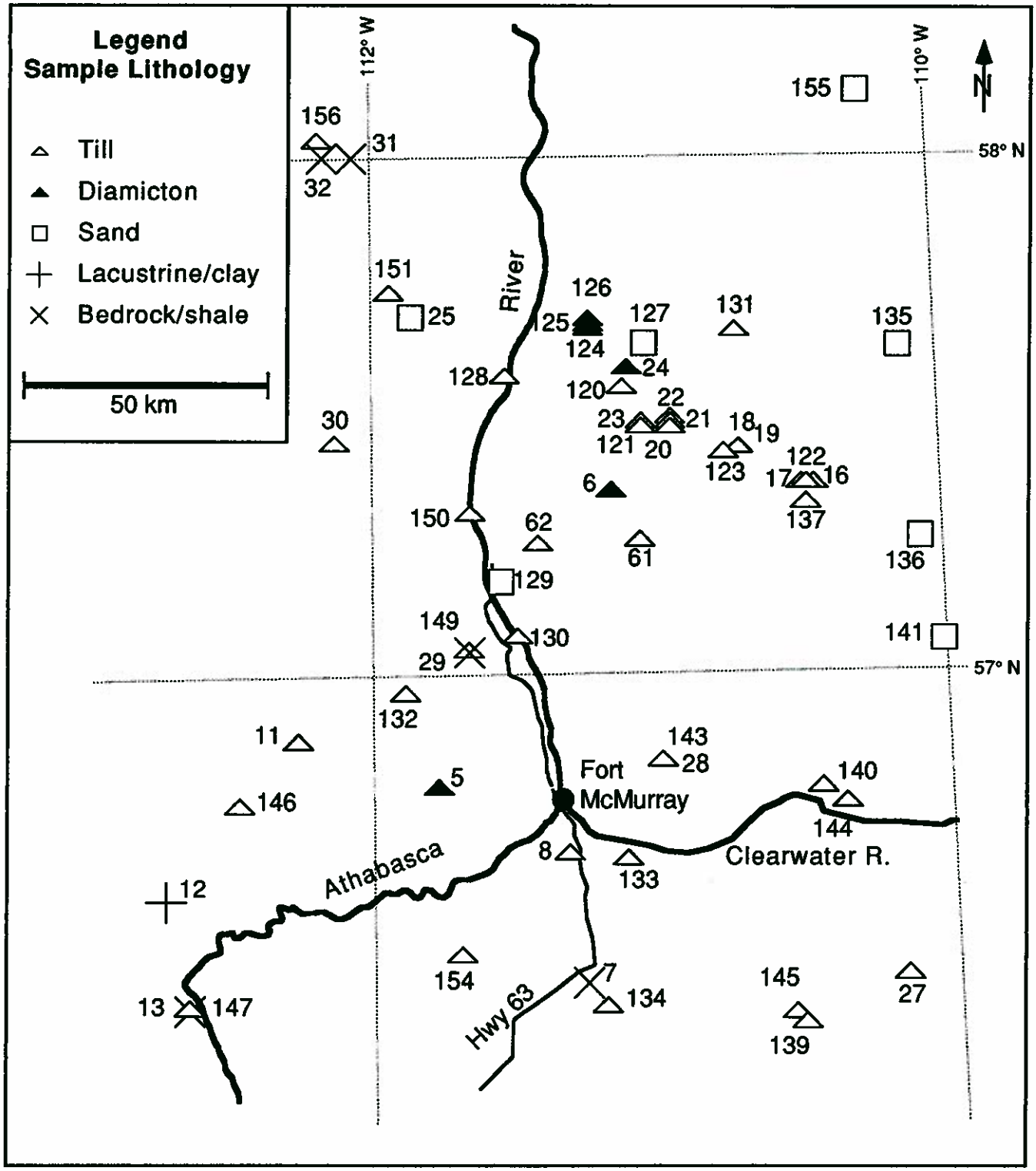

Figure 1.2b. Expanded map of detailed area in Figure 1.2a, showing site ID numbers for samples collected in and near the Athabasca River valley.

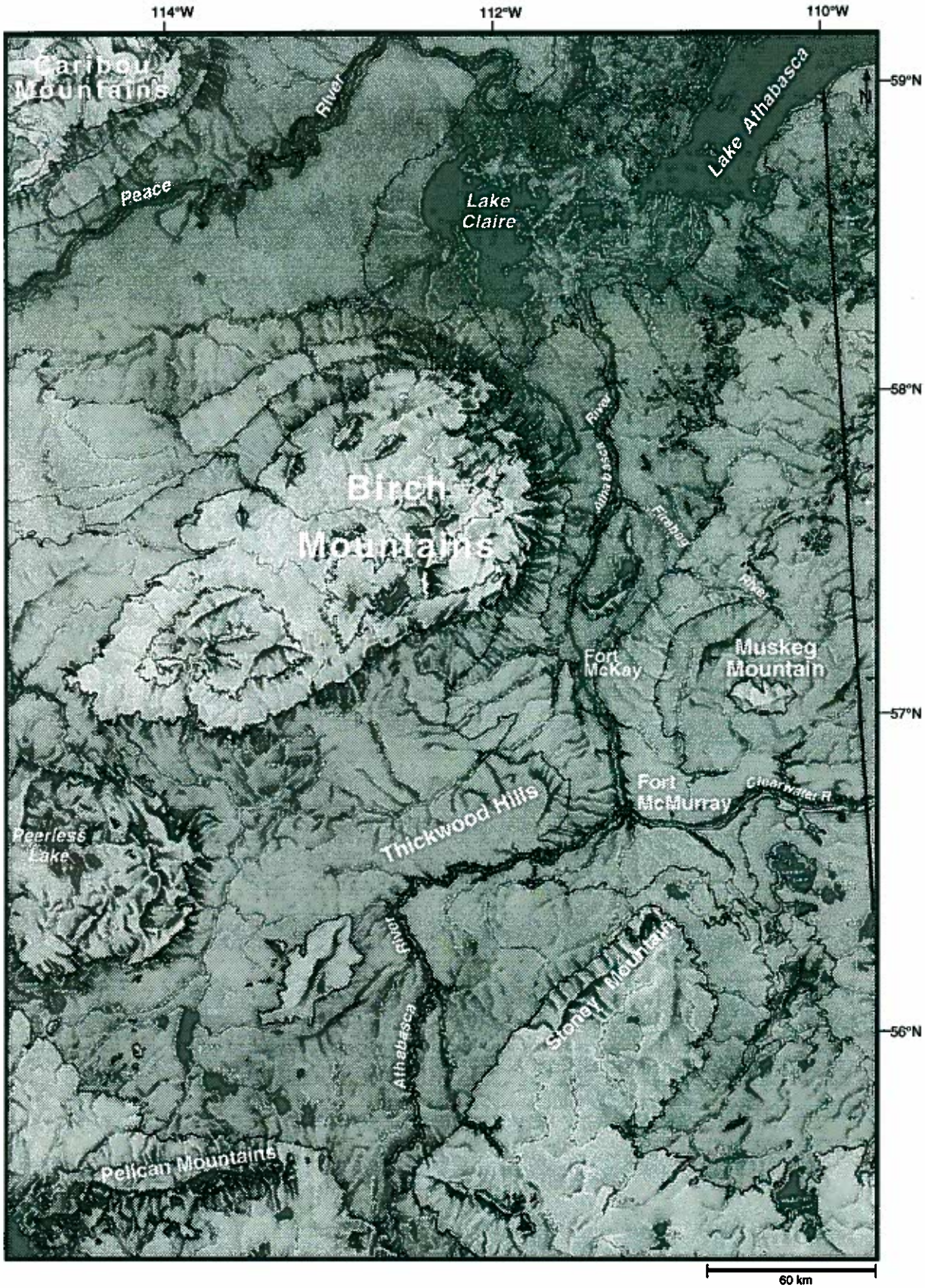

Figure 1.3. Physiographic map of northeastern Alberta showing location of major topographic features (from Alberta Transportation, 1978).

2. TILL MATRIX GEOCHEMISTRY

2.1 PROCEDURES

The matrix fraction (<0.063 mm or <230 mesh) was recovered from the 2 to 3 kg set of samples which were collected for geochemical analysis. Each sample was air dried, gently disaggregated to avoid the crushing of rock and mineral grains, and was screened using 2.00 mm and 0.063 mm stainless steel sieves. About 50 grams of the <0.063 mm fraction was recovered from each sample. The remaining part was retained for possible future analysis. The <0.063 m fractions were then subdivided to provide a subset for Atomic Absorption (AA) and for Instrumental Neutron Activation Analysis(NA).

Prior to submission of the samples to the laboratories, the sample order was randomized and both duplicate and standard samples were inserted. About five percent of the samples which were submitted, are duplicates or standards.

The AA analyses (flame atomic absorption spectrophotometry) were done by CanTech Laboratories Inc.. A "total digestion" procedure was used. Following sieving through the stainless steel sieve a 1 gram subsample was selected and dissolved in a fuming HF-HClO4-HNO3 mixture and then analysed. The procedure determined the concentration of silver (Ag), cadmium (Cd), cobalt (Co), copper (Cu), iron (Fe), lithium (Li), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), vanadium (V), and zinc (Zn). Table 2.1 lists the detection limits for each element.

The instrumental neutron activation analysis (NA) used subsamples of about 30 grams to determine the concentrations of silver (Ag), arsenic (As), gold (Au), barium (Ba), bromine (Br), cadmium (Cd), cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), iridium (Ir), lanthanum (La), lutetium (Lu), molybdenum (Mo), sodium

(Na), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), selenium (Se), samarium (Sm), tin (Sn), tantalum, (Ta), terbium (Tb), tellurium (Te), thorium (Th), tungsten (W), uranium (U), ytterbium (Yb), zinc (Zn), and zirconium (Zr). Each sample was encapsulated by Becquerel Laboratories, Inc., sealed and irradiated with neutron flux monitors in a 2 megawatt (MW) pool type reactor. Following a 7 day decay period to remove transient decay products the gamma radiation from the samples was counted for approximately 500 seconds using a high resolution Ge detector system. Note, only the following elements are discussed in this report: arsenic (As), gold (Au), barium (Ba), bromine (Br), chromium (Cr), sodium (Na), rubidium (Rb), antimony (Sb), tin (Sn), thorium (Th), tungsten (W), uranium (U), and, zirconium (Zr). Table 2.1 lists the detection limits for each element.

The analytical procedures and the chemical elements being measured are the same as those selected by Drs. Garrett and Thorleifson for the complementary GSC MDA project on till mineralogy and geochemistry in the southern half of Alberta. The same laboratories are being used by both the GSC and the Alberta Geological Survey (AGS).

In addition to the above geochemical results, an estimate of the total amount of carbonate in the matrix of each sample was obtained in the field by recording the reaction of the sample to dilute HCl.

This report discusses the results for only the following twenty-five elements: silver (Ag), arsenic (As), gold (Au), barium (Ba), bromine (Br), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), lithium (Li), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), lead (Pb), rubidium (Rb), antimony (Sb), tin (Sn) thorium (Th), uranium (U), vanadium (V), tungsten (W), zinc (Zn) and zirconium (Zr). This abbreviated approach was taken because:

- the elements that members of the exploration industry had shown the most interest in during presentations at a number ofconferences,
- all the geochemical data had previously been released on a disk that

accompanied an earlier report (Fenton and others, 1994),

- the authors wished to devote the majority of their time to preparation of the final, more comprehensive, project report which will supersede this report.

2.2 SAMPLE ANALYSIS

2.2.1 Introduction

The following comments are from a preliminary examination of the data. A more comprehensive analysis will be presented in the final project report which is in preparation.

Data on the composition of the surface till samples, including those from sections, and the shallowest till sample from each of the core holes, were gathered in the field and later from the laboratory geochemical analyses.

The data from the geochemical analyses are shown in Table 5.1. Table 2.1 presents summary data such as the average, maximum, minimum, and the 95th and 60th percentiles for the elements that are discussed in this report.

Variations in the data are illustrated Figure 2.1, showing the concentration range for each element in histogram format, and a series of bubble plot maps (Figure 2.2 to 2.25) which highlight the most anomalous results for each element. Each plot is underlain by the bedrock geology map as taken from Green (1972) to help show the influence of the bedrock on the till geochemistry. (Note the new bedrock geology map of Alberta (in perparation) show a revision of the bedrock geology units east of the Birch Mountains with the subcrops of the Pelican and Grand Rapids Formations being more extensive.

2.2.2 Variations Within Individual Elements

The concentration of each element varies throughout the area. Some elements vary in a similar manner, others do not. These variations are shown in a series of bubble plot maps (Figures 2.2 to 2.25). The following discussion focuses on the sites with higher concentrations of a particular element. In general to simplify the figures only concentrations greater than the 60th percentile are plotted. Sites with values less than the 60th percentile are shown, but have no 'bubble' around them. This was done to focus on the higher concentrations of each element and produce less cluttered figures. The cut-off value for a few elements was raised above the 60th percentile to emphasize the distribution of anomalous sites. Each figure shows the actual minimum value used.

Ag: Silver

Silver, detected by AA, varies from below the detection limit of 0.2 ppm to 1.6 ppm (Figures 2.1 and 2.2; Table 2.1). The mean concentration is 0.30 ppm and the 95th percentile is 0.70 ppm.

The highest concentration of silver is in a sample from the Clearwater Shale on the west side of the Athabasca River, north of Fort McMurray #29 (1.6 ppm); note that # refers to the site ID number shown on Figures 1.2a and 1.2b, and Table 51. Sites with high concentrations of silver in till are present at a few places south of the Athabasca and Clearwater rivers, till #154 (0.9 ppm), #27 (0.7 ppm), and #153 (1.0 ppm), and in the southern portion of the lowland between the Birch Mountains and the Buffalo Head Hills to the west #103 (0.7 ppm).

As: Arsenic

Arsenic, detected by AA, varies from 1.1 to 47 ppm (Figures 2.1 and 2.3; Table 2.1). The mean concentration is 11.1 ppm and the 95th percentile is 22.2 ppm.

The highest concentrations of As were obtained from three sites:

- till covering the northeast tip of Buffalo Head Hills, #34 (47 ppm), Figure 2.3;
- sites on the northeast portion of the Birch Mountains with the till contain more arsenic, #156 (29.0 ppm) than an adjacent sample of the shale, likely from the Shaftesbury Fm., #32 (22.5 ppm);
- in shale from the site near the sharp bend in the Athabasca River west of Fort McMurray #13 (30 ppm).

The last sample is from the lower portion of the La Biche Formation and likely is from the Fish Scales marker horizon. Elevated arsenic concentrations also are present in a till sample from west of the Athabasca River north of Fort McMurray, #30 (22 ppm) and east of the river in the Kearl Lake area, #61 (22 ppm). One sample of the Clearwater shale on the west side of the Athabasca River north of McMurray contains 23 ppm arsenic (#29).

Au: Gold

Gold, detected by NA, varies from below the detection limit of 2 ppb to 21 ppb (Figures 2.1 and 2.4; Table 2.1). The mean concentration is 4.8 ppb and the 95th percentile is 14.0 ppb.

The three highest concentrations of gold are:

- #20 from upper till in a section on the central portion of the Firebag River (21 ppb, Figures 1.2a and b);
- #25 (18 ppb) from a sand and gravel lag on the northeast tip of the Birch Mountains;
- #118 (18 ppb) from till near Senex Creek east of the central portion of the Buffalo Head Hills.

Two sites with elevated gold concentrations exist in the southwest quadrant of the study area: #104 (13 ppb) near the Red Earth Fire Tower

and #103 (14 ppb) west of the bridge over the Meandering River. Lastly a site on the Thickwood Hills west of the sharp southward bend in the Athabasca River yielded lacustrine sediment, which likely is water laid diamicton, with #12 (15 ppb) gold.

Ba: Barium

Barium, detected by NA, varies from 170 ppm to 1300 ppm (Figures 2.1 and 2.5; Table 2.1). The mean concentration is 602 ppm and the 95th percentile is 984 ppm.

High concentrations of barium are present in samples collected from the northeast corner of the Buffalo Head Hills, the northwest and northeast flanks of the Birch Mountains and south of Fort McMurray and along the southern reach of the Athabasca River. The three highest concentrations are:

- #42 (1200 ppm, Figures 1.2a and b) from till northeast tip of Buffalo Head Hills,
- #13 (1300 ppm) in shale collected near the sharp bend on the Athabasca River upstream of Fort McMurray,
- #10 (1200 ppm) from till southeast of Fort McMurray (Figure 2.5).

Br: Bromine

Bromine, detected by NA, varies from below the detection limit of 0.5 ppm to 12 ppm (Figures 2.1 and 2.6; Table 2.1). The mean concentration is 2.3 ppm and the 95th percentile is 4.1 ppm.

The location of sample sites with high concentrations of bromine differs from that for most other elements. High bromine concentrations are:

- possible till from near Saline Lake on the east side of the Athabasca River north of Fort McMurray, #130 (12 ppm, Figures 1.2b and 1.2c),
- at a site, #45 (12 ppm) south of the central portion of the Caribou Mountains,

- at site on lowland between the Peace River and the Birch Mountains, #161 (8.1 ppm) in fluvial sediment from a creek near the contact between the Loon River shale and the Devonian carbonates. Concentrations of bromine are below 4 ppm at most other sites.

Cd: Cadmium

Cadmium, detected by AA, varies from below the detection limit of 0.2 ppm to 0.5 ppm (Figure 2.1 and 2.7; Table 2.1). The mean concentration is 0.15 ppm and the 95th percentile is 0.30 ppm.

The highest concentrations of cadmium are found at:

- site #159 (0.5 ppm) on the northwest flanks of the Birch Mountains,
- site #34 (0.4 ppm) on the extreme northeast side of the Buffalo Head Hills,
- site #117 (0.4 ppm) midway between the Buffalo Head Hills and the Birch Mountains,
- site #143 (0.4 ppm) till exposed in a section on the Steepbank River, northeast of the junctions of the Clearwater and Athabasca rivers.

Co: Cobalt

Cobalt, detected by AA, varies from 2 ppm to 41 ppm (Figures 2.1 and 2.8; Table 2.1). The mean concentration is 11.7 ppm and the 95th percentile is 26.5 ppm.

There are elevated concentrations of cobalt (≥24 ppm) from several sample sites along the north flanks of the Buffalo Head Hills and the Birch Mountains, and the southeast flanks of the Caribou Mountains where the glacial ice was moving across the Shaftesbury Formation (Figure 2.8). The highest values are from:

- till at site #34 (41 ppm) on Buffalo Head Hills,
- till at site #37 (33 ppm) northwest Birch Mountains,
- shale (which is likely from the Shaftesbury Formation) at site #31

(38 ppm) northeastern Birch Mountains.

There is also one site south of Fort McMurray #7 (26 ppm) near the subcrop of what has been mapped as the Joli Fou Formation (Figure 1.2a) but which based on new subsurface data may include the subcrop of the Base of Fish Scales Zone.

Cr: Chromium

Chromium concentration, detected by NA, varies from below the detection limit of 20 ppm at some sites to 130 ppm (Figures 2.1,and 2.9; Table 2.1). The mean concentration is 68.4 ppm and the 95th percentile is 104.5 ppm. Sites with high concentrations of chromium include those on the northeast tip of the Buffalo Head Hills, till #42 (110 ppm) and the northwest, till #37 (110 ppm) , NE, till #156 (110 ppm) and E, till #30 (110 ppm) flanks of the Birch Mountains. The highest chromium value is from a sample of the Clearwater shale, at site #29 (130 ppm) on the west side of the Athabasca River valley north of Fort McMurray.

Cu: Copper

Copper, detected by AA, varies from 3 ppm to 50 ppm (Figures 2.1 and 2.10; Table 2.1). The mean concentration is 21.8 ppm and the 95th percentile is 34.5 ppm.

The higher concentrations of copper (≥ 34 ppm), in general, are found on the NE and E flanks of the Birch Mountains and south from there along the southernmost reach of the Athabasca River. Samples with high concentrations of the metal include:

- shale from the Fish Scales zone, site #13 (50 ppm) near the sharp bend on the southern Athabasca River,
- till collected from site #156 (38 ppm) at the northeastern tip of the Birch Mountains,
- till at site #30 (38 ppm) on the northeastern flank of the Birch

Mountains,

- till at site #15 (35 ppm) from the center of the Birch Mountains,
- Clearwater shale at site #29 (34 ppm) from west of the central portion of the Athabasca River,
- clay, likely water laid diamicton,from site #12 (36 ppm) on the Thickwood Hills.

Fe: Iron

Iron detected by AA, varies from 0.1 percent to 6.2 percent (Figure 2.1 and 2.11; Table 2.1). The mean concentration is 2.56 percent and the 95th percentile is 3.95 percent.

The highest concentration of iron is in two samples from near the Athabasca River north of Fort McMurray:

- Clearwater Shale site #29 (6.2 percent);
- till overlying oil sands at site #130 (6.1 percent).

High concentrations of iron (≥ 38 ppm) were found in samples from:

- till at site #34 (4.6 percent) on the northeast tip of the Buffalo Head Hills;
- till at site#156 (4.0 percent), and shale at site #13 (4.3 percent) from the northeast tip of the Birch Mountains;
- till from site #30 (3.9 percent) on the eastern flanks of the Mountains;
- till from site #31 (3.8 percent) in the south central part, southeast of the Buffalo Head Hills.

Li: Lithium

This element was analysed only during the last year of the project, therefore a smaller number of analyses. Lithium, detected by AA, varies from 6 ppm to 40 ppm (Figure 2.1 and Figure 2.12; Table 2.1). The mean concentration is 19.5 ppm and the 95th percentile is 32.1 ppm.

The highest concentrations are from:

- till at site #34 (34 ppm) the northeast tip of the Buffalo Head Hills;
- till at site #35 (35 ppm) on the southeast side of the Caribou Mountains;
- till on the northwest flanks of the Birch Mountains, sites #37 (40 ppm) and #160 (29 ppm);
- lacustrine clay, likely water laid diamicton, at site #12 (32 ppm) on the Thickwood Hills west of Fort McMurray.

Mn: Manganese

Manganese, detected by AA, varies from 34 ppm to 940 ppm (Figures 2.1 and 2.13; Table 2.1). The mean concentration is 268 ppm and the 95th percentile is 471 ppm.

The sites with high concentration are generally different from those of many of the other elements. Sites with the highest concentrations (≥ 480 ppm) include:

- till at site #130 (940 ppm) overlying oil sands east of the Athabasca River north of Fort McMurray;
- till at site #157 (494 ppm) on the southeast side of the Caribou Mountains;
- sand at site #161 (620 ppm) from south of the Peace River and north of the Birch Mountains;
- till at site #81 (526 ppm) in the south central portion of the area.

Sites with high values (≤ 450) are:

- till at site #118 (465 ppm) near Senex Creek in the lowland east of the northern portion of the Buffalo Head Hills;
- till at site #123 (460 ppm) a section on the Firebag River east of the central portion of the Athabasca River;
- till from site #143 (478 ppm) on the Steepbank River northeast of Fort McMurray.

Mo: Molybdenum

Molybdenum concentration, detected by AA, varies from below the detection limit of 2 ppm at some sites to 12 ppm (Figures 2.1 and 2.14; Table 2.1). The mean concentration is 4.45 ppm and the 95th percentile is 8.0 ppm.

The highest concentrations of molybdenum are from till at site #157 (11 ppm) on the southeastern flanks of the Caribou Mountains and till at site #34, (12 ppm) on the northeast tip of the Buffalo Head Hills. Other sites with elevated values of this element (≥ 8 ppm) include:

- till from site #33 (9 ppm) located on the lowlands east of the northeast portion of the Buffalo Head Hills;
- till at site #37 (8 ppm) exposed on the northwest slopes of the Birch Mountains;
- till at site #160 (8 ppm) on the Birch River in the lowlands southwest of the Birch Mountains;
- till from site #153 (8 ppm) east of the southernmost segment of the Athabasca River.

Na: Sodium

Sodium detected by NA, varies from 0.05 percent to 0.78 percent (Figures 2.1 and 2.15; Table 2.1). The mean concentration is 0.468 percent and the 95th percentile is 0.699 percent.

The higher concentration of sodium (≥70 ppm) come from sites in the southeastern quadrant. These include:

- till at site #19 (0.78 percent), from the lower unit on a section along the Firebag River, northeast of Fort McMurray;
- shale from site # 29 (0.75 percent) on the west side of the Athabasca River north of Fort McMurray;
- glaciofluvial sand from site #148 (0.74 percent) west of the sharp bend in the southern portion of the Athabasca River;

- till from site #14 (0.72 percent) a section on the southern segment of the Athabasca River;
- till from site #26, (0.71 percent) on the Newby River in the southeast corner of the areas.

Ni: Nickel

Nickel, detected by AA, varies from 4 ppm to 236 ppm (Figures 2.1 and 2.16; Table 2.1). The mean concentration is 27.3 ppm and the 95th percentile is 40.3 ppm.

Elevated concentrations of nickel come from the samples collected on or adjacent to the northern portion of the Buffalo Head Hills, the flanks of the Birch Mountains and, further south, from sections along the southern segment of the Athabasca River. An extremely anomalous result of 236 ppm comes from shale (likely Shaftesbury Fm.) at site #31 (Figure 2.16) along the McIvor River near the northeast tip of the Birch Mountains. High nickel concentrations (≥ 35 ppm) also exist in a number of areas, including:

- the northeast flank of the Buffalo Head Hills (till site #34 (47 ppm) and the lowland to the east, till site #118 (37 ppm);
- the northwest flank of the Birch Mountains and adjacent lowlands, till sites #37 (43 ppm), #160 (38 ppm), and #159 (37 ppm);
- the northeast slopes of the Birch Mountains, till sites #151 (37 ppm) and #30 (37 ppm);
- lacustrine sediment which is likely water laid diamicton, from the Thickwood Hills at site #12 (52 ppm);
- from near the major bend in the Athabasca River southwest of Fort McMurray, till site #147 (48 ppm) and shale site #13 (37 ppm).

Pb: Lead

Lead, detected by AA, varies from 2 ppm to 44 ppm (Figures 2.1 and 2.17; Table 2.1). The mean concentration is 14.3 ppm and the 95th percentile is 20.0 ppm.

The areas with the highest concentration of lead (≥19 ppm) are primarily along the northern side of the Buffalo Head Hills and the Birch Mountains (Figure 2.17). These include till sites #34 (20 ppm) and #42 (20 ppm) on the northeastern tip of the Buffalo Head Hills. Also on the northwest flank of the Birch Mountains till sites #37 (19 ppm), and on the northeast tip till site #156 (21 ppm), carbonaceous siltstone site #32 (20 ppm) and shale site #31 44 ppm). Other sites with high concentrations include:

- till site #128 (20 ppm) west of the central portion of the Athabasca;
- till site #61 (29 ppm) east of Kearl Lake;
- shale from site #13 (39 ppm) on the southern segment of the Athabasca;
- shale site #7 (26 ppm) from a section on Stoney Mountain south of Fort McMurray.

Rb: Rubidium

Rubidium, detected by NA, varies from 14 ppm to 180 ppm (Figures 2.1 and 2.18; Table 2.1). The mean concentration is 80.1 ppm and the 95th percentile is 120 ppm.

High concentrations of rubidium (≥110 ppm) are present in samples from the lowland south of the Caribou Mountains, the northeast tip of the Buffalo Head Hills, the lowland to the east, the Birch Mountains and the southern segment of the Athabasca River (Figure 2.18). Specifically the sites are:

- south of the Caribou Mountains, till site #163 (110 ppm) and site #107 (110 ppm);

- northeast tip of the Buffalo Head Hills and adjacent lowland, till sites #42 (120 ppm), #118 (110 ppm), #2 (110 ppm), and #105 (110 ppm);
- Birch Mountain till sites #37 (110 ppm), #156 (120 ppm), shale site # 31 (140 ppm) , and till sites #30 (130 ppm), #15 (120 ppm);
- the southern Athabasca River, lacustrine sediment, likely water laid diamicton, site #12 (120 ppm), and shale site #13 (130 ppm). Other sites with high concentrations of rubidium are Clearwater shale from site #29 (180 ppm) northwest of Fort McMurray, and till from site #61 (120 ppm) east of Kearl Lake northeast of Fort McMurray.

Sb: Antimony

Antimony, detected by NA, varies from 0.2 ppm to 2.2 ppm (Figures 2.1 and 2.19; Table 2.1). The mean concentration is 0.80 ppm and the 95th percentile is 1.55 ppm.

Antimony occurs in higher concentrations (≥1.4 ppm) primarily in two areas:

- sites on the northeast portion of the Buffalo Head Hills, till sites #34 (1.8 ppm) and #42 (1.5 ppm);
- the Birch Mountains (till sites #159 (1.7 ppm), #37 (1.4 ppm), and #156 (2.2 ppm) and shale site #31 (1.5 ppm), and till sites #15 (1.4 ppm), and #30 (1.9 ppm).

High concentrations are also in till from site #61 (1.4 ppm) east of Kearl Lake, situated northeast of Fort McMurray, and at two tills sites southwest (site #153, 1.6 ppm) and site #10 (1.4 ppm) southeast of Fort McMurray

Sn: Tin

Tin was analysed for using neutron activation. Tin is below the detection limit at all the sampled sites.

Th: Thorium

Thorium, detected by NA, varies from 3.6 ppm to 28.3 ppm (Figures 2.1 and 2.20; Table 2.1). The mean concentration is 10.7 ppm and the 95th percentile is 15.0 ppm.

The pattern for high concentrations of thorium differs from the other elements. There are no high results from sites on the west side of the Birch Mountains, in the lowland west of there, and only one site on the Buffalo Head Hills (Figure 2.20). The highest concentrations are from a sample of glaciofluvial sand collected at site #48 (22 ppm) northwest of the southward bend in the Athabasca River, and site #7 (28 ppm) at shale section on Stoney Mountain south of Fort McMurray. Moderately elevated amounts (≥ 14 ppm) of thorium are present in samples from:

- south of the Caribou Mountains, till sites #45 (14 ppm) and #163 (15 ppm);
- the northeast flank of Buffalo Head Hills, till site #42, (14 ppm);
- the Birch Mountains, till sites #15, (14 ppm), and #30 (15 ppm);
- south and east of the Athabasca and Clearwater River, till sites #26 (14 ppm), #27 (14 ppm), #10 (16 ppm), and #65 (14 ppm)
- from shale near the sharp bend in the southern portion of the Athabasca River, site #13 (14 ppm).

U: Uranium

Uranium, detected by NA, varies from 1.1 ppm to 7.75 ppm (Figures 2.1 and 2.21; Table 2.1). The mean concentration is 3.35 ppm and the 95th percentile is 5.65 ppm. The distribution pattern for sites with high concentrations of uranium (≥4 ppm) differs from that of other elements, because there are no values in the southwest quadrant of the study area (Figure 2.21).

The highest concentrations of uranium (≥6 ppm) are from a till site (6.2

ppm) on the northeast tip of the Buffalo Head Hills; sites on the northeast tip of the Birch Mountains near McIvor River, till site #156 (6 ppm) and shale site #32 (7.8 ppm) and till from a site overlying the Grand Rapids Sandstone on the Clearwater River southeast of Fort McMurray, till site #10 (6.8 ppm).

Sites with concentrations (≥5 ppm) are situated on:

- the northeast tip of the Buffalo Head Hills, till site #42 (5.0 ppm);
- the west flank of the Birch Mountains, till site #37 (5.7 ppm);
- the east flank of the Birch Mountains, till site # 30 (5.3 ppm);
- the southern flank of the Birch Mountains, glaciofluvial site #148 (5.2 ppm);
- the east of the central portion of the Athabasca River, till site #61 (5.2 ppm);
- the south of Fort McMurray, shale site # 7 (5.0 ppm).

V: Vanadium

Vanadium, detected by AA, varies from 25 ppm to 261 ppm (Figure 2.1 and 2.22; Table 2.1). The mean concentration is 123 ppm and the 95th percentile is 217 ppm.

Vanadium shows a concentration pattern that is similar to that exhibited by many other elements with higher concentrations (≥200 ppm) from:

- sites on the northeast portion of the Buffalo Head Hills, till site #34 (250 ppm);
- the flanks and top of the Birch Mountains, till sites #37 (261 ppm), #159 (200 ppm), #156 (230 ppm), #30 (236 ppm) and #15 (204 ppm);
- the sites near the bend in the southern portion of the Athabasca River, shale site #13 (237 ppm) and lacustrine sediment from site #12 (207 ppm);
- a site in the Clearwater Shale north of Fort McMurray, site #29 (201 ppm) and one site overlying the Grand Rapids Sandstone on the

Clearwater River southeast of Fort McMurray, till site #10 (206 ppm).

W: Tungsten

Tungsten concentration, detected by NA, varies from below the detection limit of 1 ppm at most sites to 2 ppm at a few sites (Figure 2.1 and 2.23; Table 2.1). The 95th percentile is 1.0 ppm.

Tungsten has a low concentration throughout most of the area. The only sites with comparatively high values (all 2 ppm) are:

- waterlain till at site #5 (2 ppm) west of Fort McMurray;
- shale from site #13 (2 ppm) and till at site #147 (2 ppm) near the bend in the southern portion of the Athabasca River;
- till site #27 (2 ppm) near Gypsy Lake southeast of Fort McMurray.

Zn: Zinc

Zinc, detected by AA, varies from 19 ppm to 150 ppm (Figures 2.1 and 2.24; Table 2.1). The mean concentration is 73.9 ppm and the 95th percentile is 119 ppm.

The highest concentrations of zinc (≥124 ppm) are from:

- sites on the northeast tip of the Buffalo Head Hills, till site #34 (147 ppm);
- on the flanks of the northern portion of the Birch Mountains, till site #37 (136 ppm), and shale site #31 (150 ppm);
- at the big bend in the southern portion of the Athabasca River, shale site #13 (148 ppm);
- west of the Athabasca River north of Fort McMurray, Clearwater Shale site #29 (124 ppm).

Sites with concentration greater than 100 ppm include:

- those in the lowland between the Buffalo Head Hills and the Birch

Mountains, till sites #118 (109 ppm), #2 (114 ppm), #117 (107 ppm), #105 (101 ppm), and #103 (103 ppm);

- sites along the margins of the Birch Mountains, till sites #159 (107 ppm; #151 (103 ppm); and sites along the southern portion of the Athabasca River, till sites #147 (102 ppm) and #14 (100 ppm).

Zr: Zirconium

Zirconium concentration, detected by NA, varies from below the detection limit of 200 ppm at some sites to 1900 ppm (Figures 2.1 and 2.25; Table 2.1). The mean concentration is 407 ppm and the 95th percentile is 622 ppm.

The sites with high concentrations of zirconium are mainly on the east side of the Birch Mountains (Figure 2.25). A result of 1900 ppm was obtained from glaciofluvial sand at site #148 which is northwest of the southward bend in the Athabasca River. Other sites with elevated amounts of zirconium (≥ 600 ppm) include:

- shale from the northeast portion of the Birch Mountains, site #32 (615 ppm);
- till on the west side of the Athabasca River north of Fort McMurray, site #149 (670 ppm);
- till from a section on the MacKay River west of Fort McMurray, site #146 (630 ppm);
- till from a section on the north wall of the broad valley containing the Clearwater River, site #144 (630 ppm);
- till from a section on the southern segment of the Athabasca River, site #147 (860 ppm);
- till from a section on the Christina River which overlies the Grand Rapids Sandstone, site #10 (600 ppm).

2.2.3 Inter-element Variations

Comprehensive comparison of the relative variations in concentrations between all the elements is beyond the scope of this interim report. However, scatter plots for each pair of elements were made. This process revealed that there were three sites which contain elevated concentrations of Co, Cr, Li, Sb, and Zn (Figure 2.26a). These three anomalous sites are in the northeast corner of the Buffalo Head Hills (site #34 in Figure 2.26b) and the northwest and northeast corners of the Birch Mountains (site #37 and #31, respectively, in Figure 2.26b). These sites fall along an east-west linear trend that extends from the Birch Mountains to the Buffalo Head Hills. This may just be a coincidence or it may indicate a possible control by an underlying geological structure. One of these sites is from a bedrock sample (site #31, northeast Birch Mountains). The other two are samples of till, which indicates that the bedrock source of the till was derived from, should have an even higher concentration of these elements.

2.2.4 Multiple-till Section

Fenton (in Dufresne, 1994) has described the Quaternary geology along the Firebag River, a drainage way which lies in the northeastern portion of the study area and drains northwestward into the Athabasca River (Figure 1.3). Geological sections exposed along the Firebag River show at a few sites that multiple till units are present. Samples were collected from a number of the Firebag River sections, including those that contain more than one till unit.

The preliminary results of geochemical analysis of one section which exposed three till units is shown in Figure 2.27 and Table 5.2. This figure is based on data from three samples, collected from each of the units. The sample from unit 1 came from about 3.5 m, the sample from unit 2 at 7.5 m, and the sample from unit 3 at 15 m down from the top of the section.

Figure 2.27 shows that there is a variation in the geochemical composition between the three layers, with the trend or direction of inter-layer variation differing between the elements. For example, the concentration of some elements, such as Ba, Mo, Cr, U, and V increases with depth, where others such as Au, Br, Co, Cu, Fe, Mn, Na, Rb, Th, and Zr, decrease with depth. Finally, some elements are most concentrated in the middle layer, including Ag, As, Cd, Li, Pb, Rb, and Zn. Whether these changes are consistent between sections is presently unknown.

Table 2.1 Geochemical data: detection limit and summary statistics for each of the elements discussed in this report.

Element Symbol	Element Name	Analytical Method	Detection Limit	Min. (1)	Max.	Mean	95th percentile	60th percentile
Ag	silver	AA	0.2 ppm	0.1	1.6	0.3	0.7	0.3
As	arsenic	NA	0.5 ppm	1.1	47.0	11.1	22.2	12.0
Au	gold	NA	2 ppb	1.0	21.0	4.8	14.0	4.0
Ba	barium	NA	50 ppm	170	1300	602	984	658
Br	bromine	NA	0.5 ppm	bdl 0.25	12	2.3	4.1	2.2
Cd	cadmium	AA	0.2 ppm	bdl 0.1	0.5	0.15	0.30	0.10
Co	cobalt	AA	2 ppm	2	41	11.7	26.5	11.0
Cr	chromium	NA	20 ppm	bdl 10	130	68.4	104.5	77.0
Cu	copper	AA	2 ppm	3	50	21.8	34.5	26.0
Fe	iron	AA	0.02 %	0.10	6.20	2.56	3.95	2.80
Li	lithium	AA	1.0 ppm	6	40	19.2	32.1	21.2
Mn	manganese	AA	5 ppm	34	940	269	471	281
Mo	molybdenum	AA	2 ppm	bdl 1	12	4.5	8.0	5.0
Na	sodium	NA	0.02%	0.05	0.78	0.47	0.70	0.51
Ni	nickel	AA	2 ppm	4	236	27.3	40.3	27.0
Pb	lead	AA	2 ppm	2	44	14.3	20.0	15.0
Rb	rubidium	NA	5 ppm	14	180	80.1	120.0	89.0
Sb	antimony	NA	0.1 ppm	0.2	2.2	0.80	1.55	0.80
Th	thorium	NA	0.2 ppm	3.6	28.3	10.7	15.0	11.0
U	uranium	NA	0.2 ppm	1.1	7.8	3.4	5.6	3.4
V	vanadium	AA	5 ppm	25	261	123	217	137
W	tungsten	NA	1 ppm	bdl 0.5	2	0.82	1.00	1.00
Zn	zinc	AA	2 ppm	19	150	73.9	119.0	84.0
Zr	zirconium	NA	200 ppm	bdl100	1900	407	622	438

AA = atomic absorption, total = total digestion of sample, NA = neutron activation,
ppm = parts per million, ppb = parts per billion

(1) Note the statistics were calculated using a value of one half of the detection limit for any sample that was below the detection limit. The minimum value calculated for this table may therefore be less than the detection limit. These values are prefixed by "bdl"

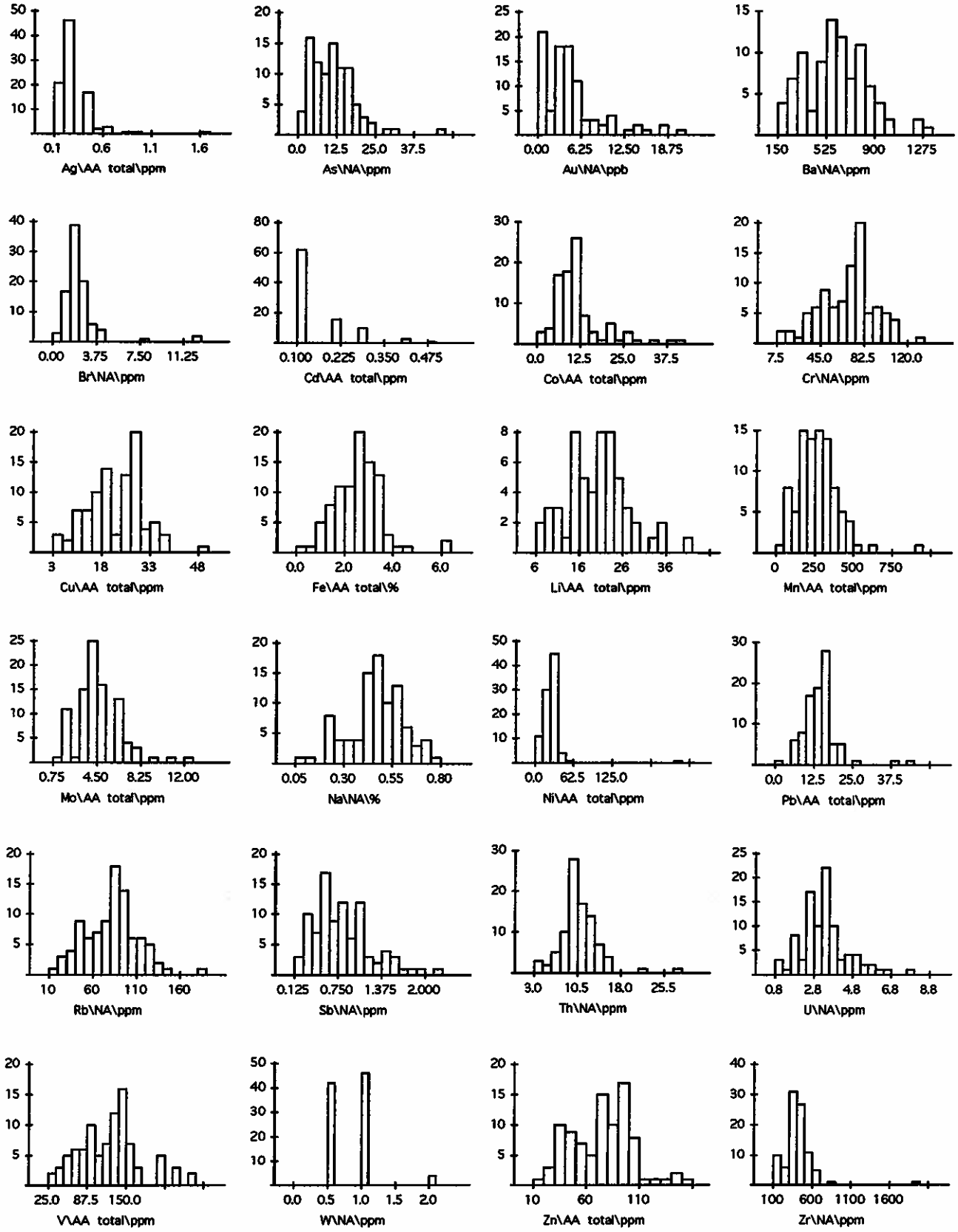

Figure 2.1. Histograms showing the variation in concentration of each element. Abbreviations: AA= atomic absorption, NA = neutron activation, total = total digestion prior to AA.

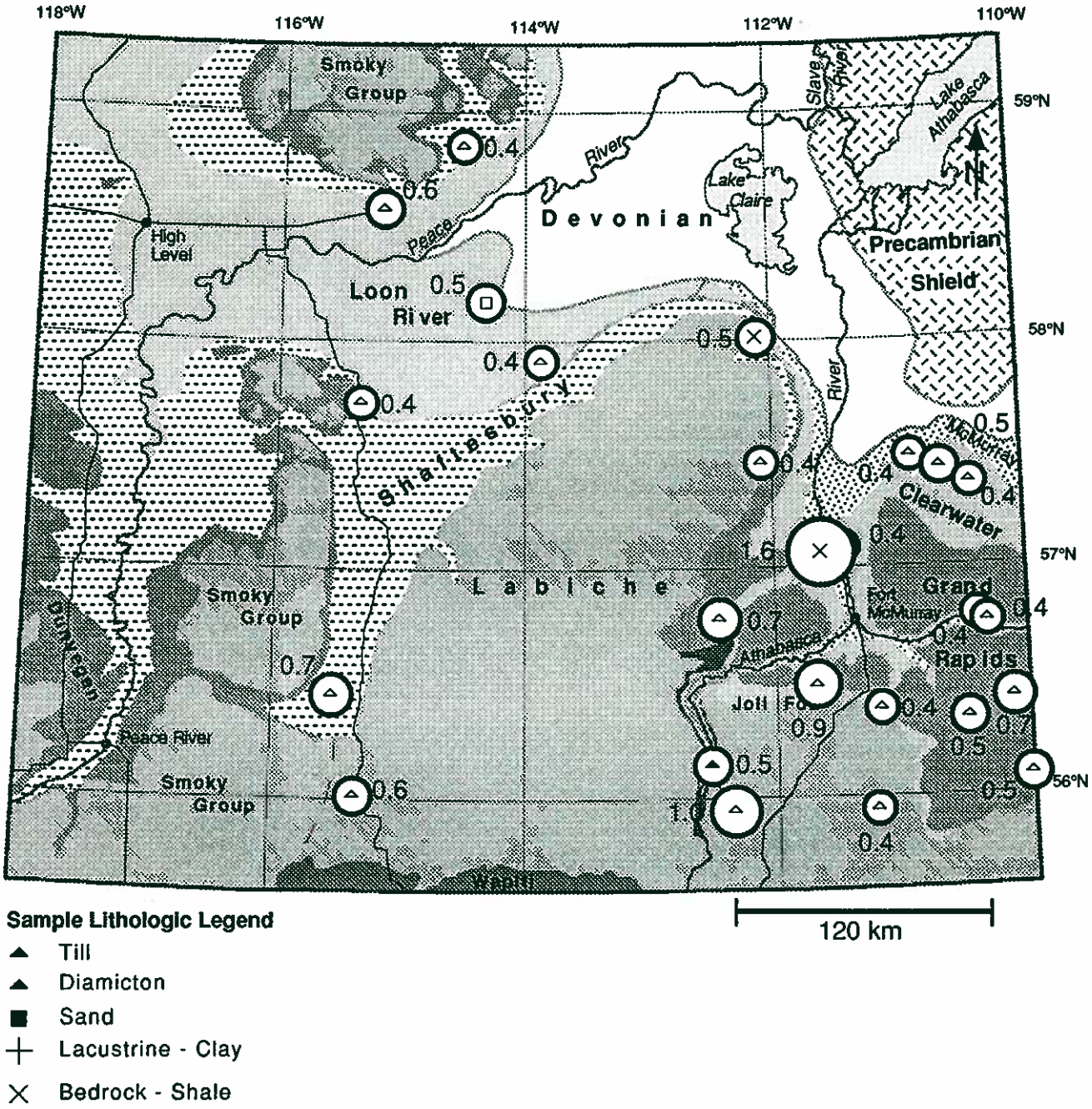

Figure 2.2. Silver concentration (AA), greater than 0.3 ppm: bubble plot map.

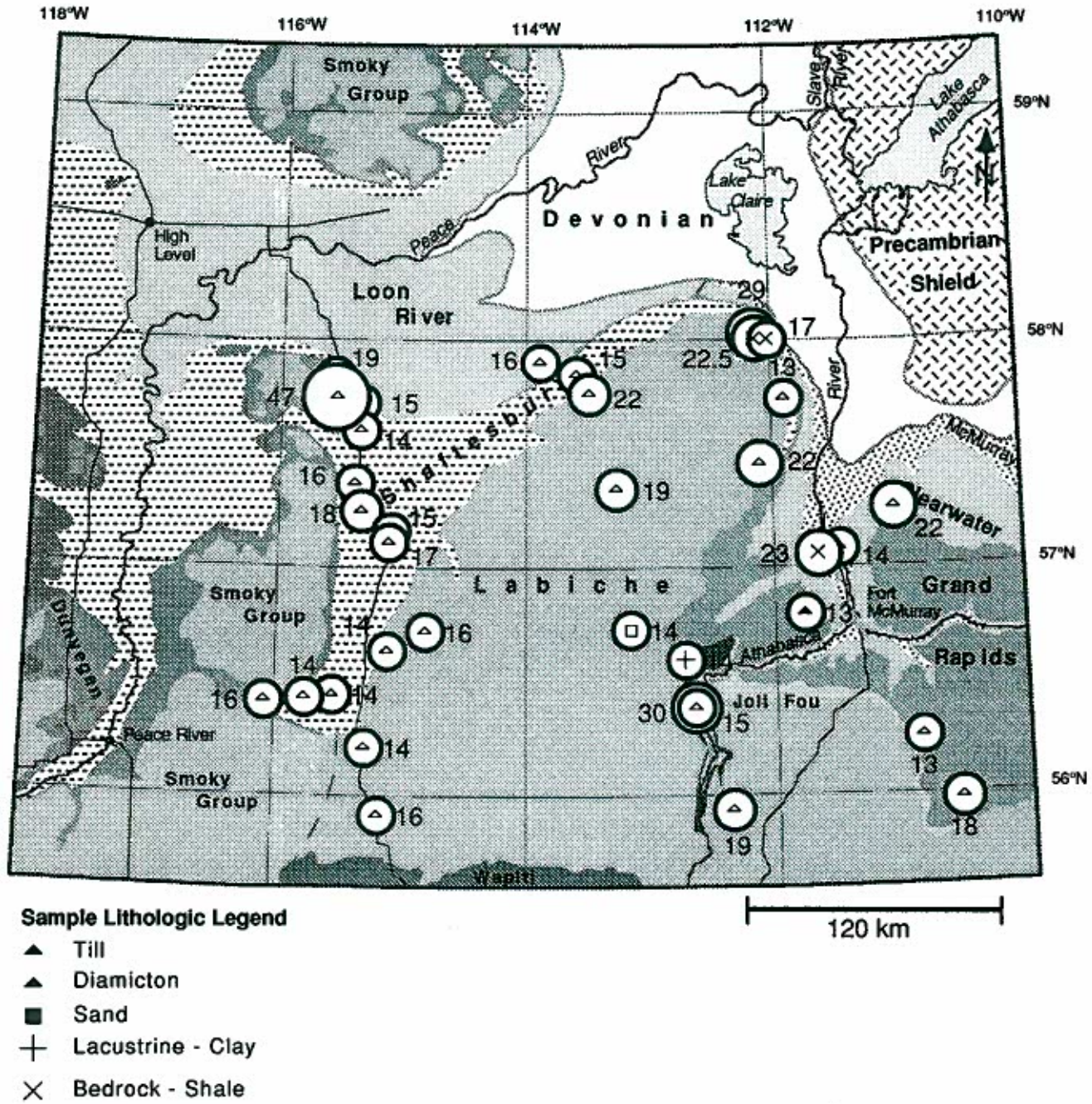

Figure 2.3. Arsenic concentration (NA), greater than 12 ppm: bubble plot map.

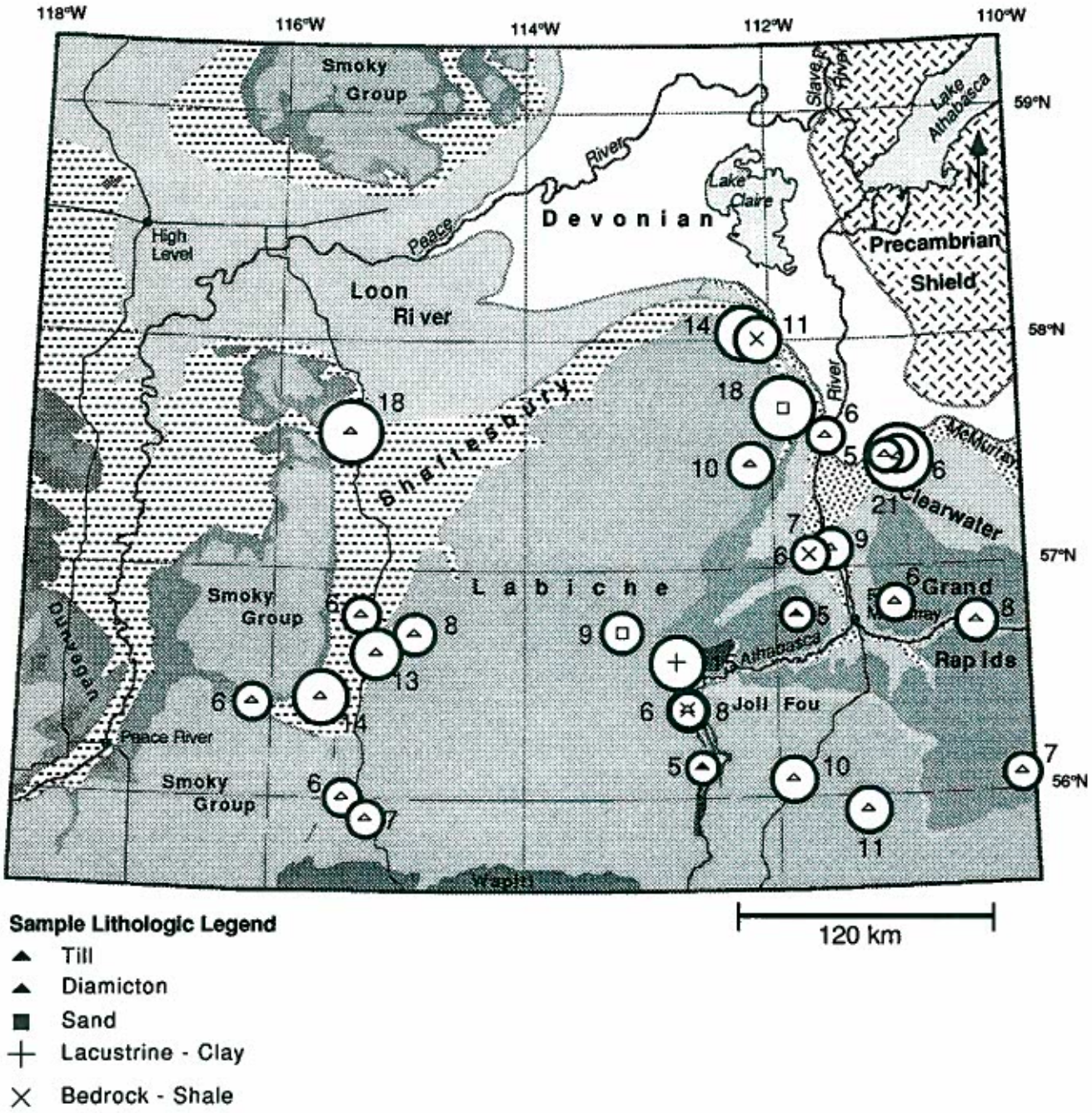

Figure 2.4. Gold concentration (NA), greater than 4 ppb: bubble plot map.

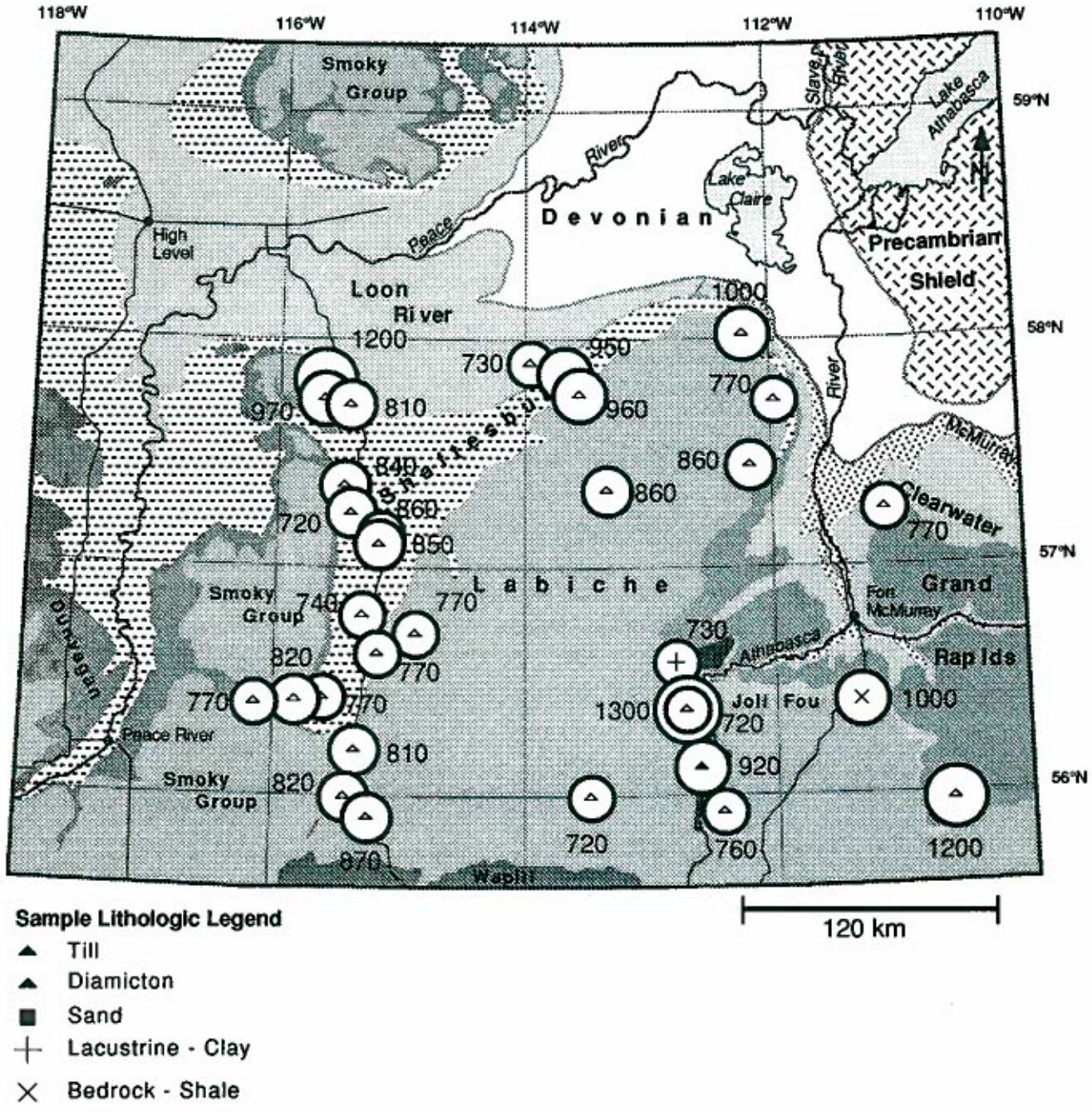

Figure 2.5. Barium concentration (NA), greater than 700 ppm: bubble plot map.

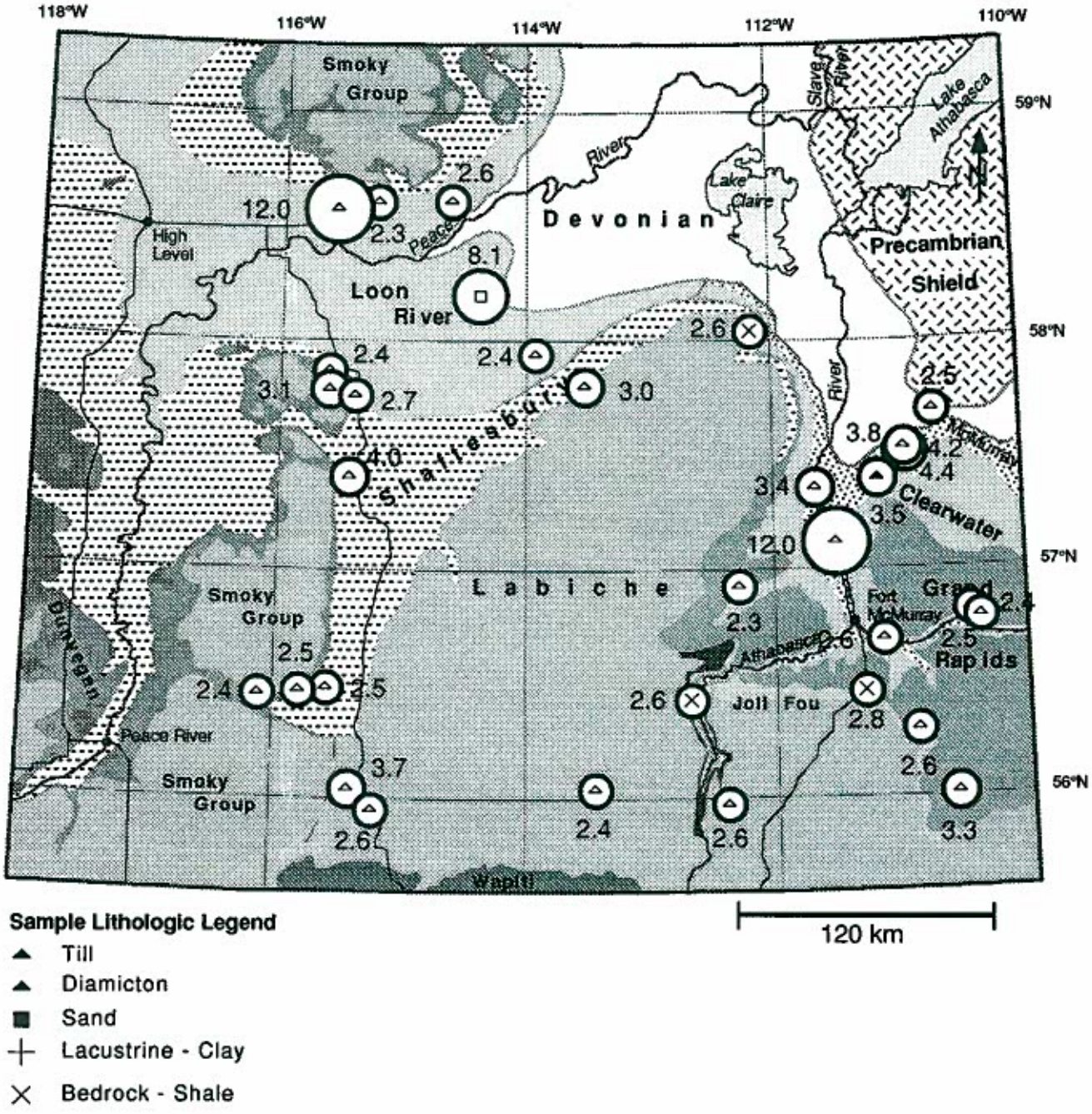

Figure 2.6. Bromine concentration (NA), greater than 2 ppm: bubble plot map.

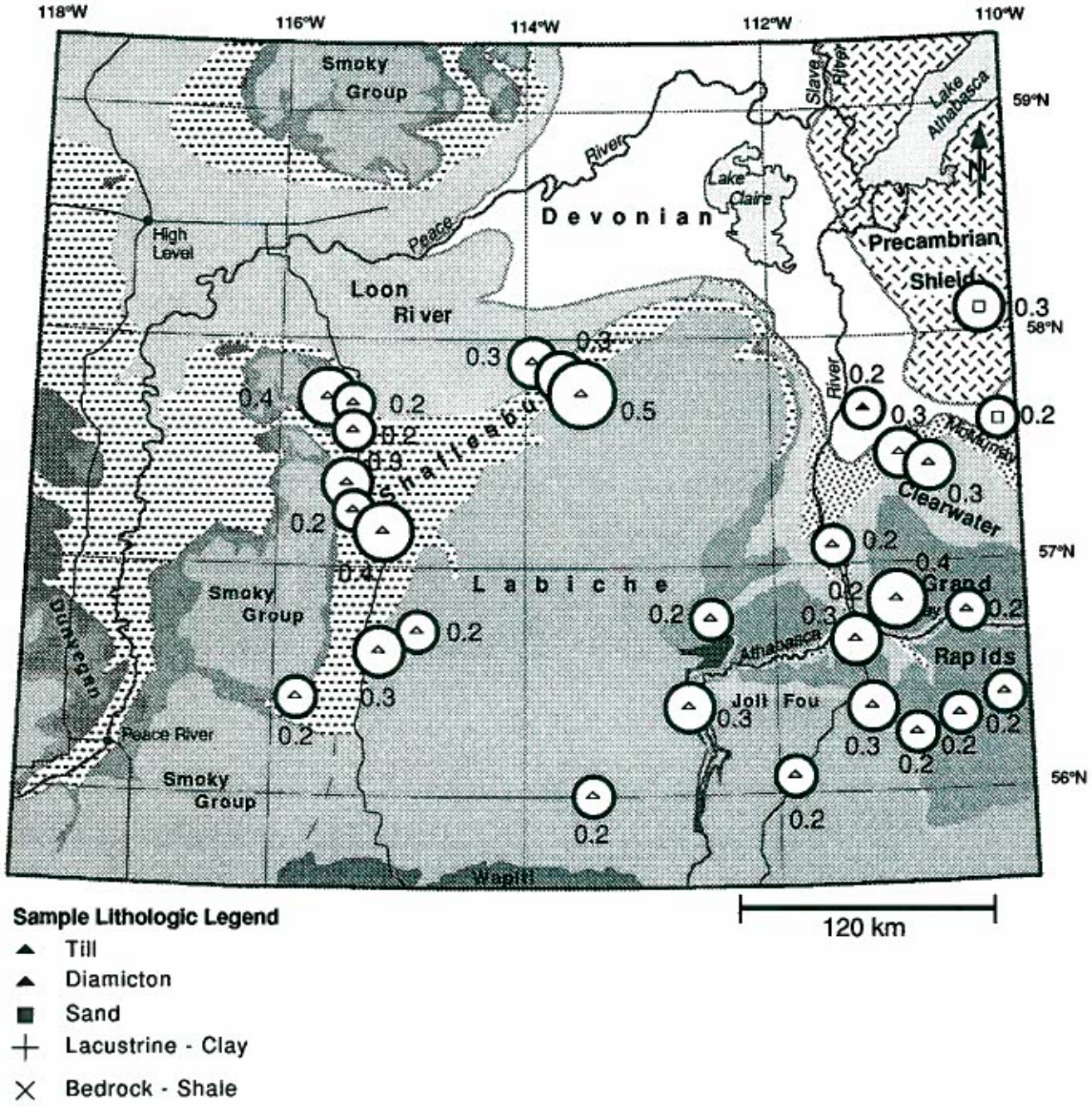

Figure 2.7. Cadmium concentration (AA), greater than 0.1 ppm: bubble plot map.

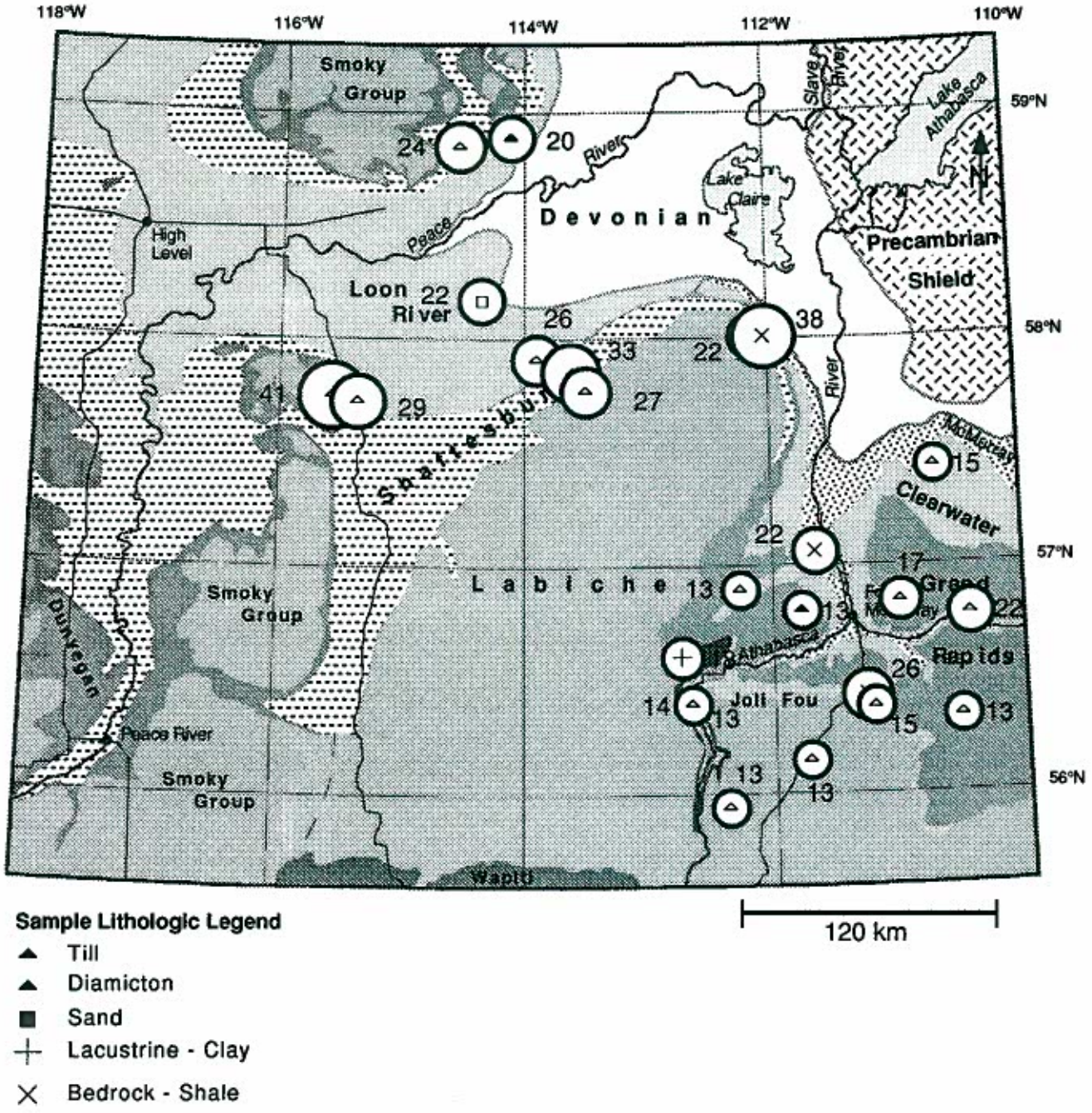

Figure 2.8. Cobalt concentration (AA), greater than 12 ppm: bubble plot map.

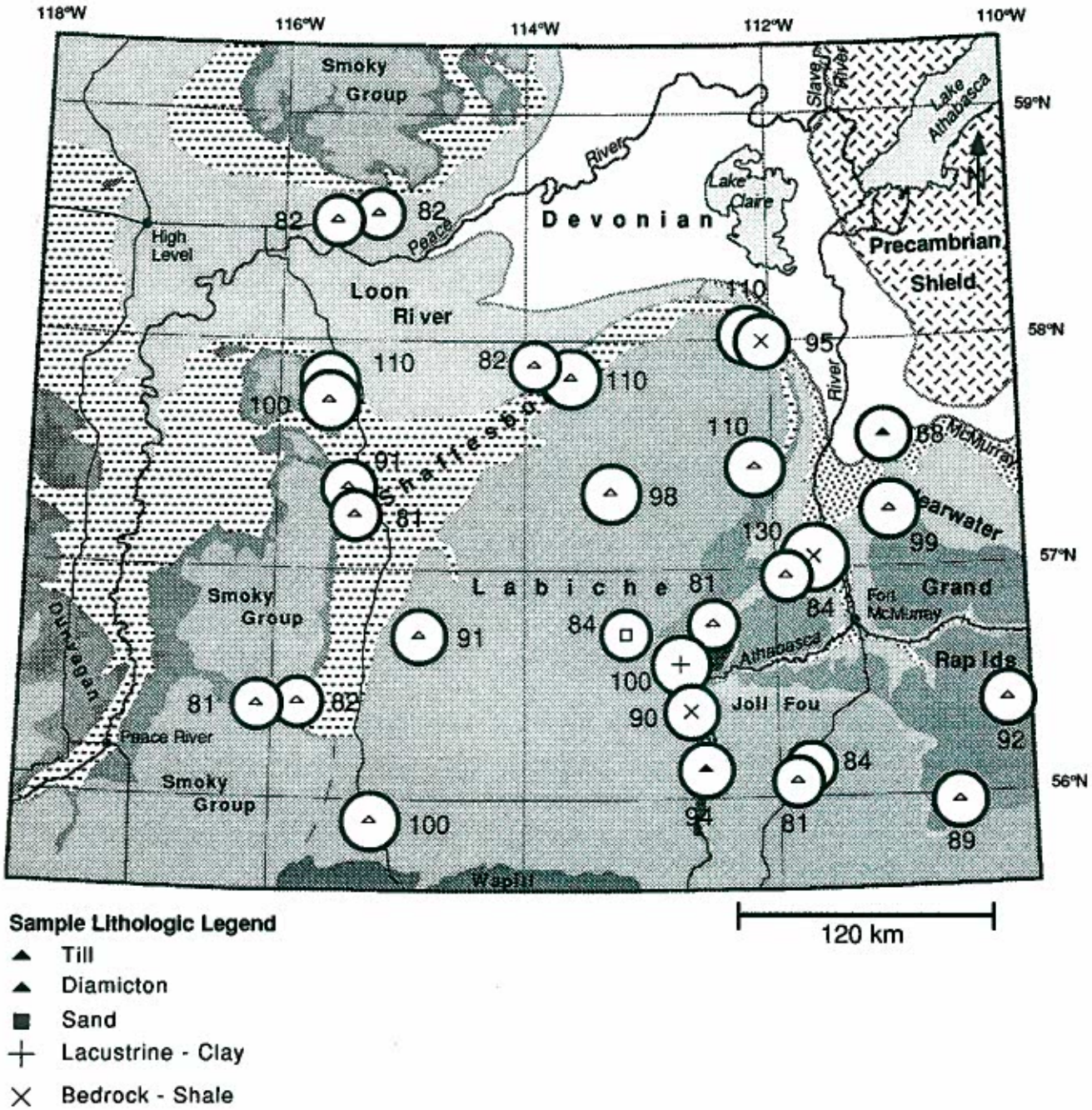

Figure 2.9. Chromium concentration (NA), greater than 80 ppm: bubble plot map.

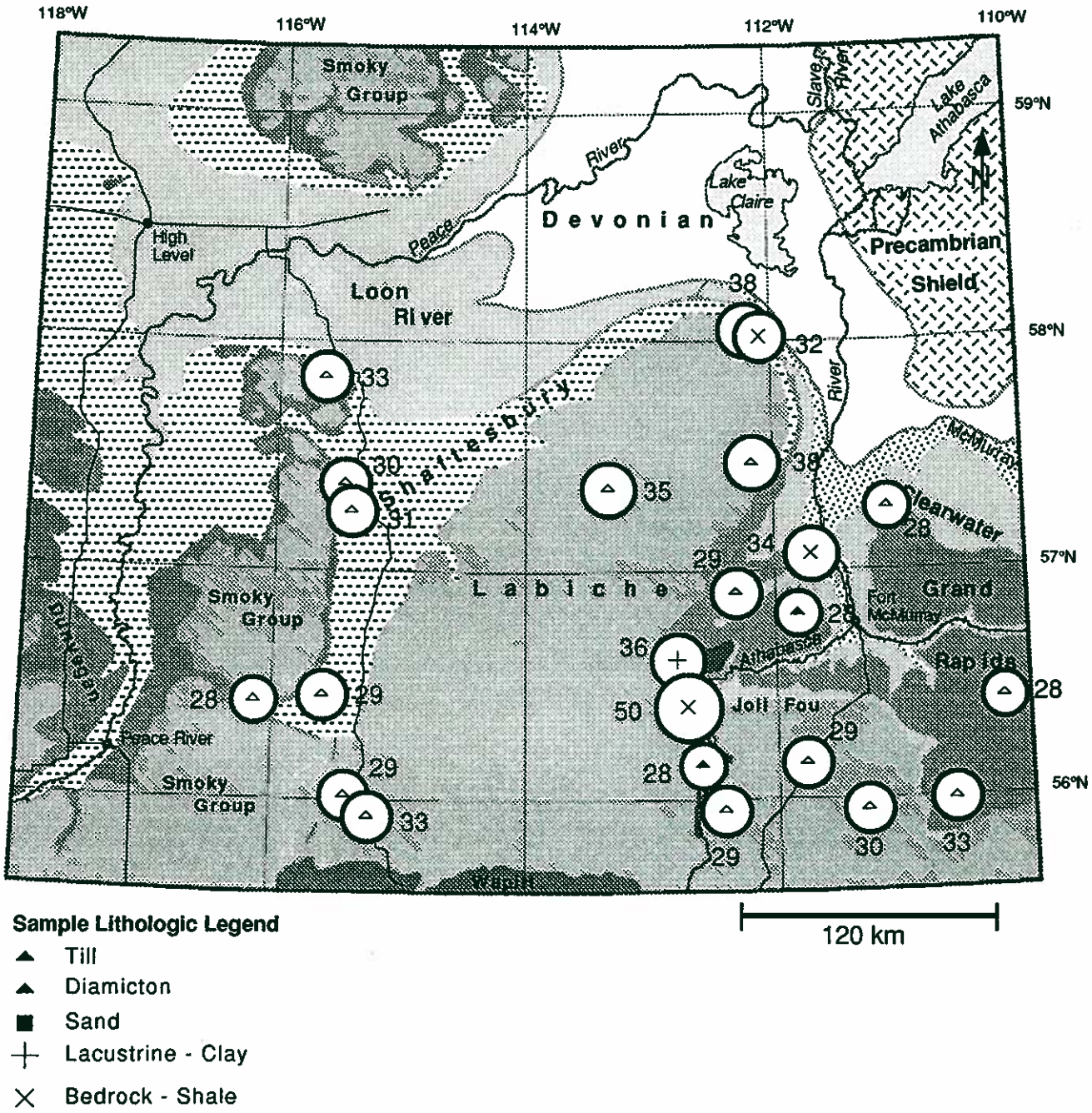

Figure 2.10. Copper concentration (NA), greater than 27 ppm: bubble plot map.

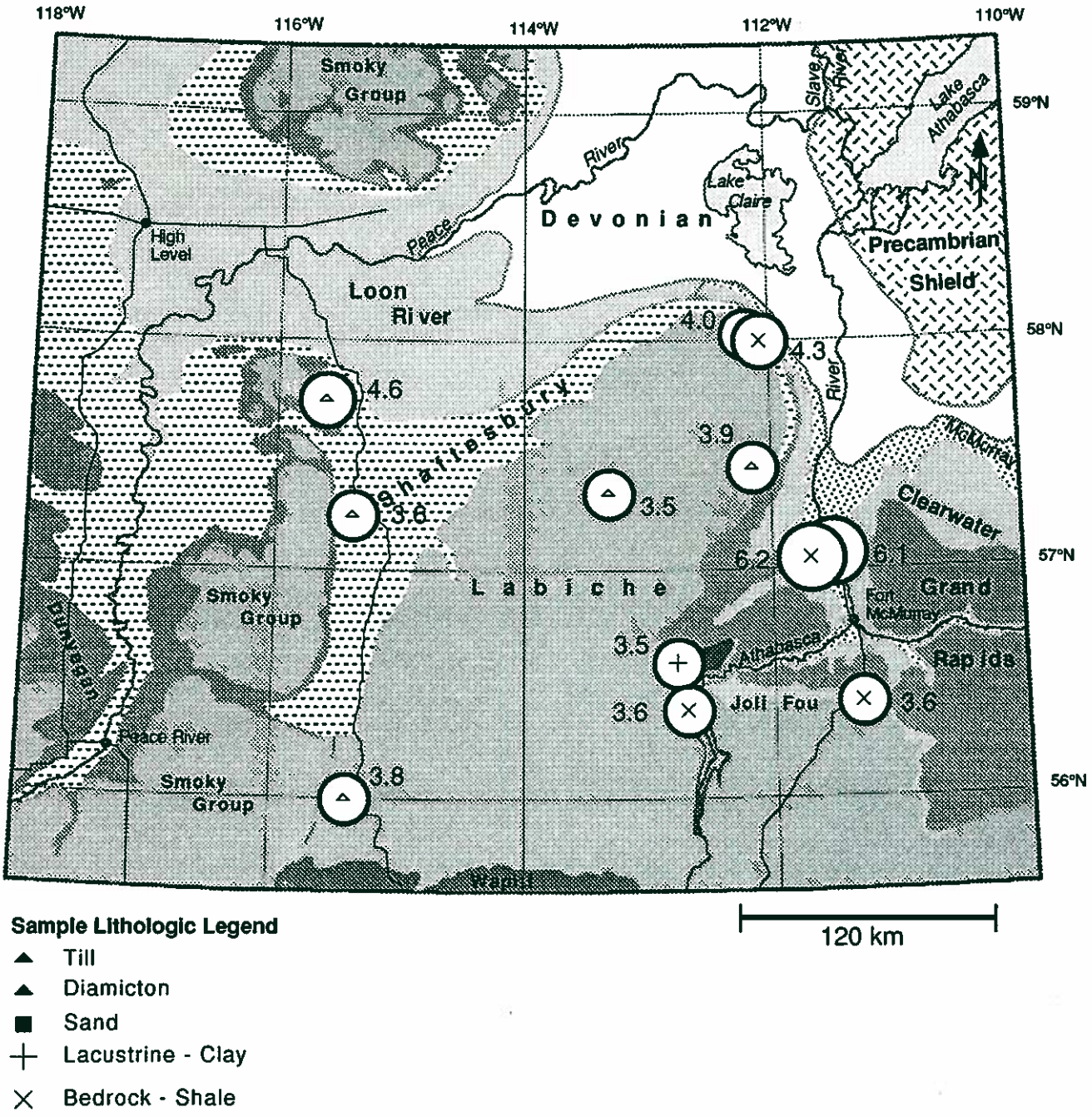

Figure 2.11. Iron concentration (AA), greater than 3 percent: bubble plot map.

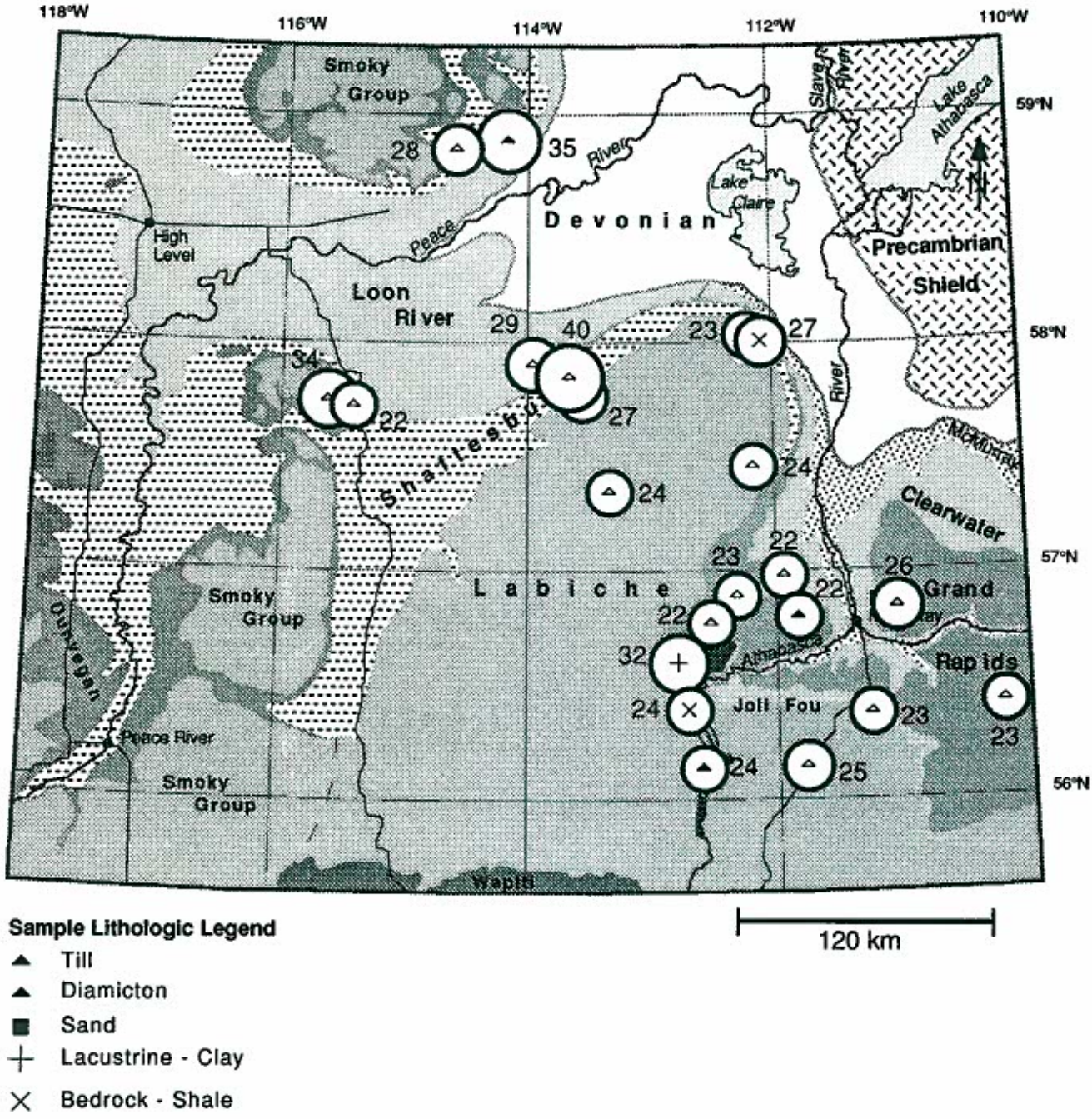

Figure 2.12. Lithium concentration (AA), greater than 21 ppm: bubble plot map.

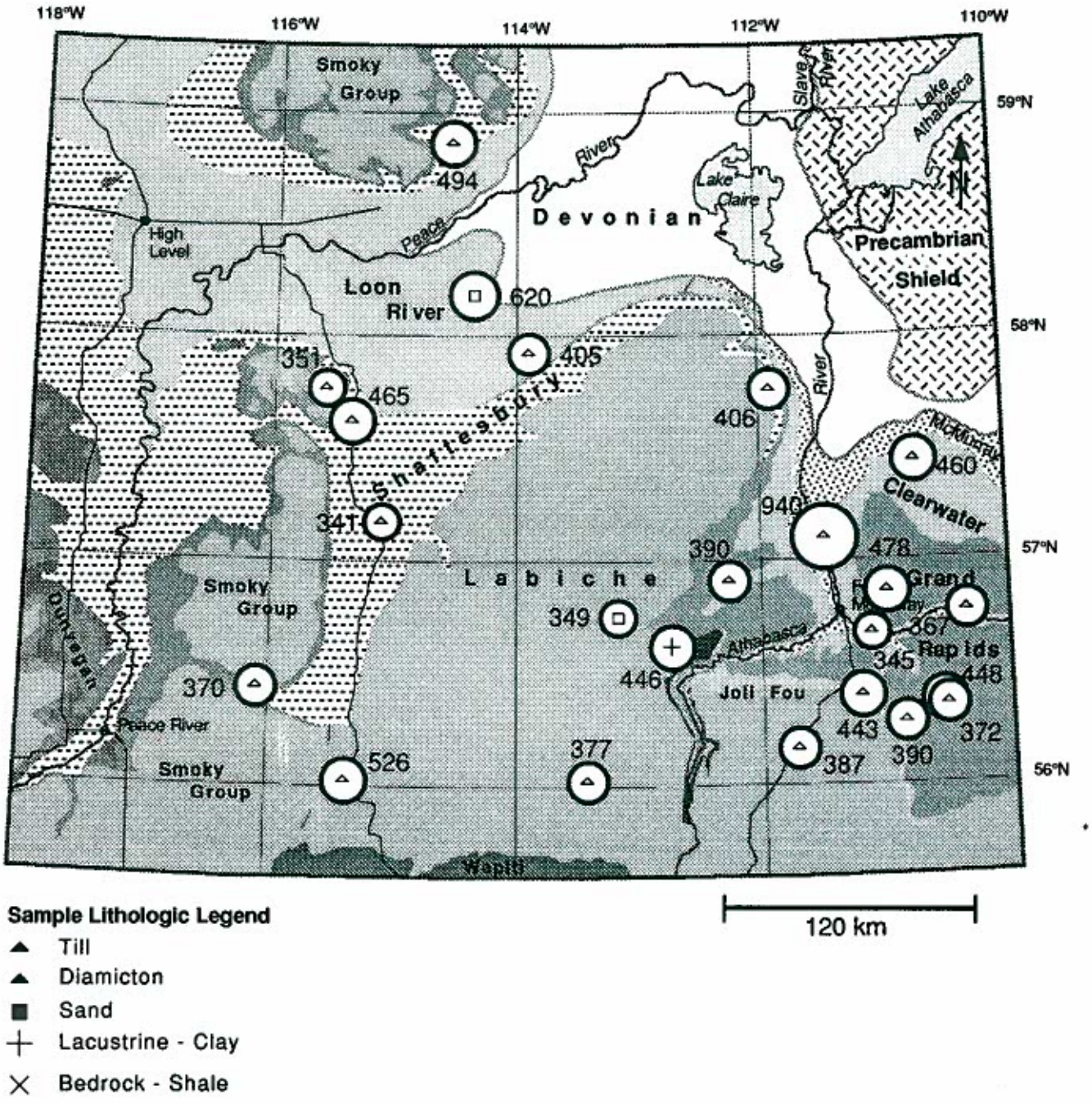

Figure 2.13. Manganese concentration (AA), greater than 340 ppm: bubble plot map.

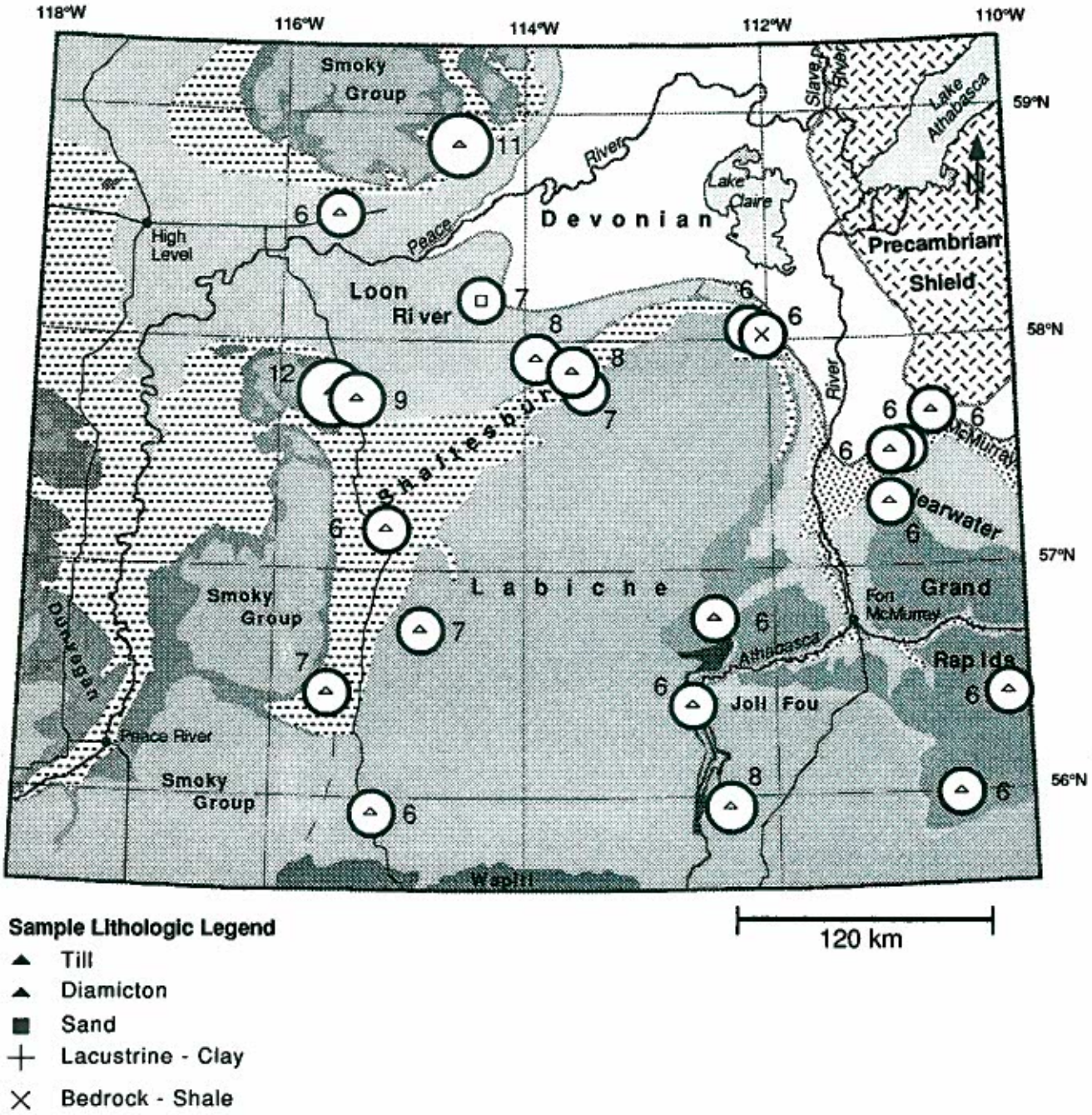

Figure 2.14. Molybdenum concentration (AA), greater than 5 ppm: bubble plot map.

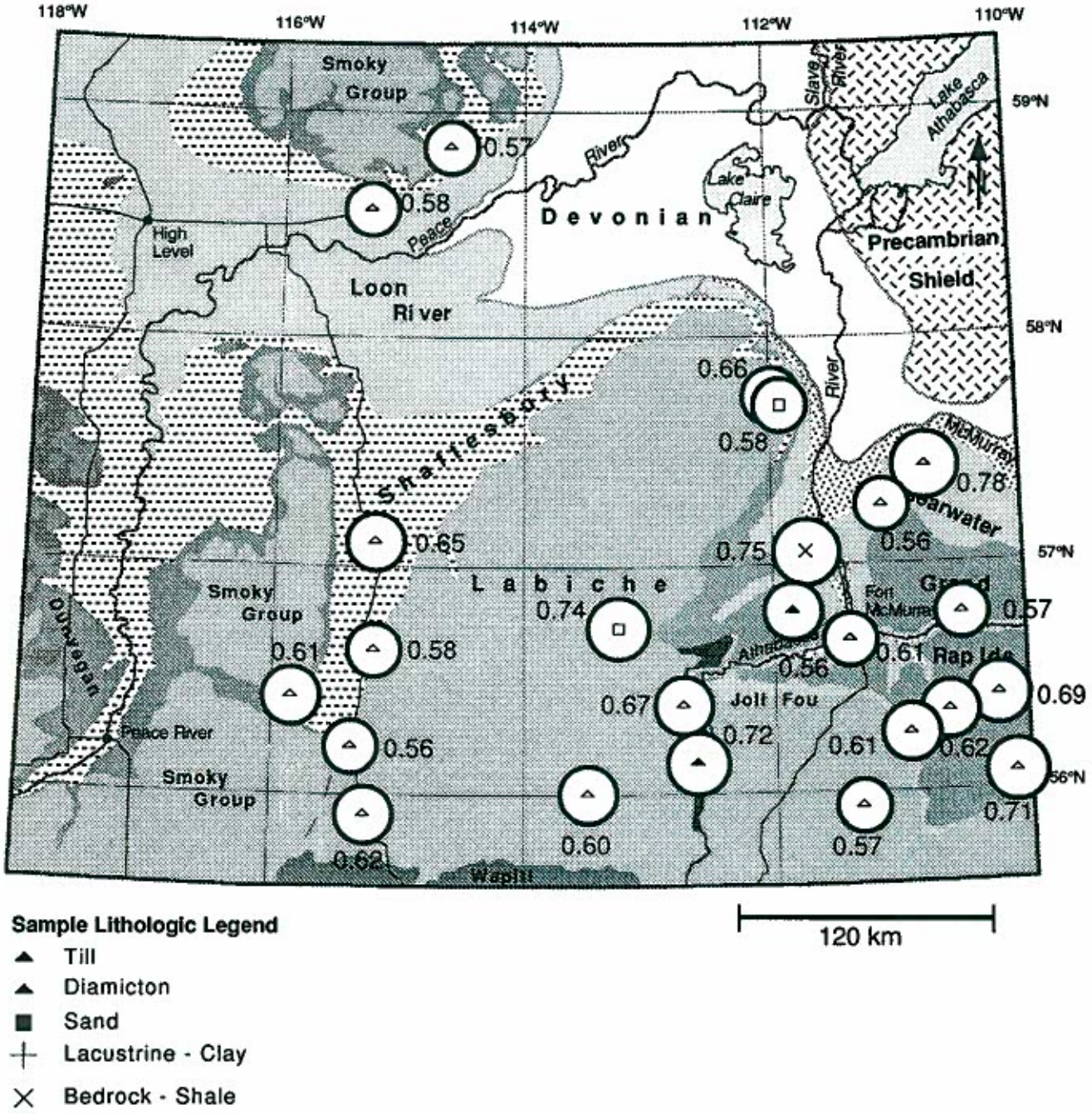

Figure 2.15. Sodium concentration (NA), greater than 0.55 percent: bubble plot map.

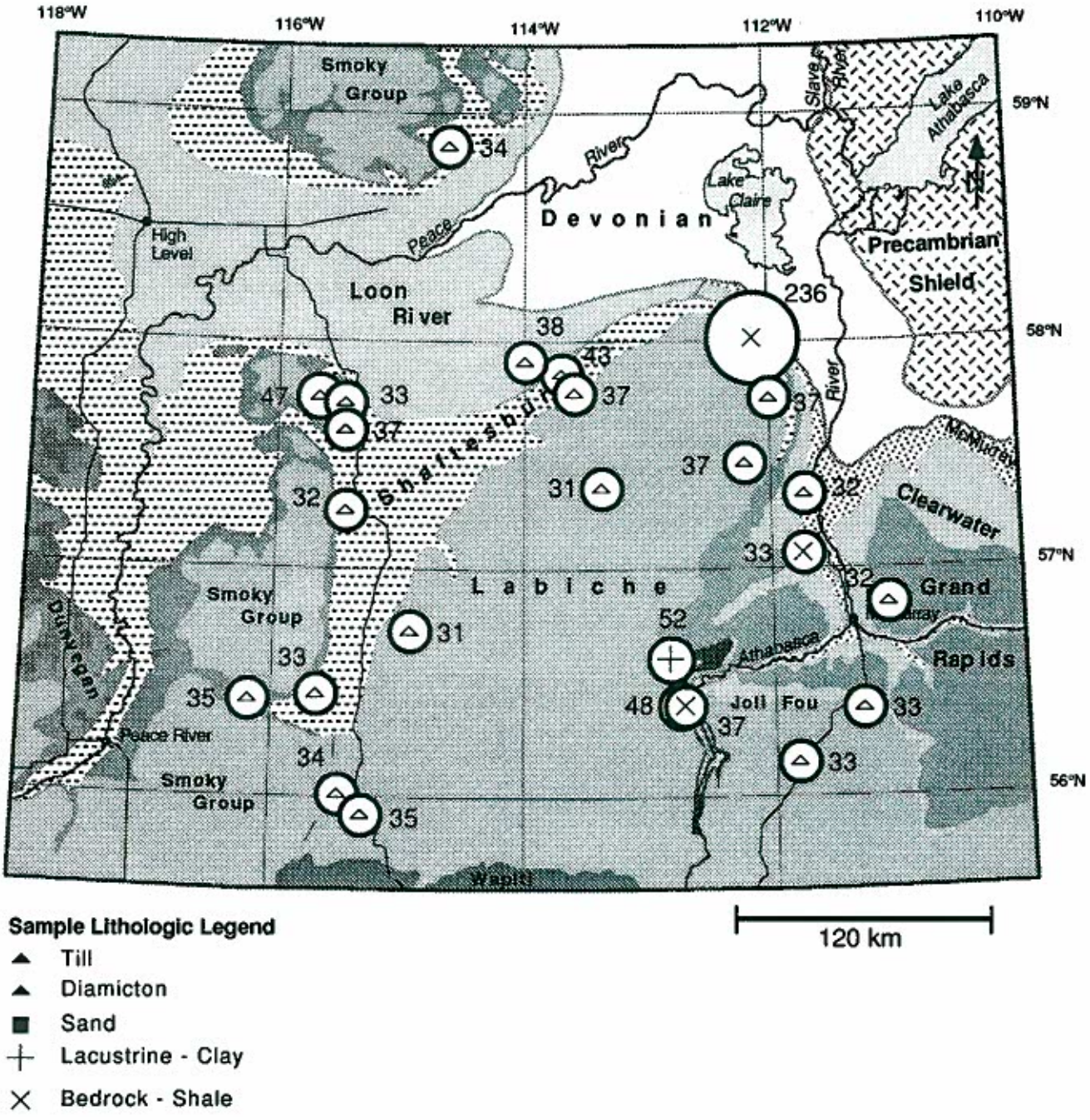

Figure 2.16. Nickel concentration (AA), greater than 30 ppm: bubble plot map.

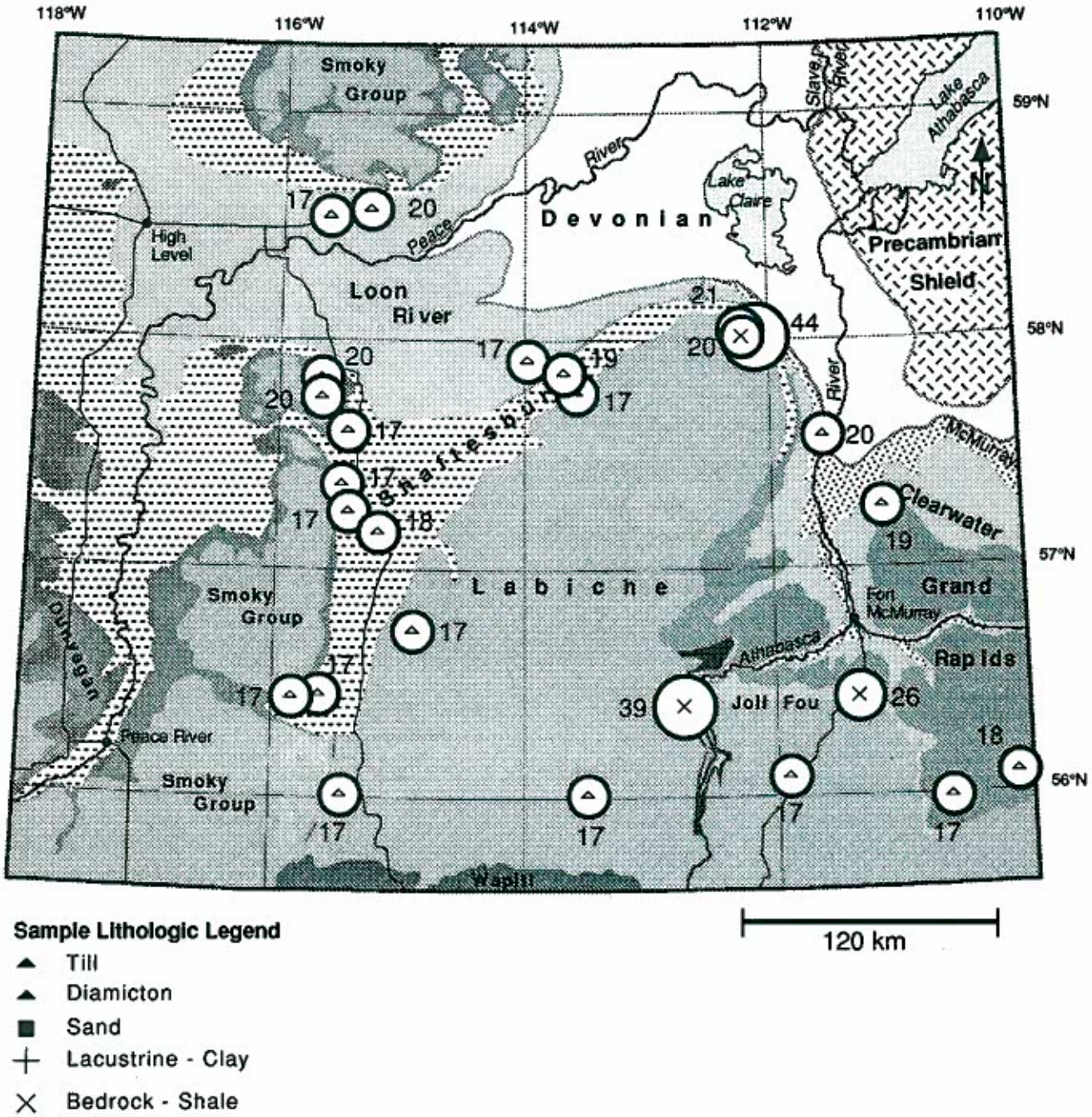

Figure 2.17. Lead concentration (AA), greater than 16 ppm: bubble plot map.

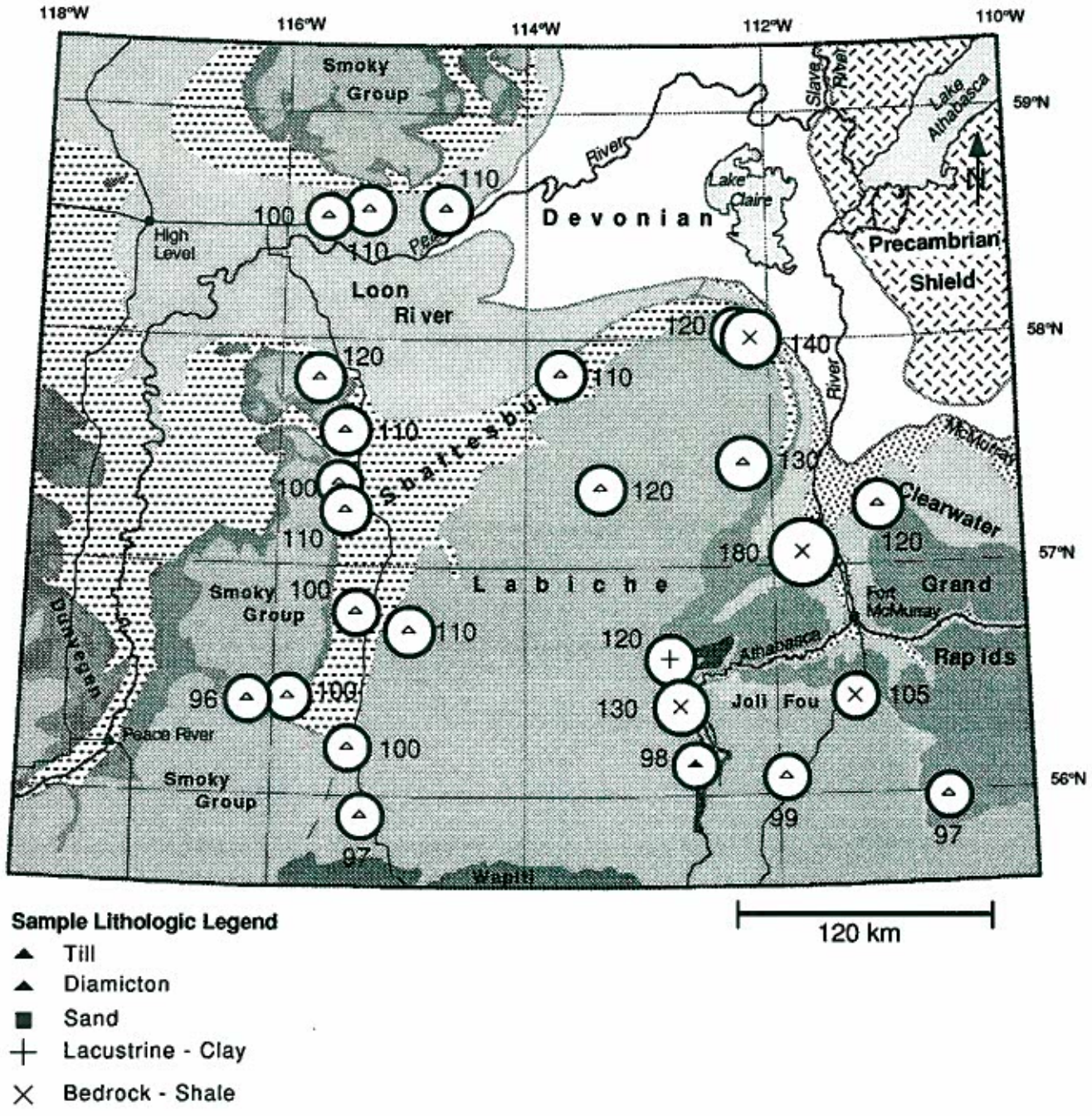

Figure 2.18. Rubidium concentration (NA), greater than 95 ppm: bubble plot map.

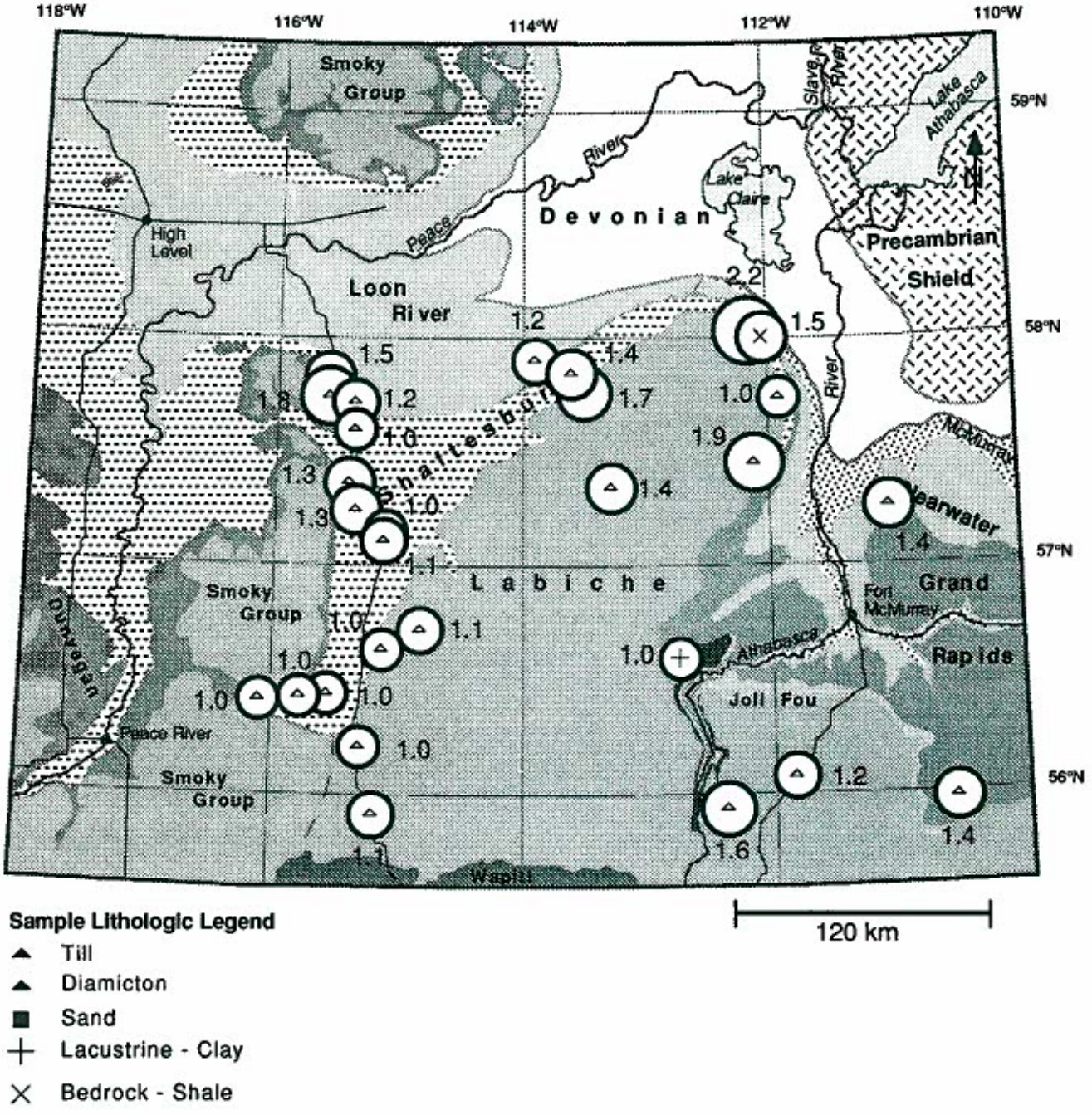

Figure 2.19. Antimony concentration (NA), greater than 0.9 ppm: bubble plot map.

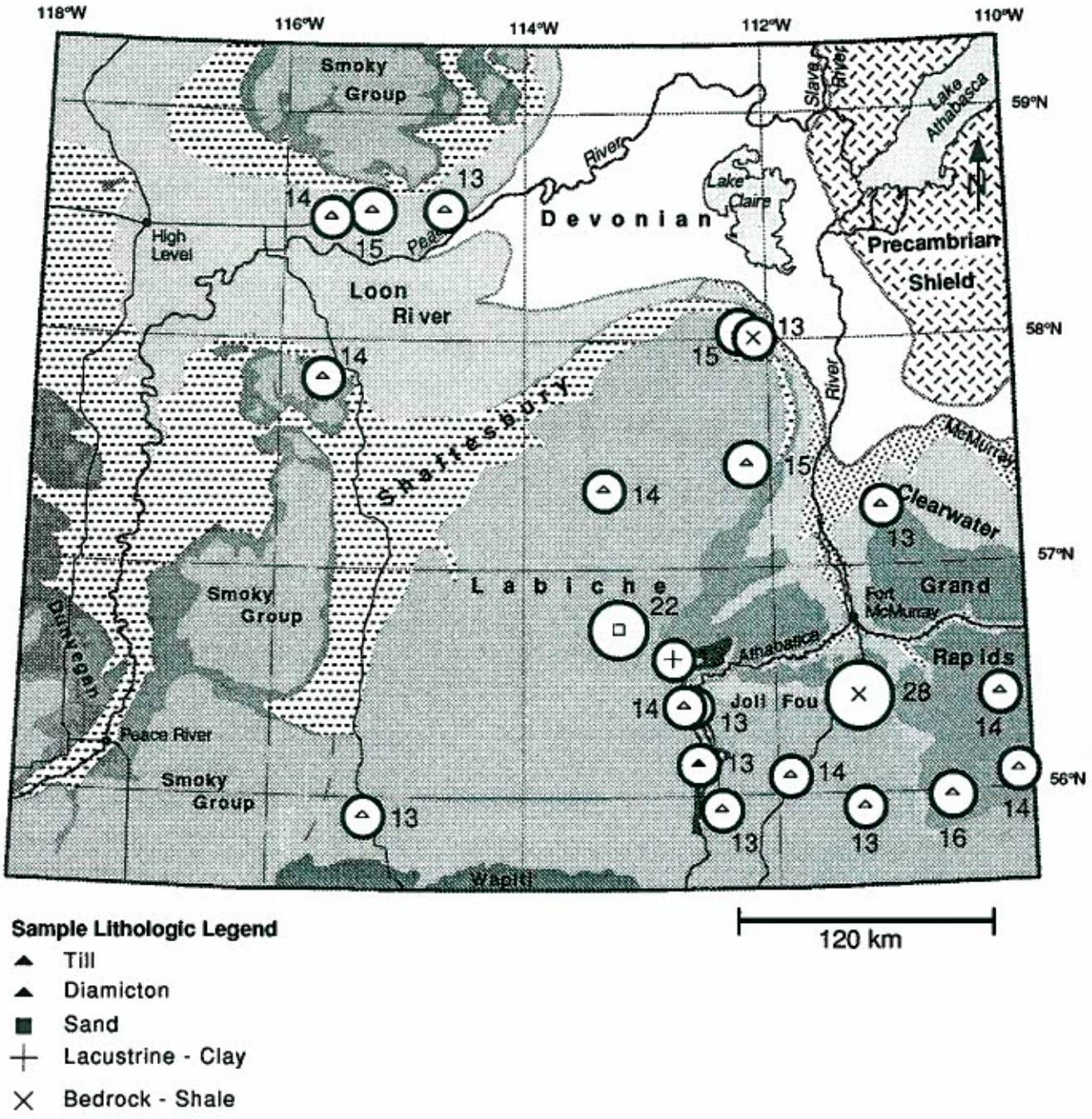

Figure 2.20. Thorium concentration (NA), greater than 12 ppm: bubble plot map.

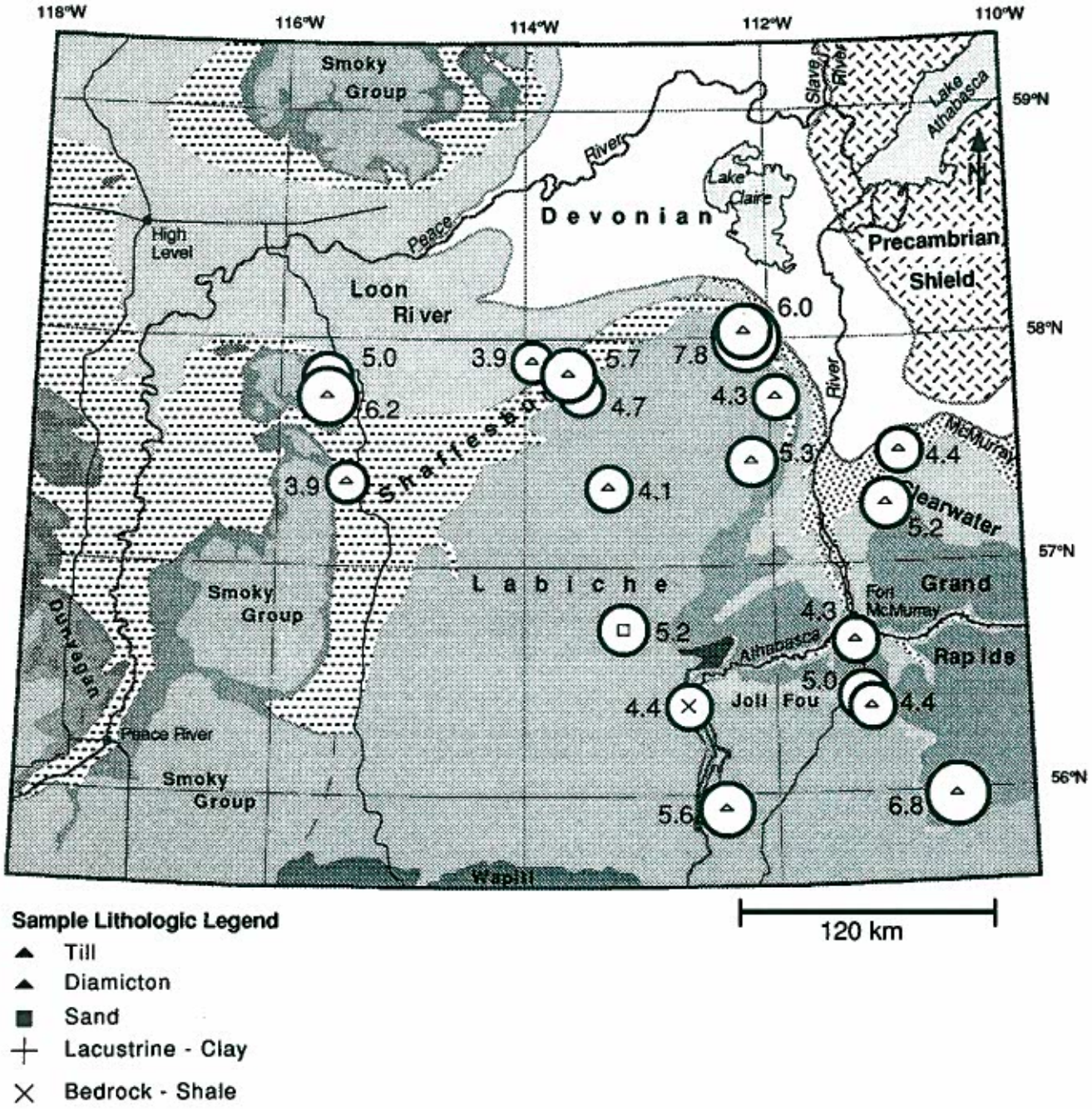

Figure 2.21. Uranium concentration (NA), greater than 3.8 ppm: bubble plot map.

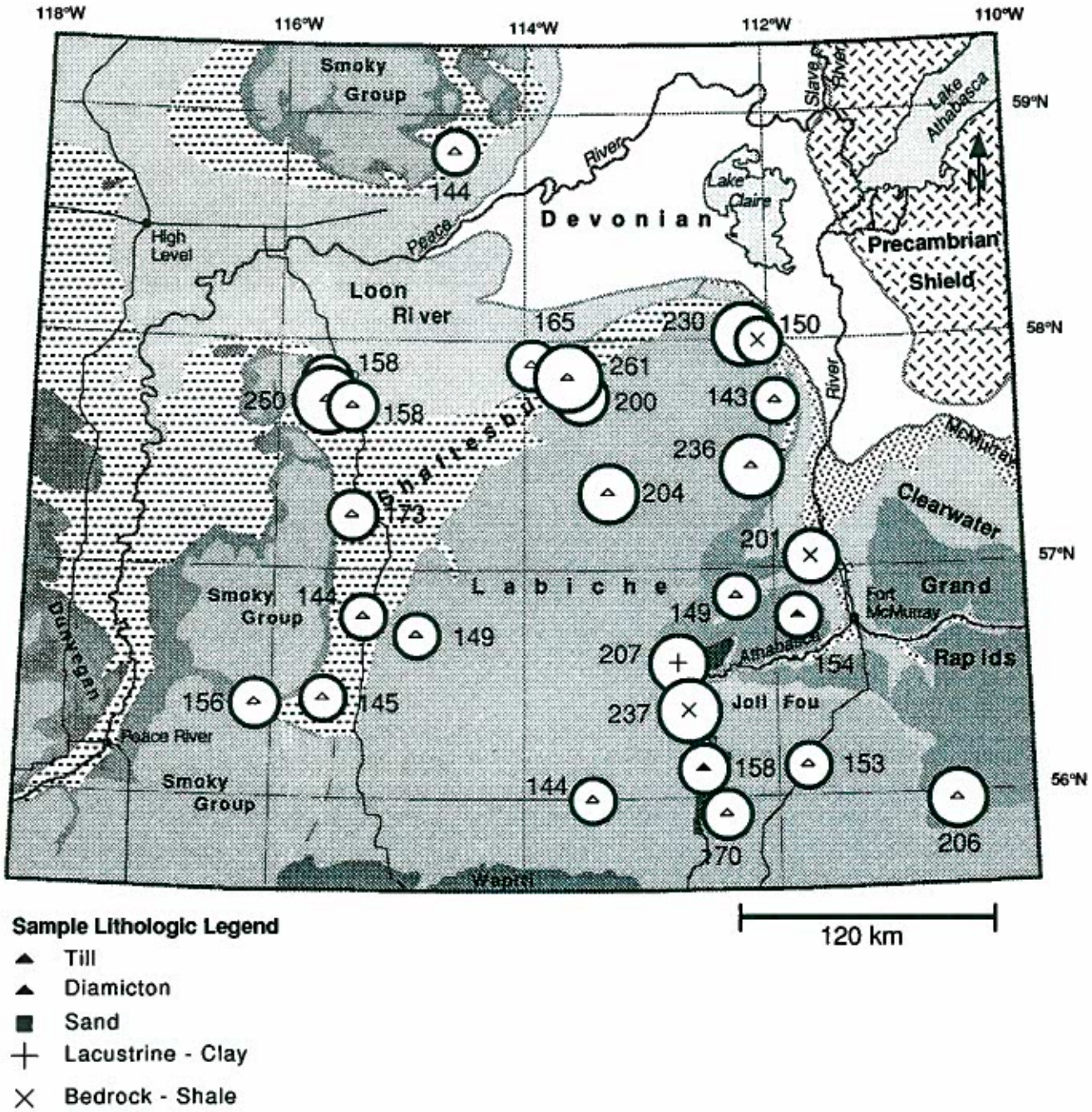

Figure 2.22. Vanadium concentration (AA), greater than 142 ppm: bubble plot map.

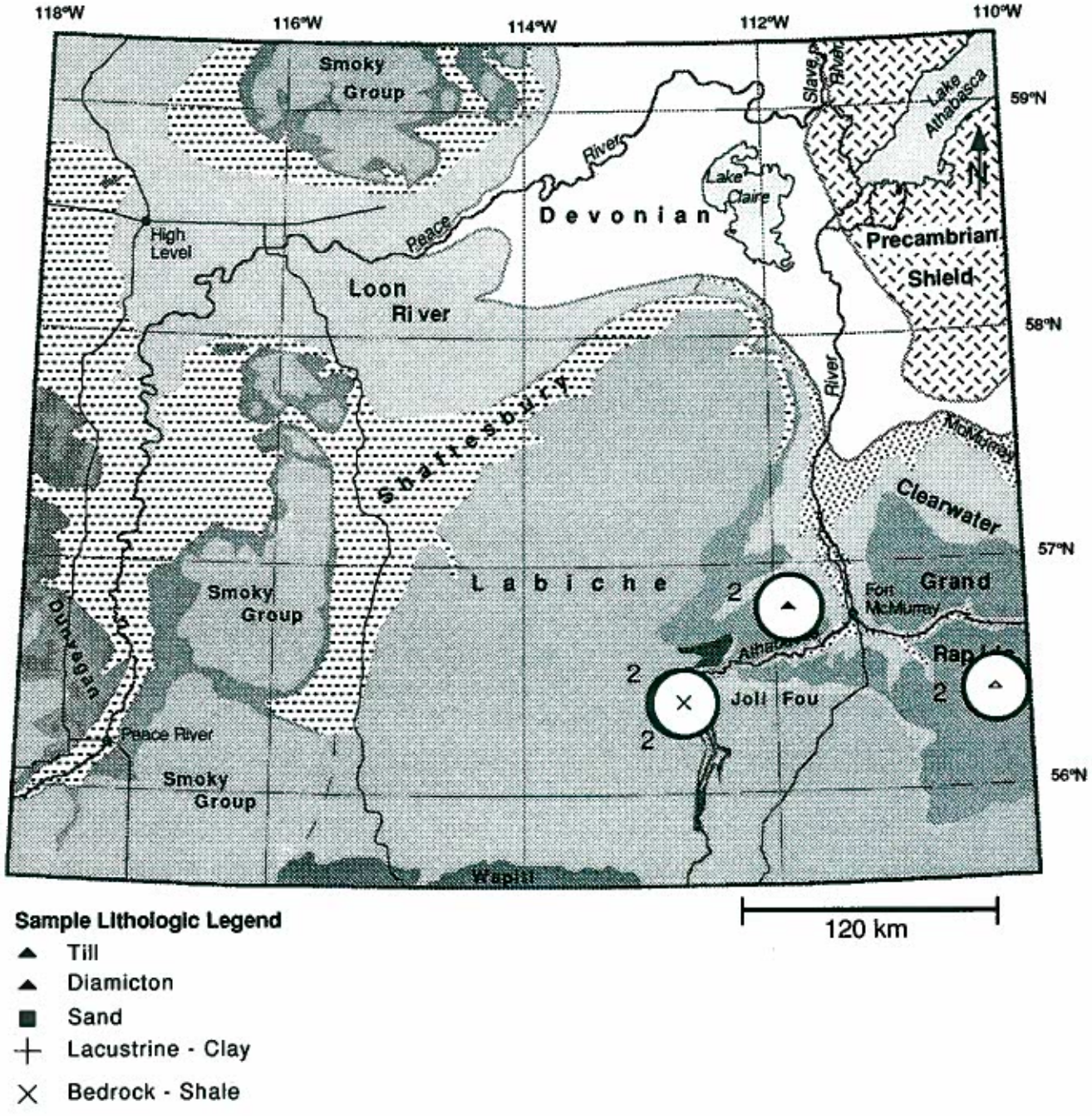

Figure 2.23. Tungsten concentration (NA), greater than 1 ppm: bubble plot map.

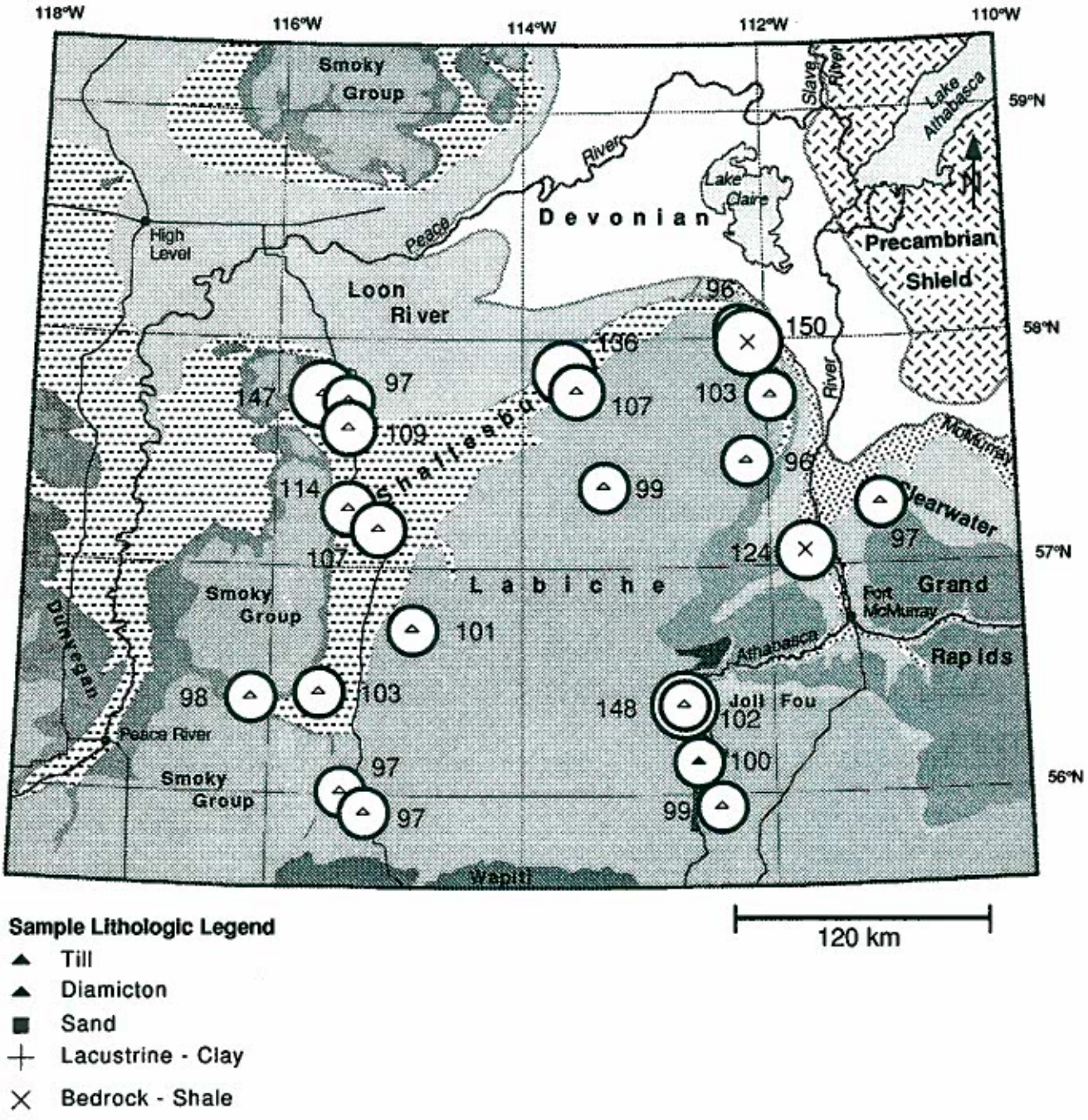

Figure 2.24. Zinc concentration (AA), greater than 95 ppm: bubble plot map.

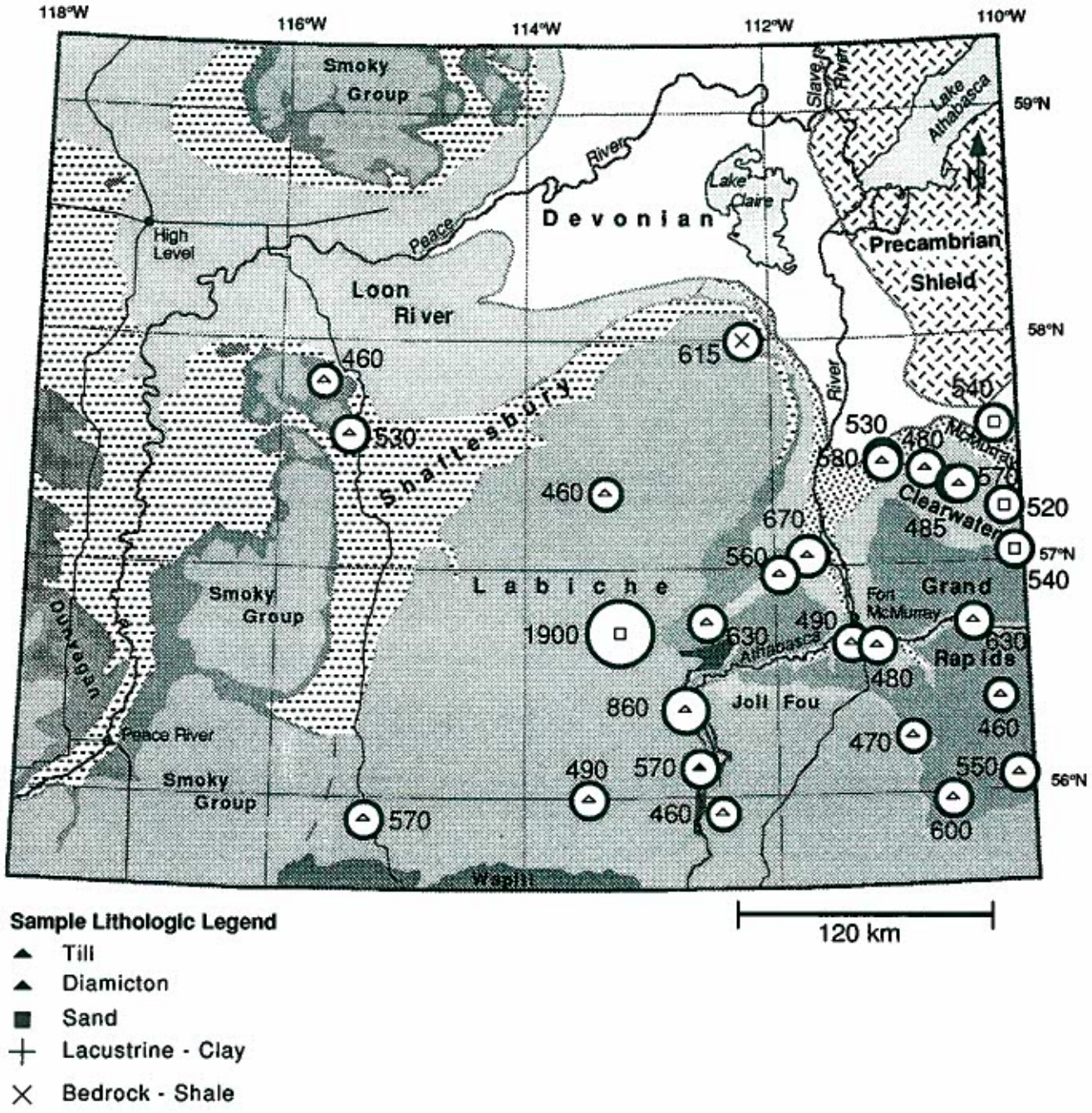

Figure 2.25. Zirconium concentration (NA), greater than 450 ppm: bubble plot map.

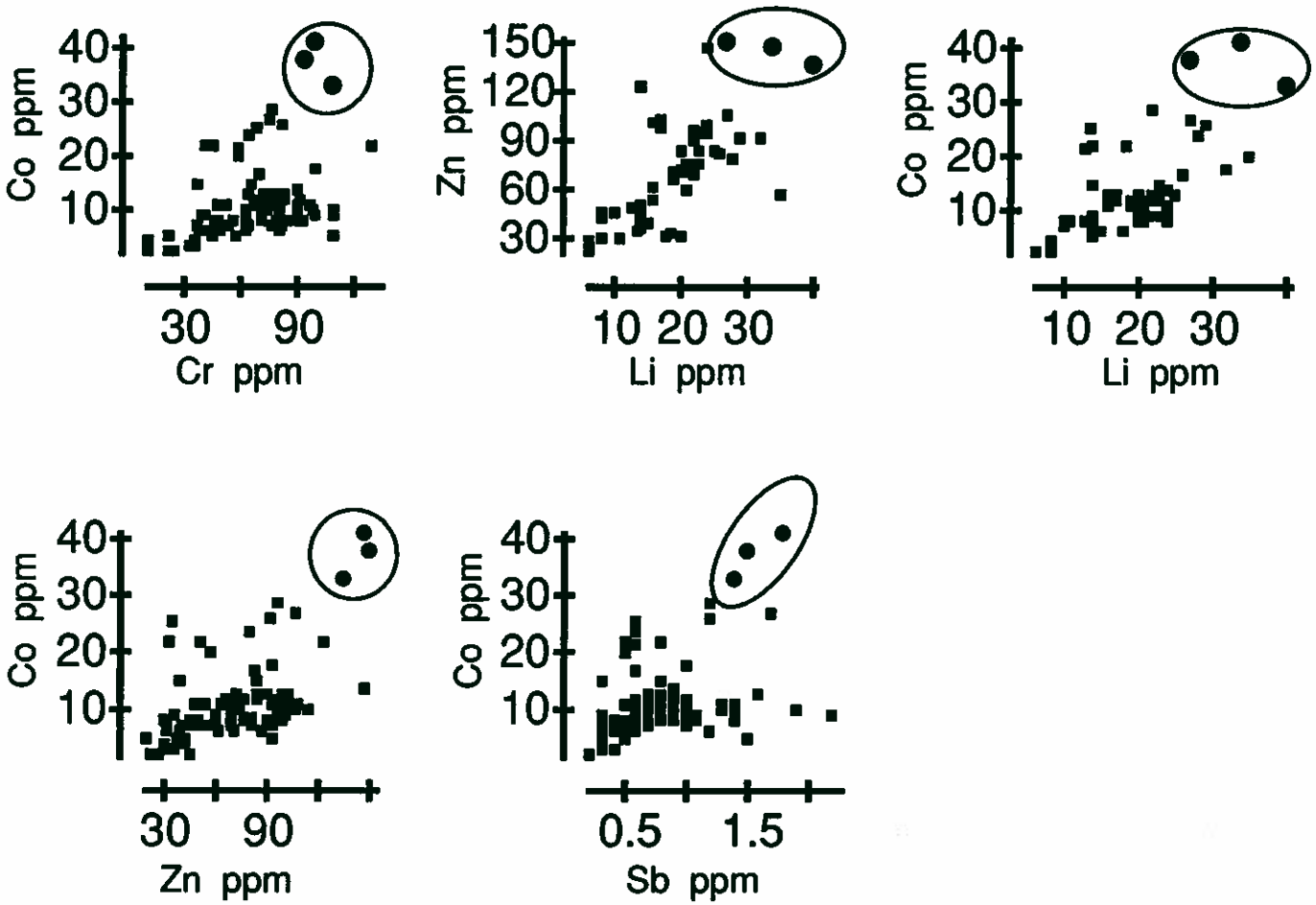

Figure 2.26a. Scatter plots showing elevated concentrations of cobalt, chromium, lithium, antimony and zinc from three common sites (circled).

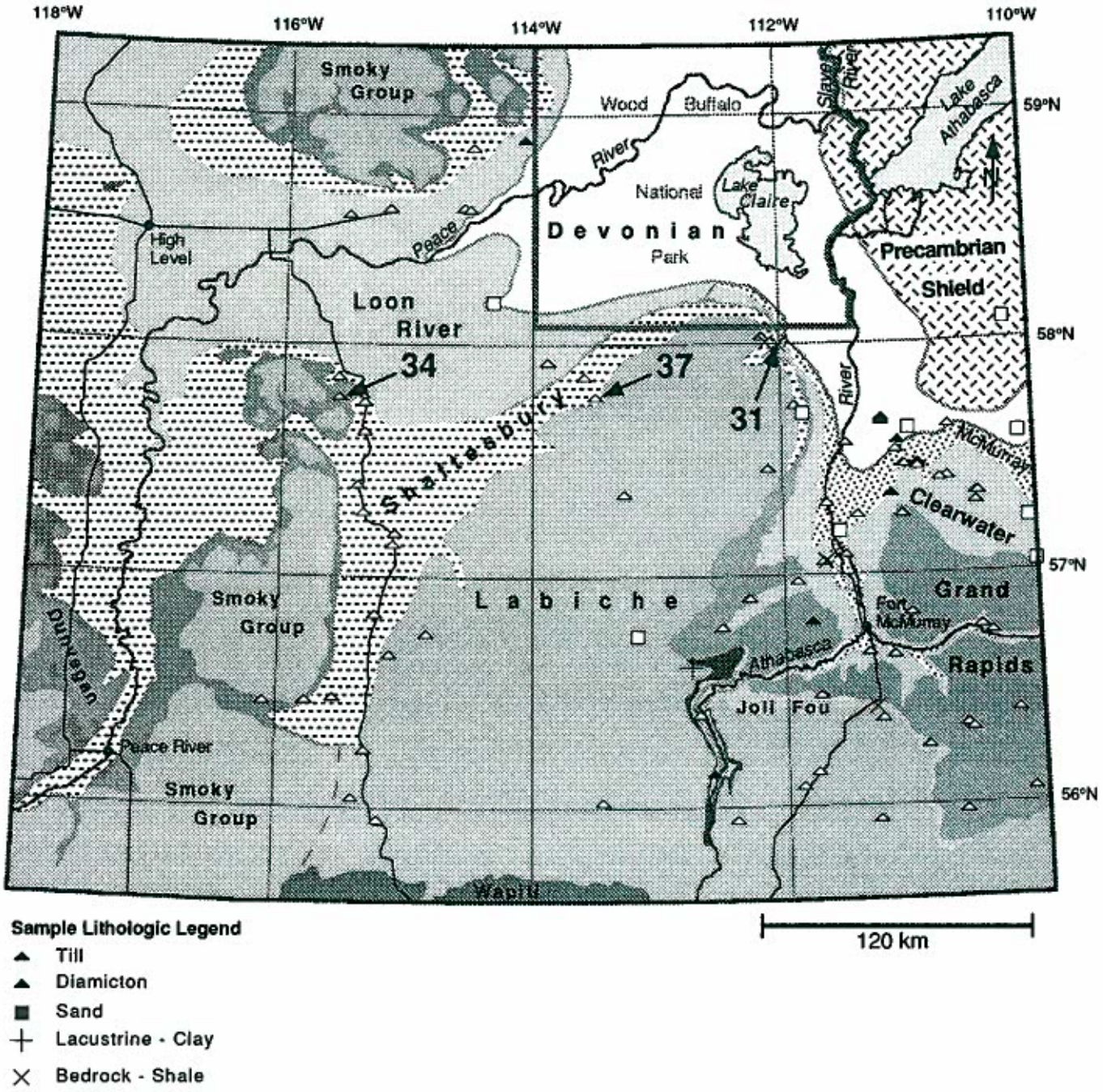

Figure 2.26b. Location of the three sites from figure 2.26a with elevated concentrations of cobalt, chromium, lithium, antimony and zinc.

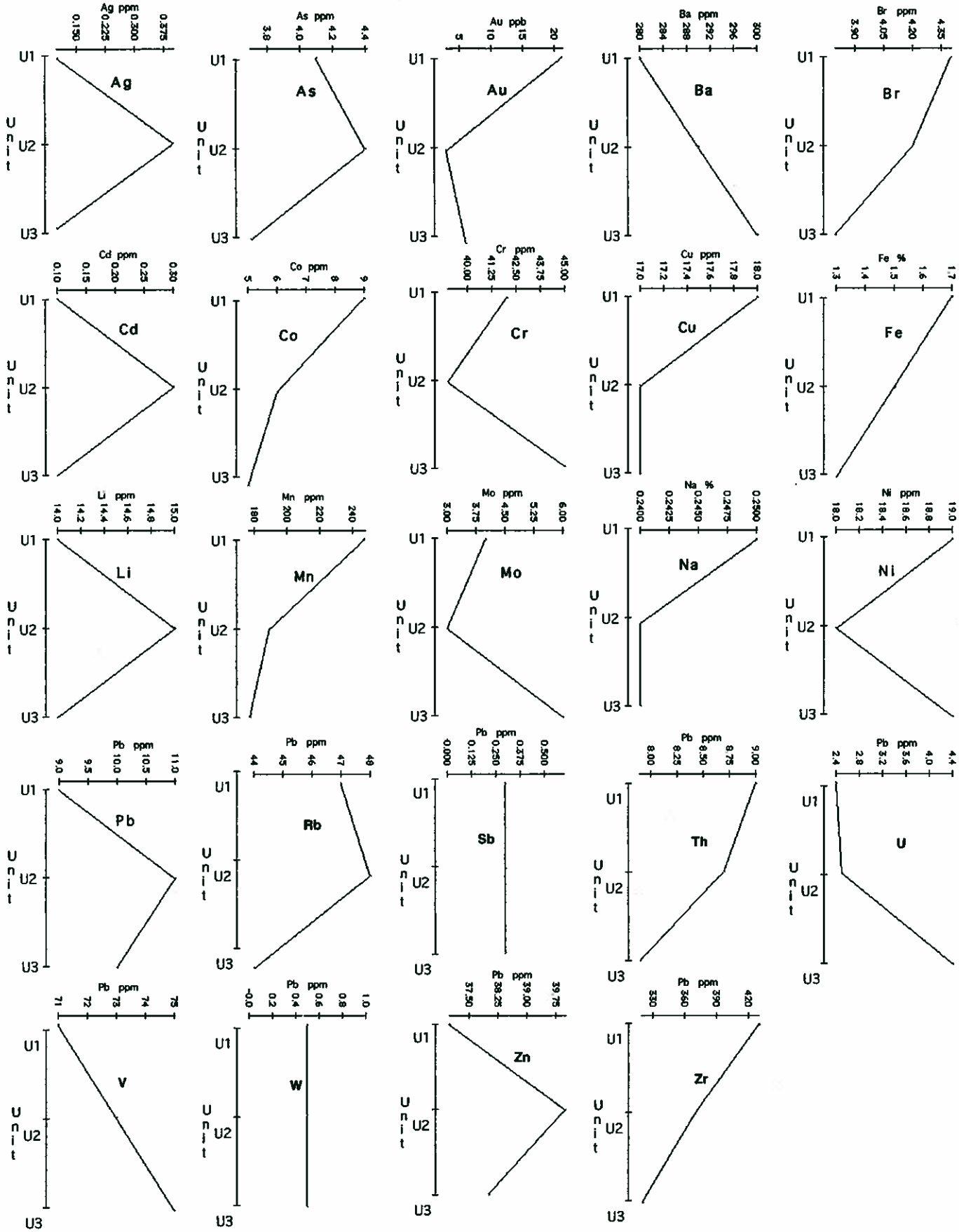

Figure 2.27. Plots showing the variation in the concentration of Ag, As, Au, Ba, Br, Cd, Co, Cr, Cu, Fe, Li, Mn, Mo, Na, Ni, Pb, Sb, Rb, Th, U, V, W, Zn, and Zr with depth in a geological section along the Firebag River. Exposure includes three till units. Sample from Unit 1 taken at 3.5 m, Unit 2 at 7.5 m and Unit 3 at 15 m from surface.

3. CONCLUSIONS

1) The concentrations of the twenty-five elements: silver (Ag), arsenic (As), gold, (Au), barium (Ba), bromine (Br), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), lithium (Li), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), sodium (Na), rubidium (Rb), antimony (Sb), thorium (Th), tungsten (W), uranium (U), vanadium (V), zinc (Zn) and zirconium (Zr) that are the subject of this report, vary throughout northeastern Alberta.

2) Many of the elements show high concentrations in samples from sites that are down the direction of glacial flow from the subcrop of the Shaftesbury Formation, particularly those samples from the northeast portion of the Buffalo Head Hills, and the northwest and northeast portion of the Birch Mountains.

3) The three sites having the highest concentrations of Co, Cr, Li, Sb, and Zn are located along an imaginary line that passes through the northeast corner of the Buffalo Head Hills and the northern margin of the Birch Mountains. The cause of this linear trend is uncertain, but may reflect an underlying structural control.

4) Data from a three till section on the Firebag River reveal vertical variations in the geochemistry with depth: some elements decrease in concentration, other increase, and others have elevated concentrations in the middle till unit.

4. REFERENCES

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Green, R., 1972, Geological map of Alberta, Alberta Research Council, Map 27.

5. APPENDICES

TABULATION OF ANALYTICAL DATA

Table 5.1. Results from geochemical analysis of sample matrix (<0.063mm) for samples collected in northeastern Alberta.

Samples are primarily till; however a few are of lacustrine, fluvial or bedrock origin.

Notes: 1) Duplicate samples were averaged to single value.

2) Value of 1/2 of detection limit replaces values below detection limit: Detection limit is included in column headers

3) Analytical methods were: AA, flame atomic absorption spectrophotometry utilizing total digestion, and NA, neutron activation analysis

4) In 'Field #AGS' the (A) denotes results are an average of a duplicate sample.

Field #AGS Sample	Site ID #	Longitude Original	Latitude Original	Lithology	Element >>>>		Ag	As	Au	Ba	Sr	Cd	Co	Cr	Cu	Fe	Li	Mn	Mo	Na	Ni	Pb	Rb	Sb	Th	U	V	W	Zn	Zr	Weight
					Method >>>>		AA	NA	NA	NA	NA	AA	AA	NA	AA	AA	AA	AA	AA/	NA	AA	AA	NA	NA	NA	NA	AA	NA	AA	NA	NA Samp
					Detection Limit >>		0.2 ppm	0.5 ppm	2 ppb	50 ppm	0.5 ppm	0.2 ppm	2 ppm	20 ppm	2 ppm	0.02%	1.0 ppm	5 ppm	2 ppm	0.02%	2 ppm	2 ppm	5 ppm	0.1 ppm	0.2 ppm	0.2 ppm	5 ppm	1 ppm	2 ppm	200 ppm	gms
					Depth (m) from	To																								
NAG93-501	2	115.342733	57.273683	Till	3.0	3.2	0.3	18.00	3	860	2.1	0.2	10.0	81	31.0	3.6		274	5.0	0.45	32.0	18.0	110	1.3	11	3.1	173.0	0.5	114.0	100	10.41
NAG94-504	5	111.793212	56.789720	Till	1.8	1.9	0.3	13	5	620	2.0	0.1	13.0	73	28	3.2	22	319	5.0	0.61	30	15	89	0.9	11	2.9	154	2	90	390	12.55
NAG94-505	6	111.144116	57.342409	Till	1.8	2.0	0.2	4.3	1	230	3.5	0.1	6.0	43	19	1.9	18	183	4.0	0.21	18	7	40	0.4	7	1.8	64	1	32	350	12.87
NAG94-506	7	111.310093	56.418814	Shale	3.0	3.2	0.3	9.35	4	1000	2.8	0.1	25.5	69	3.00	3.6	13.50	34	4.5	0.34	11.50	26.50	105	0.6	28.30	5.00	139.5	1.0	35.0	440.0	9.63
NAG94-507(A)	8	111.342001	56.658805	Till	3.8	4.0	0.1	10	3	570	2.0	0.3	11.0	69	25	2.6	21	202	3.0	0.56	27	8	87	0.8	10	4.3	130	0.5	72	490	14.53
NAG94-508	9	111.761004	56.142445	Till	1.5	2.0	0.1	12	4	660	2.0	0.1	13.0	84	29	3.4	25	387	4.0	0.48	33	13	93	0.8	10	3.2	153	1	85	420	12.06
NAG94-509	10	110.626200	55.963433	Till	1.0	1.5	0.3	18	4	1200	3.3	0.1	8.0	89	33	2.6	21	103	6.0	0.39	21	17	97	1.4	16	6.8	206	0.5	61	600	9.59
NAG94-510	11	112.273917	56.891067	Till	0.5	1.0	0.2	11	4	530	2.3	0.1	13.0	79	29	3.0	23	390	2.0	0.52	30	16	88	0.8	11	2.8	149	1	84	100	12.51
NAG94-511	12	112.746550	56.600650	Clay	1.8	2.0	0.2	14	15	730	1.9	0.1	18.0	100	36	3.5	32	446	5.0	0.44	52	14	120	1.0	13	3.2	207	1	93	290	10.01
NAG94-512	13	112.676483	56.389900	Shale	5.0	5.5	0.3	30	6	1300	2.6	0.1	14.0	90	50	3.6	24	61	2.0	0.41	37	39	130	0.9	14	4.4	237	2	148	100	8.73
NAG94-513	14	112.575833	56.137817	Till	1.2	1.5	0.5	12	5	920	2.0	0.1	8.0	94	28	2.5	24	261	4.0	0.72	27	14	98	0.9	13	3.6	158	1	100	570	14.18
NAG94-514	15	113.268617	57.351117	Till	0.8	1.0	0.2	19	4	860	0.8	0.1	11.0	98	35	3.5	24	151	4.0	0.53	31	15	120	1.4	14	4.1	204	0.5	99	460	12.93
NAG94-515	16	110.459617	57.339050	Till	4.0	4.5	0.4	3.3	4	330	2.1	0.1	4.0	36	13	0.9	8	151	2.0	0.44	9	9	41	0.3	6.6	1.7	59	0.5	43	570	14.11
NAG94-516	17	110.459617	57.339050	Till	6.0	6.5	0.3	3.7	3	360	2.0	0.1	7.0	37	13	1.1	10	231	2.0	0.41	15	7	43	0.4	7.3	2.7	63	0.5	46	480	15.99
NAG94-517(A)	18	110.689050	57.410050	Till	2.0	2.2	0.3	3.65	3	295	2.1	0.3	15.0	36	7.00	1.8	14.00	154	4.0	0.38	13.00	8.50	41	0.3	8.2	1.8	60.00	0.5	39.5	485.0	14.14
NAG94-518	19	110.689050	57.410050	Till	6.5	7.0	0.5	3.6	3	530	1.2	0.1	8.0	47	17	1.7	14	230	5.0	0.78	16	11	63	0.4	8.9	2.7	82	0.5	45	430	11.78
NAG94-519	20	110.921783	57.451383	Till	3.5	4.0	0.1	4.1	21	280	4.4	0.1	9.0	42	18	1.7	14	247	4.0	0.25	19	9	47	0.3	9	2.4	71	0.5	37	430	11.61
NAG94-520	21	110.921783	57.451383	Till	7.5	8.0	0.4	4.4	3	290	4.2	0.3	6.0	39	17	1.5	15	189	3.0	0.24	18	11	46	0.3	8.7	2.5	73	0.5	40	370	12.30
NAG94-521	22	110.921783	57.451383	Till	15.0	16.0	0.1	3.7	6	300	3.8	0.1	5.0	45	17	1.3	14	177	6.0	0.24	19	10	44	0.3	7.9	4.4	75	0.5	38	320	10.41
NAG94-522	23	111.034067	57.464350	Till	15.0	16.0	0.2	3.8	5	340	1.4	0.1	8.0	56	18	1.3	20	246	6.0	0.24	25	11	55	0.4	9.3	3	96	0.5	32	580	9.97
NAG94-523	24	111.070983	57.571150	Till	4.5	5.0	0.2	3.4	1	190	0.6	0.1	8.0	88	16	1.1	11	241	5.0	0.05	24	8	32	0.3	3.9	2.6	57	0.5	29	350	19.00
NAG94-524	25	111.832750	57.694350	SdLag	0.5	0.7	0.2	6.6	18	580	0.8	0.1	5.0	58	12	1.5	14	128	4.0	0.58	13	13	63	0.5	10	2.8	97	0.5	43	360	15.95
NAG94-525	26	110.100333	56.054333	Till	1.0	1.5	0.5	7.8	7	620	1.2	0.1	10.0	72	27	2.6	20	338	4.0	0.71	22	18	82	0.8	14	3.8	131	0.5	72	550	7.95
NAG94-526	27	110.200833	56.394833	Till	0.5	0.8	0.7	10	4	650	2.2	0.2	12.0	92	28	2.7	23	248	6.0	0.69	25	13	92	0.7	14	3.6	140	2	76	460	13.96
NAG94-527	28	111.010229	56.826097	Till	2.0	3.0	0.1	8.6	4	530	1.8	0.2	12.0	68	26	2.8	21	337	5.0	0.5	24	12	80	0.7	11	2.8	124	1	76	100	10.98
NAG94-528	29	111.675921	57.051528	Shale	4.0	4.5	1.6	23	6	540	1.7	0.1	22.0	130	34	6.2	14	88	3.0	0.75	33	14	180	0.8	9.5	3.7	201	0.5	124	100	11.11
NAG94-529	30	112.111333	57.454667	Till	0.9	1.0	0.4	22	10	860	1.5	0.1	10.0	110	38	3.9	24	157	5.0	0.48	37	14	130	1.9	15	5.3	236	0.5	96	380	12.02
NAG94-530	31	112.018056	57.992500	Shale	?	?	0.2	17	11	460	0.3	0.1	38.0	95	32	4.3	27	274	6.0	0.38	236	44	140	1.5	13	3.3	150	1	150	290	9.85
NAG94-531(A)	32	112.115833	57.998833	Siltst.	?	?	0.5	22.5	4	490	2.6	0.1	22.0	41	3.00	1.6	18.50	50	4.0	0.1	8.00	19.50	26	0.8	10	7.75	83.50	1.0	34.0	615.0	10.825
NAG94-532	33	115.341924	57.742612	Till	1.5	2.0	0.4	15	1	810	2.7	0.2	29.0	77	11	2.8	22	304	9.0	0.46	33	16	94	1.2	10	3.3	158	1	97	330	9.84
NAG94-533	34	115.546667	57.771690	Till	3.0	3.5	0.3	47	1	970	3.1	0.4	41.0	100	16	4.6	34	351	12.0	0.4	47	20	95	1.8	12	6.2	250	1	147	100	8.60
NAG94-534	35	114.053667	58.887559	Till/pink	3.0	3.5	0.3	5.6	1	510	1.3	0.1	20.0	59	13	2.1	35	299	4.0	0.51	23	16	77	0.5	12	3	122	0.5	58	100	8.22
NAG94-536	37	113.579167	57.856111	Till	2.0	2.5	0.3	15	1	950	2.2	0.3	33.0	110	18	2.4	40	203	8.0	0.44	43	19	110	1.4	11	5.7	261	0.5	136	100	8.46
NAT92-2	39	115.311295	56.241127	Till	3.0	3.3	0.2	14	3	810	1.8	0.1	12.0	80	27.0	3.0		324	4.0	0.56	27.0	16.0	100	1.0	11	3.3	130.0	0.5	85.0	330	11.70
NAT92-3	40	115.104530	57.128601	Till	2.5	3.0	0.2	17	1	850	1.9	0.1	8.0	80	24.0	2.6		160	3.0	0.65	21.0	15.0	89	1.1	10	3.8	111.0	1	81.0	450	12.73
NAT92-4	41	115.392570	57.388626	Till	3.3	3.5	0.2	16	3	840	4.0	0.3	11.0	91	30.0	3.3		250	5.0	0.5	29.0	17.0	100	1.3	11	3.9	126.0	1	93.0	320	11.09
NAT92-5	42	115.552650	57.855755	Till	3.0	3.3	0.2	19	4	1200	2.4	0.1	5.0	110	33.0	2.9		94	4.0	0.5	28.0	20.0	120	1.5	14	5	158.0	1	94.0	460	9.30
NAT92-7	44	114.554718	58.589458	Till	2.8	3.0	0.1	7.4	3	550	2.6	0.1	7.0	77	18.0	2.7		274	3.0	0.47	22.0	12.0	91	0.5	13	2.9	82.0	1	53.0	400	9.29
NAT92-8(A)	45	115.496025	58.556770	Till	2.0	2.2	0.2	8.75	3	645	12.0	0.1	8.0	82	27.0	2.8		275	6.0	0.55	26.0	17.0	100	0.8	14.5	3.45	110.0	1	70.0	380	10.02
NAT92-24	61	111.057915	57.249889	Till	2.0	2.2	0.1	22	4	770	2.2	0.1	10.0	99	28.0	3.1		268	6.0	0.56	27.0	19.0	120	1.4	13	5.2	140.0	1	97.0	380	11.48
NAT92-25	62	111.403374	57.249889	Till	1.8	2.0	0.1	2.8	1	210	2.1	0.1	5.0	21	10.0	1.5		157	4.0	0.26	11.0	11.0	34	0.3	6.7	1.6	47.0	0.5	19.0	380	15.86
NAT92-27	64	110.903815	56.246296	Till	2.0	2.2	0.1	13	3	610	2.6	0.2	10.0	74	22.0	3.1		390	5.0	0.61	25.0	15.0	84	0.9	12	2.9	114.0	0.5	70.0	470	11.95
NAT92-28	65	111.877754	56.077339	Till	1.5	1.8	0.2	7.3	10	620	1.2	0.2	6.0	81	27.0	2.9		109	3.0	0.48	20.0	17.0	99	1.2	14	3.8	142.0	1	71.0	450	13.09
NAT93-40	80	115.202941	55.943092	Till	1.0	1.3	0.3	16.00	7	870	2.6	0.1	9.0	100	33.0	3.1		247	6.0	0.62	35.0	16.0	97	1.1	13	3.6	129.0	1	97.0	570	10.75
NAT93-41	81	115.391913	56.033980	Till	1.8	2.0	0.8	12.00	6	820	3.7	0.1	12.0	89	29.0	3.8		526	3.0	0.54	34.0	17.0	83	0.9	11	2.9	141.0	1	97.0	260	10.59
NAT93-61	101	116.101513	56.452063	Till	2.0	2.2	0.2	16.00	6	770	2.4	0.1	12.0	81	28.0	3.2		370	4.0	0.55	35.0	15.0	96	1.0	12	3.8	156.0	1	98.0	220	11.47
NAT93-62	102	115.772750	56.459370	Till	3.0	3.2	0.1	14.00	2	820	2.5	0.2	7.0	82	25.0	2.8		253	5.0	0.61	27.0	17.0	100	1.0	11	3.8	141.0	1	94.0	350	11.37
NAT93-63	103	115.555767	56.470267	Till	1.5	1.7	0.7	14.00	14	770	2.5	0.1	11.0	74	29.0	3.3		332	7.0	0.48	33.0	17.0	92	1.0	11	3.5	145.0	1	103.0	340	10.39
NAT93-64	104	115.118842	56.655675	Till	2.0	2.2	0.3	14.00	13	770	1.7	0.3	8.0	72	24.0	3.2		280	4.0	0.58	26.0	15.0	85	1.0	10	3.1	125.0	0.5	94.0	100	11.16
NAT93-65	105	114.826878	58.742928	Till	2	2.2	0.1	16	8	770	1.7	0.2	9	91	25	2.9		330	7	0.52	31	17	110	1.1	12	3.2	149	1	101	360	10.19
NAT93-67	107	114.512365	58.585885	Till	15	15.5	0.3	7.1	1	580	1.6	0.1	8	64	24	3.1		337	4	0.42	27	13	110	0.5	10	3	121	1	77	370	11.17
NAT93-76	116	115.244917	56.826557	Till	0.3	0.5	0.1	12.00	6	740	2.2	0.1	7.0	65	17.0	2.6		110	4.0	0.52	23.0	14.0	100	0.7	10	2.8	144.0	1	82.0	310	11.05
NAT93-77	117	115.089082	57.175534	Till	8.0	8.3	0.2	15.00	4	720	1.8	0.4	10.0	71	27.0	3.0		341	6.0	0.53	30.0	17.0	89	1.0	10	3.7	137.0	1	107.0	350	10.30
NAT93-78	118	115.335099	57.622666	Till	3.0	3.3	0.2	14.00	18	700	1.8	0.2	11.0	73	27.0	3.2		465	5.0	0.43	37.0	17.0	110	1.0	11	3.4	141.0	1	109.0	530	10.42
NAT93-80	120	111.086795	57.531475	Sand	Fluvial sand																									

Table 5.1 continued. Results from geochemical analysis of sample matrixfor those samples collected in northeastern Alberta.

Field #AGS	Site ID #	Longitude Original	Latitude Original	Lithology	Element >>>>		Ag	As	Au	Ba	Br	Cd	Co	Cr	Cu	Fe	Li	Mn	Mo	Na	Ni	Pb	Rb	Sb	Th	U	V	W	Zn	Zr	Weight
					Method >>>>		AA	NA	NA	NA	NA	AA	AA	NA	AA	AA	AA	AA	AA/	NA	AA	AA	NA	NA	NA	NA	NA	AA	NA	AA	NA	NA Samp
					Detection Limit >>		0.2 ppm	0.5 ppm	2 ppb	50 ppm	0.5 ppm	0.2 ppm	2 ppm	20 ppm	2 ppm	0.02%	1.0 ppm	5 ppm	2 ppm	0.02%	2 ppm	2 ppm	5 ppm	0.1 ppm	0.2 ppm	0.2 ppm	5 ppm	1 ppm	2 ppm	200 ppm	gms
NAT93-81	121	111.029191	57.462403	Till	10.0	10.5	0.2	3.90	1	320	1.4	0.1	7.0	49	15.0	1.8		185	3.0	0.24	23.0	13.0	63	0.4	10	2.7	80.0	0.5	56.0	530	10.09
NAT93-82	122	110.454578	57.338768	Till	3.0	3.5	0.2	3.20	1	300	2.2	0.1	3.0	36	11.0	1.8		169	2.0	0.41	11.0	10.0	49	0.3	7.1	1.6	54.0	0.5	37.0	360	13.50
NAT93-83	123	110.745265	57.404221	Till	10.0	10.5	0.1	6.00	2	480	1.0	0.1	9.0	40	18.0	2.3		460	4.0	0.44	24.0	15.0	82	0.6	11	2.8	84.0	0.5	60.0	440	10.57
NAT93-84	124	111.202795	57.647831	Till/gry	6.0	6.5	0.3	7.60	3	430	0.9	0.1	7.0	49	19.0	2.4		253	4.0	0.5	19.0	13.0	70	0.5	9.2	2.7	88.0	0.5	70.0	360	14.14
NAT93-84G	125	111.202795	57.647831	Till/gm	6.0	6.5	0.3	7.40	3	390	0.8	0.1	6.0	50	18.0	3.0		251	2.0	0.48	17.0	12.0	60	0.5	8.6	2.6	89.0	0.5	62.0	310	13.01
NAT93-84P	126	111.202795	57.647831	Till/pink	6.0	6.5	0.2	4.20	1	240	0.7	0.2	3.0	34	11.0	2.1		160	3.0	0.33	12.0	12.0	36	0.4	10	2	54.0	0.5	31.0	210	8.48
NAT93-85	127	111.004878	57.622381	Sand	Fluvial sand																										
NAT93-86	128	111.496257	57.564205	till	5.0	Dup	0.2	6.60	6	350	1.1	0.1	6.0	64	18.0	2.0		168	2.0	0.35	17.0	20.0	83	0.6	11	2.6	97.0	1	88.0	310	11.27
NAT93-87	129	111.562086	57.182424	Sand	Fluvial sand																										
NAT93-88	130	111.501796	57.076978	till	1.2	1.5	0.4	14.00	9	350	12.0	0.2	11.0	49	19.0	6.1		940	4.0	0.2	24.0	13.0	62	0.6	7.9	2.4	88.0	1	48.0	280	11.63
NAT93-89	131	110.677291	57.629659	till	2.0	2.5	0.1	4.80	1	340	2.5	0.1	7.0	37	15.0	2.2		167	6.0	0.24	28.0	14.0	59	0.3	10	2.4	94.0	0.5	41.0	320	11.19
NAT94-90	132	111.890228	56.967898	Till	2.7	3.0	0.2	11	4	550	1.3	0.1	12.0	84	26	2.4	22	281	4.0	0.53	28	16	78	0.8	10	3.2	140	1	77	560	8.74
NAT94-91	133	111.142938	56.640626	Till	1.2	1.5	0.2	10	4	490	2.6	0.1	10.0	64	26	3.1	21	345	4.0	0.46	21	14	76	0.7	9.4	2.6	122	1	74	480	10.59
NAT94-92	134	111.250917	56.371549	Till	4.0	4.5	0.4	8.4	1	590	1.6	0.3	15.0	66	27	2.0	23	443	5.0	0.48	33	14	85	0.8	11	4.4	141	0.5	84	320	6.32
NAT94-93	135	110.117666	57.589651	Sand	1.0	1.3	0.2	1.1	1	170	1.6	0.2	2.0	10	10	0.1	6	78	3.0	0.29	4	6	14	0.2	3.6	1.1	25	0.5	27	540	18.28
NAT94-94	136	110.069247	57.226057	Sand	0.3	0.6	0.3	1.8	1	290	2.1	0.1	2.0	21	11	1.0	8	90	2.0	0.33	6	7	27	0.2	5	1.2	38	0.5	46	520	17.36
NAT94-95	137	110.461337	57.298775	Till	4.5	5.0	0.2	4.5	2	330	1.8	0.1	7.0	54	13	1.4	14	167	3.0	0.43	16	9	46	0.4	8.4	1.9	70	0.5	51	450	11.03
NAT94-97	139	110.562283	56.317700	Till	3.0	3.5	0.5	8.7	4	510	2.2	0.2	13.0	65	25	3.3	20	372	3.0	0.46	26	10	73	0.7	10	2.5	110	0.5	73	440	13.19
NAT94-98(A)	140	110.459487	56.756991	Till	4.0	4.5	0.4	6.35	2	500	2.4	0.2	21.5	59	10.00	1.9	13.00	201	2.5	0.57	19.50	7.00	64	0.6	9.1	2.7	109	1.0		385.0	12.165
NAT94-99	141	110.015038	57.033340	Sand	1.0	1.2	0.1	1.1	3	220	1.6	0.1	2.0	24	3	0.4	6	63	1.0	0.26	5	2	21	0.2	3.8	1.1	33	0.5	22	540	18.30
NAT94-100	142	113.448695	56.018802	Till	0.8	1.0	0.1	11	1	720	2.4	0.2	12.0	77	26	2.7	20	377	3.0	0.6	27	17	92	0.8	11	3.3	144	0.5	84	490	10.98
NAT94-101	143	111.010229	56.826091	Till	5.0	6.0	0.1	7.5	6	540	1.1	0.4	17.0	70	27	2.8	26	478	4.0	0.53	32	12	84	0.6	11	3.4	135	1	83	450	14.30
NAT94-102	144	110.373226	56.731539	Till	1.0	2.0	0.4	5.6	8	450	2.5	0.1	8.0	49	14	1.3	13	367	3.0	0.55	14	11	52	0.6	8.9	3.3	74	1	50	630	13.22
NAT94-103	145	110.593403	56.335169	Till	8.0	8.5	0.2	7.7	2	560	1.7	0.1	11.0	53	19	2.1	16	448	3.0	0.62	25	8	68	0.7	10	3.6	116	1	63	430	13.26
NAT94-104	146	112.490133	56.769817	Till	2.5	3.0	0.7	11	1	660	2.1	0.2	9.0	81	26	2.9	22	210	6.0	0.53	27	10	78	0.7	10	3.2	125	1	70	630	9.72
NAT94-105	147	112.676483	56.389900	Till	2.0	2.5	0.3	15	8	720	1.6	0.3	13.0	79	27	2.6	16	334	6.0	0.67	48	12	77	0.8	13	3.8	117	2	102	860	14.25
NAT94-106	148	113.175833	56.736167	Sand	1.0	1.5	0.3	14	9	530	2.0	0.1	8.0	84	13	2.7	10	349	2.0	0.74	12	9	52	0.7	22.2	5.2	90	0.5	47	1900	16.06
NAT94-107	149	111.675921	57.051528	Till	2.5	3.0	0.1	7.6	7	510	1.1	0.1	12.0	69	23	2.2	19	203	4.0	0.45	24	10	74	0.6	9	3.4	110	1	67	670	12.47
NAT94-108	150	111.651129	57.306055	Till	1.0	1.5	0.2	10	3	560	3.4	0.1	12.0	79	24	2.5	19	224	5.0	0.44	32	13	88	0.7	10	3.2	132	1	72	380	13.24
NAT94-109	151	111.898915	57.731456	Till	3.0	3.5	0.3	13	4	770	1.9	0.1	12.0	77	22	1.9	17	406	5.0	0.66	37	15	90	1.0	11	4.3	143	1	103	440	12.56
NAT94-110	152	111.297000	55.935000	Till	0.5	1.0	0.4	10	11	610	1.4	0.1	11.0	79	30	2.9	19	314	4.0	0.57	29	13	83	0.8	13	3.5	135	1	71	420	13.06
NAT94-111	153	112.402333	55.939167	Till	8.5	9.0	1.0	19	4	760	2.6	0.1	13.0	75	29	2.4	17	277	8.0	0.49	30	13	79	1.6	13	5.6	170	1	99	460	10.44
NAT94-112	154	111.740333	56.475833	Till	7.0	7.5	0.9	5.9	3	410	1.6	0.1	11.0	50	20	1.3	16	295	2.0	0.36	22	10	58	0.5	7.6	2.7	92	0.5	54	420	12.77
NAT94-113	155	110.201820	58.082764	Sand	0.0	1.0	0.1	1.6	1	290	1.6	0.3	4.0	10	6	0.9	8	86	2.0	0.46	8	7	32	0.3	5.3	1.4	40	0.5	30	440	16.57
NAT94-114	156	112.145878	58.023569	Till	0.3	0.6	0.1	29	14	1000	2.2	0.1	9.0	110	38	4.0	23	101	6.0	0.41	25	21	120	2.2	15	6	230	1	96	310	12.83
NAT94-115	157	114.488889	58.856667	Till	10.0	10.5	0.4	7.4	3	600	1.3	0.1	24.0	65	19	2.5	28	494	11.0	0.57	34	16	85	0.6	10	2.9	144	1	80	340	8.82
NAT94-117	159	113.486167	57.771111	Till	10.0	10.5	0.1	21.50	4	960	3.0	0.5	27.0	76	18	2.6	27	340	7.0	0.50	37	17	87	1.7	9.70	4.70	200	0.5	107	305	9.32
NAT94-118	160	113.876389	57.917500	Till	5.0	6.0	0.4	16	1	730	2.4	0.3	26.0	82	17	2.5	29	405	8.0	0.47	38	17	93	1.2	10	3.9	165	1	92	100	9.76
NAT94-119	161	114.325333	58.180278	Sand	1.0	1.3	0.5	10	1	670	8.1	0.1	22.0	46	15	2.1	14	620	7.0	0.28	24	14	55	0.5	8.2	1.9	93	0.5	52	410	10.46
HL93-4	163	115.159492	58.593159	Till	6.9	10.2	0.6	10.00	3	670	2.3	0.1	8.0	82	27.0	3.0		247	5.0	0.58	28.0	20.0	110	0.9	15	3.5	128.0	1	90.0	390	10.47
					Min		0.1	1.1	1.0	170.0	0.3	0.1	2.0	10.0	3.0	0.0	6.0	34.0	1.0	0.0	4.0	2.0	14.0	0.2	3.6	1.1	25.0	0.5	19.0	100.0	6.3
					Max		1.6	47.0	21.0	1300.0	12.0	0.5	41.0	130.0	50.0	62.0	40.0	940.0	12.0	0.8	236.0	44.0	160.0	2.2	28.3	7.8	261.0	2.0	150.0	1900.0	18.3
					Mean		0.3	11.1	4.8	601.8	2.3	0.2	11.7	68.4	21.8	3.2	19.2	268.6	4.5	0.5	27.3	14.3	80.1	0.8	10.7	3.4	123.4	0.8	73.9	406.7	11.8
					95%ile		0.7	22.23	14	983.5	4.09	0.3	26.45	104.5	34.45	4.11	32.1	470.85	8	0.70	40.25	20	120	1.55	15	5.65	217.4	1.0	119	621.75	16.29
					75%ile		0.4	14.5	6	770	2.5	0.2	13	82	27	3.1	23	340.5	5.5	0.56	31	17	97	1	12	3.8	144	1.0	94	475	13.075
					60%ile		0.3	12	4	650	2.2	0.1	11	77	25	2.8	21	280	4.5	0.5	27	15	88	0.8	11	3.4	135	1.0	82.4	440	12.02
					Count		92	92	92	92	92	92	92	92	92	94	60	92	92	93	92	92	92	92	92	92	92	92	91	92	92