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Quaternary Geology and Till Geochemistry, Wapiti Map Area (NTS 83L)

Alberta Energy and Utilities Board
Alberta Geological Survey

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Earth Sciences Report 2000-12: Quaternary Geology and Till Geochemistry, Wapiti Map Area (NTS 83L)

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The surficial geology map was compiled by Andriashek (1983) based on unpublished work done by Bayrock and Twardy. D. Chao transformed the original draft map into the ARCINFO document used to print the enclosed map.

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Abstract

This report provides the current data and interpretations concerning the surficial geology and till geochemistry of the Wapiti map area (NTS 83L). Work on the project was suspended during the second year due to reprioritizing of staff effort.

The area encompasses the transition zone from the Interior Plains to the Eastern Cordillera, with elevation rising from about 525 m (1720 ft) in the northeast to 2455 m (8050 ft) in the southwest. Four physiographic regions can be defined: the Wapiti Plains, the Alberta Plateau Benchlands, the Rocky Mountain Foothills, and the Rocky Mountains.

The surficial geology is shown on a 1:250 000 scale map, compiled by Andriashek (1983) based on unpublished work by A. Twardy and L. Bayrock. The main surficial materials are till, glaciolacustrine sediment, weathered bedrock, and, to a lesser extent, glaciofluvial sediment. The till includes units deposited by Laurentide (Continental), Cordilleran, and Rocky Mountain ice sheets.

The ice-flow direction, from the Rocky Mountain, Cordilleran, and Laurentide glacial centres, and the relationships between the various lobes are poorly understood. Field examination of the pebble to boulder fraction indicates that the till units are characterized by 1) clasts of green metaconglomerate and low-grade greenish grey schist, plus granite and other igneous rocks (mixed Laurentide and Cordilleran sources), in the northwest; 2) clasts of grey carbonate (Rocky Mountain or Cordilleran source) in the west and southwest; 3) mainly quartzite and igneous (primarily granite) clasts (Laurentide source) in the east; 4) abundant well-rounded quartzite clasts, incorporated from the underlying Tertiary gravel deposits, in parts of the centre and south; 5) boulders of low-grade schist (?earlier Cordilleran source) at three sites in the south-central part of the area; and 6) a boulder of low-grade, grey metamorphic rock, perhaps phyllite, in the southeast (source uncertain).

The majority of the samples were collected from areas accessible by road, although a few were obtained using a helicopter to reach less accessible sites. Most of the samples collected are from till, although a few are from bedrock, lacustrine, colluvial, or fluvial units. At each site, a 2–3 kg sample was collected from below the top of the C soil horizon (at a depth of about 2 m) for geochemical and carbonate analysis of the less than 0.063 mm fraction and texture analysis of the less than 2 mm fraction. Field data recorded at each site included information on the general sampling environment and observations on the colour, texture, moisture content, and mineralogy of the till.

The matrix fraction (<0.063 mm or <230 mesh) was analyzed by flame atomic absorption spectrometry (AA) for Ag, Cd, Co, Cu, Fe, Li, Mn, Mo, Ni, Pb, V, Zn, and (for a few samples) Mg, and by instrumental neutron activation analysis (INAA) for Ag, As, Au, Ba, Br, Cd, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ir, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Te, Th, W, U, Yb, Zn, and Zr. The results are shown as a series of element distribution maps.

There is a good correlation between Ce, La, Sm, and Th. The concentrations for this group of elements are low in the southwest quadrant and high in the southeast quadrant. There is also a strong correlation between Cr and Sc. These two elements, with three exceptions, show higher concentrations in the southwest-central part of the area and predominantly low concentrations in the southeast quadrant.

There is also a strong correlation between Co, Cu, and Ni, with the correlation between Co and Cu being slightly weaker. Sites with high concentrations ($\geq$75 percentile) of this group of elements occur

primarily in the north half of the area, except for two small clusters of sites with high concentrations in the southwest quadrant.

1 Introduction

1.1 Study Location and Objectives

The Wapiti map area (NTS 83L) is located in northwestern Alberta, adjacent to the border with British Columbia (Fig. 1, 2) approximately twp 58 to 69, rge 1 to 13, W6). The area covers approximately 13 000 km^2 (about 5000 mile^2).

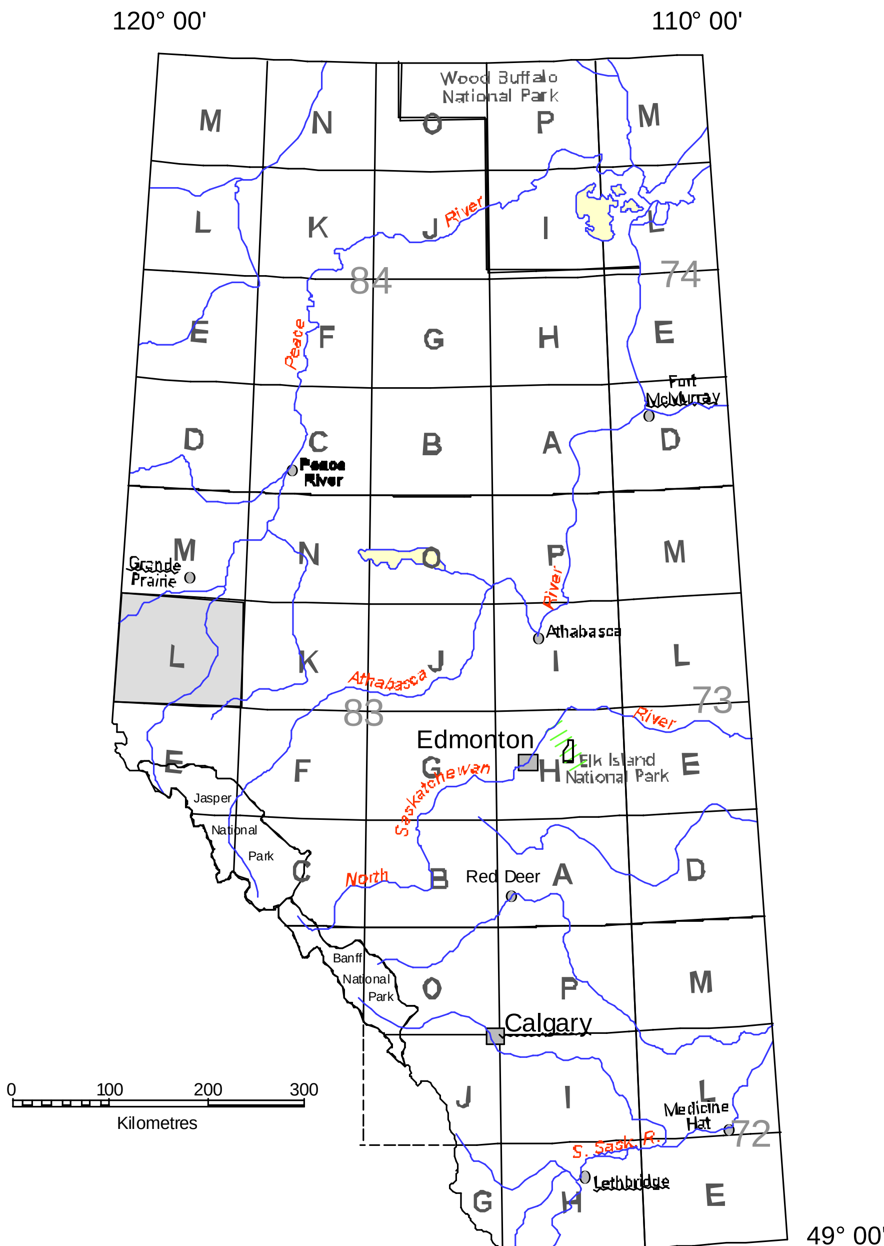

Figure 1. Location of the map area (NTS 83L).

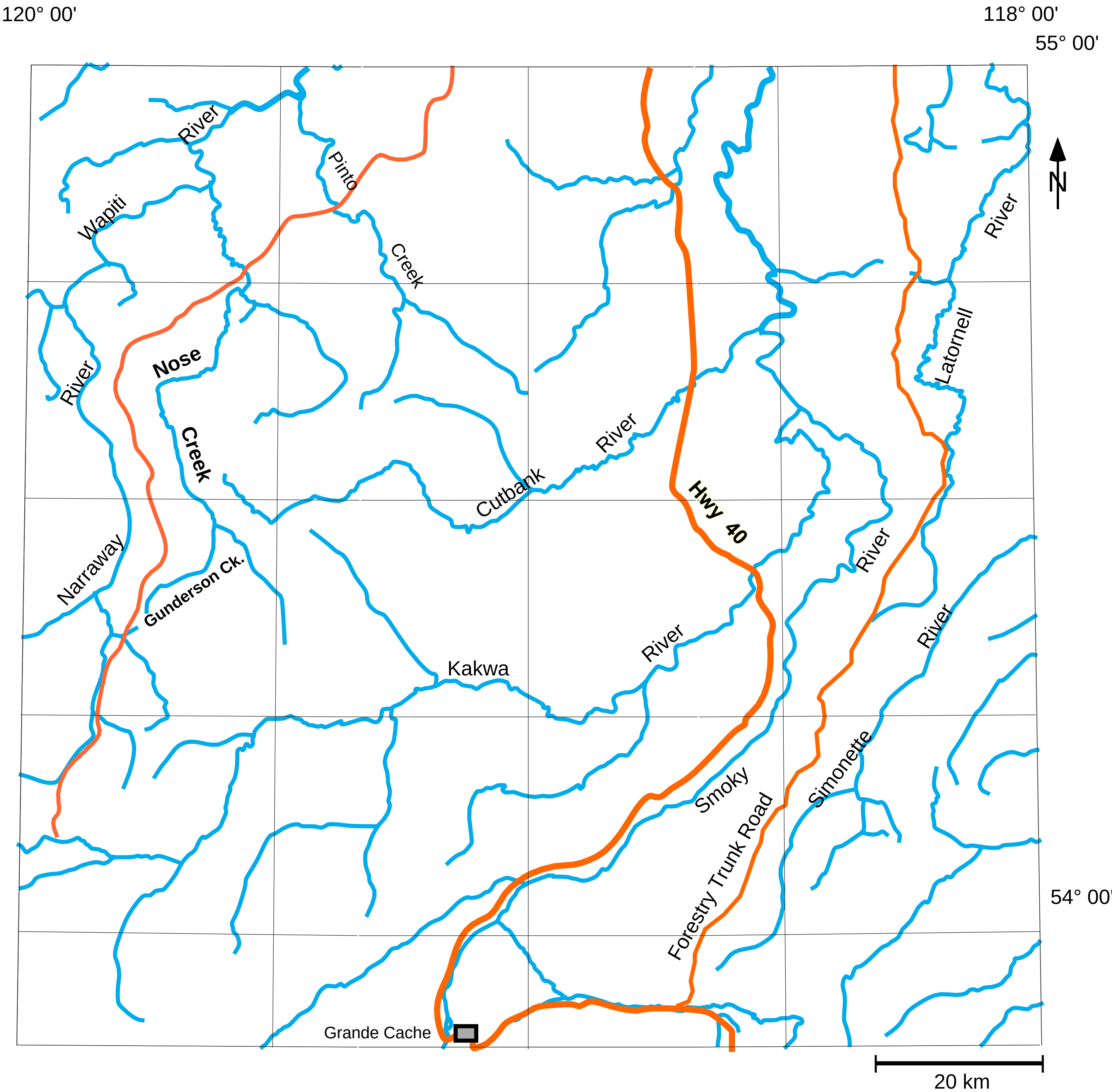

Figure 2. Geographical features in the Wapiti area.

The first objective of the study was to provide information on the surficial and Quaternary geology, including till petrology, geochemistry, diamond-indicator mineralogy, ice-flow directions, and glacial-dispersion patterns. The second objective was to prepare surficial geology maps at scales of 1:250 000 and 1:50 000. A surficial geology map at 1:250 000 scale accompanies this report, but there were insufficient resources to gather the ground control needed to produce the 1:50 000 scale maps.

Work on this project was suspended during the second of the three years originally planned due to redirection of staff effort to higher priority areas in northern Alberta. There was a complete field season only during year one; year two had a much reduced field season due to restructuring of the Alberta Geological Survey.

This report releases the current data and interpretations pertaining to the surficial geology and till geochemistry. A separate report will provide information on the kimberlite indicator minerals recovered from the till.

1.2 Sample Collection

Most of the surface samples were collected from areas accessible by road, although a few were obtained using a helicopter to reach less accessible sites. As a result, the distribution of sample sites is not uniform (*see* Fig. 7).

Most samples collected were from till, although a few were obtained from bedrock, lacustrine, colluvial, or fluvial units. Samples were taken from below the top of the C soil horizon, generally between a depth of 1.5 to 2.5 m, to minimize the effects of weathering on the carbonate, iron, and clay content of the till and to maximize the preservation of indicator mineral grains. About three-quarters of the samples were collected from roadcuts or other naturally exposed sections; the remainder were collected from sample pits dug by hand into the undisturbed land surface. Till samples of about 25 kg were collected for analysis of diamond-indicator minerals, whereas 2 to 3 kg samples were taken for geochemical analysis. The small samples were placed in plastic bags, and the large till samples in 5-gallon (approx. 23 l) plastic pails. The field data recorded at each site included information on the natural setting and sampling environment, and observations on the colour, texture, moisture content, and mineralogy of the till.

1.3 Physiography

The physiography of Alberta, including the Wapiti map area, has been described by Bostock (1970a, b), Klassen (1989), and Pettapiece (1986). Some of the information given below was derived from Twardy and Corns (1980), a soils report dealing specifically with the Wapiti map area.

The Wapiti map area encompasses the transition zone from the Interior Plains to the Eastern Cordillera. Elevation rises from about 525 m (1720 ft) in the northeast to 2455 m (8050 ft) in the southwest (Fig. 3). Four physiographic regions can be defined: the Wapiti Plains, the Alberta Plateau Benchlands, the Rocky Mountain Foothills, and the Rocky Mountains (Fig. 4).

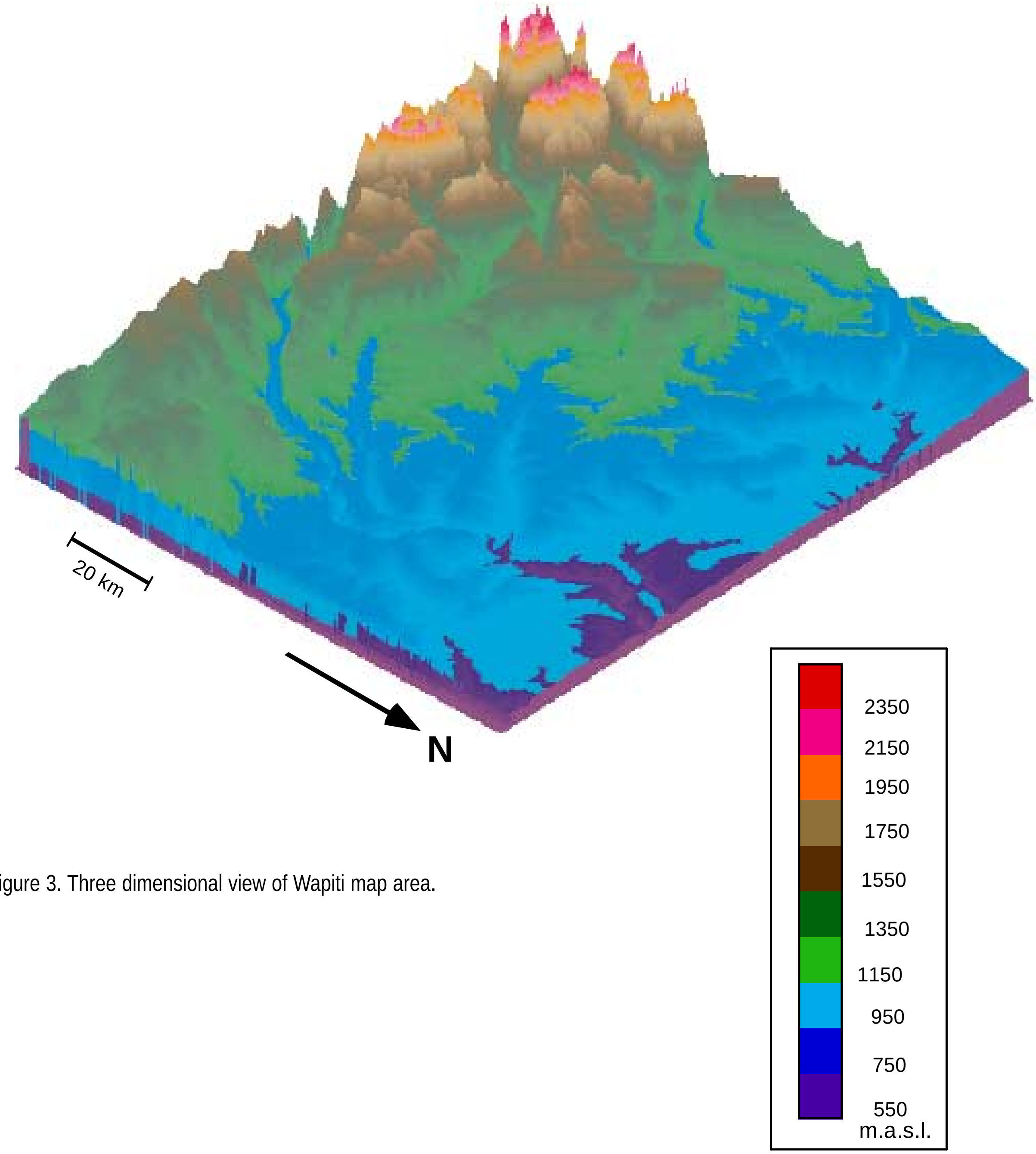

Figure 3. Three dimensional view of Wapiti map area.

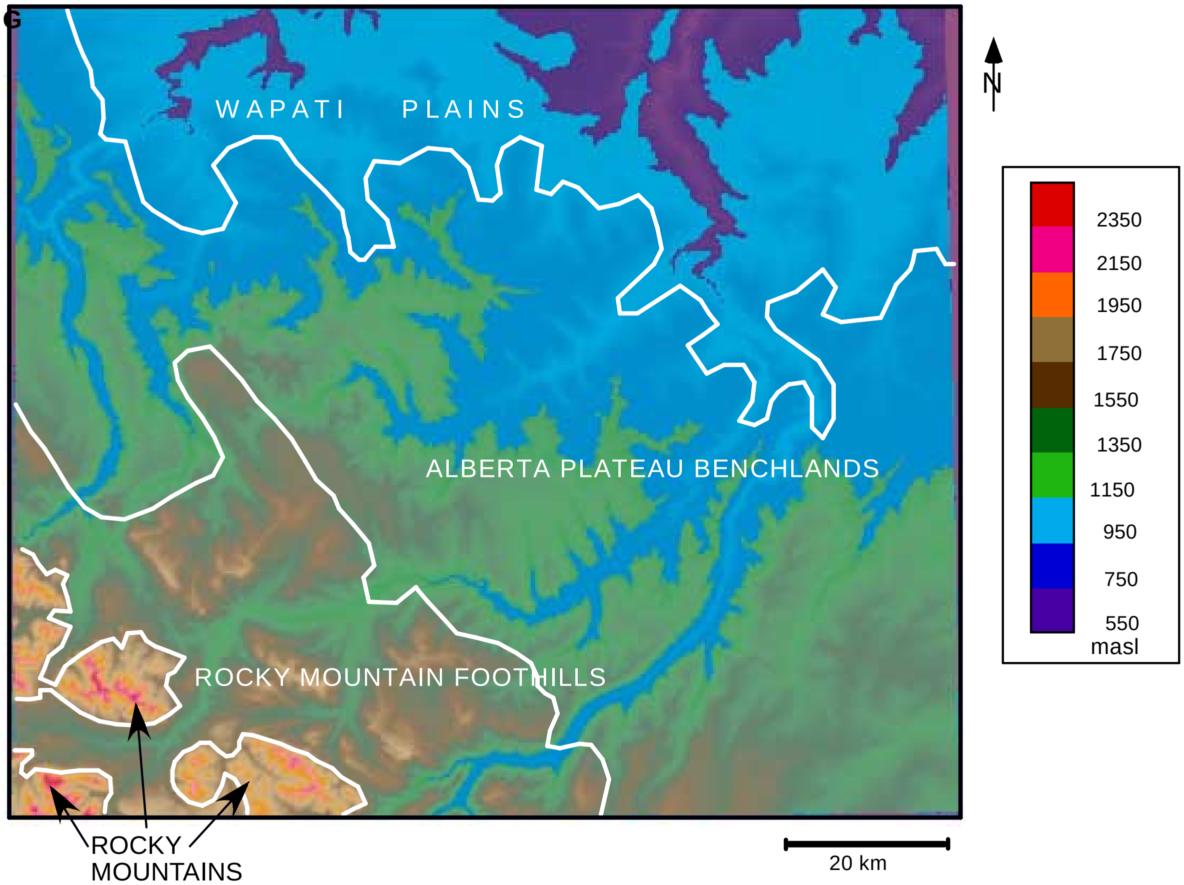

Figure 4. Pysiographic map, Wapiti map area. (from Twardy and Corns, 1980 and Pettapiece, 1986)

The **Wapiti Plains** cover the northern and northeastern portions of the area. Maximum elevation is about 855 m (2800 ft) and the landscape is low relief, undulating to rolling. The area is underlain primarily by glaciolacustrine and glaciofluvial sediment.

The **Alberta Plateau Benchlands**, which forms a northwest-trending unit through the centre of the map area, is a dissected benchland with high local relief. The surface is underlain by till, weathered bedrock, or local Tertiary quartzite gravel. Weathered bedrock forms the surface mainly in the southwestern part of the area. The gently dipping soft bedrock is relatively easily eroded and colluvium partially mantles many of the eroded slopes. Average elevation ranges from about 855 to 1465 m (2800–4800 ft), with a few highlands rising to about 1525 m (5000 ft).

The **Rocky Mountain Foothills** form a generally northwest-trending division between the Benchlands and the Rocky Mountains. The surface is underlain by folded Cretaceous and Tertiary bedrock with a thin and discontinuous cover of Quaternary sediment, primarily till and colluvium. Elevations range from 1065 to 1830 m (3500–6000 ft), although they are generally between 1525 and 1585 m (5000–5200 ft).

The **Rocky Mountains** occupy the southwest portion of the area. Landforms in this unit consist of steep valleys and peaks that have been modified by glacial action. Features such as cirques, aretes, and U-shaped valleys are common. The mountains are composed of highly folded and faulted rock, primarily of Mesozoic age. Elevations range from 1525 to 2455 m (5000–8050 ft).

2 Surficial Geology

The surficial geology is shown on Map 239 (on cd). This map was compiled by Andriashek (1983) from unpublished work by L. Bayrock and A. Twardy. This is the first colour version of this map to be released.

Preliminary field data indicated that the boundaries of some of the polygons on the original map are not sufficiently reliable for a 1:50 000 map. This is particularly true for the thin and/or discontinuous till units, and the adjacent exposed bedrock units.

One of the objectives of this project was therefore to validate and perhaps refine this map, so that it could be produced at 1:50 000 scale. However, suspension of the project in year two precluded the collection of enough data to allow production of the 1:50 000 scale maps.

2.1 Map Units

There are twenty-four primary surficial map units on Map 239. There are also a number of composite units, indicated by a pattern superimposed on the unit colour, which signifies a thin and/or discontinuous unit overlying another unit. The properties of the various map units are summarised in the legend for Map 239.The sediment types covering major portions of the region are till, glaciolacustrine sediment, weathered bedrock, and, to a lesser extent, glaciofluvial sediment. Glaciolacustrine sediment (map units 5, 6, and 7) and glaciofluvial sediment (map units 8, 9, and 10) are confined mainly to the Wapiti lowland in the north and northeast. There are also significant quantities of glaciofluvial sediment in the upstream terraces along rivers such as the Narraway, Kakwa, Wapiti, and Smoky, and along Gunderson Creek.

The moraine units, composed predominantly of till, include those of Continental–Laurentide origin (units 12 to 16), Cordilleran–Rocky Mountain origin (units 16 to 19), and mixed origin (units 20 and 21). The units consist primarily of ground moraine (low relief with an undulating to rolling topography) and hummocky moraine (moderate to high relief with a hummocky topography).

The bedrock units consist of shale and siltstone (unit 22), sandstone of the Paskapoo Formation (unit 23), and more indurated conglomerate and sandstone (unit 24). Units 22 and 23 are in the central and southwest portion of the area, whereas unit 24 outcrops in the Rocky Mountains.

2.2 Ice Flow and History

The Wapiti area is located in a region that was subjected to glacial flow from three sources: the Rocky Mountains, the Cordillera, and the Laurentide (Continental) glacial centres. The ice-flow direction and relationships between the various lobes are, however, poorly understood.

Limited examination, primarily in the field, of the pebble to boulder clast sizes reveals that distinctive clasts types are found in the till only in certain parts of the study area. The till units are characterized by:

- clasts of green metaconglomerate and low-grade greenish grey schist, plus granite and other igneous rocks, in the northwest;
- clasts of grey carbonate in the west and southwest;

- mainly quartzite and igneous (primarily granite) clasts in the east;

- abundant well-rounded quartzite clasts incorporated from the underlying Tertiary gravel deposits in parts of the centre and south (Fig. 5);

- boulders of low-grade schist at three relatively closely spaced sites west of the Smokey River in the south-central portion of the area (twp 59, rge 8, W6, Map 239 near site NAT96-176, Fig. 7 and Appendix A); and

- a boulder of low-grade, grey metamorphic rock, perhaps phyllite, east of the Smoky River in the southeastern part of the area (twp 61, rge 3, W6, Map 239; site NAG96-594, Fig. 7 and Appendix A).

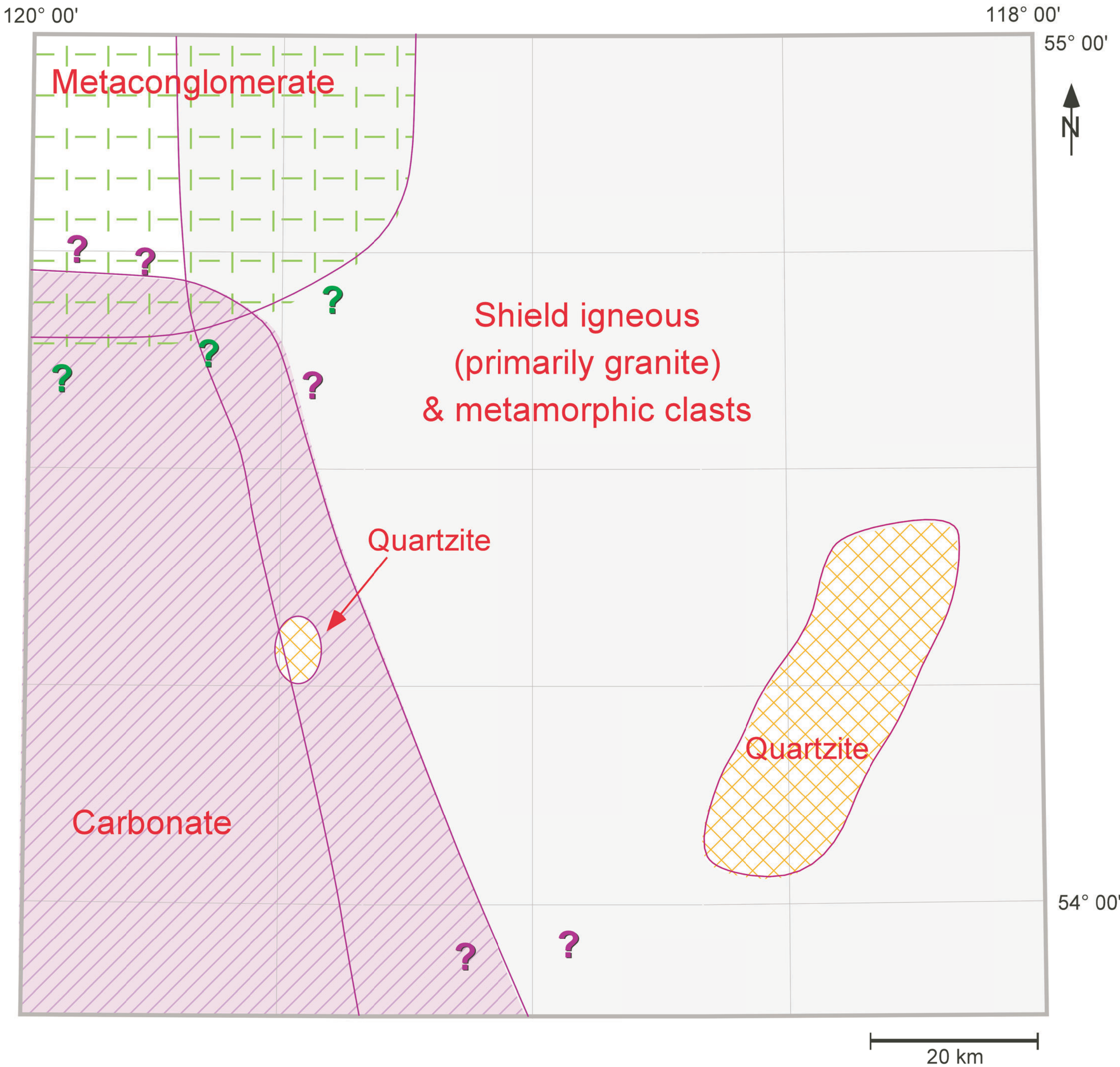

Figure 5. Preliminary subdivision of map area based on coarse clast lithology.

The low-grade metamorphic and the metaconglomerate clasts are believed to have come from sources west and slightly northwest of the northwest corner of the map area, perhaps as far west as the Cordillera. The carbonate rocks are believed to have been eroded from the Paleozoic formations exposed in the Rocky Mountains.

The granite and related rock types were transported into the area by the Laurentide glaciers which incorporated these rock types as they flowed over the Precambrian Shield. This source is also supported by the occurrence of one boulder-sized clast of a very distinctive reddish brown conglomerate on Pinto Creek in the northwestern portion of the area (Fig. 7, site NAG96-681). This boulder likely came from conglomerate that is part of the Precambrian Martin Lake Formation. The distribution of this formation is confined to the north-central arm of Lake Athabasca in northwestern Saskatchewan.

The above petrological information indicates that glaciers may have flowed from the northeast (Laurentide), the Cordillera and the Rocky Mountains. The occurrence of clasts of metaconglomerate and low-grade schist, together with granite and related rocks, indicates a mixing of sediment transported by the Cordilleran and Laurentide ice sheets. This may have been a Laurentide glacier overriding Cordilleran deposits or the vice-versa. The data collected so far are inconclusive.

The till containing the grey carbonate clasts was likely deposited by glaciers flowing out of the Rocky Mountains, or perhaps out of a different portion of the Cordillera. When the eastern margin of the Cordilleran till units, (shown on Map 239), and units 16 and 19 are plotted on the three-dimensional map (Fig. 6), it is obvious that the ice responsible for depositing these sediments was confined to the higher parts of the landscape. This suggests either the presence of the Laurentide glacial front directly to the east, or that the ice that deposited this till lacked the energy to continue advancing to the lower elevations.

The till in unit 19 is distinctly different from the other till units in that it is deeply weathered. The carbonate sediments are leached to a depth of at least 2.5 m, whereas the other units are generally leached to less that 1.5 m. Bayrock (unpublished field notes, 1972) interpreted this to mean that unit 19 is much older than the other glacial units. He also believed that this unit was of Cordilleran origin.

The presence of boulders of low-grade schist (*see* item [5] above) at a few sites near where this unit 19 has been mapped also suggests that this sediment was deposited by ice flowing from a Cordilleran source. These boulders are probably not directly related to the ice advance that deposited the unit containing the clasts of low-grade metamorphic and the metaconglomerate rocks in the northwestern part of the map area.

The presence of a boulder of low-grade metamorphic rock (*see* item [6] above), suggests that the till at this site incorporated sediment from a Cordilleran source. However, as this till directly overlies a Tertiary gravel deposit, the clast may have been derived from the underlying gravel, although no other metamorphic clasts were found in the gravel pit at this site.

The contribution of clasts transported by rivers flowing out of the Cordillera and subsequently eroded by the Laurentide glaciers is unknown. However, this is believed to be comparatively minor because the existing streams flowing from the Cordillera are relatively small and do not originate in the areas where the distinctive clasts are believed to outcrop.

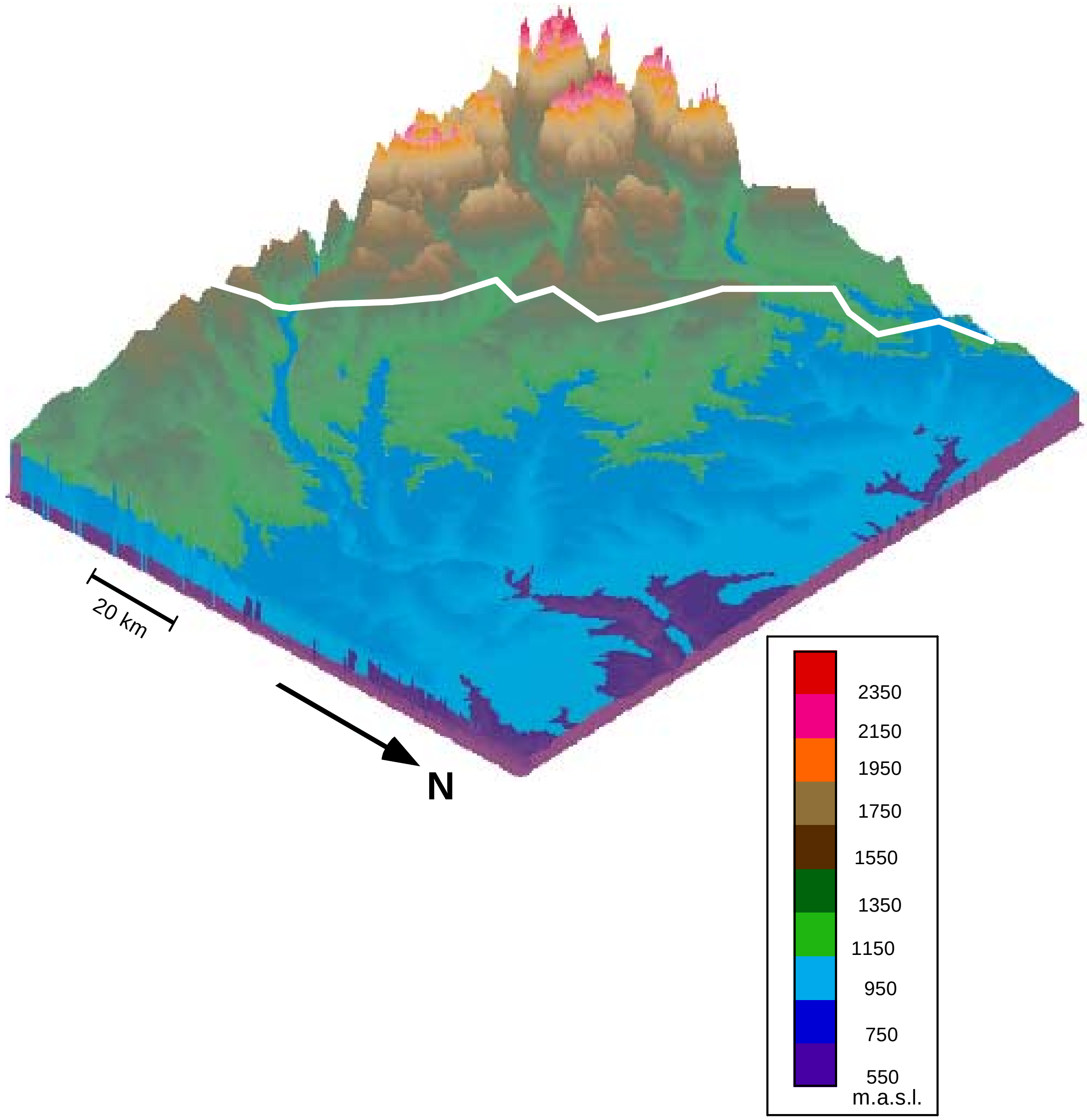

Figure 6. Three dimensional map showing approximate eastern limit of the Cordillearan/Rocky Mountain tills (based on surficial geology map 239)

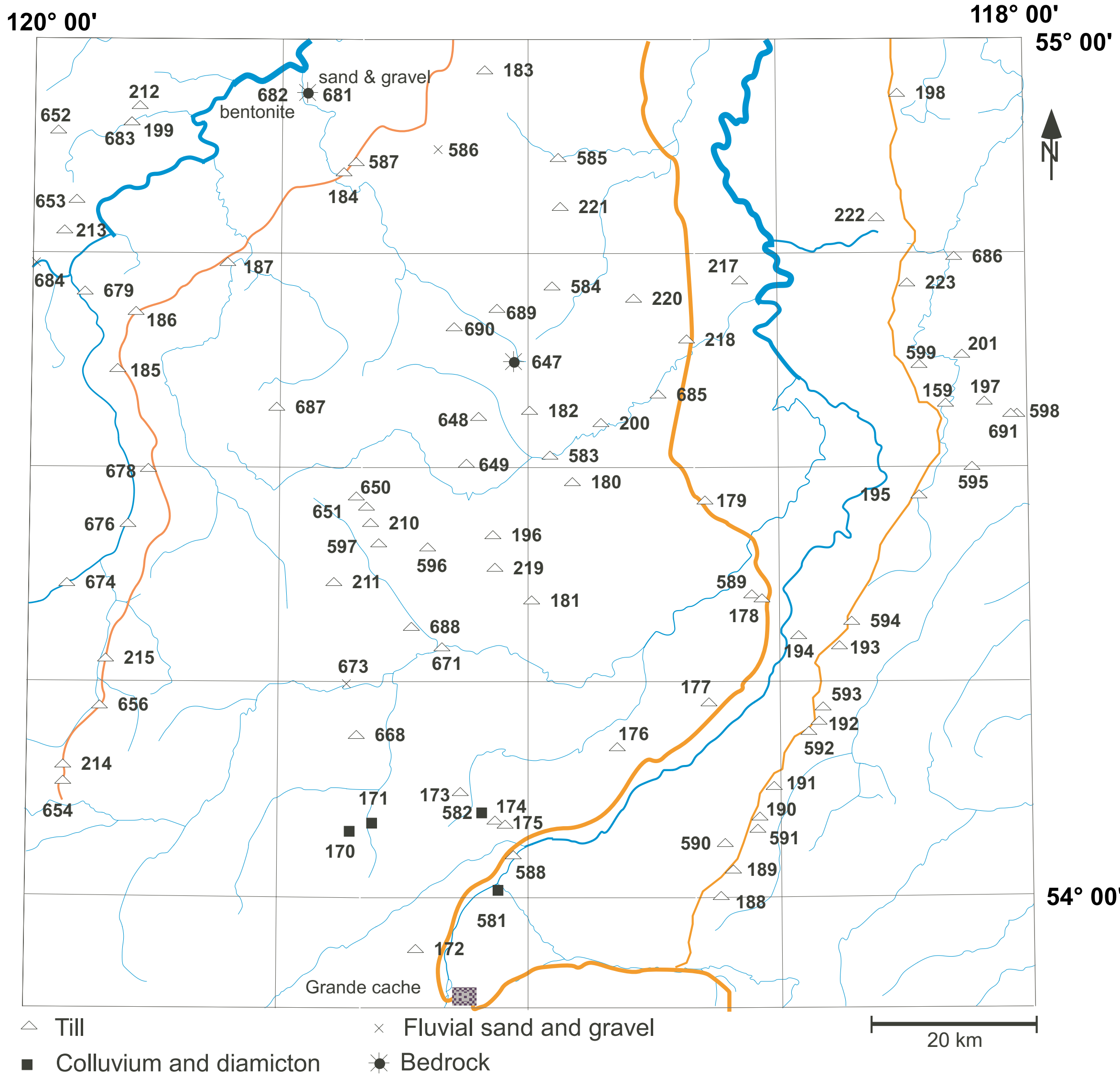

Figure 7. Location of geochemical samples. The sample number prefixes such as NAT96-, NAT97- NAG96- and NAT97-, shown in the appendix have been omitted here. There are two sites, both located in the northwest quadrant at which two samples were collected: samples 199 and 683 are both till; sample 681 is gravel and 682 is bentonite. In later figures the analytical values for the two samples at each of these sites, will always be in the same position relative to the site symbol as are the sample numbers in this figure, for example the value for sample 681 will always be to the right of the symbol.

3 Analytical Methods

Each of the 2 to 3 kg samples was air dried, gently disaggregated to avoid the crushing of rock and mineral grains, and screened using 2.00 mm and 0.063 mm stainless steel sieves. About 50 grams of the <0.063 mm (-230 mesh) fraction was recovered from each sample. This was then divided to provide subsamples for flame atomic absorption spectrometry (AA), instrumental neutron activation analysis (INAA), and reference-sample storage. The remainder of the sample was retained for possible future analysis.

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 submitted were duplicates or standards.

The AA analyses were done by CanTech Laboratories Inc. using a 'total digestion' procedure. A 1 g subsample of the <0.063 mm fraction was dissolved in a fuming $HF-HClO_4-HNO_3$ mixture and then analyzed. The procedure determined the concentrations of Ag, Cd, Co, Cu, Fe, Li, Mn, Mo, Ni, Pb, V, Zn, and, for a few samples, Mg.

The INAA analyses were carried out by Becquerel Laboratories, Inc. Each subsample of about 10 g was encapsulated, sealed and irradiated with neutron flux in a 2 MW pool-type reactor. Following a 7-day period to allow transient products to decay, the gamma radiation from the samples was counted for approximately 500 seconds using a high resolution Ge detector system. This procedure was used to determine the concentrations of Ag, As, Au, Ba, Br, Cd, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ir, La, Lu, Mo, Na, Ni), Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Te, Th, W, U, Yb, Zn, and Zr.

Table 1 lists the detection limit for each element. Appendix A contains all geochemical data. Note that sample-number prefixes such as NAT96-, NAT97-, NAG96-, and NAT97-, shown in the appendix, have been omitted from Figure 7 for simplicity (so that NAG96-587 becomes 587). There are two sites, both located in the northwest quadrant of the map area, at which two samples were collected: samples 199 and 683 are both till; sample 681 is gravel and sample 682 is bentonite. In the element distribution plots that follow, the analytical values for the two samples in each of these pairs will always be in the same position, relative to the site symbol, as are the sample numbers in Figure 7 (e.g. the value for sample 681 will always be to the right of the symbol).

Additional analyses were carried out to determine the texture and carbonate content of each sample. The texture analyses used sieving and hydrometer techniques to determine the proportions of sand, silt, and clay (0.063 mm, 0.050 mm, 0.004 and 0.002 mm boundaries). The Alberta Geological Survey laboratory uses a slightly modified version of the American Society for Testing Materials (1954) procedure for grain-size analysis. The values obtained by the Survey's procedure were found to differ little from those obtained by the American Society for Testing Materials (ASTM) procedure, and reduced the analytical time required. The fundamental difference between the two methods is that the Survey's laboratory uses a computer program to determine the silt-clay boundary, based on only the 2-, 4-, 8-, and 24-hour hydrometer readings. Dry sieves and an electronic balance were used to calculate the percentage of sand, using the conventional ASTM procedure.

Carbonate content in the silt-clay fraction (<0.063 mm) was determined using the Chittick apparatus, a procedure that was first designed and successfully applied to till analyses by Dreimanis (1962) and later adapted by Christiansen and Ross (1971). The Survey's technique involves adding 10% HCl to the sample and measuring the volume of CO_2 gas released, through the reaction between the acid and sample, as a function of time. A curve showing the rate of CO_2 production with time can then be plotted, and the percentage of calcite and dolomite can be calculated from this.

Table 1. Analytical methods and detection limits, for till matrix geochemistry.

Element symbol	Element name	Detection limit	Method
Ag	silver	0.2 ppm	AA / total digestion
As	arsenic	0.5 ppm	INNA
Au	gold	2 ppb	INNA
Ba	barium	50 ppm	INNA
Br	bromine	0.5 ppm	INNA
Cd	cadmium	0.2 ppm	AA / total digestion
Ce	cerium	5 ppm	INNA
Co	cobalt	2 ppm	AA / total digestion
Cr	chromium	20 ppm	INNA
Cs	cesium	0.5 ppm	INNA
Cu	copper	2 ppm	AA / total digestion
Eu	europium	1 ppm	INNA
Fe	iron	0.02%	AA / total digestion
Hf	hafnium	1 ppm	INNA
Ir	iridium	50 ppm	INNA
La	lanthanum	2 ppm	INNA
Li	lithium	1.0 ppm	AA / total digestion
Lu	lutetium	0.2 ppm	INNA
Mg	magnesium	0.01%	AA / total digestion
Mn	manganese	5 ppm	AA / total digestion
Mo	molybdenum	2 ppm	AA / total digestion
Na	sodium	0.02 %	INNA
Ni	nickel	2 ppm	AA / total digestion
Pb	Lead	2 ppm	AA / total digestion
Rb	rubidium	5 ppm	INNA
Sb	antimony	0.1 ppm	INNA
Sc	scandium	0.2 ppm	INNA
Se	selenium	5 ppm	INNA
Sm	samarium	0.1 ppm	INNA
Sn	tin	100 ppm	INNA
Ta	tantalum	0.5 ppm	INNA
Tb	terbium	0.5 ppm	INNA
Te	tellurium	10 ppm	INNA
Th	thorium	0.2 ppm	INNA
U	uranium	0.2 ppm	INNA
V	vanadium	5 ppm	AA / total digestion
W	tungsten	1 ppm	INNA
Yb	ytterbium	1 ppm	INNA
Zn	zinc	2 ppm	AA / total digestion
Zr	zirconium	200 ppm	INNA

AA = Flame Atomic Absorption Spectrophotometry
NA = Instrumental Neutron Activation Analysis

4 Analytical Results

4.1 Regional Geochemistry

Part of the primary purpose of this report is to release the geochemical data. This section presents only preliminary comments on the distribution of, and relationships between, the target elements.

The analytical data are listed in Appendix A and plotted on Figures 8 to 76. Table 2 provides a statistical summary of all analytical data, whereas Table 3 summarizes only the data for the till and diamicton samples. Because of the large number of figures compared to the amount of text, Figures 8 to 76 have been placed in a block at the end of this section.

Ag, Silver

This element as determined by AA, varies from below the detection limit of 0.2 ppm up to 0.9 ppm, and averages 0.18 ppm (Fig. 8; Tables 2, 3). The 75th percentile is 0.2 ppm and the 95th percentile is 0.4 ppm.

Higher concentrations of Ag (≥75th percentile) are found locally throughout the area (Fig. 8). The highest concentrations (≥95th percentile) are primarily from samples collected from the northern half of the area at the sites where the till surface is exposed above the lacustrine cover. The highest value (0.9 ppm) is from a site on the Narraway River on the west side of the area.

As, Arsenic

This element as determined by INAA, varies from 3 to 40 ppm, and averages 9.02 ppm (Fig. 9; Tables 2, 3). The 75th percentile is 10 ppm and the 95th percentile is 14 ppm.

Higher concentrations of As (≥75th percentile) are found primarily in the northern part of the area, with other concentrations in the central and south-central parts (Fig. 9). The highest concentrations (≥95th percentile) are primarily in till samples from sites in the northeast (14, 17, and 18 ppm), and from one site in the southeast (17 ppm). The highest value (40 ppm) is from a till site in the west-central portion of the area.

Au, Gold

This element as determined by INAA, varies from below the detection limit of 2 ppb up to 36 ppb, and averages 4.3 ppb; the maximum for the till samples is 15 ppb (Fig. 10; Tables 2, 3). The 75th percentile is 5 ppb and the 95th percentile is 11.6 ppb for all samples.

Higher concentrations of Au (≥75th percentile) are present throughout the area (Fig. 10). The highest concentrations (≥95th percentile) are primarily from two till sites and one fluvial site in the west quarter of the area (12, 15, and 17 ppb), one site in the east (13 ppb), and one site in the northwest (36 ppb; sample no. 681). Note that, on Figure 10, the bedrock lithology symbol at this last site obscures the smaller cross identifying it as a fluvial sample.

Ba, Barium

This element as determined by INAA, varies from 400 to 2400 ppm, and averages 873 ppm; the maximum for the till samples is 1400 ppm (Fig. 11; Tables 2, 3). The 75th percentile is 940 ppm and the 95th

Table 2. Statistical summary of analytical data from surface samples of all sediment types. (<0.063 mm fraction) and texture (<2.00 mm).

Element	**Ag**	~~**Ag**~~	**As**	**Au**	**Ba**	**Br**	**Cd**	~~**Cd**~~	**Ce**	**Co**	~~**Co**~~	**Cr**	**Cs**	**Cu**	**Eu**
Method	AA/Total	~~NA~~	NA	NA	NA	NA	AA/Total	~~NA~~	NA	AA/Total	~~NA~~	NA	NA	AA/Total	NA
DetectionLimit	0.2 ppm	~~2 ppm~~	0.5 ppm	2 ppb	50 ppm	0.5 ppm	0.2 ppm	~~5 ppm~~	5 ppm	2 ppm	~~5 ppm~~	20 ppm	0.5 ppm	2 ppm	1 ppm
Number of samples	92	~~90~~	90	90	90	90	92	~~90~~	90	92	~~90~~	90	90	92	90
Min	**0.1bd**	~~**1bd**~~	**3.0**	**1bd**	**400**	**0.25bd**	**0.1bd**	~~**2.5bd**~~	**39**	**3**	~~**2.5bd**~~	**10bd**	**1.3**	**13**	**0.5bd**
Max	**0.90**	~~**4**~~	**40.0**	**36**	**2400**	**2.9**	**2.0**	~~**2.5**~~	**90**	**19**	~~**22**~~	**140**	**6.4**	**38**	**2.0**
Average	0.18	~~1~~	9.02	4.3	873	1.15	0.35	~~2.5~~	62.2	11.4	~~13~~	85.8	4.45	24.7	0.7
75%ile	**0.20**	~~**1**~~	**10.00**	**5.0**	**940**	**1.44**	**0.40**	~~**2.5**~~	**70.8**	**13.0**	~~**15**~~	**94.0**	**5.20**	**28.1**	**1.0**
95% ile	**0.40**	~~**2**~~	**14.00**	**11.6**	**1155**	**2.38**	**0.80**	~~**2.5**~~	**77.6**	**17.0**	~~**19**~~	**115.5**	**6.06**	**33.9**	**1.0**

Element	**Fe**	~~**Fe**~~	**Hf**	**Ir**	**La**	**Li**	**Lu**	**Mg**	**Mn**	**Mo**	~~**Mo**~~	**Na**	**Ni**	~~**Ni**~~	**Pb**
Method	AA/Total	~~NA~~	NA	NA	NA	AA/Total	NA	AA/Total	AA/Total	AA/Total	~~NA~~	NA	AA/Total	~~NA~~	AA/Total
DetectionLimit	0.02%	~~0.2%~~	1 ppm	50 ppm	2 ppm	1.0 ppm	0.2 ppm	0.01%	5 ppm	2 ppm	~~1 ppm~~	0.02%	2 ppm	~~10 ppm~~	2 ppm
Number of samples	92	~~90~~	90	90	90	92	90	12	92	92	~~90~~	90	92	~~90~~	92
Min	**1.5**	~~**1.6**~~	**3**	**25bd**	**22**	**8**	**0.1bd**	**0.97**	**63**	**2**	~~**0.5bd**~~	**0.1**	**5**	~~**5bd**~~	**8**
Max	**4.5**	~~**4.2**~~	**18**	**25bd**	**48**	**37**	**0.5**	**1.55**	**2300**	**6**	~~**1.0**~~	**1.4**	**45**	~~**61**~~	**44**
Average	3.10	~~2.80~~	7.2	25	31.8	16.6	0.19	1.27	371	4.0	~~0.5~~	0.53	31.5	~~34.0~~	15.5
75%ile	**3.40**	~~**3.10**~~	**8.0**	**25**	**35.0**	**19.0**	**0.30**	**1.35**	**382**	**5.0**	~~**0.5**~~	**0.66**	**36.0**	~~**42.9**~~	**17.0**
95% ile	**4.05**	~~**3.56**~~	**11.8**	**25**	**38.6**	**33.0**	**0.36**	**1.54**	**534**	**5.0**	~~**0.8**~~	**1.10**	**42.0**	~~**58.0**~~	**19.0**

Element	**Rb**	**Sb**	**Sc**	**Se**	**Sm**	**Sn**	**Ta**	**Tb**	**Te**	**Th**	**U**	**V**	**W**	**Yb**	**Zn**	~~**Zn**~~	**Zr**
Method	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	AA/Total	NA	NA	AA/Total	~~NA~~	NA
DetectionLimit	5 ppm	0.1 ppm	0.2 ppm	5 ppm	0.1 ppm	100 ppm	0.5 ppm	0.5 ppm	10 ppm	0.2 ppm	0.2 ppm	5 ppm	1 ppm	1 ppm	2 ppm	~~100 ppm~~	200 ppm
Number of samples	90	90	90	~~90~~	90	90	90	90	90	90	90	92	90	90	92	~~90~~	90
Min	**29**	**0.5**	**7.0**	~~**2.5bd**~~	**3.4**	**50bd**	**0.6**	**0.25bd**	**5bd**	**5.1**	**1.7**	**21**	**0.5bd**	**0.5bd**	**58**	~~**50bd**~~	**100bd**
Max	**120**	**1.7**	**17.0**	~~**2.5bd**~~	**8.4**	**50bd**	**1.6**	**1.3**	**5bd**	**22.6**	**6.5**	**143**	**2.0**	**4**	**181**	~~**160**~~	**630**
Average	81.5	1.05	11.28	~~2.5~~	4.96	50	1.01	0.7	5.0	10.3	3.5	97.1	0.7	2.2	104.2	~~52~~	252
75%ile	**92.8**	**1.18**	**12.00**	~~**2.5**~~	**5.30**	**50**	**1.10**	**0.8**	**5.0**	**11.0**	**3.7**	**109.0**	**1.0**	**3.0**	**112.3**	~~**50**~~	**390**
95% ile	**100.0**	**1.40**	**14.55**	~~**2.5**~~	**6.11**	**50**	**1.30**	**1.0**	**5.0**	**12.3**	**4.3**	**120.7**	**1.0**	**3.0**	**135.5**	~~**50**~~	**550**

	Lab Text **Sand % 1-2mm**	Lab Text **Sand (>63)**	Lab Text **Silt (<63)**	Lab Text **Clay (<4)**	Lab Text **Sand (>50)**	Lab Text **Silt (<50)**	Lab Text **Clay (<2)**	Chittick **Calcite ml/g)**	Chittick **Total carbonate ml/g**	Chittick **Calcite %**	Chittick **Dolomite %**	Chittick **Tota carbonates %**	Chittick **Cct/Dmt ratio**	Field **Reaction with HCl**	Field Text **Sand %**	Field Text **Silt%**	Field Text **Clay%**
Count	92	92	92	92	92	92	92	91	91	91	91	91	91	68	67	67	67
Min	**0.2**	**1.8**	**11.6**	**2.4**	**2.5**	**11.3**	**1.3**	**1.0**	**3.1**	**0.5**	**0.5**	**1.30**	**0.09**	**1**	**5**	**7**	**3**
Max	**25.0**	**85.9**	**60.0**	**71.0**	**87.2**	**66.7**	**65.5**	**59.4**	**88.2**	**26.6**	**17.5**	**38.45**	**2.25**	**4**	**90**	**65**	**70**
Average	2.95	27.26	41.84	30.90	29.78	46.59	23.63	9.29	25.14	4.17	6.52	10.69	0.62	3.4	23.5	41.9	34.4
75%ile	**2.43**	**32.48**	**47.40**	**38.23**	**34.88**	**52.10**	**30.15**	**12.40**	**32.25**	**5.55**	**8.50**	**13.80**	**0.77**	**4.0**	**27.5**	**52.5**	**45.0**
95% ile	**10.71**	**49.01**	**55.12**	**45.95**	**51.10**	**61.38**	**35.35**	**19.85**	**48.65**	**8.90**	**10.60**	**21.05**	**1.15**	**4.0**	**67.0**	**60.0**	**60.0**

bd = below detection limit

All values below detection limit are shown as one half of detection limit

~~1.60~~ = data not discussed because either they were below the detection limit or because data from and alternative analytical method were discussed for this element.

Table 3. Statistical summary of analytical data from surface samples of till and diamicton only.

Element	Ag	~~Ag~~	As	Au	Ba	Br	Cd	~~Cd~~	Ce	Co	~~Co~~	Cr	Cs	Cu	Eu
Method	AA/Total	~~NA~~	NA	NA	NA	NA	AA/Total	~~NA~~	NA	AA/Total	~~NA~~	NA	NA	AA/Total	NA
DetectionLimit	0.2 ppm	~~2 ppm~~	0.5 ppm	2 ppb	50 ppm	0.5 ppm	0.2 ppm	~~5 ppm~~	5 ppm	2 ppm	~~5 ppm~~	20 ppm	0.5 ppm	2 ppm	1 ppm
Count	81	~~79~~	79	79	79	79	81	~~79~~	79	81	~~79~~	79	79	81	79
Min	**0.1bd**	~~**1**~~	**3.0**	**1bd**	**400**	**0.25bd**	**0.1bd**	~~**2.5bd**~~	**39**	**5**	~~**6**~~	**48**	**2.1**	**13**	**0.5bd**
Max	**0.9**	**4**	**40.0**	**15**	**1400**	**2.9**	**1.5**	~~**2.5**~~	**90**	**19**	~~**22**~~	**120**	**6.4**	**38**	**2.0**
Average	0.19	~~1~~	9.17	3.8	851	1.19	0.31	~~2.5~~	63.3	11.4	~~13~~	84.4	4.56	24.5	0.7
75%ile	0.20	~~1~~	9.75	5.0	930	1.50	0.40	~~2.5~~	71.0	13.0	~~15~~	93.0	5.20	28.0	1.0
95% ile	0.40	~~2~~	14.30	8.3	1110	2.36	0.70	~~2.5~~	77.0	16.0	~~19~~	110.0	6.01	33.0	1.0

Element	Fe	~~Fe~~	Hf	Ir	La	Li	Lu	Mg	Mn	Mo	~~Mo~~	Na	Ni	~~Ni~~	Pb
Method	AA/Total	~~NA~~	NA	NA	NA	AA/Total	NA	AA/Total	AA/Total	AA/Total	~~NA~~	NA	AA/Total	~~NA~~	AA/Total
DetectionLimit	0.02%	~~0.2%~~	1 ppm	50 ppm	2 ppm	1.0 ppm	0.2 ppm	0.01%	5 ppm	2 ppm	~~1 ppm~~	0.02%	2 ppm	~~10 ppm~~	2 ppm
Number of samples	81	~~79~~	79	79	79	81	79	12	81	81	~~79~~	79	81	~~79~~	81
Min	**1.5**	~~**1.6**~~	**4**	**25bd**	**22**	**9**	**0.1bd**	**0.97**	**145**	**2**	~~**0.5bd**~~	**0.1**	**19**	~~**5bd**~~	**9**
Max	**4.5**	~~**4.2**~~	**12**	**25bd**	**48**	**37**	**0.5**	**1.55**	**588**	**6**	~~**1.0**~~	**1.3**	**43**	~~**59**~~	**20**
Average	3.10	~~2.8~~	6.8	25	32.4	17.1	0.19	1.27	326	4.0	~~0.5~~	0.49	31.5	~~33.1~~	15.4
75%ile	3.40	~~3.1~~	8.0	25	35.0	20.0	0.30	1.35	371	5.0	~~0.5~~	0.57	36.0	~~41.0~~	17.0
95% ile	4.10	~~3.6~~	10.0	25	38.1	33.0	0.40	1.54	503	5.0	~~0.8~~	1.00	41.0	~~53.2~~	19.0

Element	Rb	Sb	Sc	Se	Sm	Sn	Ta	Tb	Te	Th	U	V	W	Yb	Zn	~~Zn~~	Zr
Method	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	AA/Total	NA	NA	AA/Total	~~NA~~	NA
DetectionLimit	5 ppm	0.1 ppm	0.2 ppm	5 ppm	0.1 ppm	100 ppm	0.5 ppm	0.5 ppm	10 ppm	0.2 ppm	0.2 ppm	5 ppm	1 ppm	1 ppm	2 ppm	~~100 ppm~~	200 ppm
Number of samples	79	79	79	~~79~~	79	79	79	79	79	79	79	81	79	79	81	~~79~~	79
Min	**42**	**0.5**	**7.0**	~~**2.5bd**~~	**3.7**	~~**50bd**~~	**0.6**	**0.25bd**	~~**5bd**~~	**6.3**	**2.5**	**66**	**0.5bd**	**0.5bd**	**58**	~~**50bd**~~	**100bd**
Max	**120**	**1.5**	**15.0**	~~**2.5**~~	**8.4**	~~**50bd**~~	**1.4**	**1.3**	~~**5bd**~~	**14.0**	**5.1**	**143**	**2.0**	**4.0**	**181**	~~**160**~~	**610**
Average	84.2	1.05	11.22	~~2.5~~	5.01	~~50~~	1.01	0.71	~~5~~	10.4	3.43	99.1	0.71	2.2	104	~~51~~	228
75%ile	93.5	1.10	12.00	~~2.5~~	5.30	~~50~~	1.10	0.80	~~5~~	11.0	3.70	109.0	1.00	3.0	112	~~50~~	370
95% ile	100.1	1.31	14.00	~~2.5~~	6.02	~~50~~	1.30	1.00	~~5~~	12.1	4.01	120.5	1.00	3.0	133	~~50~~	490

	Lab texture							Carbonate by Chittick						Field	Field Texture		
	Sand	**Sand**	**Silt**	**Clay**	**Sand**	**Silt**	**Clay**	**Calcite**	**Total**	**Calcite**	**Dolomite**	**Total**	**Cct/Dmt**	**Reaction**			
	%	**(>63)**	**(<63)**	**(<4)**	**(>50)**	**(<50)**	**(<2)**		**carbonate**			**carbonates**	**ratio**	**with HCl**	**Sand %**	**Silt%**	**Clay%**
	1-2mm							**ml/g)**	**ml/g**	**%**	**%**	**%**					
Number of samples	81	81	81	81	81	81	81	81	81	81	81	81	81	63	63	63	63
Min	**0.2**	**3.1**	**26.7**	**6.7**	**3.6**	**34.0**	**3.5**	**1.7**	**3.1**	**0.8**	**0.5**	**1.3**	**0.2**	**1**	**5**	**15**	**5**
Max	**25.0**	**49.5**	**60.0**	**53.2**	**50.6**	**66.7**	**39.2**	**59.4**	**88.2**	**26.6**	**17.5**	**38.5**	**2.2**	**4**	**75**	**65**	**70**
Average	2.47	24.40	43.02	32.58	26.97	48.12	24.91	9.42	25.69	4.22	6.69	10.91	0.61	3.5	20.9	42.9	36.0
75%ile	2.26	30.10	47.90	38.60	32.60	53.30	30.30	12.40	32.50	5.60	8.60	13.90	0.77	4.0	25.0	55.0	45.0
95% ile	7.31	39.50	55.50	45.50	41.60	62.70	35.20	19.20	47.20	8.60	10.70	20.30	1.11	4.0	57.5	60.0	60.0

bd = below detection limit

All values below the detection limit are shown as one half of the detection limit.

~~1.60~~ = data not discussed because either they were below the detection limit or because data from and alternative analytical method were discussed for this element.

percentile is 1155 ppm for all samples.

Higher concentrations of Ba (≥75th percentile) are primarily from sites in the west half of the area (Fig. 11). The highest concentrations (≥95th percentile) are primarily from till samples collected at sites in the northwest (1200 ppm) and south-central (1200,1400 ppm) portions of the area, as well as one site in the northeast (1300 ppm). The highest value (2400 ppm) is from sand and gravel collected in the northwestern part of the area, near the northern border; this is the the same site that yielded the highest Au concentration.

Br, Bromine

This element as determined by INAA, varies from below the detection limit of 0.5 ppm up to 2.9 ppm, and averages 1.15 ppm (Fig. 12; Tables 2, 3). The 75th percentile is 1.44 ppm and the 95th percentile is 2.38 ppm.

Higher concentrations of Br (≥75th percentile) are found primarily in the northern half of the area, with a few sites in the south (Fig. 12). The highest concentrations (≥95th percentile) are primarily from till samples in the north and northeast (2.4, 2.4, 2.5, and 2.4 ppm). The highest value (2.9 ppm) is from two sites in the southwest where till from a Rocky Mountain or Cordilleran source covers the area.

Cd, Cadmium

This element as determined by INAA, varies from below the detection limit of 0.2 ppm up to 2.0 ppm, and averages 0.35 ppm; the maximum for the till samples is 1.5 ppm (Fig. 13; Tables 2, 3). The 75th percentile is 0.40 ppm and the 95th percentile is 0.80 ppm for all samples.

Higher concentrations of Cd (≥75th percentile) are found primarily in the west half of the area (Fig. 13). The highest concentrations (≥95th percentile) are primarily from till samples in the southwestern part of the area (1.4, 0.8, 0.8, 1.5, and 1.4 ppm). The highest value (2.0 ppm) is from a diamicton site in the southwest. These are all sites where Cordilleran ice flowed over the area.

Ce, Cerium

This element as determined by INAA, varies from 39 to 90 ppm, and averages 62.2 ppm (Fig. 14; Tables 2, 3). The 75th percentile is 70.8 ppm and the 95th percentile is 77.6 ppm.

Higher concentrations of Ce (≥75th percentile) are found locally throughout the area (Fig. 14) except in the southwest corner, which was covered by the Cordilleran glacial advance (Map 239). The highest concentrations (≥95th percentile) are found at four sites (80, 81, 90, and 81 ppm), all near the eastern or northern margin of the area where the Laurentide till outcrops.

Co, Cobalt

This element as determined by AA, varies from 3 to 19 ppm, and averages 11.4 ppm; the minimum for the till samples is 5 ppm (Fig. 15; , Tables 2, 3). The 75th percentile is 13 ppm and the 95th percentile is 17 ppm for all samples.

Higher concentrations of Co (≥75th percentile) are found locally throughout the area (Fig. 15). The highest concentrations (≥95th percentile) are primarily from samples collected in the northwest quadrant of the map area (17, 17, 18, and 17 ppm). High concentrations were also present at two sites in the south-central part of the area (17 and 19 ppm).

Cr, Chromium

This element as determined by INAA, varies from below the detection limit of 20 ppm up to 140 ppm, and averages 85.8 ppm; the till samples have a minimum of 48 ppm and a maximum of 120 ppm (Fig. 16; Tables 2, 3). The 75th percentile is 94 ppm and the 95th percentile is 115.5 ppm for all samples.

Higher concentrations of Cr (≥75th percentile) are found primarily in the north half of the area, with another cluster of sites in the southwest-central part (Fig. 16). The highest concentrations (≥95th percentile) reflect the above pattern and are primarily from nontill samples. Sites include, in the northwest, 120 ppm (sand and gravel sample), 140 ppm (sandstone), 130 ppm (diamicton that is either colluvium derived from bedrock or till with a high bedrock component), and two with 120 ppm, one in the south-central part and the other in the northeast. This may be a reflection of the abundant chromite grains found in the bedrock and till.

Cs, Cesium

This element as determined by INAA, varies from 1.3 to 6.4 ppm, and averages 4.45 ppm; the minimum for the till samples is 2.1 ppm (Fig. 17; Tables 2, 3). The 75th percentile is 5.2 ppm and the 95th percentile is 6.06 ppm for all samples.

Higher concentrations of Cs (≥75th percentile) are found locally throughout the area influenced by the Laurentide glacial advance (Fig. 17; Map 239). High values are absent in the southwest, the area effected by the Cordilleran and Rocky Mountain glaciers. The highest concentrations of Cs (≥95th percentile) are from widely scattered sample sites, in the extreme northwest (6.4 ppm), extreme northeast (6.3 ppm), west-central (6.1 ppm), and southwest-central (6.3 and 6.4 ppm) parts of the area.

Cu, Copper

This element as determined by AA, varies from 13 to 38 ppm, and averages 24.7 ppm (Fig. 18; Tables 2, 3). The 75th percentile is 28.1 ppm and the 95th percentile is 33.9 ppm.

Higher concentrations of Cu (≥75th percentile) are found at sites scattered through the northern half of the area and in a cluster of sites in the southwest-central part (Fig. 18). The highest concentrations of copper (≥95th percentile) are from till samples in the northeast (38 and 37 ppm) and from colluvium samples in the southwest-central part (36, 35, and 36 ppm).

Eu, Europium

This element as determined by INAA, varies from below the detection limit of 1 ppm up to 2.0 ppm, and averages 0.7 ppm (Fig. 19; Tables 2, 3). The 75th percentile and the 95th percentile are both 1.0 ppm.

Europium is barely detectable in the area. This element is at or below the detection limit for all but two sites, both of which are till with Eu concentrations of 2 ppm in the central part of the area.

Fe, Iron

This element as determined by AA, varies, for all samples, from 1.5 ppm to 4.5 ppm, and averages 3.10 ppm (Figure 20; Table 2 and 3). The 75th percentile is 3.40 ppm and the 95th percentile 4.05 ppm.

Higher concentrations of iron (≥75th percentile) are found primarily in the northwest and northeast with three others in the southwest quarter (Figure 20). The highest concentrations (≥95th percentile) are primarily from sample sites near the northeastern boarder (4.5, 4.5 4.1 and 4.3 ppm). One sample collected near the west central boarder yielded 4.4 ppm iron.

HF, Hafnium

This element as determined by NA, varies, for all samples, from below the detection limit of 3 ppm to 18 ppm, and averages 7.2 ppm; the till samples have a minimum of 4 ppm and a maximum of 12 ppm (Figure 21; Tables 2, 3). The 75th percentile is 8.0 ppm and the 95th percentile is 11.8 ppm for all samples.

Higher concentrations of Hf (≥75th percentile) are found mainly in the south half of the area (Fig. 21). This is primarily where the Laurentide till is thin and/or discontinuous over bedrock and for the sites near the west boundary, where the area may have been effected by Rocky Mountain or Cordilleran ice. The highest concentrations (≥95th percentile) are mainly from samples collected in the southwest (12 ppm in till, 18 ppm in gravel, 12 ppm in diamicton, 14 ppm in colluvium, and 12 ppm in colluvium), the area effected primarily by the Rocky Mountain and Cordilleran glaciers. There is also one site on Pinto Creek, near the western part of the northern border of the area, where quartzite gravel yielded a value of 12 ppm Hf.

Ir, Iridium

This element as determined by INNA is below the detection limit of 50 ppm for all samples.

La, Lanthanum

This element as determined by INAA, varies from 22 to 48 ppm, and averages 31.8 ppm; the minimum for till samples is 22 ppm (Fig. 22; Tables 2, 3). The 75th percentile is 35.0 ppm and the 95th percentile is 38.6 ppm for all samples.

In contrast to the elements described thus far, higher concentrations of La (≥75th percentile) are found primarily at sites in the central and southeastern parts of the map area (Fig. 22). The highest concentrations (≥95th percentile) are found at five sites: two in the central and south central part of the area (both at 40 ppm) where till is thin and/or discontinuous over bedrock, and three in the southeastern part (48, 39, and 39 ppm) where the till overlies Tertiary quartzite gravel.

Li, Lithium

This element as determined by AA, varies from 8 to 37 ppm, and averages 16.6 ppm; the minimum for the till samples is 9 ppm (Fig. 23; Tables 2, 3). The 75th percentile is 19 ppm and the 95th percentile is 33 ppm for all samples.

Higher concentrations of Li (≥75th percentile) are found locally at sites in the northeastern part of the area and at a few sites in the central and south-central parts (Fig. 23). The highest concentrations (≥95th percentile) are primarily from samples collected in the northeastern quadrant (34, 33, 37, 35, and 34 ppm), where the till contains the highest proportion of the less than 4 µm clay. One other site (with 33 ppm) occurs in the central part of the area, where the till onlaps the weathered bedrock.

Lu, Lutetium

This element as determined by INAA, varies from below the detection limit of 0.2 ppm up to 0.5 ppm, and averages 0.19 ppm (Fig. 24; Tables 2, 3). The 75th percentile is 0.30 ppm and the 95th percentile is 0.36 ppm.

Higher concentrations of Lu (≥75th percentile) are found locally in the eastern two thirds of the map area (Fig.24). The highest concentrations (≥95th percentile) are primarily from samples collected from the east-central part of the area (0.4, 0.5, 0.4, and 0.5 ppm). One other site (with 0.4 ppm) is located in the west-central part.

Mg, Magnesium

This element was determined by AA, only in the last few samples collected. The concentrations for these few samples vary from 0.97 to 1.55 ppm, and average 1.27 ppm (Tables 2, 3). The 75th percentile is 1.35 ppm and the 95th percentile is 1.54 ppm. There were not enough samples to produce an element distribution plot.

Mn, Manganese

This element as determined by AA, varies from 63 to 2300 ppm, and averages 371 ppm; the till samples have a minimum of 145 ppm and a maximum of 588 ppm (Fig.25; Table 2 and 3). The 75th percentile is 382 ppm and the 95th percentile is 534 ppm for all samples.

Higher concentrations of Mn (≥75th percentile) are found locally throughout the area (Fig. 25). The highest concentrations (≥95th percentile) are from two sites: quartzite gravel on Pinto Creek in the northwest (2100 ppm) and sandstone in the central part (2300 ppm). Till samples with concentrations exceeding the 95th percentile (≥506 ppm) are found primarily in the northern half of the area,. (going clockwise, from the northeast, 549, 506, 588, and 523 ppm). There is also one diamicton sample site in the southwest with 656 ppm Mn.

Mo, Molybdenum,

This element as determined by AA, varies from 2 to 6 ppm, and averages 4 ppm (Fig. 26; Tables 2, 3). The 75th percentile is 5 ppm and the 95th percentile is 5 ppm.

There is little variation in Mo concentration (only 4 ppm). Higher concentrations (≥75th percentile and ≥95th percentile) are found locally throughout the area (Fig. 26). The highest concentrations (6 ppm) are in samples collected from the northern half of the area, primarily in the northwest quadrant.

Na, Sodium

This element as determined by INAA, varies from below the detection limit of 0.02% up to 1.4%, and averages 0.53%; the minimum for till samples is 0.7% and the maximum 1.3% (Fig. 27; Tables 2, 3). The 75th percentile is 0.66% and the 95th percentile is 1.10%.

The distribution of Na is unique. The higher concentrations (≥75th percentile) are confined primarily to the northwestern portion of the area (Fig. 27). The exception is a cluster of sites in the south-central part. The values for the highest concentrations of sodium (≥95th percentile) are similar in the northwest (1.2, 1.3, 1.1, 1.2, and 1.4 ppm) and south-central (1.1 and 1.1 ppm) parts. The high concentrations in the northwest are from a variety of sediments: recent fluvial gravel on the Wapiti River, till, quartzite-rich gravel, and sandstone bedrock.

Ni, Nickel

This element as determined by AA, varies from 5 to 45 ppm, and averages 31.5 ppm; the till samples contain a minimum of 19 ppm and a maximum of 43 ppm (Fig. 28; Tables 2, 3). The 75th percentile is 36 ppm and the 95th percentile is 42 ppm for all samples.

Higher concentrations of Ni (≥75th percentile) are found locally throughout the area except the southeast quadrant (Fig. 28). The highest concentrations (≥95th percentile) are from till sites in the northeast quadrant (42 and 42 ppm) and the southwest quadrant (43 ppm in till, and 44 and 45 ppm in colluvium).

Pb, Lead

This element as determined by AA, varies from 8 to 44 ppm, and averages 15.5 ppm; the till samples have a minimum of 9 ppm and a maximum of 20 ppm (Fig. 29; Tables 2, 3). The 75th percentile is 17 ppm and the 95th percentile is 19 ppm for all samples.

Higher concentrations of Pb (≥75th percentile) are found locally throughout the area (Fig. 29). A similar pattern exists for the highest concentrations (≥95th percentile; 19 to 20 ppm). The highest concentration (44 ppm) is from one bentonite sample collected in the west, near the western part of the northern border of the area.

Rb, Rubidium

This element as determined by INAA, varies from 28 to 120 ppm, and averages 81.5 ppm; the minimum for the till samples is 42 ppm (Fig. 30; Table 2 and 3). The 75th percentile is 92.8 ppm and the 95th percentile 100.0 ppm.

Higher concentrations of Rb (≥75th percentile) are found locally throughout much of the area (Fig. 30), except in the west and southwest where till of Rocky Mountain or Cordilleran origin is present. A similar pattern exists for the highest concentrations (≥95th percentile; 100 to 110 ppm). The highest concentration (120 ppm) is from one till sample collected in the southeast quadrant of the area.

Sb, Antimony

This element as determined by INAA, varies from 0.50 to 1.7 ppm, and averages 1.05 ppm; the maximum for the till samples is 1.5 ppm (Fig. 31; Tables 2, 3). The 75th percentile is 1.18 ppm and the 95th percentile is 1.40 ppm for all samples.

Higher concentrations of Sb (≥75th percentile) are found locally throughout the area (Fig. 31). The highest concentrations (≥95th percentile) are found in the central part of the area where a thin and discontinuous till rests on weathered bedrock (1.5. 1.4, 1.4, and 1.4 ppm) and in two samples of colluvium, from the south-central part (1.5 and 1.7 ppm), which may have a high proportion of bedrock

Sc, Scandium

This element as determined by INAA, varies from 7.0 to 17.0 ppm, and averages 11.28 ppm; the maximum for the till samples is 15.0 ppm (Fig. 32; Tables 2, 3). The 75th percentile is 12.0 ppm and the 95th percentile is 14.55 ppm for all samples.

Higher concentrations of Sc (≥75th percentile) are found locally throughout the area, except in the southwest (Fig. 32). The highest concentrations (≥95th percentile) are from five sites scattered throughout the area (going clockwise, from the northwest corner, 15 ppm and 15 ppm in till, 17 ppm in sandstone, 15 ppm in till and 16 ppm in colluvium).

Se, Selenium

This element as determined by INAA, is below the detection limit of 5 ppm.

Sm, Samarium

This element as determined by INAA, varies from 3.4 to 8.4 ppm, and averages 4.96 ppm; the minimum for the till samples is 3.7 ppm (Fig. 33; Tables 2, 3). The 75th percentile is 5.30 ppm and the 95th percentile is 6.11 ppm for all samples.

Higher concentrations of Sm (≥75th percentile) are found locally throughout the northeastern two-thirds of the area; high values are absent in the southwest (Fig. 33). The highest concentrations (≥95th percentile) are from five sites scattered throughout the area (going clockwise, from the northwest corner, 6.6, 6.2, 8.4, 6.8, and 6.5 ppm). Except for the absence of a cluster of high values in the south-central part of the area, the distribution pattern for samarium is similar to that for scandium.

Sn, Tin

This element as determined by INAA, is below the detection limit of 100 ppm.

Ta, Tantalum

This element as determined by INAA, varies from 0.6 to 1.6 ppm, and averages 1.01 ppm; the maximum for the till samples is 1.4 ppm (Fig. 34; Tables 2, 3). The 75th percentile is 1.10 ppm and the 95th percentile is 1.30 ppm for all samples.

Higher concentrations of Ta (≥75th percentile) are found locally throughout the area, except in the southwest (Fig. 34). The highest concentrations (≥95th percentile) are from ten sites scattered throughout the area, the highest being from a bentonite sample in the northwest corner (1.6 ppm).

Tb, Terbium

This element as determined by INAA, varies from below the detection limit of 0.5 ppm up to 1.3 ppm, and averages 0.7 ppm; (Fig. 35; Tables 2, 3). The 75th percentile is 0.8 ppm and the 95th percentile is 1.0 ppm for all samples.

Higher concentrations of Tb (≥75th percentile) are found locally throughout the area, including one site in the southwest (Fig. 35). The highest concentrations (≥95th percentile) are from sites in the southeastern two-thirds of the area (going clockwise, from the northeast, 1.0, 1.3, 1.0, 1.1, 1.0, 1.1, and 1.0 ppm).

Te, Tellurium

This element as determined by INAA, is below the detection limit of 10 ppm.

Th, Thorium

This element as determined by INAA, varies from 5.1 to 22.6 ppm, and averages 10.3 ppm; the till samples have a minimum of 6.3 ppm and a maximum of 14.0 ppm (Fig. 36; Tables 2, 3). The 75th percentile is 11.0 ppm and the 95th percentile is 12.3 ppm for all samples.

Higher concentrations of Th (≥75th percentile) are found locally throughout the area, except in the southwest and west-central parts (Fig. 36). The highest concentrations (≥95th percentile) are from five sites (going clockwise, the southeast, 14, 13, 13, 12.5, and 22.6 ppm); the highest concentration comes from a bentonite sample collected in the northwest corner of the area.

U, Uranium

This element as determined by INAA, varies from 1.7 to 6.5 ppm, and averages 3.5 ppm; the till samples have a minimum of 2.5 ppm and a maximum of 5.1 ppm (Fig. 37; Tables 2, 3). The 75th percentile is 3.7 ppm and the 95th percentile is 4.3 ppm for all samples.

Higher concentrations of U (≥75th percentile) are found at sites scattered widely throughout the area (Fig. 37). The highest concentrations (≥95th percentile) are primarily from samples collected from the northern third (going clockwise, from the northwest corner, 4.4, 4.3, 6.5, 5.1, and 4.3 ppm); there is also one site with a high concentration in the southwest-central part of the area (4.6 ppm). The highest value (6.5 ppm) is from a bentonite sample.

V, Vanadium

This element as determined by INAA, varies from 21 to 143 ppm, and averages 97.1 ppm; the minimum for the till samples is 66 ppm (Fig. 38; Tables 2, 3). The 75th percentile is 109.0 ppm and the 95th percentile is 120.7 ppm for all samples.

Higher concentrations of V (≥75th percentile) are found primarily in the northwestern two-thirds of the area, although there are also three sites in the south-central part (Fig. 38). Vanadium is one of several elements absent in higher concentrations from the southeast quadrant. The highest concentrations (≥95th percentile) are found at six sites: two in the northeastern part (121 and 130 ppm), one in the west-central part (121 ppm), and three in the south-central part (141, 143, and 128 ppm).

W, Tungsten

This element as determined by INAA, varies from below the detection limit of 1 ppm up to 2 ppm, and averages 0.7 ppm (Fig. 39; Tables 2, 3). The 75th percentile is 1.0 ppm and the 95th percentile is 1.0 ppm for all samples.

The concentration of W is low in the area, being at or below the detection limit (1 ppm) in all but three samples. The ‘higher’ concentrations (1 ppm) of W (≥75th percentile) are found locally throughout the area except in the southwest (Fig. 39). The highest concentrations (2 ppm) are from samples collected in the central part (2 ppm) and near the east-central boundary (2 and 2 ppm).

Yb, Ytterbium

This element as determined by INAA, varies from below the detection limit of 1 ppm up to 4 ppm, and averages 2.2 ppm (Fig. 40; Tables 2, 3). The 75th percentile is 3.0 ppm and the 95th percentile is 3.0 ppm for all samples.

The concentration of Yb is low in the area. The higher concentrations (≥75th percentile) are found primarily in the southeastern two-thirds of the area (Fig. 40). The highest concentrations (4 ppm) are from two sample sites in the southeast. No other element shows this sort of distribution.

Zn, Zinc

This element as determined by INAA, varies from 58 to 181 ppm, and averages 104.2 ppm (Fig. 41; Tables 2, 3). The 75th percentile is 112.3 ppm and the 95th percentile is 135.5 ppm.

Higher concentrations of Zn (≥75th percentile) are found primarily in a southwest-trending area, extending from the northeast corner to the west-central part. A second area is present in the south-central part (Fig. 41). Zinc is another element that is absent in higher concentrations in the southeast quadrant. The highest concentrations (≥95th percentile) are primarily from three sites in the south-central part (136, 141, and 156 ppm). One site in the extreme northeast corner contains 139 ppm; another site near the west-central boundary contains the greatest concentration in the area (181 ppm).

Zr, Zirconium

This element as determined by INAA, varies from below the detection limit of 200 ppm up to 630 ppm, and averages 252 ppm; the till samples have a maximum of 610 ppm (Fig. 42; Tables 2, 3). The 75th percentile is 390 ppm and the 95th percentile is 550 ppm for all samples.

Higher concentrations of Zr (≥75th percentile) are found locally throughout the area (Fig. 42). The highest concentrations (≥95th percentile) are primarily from four samples collected from the southwest-central part of the area (630, 560, 510, and 600 ppm). One sample was also collected from near the east-central boundary (610 ppm).

As has been shown for other parts of Alberta, there is a correspondence between Zr concentration and sand content (e.g. Fenton et al., 1994). This is the case here as well, in that a number of samples with high concentrations of Zr are either sand and gravel samples or are from the area where the glacier moved over quartzite gravel in the southeast quadrant of the map area (Fig. 5).

4.2 Regional Carbonate Content

A portion of the matrix (<0.063 mm fraction) of each sample was subjected to Chittick analysis to determine the amount of calcite and dolomite. The results from these analyses are shown in Tables 2 and 3, and Figures 43 to 51.

4.2.1 Total Carbonate

Carbonate content of the matrix varies from 1.3 to 38.5% (3.1 to 88.15 ml/g; Tables 2, 3). The 75th percentile is 13.80% and the 95th percentile is 21.05%. Carbonate was measurable in all samples (Fig. 43, 44). The higher concentrations (≥75th percentile) are confined primarily to till samples collected in the southwestern two-thirds of the area. Carbonate is lower in the areas covered by bedrock and by fluvial or lacustrine sediment.

4.2.2 Dolomite

Dolomite content of the matrix varies from 0.5 to 17.5% (Tables 2, 3). The 75th percentile is 8.5% and the 95th percentile is 10.6%. Dolomite is found throughout the area, with the higher concentrations (≥75th percentile) occurring in the southwestern half (Fig. 45, 46). See also the comments in the following section on calcite.

4.2.3 Calcite

Calcite content of the matrix varies from 0.5 to 26.6% (Tables 2, 3). The 75th percentile is 5.55% and the 95th percentile is 8.90%. Calcite is found throughout the area, with the higher concentrations (≥75th percentile) primarily in the southeast quadrant and, to a lesser extent, the northwest and southwest quadrants. (Fig. 47, 48). This differs from the distribution for dolomite in that the higher concentrations of calcite are found mainly in a north-northwest trending band through the central portion of the area, whereas dolomite is also high in the western half of the area.

4.2.4 Calcite:Dolomite Ratio

The calcite:dolomite ratio of the matrix for all samples varies from 0.09 to 2.25, whereas that of the till samples varies only from 0.2 to 2.2 (Tables 2, 3). The 75th percentile is 0.77 and the 95th percentile is 1.15 for all samples. Calcite is more abundant in a north-northwest trending band through the centre of the area. Figures 45, 50 and 51 show the gradual elimination of the sites with high dolomite.

4.3 Regional Texture

The proportion of sand, silt, and clay and that of 1 to 2 mm sand, in the less than 2 mm matrix was determined for each sample.

4.3.1 Sand (2.00 to 0.063 mm)

Sand content of the matrix for all samples varies from 1.8 to 85.9%, whereas that of the till samples varies only from 3.1 to 49.5% (Tables 2, 3). For all samples, the 75th percentile is 32.48% and the 95th percentile is 49.01%. For till samples, the 75th percentile is 30.35% and the 95th percentile is 44.20%

The sediment is sandier in the west half of the area (Fig. 52, 53). This is likely a result of the glaciers incorporating more sand as they moved over the sandstone bedrock, and of the till being thinner, than in the eastern portion of the area. The samples, all of which were shallow, therefore reflect the basal sandier portion of the till layer.

4.3.2 Clay (< 0.004 mm)

Clay content of the matrix for all samples varies from 2.4 to 71.0%, whereas that of the till samples varies only from 6.7 to 53.2% (Tables 2, 3). For all samples, the 75th percentile is 38.23% and the 95th percentile is 45.95%. For the till samples, the 75th percentile is 38.35% and the 95th percentile is 45.49%.

The clay content is higher in the samples from the eastern half of the area (Fig. 54, 55). This is likely a result of the glaciers incorporating clay and silt as they moved over the extensive areas of fine-grained bedrock to the east and northeast.

4.3.3 1 to 2 mm Fraction

The coarse sand content for all samples varies from 0.2 to 25.0%, and the range is similar for that of just the till samples (Tables 2, 3). For all samples, the 75th percentile is 2.43% and the 95th percentile is

10.71%. For just the till samples, the 75th percentile is 2.31% and the 95th percentile is 10.54%.

The distribution pattern of this coarse sand fraction reflects that of the sand, with the coarse sand constituting a larger proportion (≥75th percentile) of the sediment in the samples collected in the west half of the area (Fig. 56, 57). This fraction was recovered primarily for later mineralogical analysis.

4.4 Regional Coarse-Clast Composition

Although the tills were not sampled to the extent that would have been possible with one more year of fieldwork, general trends in the composition of the pebble- to-boulder sized clasts can be determined.

As previously mentioned in the 'Ice Flow Direction and History' section, the pebble to boulder clast sizes reveal that particular clast types are found in the till only in certain portions of the study area (Fig. 5). The till units are characterized by:

- clasts of green metaconglomerate and low-grade greenish grey schist, plus granite and other igneous rocks, in the northwest;
- clasts of grey carbonate in the west and southwest;
- mainly quartzite and igneous (primarily granite) clasts in the east;
- abundant well-rounded quartzite clasts incorporated from the underlying Tertiary gravel deposits in parts of the centre and south (Fig. 5);
- boulders of low-grade schist at three relatively closely spaced sites west of the Smoky River in the south-central portion of the area (twp 59, rge 8, W6, Map 239; near site NAT96-176, Fig. 7 and Appendix 1); and
- a boulder of low-grade, grey metamorphic rock, perhaps phyllite, east of the Smoky River in the southeastern part of the area (twp 61, rge 3, W6, Map 239; site NAG96-594, Fig. 7 and Appendix 1).

4.5 Geochemical, Carbonate, and Textural Relationships

Detailed comparison of the relative variations in concentration among all the elements, the carbonate content, and the texture is beyond the scope of this report. Preliminary information on these relationships was, however, derived through inspection of the element distribution plots and preparation of selected scatter plots. The Pearson product-moment and Spearman rank correlation coefficients were also calculated. There are some groups of elements that have similar distribution patterns.

4.5.1 Interelement Associations

Cesium, Lanthanum, Samarium, and Thorium

There is a good correlation between Ce, La, Sm, and Th (Fig. 58). There also appears to be a weaker correlation between these elements and Rb (Fig. 59) and a slightly weaker relationship between Pb and Th that does not extend to Ce, La, and Sm (Fig. 60).

Examination of the element distribution plots, both the earlier figures showing the concentrations at or above the 75th percentile level (Fig. 14, 22, 33, 36) and those showing the concentrations for all samples (Fig. 61-66), reveals that the concentrations for this group of elements is low in the southwest quadrant of the map area and high in the southeast quadrant.

Cesium and rubidium show a somewhat similar pattern. Both are low in the southwest quadrant, whereas Rb, and to a lesser extent Cs, is high in the southeast quadrant.

Chromium and Scandium

There is a strong correlation between Cr and Sc (Fig. 67). There is also a weak correlation between Sc and Ni, but none between Cr and Ni. The concentrations for this group of elements are low in the southwest and high in the north (Fig. 16, 32, 68, 69).

This group differs from the previous group mainly in that the elements have, with three exceptions, predominantly low concentrations in the southeast quadrant and higher concentrations in the southwest-central part of the area (Fig. 70).

Cobalt, Copper, and Nickel

There is a strong correlation between Co, Cu, and Ni, with the correlation between Co and Cu being slightly weaker (Fig. 71). Although there is a weak correlation between Ni and Sc, there is little correlation between Sc and either Co or Cu.

This group differs from the previous groups in that the sites with high concentrations ($\geq$75th percentile) occur primarily in the north half and southwest quadrant (two small clusters) of the area, and those with low concentrations in the southeast quadrant (Fig. 15, 18, 28, 70, 72-74).

4.5.2 Textural and Carbonate Associations

The Pearson product-moment and Spearman rank correlations suggested there is weak relationship between clay ($<$ 0.004 mm) content and the concentrations of Ce, Cs, La, Pb, Rb, Sm, and Th. The scatter plots in Figures 75 and 76 indicate that there is a weak correlation between clay content and only the Cs and Rb concentrations. This is probably because there is also a good correlation between Cs and Rb.

There is also a weak negative correlation between silt (0.063–0.004 mm) content and the concentrations of Co, Cu, Ni, and Fe (Fig. 76). The reason for this is unknown. There is no positive correlation between these elements and the content of either clay or sand.

Other than the expected strong correlation between total carbonate and/or dolomite, as they are calculated from the same formula set, there are no strong correlations between carbonate content and element concentrations.

5 Summary

This interim report provides the current data and interpretations concerning the surficial geology and till geochemistry of the Wapiti map area (NTS 83L). Work on the project was suspended during the second of the three years originally planned due to redirection of staff effort to higher priority areas in northern Alberta.

The area encompasses the transition zone from the Interior Plains to the Eastern Cordillera, with elevation rising from about 525 m (1720 ft.) in the northeast to 2455 m (8050 ft.) in the southwest. Four physiographic regions can be defined: the Wapiti Plains, the Alberta Plateau Benchlands, the Rocky Mountain Foothills, and the Rocky Mountains.

The surficial geology is shown on a 1:250 000 scale map, compiled by Andriashek (1983) based on unpublished work by A. Twardy and L. Bayrock (Map 239). The main surficial materials are till, glaciolacustrine sediment, weathered bedrock, and, to a lesser extent, glaciofluvial sediment. The till includes units deposited by Laurentide (Continental), Cordilleran, and Rocky Mountain ice sheets.

The ice-flow direction, from the Rocky Mountain, Cordilleran, and Laurentide glacial centres, and the relationships between the various lobes are poorly understood. Field examination of the pebble to boulder fraction indicates that the till units are characterized by 1) clasts of green metaconglomerate and low-grade greenish grey schist, plus granite and other igneous rocks (mixed Laurentide and Cordilleran sources), in the northwest; 2) clasts of grey carbonate (Rocky Mountain or Cordilleran source) in the west and southwest; 3) mainly quartzite and igneous (primarily granite) clasts (Laurentide source) in the east; 4) abundant well-rounded quartzite clasts, incorporated from the underlying Tertiary gravel deposits, in parts of the centre and south; 5) boulders of low-grade schist (?earlier Cordilleran source) at three sites in the south-central part of the area; and 6) a boulder of low-grade, grey metamorphic rock, perhaps phyllite, in the southeast (source uncertain).

Most of the surface samples were collected from areas accessible by road, although a few were obtained using a helicopter to reach less accessible sites. Most of the samples collected were from till, although a few were collected from bedrock, lacustrine, colluvial, or fluvial units. At each site, a 2–3 kg sample was collected from below the top of the C soil horizon (at a depth of about 2 m) for geochemical and carbonate analysis of the less than 0.063 mm fraction and texture analysis of the less than 2 mm fraction. Field data recorded at each site included information on the general sampling environment and observations on the colour, texture, moisture content, and mineralogy of the till.

The matrix fraction (<0.063 mm or <230 mesh) was analyzed by flame atomic absorption spectrometry (AA) for Ag, Cd, Co, Cu, Fe, Li, Mn, Mo, Ni, Pb, V, Zn, and (for a few samples) Mg, and by instrumental neutron activation analysis (INAA) for Ag, As, Au, Ba, Br, Cd, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ir, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Te, Th, W, U, Yb, Zn, and Zr. The results are shown as a series of element distribution plots.

There is a good correlation between Ce, La, Sm, and Th. The concentrations for this group of elements are low in the southwest quadrant and high in the southeast quadrant. There is also a strong correlation between Cr and Sc. These two elements, with three exceptions, show higher concentrations in the southwest-central part of the area and predominantly low concentrations in the southeast quadrant.

There is also a strong correlation between Co, Cu, and Ni, with the correlation between Co and Cu being slightly weaker sites with high concentrations (≥75 percentile) of this group of elements occurring primarily in the north half of the area, except for two small clusters of sites with high concentrations in the southwest quadrant.

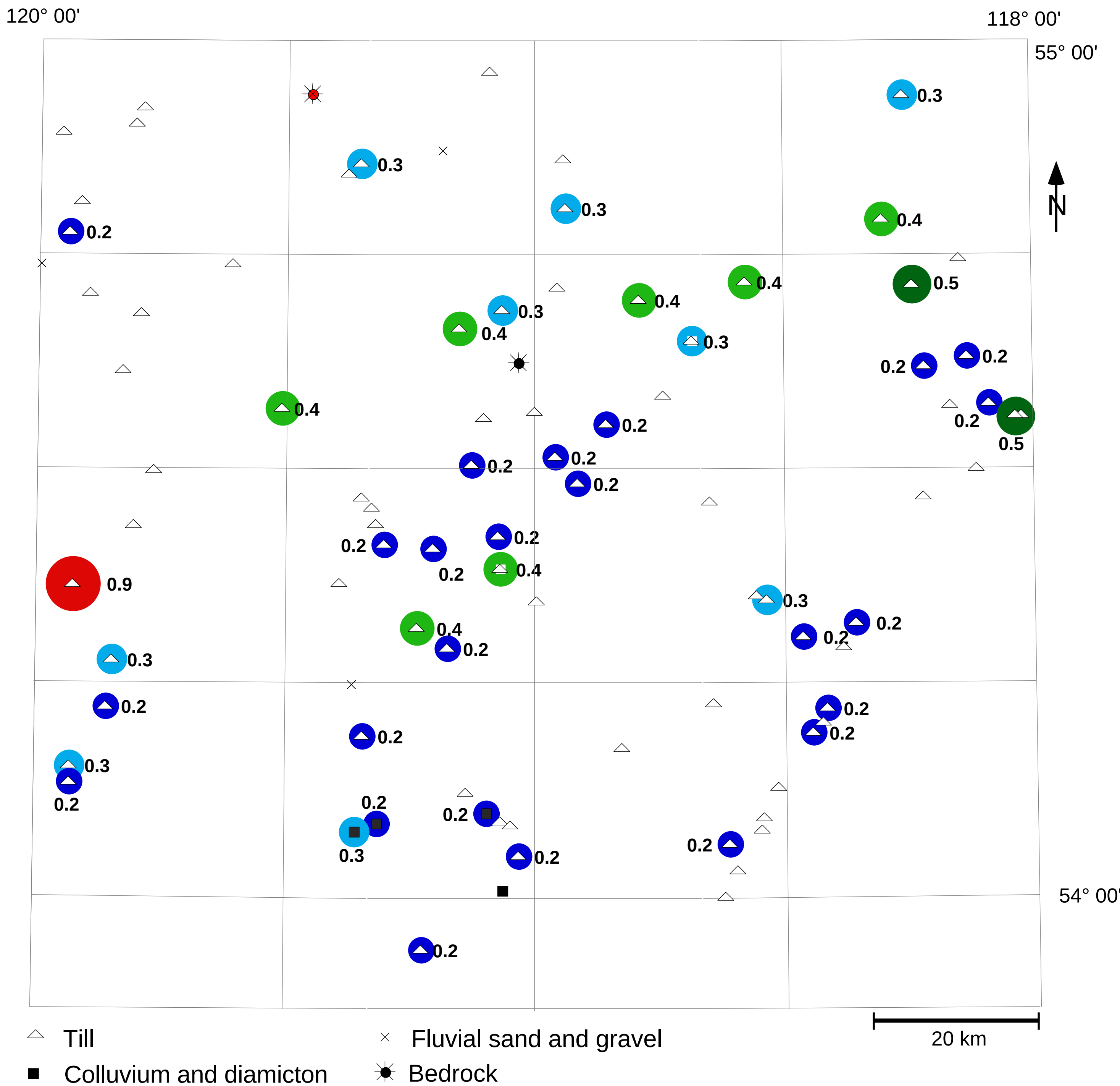

Figure 8. Concentration of Ag in ppm by AA for sites with values ≥75th percentile. The size of the circle is proportional to the element concentration. Note that, at some sites the symbol indicating sample type is obscured because the element concentration symbol has a similar shade to the bubble. Where this has happened Figure 7, site numbers, provides this information.

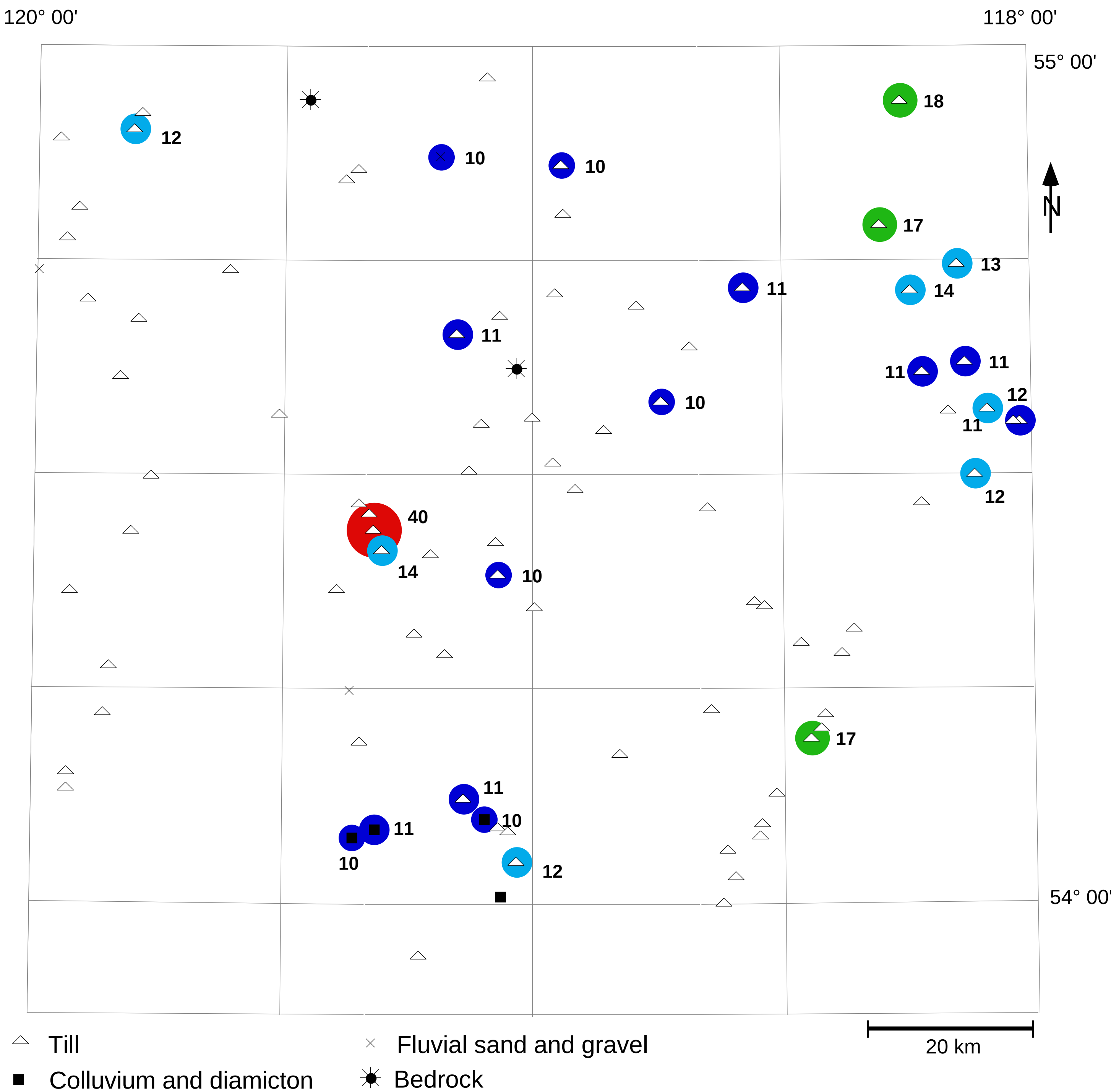

Figure 9. Concentration os As in ppm by INNA for sites with values $\geq$75th percentile.

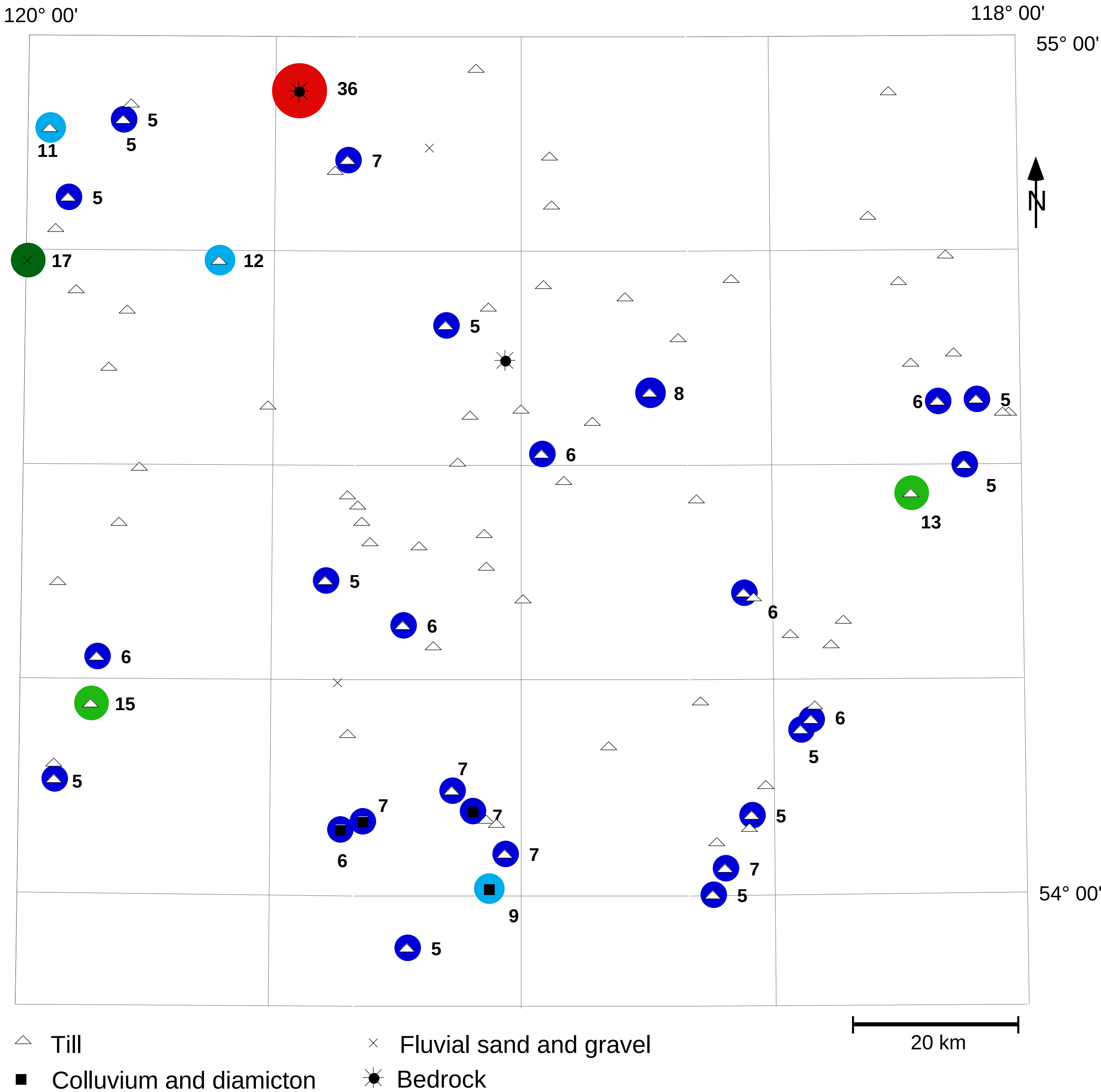

Figure 10. Concentration of Au in ppb by INNA for sites with values ≥75th percentile.

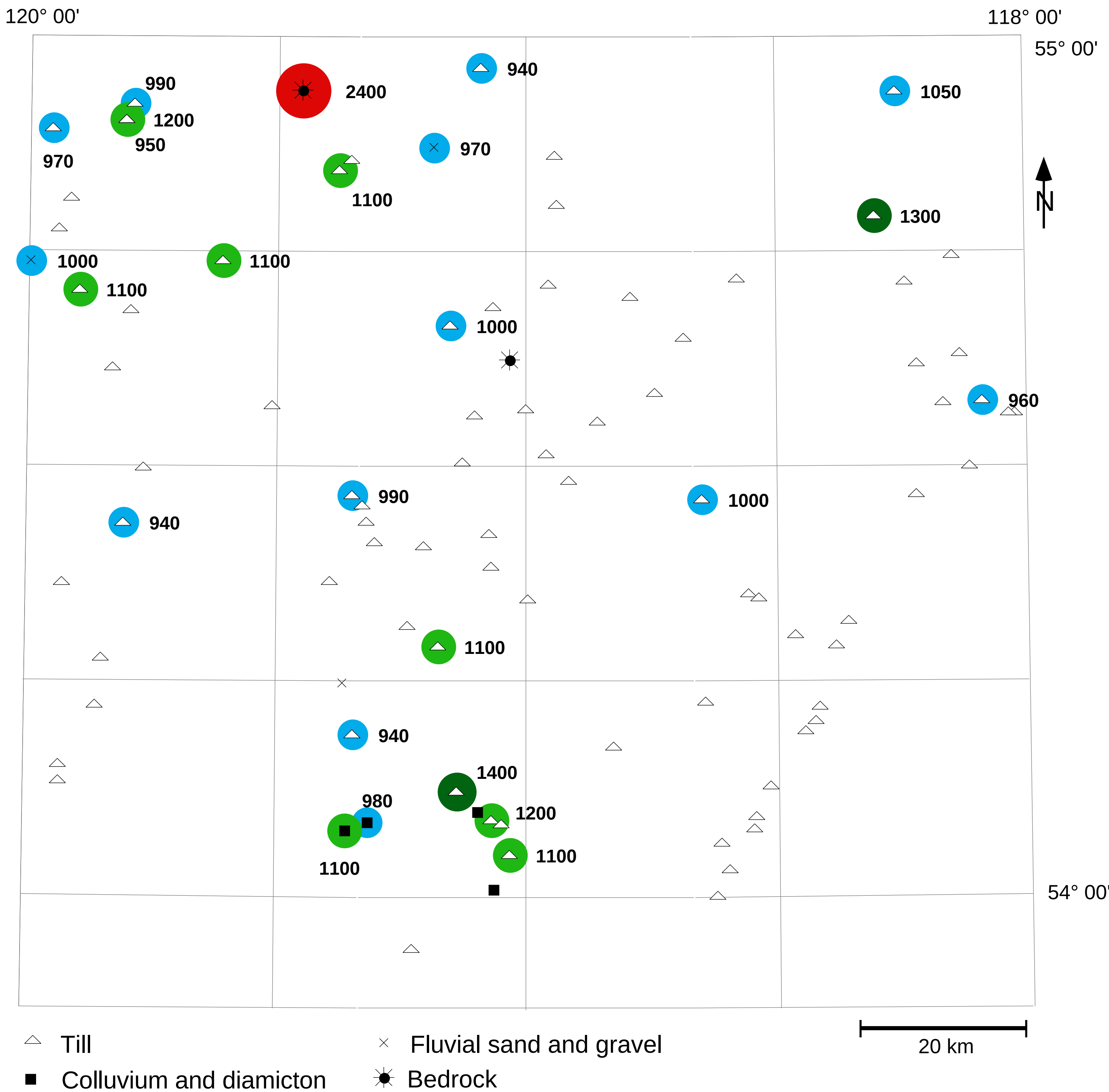

Figure 11. Concentration of Ba in ppm by INNA for sites with values ≥75th percentile.

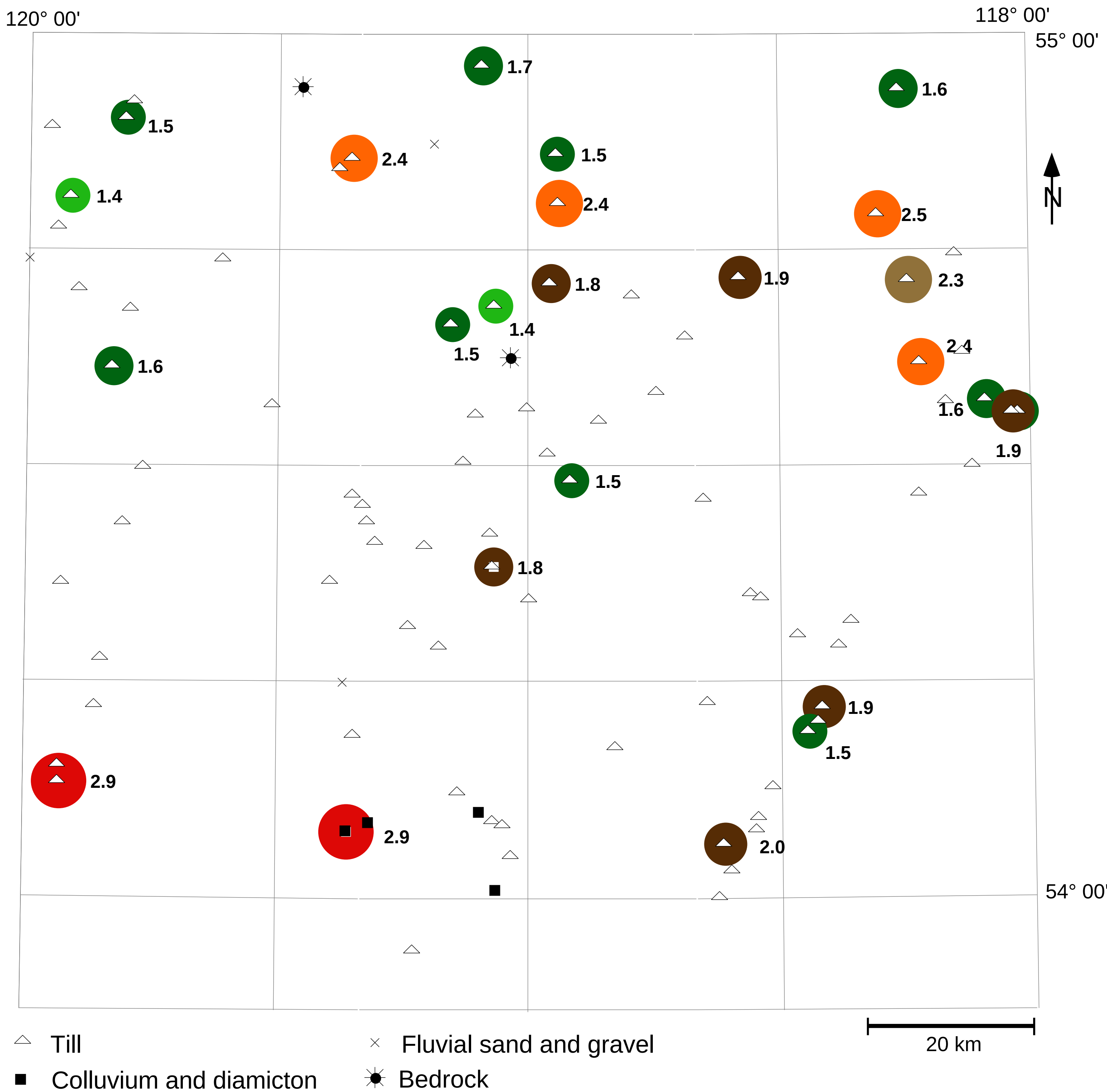

Figure 12. Concentration of bromine in ppm by INNA for sites with values ≥75th percentile.

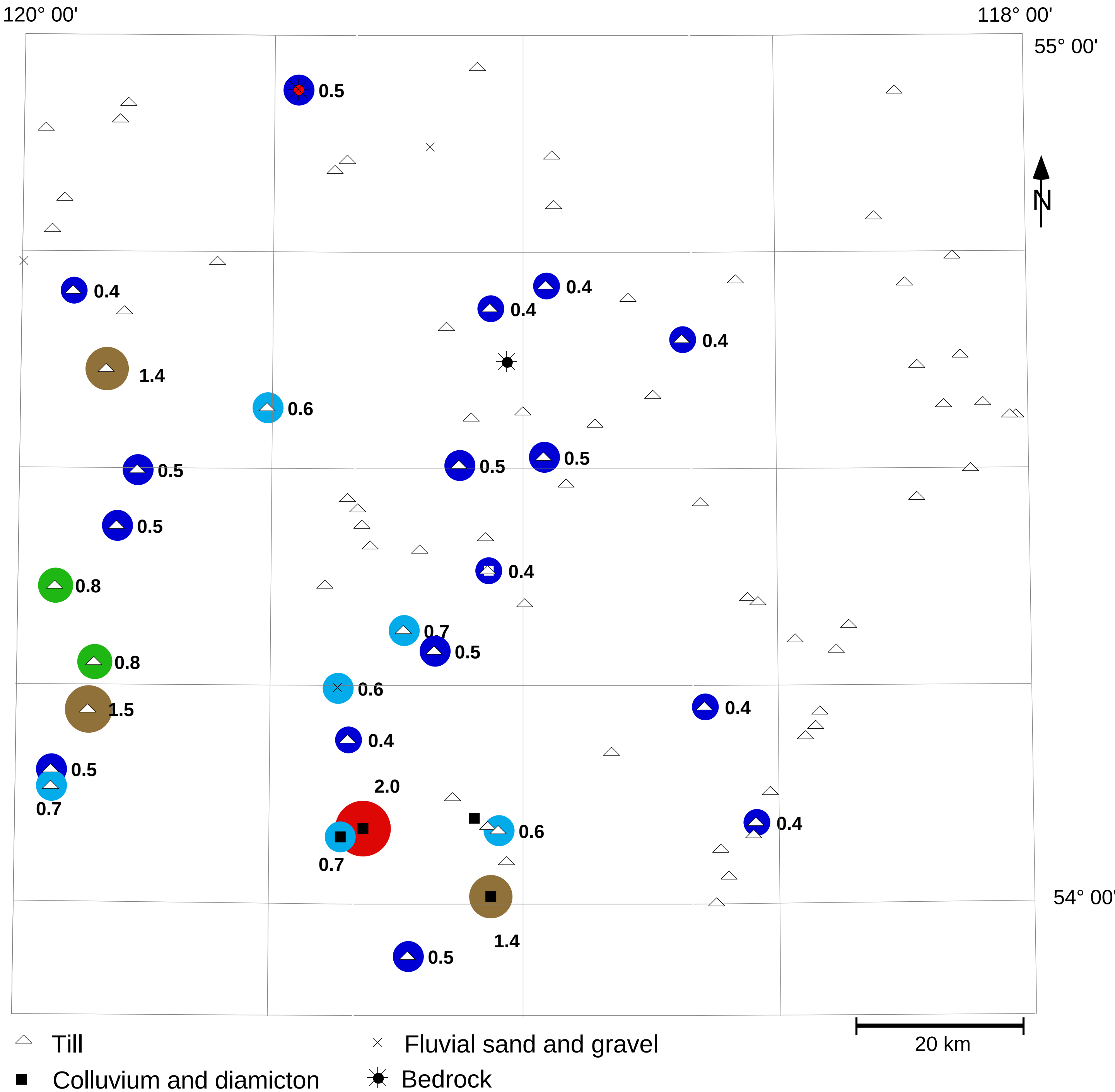

Figure 13. Concentration of Cd in ppm by AA for sites with values ≥75th percentile.

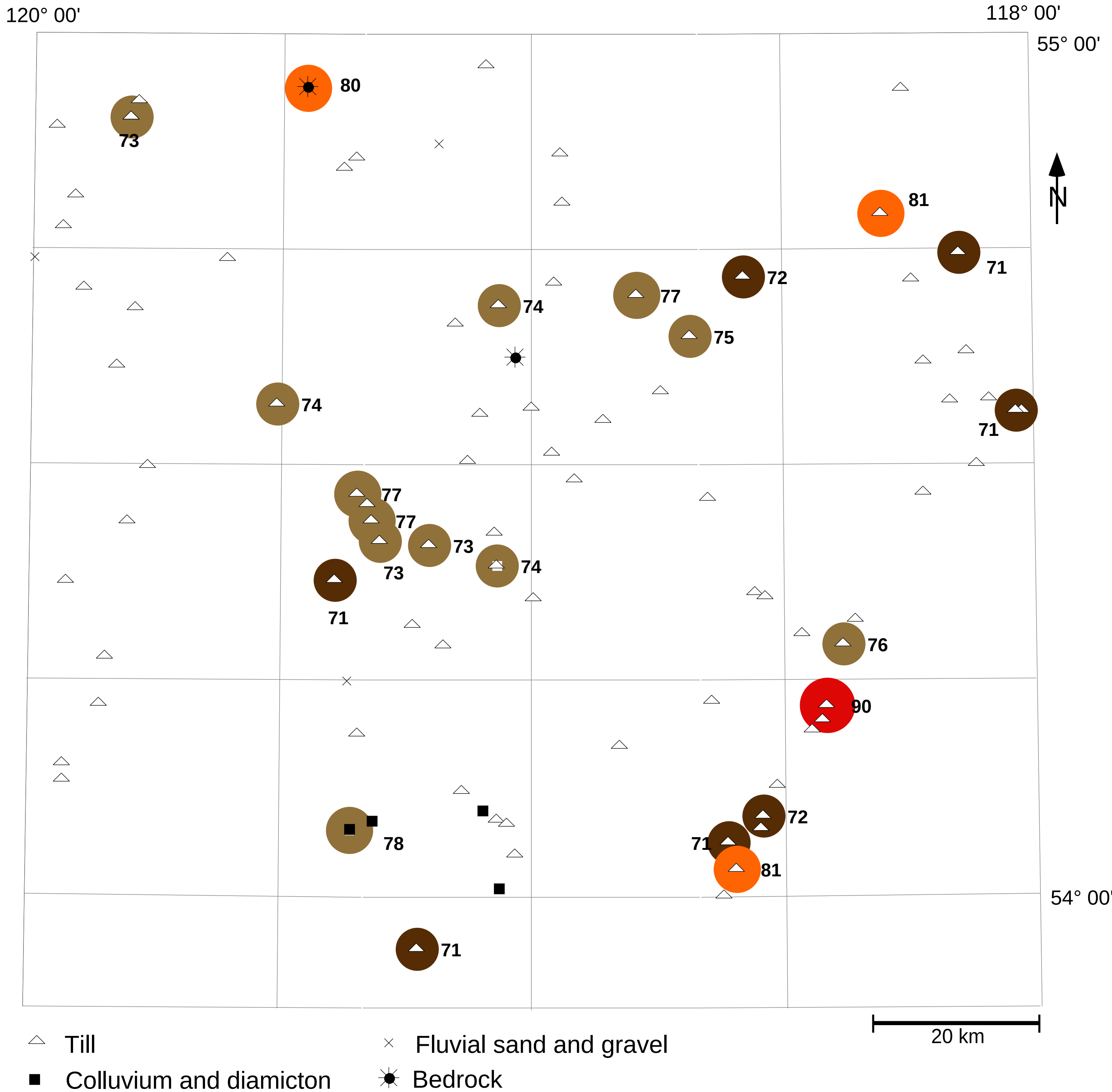

Figure 14. Concentration of Ce in ppm by INNA for sites with values ≥75th percentile.

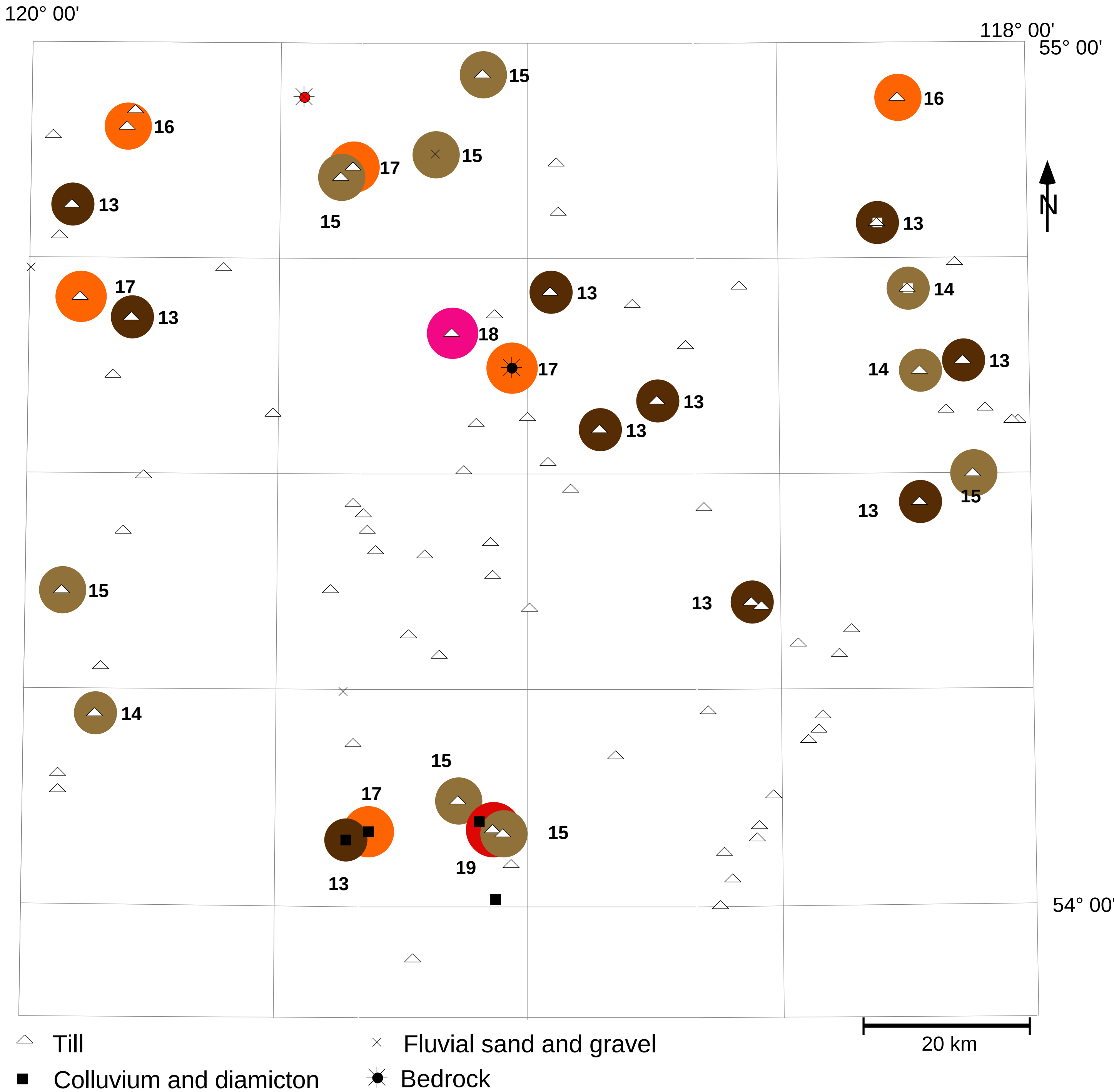

Figure 15. Concentration of Co in ppm by AA for sites with values ≥75th percentile.

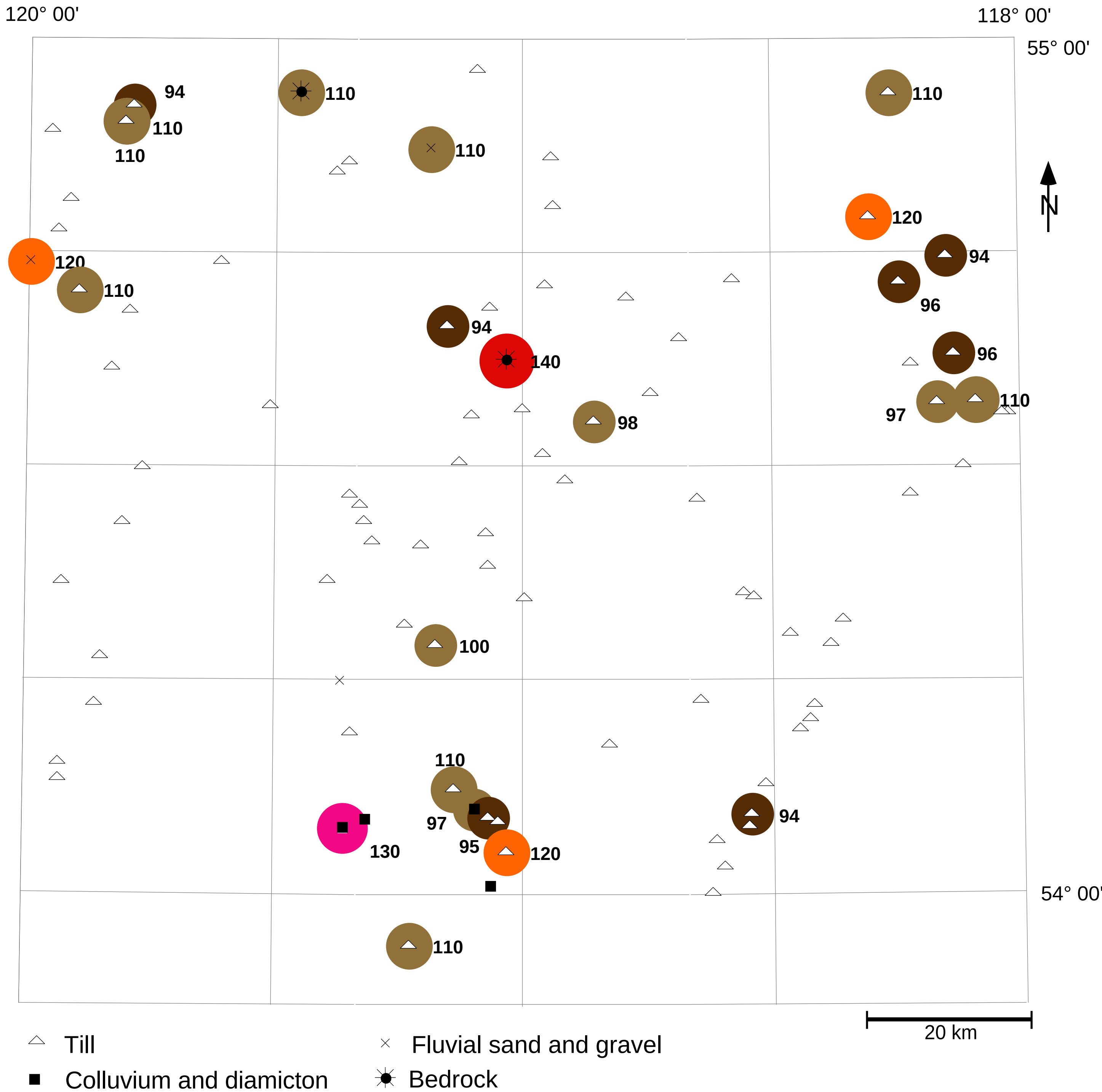

Figure 16. Concentration of Cr in ppm by INNA for sites with values ≥75th percentile.

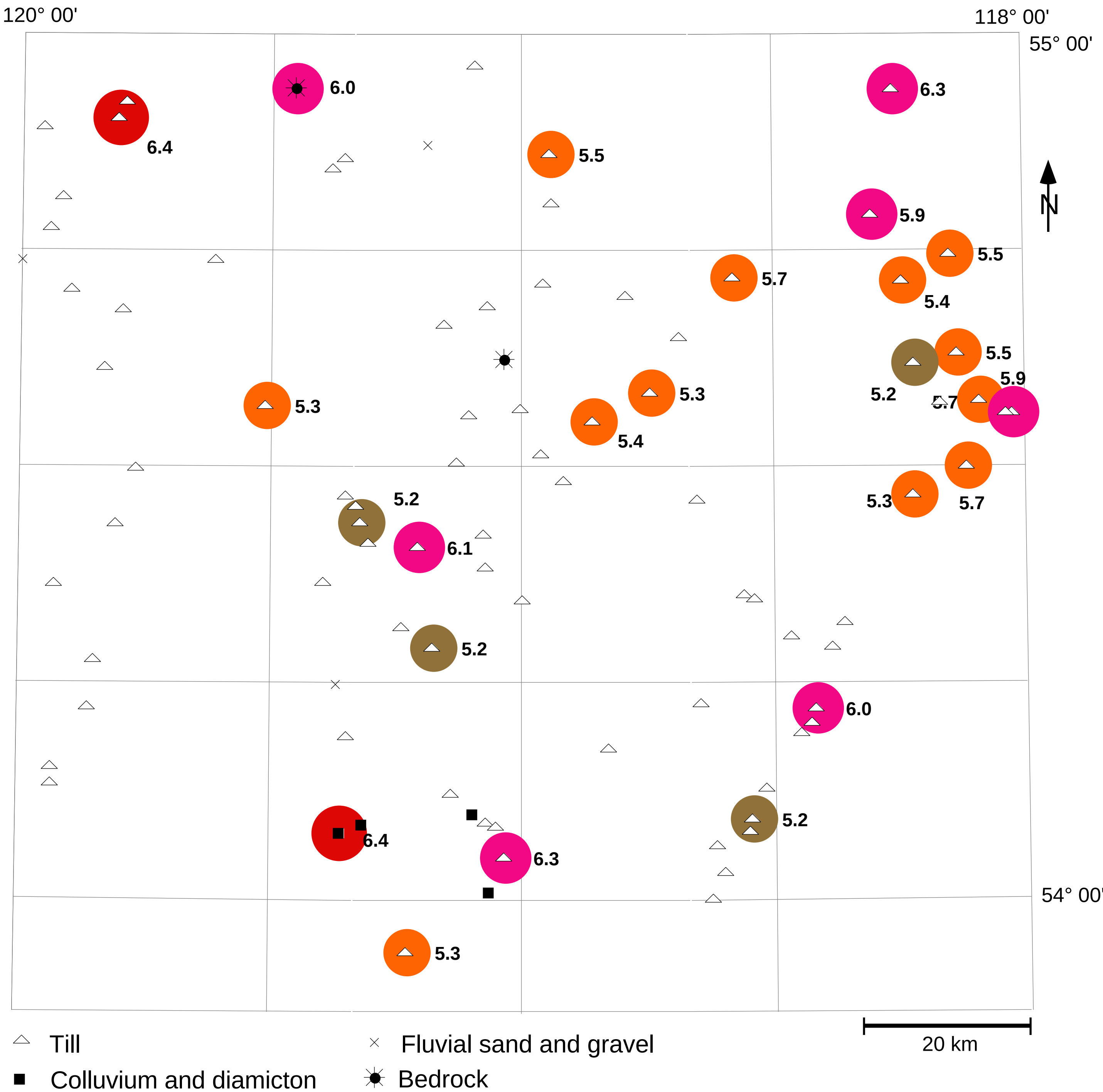

Figure 17. Concentration of Cs in ppm by INNA for sites with values ≥75th percentile.

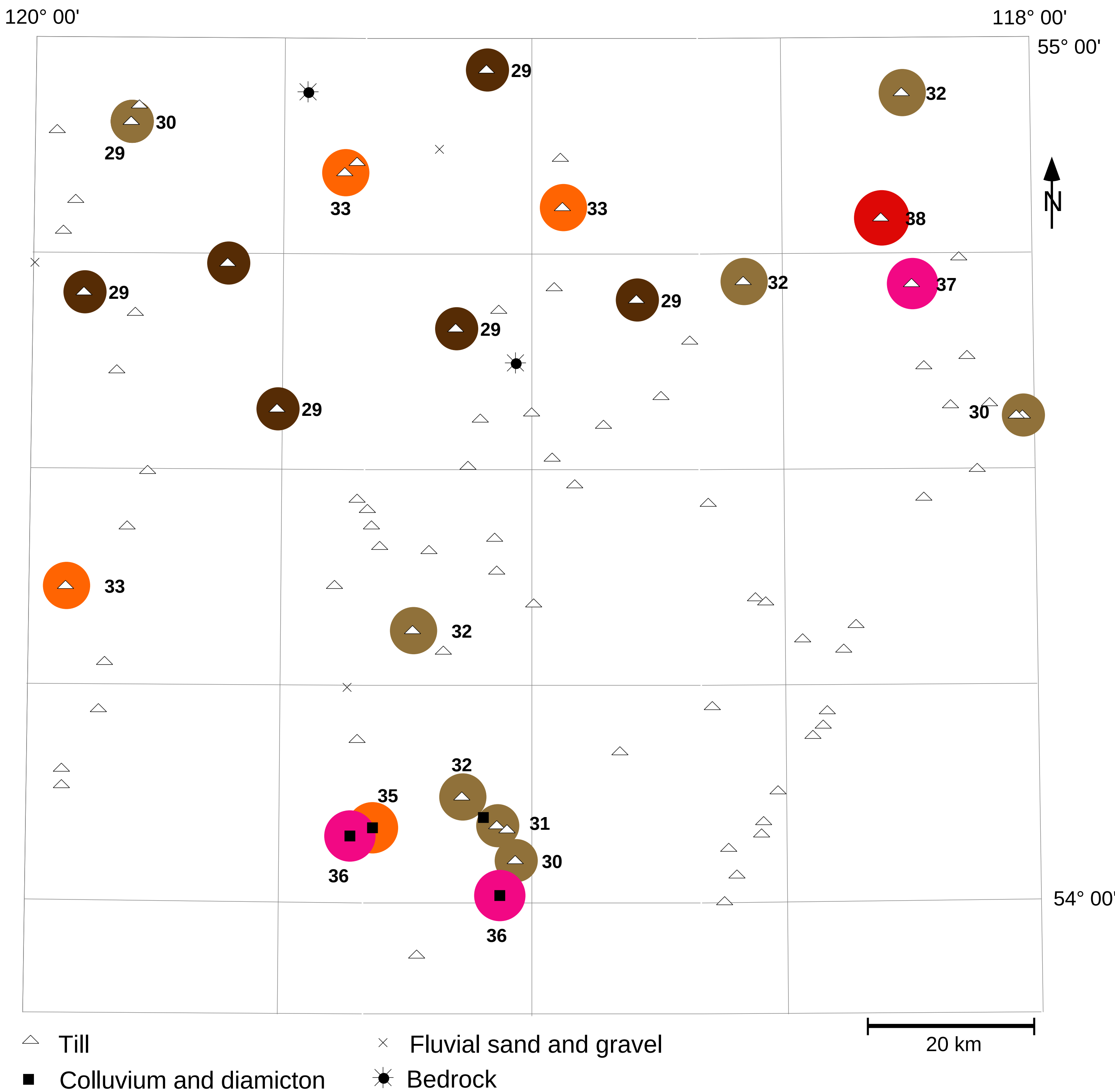

Figure 18. Concentration of Cu in ppm by AA for sites with values ≥75th percentile.

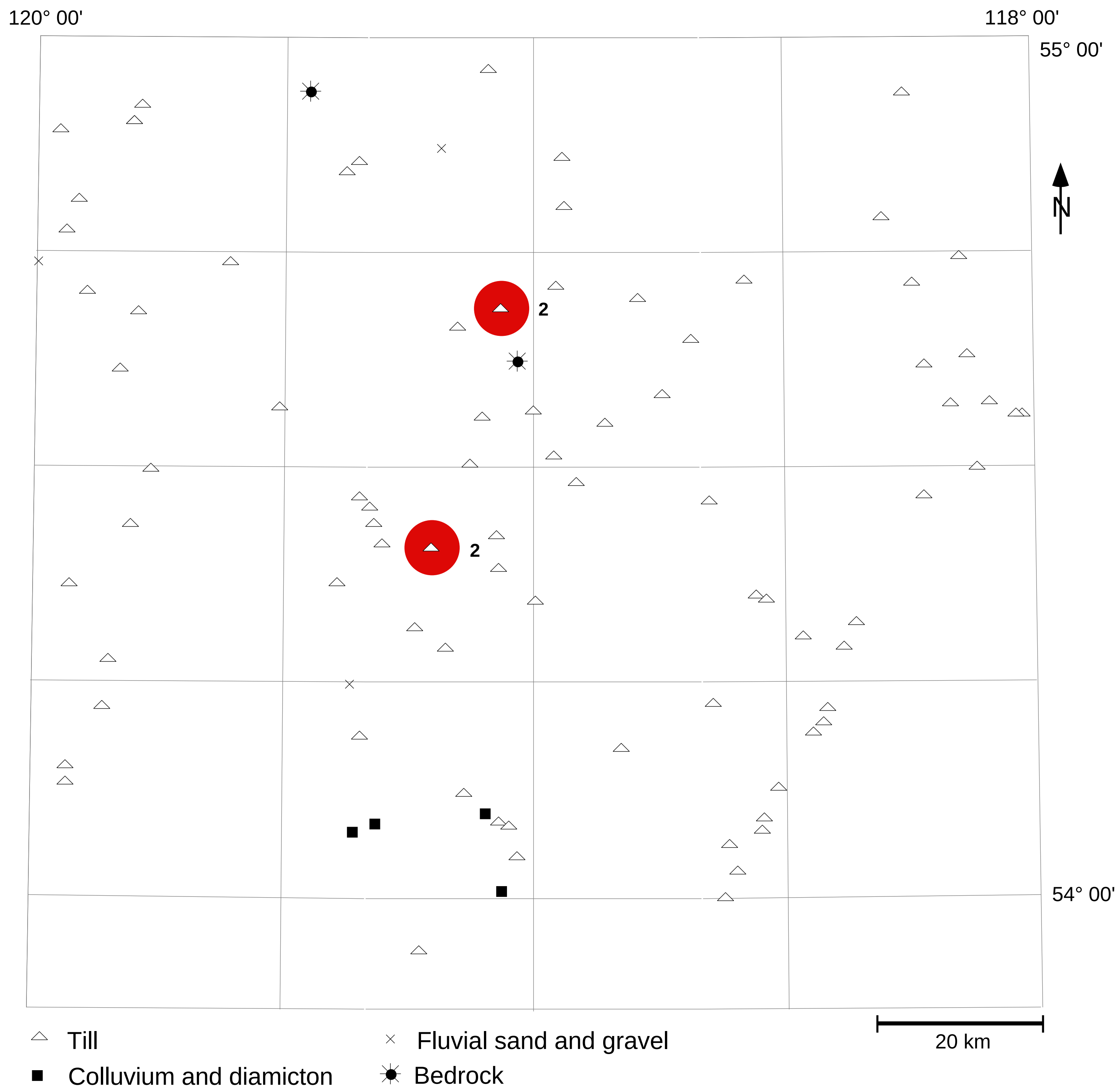

Figure 19. Concentration of Eu in ppm by INNA for sites with values ≥75th percentile.

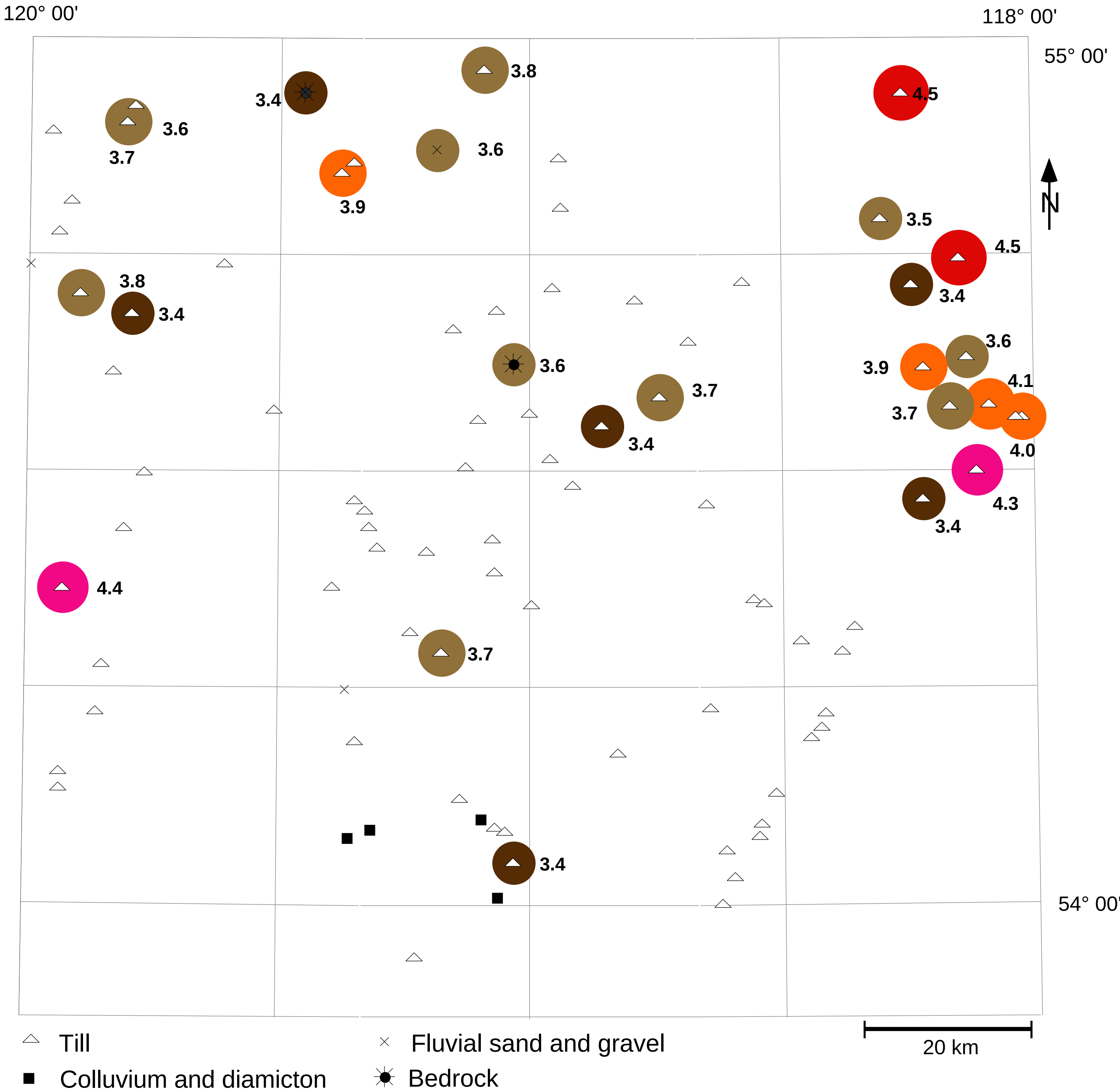

Figure 20. Concentration of Fe in % by AA for sites with values ≥75th percentile.

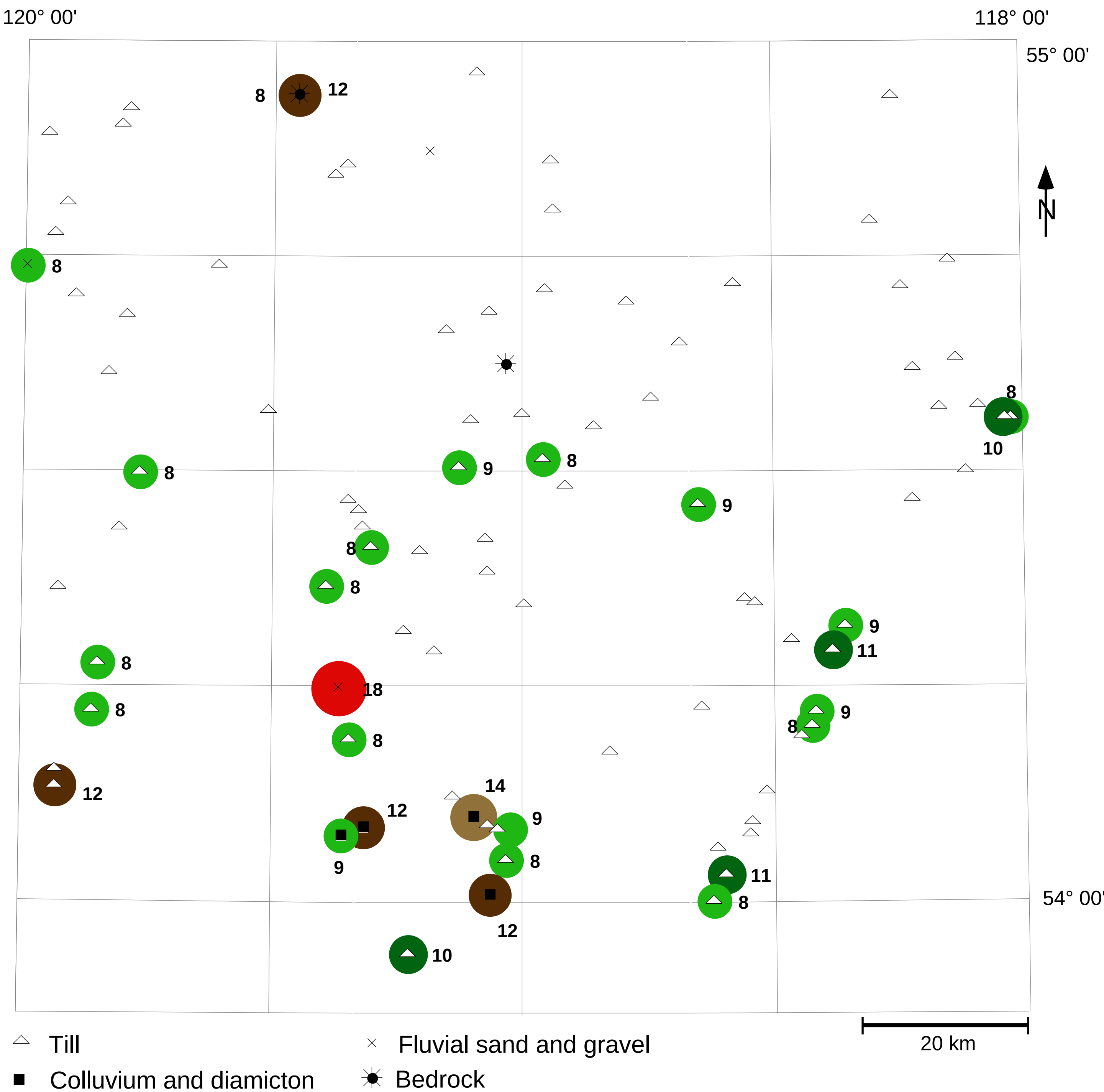

Figure 21. Hafnium concentration (ppm by NA) for sites with values 75th percentile.

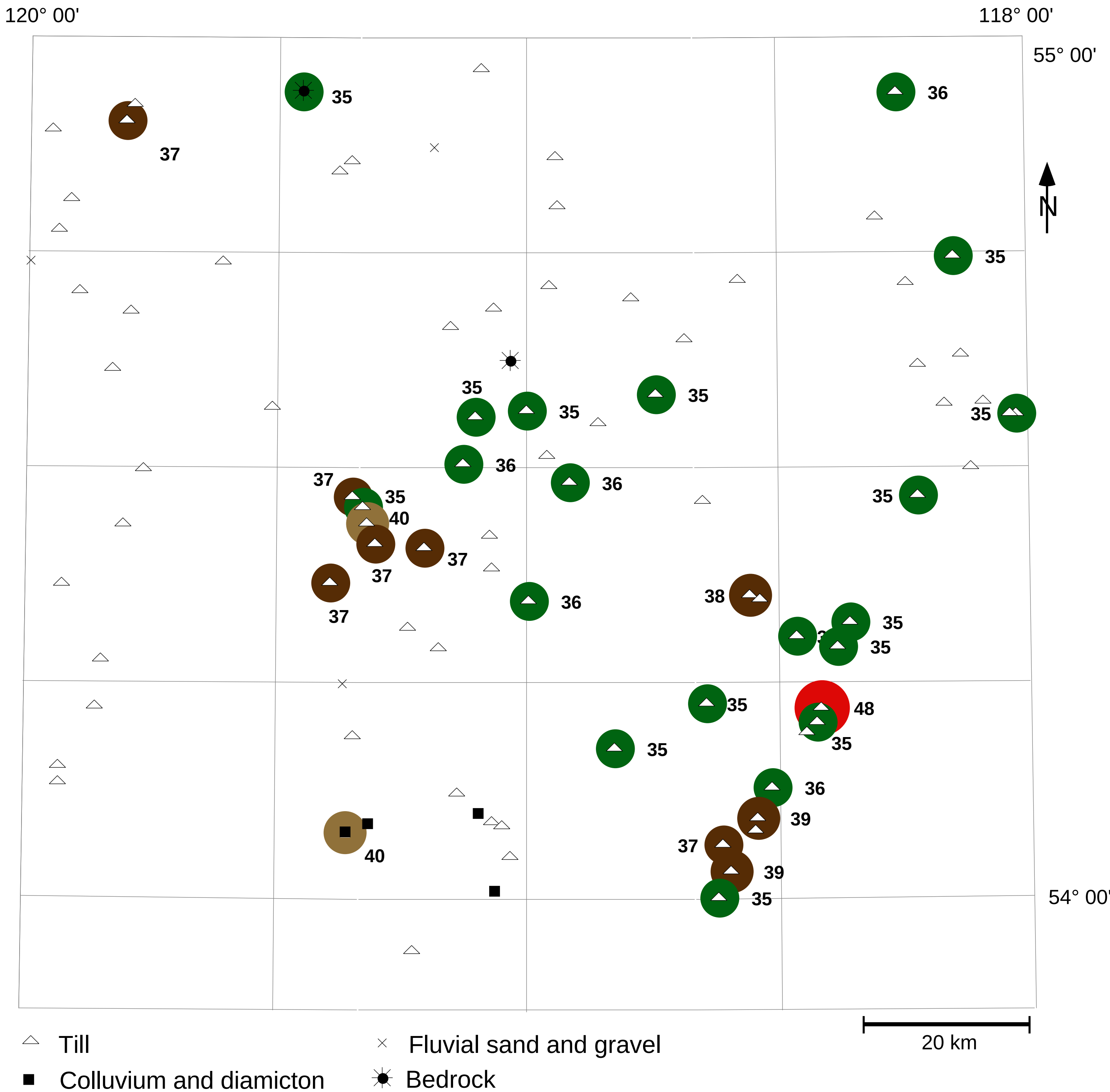

Figure 22. Concentration of La in ppm by INNA for sites with values ≥75th percentile.

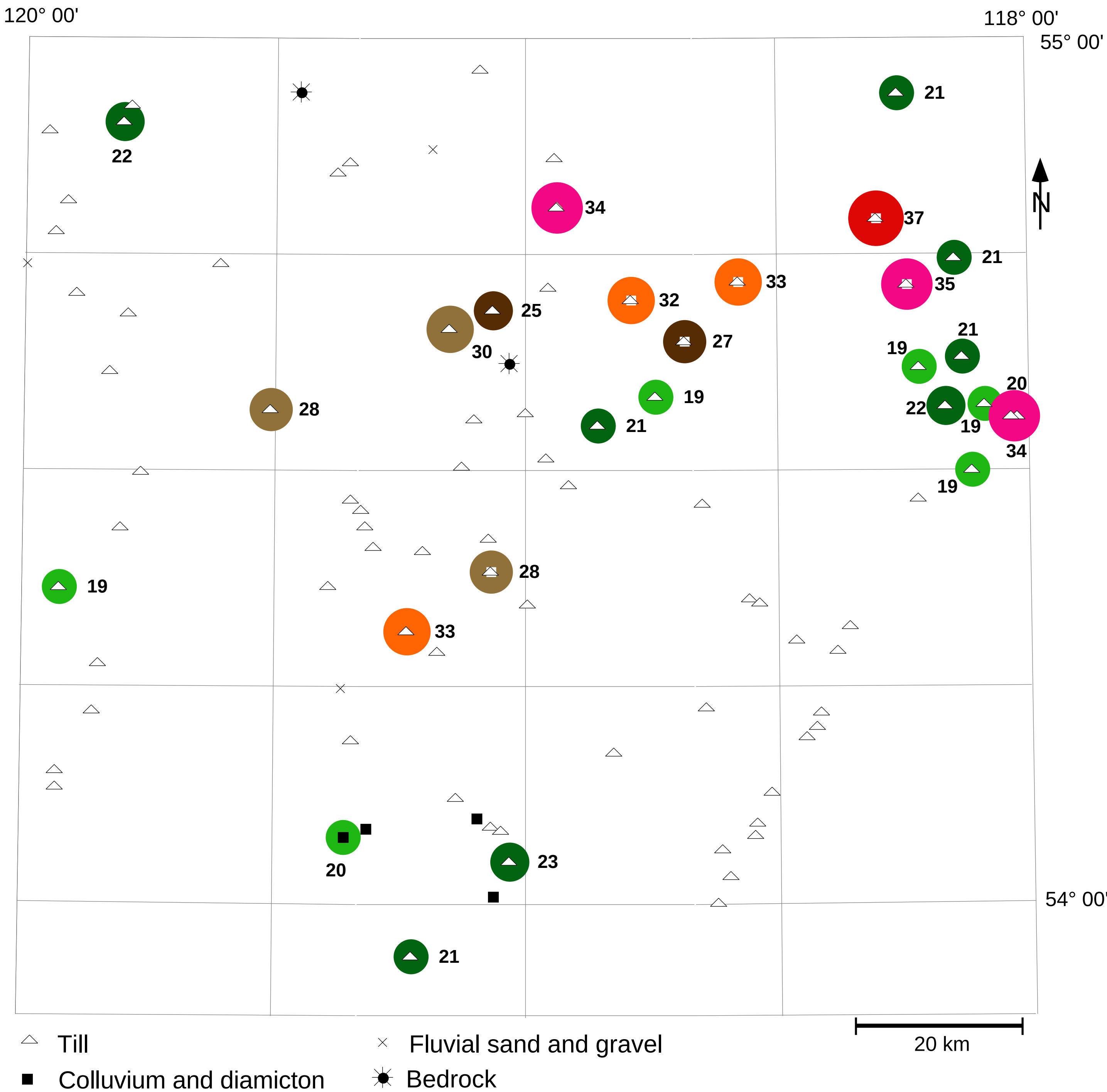

Figure 23. Concentration of Li in ppm by AA for sites with values ≥75th percentile.

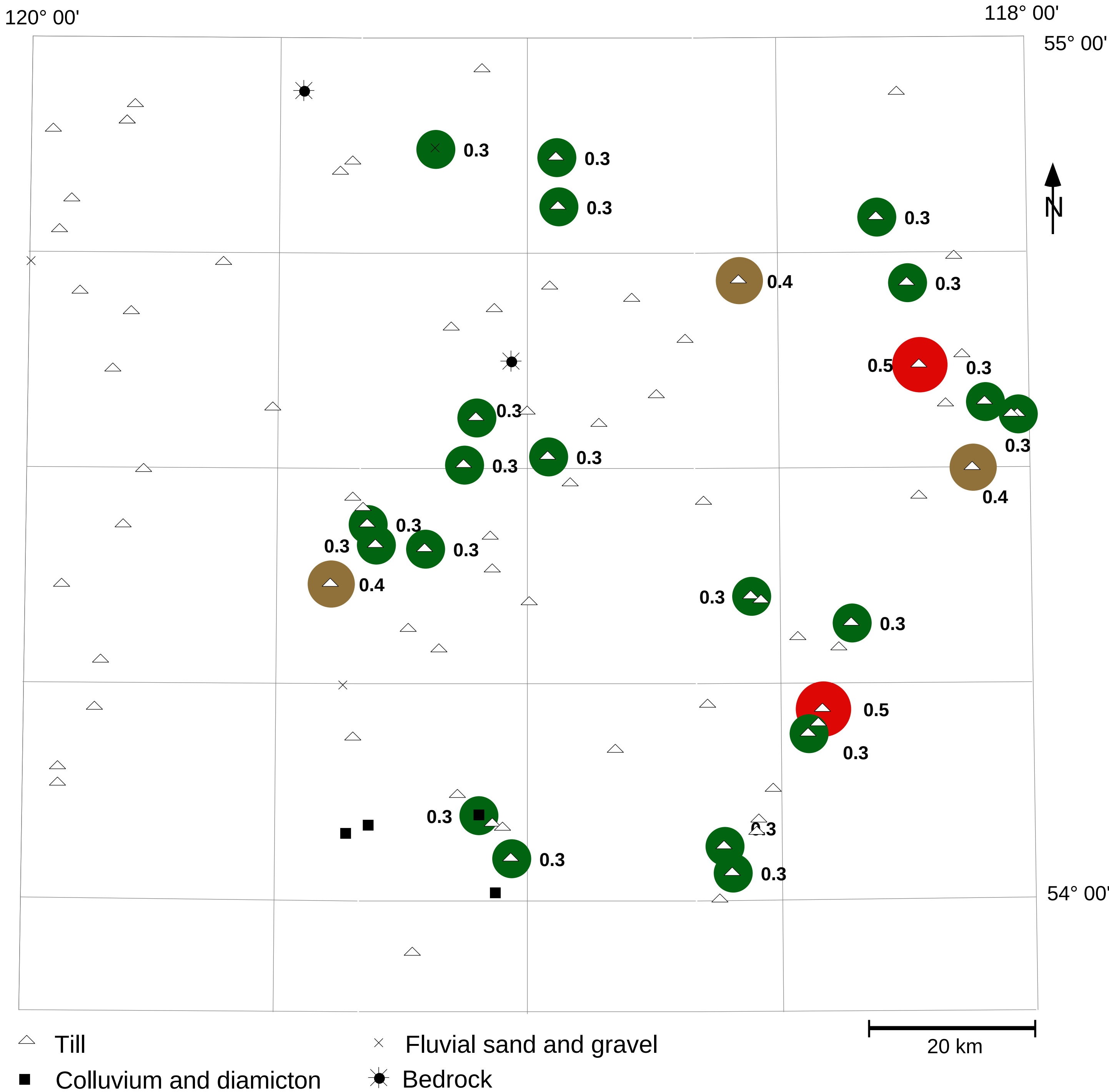

Figure 24. Concentration of Lu in ppm by INNA) for sites with values ≥75th percentile.

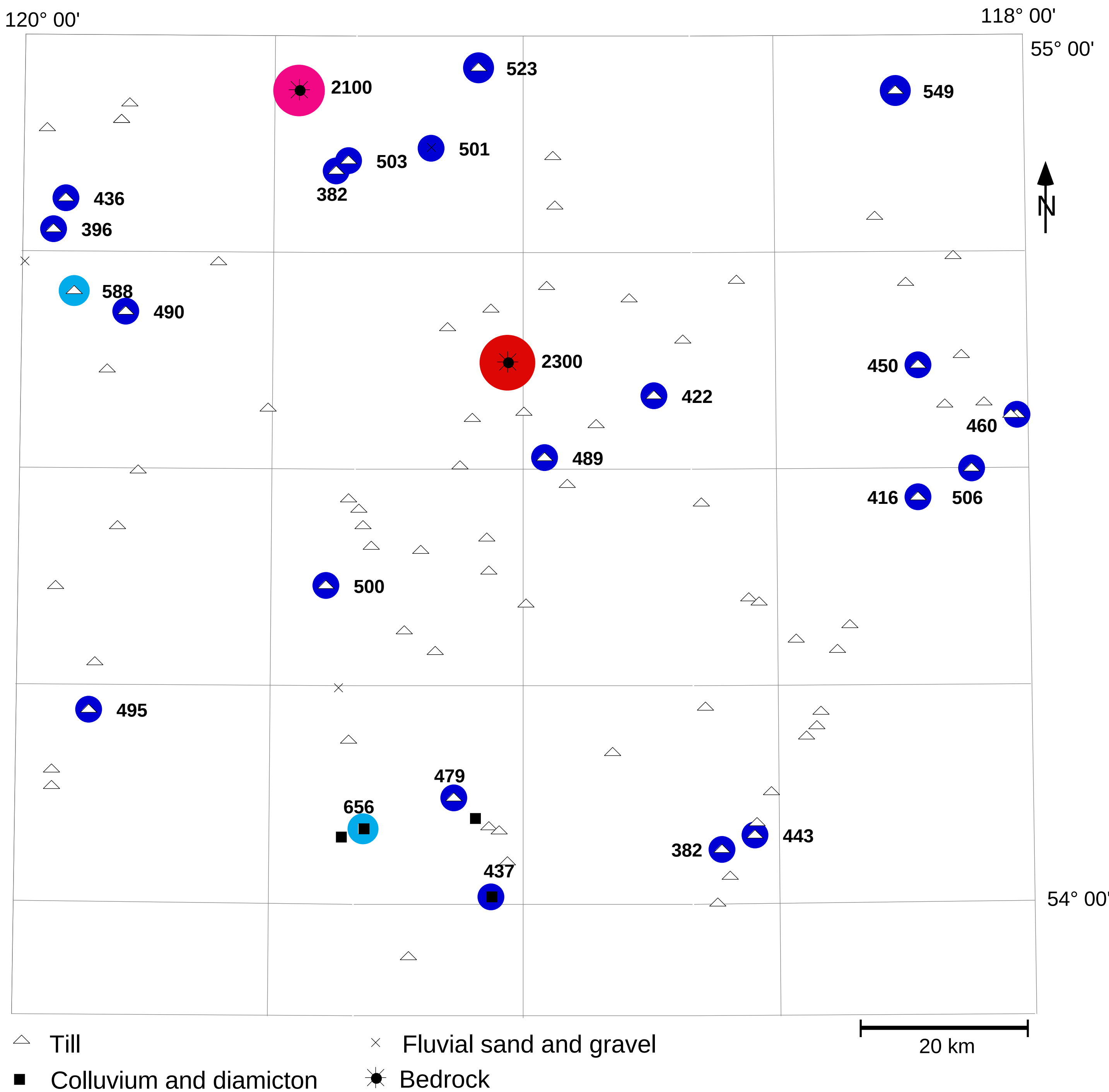

Figure 25. Concentration Mn in ppm by AA for sites with values ≥75th percentile.

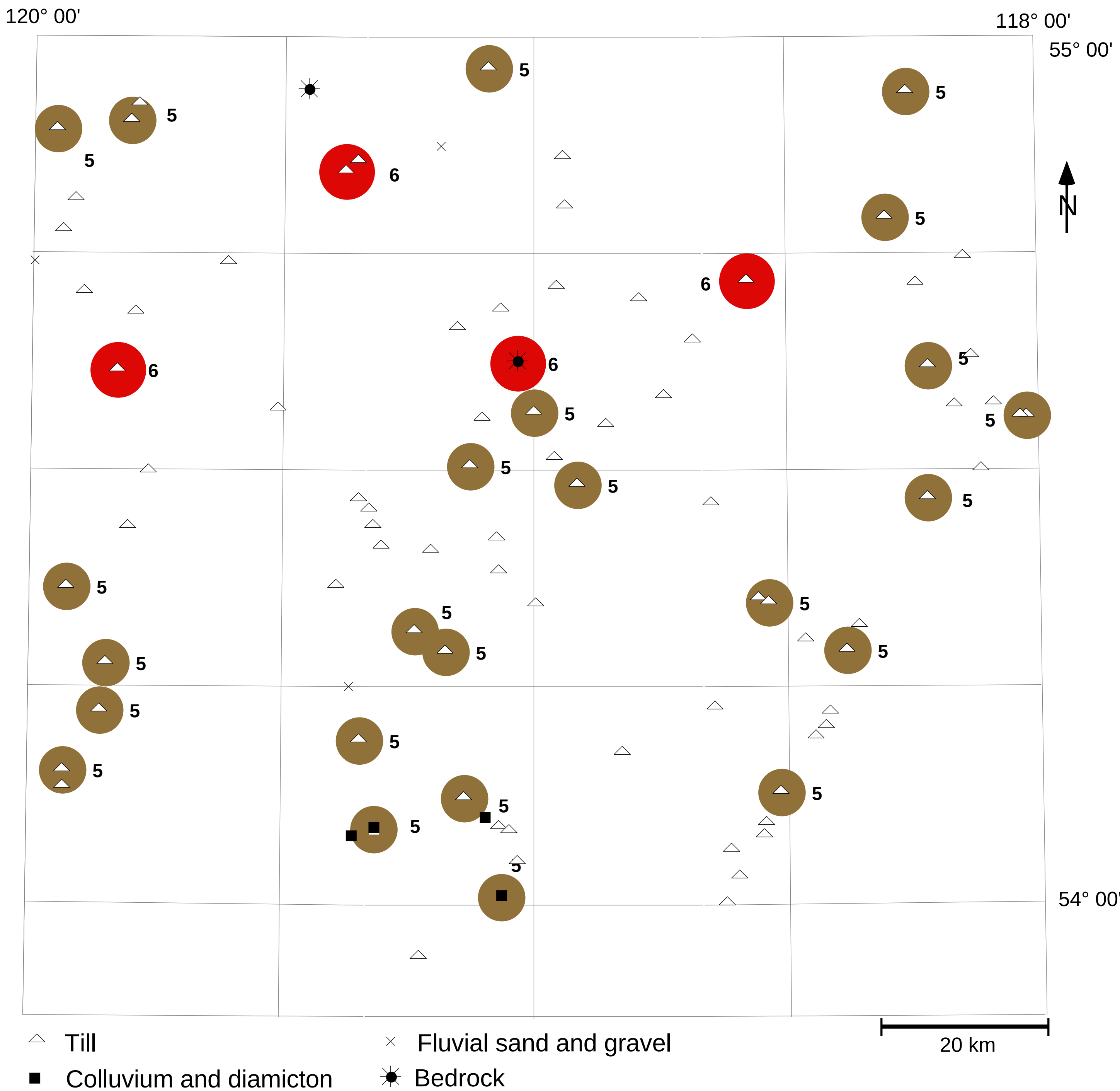

Figure 26. Concentration of Mo in ppm by AA for sites with values ≥75th percentile.

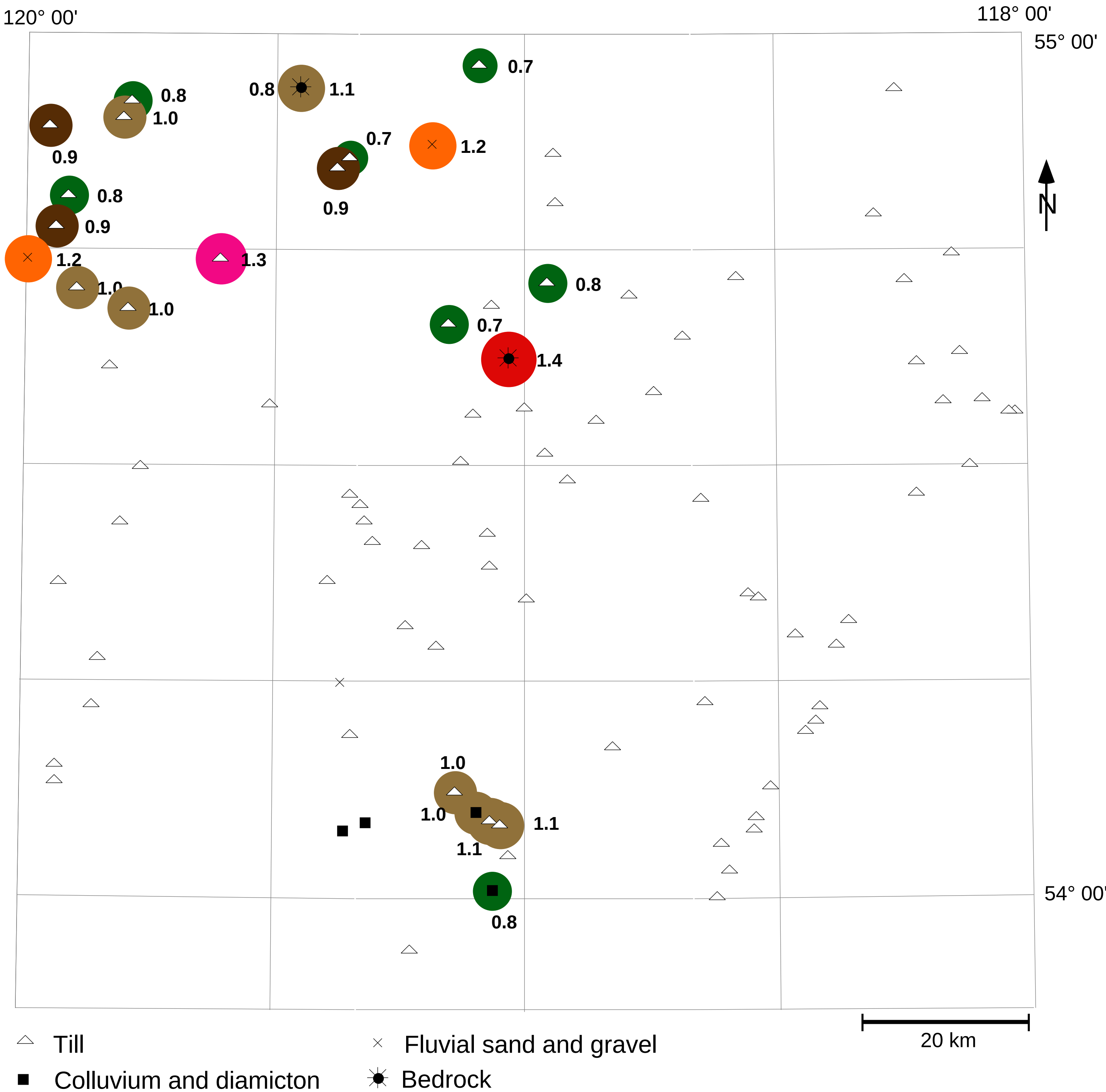

Figure 27. Concentration of Na in % by INNA for sites with values ≥75th percentile.

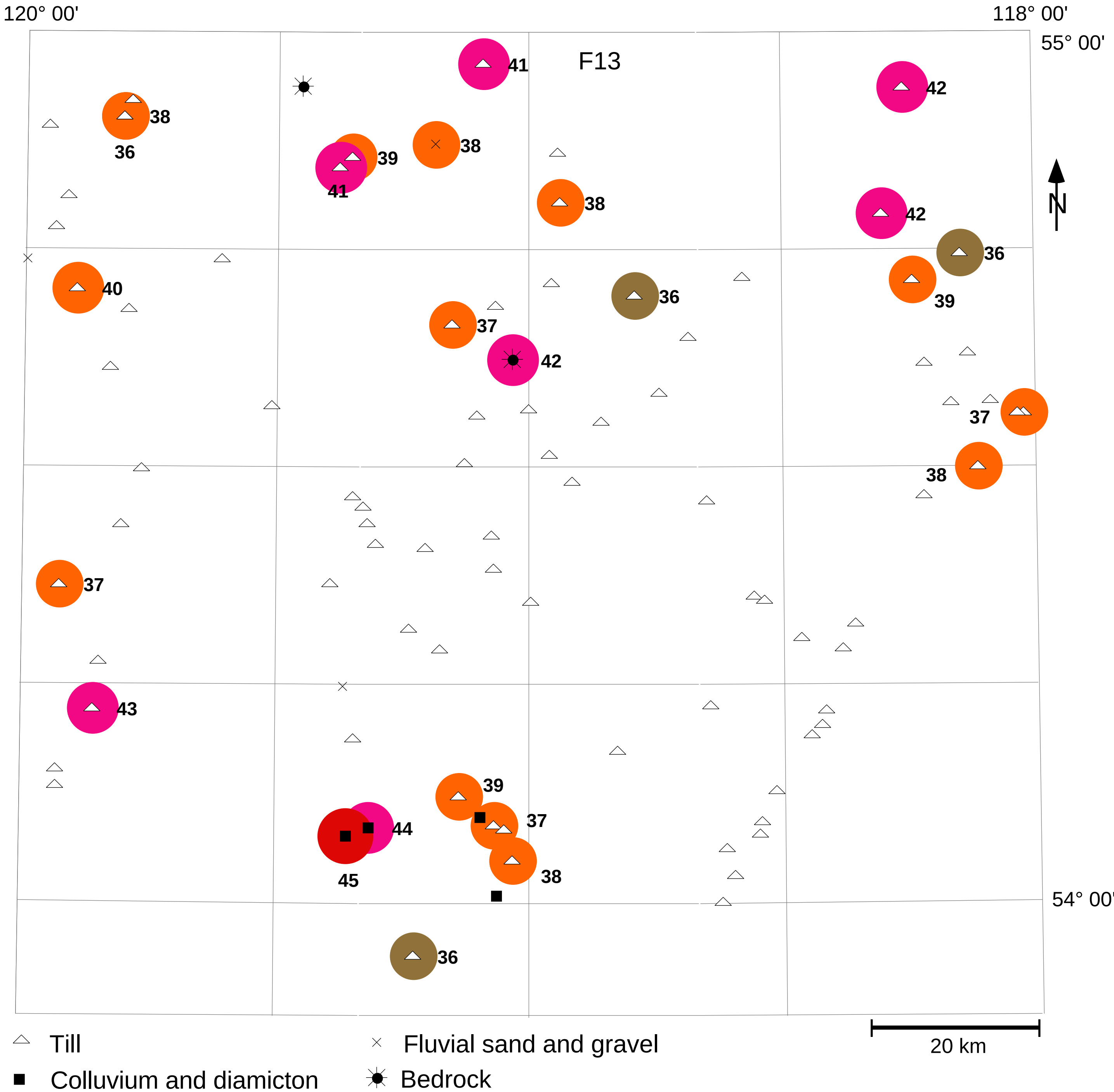

Figure 28. Concentration of Ni in ppm by AA for sites with values ≥75th percentile.

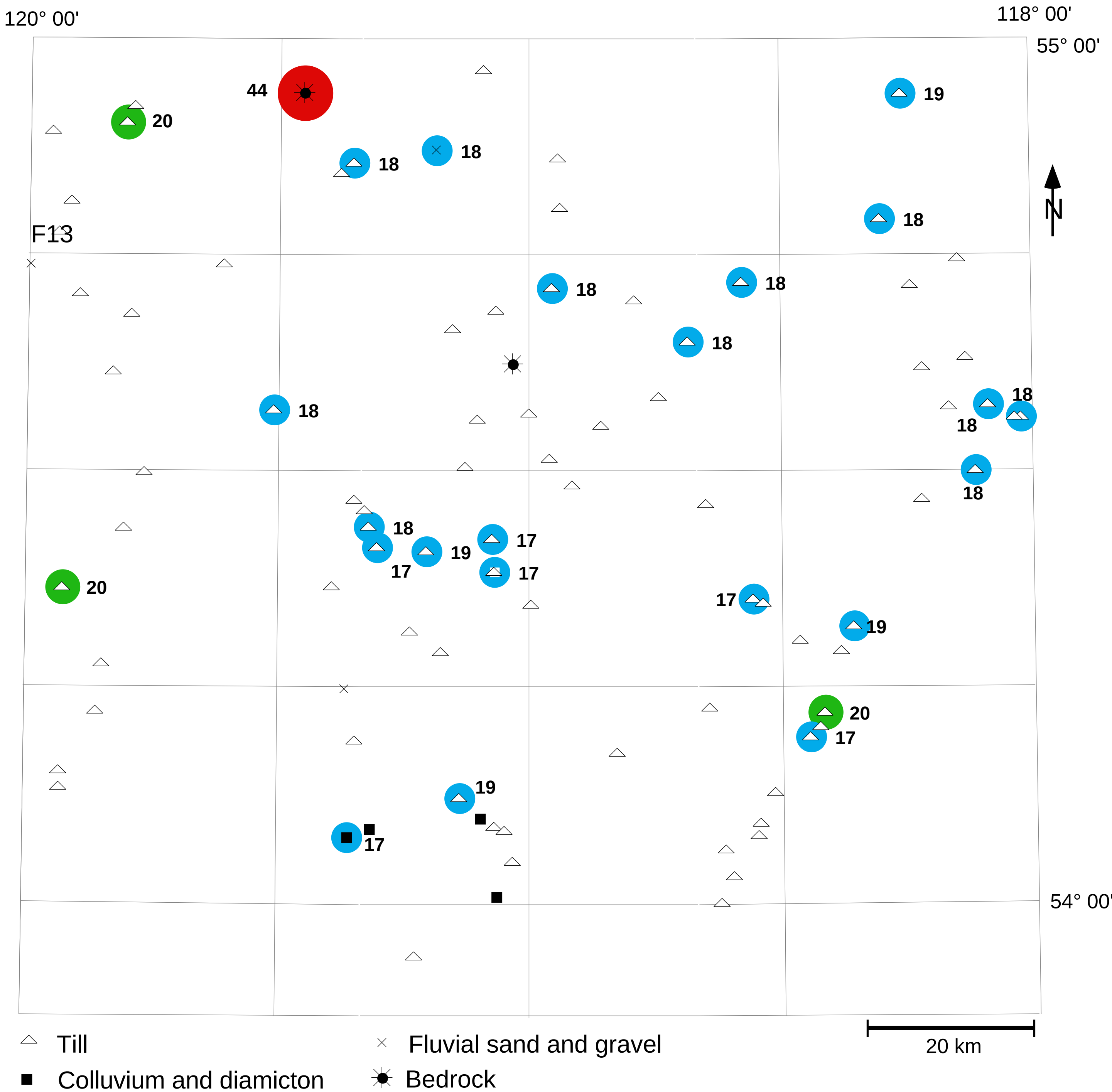

Figure 29. Concentration of Pb in ppm by AA for sites with values ≥75th percentile.

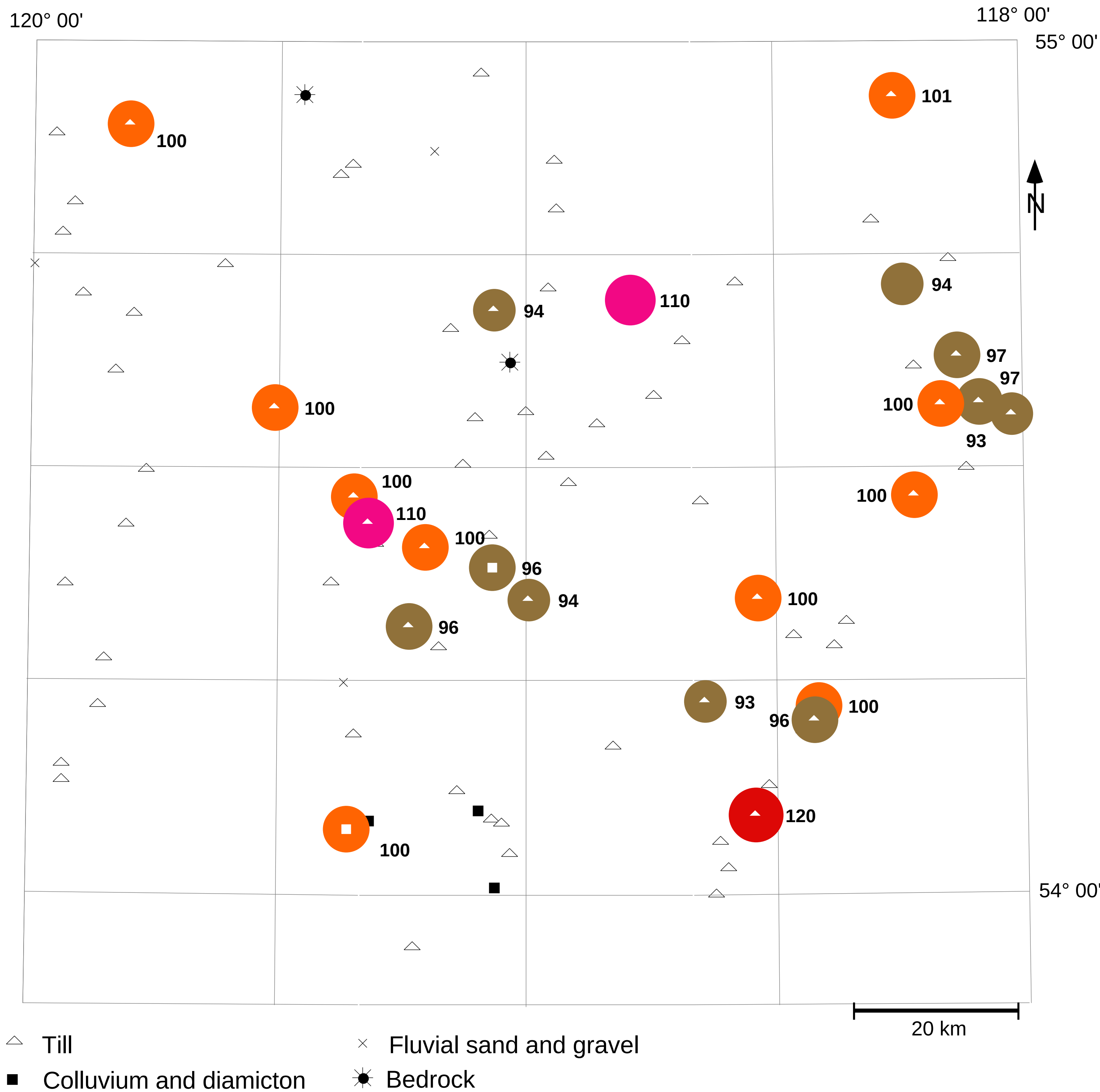

Figure 30. Concentration of Rb in ppm by INNA for sites with values ≥75th percentile.

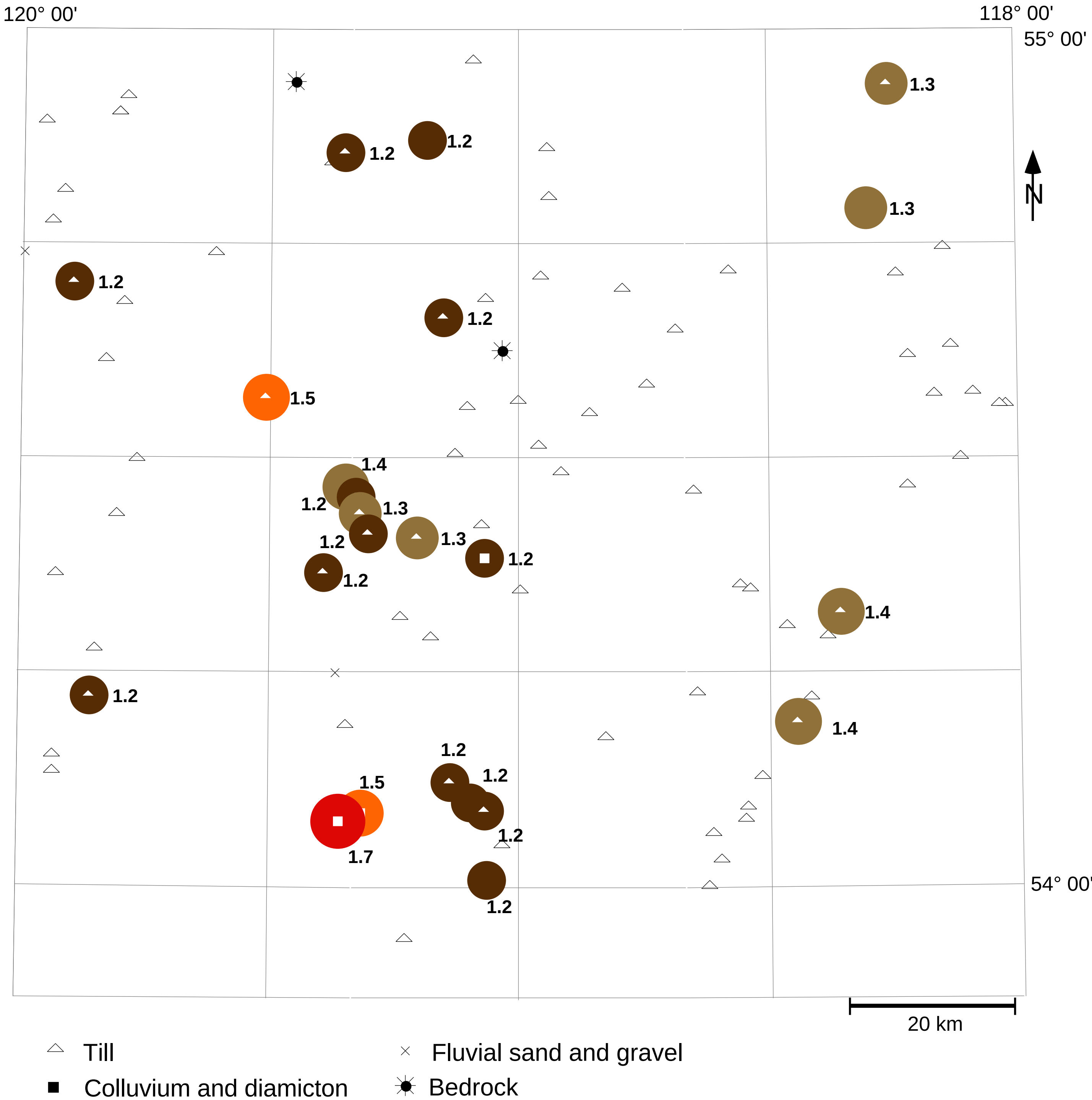

Figure 31. Concentration of Sb in ppm by INNA for sites with values ≥75th percentile.

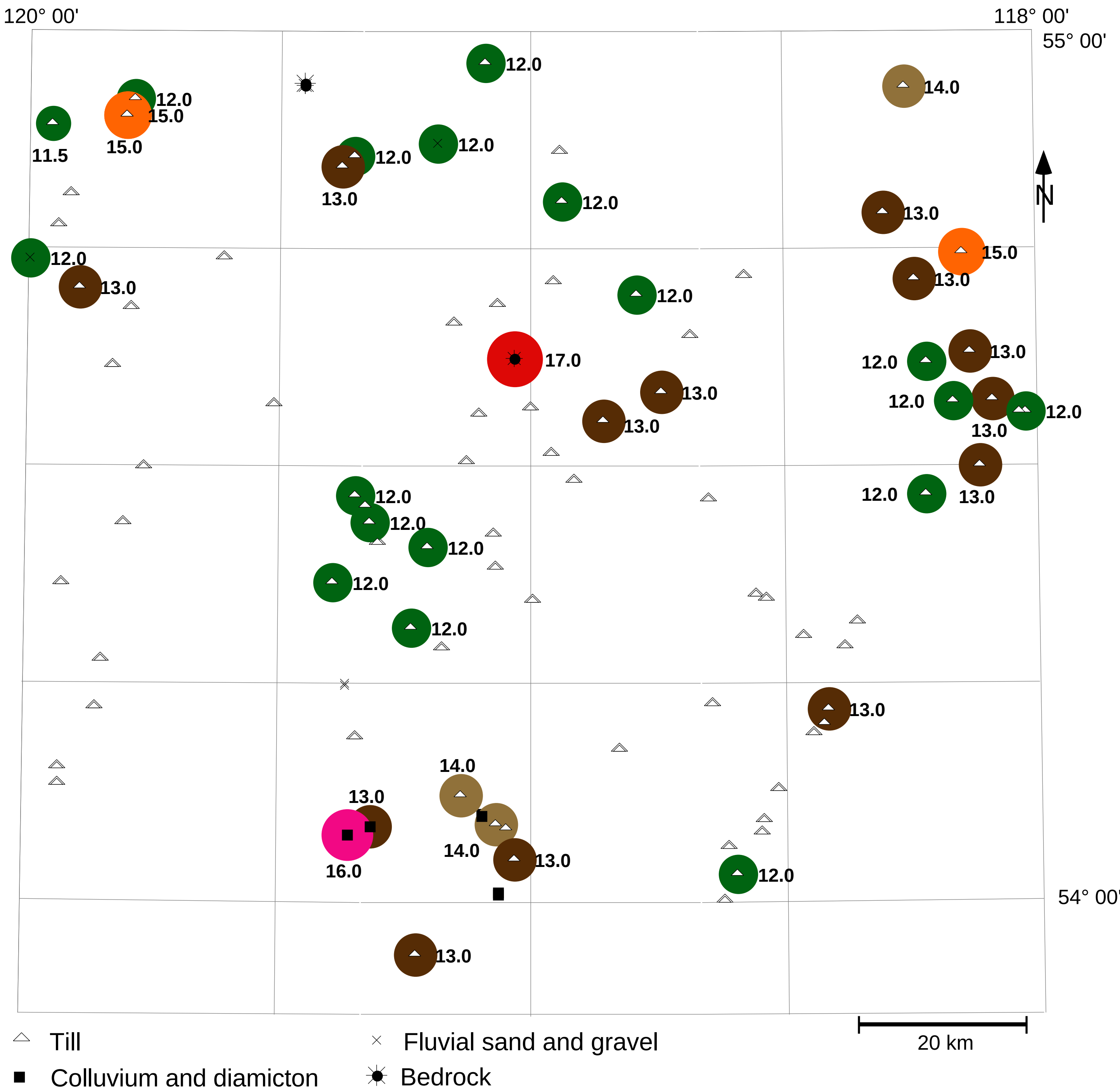

Figure 32. Concentration of Sc in ppm by INNA for sites with values ≥75th percentile.

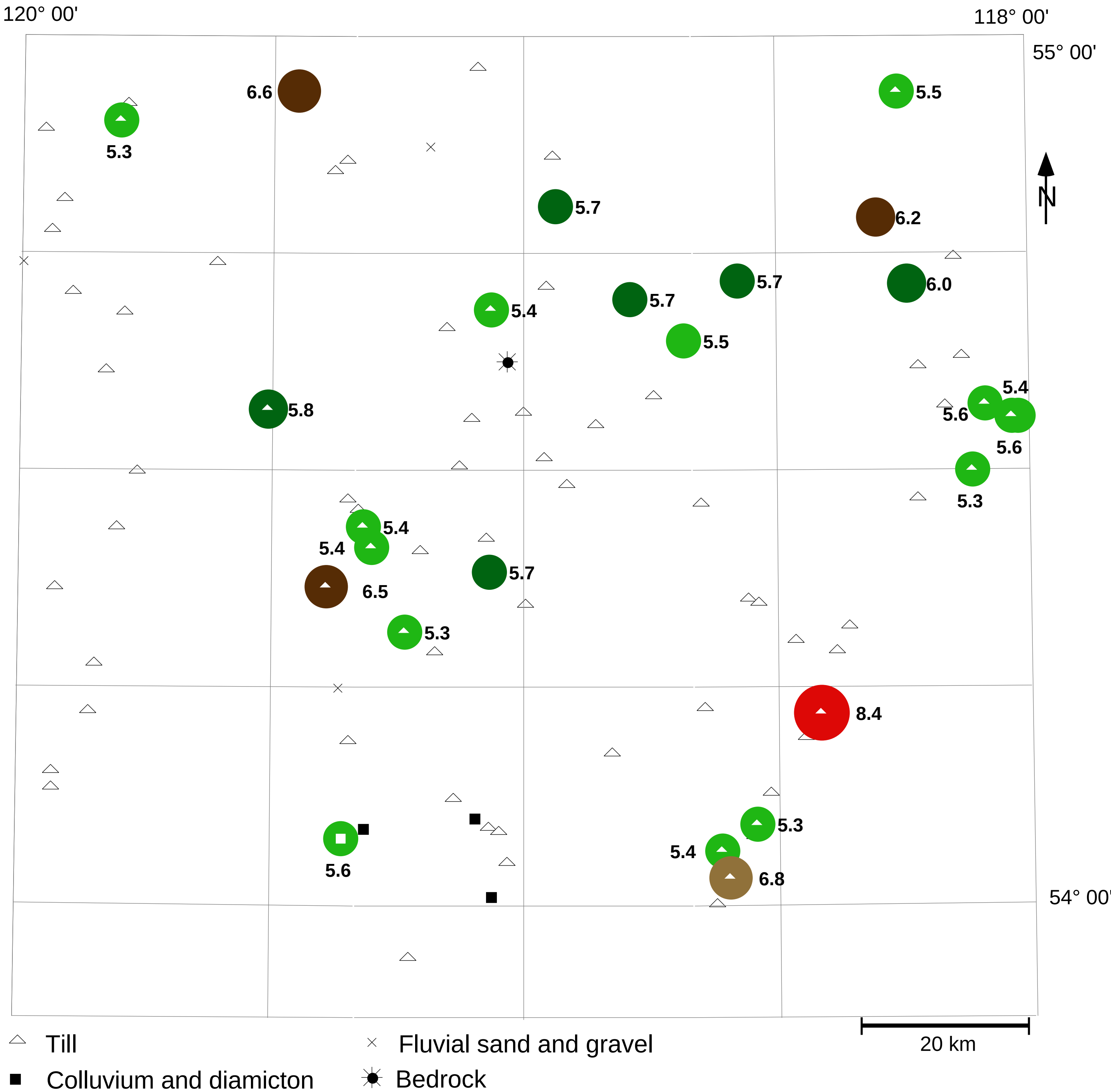

Figure 33. Concentration of Sm in ppm by INNA for sites with values ≥75th percentile.

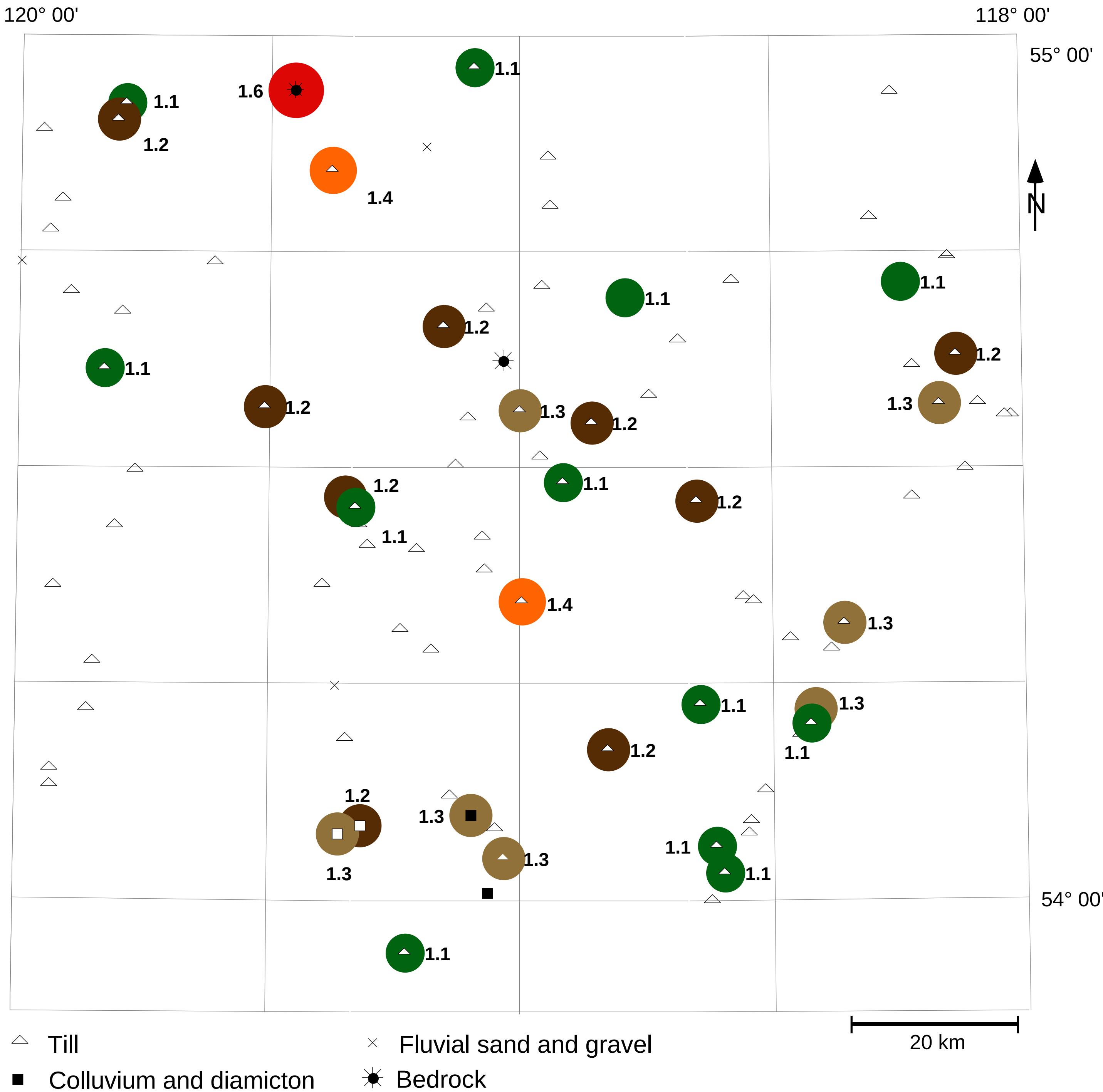

Figure 34. Concentration of Ta in ppm by INNA for sites with values ≥75th percentile.

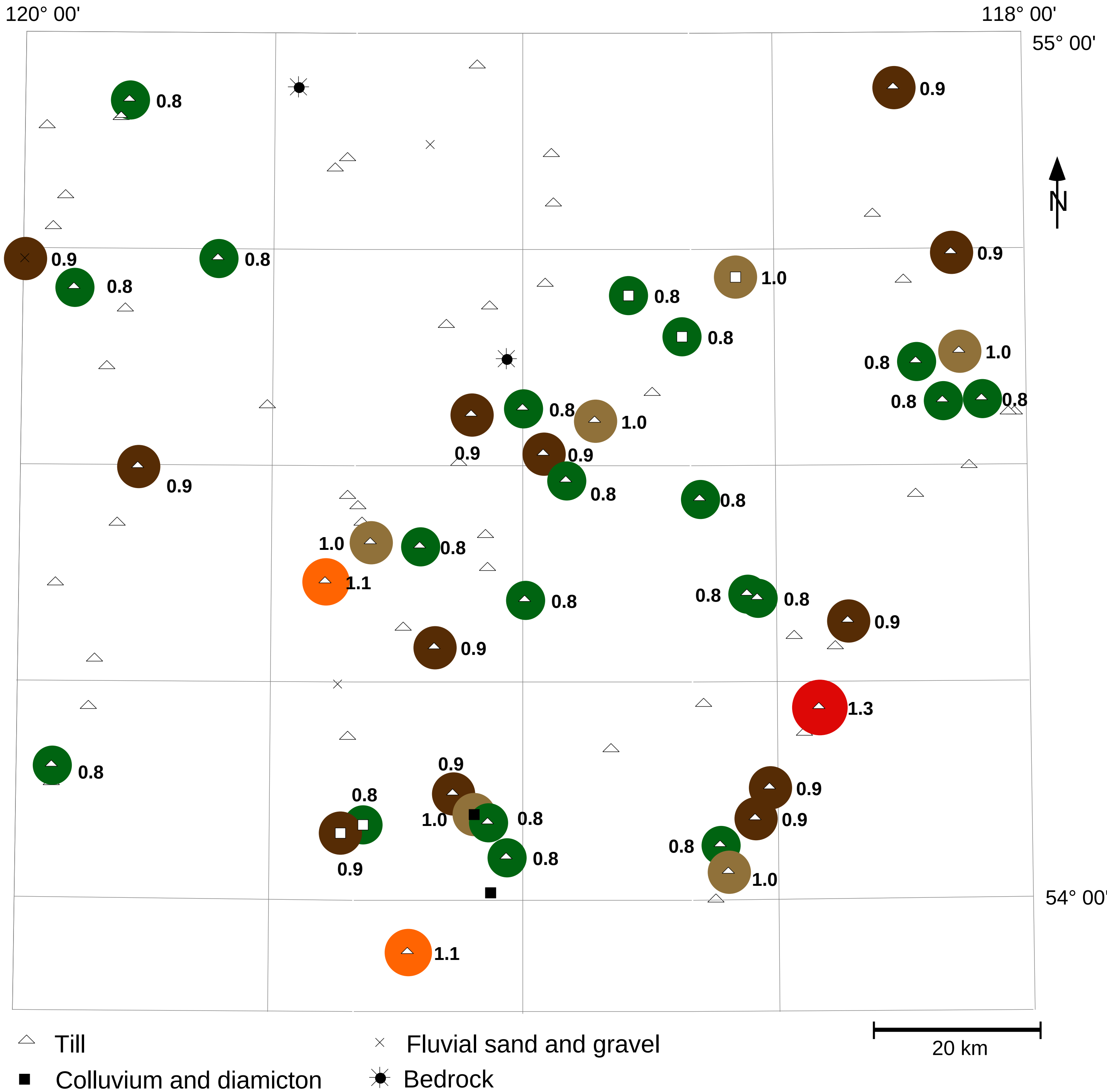

Figure 35. Concentration of Tb in ppm by INNA for sites with values ≥75th percentile.

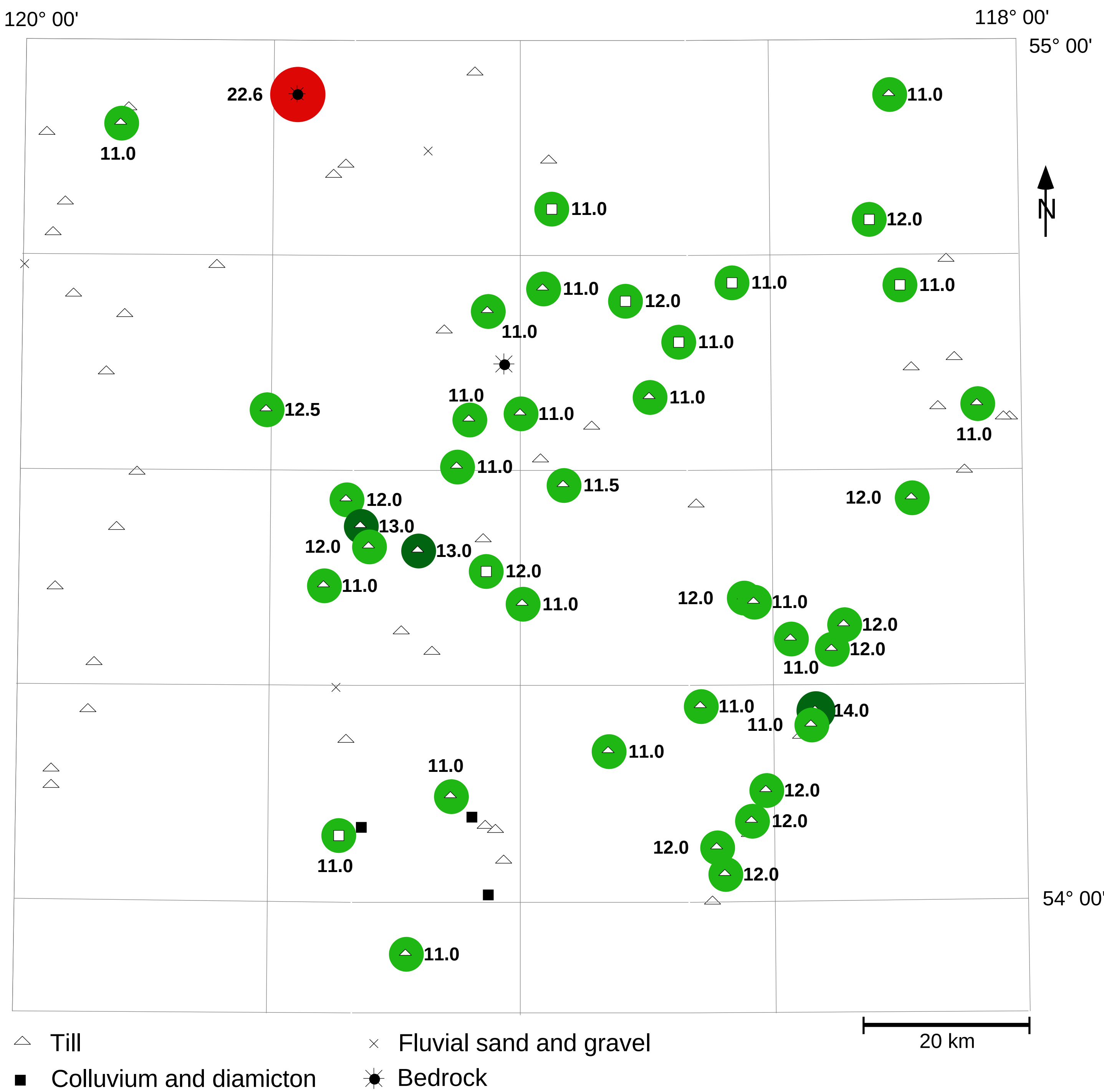

Figure 36. Concentration of Th in ppm by INNA for sites with values ≥75th percentile.

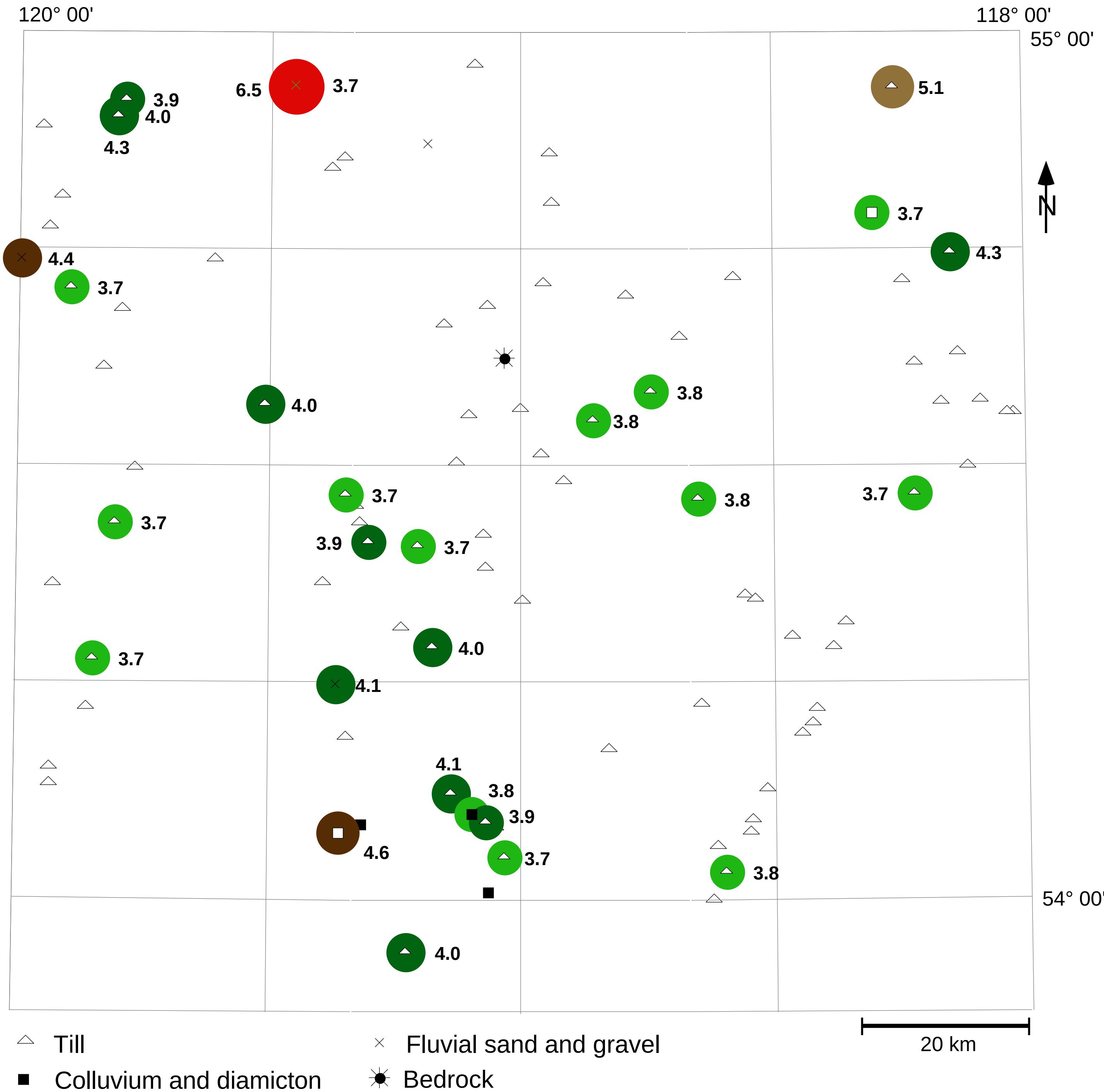

Figure 37. Concentration of U in ppm by INNA for sites with values ≥75th percentile.

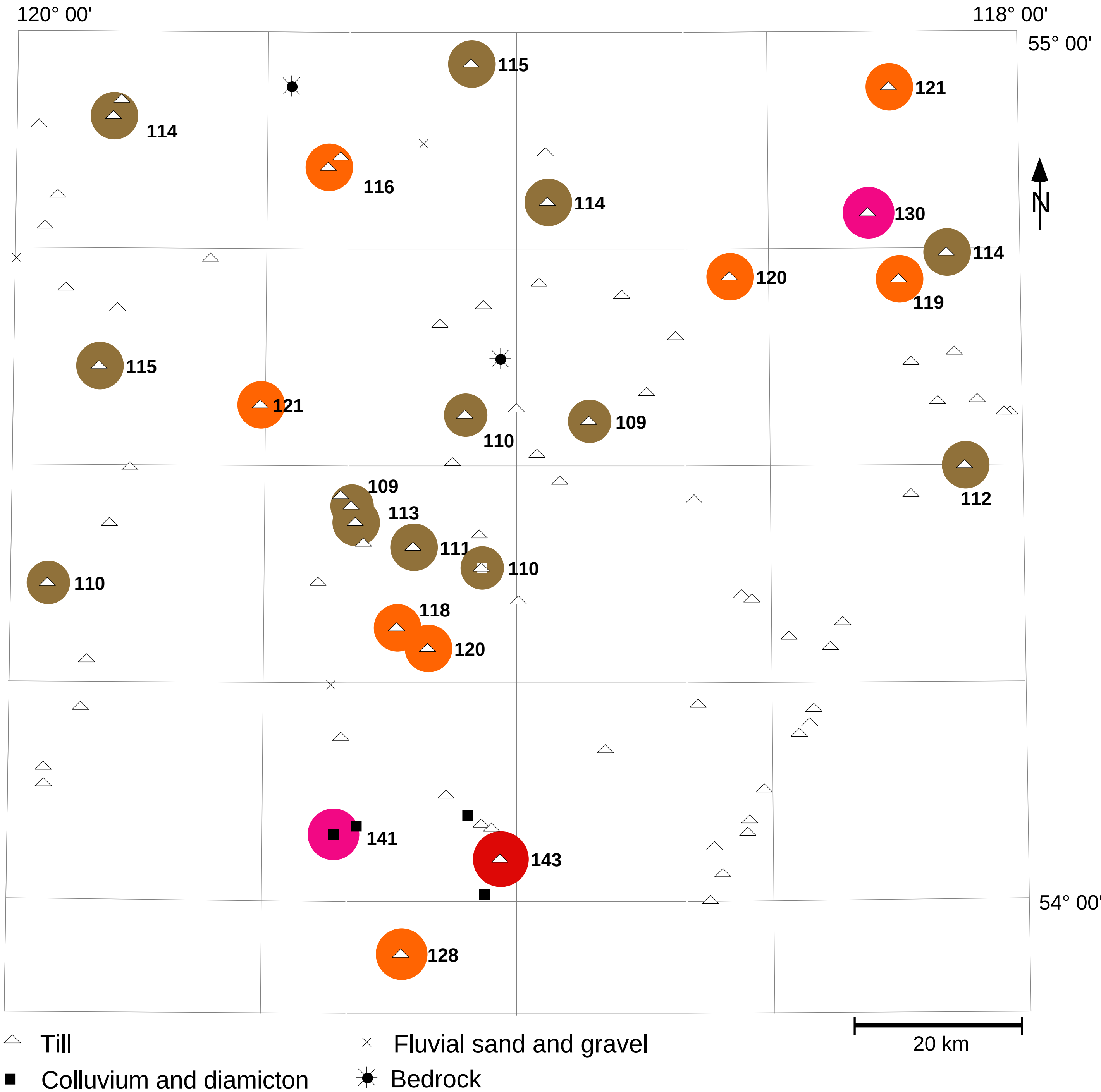

Figure 38. Concentration of V in ppm by AA for sites with values ≥75th percentile.

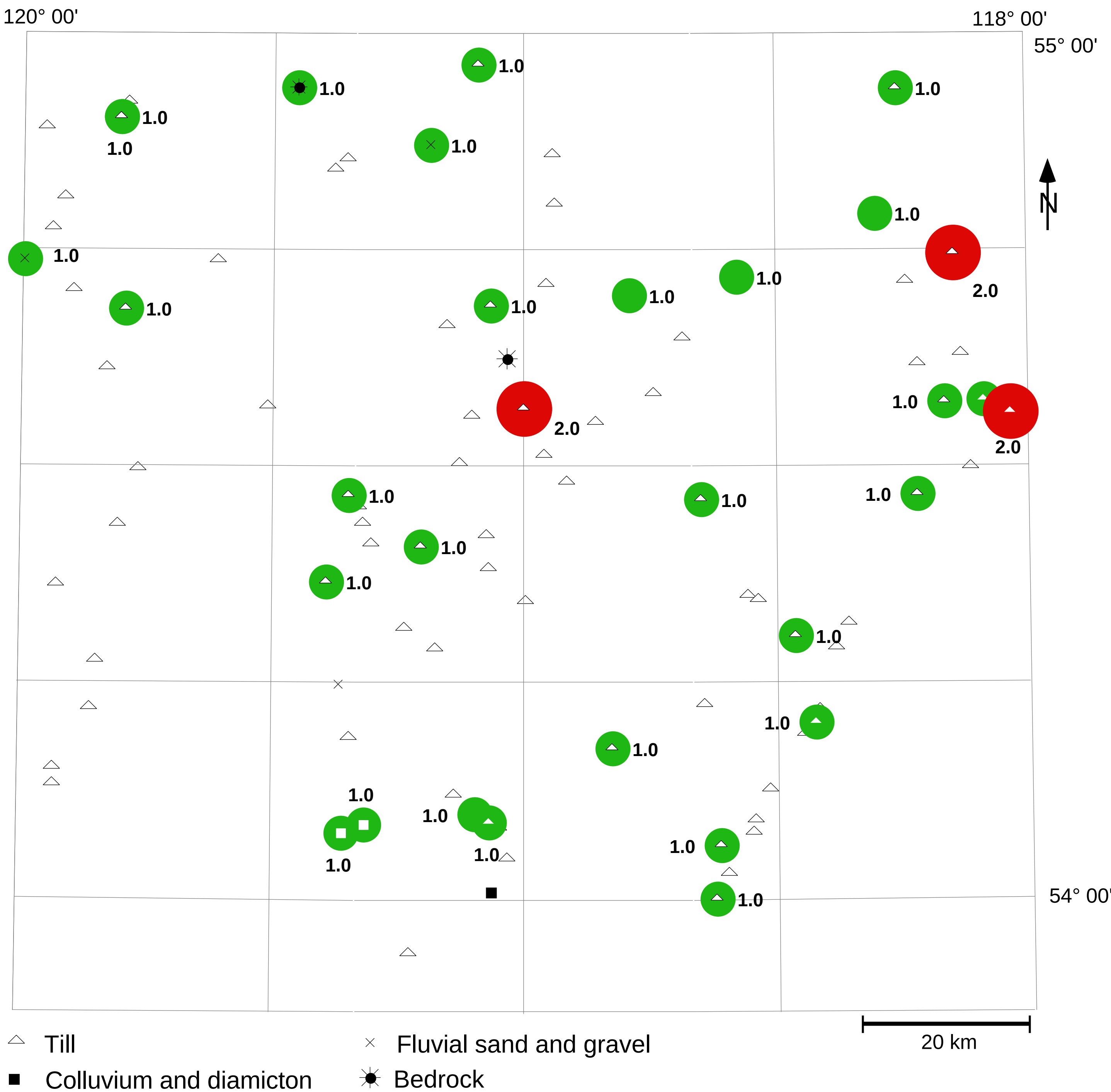

Figure 39. Concentration of W in ppm by INNA for sites with values ≥75th percentile.

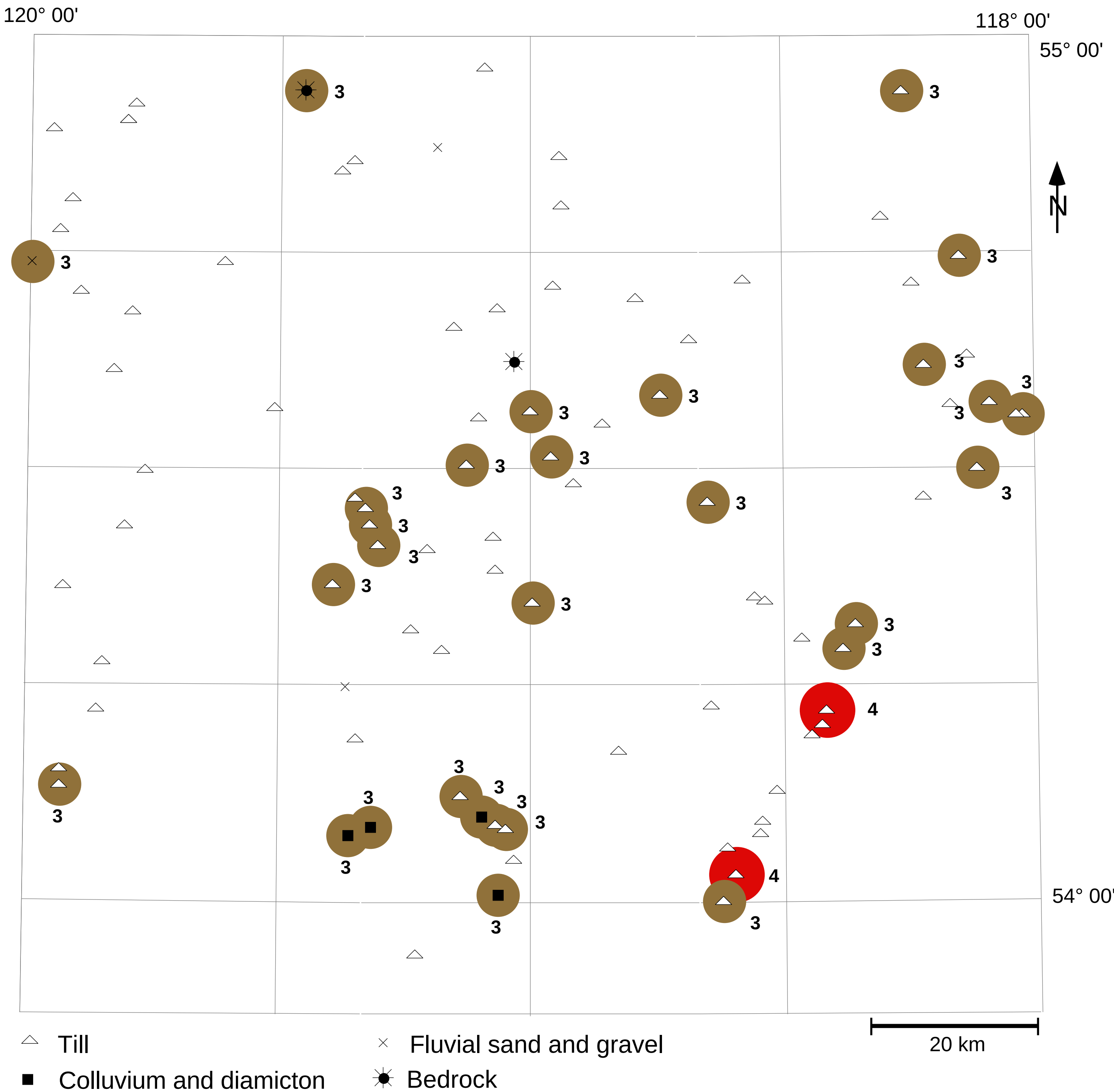

Figure 40. Concentration of Yb in ppm by INNA for sites with values ≥75th percentile.

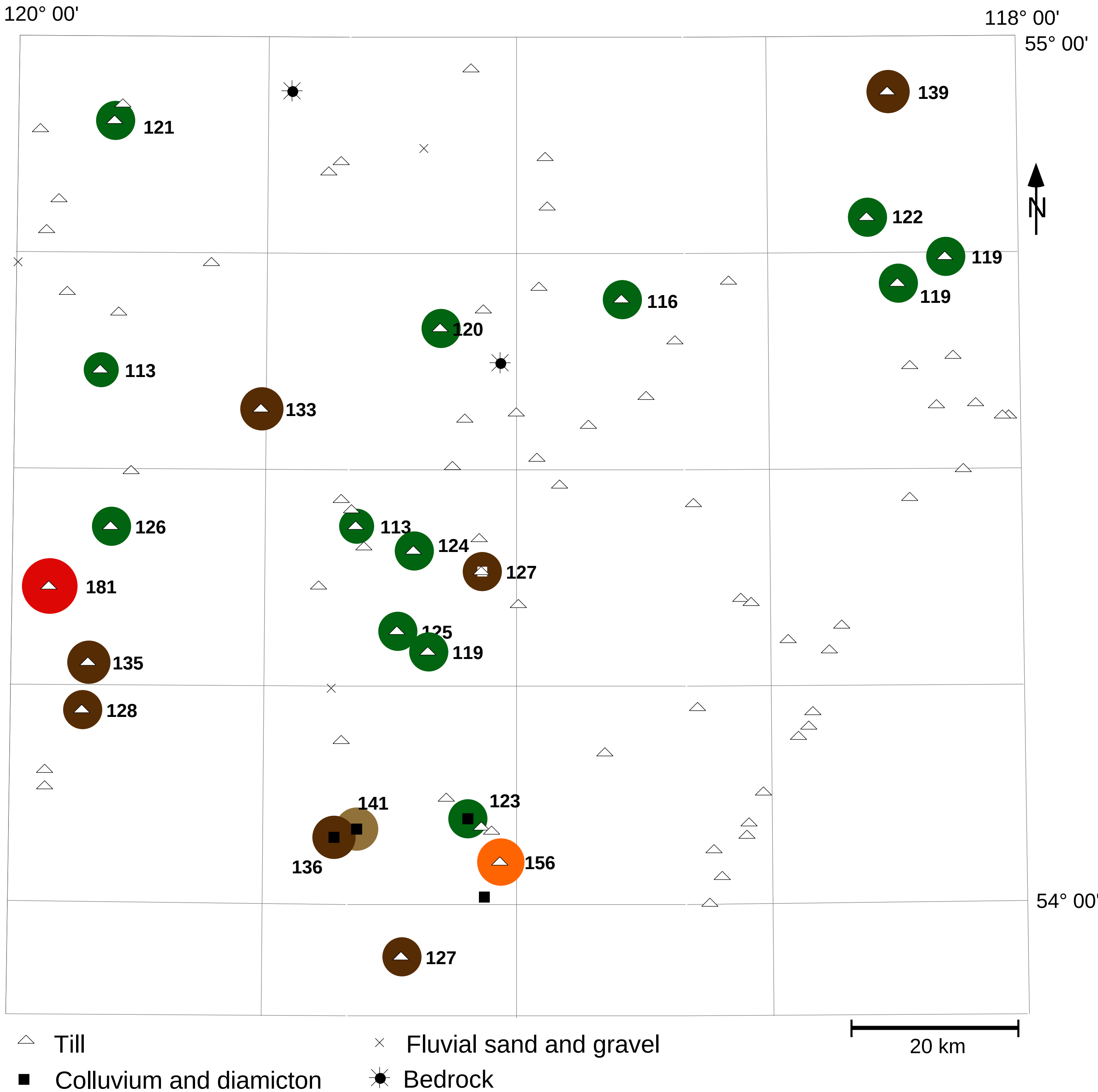

Figure 41. Concentration of Zn in ppm by AA for sites with values ≥75th percentile.

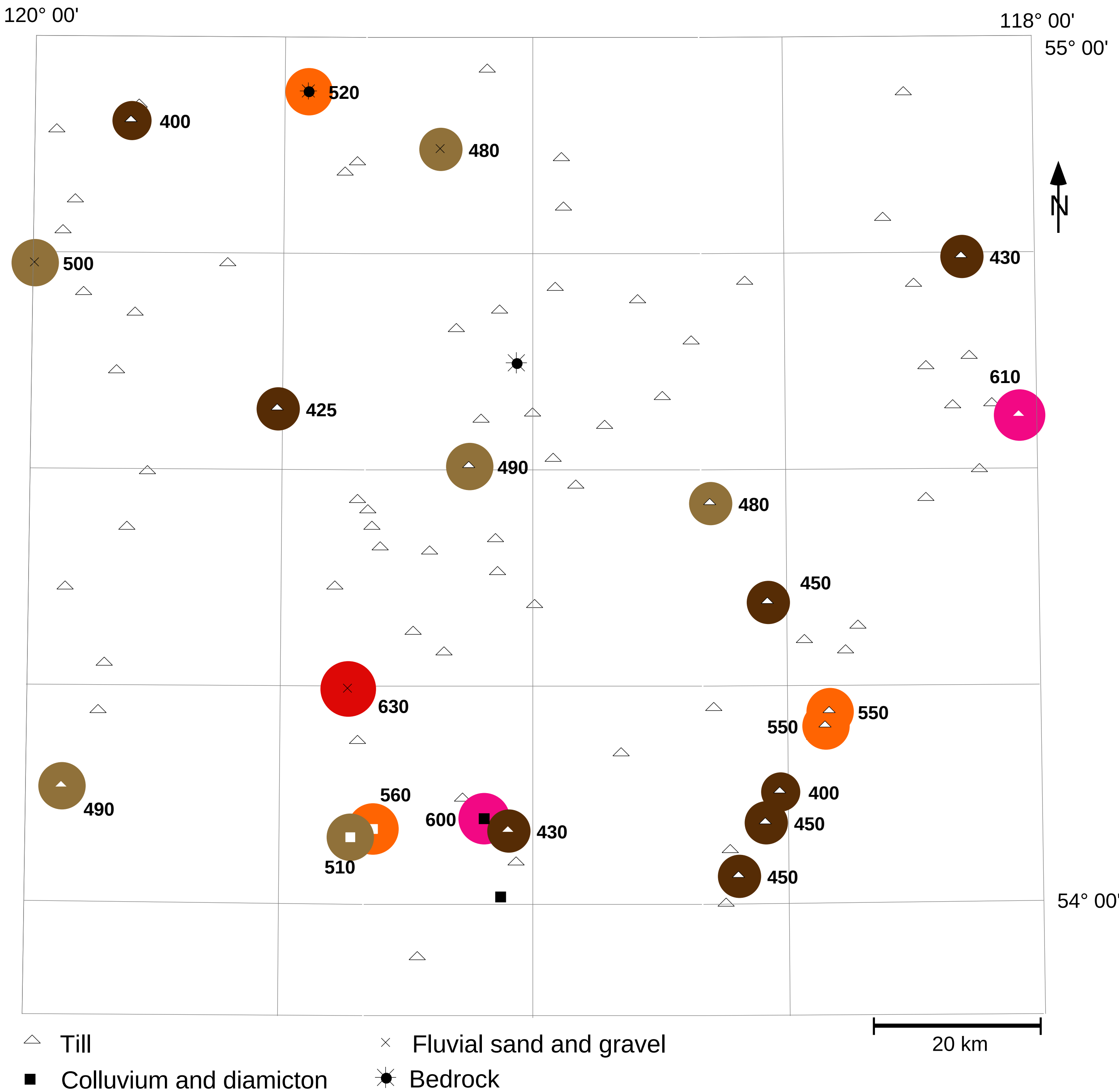

Figure 42. Concentration of Zr in ppm by INNA for sites with values ≥75th percentile.

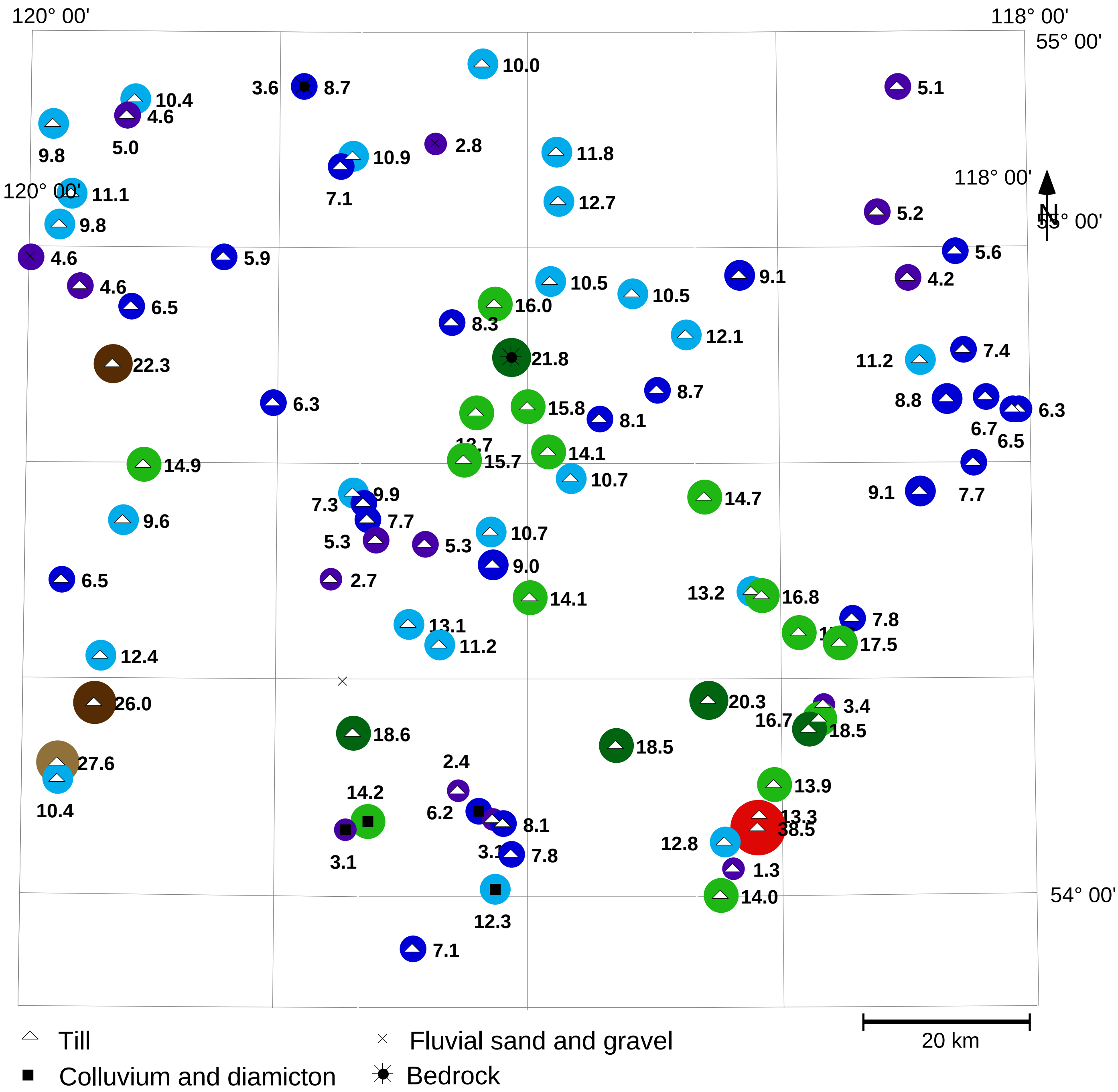

Figure 43. Total carbonate content (in % of the <0.063mm fraction) for all samples. Note that at some sites the symbol indicating the sample type is obscured due to a similar shade to the bubble. Where this has happened refer to Figure 7, site numbers, for this information.

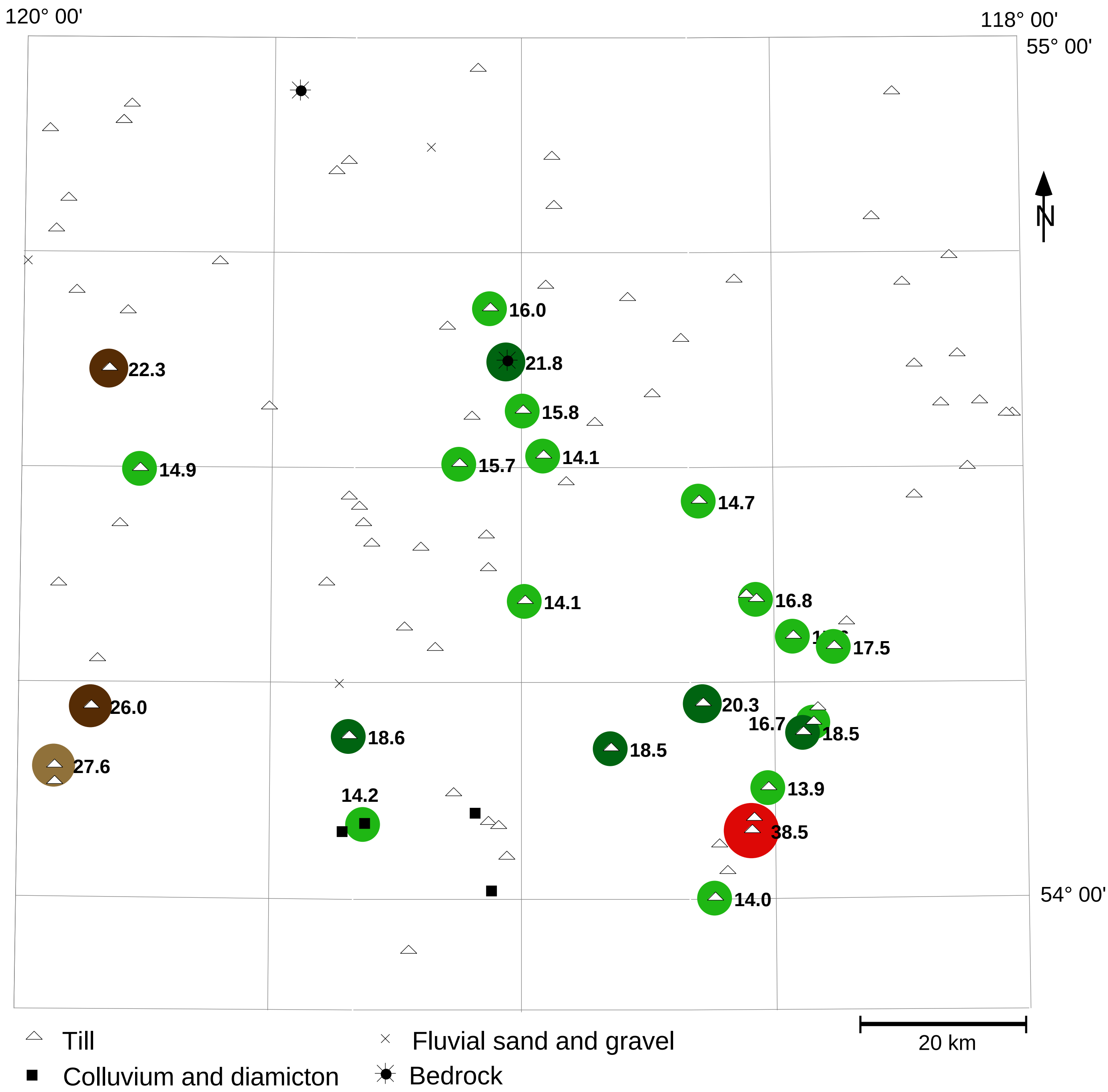

Figure 44. Total carbonate content (in % of the <0.063mm fraction) for samples with concentrations ≥75th percentile.

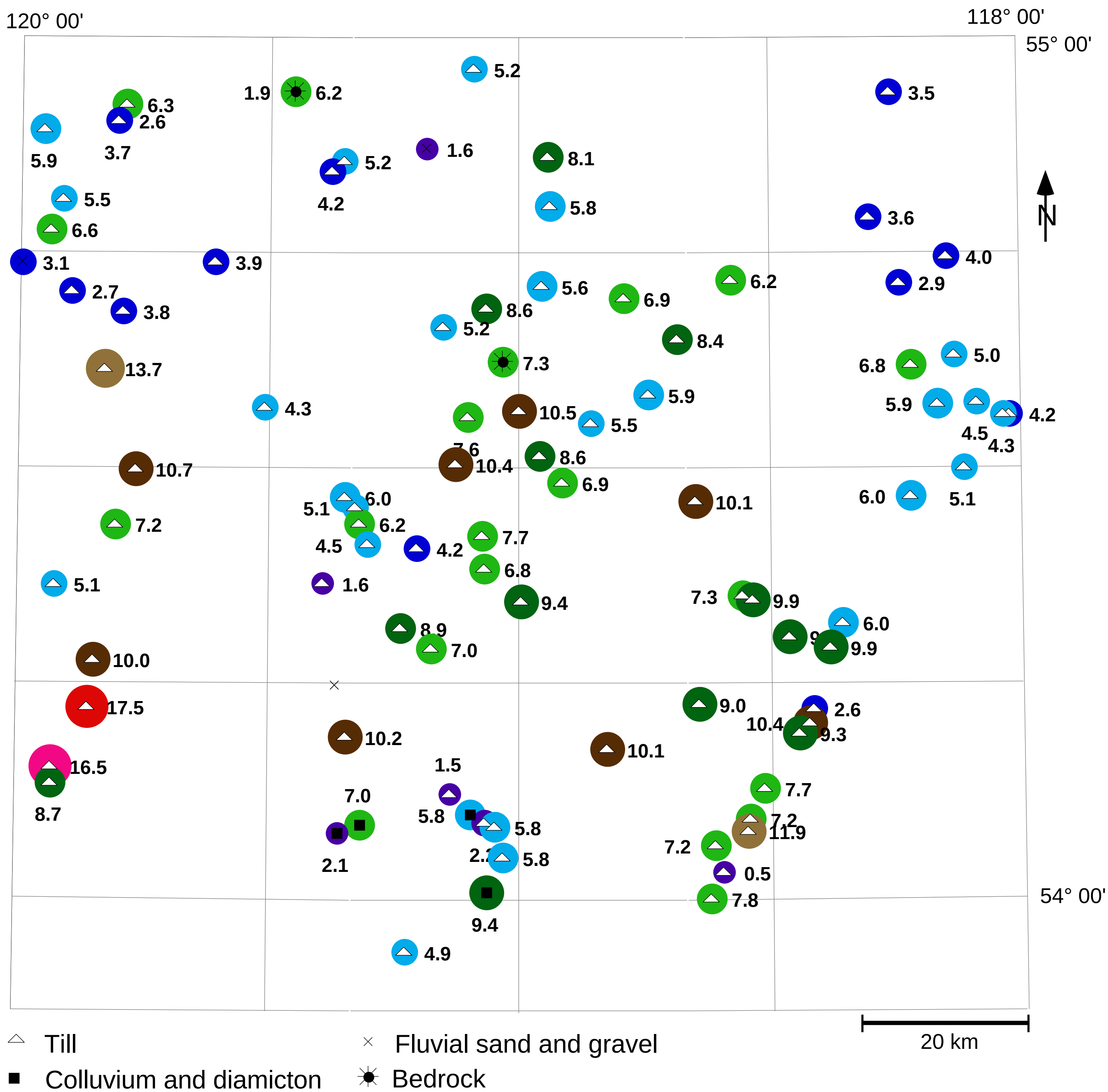

Figure 45. Dolomite content (in % of the <0.063mm fraction) for all samples.

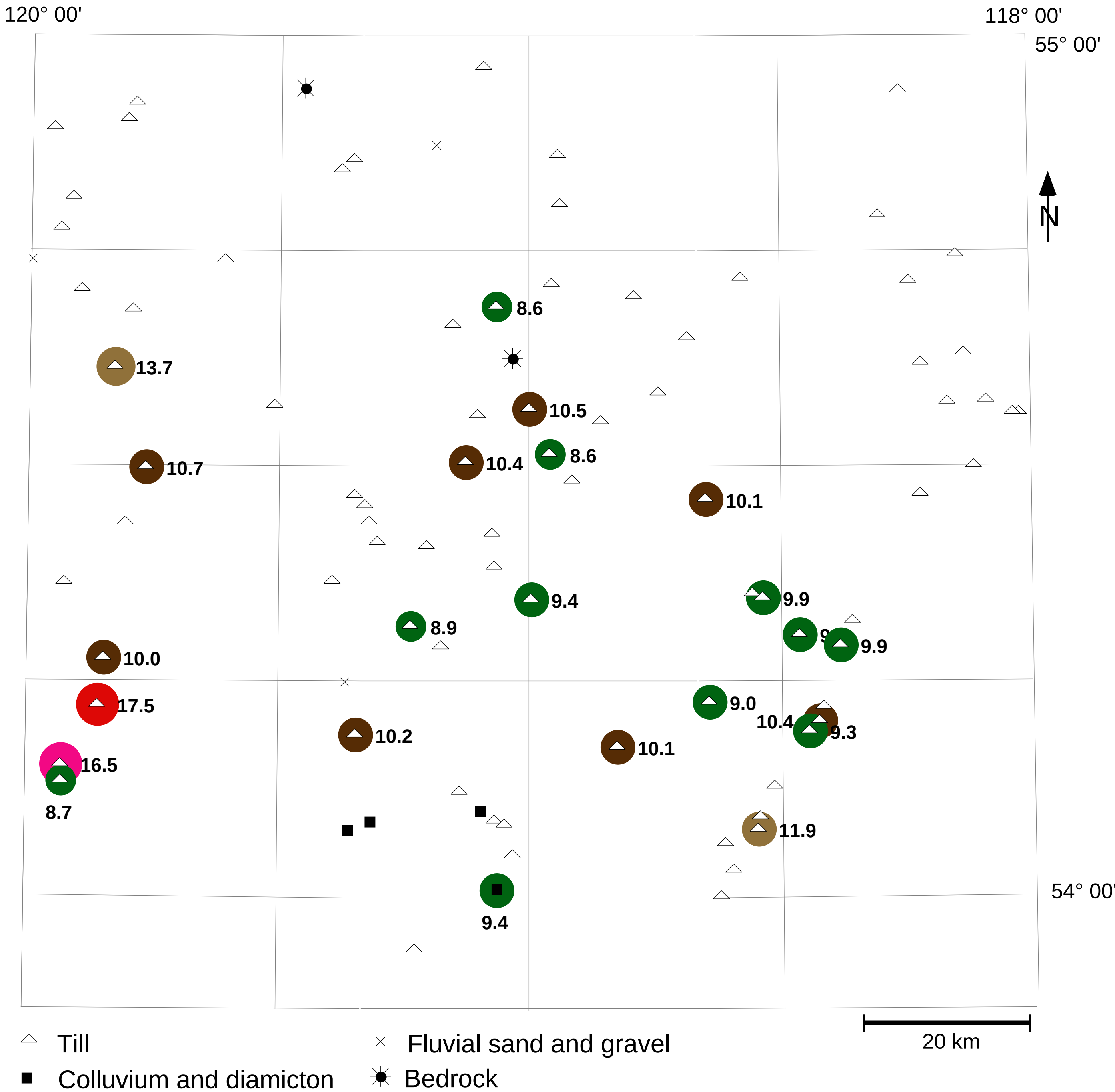

Figure 46. Dolomite content (in % of the <0.063mm fraction) for samples with concentrations ≥75th percentile .

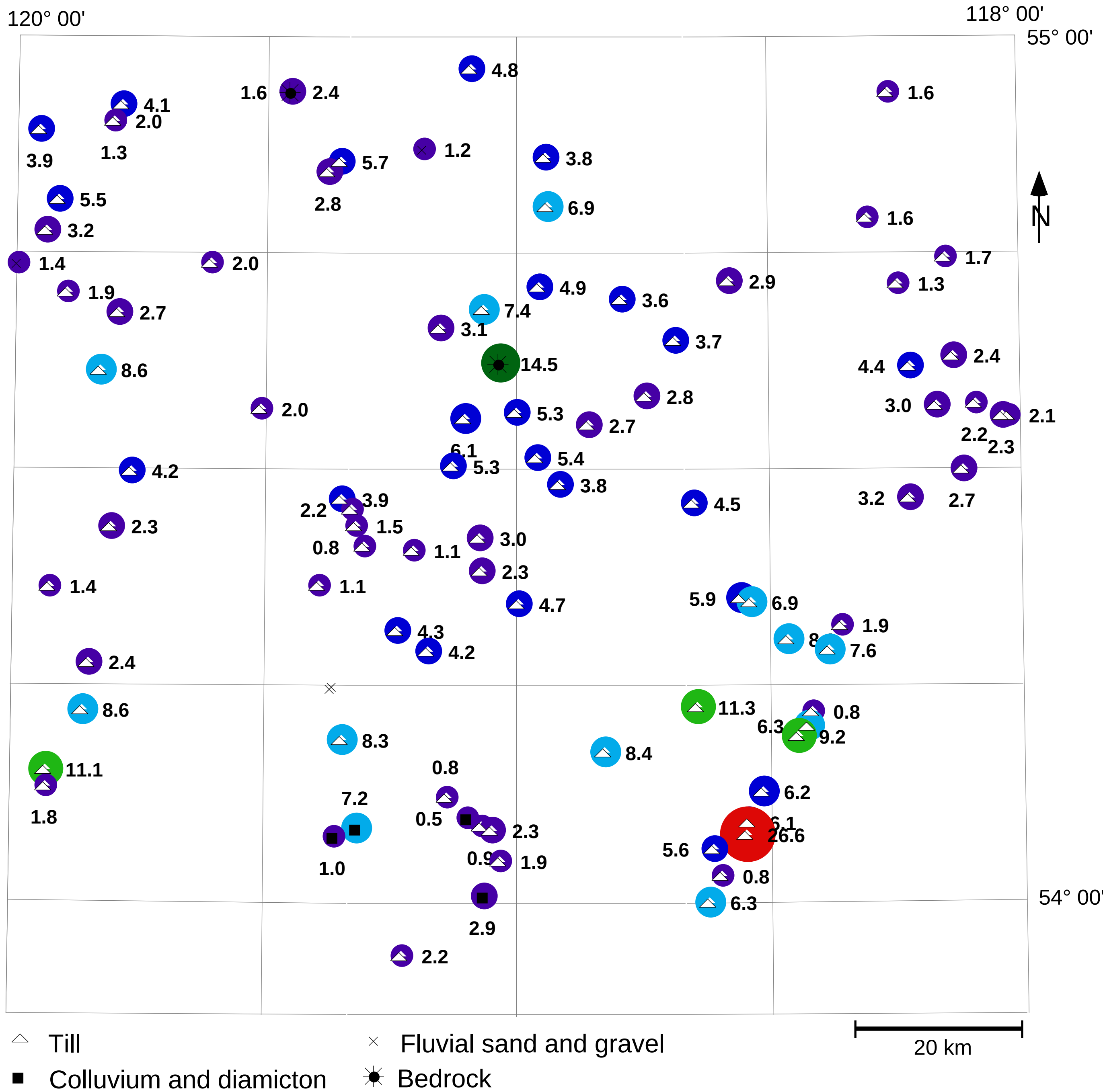

Figure 47. Calcite content (in % of the <0.063mm fraction) for all samples .

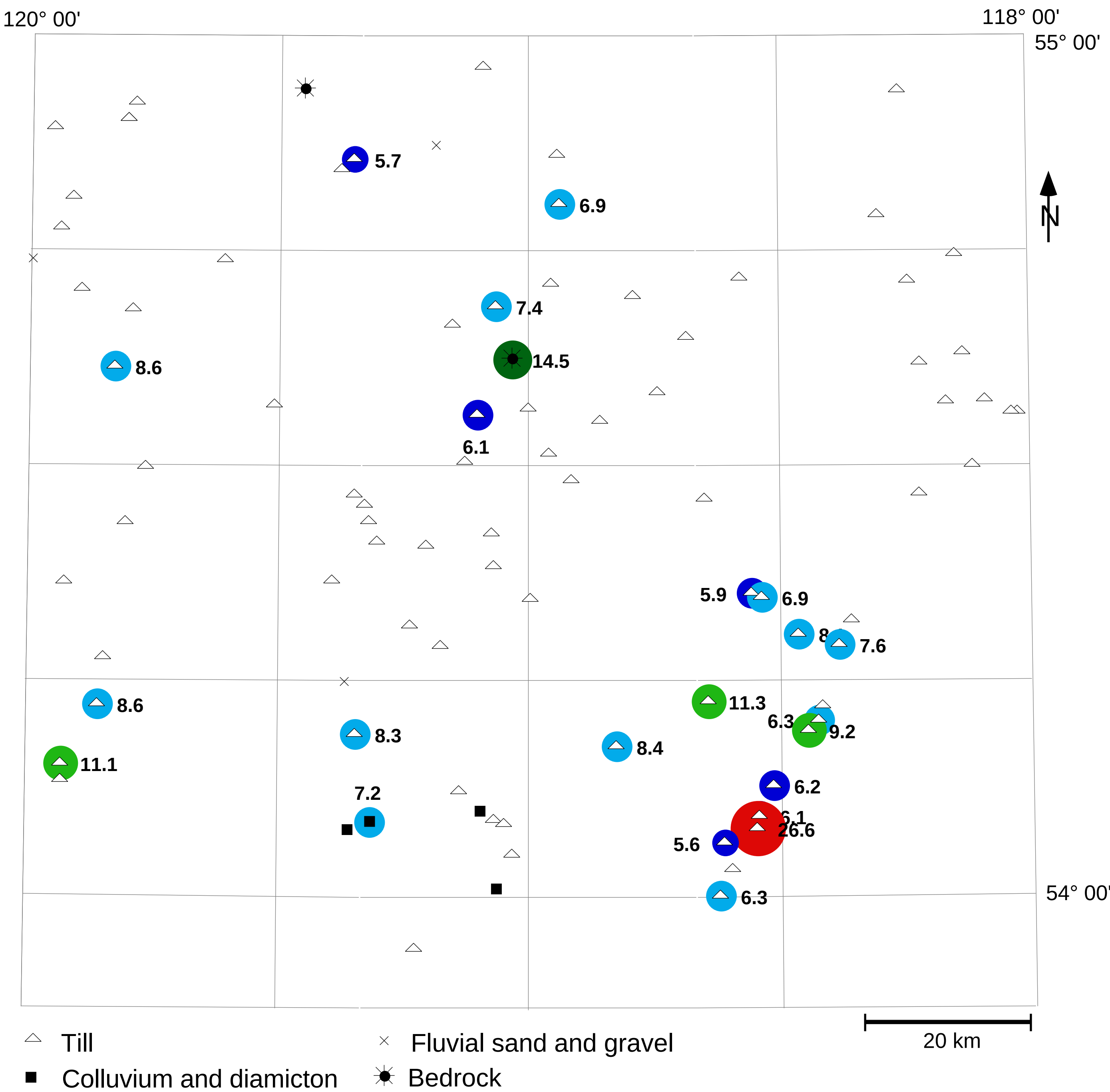

Figure 48. Calcite content (in % of the <0.063mm fraction) for samples with concentrations ≥75th percentile.

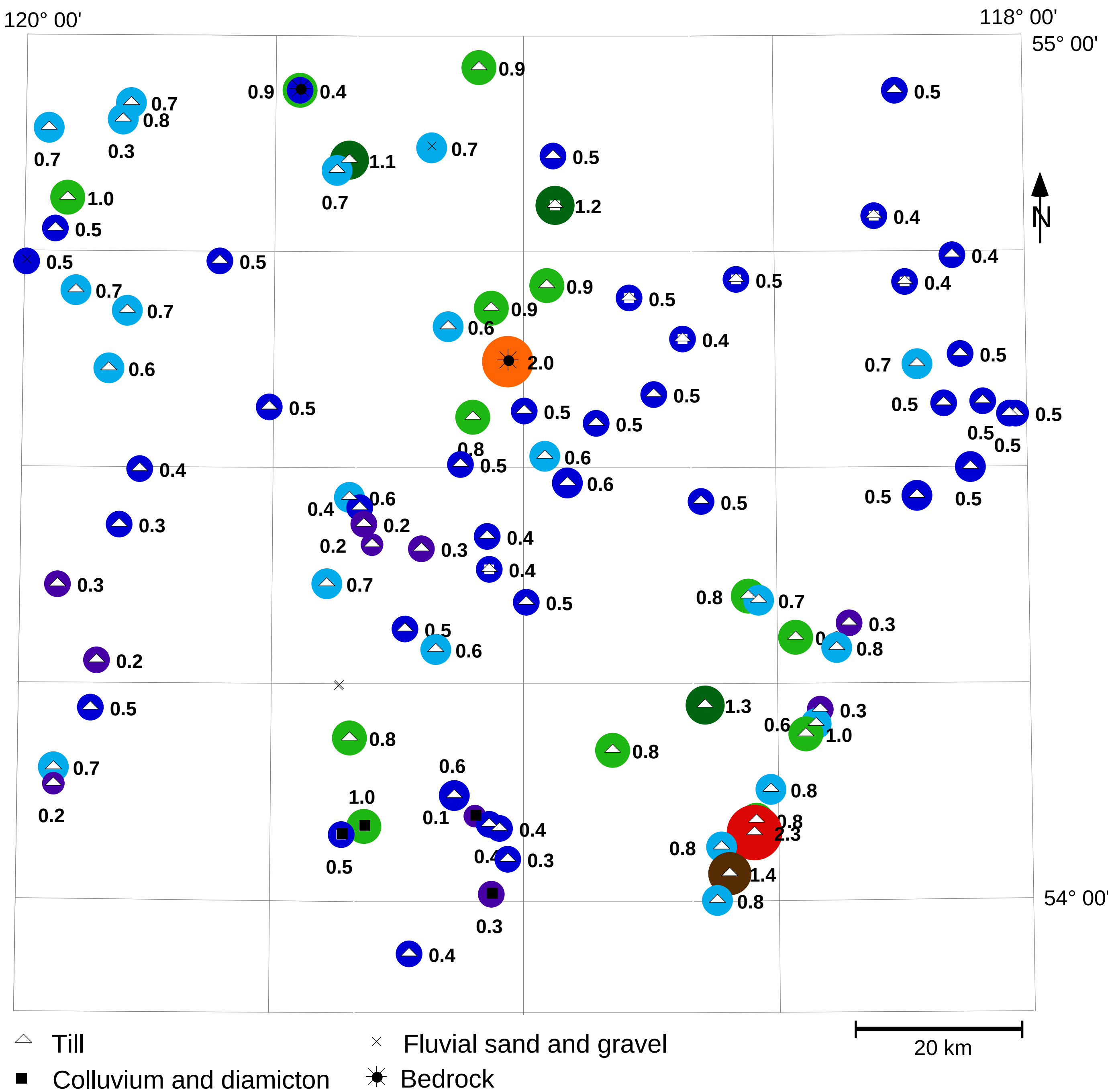

Figure 49. Calcite:dolomite ratio for all samples (<0.063mm fraction).

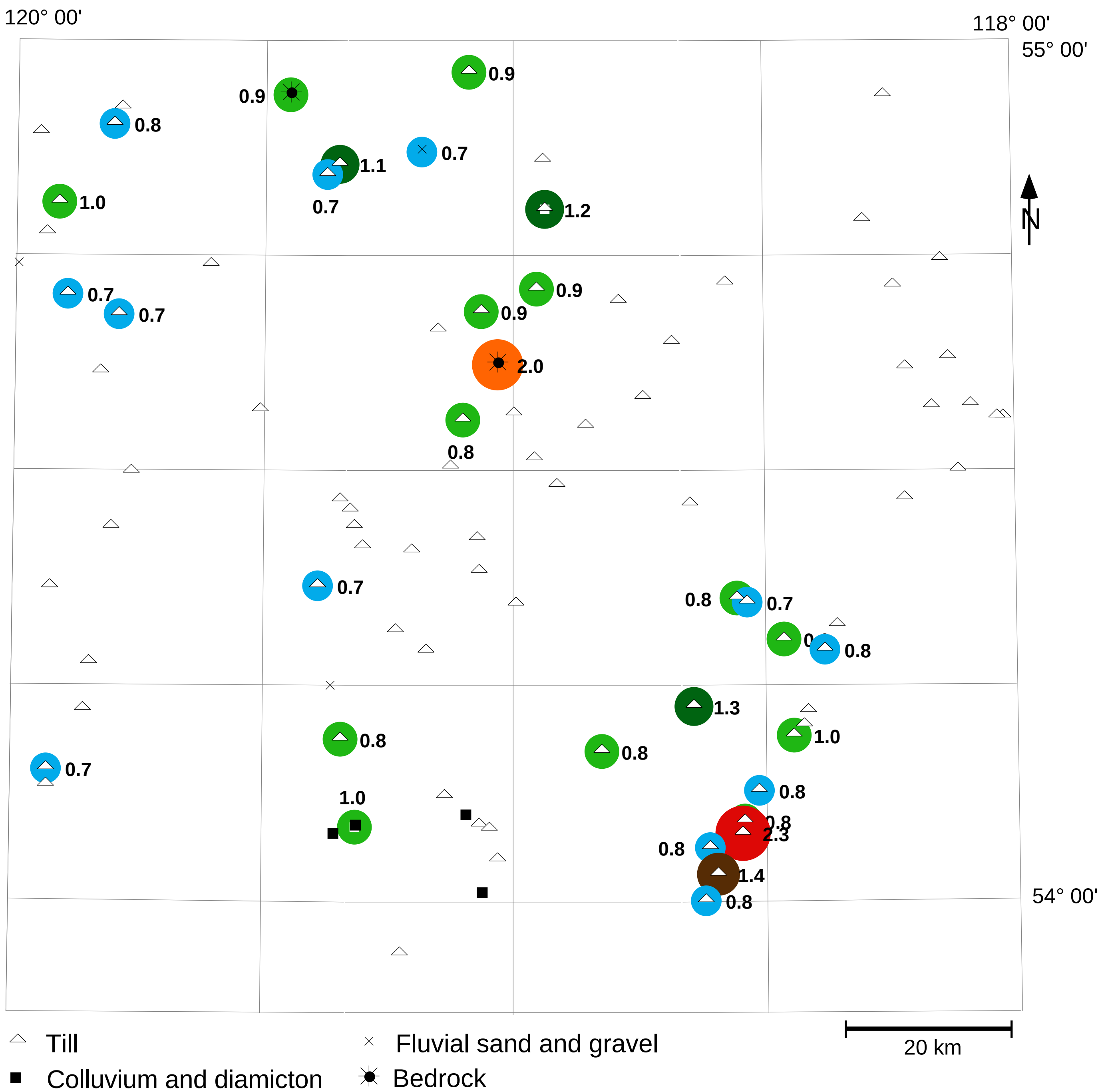

Figure 50. Calcite:dolomite ratio for samples with ratios ≥ 0.7 (<0.063mm fraction).

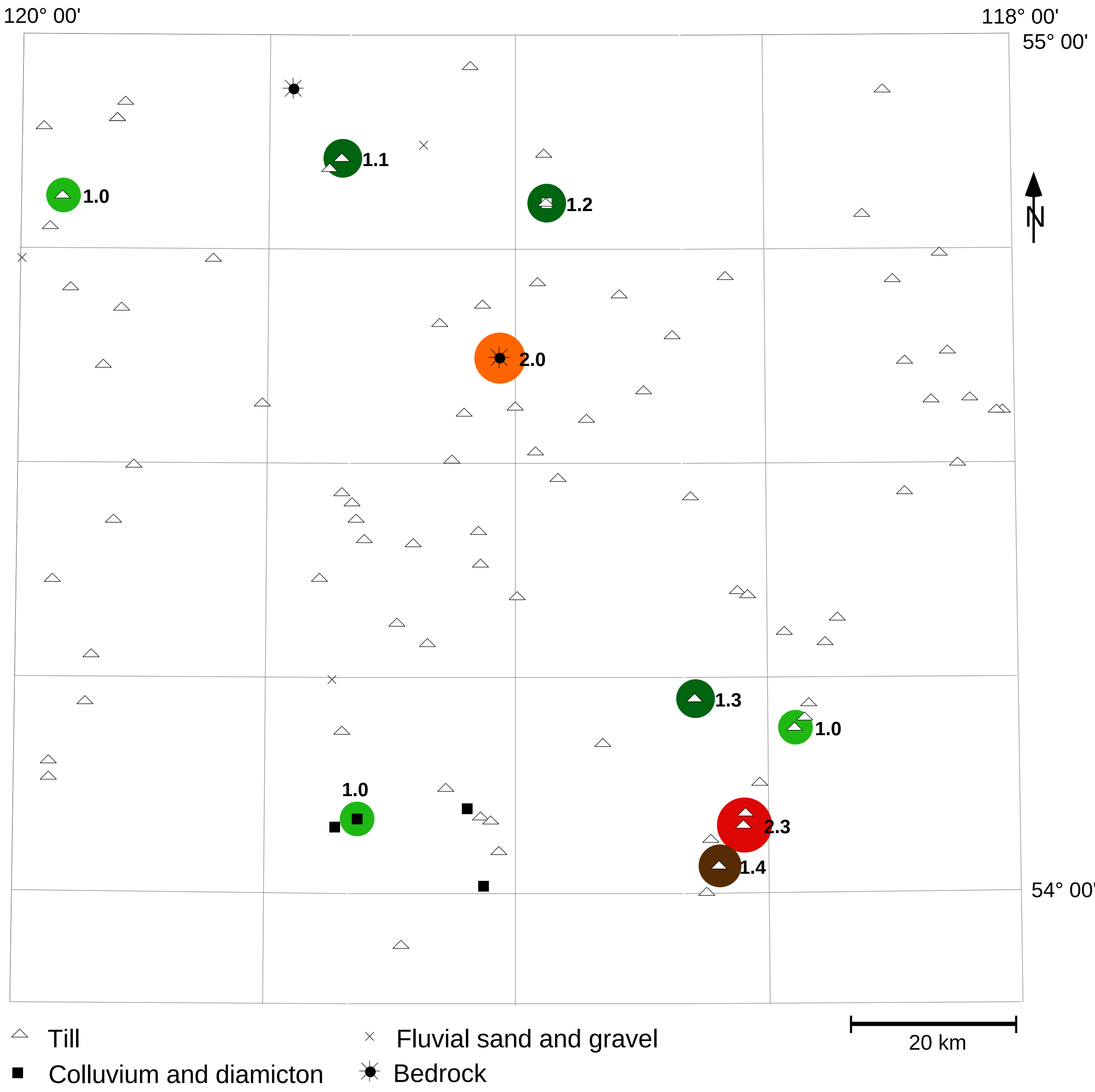

Figure 51. Calcite:dolomite ratio for samples with ratios ≥10 (<0.063mm fraction).

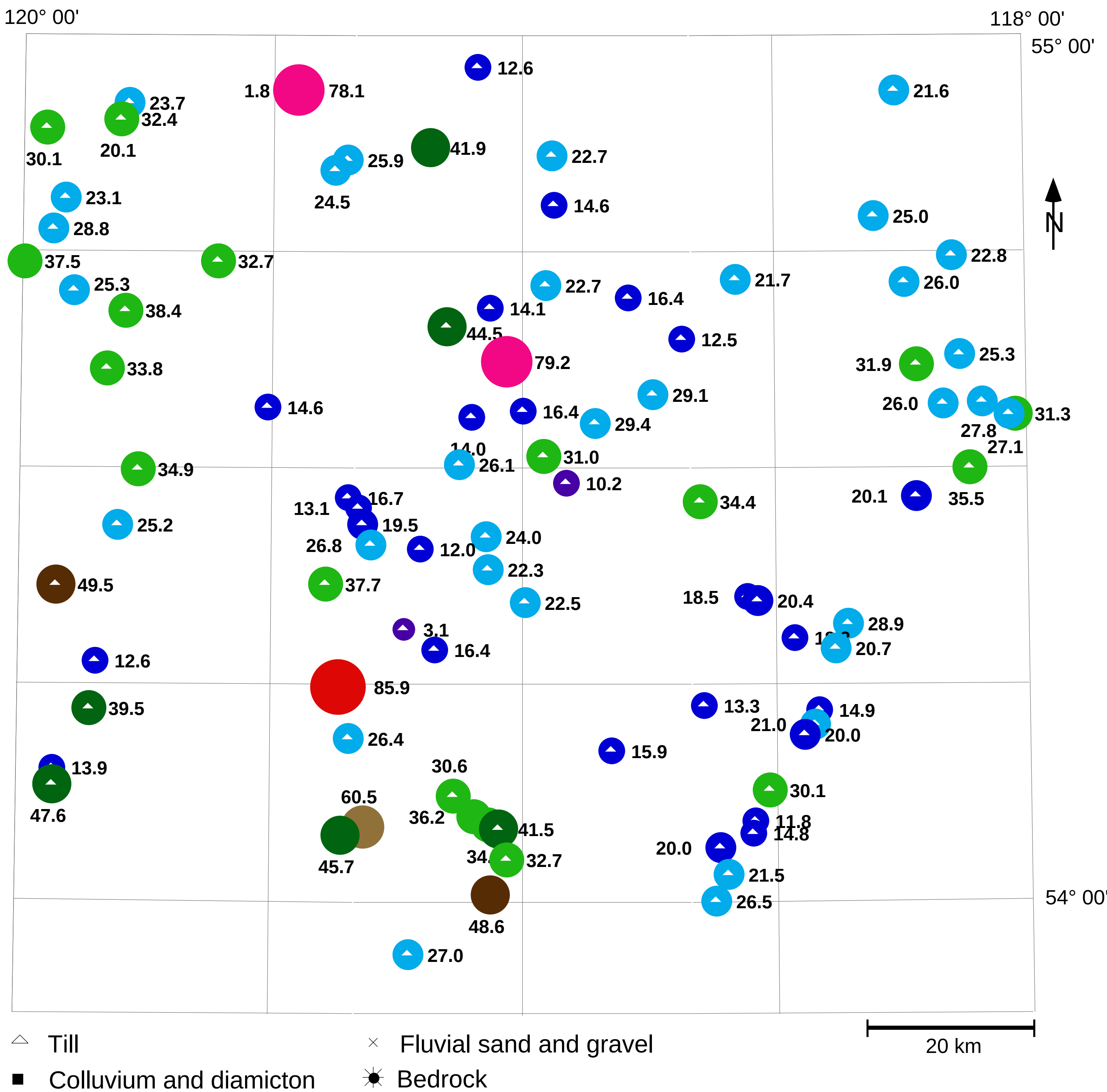

Figure 52. Sand content (in % of the >0.06 3 mm fraction) for all samples. Note that at some sites the symbol indicating the sample type is obscured because the element concentration symbol is a similar shade to the bubble. Where this happens refer to Figure 7, site numbers, for this information.

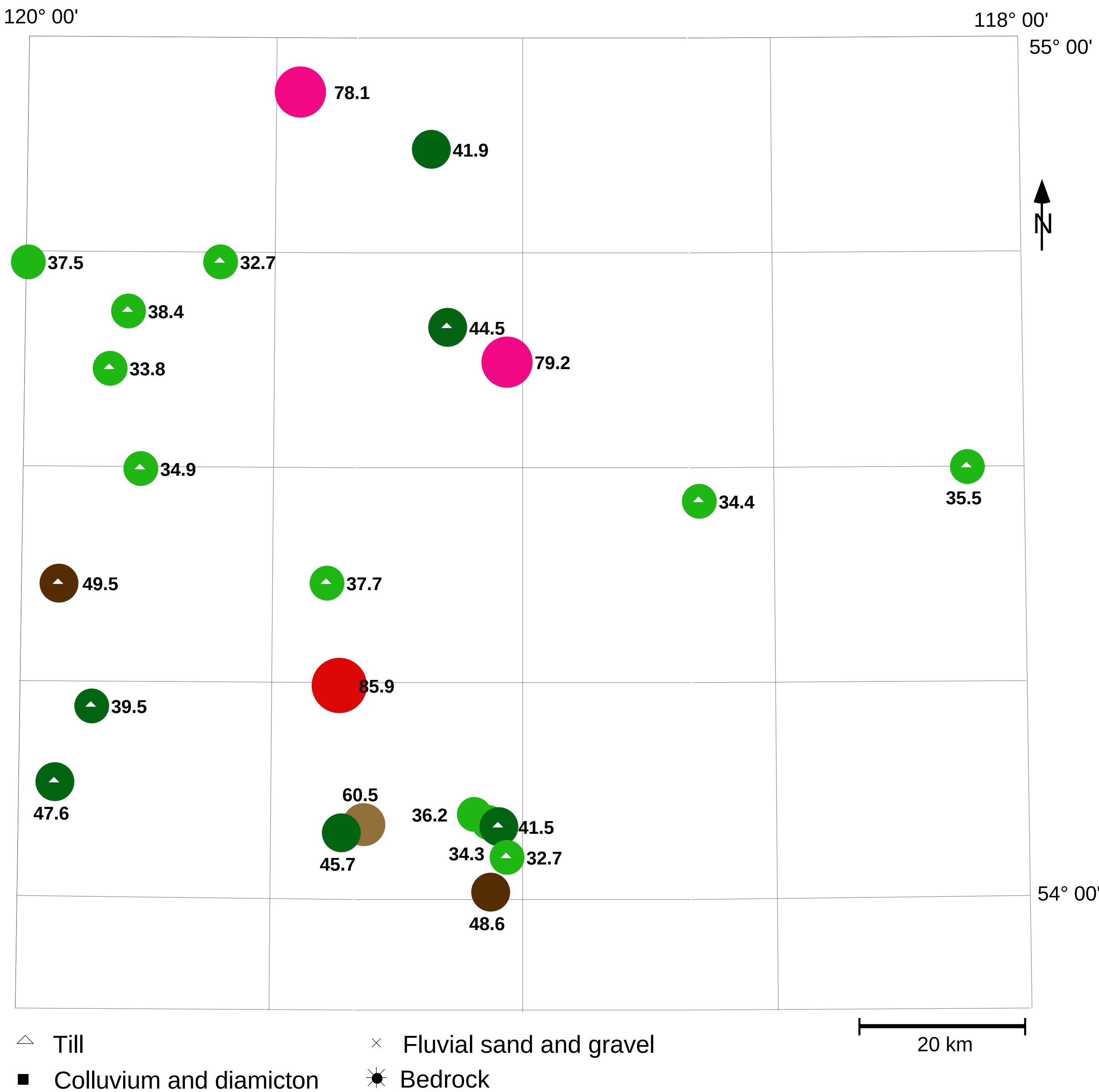

Figure 53. Sand content (in % of the >0.063 mm fraction) for samples with concentrations ≥75th percentile.

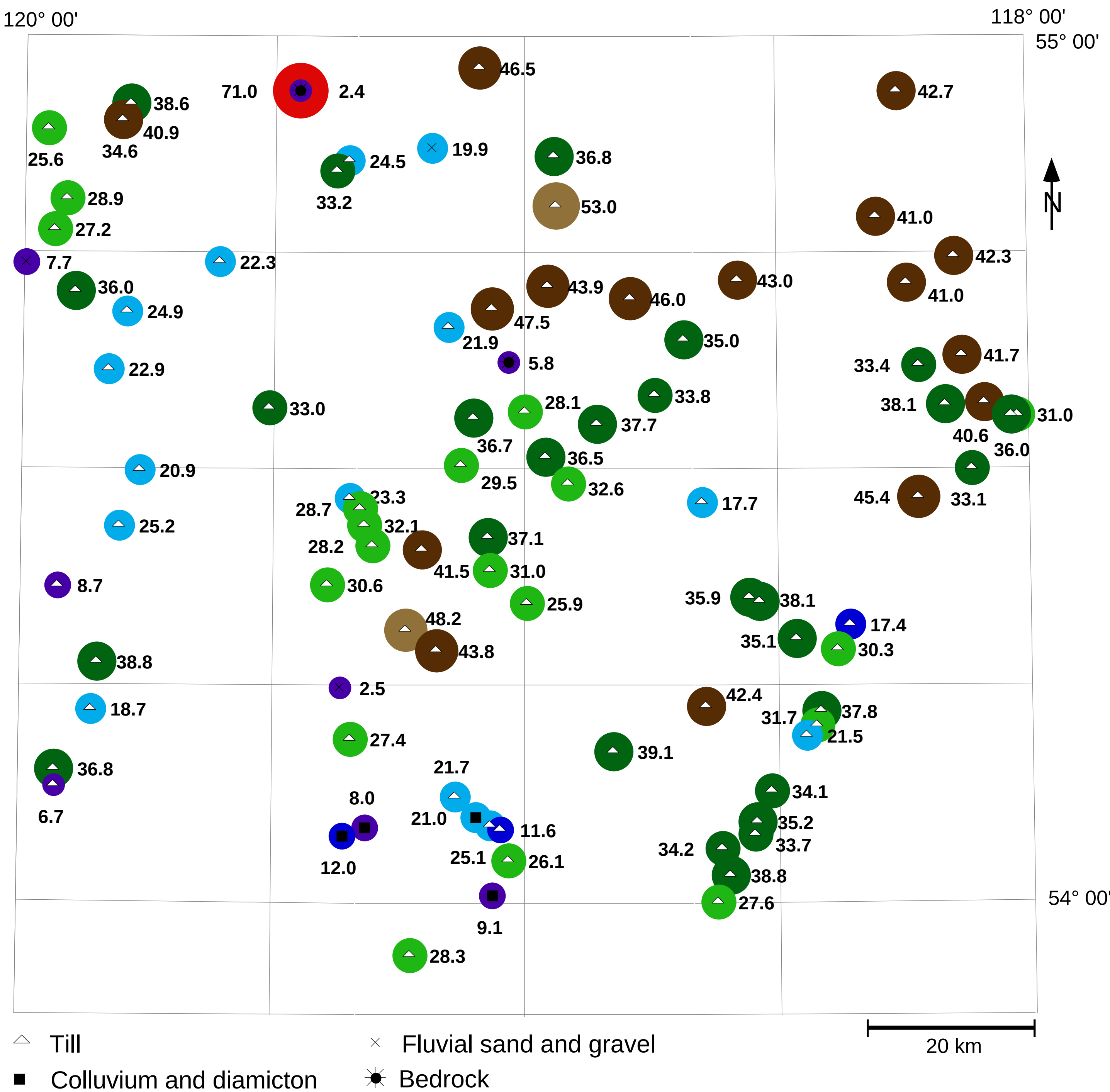

Figure 54. Clay content (in % of the <0.004 mm fraction) for all samples.

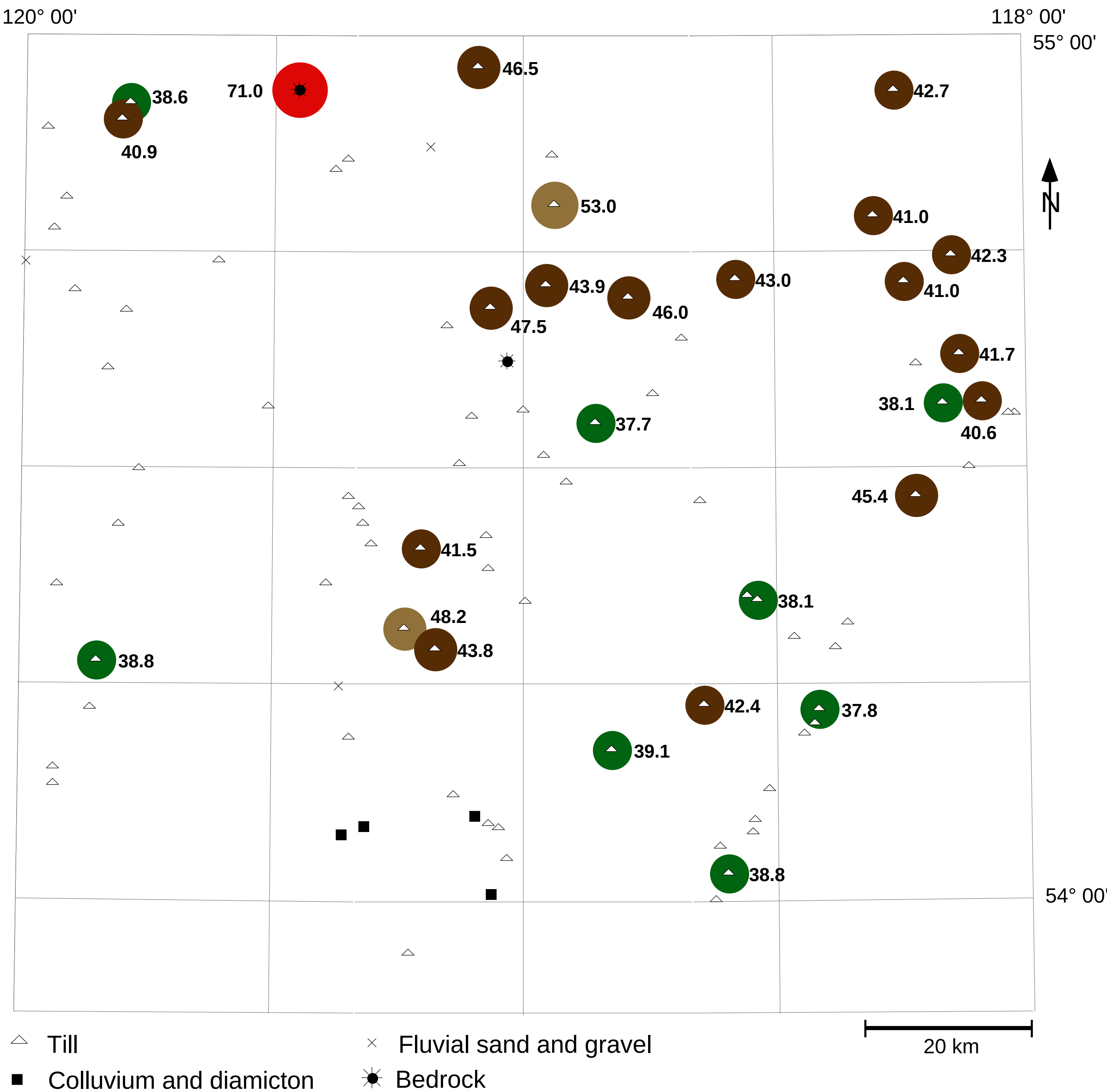

Figure 55. Clay content (in % of the >0.004 mm fraction) for samples with concentrations ≥75 percentile.

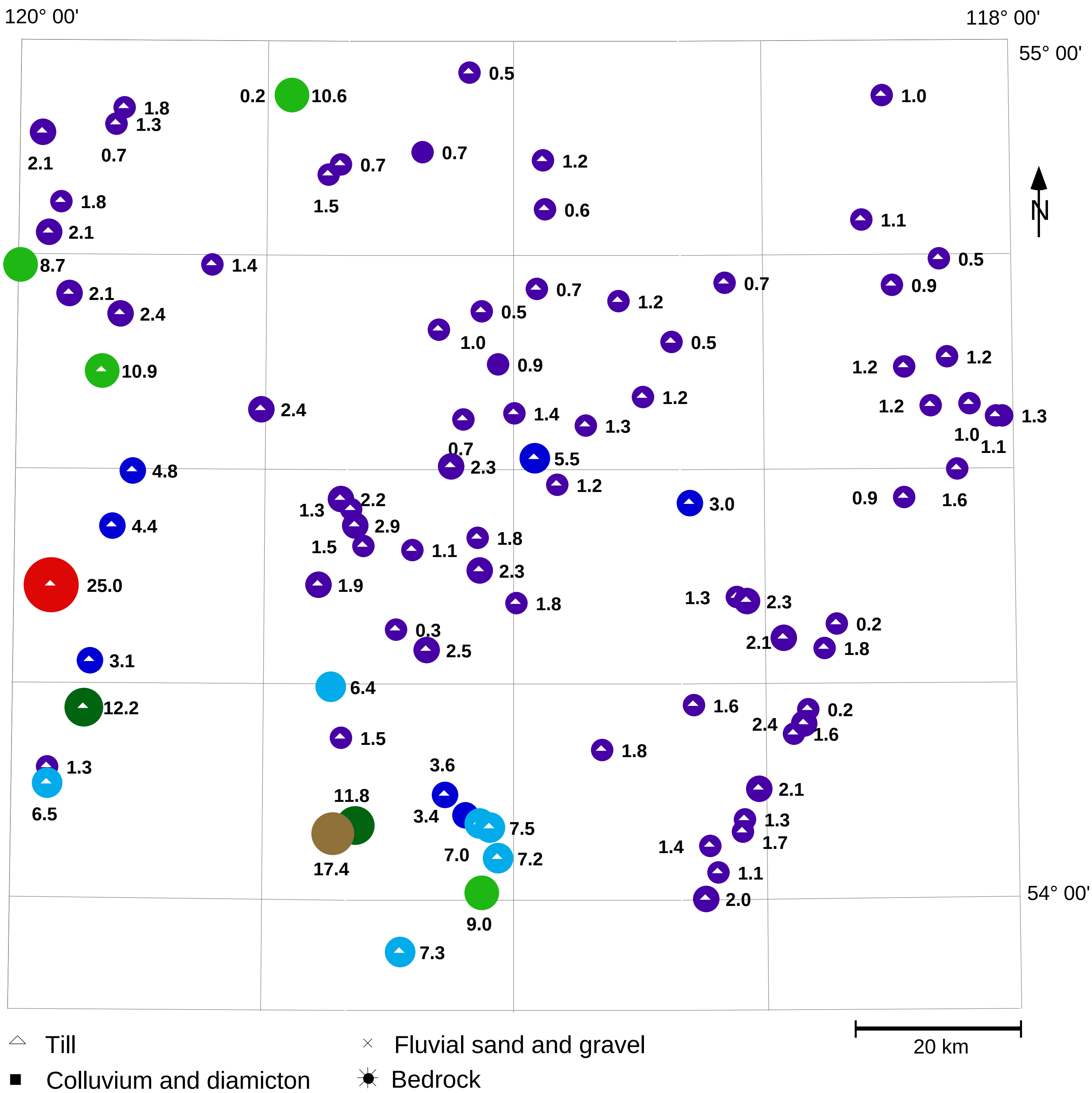

Figure 56. Coarse sand content (in % of the 1-2 mm fraction) for all samples.

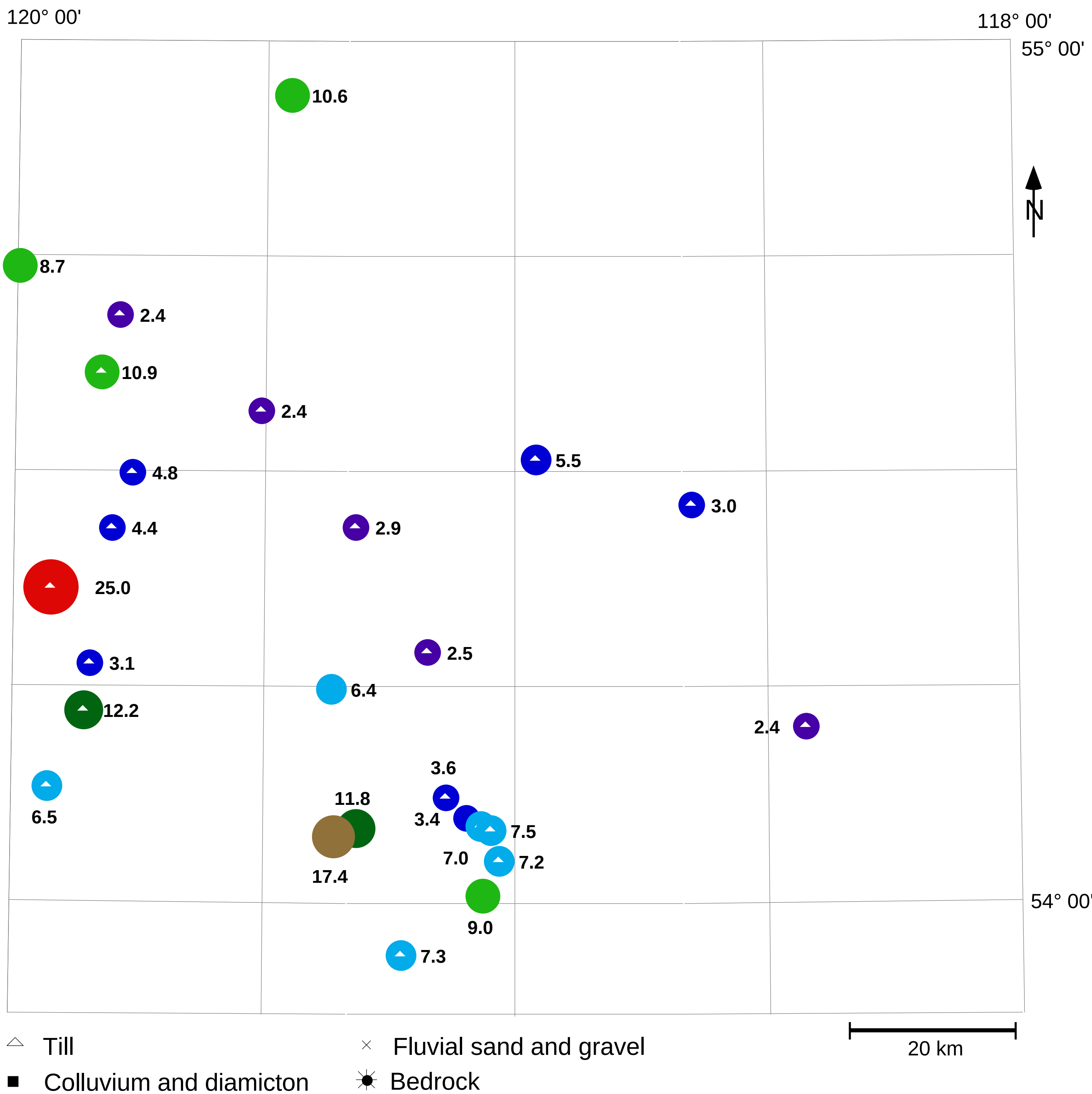

Figure 57. Coarse sand content (percent of the 1-2 mm fraction) for samples with concentrations ≥75 percentile.

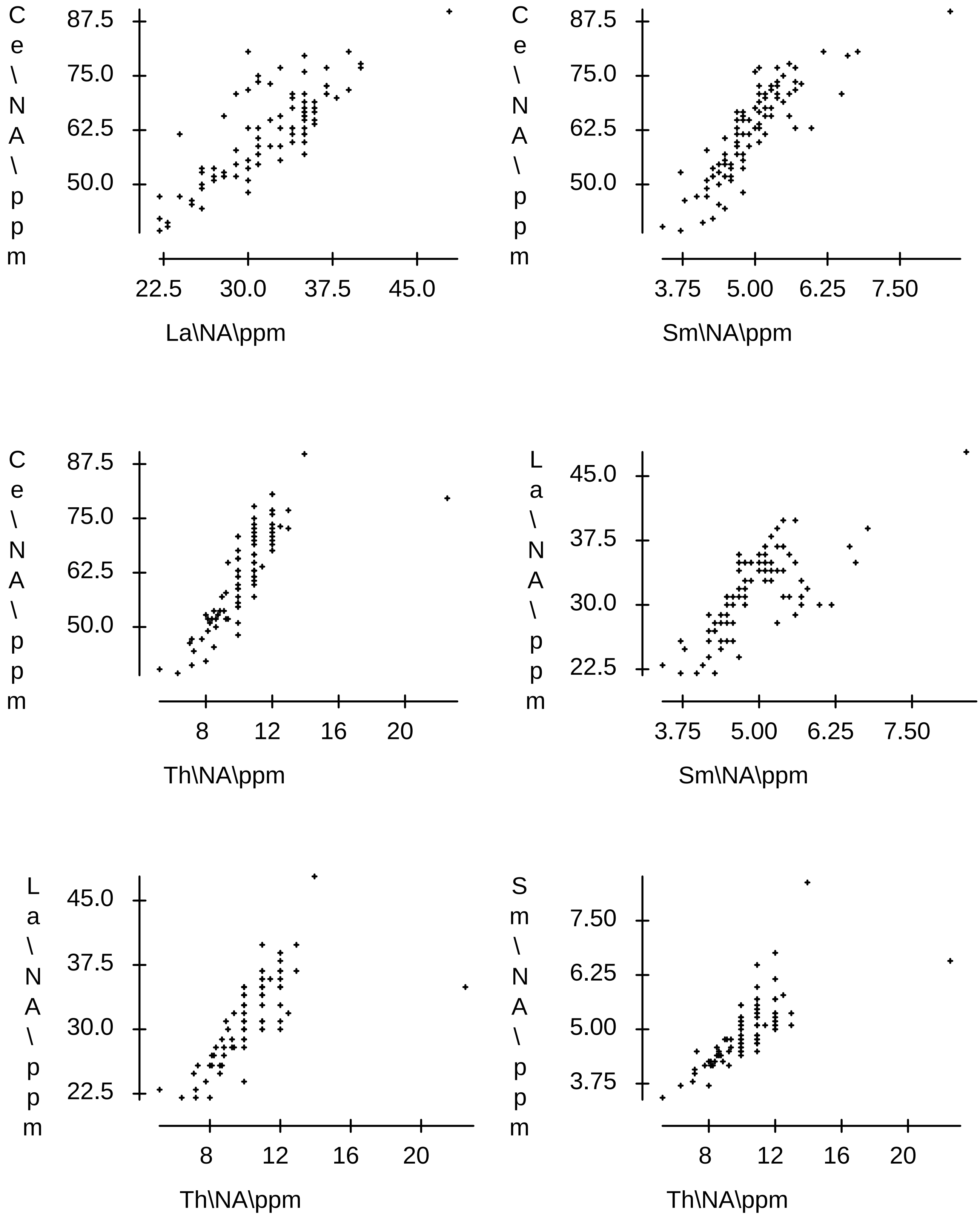

Figure 58. Scatter plots showing relationship between Ce, La, Sm and Th. Axis labels indicate the element (Th) , the analytical method (NA = INNA) and concentration (ppm).

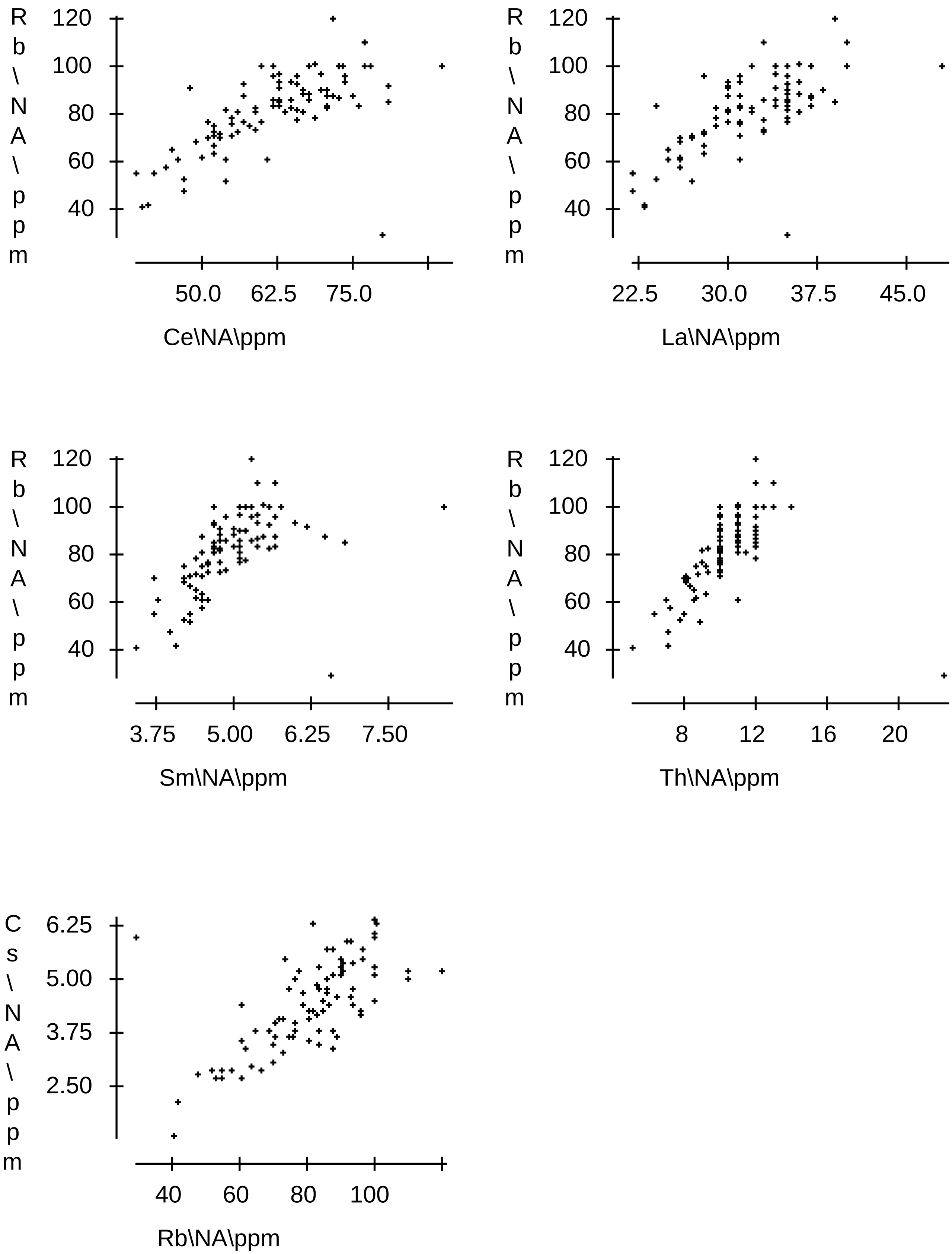

Figure 59. Scatter plots showing correlation between Rb and Ce, Cs, La, Sm and Th. Axis labels indicate the element, the analytical method and concentration.

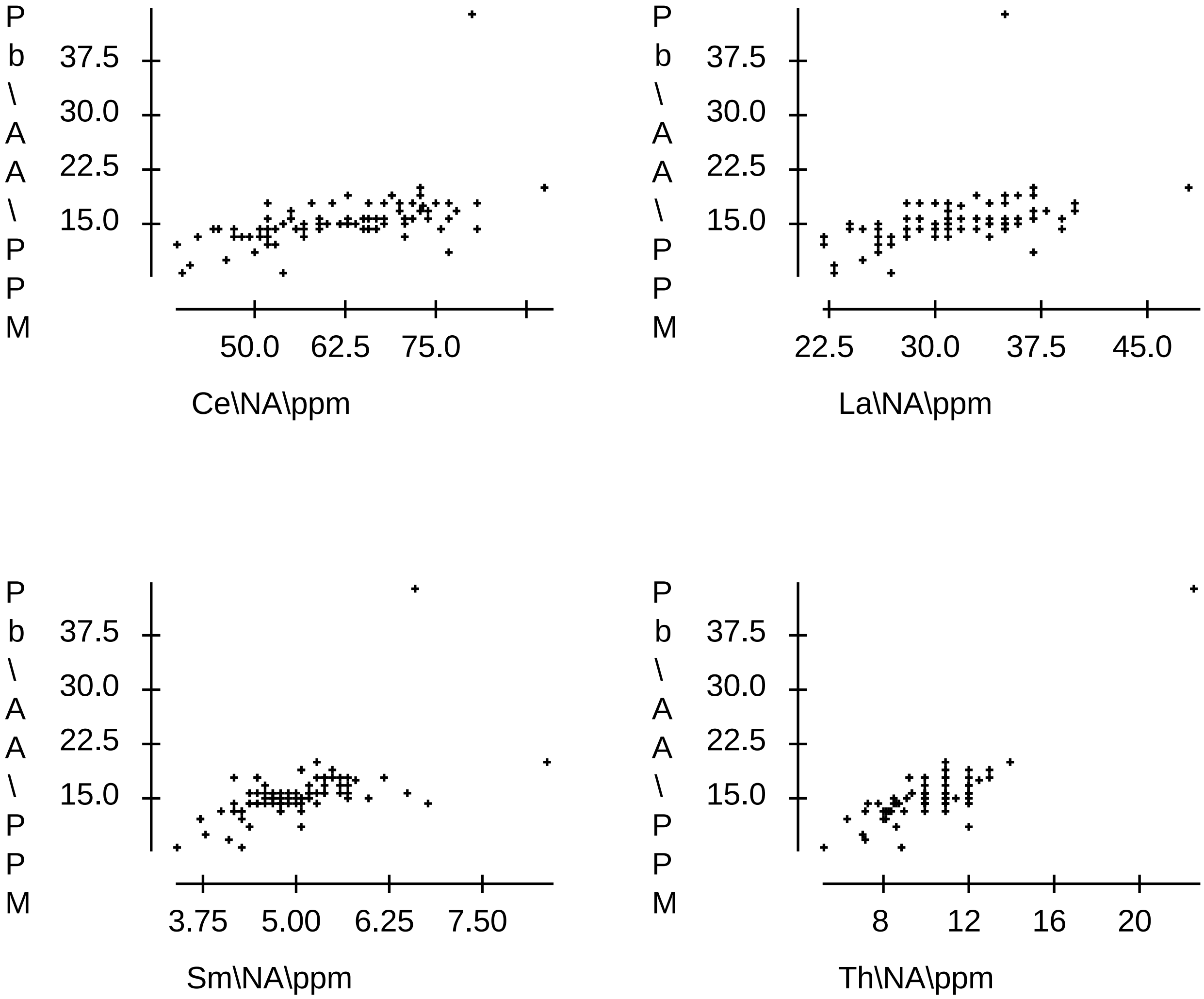

Figure 60. Scatter plots showing correlation between Pb and Ce, La, Sm and Th. Axis labels indicate the element, the analytical method and concentration.

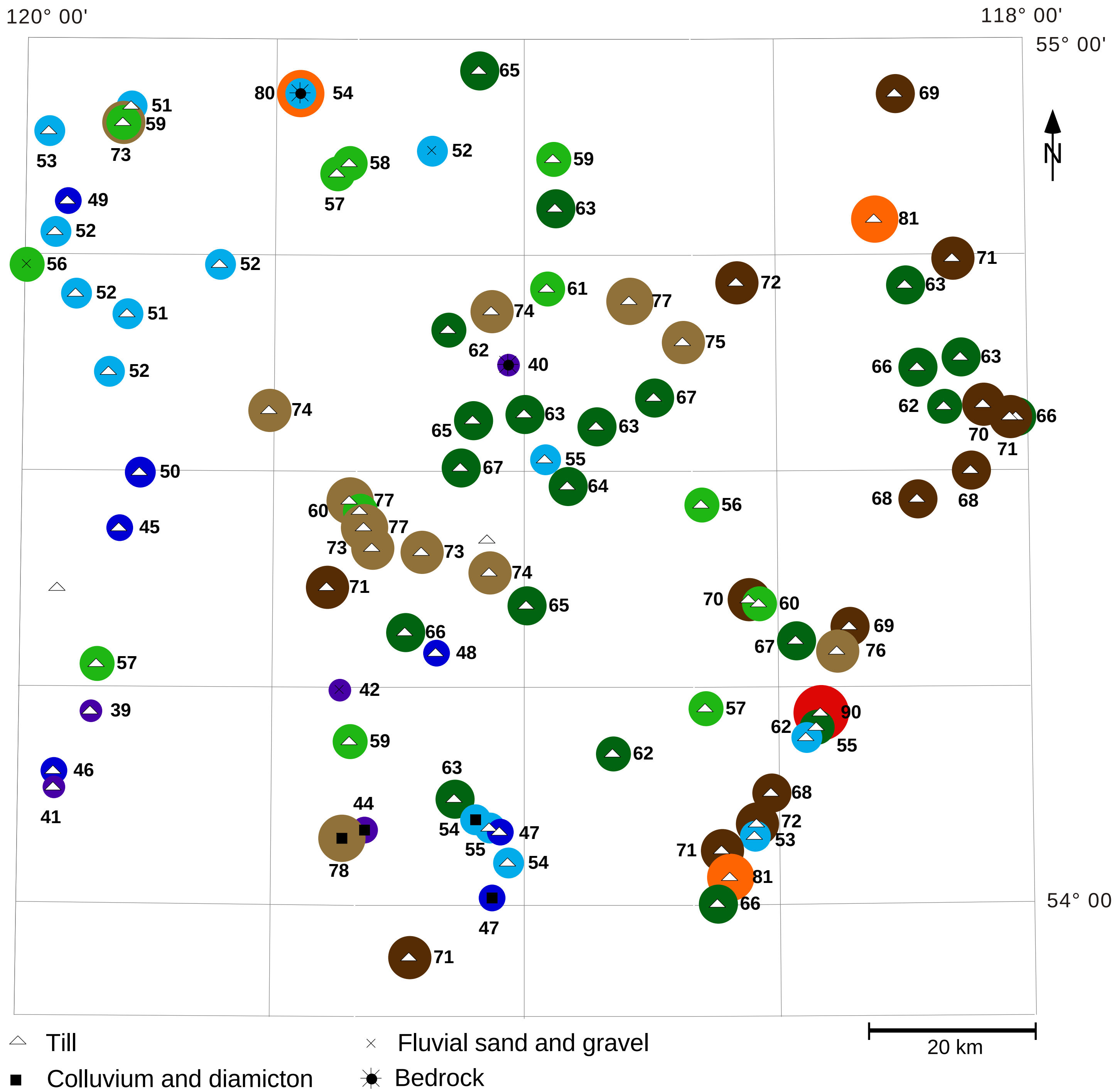

Figure 61. Concentrations if Ce in ppm by INNA for all samples.

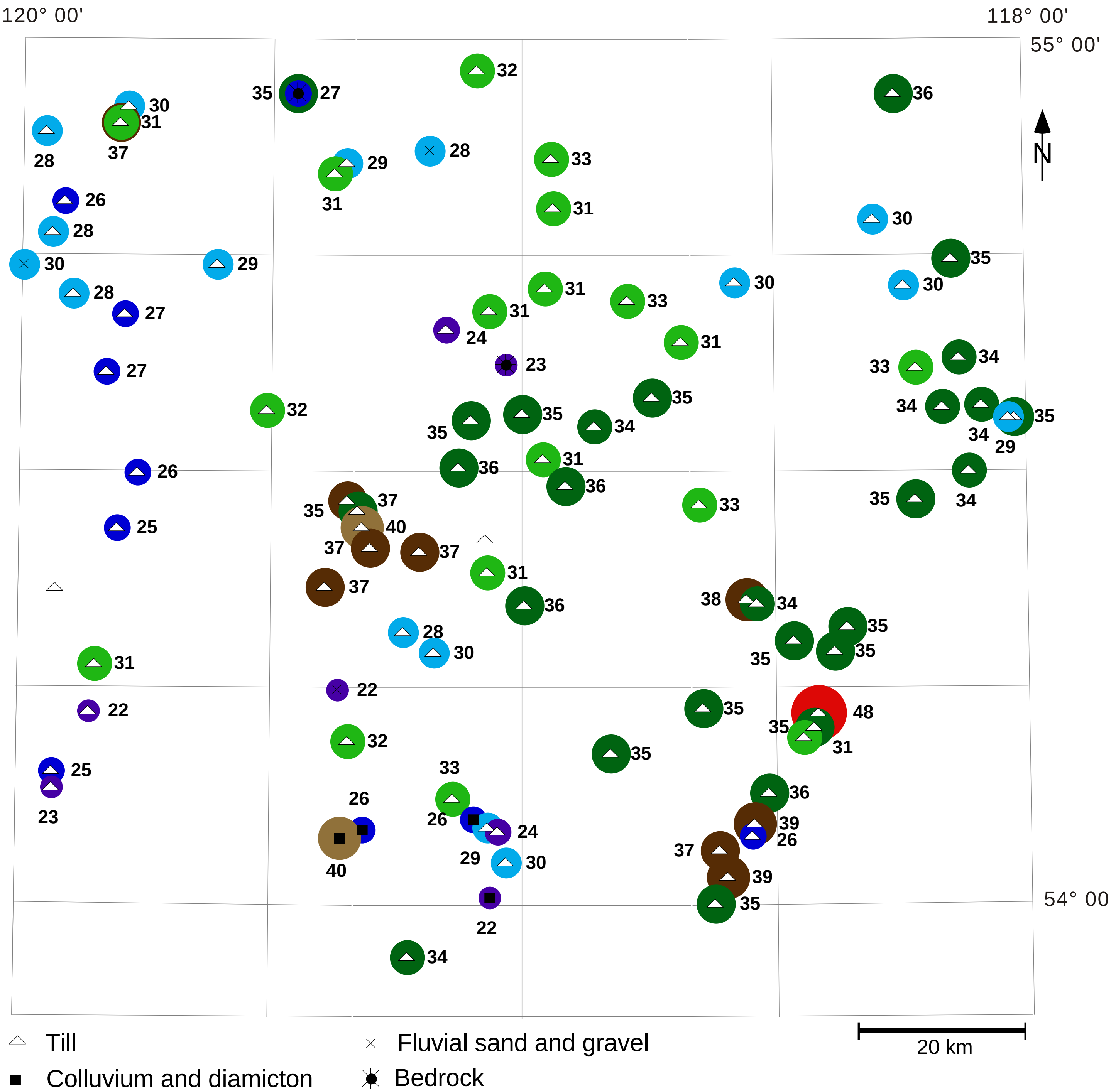

Figure 62. Concentrations of La in ppm by INNA for all samples.

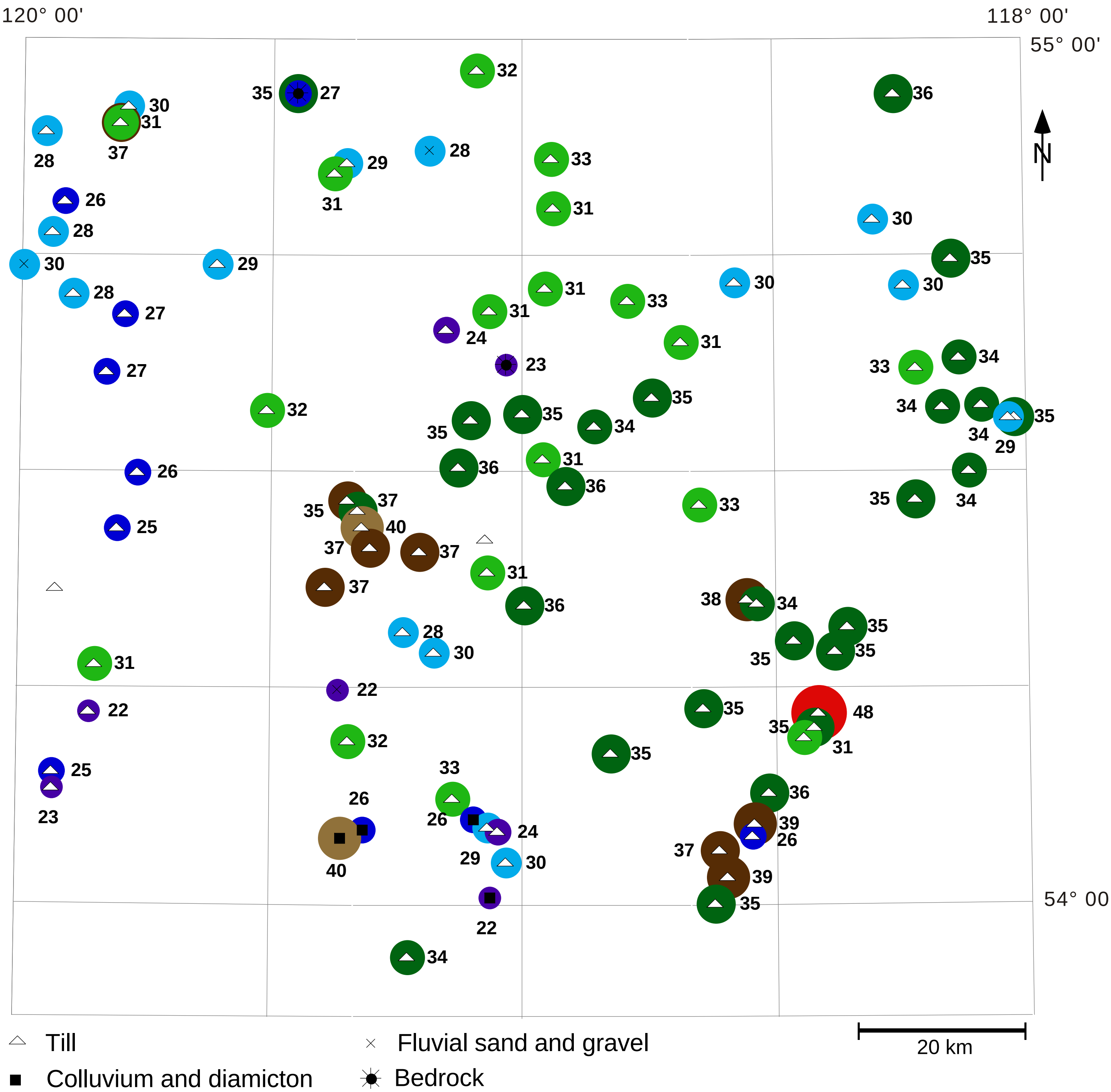

Figure 62. Concentrations of La in ppm by INNA for all samples.

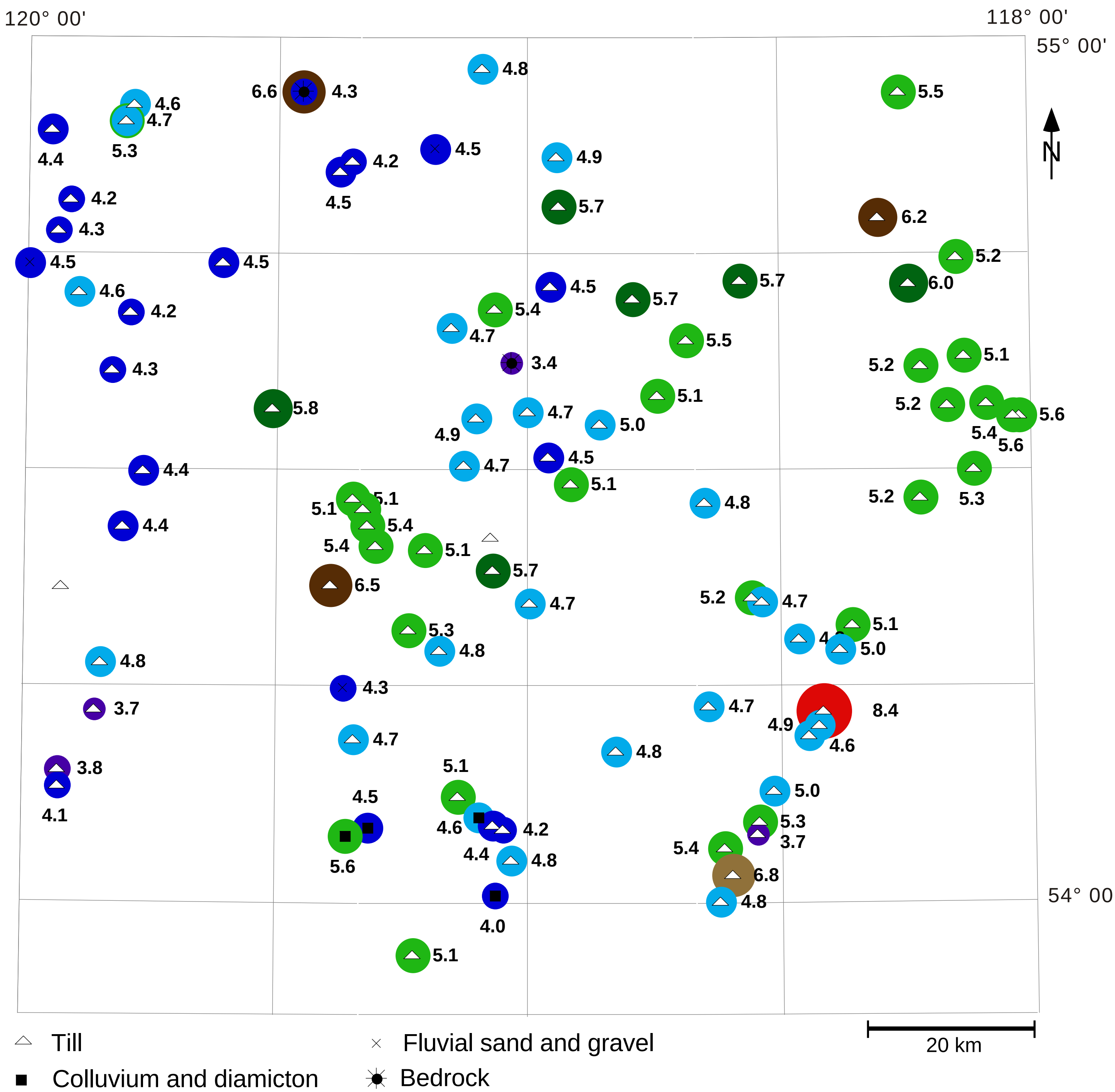

Figure 63. Concentrations of Sm in ppm by INNA for all samples.

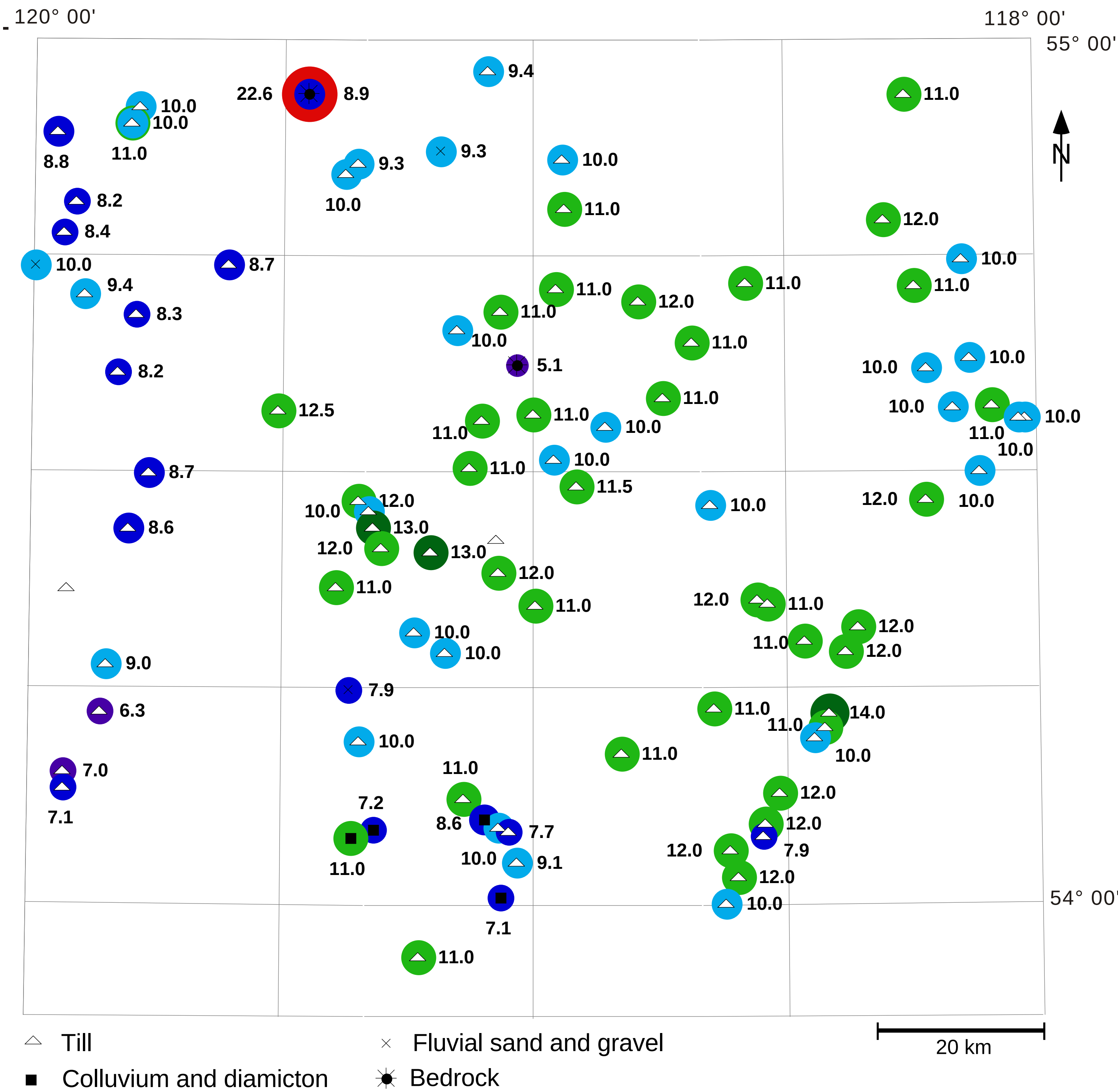

Figure 64. Concentrations of Th in ppm by INNA for all samples.

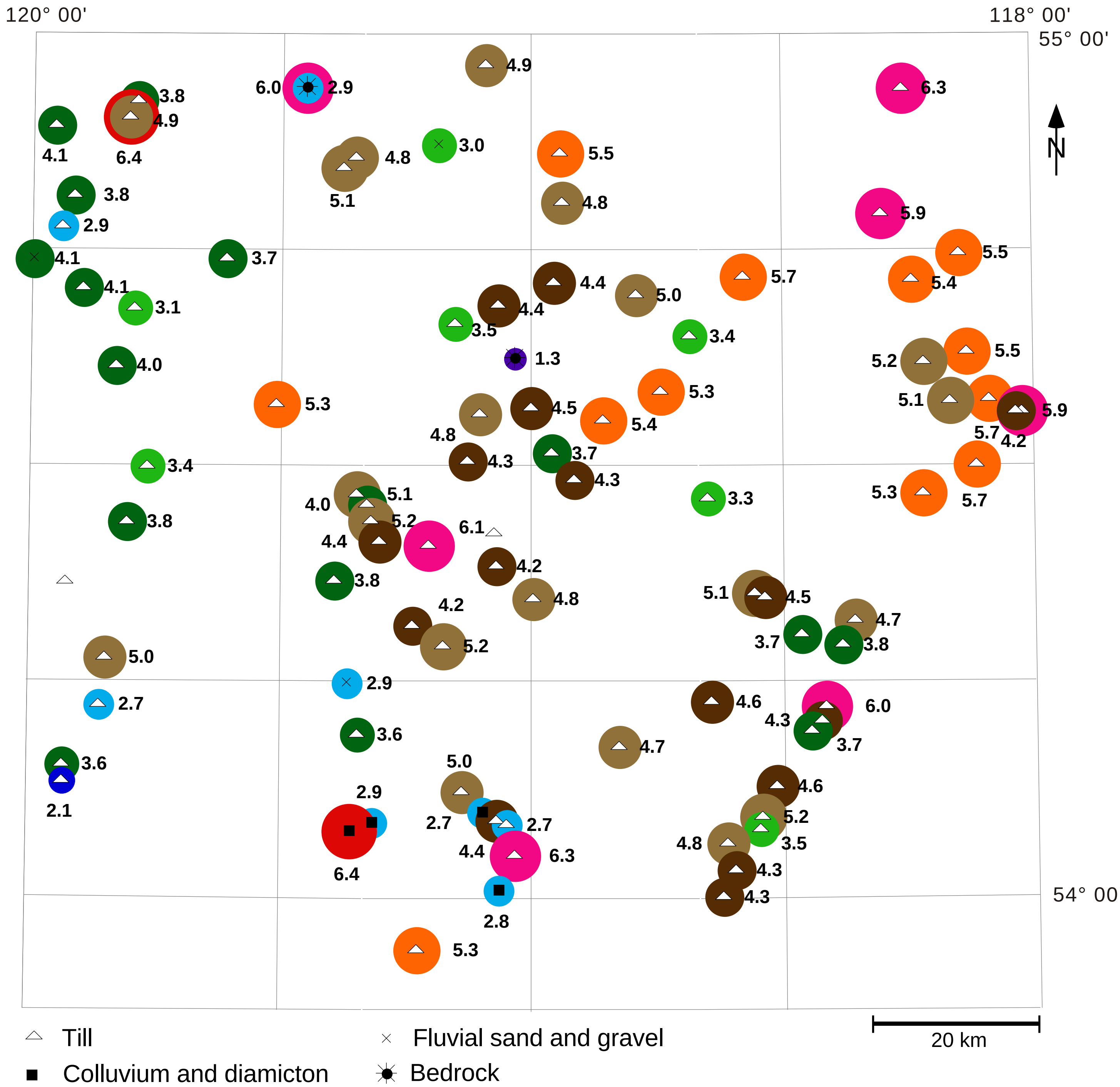

Figure 65. Concentrations of Cs in ppm by INNA for all samples.

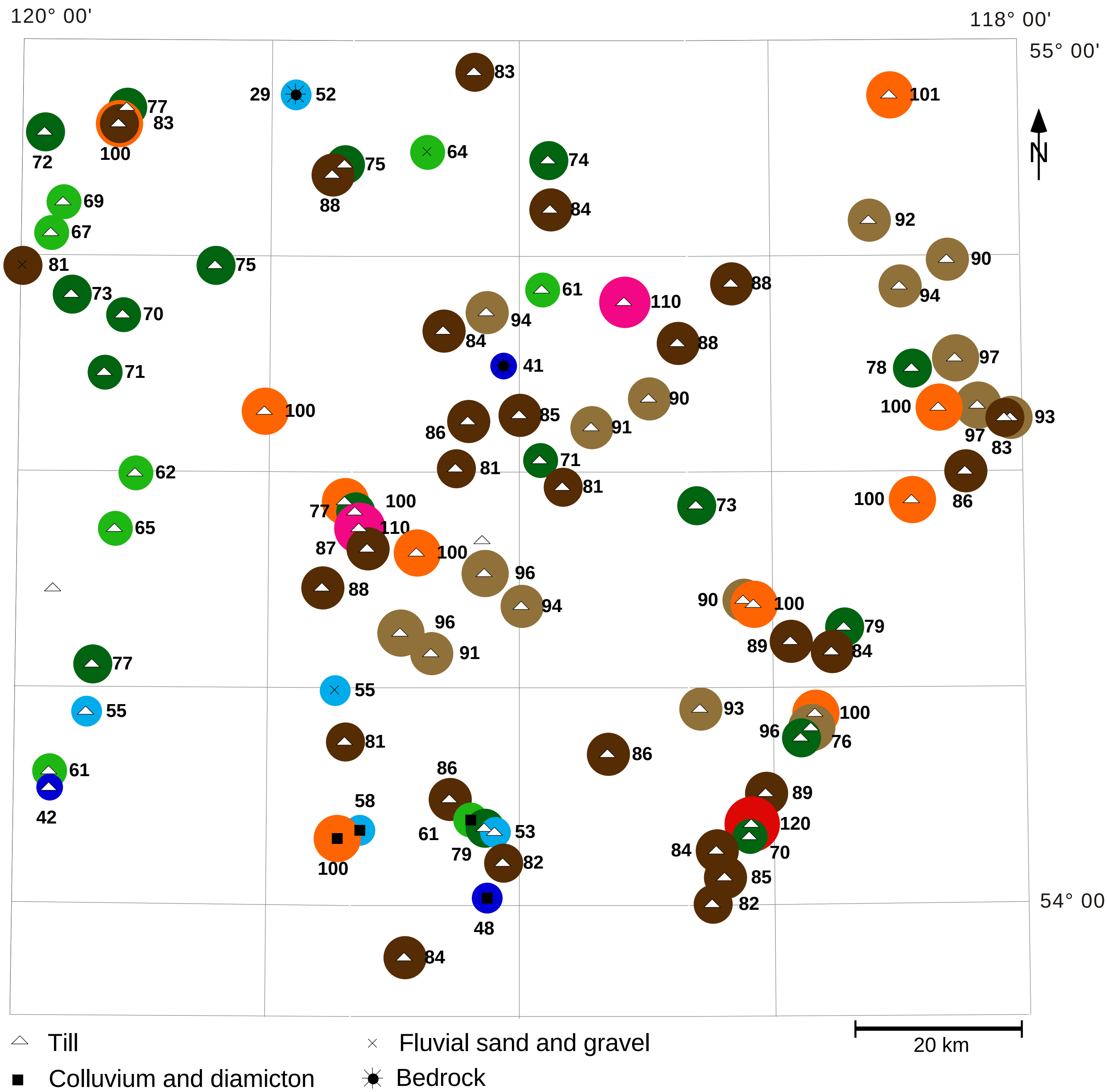

Figure 66. Concentrations of Rb in ppm by INNA for all samples.

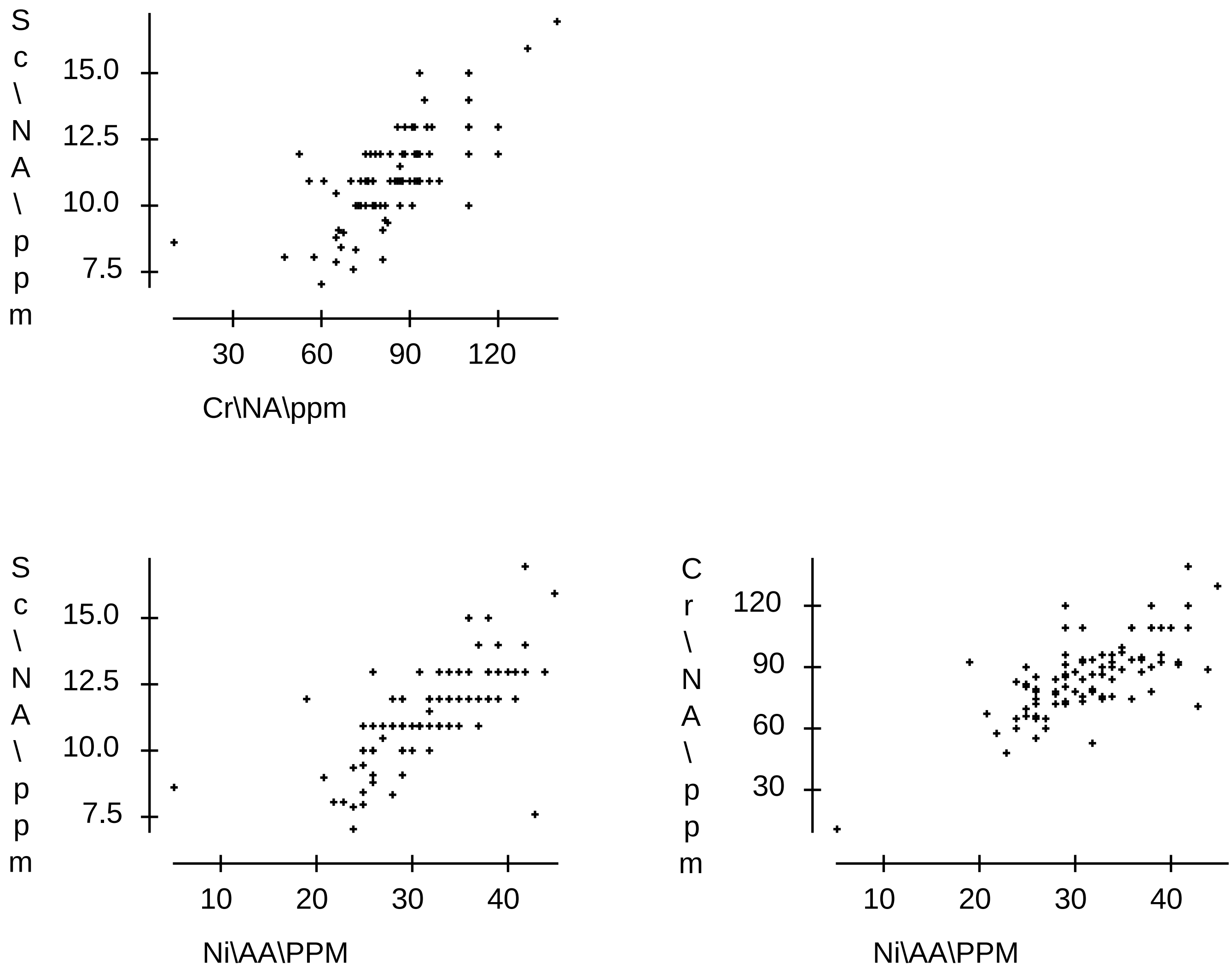

Figure 67. Scatterplots showing relationship between Cr, Sc and Ni. Axis labels indicate the element (Ni), the analytical method (NA = INNA, or AA) and concentration (ppm).

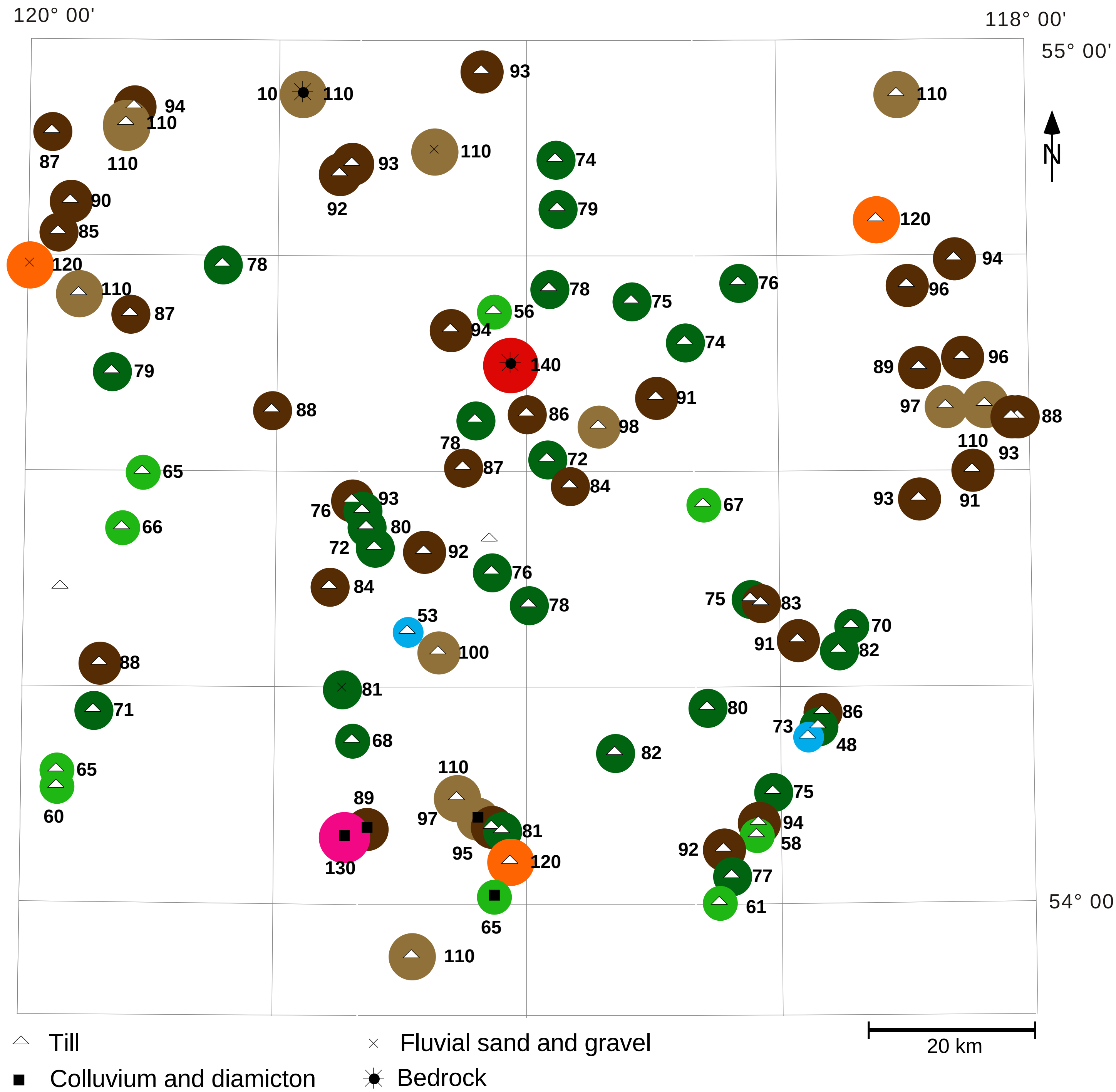

Figure 68. Concentrations of Cr in ppm by INNA for all samples.

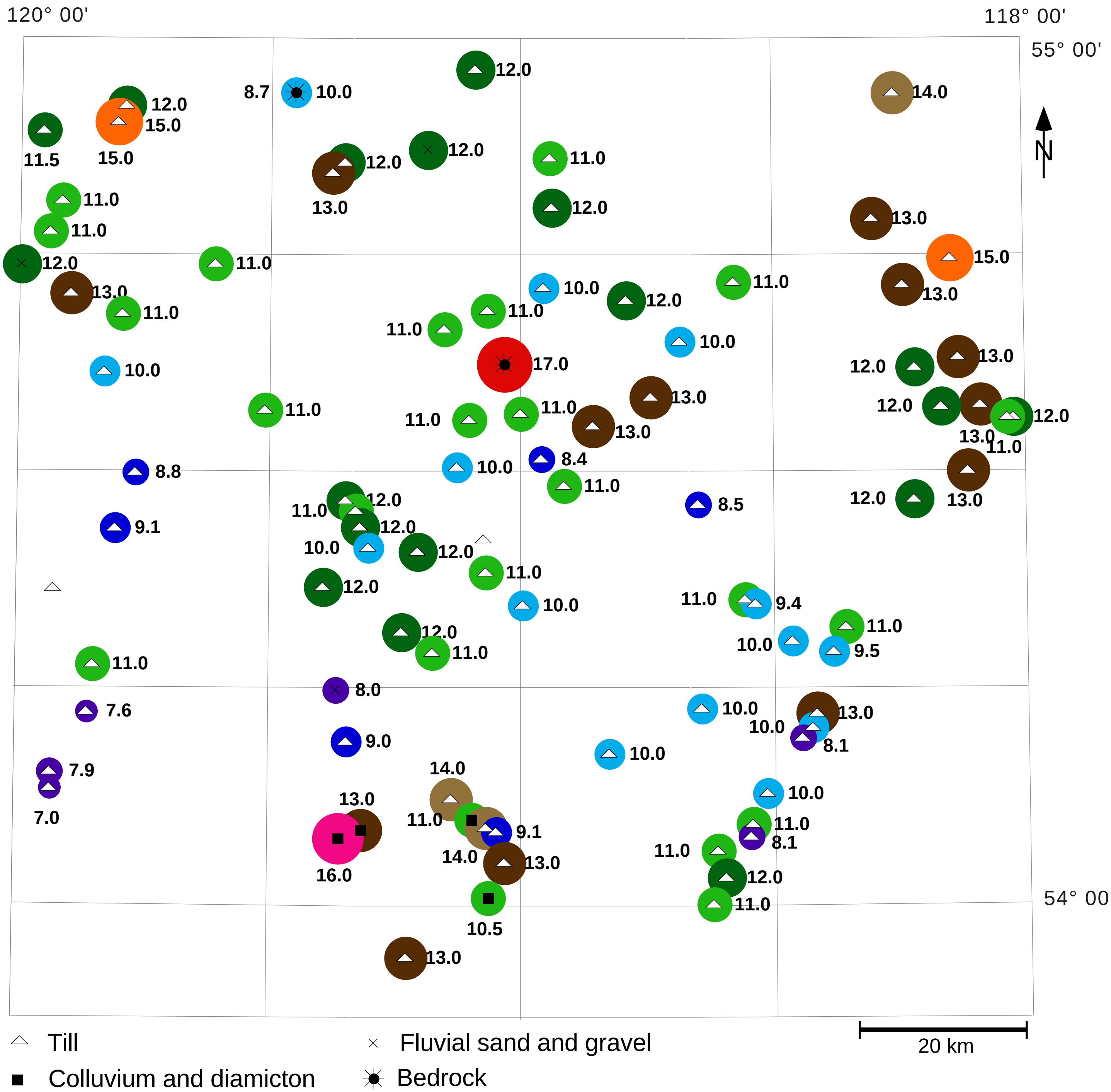

Figure 69. Concentrations of Sc in ppm by NA for all samples.

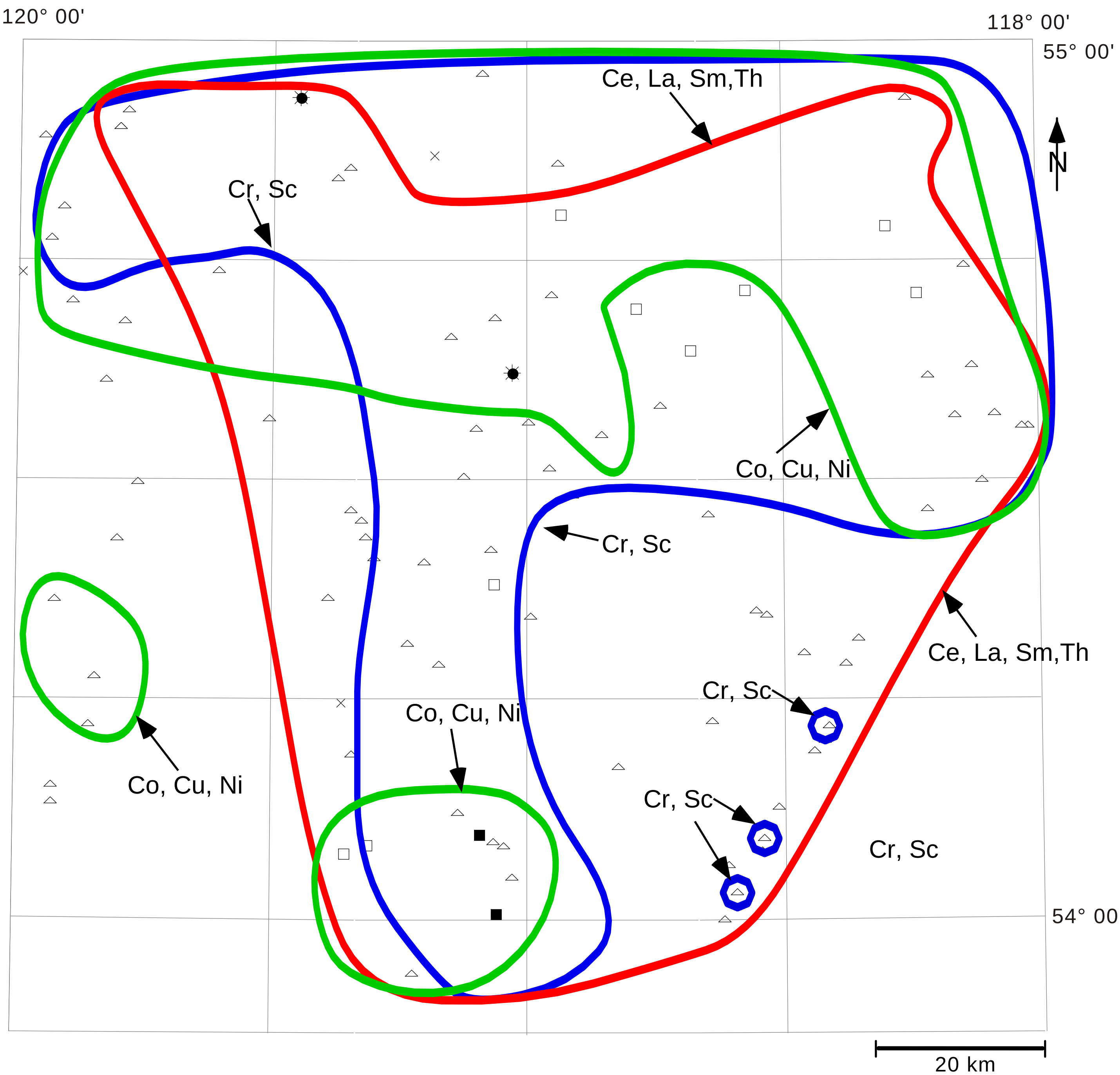

Figure 70. Distribution of samples with higher concentrations of: Group 1 (Ce, La, Sm and Th), Group 2 (Cr and Sc), and Group 3 (Co, Cu and Ni) elements.

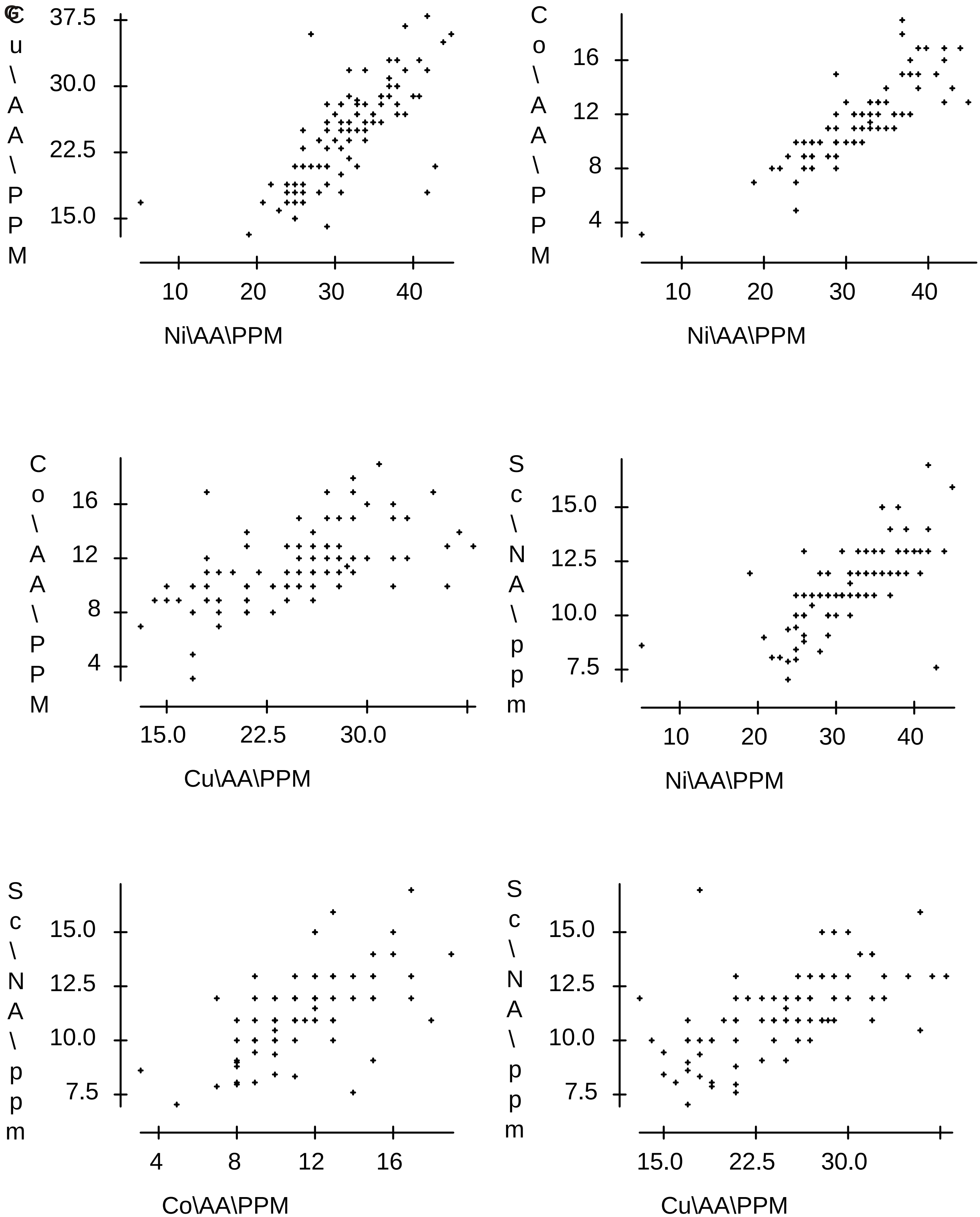

Figure 71. Scatter plots showing correlations among Co, Cu, Ni, and Sc. Axis labels indicate the element, the analytical method and concentration.

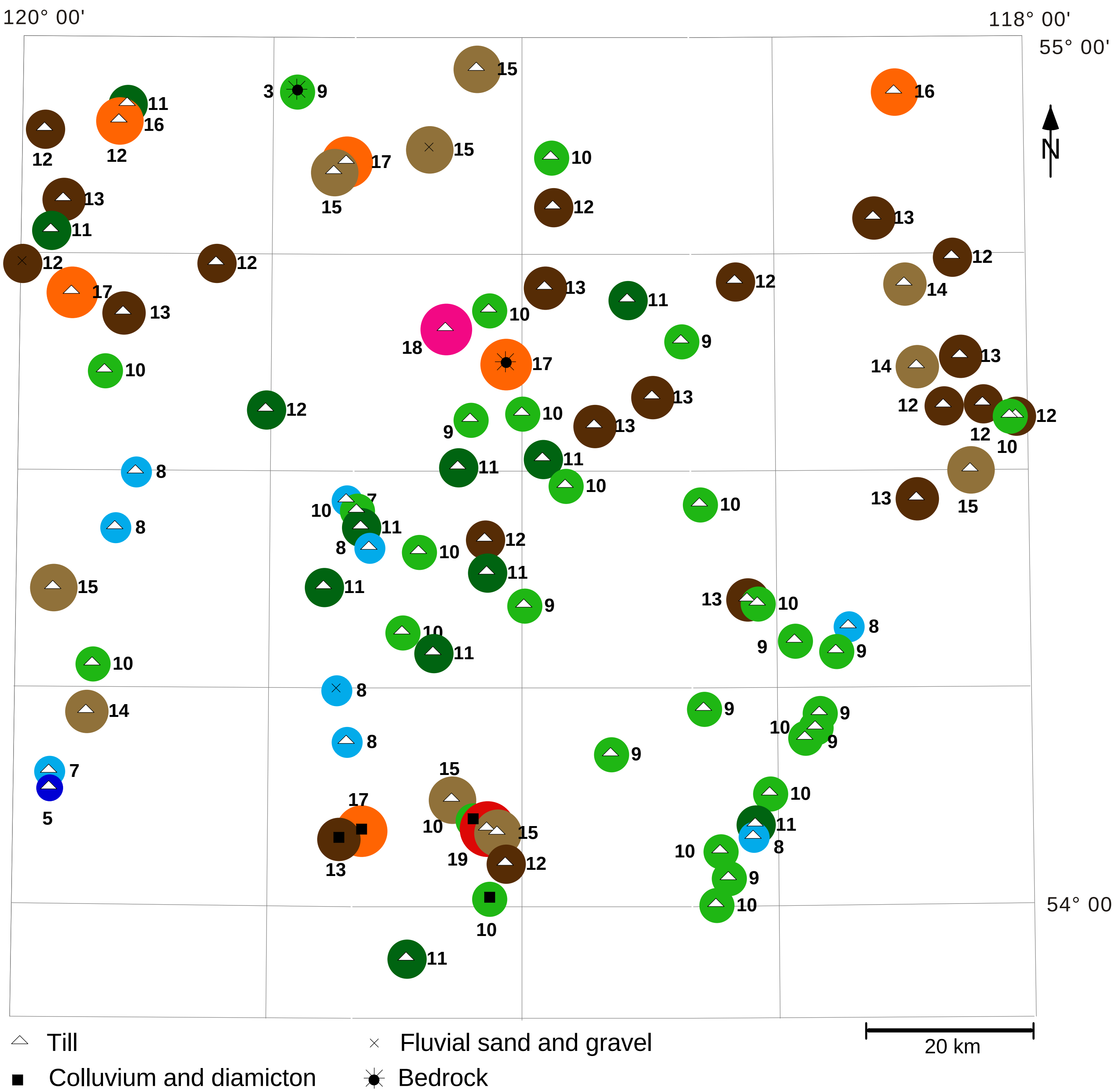

Figure 72. Concentrations of Co in ppm by AA for all samples.

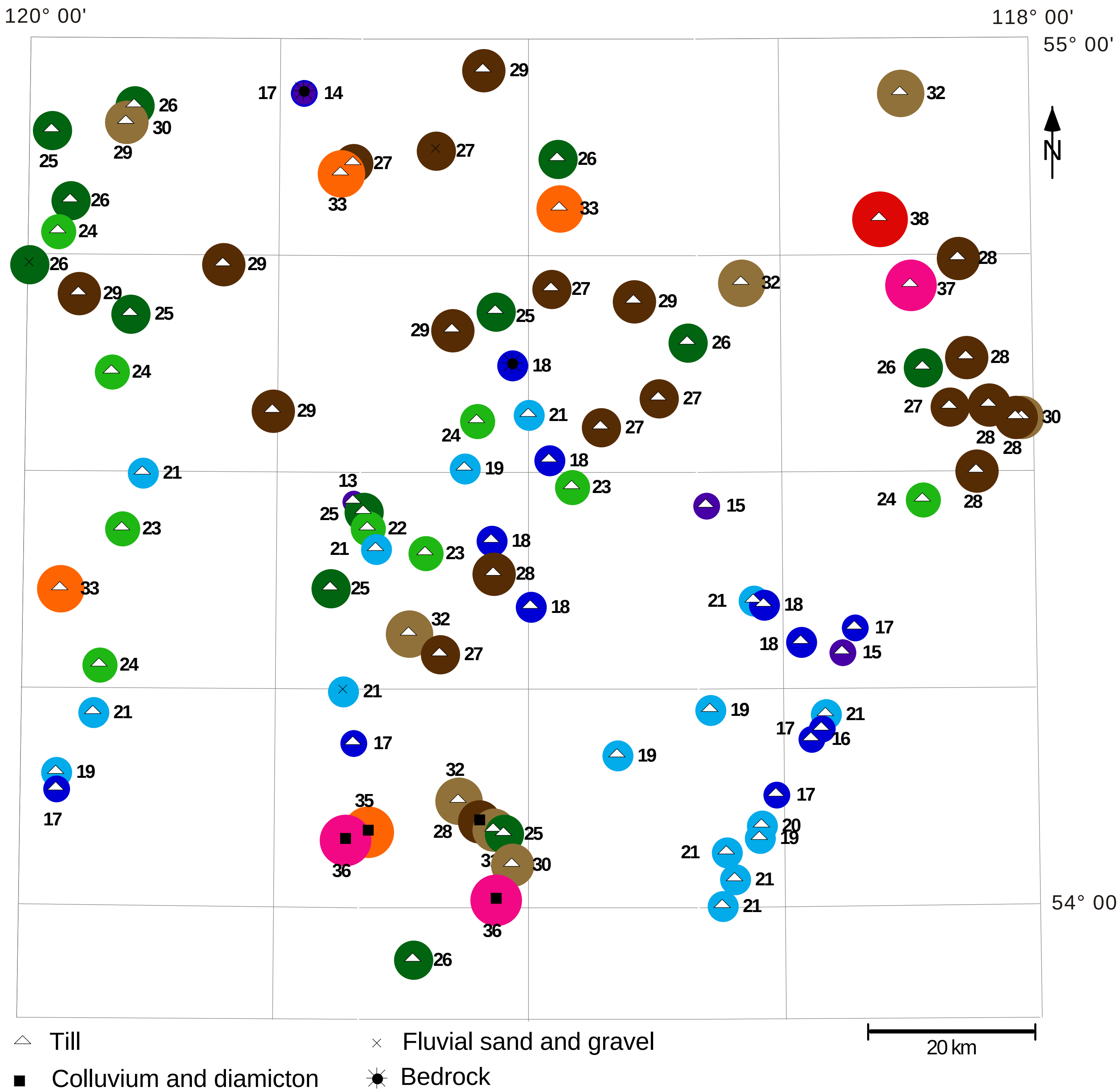

Figure 73. Concentrations of Cu in ppm by AA for all samples.

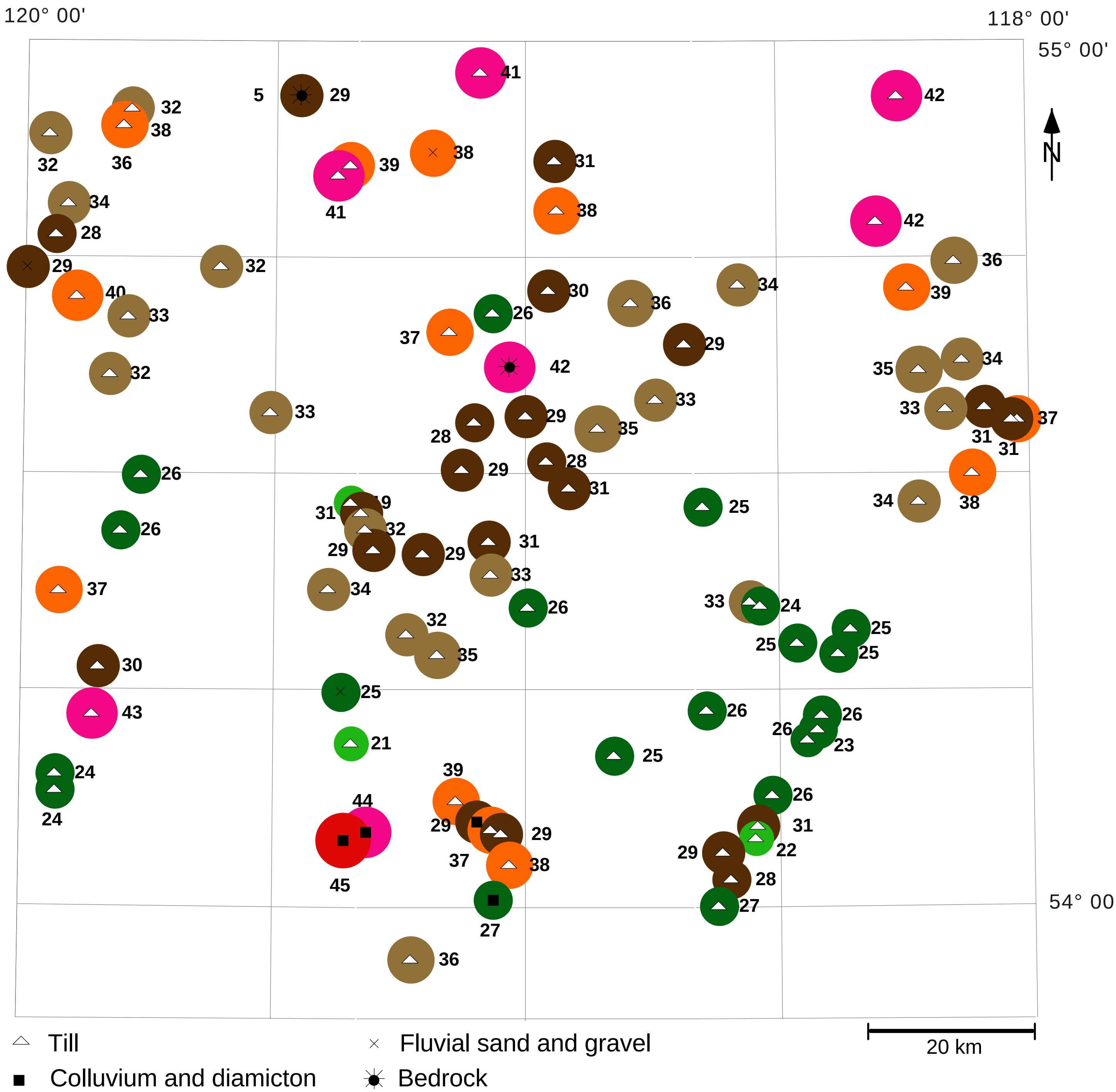

Figure 74. Concentrations of Ni in ppm by AA for all samples.

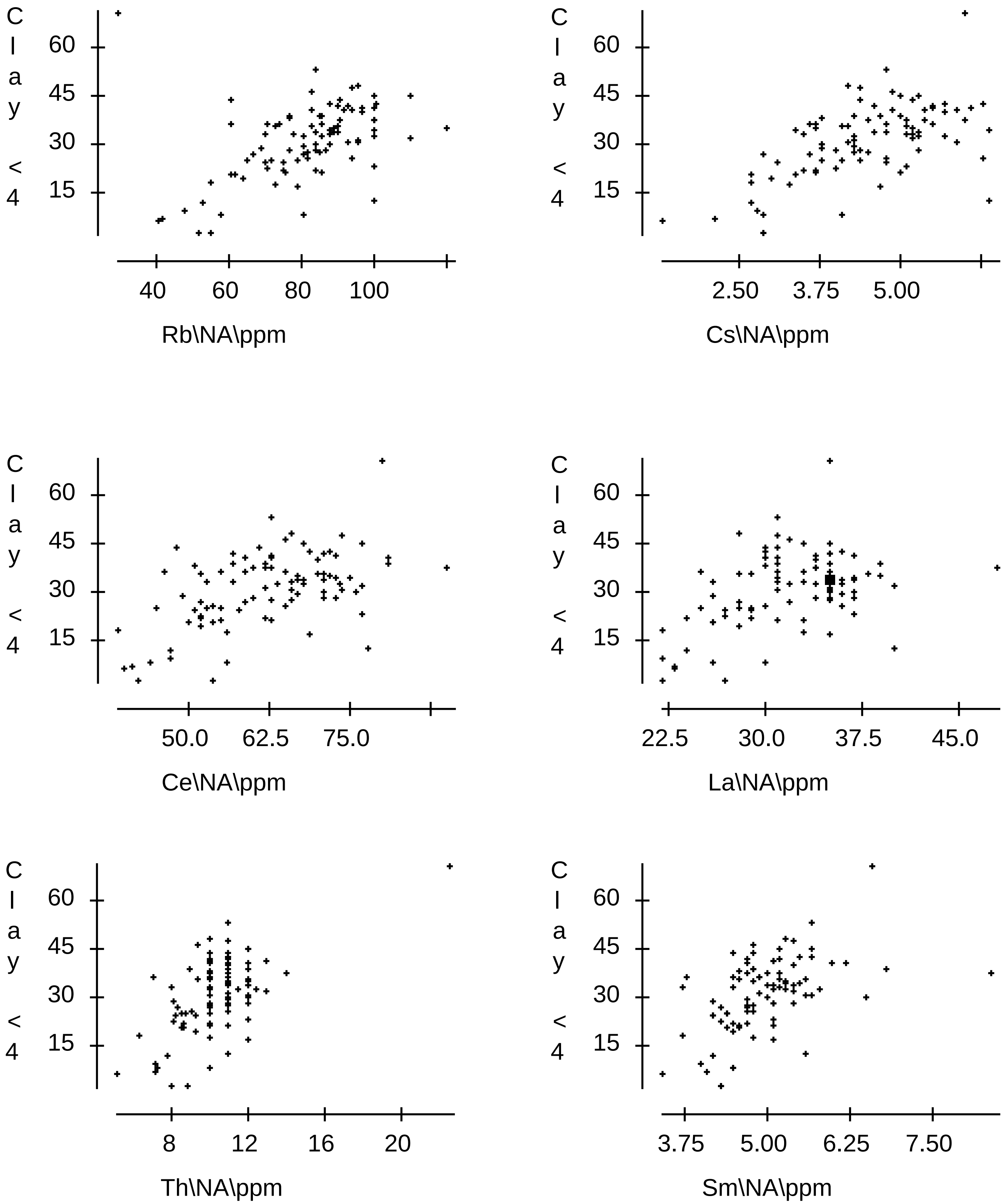

Figure 75. Scatter plots showing correlation between clay (<0.004 mm) content and Rb, Cs, Ce, La, Th and Sm concentrations. Axis labels, for geochemistry, indicate the element, the analytical method and concentration.

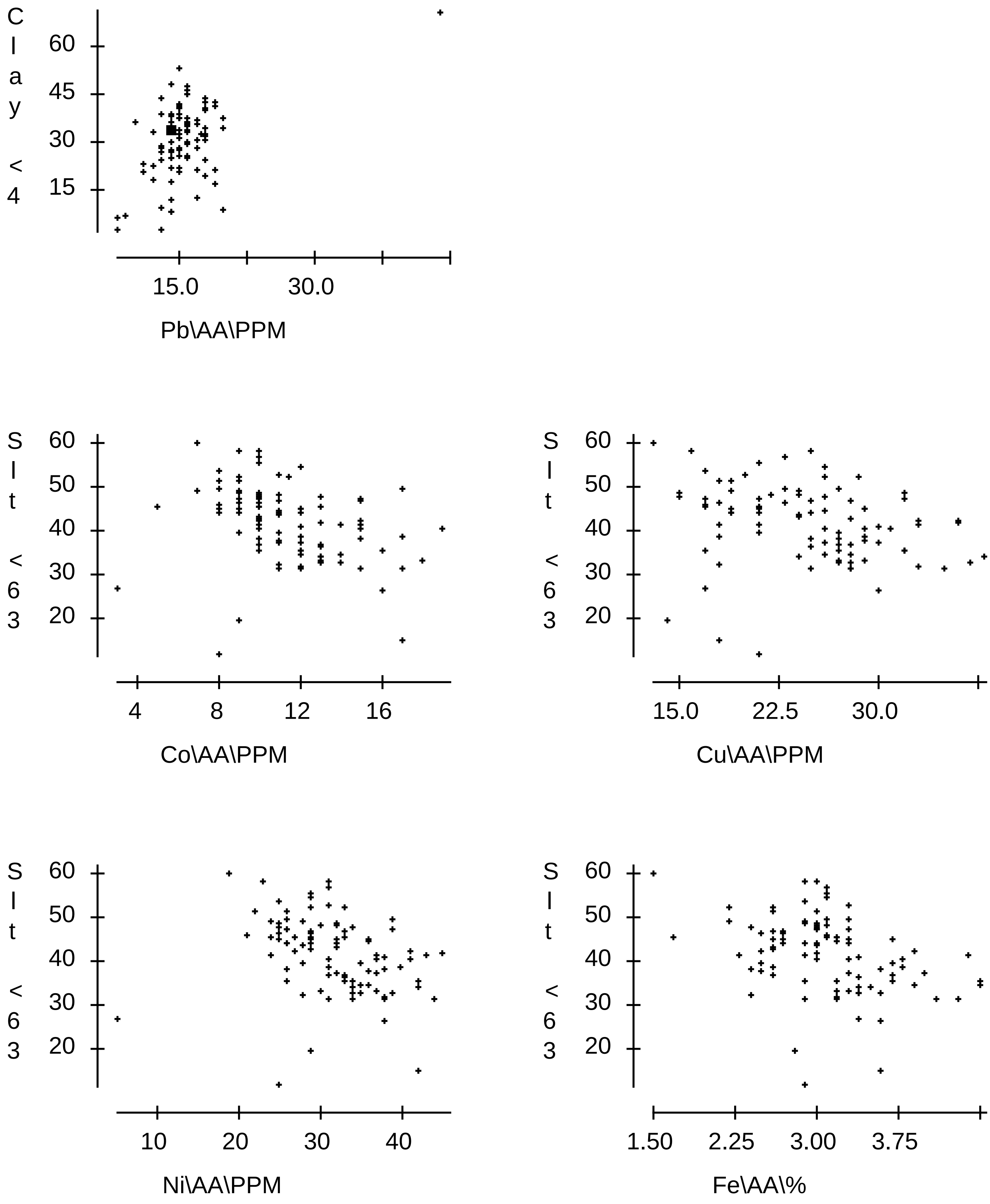

Figure 76. Scatter plots showing correlations: between clay (<0.004 mm) content and Pb concentration, and between silt (0.063mm to 0.004 mm) conetent and Co, Cu, Ni, and Fe concentrations. Axis labels, for geochemistry, indicate the element, the analytical method and concentration.

Appendix 1, part 1. Geochemical and related data from surface samples discussed in this report.

TILL SAMPLES ONLY

Short ID	Field sample #	Lithology	Long original	Lat original	Ag	Ag	As	Au	Ba	Br	Cd	Cd	Ce	Co	Co	Cr	Cs	Cu	Eu	Fe	Fe	Hf	Ir
			Method		AA	NA	NA	NA	NA	NA	AA	NA	NA	AA	NA	NA	NA	AA	NA	AA	NA	NA	NA
			DetectionLimit		0.2 ppm	2 ppm	0.5 ppm	2 ppb	50 ppm	0.5 ppm	0.2 ppm	5 ppm	5 ppm	2 ppm	5 ppm	20 ppm	0.5 ppm	2 ppm	1 ppm	0.0	0.0	1 ppm	50 ppm
3	NAG96-583	till	118.962832	54.515635	0.2	1	8.1	6	850	0.3	0.5	2.5	55	11	11	72	3.7	18	0.5	2.4	2.0	8	25
4	NAG96-584	till	118.958523	54.714568	0.1	1	7.1	1	810	1.8	0.4	2.5	61	13	15	78	4.4	27	0.5	3.2	2.8	6	25
5	NAG96-585	till	118.945304	54.864058	0.1	1	10.0	1	860	1.5	0.1	2.5	59	10	10	74	5.5	26	0.5	3.3	2.9	5	25
7	NAG96-587	till	119.351112	54.859121	0.3	1	8.7	7	920	2.4	0.3	2.5	58	17	20	93	4.8	27	0.5	3.3	2.9	5	25
8	NAG96-588	till	119.033350	54.051583	0.2	4	12.0	7	1100	1.0	0.2	2.5	54	12	13	120	6.3	30	0.5	3.4	3.1	8	25
9	NAG96-589	till	118.558200	54.353367	0.1	1	6.0	6	730	0.6	0.2	2.5	70	13	15	75	5.1	21	1.0	3.1	2.5	7	25
10	NAG96-590	till	118.613639	54.064861	0.2	1	7.2	1	610	2.0	0.1	2.5	71	10	13	92	4.8	21	1.0	3.2	2.8	7	25
11	NAG96-591	till	118.550694	54.080194	0.1	1	3.0	3	400	1.3	0.1	2.5	53	8	9	58	3.5	19	1.0	3.0	2.4	5	25
12	NAG96-592	till	118.447222	54.193556	0.2	1	17.0	6	620	1.5	0.2	2.5	55	9	13	48	3.7	16	0.5	2.9	2.4	6	25
13	NAG96-593	till	118.419639	54.223472	0.2	1	8.5	4	570	1.9	0.1	2.5	90	9	11	86	6.0	21	1.0	3.0	3.3	9	25
14	NAG96-594	till	118.359444	54.322306	0.2	1	9.4	1	820	1.3	0.1	2.5	69	8	11	70	4.7	17	0.5	2.9	2.8	9	25
15	NAG96-595	till	118.115517	54.502133	0.1	1	12.0	5	770	1.1	0.1	2.5	68	15	19	91	5.7	28	0.5	4.3	3.4	7	25
16	NAG96-596	till	119.206883	54.409367	0.2	1	8.2	4	820	1.2	0.1	2.5	73	10	12	92	6.1	23	2.0	2.5	2.5	5	25
17	NAG96-597	till	119.304750	54.414333	0.2	1	14.0	1	630	0.7	0.3	2.5	73	8	7	72	4.4	21	1.0	2.7	2.5	8	25
18	NAG96-598	till	118.024750	54.563267	0.1	1	11.0	1	770	1.6	0.2	2.5	66	12	14	88	5.9	30	1.0	4.0	3.3	8	25
19	NAG96-599	till	118.219250	54.620250	0.2	1	11.0	3	740	2.4	0.1	2.5	66	14	17	89	5.2	26	0.8	3.9	3.0	7	25
21	NAG96-648	till	119.102800	54.561367	0.1	1	5.4	1	670	1.2	0.3	2.5	65	9	8	78	4.8	24	1.0	2.9	2.6	6	25
22	NAG96-649	till	119.129367	54.507833	0.2	1	5.6	1	850	1.3	0.5	2.5	67	11	13	87	4.3	19	0.5	2.7	2.5	9	25
23	NAG96-650	till	119.350600	54.467450	0.1	1	9.5	4	990	0.9	0.1	2.5	77	7	13	93	5.1	13	0.5	1.5	2.6	6	25
24	NAG96-651	till	119.329550	54.455683	0.1	1	6.7	4	890	0.7	0.3	2.5	60	10	12	76	4.0	25	0.5	3.0	2.6	7	25
25	NAG96-652	till	119.956133	54.892250	0.1	1	7.8	11	970	1.2	0.3	2.5	53	12	14	87	4.1	25	0.5	3.3	2.9	6	25
26	NAG96-653	till	119.914983	54.813700	0.1	1	7.5	5	850	1.4	0.1	2.5	49	13	16	90	3.8	26	0.5	3.0	2.5	5	25
27	NAG96-654	till	119.930517	54.136050	0.2	1	5.8	5	450	2.9	0.7	2.5	41	5	6	60	2.1	17	0.5	1.7	1.6	12	25
29	NAG96-656	till	119.856600	54.223833	0.2	1	7.2	15	700	0.7	1.5	2.5	39	14	13	71	2.7	21	0.5	2.3	1.8	8	25
35	NAG96-668	till	119.347917	54.189267	0.2	1	8.0	1	940	0.8	0.4	2.5	59	8	11	68	3.6	17	0.5	3.1	2.4	8	25
41	NAG96-674	till	119.928333	54.365000	0.9	nd	nd	nd	nd	nd	0.8	nd	nd	15	nd	nd	nd	33	nd	4.4	nd	nd	nd
43	NAG96-676	till	119.805000	54.436667	0.1	1	9.3	1	940	0.3	0.5	2.5	45	8	9	66	3.8	23	0.5	3.1	2.4	7	25
45	NAG96-678	till	119.767556	54.498972	0.1	1	7.7	1	820	0.6	0.5	2.5	50	8	8	65	3.4	21	0.5	2.9	2.3	8	25
46	NAG96-679	till	119.898556	54.705417	0.1	3	8.4	4	1100	0.7	0.4	2.5	52	17	19	110	4.1	29	0.5	3.8	3.4	6	25
50	NAG96-683	till	119.807417	54.903383	0.1	1	12.0	5	950	1.5	0.3	2.5	73	12	12	110	6.4	29	1.0	3.7	3.4	6	25
52	NAG96-685	till	118.745167	54.587833	0.1	1	10.0	8	860	1.3	0.2	2.5	67	13	17	91	5.3	27	0.5	3.7	3.2	6	25
53	NAG96-686	till	118.145889	54.747556	0.1	1	13.0	4	930	0.6	0.3	2.5	71	12	15	94	5.5	28	1.0	4.5	3.9	6	25
54	NAT96-159	till	118.168241	54.575267	0.1	1	9.2	6	770	1.2	0.2	2.5	62	12	14	97	5.1	27	1.0	3.7	3.1	6	25
57	NAT96-172	till	119.228611	53.940980	0.2	1	8.8	5	930	0.3	0.5	2.5	71	11	12	110	5.3	26	1.0	3.2	2.8	10	25
58	NAT96-173	till	119.139549	54.125253	0.1	1	11.0	7	1400	0.8	0.1	2.5	63	15	16	110	5.0	32	0.5	3.3	3.2	7	25
59	NAT96-174	till	119.070536	54.091981	0.1	1	8.5	3	1200	0.3	0.3	2.5	55	19	22	95	4.4	31	1.0	3.0	3.2	6	25
60	NAT96-175	till	119.050955	54.085940	0.1	1	8.7	3	870	0.8	0.6	2.5	47	15	16	81	2.7	25	0.5	2.7	2.3	9	25
61	NAT96-176	till	118.826409	54.176227	0.1	1	6.4	1	650	1.3	0.2	2.5	62	9	10	82	4.7	19	0.5	2.6	2.3	7	25
62	NAT96-177	till	118.646324	54.228147	0.1	1	5.9	1	690	0.9	0.4	2.5	57	9	11	80	4.6	19	0.5	3.0	2.5	7	25
63	NAT96-178	till	118.539422	54.349903	0.3	1	6.9	1	820	0.8	0.3	2.5	60	10	10	83	4.5	18	0.5	2.9	2.2	7	25
64	NAT96-179	till	118.650834	54.463445	0.1	1	8.4	3	1000	0.5	0.1	2.5	56	10	12	67	3.3	15	1.0	2.4	2.0	9	25
65	NAT96-180	till	118.915042	54.484814	0.2	1	7.1	2	895	1.5	0.1	2.5	64	10	9	84	4.3	23	1.0	3.1	2.6	6	25
66	NAT96-181	till	118.998010	54.348990	0.1	1	6.8	1	700	1.3	0.2	2.5	65	9	8	78	4.8	18	1.0	2.6	2.2	5	25
67	NAT96-182	till	119.004015	54.568491	0.1	1	6.2	4	860	1.3	0.2	2.5	63	10	9	86	4.5	21	0.5	3.1	2.5	6	25
68	NAT96-183	till	119.091954	54.966339	0.1	1	9.4	1	940	1.7	0.3	2.5	65	15	19	93	4.9	29	1.0	3.8	3.0	6	25
69	NAT96-184	till	119.375866	54.847095	0.1	1	8.2	1	1100	0.3	0.3	2.5	57	15	14	92	5.1	33	1.0	3.9	3.3	5	25
70	NAT96-185	till	119.829509	54.616762	0.1	1	7.4	4	780	1.6	1.4	2.5	52	10	14	79	4.0	24	1.0	2.6	2.2	6	25
71	NAT96-186	till	119.795167	54.683599	0.1	1	8.4	1	930	0.9	0.3	2.5	51	13	15	87	3.1	25	1.0	3.4	2.8	6	25
72	NAT96-187	till	119.611723	54.741571	0.1	1	8.4	12	1100	1.0	0.2	2.5	52	12	14	78	3.7	29	0.5	3.3	2.9	5	25
73	NAT96-188	till	118.624068	54.002461	0.1	1	6.9	5	630	1.2	0.2	2.5	66	10	12	61	4.3	21	1.0	3.2	2.6	8	25
74	NAT96-189	till	118.598083	54.032528	0.1	1	6.2	7	680	1.2	0.1	2.5	81	9	10	77	4.3	21	0.5	2.5	3.1	11	25
75	NAT96-190	till	118.545778	54.094889	0.1	1	7.7	5	750	1.1	0.4	2.5	72	11	10	94	5.2	20	0.5	3.3	2.9	5	25
76	NAT96-191	till	118.516500	54.129667	0.1	1	8.5	3	730	1.1	0.2	2.5	68	10	11	75	4.6	17	0.5	3.2	2.7	7	25
77	NAT96-192	till	118.424278	54.206250	0.1	1	8.1	5	910	1.2	0.3	2.5	62	10	11	73	4.3	17	0.5	3.0	2.3	8	25
78	NAT96-193	till	118.384500	54.294278	0.1	1	6.8	4	850	0.9	0.2	2.5	76	9	11	82	3.8	15	0.5	2.9	2.4	11	25
79	NAT96-194	till	118.463900	54.305417	0.2	1	6.6	3	780	1.3	0.3	2.5	67	9	11	91	3.7	18	0.5	2.7	2.5	7	25
80	NAT96-195	till	118.223667	54.469550	0.1	1	8.5	13	930	0.8	0.2	2.5	68	13	16	93	5.3	24	0.5	3.4	3.2	7	25
81	NAT96-196	till	119.074500	54.424250	0.2	nd	nd	nd	nd	nd	0.3	nd	nd	12	nd	nd	nd	18	nd	2.6	nd	nd	nd
82	NAT96-197	till	118.090833	54.576417	0.2	1	12.0	5	960	1.6	0.1	2.5	70	12	16	110	5.7	28	0.5	4.1	3.5	7	25
83	NAT96-198	till	118.257426	54.938170	0.3	1	17.5	4	1050	1.6	0.3	2.5	69	16	19	110	6.3	32	0.8	4.5	4.2	6	25
84	NAT96-199	till	119.807417	54.903383	0.1	1	9.1	5	1200	0.6	0.1	2.5	59	16	18	110	4.9	30	1.0	3.6	3.6	5	25
85	NAT96-200	till	118.859667	54.554000	0.2	1	9.5	3	850	1.3	0.1	2.5	63	13	15	98	5.4	27	0.5	3.4	3.1	6	25
86	NAT96-201	till	118.135167	54.632167	0.2	2	11.0	4	870	1.1	0.1	2.5	63	13	15	96	5.5	28	1.0	3.6	3.2	6	25
87	NAT96-210	till	119.320733	54.437933	0.1	1	40.0	4	720	1.3	0.2	2.5	77	11	12	80	5.2	22	1.0	3.0	2.6	7	25
88	NAT96-211	till	119.393983	54.369200	0.1	1	7.7	5	880	0.7	0.2	2.5	71	11	14	84	3.8	25	1.0	3.2	3.2	8	25
89	NAT96-212	till	119.789800	54.922450	0.1	1	8.3	1	990	0.9	0.3	2.5	51	11	13	94	3.8	26	0.5	3.3	2.9	5	25
90	NAT96-213	till	119.941967	54.776833	0.2	1	7.8	1	920	1.1	0.3	2.5	52	11	13	85	2.9	24	0.5	3.0	2.8	6	25
91	NAT96-214	till	119.930300	54.152883	0.3	1	5.5	4	670	0.3	0.5	2.5	46	7	7	65	3.6	19	0.5	2.2	1.9	6	25
92	NAT96-215	till	119.846467	54.277833	0.3	1	7.5	6	890	0.3	0.8	2.5	57	10	11	88	5.0	24	1.0	3.1	2.5	8	25
93	NAT97-217	till	118.578166	54.721016	0.4	1	11.0	1	820	1.9	0.3	2.5	72	12	12	76	5.7	32	1	2.9	3.1	6	25
94	NAT97-218	till	118.685816	54.652816	0.3	1	7.4	1	840	1.2	0.4	2.5	75	9	12	74	3.4	26	0.5	2.2	2.3	6	25
95	NAT97-219	till	119.070150	54.385466	0.4	1	10.0	4	880	1.8	0.4	2.5	74	11	13	76	4.2	28	1	2.6	2.7	5	25
96	NAT97-220	till	118.792833	54.700433	0.4	1	6.7	4	800	0.7	0.3	2.5	77	11	11	75	5	29	0.5	2.5	2.7	6	25
97	NAT97-221	till	118.942233	54.805633	0.3	1	9.3	2	750	2.4	0.3	2.5	63	12	10	79	4.8	33	0.5	3.2	3	5	25
98	NAT97-222	till	118.304550	54.793400	0.4	1	17.0	4	1300	2.5	0.2	2.5	81	13	14	120	5.9	38	0.5	3.5	4	6	25
99	NAT97-223	till	118.242050	54.715566	0.5	1	14.0	1	830	2.3	0.2	2.5	63	14	16	96	5.4	37	1	3.4	3.6	6	25
100	NAG97-687	till	119.507900	54.572100	0.4	1	7.2	1	810	1.2	0.6	2.5	74	12	12	88	5.3	29	1.0	2.6	2.9	7	25
101	NAG97-688	till	119.239050	54.317833	0.4	3	8.3	6	870	0.8	0.7	2.5	66	10	7	53	4.2	32	0.5	3	3	4	25
102	NAG97-689	till	119.067933	54.687366	0.3	1	5.5	1	680	1.4	0.4	2.5	74	10	7	56	4.4	25	2	2.4	2.6	7	25
103	NAG97-690	till	119.152800	54.667166	0.4	2	11.0	5	1000	1.5	0.3	2.5	62	18	20	94	3.5	29	0.5	3.3	3.4	6	25
104	NAG97-691	till	118.034783	54.561916	0.5	1	9.1	1	830	1.9	0.1	2.5	71	10	8	93	4.2	28	1	2.6	2.8	10	25
				Count	81	79	79	79	79	79	81	79	79	81	79	79	79	81	79	81	79	79	79
				Average	0.19	1.11	9.2	3.8	851	1.19	0.31	2.5	63.3	11.4	12.7	84.4	4.56	24.5	0.73	3.10	2.80	6.8	25
				Min	0.10	1.00	3.0	1.0	400	0.25	0.10	2.5	39.0	5.0	6.0	48.0	2.10	13.0	0.50	1.50	1.60	4.0	25
				Max	0.90	4.00	40.0	15.0	1400	2.90	1.50	2.5	90.0	19.0	22.0	120.0	6.40	38.0	2.00	4.50	4.15	12.0	25
				75%ile	0.20	1.00	9.8	5.0	930	1.50	0.40	2.5	71.0	13.0	15.0	93.0	5.20	28.0	1.00	3.40	3.10	8.0	25
				95% ile	0.40	2.00	14.3	8.3	1110	2.36	0.70	2.5	77.0	16.0	19.0	110.0	6.01	33.0	1.00	4.10	3.60	10.0	25

OTHER SAMPLES

Short ID	Field sample #	Lithology	Long original	Lat original																			Ir
1	NAG96-581	colluvium?	119.066233	54.010650	0.1	1	8.4	9	660	1.3	1.4	2.5	47	10	12	65	2.8	36	0.5	2.5	2.3	12	25
2	NAG96-582	colluvium?	119.098551	54.099858	0.2	1	10.0	7	890	1.2	0.3	2.5	54	10	12	97	2.7	28	0.5	2.6	2.7	14	25
6	NAG96-586	sand	119.186633	54.872360	0.1	1	10.0	1	970	0.9	0.1	2.5	52	15	16	110	3.0	27	1.0	3.6	3.2	6	25
55	NAT96-170	diamicton	119.360977	54.079487	0.3	1	10.0	6	1100	2.9	0.7	2.5	78	13	17	130	6.4	36	0.5	3.0	3.1	9	25
56	NAT96-171	diamicton	119.317378	54.087764	0.2	1	11.0	7	980	1.2	2.0	2.5	44	17	22	89	2.9	35	0.5	2.9	2.8	12	25
20	NAG96-647	ss	119.035100	54.627050	0.1	1	3.2	1	880	0.3	0.2	2.5	40	17	19	140	1.3	18	1.0	3.6	3.5	3	25
38	NAG96-671	silty clay	119.176967	54.292167	0.2	1	7.9	1	1100	0.3	0.5	2.5	48	11	10	100	5.2	27	1.0	3.7	2.7	7	25
40	NAG96-673	s&g	119.368250	54.250017	0.1	1	9.2	4	770	1.0	0.6	2.5	42	8	8	81	2.9	21	0.5	2.9	2.2	18	25
48	NAG96-681	gravel	119.454200	54.938250	0.1	1	6.8	36	2400	0.3	0.5	2.5	54	9	11	110	2.9	14	1.0	2.8	2.5	12	25
49	NAG96-682	bentonite	119.454200	54.938250	0.1	1	3.0	1	540	0.6	0.2	2.5	80	3	3	10	6.0	17	0.5	3.4	3.3	8	25
51	NAG96-684	fluvial	119.995950	54.738600	0.1	1	8.2	17	1000	0.3	0.2	2.5	56	12	16	120	4.1	26	0.5	3.1	3.0	8	25

All values below detection limit are shown as 1/2 of detection limit   nd = no data   AA= atomic absorption spectrometry   NA = instrumental neutron activation analysis

Appendix 1, part 2. Geochemical and related data from surface samples discussed in this report

TILL ONLY

Element		La	Li	Lu	Mg	Mn	Mo	Mo	Na	Ni	Ni	Pb	Rb	Sb	Sc	Se	Sm	Sn	Ta	Tb	Te	Th	U	V	W	Yb
Method		NA	AA	NA	AA	AA	AA	NA	NA	AA	NA	AA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	AA/Tota	NA	NA
DetectionLimit		2 ppm	1.0 ppm	0.2 ppm	0.01%	5 ppm	2 ppm	1 ppm	0.02%	2 ppm	10 ppm	2 ppm	5 ppm	0.1 ppm	0.2 ppm	5 ppm	0.1 ppm	100 ppm	0.5 ppm	0.5 ppm	10 ppm	0.2 ppm	0.2 ppm	5 ppm	1 ppm	1 ppm
Short ID	Lithology																									
3	till	31	11	0.3	nd	489	4	0.5	0.2	28	53	16	71	0.9	8.4	2.5	4.5	50	1.0	0.9	5	10.0	3.6	78	0.5	3
4	till	31	12	0.2	nd	329	4	0.5	0.8	30	31	18	61	0.9	10.0	2.5	4.5	50	1.0	0.3	5	11.0	3.2	86	0.5	2
5	till	33	17	0.3	nd	286	3	0.5	0.5	31	47	16	74	1.0	11.0	2.5	4.9	50	0.8	0.6	5	10.0	3.4	94	0.5	2
7	till	29	12	0.2	nd	503	4	0.5	0.7	39	36	18	75	1.2	12.0	2.5	4.2	50	0.9	0.6	5	9.3	3.0	104	0.5	2
8	till	30	23	0.3	nd	235	4	1.0	0.4	38	58	15	82	1.0	13.0	2.5	4.8	50	1.3	0.8	5	9.1	3.7	143	0.5	2
9	till	38	16	0.3	nd	309	3	0.5	0.2	33	31	17	90	1.1	11.0	2.5	5.2	50	1.0	0.8	5	12.0	3.0	97	0.5	2
10	till	37	15	0.3	nd	382	3	0.5	0.2	29	48	16	84	0.9	11.0	2.5	5.4	50	1.1	0.8	5	12.0	3.2	88	1.0	2
11	till	26	10	0.2	nd	443	4	0.5	0.1	22	24	12	70	0.5	8.1	2.5	3.7	50	0.7	0.3	5	7.9	2.5	79	0.5	2
12	till	31	11	0.3	nd	303	4	0.5	0.3	23	23	17	76	1.4	8.1	2.5	4.6	50	0.7	0.5	5	10.0	2.7	72	0.5	2
13	till	48	16	0.5	nd	216	3	0.5	0.3	26	29	20	100	1.0	13.0	2.5	8.4	50	1.3	1.3	5	14.0	3.5	84	0.5	4
14	till	35	13	0.3	nd	303	3	0.5	0.5	25	41	19	79	1.4	11.0	2.5	5.1	50	1.3	0.9	5	12.0	3.2	83	0.5	3
15	till	34	19	0.4	nd	506	4	0.5	0.5	38	37	18	86	0.9	13.0	2.5	5.3	50	0.9	0.3	5	10.0	2.9	112	0.5	3
16	till	37	16	0.3	nd	227	3	0.5	0.3	29	30	19	100	1.3	12.0	2.5	5.1	50	1.0	0.8	5	13.0	3.7	111	1.0	2
17	till	37	15	0.3	nd	197	4	0.5	0.2	29	5	17	87	1.2	10.0	2.5	5.4	50	0.9	1.0	5	12.0	3.9	100	0.5	3
18	till	35	19	0.3	nd	460	5	0.5	0.5	37	5	18	93	0.9	12.0	2.5	5.6	50	0.8	0.3	5	10.0	2.8	99	0.5	3
19	till	33	19	0.5	nd	450	5	0.5	0.5	35	35	16	78	0.8	12.0	2.5	5.2	50	1.0	0.8	5	10.0	2.9	93	0.8	3
21	till	35	14	0.3	nd	249	4	0.5	0.3	28	39	14	86	1.0	11.0	2.5	4.9	50	1.0	0.9	5	11.0	3.5	110	0.5	2
22	till	36	12	0.3	nd	302	5	0.5	0.3	29	23	16	81	1.1	10.0	2.5	4.7	50	0.8	0.7	5	11.0	3.4	99	0.5	3
23	till	37	9	0.1	nd	181	3	0.5	0.3	19	34	11	100	1.4	12.0	2.5	5.1	50	1.2	0.7	5	12.0	3.7	70	1.0	2
24	till	35	13	0.1	nd	285	4	0.5	0.6	31	35	15	77	1.2	11.0	2.5	5.1	50	1.1	0.6	5	10.0	3.5	109	0.5	3
25	till	28	14	0.1	nd	369	5	0.5	0.9	32	40	14	72	1.1	11.5	2.5	4.4	50	1.0	0.7	5	8.8	3.3	100	0.8	2
26	till	26	11	0.1	nd	436	4	0.5	0.8	34	24	13	69	1.1	11.0	2.5	4.2	50	1.0	0.7	5	8.2	3.1	81	0.5	2
27	till	23	9	0.1	nd	298	3	0.5	0.3	24	43	9	42	0.9	7.0	2.5	4.1	50	0.9	0.7	5	7.1	3.3	74	0.5	3
29	till	22	10	0.1	nd	495	5	0.5	0.2	43	40	12	55	1.2	7.6	2.5	3.7	50	0.9	0.3	5	6.3	3.6	101	0.5	2
35	till	32	12	0.1	nd	302	5	0.5	0.4	21	5	14	81	1.0	9.0	2.5	4.7	50	1.0	0.6	5	10.0	3.2	83	0.5	2
41	till	nd	19	nd	nd	270	5	nd	nd	37	nd	20	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	110	nd	nd
43	till	25	16	0.1	nd	226	4	0.5	0.4	26	5	14	65	0.9	9.1	2.5	4.4	50	1.0	0.7	5	8.6	3.7	92	0.5	2
45	till	26	13	0.1	nd	276	4	0.5	0.4	26	26	11	62	0.9	8.8	2.5	4.4	50	1.0	0.9	5	8.7	3.5	87	0.5	2
46	till	28	13	0.1	nd	588	4	0.5	1.0	40	47	16	73	1.2	13.0	2.5	4.6	50	1.0	0.8	5	9.4	3.7	95	0.5	2
50	till	37	22	0.2	nd	273	5	0.5	0.6	36	44	20	100	0.9	15.0	2.5	5.3	50	0.9	0.7	5	11.0	4.3	114	1.0	2
52	till	35	19	0.1	nd	422	3	0.5	0.6	33	27	14	90	0.9	13.0	2.5	5.1	50	1.0	0.7	5	11.0	3.8	97	0.5	3
53	till	35	21	0.1	nd	285	4	1.0	0.6	36	50	15	90	1.0	15.0	2.5	5.2	50	1.0	0.9	5	10.0	4.3	114	2.0	3
54	till	34	22	0.1	nd	326	4	0.5	0.5	33	29	15	100	0.9	12.0	2.5	5.2	50	1.3	0.8	5	10.0	3.5	104	1.0	2
57	till	34	21	0.1	nd	249	4	0.5	0.4	36	22	13	84	0.9	13.0	2.5	5.1	50	1.1	1.1	5	11.0	4.0	128	0.5	2
58	till	33	13	0.1	nd	479	5	0.5	1.0	39	5	19	86	1.2	14.0	2.5	5.1	50	0.9	0.9	5	11.0	4.1	103	0.5	3
59	till	29	12	0.1	nd	313	4	0.5	1.1	37	47	16	79	1.2	14.0	2.5	4.4	50	1.0	0.8	5	10.0	3.9	89	1.0	3
60	till	24	10	0.1	nd	372	3	0.5	1.1	29	33	14	53	1.1	9.1	2.5	4.2	50	1.0	0.6	5	7.7	3.6	66	0.5	3
61	till	35	13	0.1	nd	293	4	0.5	0.2	25	36	15	86	0.9	10.0	2.5	4.8	50	1.2	0.7	5	11.0	3.5	94	1.0	2
62	till	35	14	0.1	nd	310	4	0.5	0.2	26	33	15	93	0.9	10.0	2.5	4.7	50	1.1	0.7	5	11.0	3.1	102	0.5	2
63	till	34	14	0.1	nd	289	5	0.5	0.2	24	34	15	100	1.1	9.4	2.5	4.7	50	0.9	0.8	5	11.0	3.3	101	0.5	2
64	till	33	12	0.1	nd	361	4	0.5	0.4	25	23	14	73	1.1	8.5	2.5	4.8	50	1.2	0.8	5	10.0	3.8	77	1.0	3
65	till	36	15	0.1	nd	264	5	0.5	0.4	31	28	15	81	1.1	11.0	2.5	5.1	50	1.1	0.8	5	11.5	3.4	95	0.8	2
66	till	36	14	0.1	nd	267	4	0.5	0.2	26	32	16	94	0.9	10.0	2.5	4.7	50	1.4	0.8	5	11.0	3.2	104	0.5	3
67	till	35	15	0.1	nd	264	5	0.5	0.3	29	42	15	85	1.1	11.0	2.5	4.7	50	1.3	0.8	5	11.0	3.3	99	2.0	3
68	till	32	16	0.2	nd	523	5	0.5	0.7	41	52	16	83	1.0	12.0	2.5	4.8	50	1.1	0.6	5	9.4	3.0	115	1.0	2
69	till	31	14	0.2	nd	382	6	0.5	0.9	41	5	14	88	1.0	13.0	2.5	4.5	50	1.4	0.6	5	10.0	3.3	116	0.5	2
70	till	27	11	0.1	nd	338	6	0.5	0.4	32	23	12	71	1.1	10.0	2.5	4.3	50	1.1	0.6	5	8.2	3.2	115	0.5	2
71	till	27	12	0.1	nd	490	4	0.5	1.0	33	55	13	70	1.1	11.0	2.5	4.2	50	0.7	0.5	5	8.3	3.0	85	1.0	2
72	till	29	13	0.1	nd	342	4	0.5	1.3	32	38	14	75	1.1	11.0	2.5	4.5	50	0.9	0.8	5	8.7	3.3	80	0.5	2
73	till	35	13	0.2	nd	364	4	0.5	0.4	27	24	14	82	0.9	11.0	2.5	4.8	50	1.0	0.7	5	10.0	3.2	95	1.0	3
74	till	39	16	0.3	nd	213	3	0.5	0.3	28	19	14	85	0.9	12.0	2.5	6.8	50	1.1	1.0	5	12.0	3.8	92	0.5	4
75	till	39	15	0.1	nd	303	4	0.5	0.3	31	43	16	120	1.0	11.0	2.5	5.3	50	1.0	0.9	5	12.0	3.1	104	0.5	2
76	till	36	13	0.2	nd	284	5	0.5	0.3	26	31	15	89	1.1	10.0	2.5	5.0	50	0.8	0.9	5	12.0	3.1	91	0.5	2
77	till	35	12	0.1	nd	340	4	0.5	0.4	26	5	15	96	1.1	10.0	2.5	4.9	50	1.1	0.7	5	11.0	3.3	82	1.0	2
78	till	35	11	0.1	nd	321	5	0.5	0.5	25	31	14	84	1.0	9.5	2.5	5.0	50	0.9	0.3	5	12.0	3.4	71	0.5	3
79	till	35	12	0.2	nd	305	4	0.5	0.3	25	28	14	89	0.9	10.0	2.5	4.8	50	0.9	0.6	5	11.0	3.3	89	1.0	2
80	till	35	17	0.1	nd	416	5	0.5	0.5	34	34	16	100	1.0	12.0	2.5	5.2	50	1.0	0.7	5	12.0	3.7	108	1.0	2
81	till	nd	13	nd	nd	326	4	nd	nd	31	nd	17	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	97	nd	nd
82	till	34	20	0.3	nd	333	4	0.5	0.6	31	37	18	97	1.0	13.0	2.5	5.4	50	1.0	0.8	5	11.0	3.2	107	1.0	3
83	till	36	21	0.2	nd	549	5	0.8	0.5	42	59	19	101	1.3	14.0	2.5	5.5	50	1.0	0.9	5	11.0	5.1	121	1.0	3
84	till	31	15	0.1	nd	343	3	0.5	1.0	38	58	15	83	1.1	15.0	2.5	4.7	50	1.2	0.6	5	10.0	4.0	103	1.0	2
85	till	34	21	0.2	nd	328	4	0.5	0.6	35	41	16	91	0.9	13.0	2.5	5.0	50	1.2	1.0	5	10.0	3.8	109	0.5	2
86	till	34	21	0.2	nd	348	3	0.5	0.6	34	35	15	97	0.9	13.0	2.5	5.1	50	1.2	1.0	5	10.0	3.5	104	0.5	2
87	till	40	16	0.3	nd	285	4	0.5	0.2	32	35	18	110	1.3	12.0	2.5	5.4	50	1.0	0.6	5	13.0	3.6	113	0.5	3
88	till	37	12	0.4	nd	500	3	0.5	0.3	34	45	16	88	1.2	12.0	2.5	6.5	50	1.0	1.1	5	11.0	3.3	93	1.0	3
89	till	30	14	0.1	nd	357	4	0.5	0.8	32	36	14	77	1.0	12.0	2.5	4.6	50	1.1	0.8	5	10.0	3.9	97	0.5	2
90	till	28	12	0.2	nd	396	4	0.5	0.9	28	34	13	67	1.0	11.0	2.5	4.3	50	0.6	0.6	5	8.4	3.3	85	0.5	2
91	till	25	11	0.1	nd	262	5	0.5	0.3	24	30	10	61	0.9	7.9	2.5	3.8	50	0.7	0.8	5	7.0	3.1	98	0.5	2
92	till	31	17	0.2	nd	247	5	0.5	0.3	30	31	13	77	1.0	11.0	2.5	4.8	50	1.0	0.7	5	9.0	3.7	104	0.5	2
93	till	30	33	0.4	1.25	304	6	1	0.46	34	41	18	88	1.1	11	2.5	5.7	50	0.8	1	5	11	3	120	1	1
94	till	31	27	0.1	1.31	208	3	0.5	0.36	29	34	18	88	1	10	2.5	5.5	50	1	0.8	5	11	3.1	99	0.5	0.5
95	till	31	28	0.2	1.32	240	4	0.5	0.28	33	40	17	96	1.2	11	2.5	5.7	50	0.9	0.25	5	12	3.6	110	0.5	0.5
96	till	33	32	0.2	1.34	238	4	0.5	0.4	36	43	16	110	1.1	12	2.5	5.7	50	1.1	0.8	5	12	3.6	107	1	1
97	till	31	34	0.3	1.19	371	3	0.5	0.46	38	27	15	84	0.9	12	2.5	5.7	50	1	0.5	5	11	3.1	114	0.5	1
98	till	30	37	0.3	0.97	280	5	1	0.48	42	46	18	92	1.3	13	2.5	6.2	50	0.9	0.7	5	12	3.7	130	1	1
99	till	30	35	0.3	1.12	285	2	0.5	0.52	39	34	15	94	1.1	13	2.5	6	50	1.1	0.7	5	11	3.4	119	0.5	1
100	till	32	28	0	1	247	3	0.5	0.3	33	43	18	100	1.5	11.0	2.5	5.8	50	1.2	0.7	5	13	4.0	121	0.8	1
101	till	28	33	0.1	1.54	145	5	0.5	0.37	32	29	14	96	1.1	12	2.5	5.3	50	0.8	0.7	5	10	3.5	118	0.5	1
102	till	31	25	0.1	1.55	150	2	0.5	0.28	26	5	16	94	1	11	2.5	5.4	50	0.9	0.25	5	11	3.2	95	1	1
103	till	24	30	0.1	1.37	163	3	0.5	0.73	37	38	15	84	1.2	11	2.5	4.7	50	1.2	0.6	5	10	3.2	102	0.5	0.5
104	till	29	34	0.2	1.08	195	2	0.5	0.57	31	28	16	83	0.9	11	2.5	5.6	50	0.7	0.6	5	10	3	98	2	1
Count		79	81	79	12	81	81	79	79	81	79	81	79	79	79	79	79	79	79	79	79	79	79	81	79	79
Average		32.4	17.1	0.19	1.27	326	4.02	0.53	0.49	31.5	33.1	15.4	84.2	1.05	11.2	2.50	5.01	50	1.01	0.71	5.00	10.4	3.43	099	0.71	2.17
Min		22.0	9.0	0.10	0.97	145	2.00	0.50	0.14	19.0	5.0	9.0	42.0	0.50	7.0	2.50	3.70	50	0.60	0.25	5.00	6.3	2.50	066	0.50	0.50
Max		48.0	37.0	0.50	1.55	588	6.00	1.00	1.30	43.0	59.0	20.0	120.0	1.50	15.0	2.50	8.40	50	1.40	1.30	5.00	14.0	5.10	143	2.00	4.00
75%ile		35.0	20.0	0.30	1.35	371	5.00	0.50	0.57	36.0	41.0	17.0	93.5	1.10	12.0	2.50	5.30	50	1.10	0.80	5.00	11.0	3.70	109	1.00	3.00
95% ile		38.1	33.0	0.40	1.54	503	5.00	0.77	1.00	41.0	53.2	19.0	100.1	1.31	14.0	2.50	6.02	50	1.30	1.00	5.00	12.1	4.01	121	1.00	3.00

OTHER SAMPLE TYPES

Short ID	Litholog	La	Li	Lu	Mg	Mn	Mo	Mo	Na	Ni	Ni	Pb	Rb	Sb	Sc	Se	Sm	Sn	Ta	Tb	Te	Th	U	V	W	Yb
1	colluvium	22	11	0.1	nd	437	5	0.8	0.8	27	26	13	48	1.2	10.5	2.5	4.0	50	0.8	0.7	5	7.1	3.1	74	0.8	3
2	colluvium	26	11	0.3	nd	328	3	0.5	1.0	29	52	15	61	1.2	11.0	2.5	4.6	50	1.3	1.0	5	8.6	3.8	66	1.0	3
55	diamictor	40	20	0.1	nd	300	4	0.5	0.4	45	60	17	100	1.7	16.0	2.5	5.6	50	1.3	0.9	5	11.0	4.6	141	1.0	3
56	diamictor	26	10	0.1	nd	656	5	0.5	0.6	44	60	14	58	1.5	13.0	2.5	4.5	50	1.2	0.8	5	7.2	3.6	96	1.0	3
6	sand	28	12	0.3	nd	501	3	0.5	1.2	38	61	18	64	1.2	12.0	2.5	4.5	50	1.0	0.7	5	9.3	3.2	79	1.0	2
20	ss	23	10	0.2	nd	2300	6	0.5	1.4	42	54	8	41	0.5	17.0	2.5	3.4	50	0.6	0.3	5	5.1	1.7	102	0.5	1
38	silty clay	30	18	0.1	nd	367	5	0.5	0.4	35	44	13	91	1.0	11.0	2.5	4.8	50	1.0	0.9	5	10.0	4.0	120	0.5	2
40	s&g	22	12	0.2	nd	326	4	0.5	0.4	25	28	13	55	0.9	8.0	2.5	4.3	50	1.0	0.7	5	7.9	4.1	75	0.5	2
48	gravel	27	11	0.1	nd	2100	3	0.5	1.1	29	33	8	52	0.8	10.0	2.5	4.3	50	0.8	0.6	5	8.9	3.7	63	1.0	3
49	bentonite	35	8	0.1	nd	63	3	0.5	0.8	5	5	44	29	0.5	8.7	2.5	6.6	50	1.6	0.7	5	22.6	6.5	21	0.5	2
51	fluvial	30	12	0.2	nd	355	3	0.5	1.2	29	26	14	81	0.9	12.0	2.5	4.5	50	0.9	0.9	5	10.0	4.4	68	1.0	3

All values below detection limit are shown as 1/2 of detection limit nd = no data AA= atomic absorption spectrometry NA = instrumental neutron activation analysis

Appendix 1, part 3. Geochemical and related data from surface samples discussed in this report

Element		Zn	Zn	Zr	Wt	Lab Tex	Lab Tex	Lab Tex	Lab Tex	Lab Tex	Lab Tex	Lab Tex	Chittick	Chittick	Chittick	Chittick	Chittick	Chittick	FieldMeasur	Field Text	Field Text	Field Text		
Method		AA/Tota	NA	NA									Calcite	Total	Calcite	Dolomite	Total	Cct/Dmt	Reaction				Sample	
DetectionLimit		2 ppm	100 ppm	200 ppm		Sand	Sand	Silt	Clay	Sand	Silt	Clay		Carbonate			Carbonates	Ratio	with HCl	Sand %	Silt%	Clay%	Depth	m
TILL ONLY																								
Short ID	Lithology					% 1-2mm	(>63)	(<63)	(<4)	(>50)	(<50)	(<2)	ml/g)	ml/gm	%	%	%			(>63)	(<63)	(<4)	From	To
3	till	90	50	350	11.85	5.5	31.0	32.5	36.5	33.0	38.6	28.4	12.1	33.1	5.4	8.6	14.10	0.63	4	25	15	40	15.0	15.5
4	till	88	50	100	10.01	0.7	22.7	33.4	43.9	24.6	44.8	30.6	11.0	24.5	4.9	5.6	10.50	0.89	4	20	50	30	1.8	2.0
5	till	112	50	100	7.68	1.2	22.7	40.5	36.8	24.0	49.9	26.1	8.4	28.0	3.8	8.1	11.80	0.46	4	5	35	60	1.5	1.8
7	till	110	50	100	9.11	0.7	25.9	49.6	24.5	28.2	54.2	17.6	12.8	25.4	5.7	5.2	10.90	1.11	4	20	50	30	3.0	3.5
8	till	156	160	390	7.98	7.2	32.7	41.2	26.1	35.4	45.1	19.5	4.3	18.5	1.9	5.8	7.80	0.34	4	30	30	40	3.0	4.0
9	till	111	50	100	8.95	1.3	18.5	45.6	35.9	21.0	50.1	28.9	13.1	30.8	5.9	7.3	13.20	0.81	4	5	60	25	2.0	2.5
10	till	96	50	100	9.96	1.4	20.0	45.8	34.2	22.6	51.7	25.7	12.4	30.0	5.6	7.2	12.80	0.77	3,4	20	55	25	0.5	1.0
11	till	78	50	100	11.72	1.7	14.8	51.5	33.7	16.7	60.3	23.0	59.4	88.2	26.6	11.9	38.45	2.25	4	20	55	25	0.4	0.8
12	till	84	50	370	10.68	1.6	20.0	58.5	21.5	23.2	64.3	12.5	20.5	43.2	9.2	9.3	18.50	0.99	4	15	55	30	0.6	1.0
13	till	105	50	550	12.64	0.2	14.9	47.3	37.8	17.0	55.0	28.0	1.7	8.1	0.8	2.6	3.40	0.29	3	10	40	50	1.1	1.3
14	till	96	50	330	12.67	0.2	28.9	53.7	17.4	32.6	55.3	12.1	4.2	18.7	1.9	6.0	7.80	0.32	2	25	65	10	1.3	1.5
15	till	107	50	100	11.89	1.6	35.5	31.4	33.1	36.9	38.6	24.5	5.9	18.3	2.7	5.1	7.70	0.54	4	15	50	35	2.5	3.0
16	till	124	50	100	10.72	1.1	12.0	46.5	41.5	13.7	56.9	29.4	2.5	12.8	1.1	4.2	5.30	0.27	1	10	40	50	1.2	1.5
17	till	112	50	100	8.75	1.5	26.8	45.0	28.2	29.3	50.2	20.5	1.9	12.8	0.8	4.5	5.30	0.19	1	30	40	30	1.0	1.2
18	till	95	50	390	10.99	1.3	31.3	37.7	31.0	33.0	44.6	22.4	4.7	14.9	2.1	4.2	6.30	0.50	3	15	45	40	2.0	2.2
19	till	92	50	100	12.59	1.2	31.9	34.7	33.4	33.5	41.1	25.4	9.8	26.3	4.4	6.8	11.20	0.65	3,4	15	40	45	1.2	1.5
21	till	85	50	100	8.97	0.7	14.0	49.3	36.7	15.4	59.1	25.5	13.7	32.0	6.1	7.6	13.70	0.81	4	10	50	40	nd	nd
22	till	89	50	490	13.09	2.3	26.1	44.4	29.5	29.4	46.8	23.8	11.8	37.0	5.3	10.4	15.70	0.51	4	15	40	45	4.0	4.5
23	till	58	50	100	10.33	2.2	16.7	60.0	23.3	18.5	64.0	17.5	8.7	23.3	3.9	6.0	9.90	0.64	4	10	50	40	2.5	3.0
24	till	110	50	100	10.65	1.3	13.1	58.2	28.7	14.8	66.7	18.5	4.9	17.4	2.2	5.1	7.30	0.44	4	10	60	30	2.8	3.0
25	till	93	50	100	11.96	2.1	30.1	44.3	25.6	33.0	48.5	18.5	8.6	23.0	3.9	5.9	9.80	0.65	4	10	60	30	2.0	2.2
26	till	90	50	100	11.81	1.8	23.1	48.0	28.9	25.8	55.3	18.9	12.4	25.8	5.5	5.5	11.10	1.00	4	10	60	30	1.5	1.6
27	till	93	50	490	14.14	6.5	47.6	45.7	6.7	50.4	46.1	3.5	3.9	25.0	1.8	8.7	10.40	0.20	nd	nd	nd	nd	1.0	1.2
29	till	128	50	230	12.76	12.2	39.5	41.8	18.7	41.6	44.2	14.2	19.1	61.5	8.6	17.5	26.00	0.49	nd	nd	nd	nd	5.0	nd
35	till	90	50	100	10.38	1.5	26.4	46.2	27.4	30.3	50.3	19.4	18.6	43.5	8.3	10.2	18.60	0.82	nd	nd	nd	nd	nd	nd
41	till	181	nd	nd	nd	25.0	49.5	41.8	8.7	50.6	43.7	5.7	3.2	15.5	1.4	5.1	6.50	0.29	nd	nd	nd	nd	nd	nd
43	till	126	50	250	11.77	4.4	25.2	49.6	25.2	28.0	51.8	20.2	5.2	22.8	2.3	7.2	9.60	0.34	nd	nd	nd	nd	nd	nd
45	till	98	50	390	11.57	4.8	34.9	44.2	20.9	38.4	44.3	17.3	9.4	35.5	4.2	10.7	14.90	0.39	nd	nd	nd	nd	nd	nd
46	till	97	50	100	12.41	2.1	25.3	38.7	36.0	29.0	40.7	30.3	4.2	10.7	1.9	2.7	4.55	0.71	nd	nd	nd	nd	nd	nd
50	till	121	50	330	13.04	0.7	20.1	45.3	34.6	22.3	50.2	27.5	2.8	11.8	1.3	3.7	5.00	0.34	nd	nd	nd	nd	nd	nd
52	till	99	50	100	13.91	1.2	29.1	37.1	33.8	31.7	42.5	25.8	6.4	20.6	2.8	5.9	8.70	0.50	nd	nd	nd	nd	16.5	17.0
53	till	119	50	430	12.77	0.5	22.8	34.9	42.3	24.1	41.1	34.8	3.7	13.3	1.7	4.0	5.60	0.42	nd	nd	nd	nd	1.0	1.2
54	till	98	50	100	12.55	1.2	26.0	35.9	38.1	29.8	37.7	32.5	6.7	20.9	3.0	5.9	8.80	0.52	4	20	50	30	2.0	2.0
57	till	127	50	390	11.06	7.3	27.0	44.7	28.3	28.7	47.4	23.9	4.8	16.8	2.2	4.9	7.10	0.44	4	nd	nd	nd	2.5	3.0
58	till	106	50	100	11.70	3.6	30.6	47.7	21.7	33.4	49.5	17.1	1.9	5.6	0.8	1.5	2.40	0.55	1	15	60	25	1.5	1.8
59	till	96	50	100	11.25	7.0	34.3	40.6	25.1	35.9	42.3	21.8	2.0	7.3	0.9	2.2	3.10	0.40	3	nd	nd	nd	1.5	2.0
60	till	94	50	430	16.02	7.5	41.5	46.9	11.6	45.5	45.8	8.7	5.0	19.2	2.3	5.8	8.10	0.40	4	75	20	5	3.5	4.0
61	till	85	50	280	12.52	1.8	15.9	45.0	39.1	17.8	49.2	33	18.8	43.4	8.4	10.1	18.50	0.84	4	10	30	60	1.5	1.8
62	till	92	50	310	11.16	1.6	13.3	44.3	42.4	16.0	48.9	35.1	25.2	47.2	11.3	9.0	20.30	1.25	4	10	40	50	1.8	2.0
63	till	90	50	450	9.12	2.3	20.4	41.5	38.1	23.1	45.5	31.4	15.3	39.4	6.9	9.9	16.80	0.69	4	15	25	60	3.0	3.5
64	till	93	50	480	13.13	3.0	34.4	47.9	17.7	38.8	46.3	14.9	10.1	34.7	4.5	10.1	14.65	0.45	4	15	25	60	2.5	3.0
65	till	94	50	235	10.23	1.2	10.2	57.2	32.6	11.8	63.9	24.3	8.5	25.2	3.8	6.9	10.70	0.55	4	15	25	60	1.5	1.8
66	till	94	50	270	10.70	1.8	22.5	51.6	25.9	25.1	53.0	21.9	10.4	33.2	4.7	9.4	14.10	0.50	4	25	25	50	1.3	1.5
67	till	87	50	290	9.95	1.4	16.4	55.5	28.1	19.4	56.7	23.9	11.9	37.4	5.3	10.5	15.80	0.51	4	nd	nd	nd	1.8	2.0
68	till	98	50	100	10.04	0.5	12.6	40.9	46.5	14.3	49.1	36.6	10.7	23.4	4.8	5.2	10.00	0.92	4	20	50	30	2.0	2.3
69	till	105	50	100	8.93	1.5	24.5	42.3	33.2	27.2	46.3	26.5	6.3	16.6	2.8	4.2	7.10	0.67	4	10	30	70	20.0	21.0
70	till	113	50	250	13.74	10.9	33.8	43.3	22.9	36.4	46.1	17.5	19.2	52.6	8.6	13.7	22.30	0.63	4	60	25	15	2.5	3.0
71	till	97	50	100	10.72	2.4	38.4	36.7	24.9	41.4	40.1	18.5	6.1	15.3	2.7	3.8	6.50	0.73	4	60	20	20	2.0	2.5
72	till	107	50	100	10.07	1.4	32.7	45.0	22.3	36.7	49.8	13.5	4.5	13.9	2.0	3.9	5.90	0.52	4	30	50	20	3.0	3.5
73	till	91	50	330	11.19	2.0	26.5	45.9	27.6	30.3	47.7	22.0	13.9	32.9	6.3	7.8	14.00	0.80	3,4	15	55	30	1.8	2.3
74	till	90	50	450	10.55	1.1	21.5	39.7	38.8	25.5	41.5	33.0	1.7	3.1	0.8	0.5	1.30	1.41	1,2	20	55	25	0.0	0.5
75	till	103	50	450	9.63	1.3	11.8	53.0	35.2	14.6	57.1	28.3	13.6	31.1	6.1	7.2	13.30	0.84	1,2	15	60	25	0.8	1.2
76	till	91	50	400	13.35	2.1	30.1	35.8	34.1	31.6	39.9	28.5	13.8	32.5	6.2	7.7	13.90	0.80	4	25	45	35	1.3	1.5
77	till	89	50	550	10.97	2.4	21.0	47.3	31.7	24.4	50.4	25.2	14.1	39.3	6.3	10.4	16.70	0.61	4	30	55	15	2.2	2.4
78	till	79	50	100	12.60	1.8	20.7	49.0	30.3	23.2	54.5	22.3	16.9	41.0	7.6	9.9	17.50	0.77	nd	35	55	10	1.7	1.9
79	till	88	50	100	11.25	2.1	18.3	46.6	35.1	21.9	49.6	28.5	18.1	41.2	8.1	9.5	17.60	0.85	4	10	60	30	3.0	3.5
80	till	103	50	100	8.70	0.9	20.1	34.5	45.4	22.3	41.4	36.3	7.1	21.6	3.2	6.0	9.10	0.54	4	10	30	60	2.0	2.5
81	till	108	nd	nd	nd	1.8	24.0	38.9	37.1	27.4	42.5	30.1	6.6	25.5	3.0	7.7	10.70	0.38	3	15	40	45	2.4	2.6
82	till	105	50	280	13.63	1.0	27.8	31.6	40.6	29.8	37.6	32.6	5.0	16.0	2.2	4.5	6.70	0.50	3	15	40	45	2.3	2.5
83	till	139	50	100	10.30	1.0	21.6	35.7	42.7	24.0	41.0	35.0	3.5	12.1	1.6	3.5	5.10	0.45	2	20	35	45	3.0	3.5
84	till	104	50	400	12.36	1.3	32.4	26.7	40.9	34.7	34.0	31.3	4.5	10.8	2.0	2.6	4.60	0.77	2	20	40	40	4	4.5
85	till	101	50	100	11.08	1.3	29.4	32.9	37.7	31.9	38.5	29.6	5.9	19.1	2.7	5.5	8.10	0.50	2	15	40	45	3.3	3.5
86	till	100	50	310	10.75	1.2	25.3	33.0	41.7	27.3	39.4	33.3	5.3	17.6	2.4	5.0	7.40	0.48	nd	nd	nd	nd	nd	nd
87	till	113	50	100	11.22	2.9	19.5	48.4	32.1	22.1	55.2	22.7	3.2	18.4	1.5	6.2	7.70	0.24	1	10	50	40	1.0	1.2
88	till	103	50	390	11.71	1.9	37.7	31.7	30.6	40.4	36.4	23.2	2.5	6.4	1.1	1.6	2.70	0.68	1	30	50	20	3.0	3.5
89	till	101	50	100	11.40	1.8	23.7	37.7	38.6	26.4	47.9	25.7	9.2	24.4	4.1	6.3	10.40	0.65	4	10	60	30	2.5	2.8
90	till	91	50	370	12.99	2.1	28.8	44.0	27.2	32.1	49	18.9	7.2	23.1	3.2	6.6	9.80	0.50	4	10	60	30	2.5	2.8
91	till	92	50	100	12.24	1.3	13.9	49.3	36.8	17.8	54.2	28.0	24.8	64.9	11.1	16.5	27.60	0.67	4	nd	nd	nd	2.0	2.3
92	till	135	50	340	13.08	3.1	12.6	48.6	38.8	15.2	55.2	29.6	5.4	29.6	2.4	10.0	12.40	0.24	nd	nd	nd	nd	nd	nd
93	till	111	50	100	9.32	0.7	21.7	35.8	42.5	24.4	43.3	32.3	6.5	21.5	2.9	6.2	9.10	0.48	4	25	25	50	1.9	2.0
94	till	112	50	100	8.17	0.5	12.5	52.6	34.9	16.0	58.7	25.3	8.2	28.6	3.7	8.4	12.10	0.44	4	20	30	50	1.8	2.0
95	till	127	50	100	9.73	2.3	22.3	47.0	30.7	24.8	53.3	21.9	5.0	21.4	2.3	6.8	9.00	0.35	4	30	20	50	3.5	4.0
96	till	116	50	100	11.35	1.2	16.4	38.1	45.5	19.5	45.3	35.2	8.0	24.8	3.6	6.9	10.50	0.52	4	15	50	35	3.0	3.5
97	till	103	50	100	9.73	0.6	14.6	32.2	53.2	16.2	44.6	39.2	15.4	29.4	6.9	5.8	12.65	1.20	4	20	50	30	1.0	1.5
98	till	122	50	100	10.42	1.1	25.0	34.2	40.8	27.5	39.9	32.6	3.6	12.3	1.6	3.6	5.20	0.44	3	25	40	35	2.0	2.5
99	till	119	50	100	9.92	0.9	26.0	32.9	41.1	28.3	38.2	33.5	2.8	9.8	1.3	2.9	4.20	0.44	4	20	50	30	3.0	3.5
100	till	133	50	425	10.7	2.4	14.6	52.4	33.0	17.5	57.3	25.2	4.4	14.9	2.0	4.3	6.30	0.46	3	30	50	20	2.0	2.2
101	till	125	50	100	8.76	0.3	3.1	48.7	48.2	3.6	62.7	33.7	9.5	31.0	4.3	8.9	13.10	0.49	4	nd	nd	nd	nd	ND
102	till	106	50	100	11.55	0.5	14.1	38.4	47.5	17.2	47.5	35.3	16.6	37.5	7.4	8.6	16.00	0.87	4	nd	nd	nd	1.5	ND
103	till	120	50	100	10.04	1.0	44.5	33.6	21.9	46.8	38.9	14.3	7.0	19.6	3.1	5.2	8.30	0.61	4	70	20	10	2.5	ND
104	till	88	50	610	11.22	1.1	27.1	36.9	36.0	30.6	41.3	28.1	5.1	15.4	2.3	4.3	6.5	0.5	4	30	20	50	1.5	2.0
Count		81	79	79	79	81	81	81	81	81	81	81	81	81	81	81	81	81	63	63	63	63		
Average		104	51	228	11.1	2.47	24.4	43.0	32.6	27.0	48.1	24.9	9.4	25.7	4.22	6.69	10.9	0.61	3.52	20.9	42.9	36.0		
Min		58	50	100	7.7	0.17	3.1	26.7	6.7	3.6	34.0	3.5	1.7	3.1	0.80	0.50	1.3	0.19	1.00	5.0	15.0	5.0		
Max		181	160	610	16.0	24.98	49.5	60.0	53.2	50.6	66.7	39.2	59.4	88.2	26.60	17.45	38.5	2.25	4.00	75.0	65.0	70.0		
75%ile		112	50	370	12.4	2.26	30.1	47.9	38.6	32.6	53.3	30.3	12.4	32.5	5.60	8.60	13.9	0.77	4.00	25.0	55.0	45.0		
95% ile		133	50	490	13.6	7.31	39.5	55.5	45.5	41.6	62.7	35.2	19.2	47.2	8.60	10.70	20.3	1.11	4.00	57.5	60.0	60.0		

OTHER SAMPLE TYPES

Short ID	Litholog	Zn	Zn	Zr	Wt	% 1-2mm	(>63)	(<63)	(<4)	(>50)	(<50)	(<2)	ml/g)	ml/gm	%	%	%		HCl	(>63)	(<63)	(<4)	From	To
1	colluvium	106	50	370	14.36	9.0	48.6	42.3	9.1	51.7	44.7	3.6	6.4	29.3	2.9	9.4	12.25	0.31					2.0	3.0
2	colluvium	123	50	600	11.32	3.4	36.2	42.8	21.0	40.3	45.3	14.4	1.0	15.1	0.5	5.8	6.20	0.09	1	30	50	20	2.0	2.5
55	diamicton	136	120	510	14.19	17.4	45.7	42.2	12.1	46.8	44.2	9.0	2.1	7.3	1.0	2.1	3.10	0.45	2	60	30	10	2.0	2.5
56	diamicton	141	50	560	16.25	11.8	60.5	31.6	7.9	62.8	32.0	5.2	16.0	33.0	7.2	7.0	14.20	1.02	4	80	15	5	2.0	2.5
6	sand	102	50	480	9.80	0.7	41.9	38.2	19.9	44.4	42.1	13.5	2.6	6.5	1.2	1.6	2.80	0.72	1	90	7	3	1.0	1.3
20	ss	79	50	100	11.51	0.9	79.2	15.0	5.8	80.4	16.9	2.7	32.4	50.1	14.5	7.3	21.80	1.99	3	nd	nd	nd	nd	nd
38	silty clay	119	50	100	11.08	2.5	16.4	39.8	43.8	18.8	45.8	35.4	9.4	26.3	4.2	7.0	11.20	0.61	nd	nd	nd	nd	nd	nd
40	s&g	111	50	630	16.62	6.4	85.9	11.6	2.5	87.2	11.3	1.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
48	gravel	59	50	520	17.22	10.6	78.1	19.5	2.4	80.9	17.8	1.3	5.4	20.6	2.4	6.2	8.70	0.40	nd	nd	nd	nd	nd	nd
49	bentonite	110	50	330	11.36	0.2	1.8	27.2	71.0	2.5	32.0	65.5	3.7	8.3	1.6	1.9	3.60	0.86	nd	nd	nd	nd	nd	nd
51	fluvial	88	50	500	17.62	8.7	37.5	54.8	7.7	38.9	56.8	4.3	3.2	10.8	1.4	3.1	4.60	0.46	nd	nd	nd	nd	nd	nd

All values below detection limit are shown as 1/2 of detection limit nd = no data AA= atomic absorption spectrometry NA = instrumental neutron activation analysis

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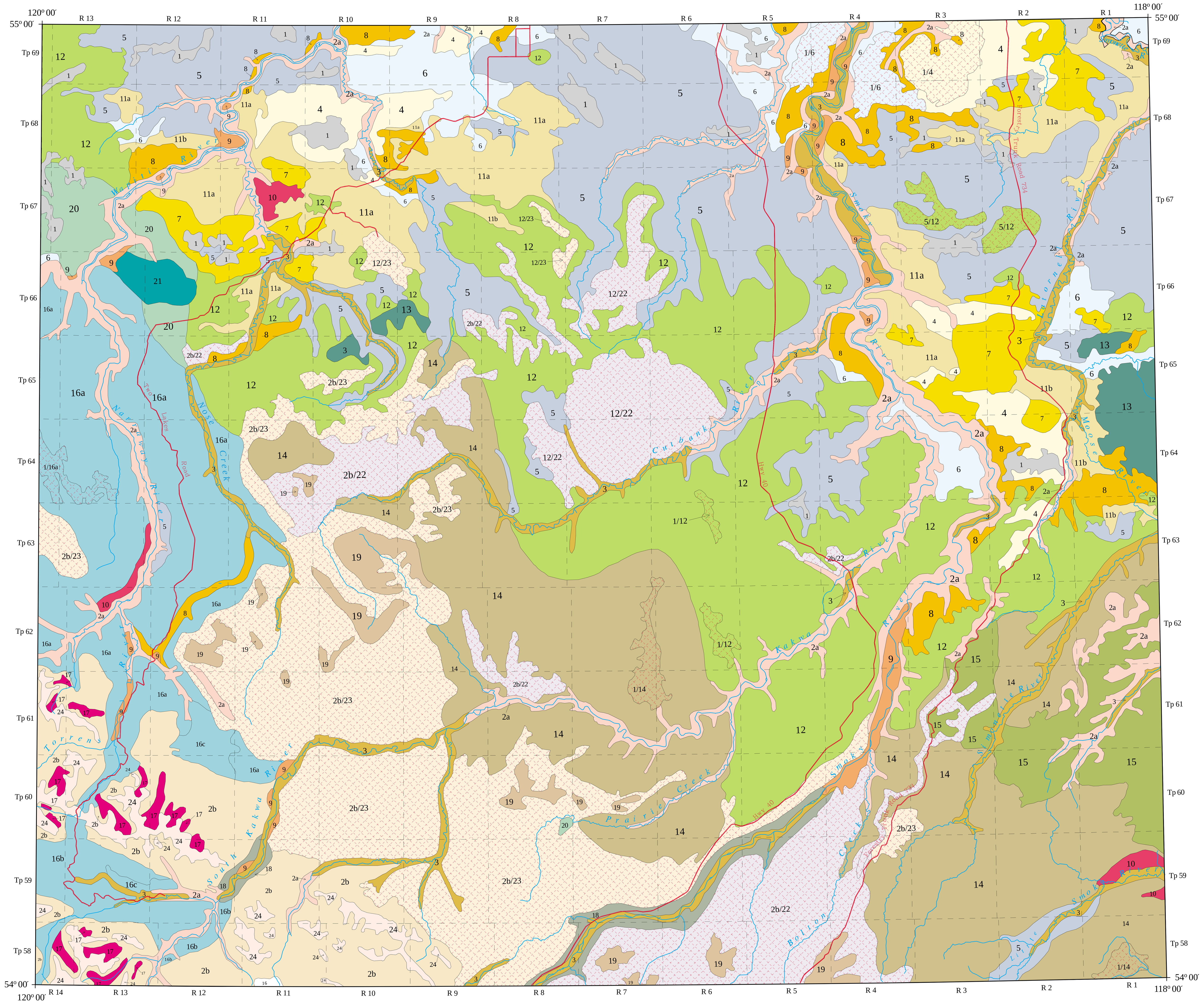


RECENT

- 1 Organic Deposits
- 2a Colluvial Deposits (mixed glacial and bedrock material)
- 2b Colluvial Deposits (soil creep)
- 3 Fluvial Deposits
- 4 Aeolian Deposits

PLEISTOCENE

Glaciolacustrine

- 5 Silt and Clay
- 6 Silt, Minor Sand
- 7 Sand

Glaciofluvial

- 8 Sand
- 9 Gravel
- 10 Ice-contact sediment
- 11 Undifferentiated Glaciofluvial and Aeolian Deposits

Moraine Continental

- 12 Ground Moraine
- 13 Hummocky Moraine
- 14 Ground Moraine (locally derived)
- 15 Ground Moraine (overlying Tertiary gravel)

Cordilleran

- 16 Ground Moraine
- 17 Cirque Valley Glacier Moraine
- 18 Lateral Moraine
- 19 Moraine-Colluvium Undifferentiated

Mixed Continental-Cordilleran Moraine

- 20 Ground Moraine
- 21 Hummocky Moraine

BEDROCK

- 22 Shale, Siltstone, Coal
- 23 Sandstone
- 24 Conglomerate, Sandstone

2b/23 Thin unit known to overlie another unit: e.g. soil creep/bedrock sandstone

Major Highway

Source of Geological Information

Surficial Geology of Wapiti Map Area (preliminary unpublished), Alberta Geological Survey, L. Bayrock, 1972.

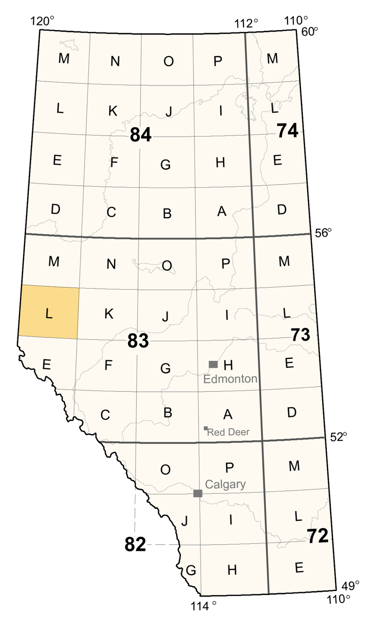
Soil Survey and Interpretations of the Wapiti Map Area, Alberta, Bulletin 39, Alberta Research Council, A.G. Twardy and I.G.W. Corns, 1980.

Surficial Geology of Wapiti Map Area, OFR 1983-23 (blue line), Alberta Research Council, L. D. Andriashek, 1983.

Unit Symbol	Unit Name	Description	General Morphology and Relief	General Thickness	Comments
	RECENT				
1	Organic Deposits	Bog, fen: peats developed from sedges and mosses; wet, poorly drained; minor silty-clay and marl sediment	Occupies depressions; concave topography; undulating morphology	< = 1.5m	
2a	Colluvial Deposits	Rough, broken land; stream and gully valleys; mixed glacial and bedrock material, slope stability variable	Veneer on low to high relief slopes; small floodplains	Generally thin (< = 1m), but variable in slump areas	
2b		Soil creep; thin deposits derived from local bedrock; may resemble till in high plateaus and benchlands; very stony with sand loam to clay loam matrix	Occurs as stone stripes, circles, boulderfields at elevation > 1800m; otherwise found as a thin veneer mantling high relief hills and plateaus	Variable, generally < = 1m though may exceed 2m in solifluction lobes	Has till-like appearance in southwest part of map area
3	Fluvial Deposits	Clay, silt, sand, gravel found along drainage channels of major rivers and creeks; variable texture both vertically and horizontally, poorly sorted.	Level to undulating topography; terraces	Variable thickness; may exceed 2m	Gravel found along large mountain streams; and sand found along streams away from mountains
4	Aeolian Deposits	Fine-grained sand in sheet or dune form; derived from fluvioglacial and lacustroglacial deposits; stone free	Local relief up to 5m; rolling to hummocky topography; in form of U-shaped and longitudinal dunes	Thick in dunes (> = 5m) but thin between dunes	Found in extensive areas east of Smoky and Wapiti rivers in northern part of map area

Unit Symbol	Unit Name	Description	General Morphology and Relief	General Thickness	Comments
	PLEISTOCENE				
	Glaciolacustrine				
5	Silt and Clay	Rhythmically bedded yellow-brown silt and dark grey-brown clay layers with occasional to common ice rafted stones	Broad, undulating topography; masks underlying morphology; may be found on terraces along rivers	Variable; <1m - 4m; typically about 3m	Found in northeastern part of map area. Stoniness due to ice rafting or turbidite flow
6	Silt, Minor Sand	Stratified silt; minor sand, clay; stone free. Surface may be poorly reworked by wind	Broad plains near meltwater channels; found as a undulating veneer	Variable; generally >1m	Found in plains especially where Pinto Creek empties into the Wapiti River
7	Sand	Fine to medium-grained sand deposited as inwash in proglacial lakes; odd quartzite pebbles; occasional beds of gravel, silt, clay	Found as deltaic plain landforms; undulating rolling topography	Generally thick (>2m)	Found in northern part of map sheet
	Glaciofluvial				
8	Sand	Outwash sand with minor gravel, silt, clay; odd pebble up to 2cm diameter	Assciated with meltwater channels; level to rolling topography	1.5 - 6m thick	
9	Gravel	Outwash gravel, coarse, minor sand; found as terrace deposits of major rivers. In part valley train derived from valley glaciers	Undulating topography on terraces	Variable; 1 - >30m thick	Terrace gravel along Little Smoky River composed mainly of rounded quartzitic cobbles
10	Ice Contact	Poorly sorted sand and gravel found in kames and eskers	Ridged to rolling topography; variable; generally >2m, <10m		
11a	Undifferentiated Glaciofluvial and Aeolian Deposits	Stone free to slightly stony sand; may be glaciofluvial deposit modified by wind; overlies glaciolacustine deposits	Reflects underlying landform; occurs as a veneer	Generally <1m	Occurs in benchland plateaus and lower plains areas
11b		As above but overlies morainal deposits			
	Moraine Continental				
12	Ground Moraine	Clayey to sandy till, slightly to moderately stony, olive brown color; numerous erratics derived from the Canadian Shield. Found in plains and plateaus of northeast half of map sheet	Undulating to gently rolling topography	Generally thin (<1m) in uplands to thick in lowlands (>5m)	Most of stones are derived from the mountains - limestone, metaquartzite, orthoquartzite, sandstone
13	Hummocky Moraine	Clayey to sandy till, numerous erratics derived from the Canadian Shield	Moderate to high relief; hummocky topography formed in stagnant ice environment	Variable; generally thick (>10m)	As above
14	Ground Moraine (locally derived)	Yellow-brown till, friable to firm; moderately to exceedingly stony, pebbles mostly well rounded metaquartzites; minor Canadian Shield erratics; derived almost entirely from local bedrock material	Occurs mostly in high plateaus and benchlands; topography determined by underlying bedrock morphology; found as a veneer in most areas	Thin on uplands and steep slopes (<2m) Thick in deeper valleys	Found in central, south-central and southwestern parts of map area. May be very stony where unit overlies Tertiary gravel
15	Ground Moraine (overlying Tertiary gravel)	Till derived from Tertiary gravel; gravel has a high content of well rounded quartzites and sandstones; till typically very stony	Till found as a discontinuous veneer over gravel caps on tablelands and plateaus; topography undulating to gently rolling	Till generally thin to discontinuous Gravel thickness ranges from 1 to 10 m	Occurs in plateaus east of Simonette Tower in southeast part of map area. Shield erratics are very few to absent
	Cordilleran				
16a	Ground Moraine	Stony calcareous till, friable, dark, grey-brown color, loam matrix; contains rocks derived from the Rocky Mountains local bedrock; stagnant ice topography uncommon	Along foothills unit forms grooves, flutes and drumlin fields; found on high relief rolling bedrock	Variable: 0 - 5m; generally <2m	Occurs in northwestern and westcentral parts of map area
16b		Coarse textured, friable yellow-brown to dark brown till; exceedingly stony; pebbles are well rounded quartzites and angular sandstones; unit contains abundant colluviated till and fan material	Occurs as a veneer of flutes, grooves, lateral and end moraines on steeply sloping ridges with high relief	Variable to discontinuous; generally <2m thick	Found in Rocky Mountain Foothills in southwestern part of map area
16c		Stony till with a silty-clay matrix; derived from massive, dense, glacially reworked shales, variable stone suite derived from mountains	Morainal veneer on a moderately rolling topography		Found in Rocky Mountain Foothills
17	Cirque Valley Glacier Moraine	Very stony till, almost gravel like composition, composed of local bedrock		Variable thickness	
18	Lateral Moraine	Dissected lateral moraine of large valley glaciers; till and glaciofluvial deposits in form of poorly defined benches; very stony and calcareous; may be capped by outwash gravel in places	Terrace bench along Smoky River	Variable; generally >2m	
19	Moraine-Colluvium Undifferentiated	Weathered till, carbonates leached to 2.5m; very stony, resembles colluviated bedrock material in places	A veneer on level, elevated benches and plateaus	Generally thin (<5m)	Found in southwest part of map area. Interpreted by L. Bayrock to be outside of Wisconsin glaciated area
	Mixed Continental-Cordilleran Moraine				
20	Ground Moraine	Till containing erratics from both the Canadian Shield and from the Rocky Mountains; stony to very stony; deposited by ice coalesced from the two source areas	Level to undulating topography	Generally thin	Found in northwest corner of the map area
21	Hummocky Moraine	Same unit as above, except till deposited from stagnant ice	Hummocky topography	Generally thick	Found in northwest corner of the map area

Unit Symbol	Unit Name	Description	General Morphology and Relief	General Thickness	Comments
	TERTIARY-CRETACEOUS-MESOZOIC				
22	Shale, Siltstone, Coal	Outcrops found in south-central and central parts of map area; commonly mantled by colluvium	Undulating to moderately rolling upland plateaus	Weathered to a depth of 0.5 - 2m	Commonly stratified; shale may resemble lacustrine deposits; weathered shale prone to slumping
23	Sandstone	Paskapoo Sandstone found in the upland plateaus; Blackstone, Cardium, Wapiabi, Brazeau sandstones in the foothills. Commonly mantled by colluvium	Steeply sloping scarps and ridges; moderate to high relief	Weathered to a depth of 0.5 - 2m	
24	Conglomerate, Sandstone	Located in the Rocky Mountain Foothills in the southwest corner of the map area; all exposuers of bare rock with less than 0.1m of mineral or organic cover	Strongly rolling to very hilly	Weathered to a depth of < 0.1m	Occurs at tops of glacially abraded mountains, mountain slopes, canyons



Surficial Geology of Wapiti Area, NTS 83L

Scale 1:250,000

Kilometres 5 0 5 10 15 20

Miles 5 0 10 15

UTM Zone 11 NAD 27

Map 239

L. D. Andriashek

Digital version of Open File Report 1983-23
Compiled from Bayrock, 1972, and Twardy, 1980;

Figure 2.1 of Earth Sciences Report 2000-12

Digital Geology Compilation
D.K. Chao

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