Newfoundland Labrador

Natural Resources

Mines

A HIGH-DENSITY LAKE SEDIMENT AND WATER SURVEY IN SOUTHEASTERN LABRADOR
(NTS MAP AREAS 2M/13, 3D/4-5, 12-13, 12P/6-7, 9-11, 14-16, 13A/1, 9, 16, and 13H/1-11)

J.W. McConnell and M.J. Ricketts

Open File LAB/1538

St. John's, Newfoundland
June, 2010

NOTE

DISCLAIMER

Recommended citation:
McConnell, J.W. and Ricketts, M.J.
2010: A high-density lake sediment and water survey in southeastern Labrador (NTS map areas 2M/13, 3D/4-5, 12-13, 12P/6-7, 9-11, 14-16, 13A/1, 9, 16, and 13H/1-11). Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File LAB/1538, 262 pages.

Cover: Photograph taken 15 km north of Port Hope Simpson (NTS map area 13A/16). Lake sample 6256711 collected from the smaller lake on the left of the photograph.

Natural Resources

Mines

A HIGH DENSITY LAKE SEDIMENT AND WATER SURVEY IN SOUTHEASTERN LABRADOR
(NTS MAP AREAS 2M/13, 3D/4-5, 12-13, 12P/6-7, 9-11, 14-16, 13A/1, 9, 16, and 13H/1-11)

J.W. McConnell and M.J. Ricketts

Open File LAB/1538

St. John's, Newfoundland
June, 2010

CONTENTS

Page

TABLES

FIGURES

Page

ABSTRACT

*A lake sediment and water survey was conducted in 2006 and 2007 over portions of NTS map areas 2M, 3D, 12P, 13A and 13H in southeast Labrador. The surveyed area is underlain primarily by rocks of the Grenville Province which, in this area, is subdivided into a northern exterior thrust belt and a southern interior magmatic belt. The Grenvillian thrust belt is composed predominantly of crust formed during the Labradorian Orogeny (*ca. *1710 to 1620 Ma). The interior magmatic belt is characterized by numerous Grenvillian (*ca. *1080 to 960 Ma) plutons emplaced into an assemblage of 1510 to 1450 Ma granitic intrusions that were themselves intruded into Labradorian crust.*

Several instances of copper, nickel and molybdenum mineralization are known. One instance of thorium and uranium are reported and one of zirconium, possibly associated with rare earth mineralization.

A nominal sample density of one per four square kilometres was used, although the presence of some areas without suitable lakes reduced the effective sample density. Lake sediment samples were collected and analyzed from 2129 sites and water samples from 2234 sites. In a few cases a scarcity of material prevented analysis of the full analytical suite. In addition, one site in twenty was sampled in duplicate for quality control purposes. Sampling was conducted by float-equipped helicopter using a weighted tubular steel gravity sampler for sediment collection. Sediment samples were analyzed for a standard suite of 48 elements and loss-on-ignition. Additionally, 13 of the elements were analyzed using two different methods. Waters were analyzed for pH, conductivity and 27 elements.

The report provides summary statistics of the geochemical data, correlation analyses of selected sediment and water data, histograms, cumulative frequency plots, sample location maps and symbol maps showing the distribution of most elements and variables in sediment and water. The symbols are overlain on maps showing geology derived from 1:1 000 000-scale mapping and 1:250 000-scale drainage. The sample location maps show more detailed 1:50 000-scale drainage features.

There are many areas demarcated by samples having anomalous contents of various ore elements. Several clusters of samples with elevated contents of copper, nickel and zinc are found in the survey. Many of the clusters are over rock units that are elsewhere known to be mineralized in these elements. Although no uranium mineralization is recorded in the MODS database, several sediment and water samples with high uranium contents are present. Most of these are over granites or granitic rocks. Several areas in the southern part of the survey, mostly granitic terrane, are distinguished by samples with high levels of rare-earth-elements. These elements include, but are not limited to, dysprosium, lanthanum, terbium, yttrium and ytterbium. Some lake sediments collected over these granites are also enriched in niobium and tantalum. Also of possible follow-up interest are anomalies in titanium and gold.

INTRODUCTION

The field work for the survey was conducted during the summers of 2006 and 2007. During the first summer, the southern portion of the area was sampled and the work was conducted from the town of Mary's Harbour. The northern portion was sampled in 2007 working from Cartwright and Charlottetown. Road access from north to south provided an easy method of putting out small fuel caches.

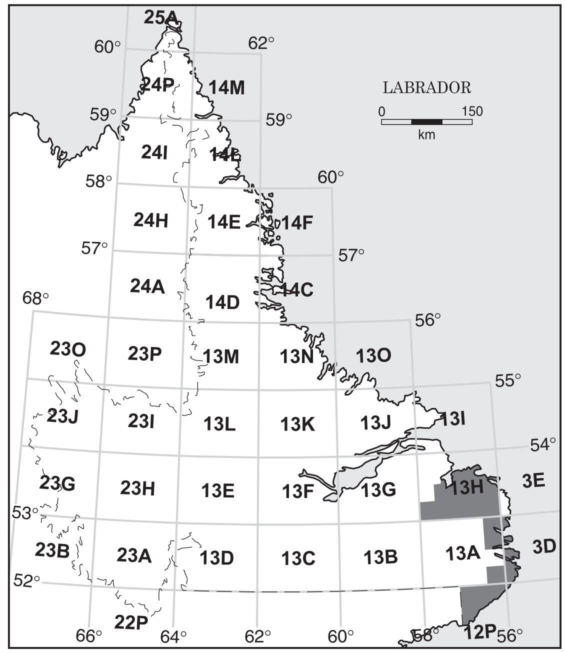

Figure 1. *Location of survey area.*

The area was selected for detailed-scale surveying for several reasons. The area had several types of mineralization already known including base metals, thorium–uranium and zirconium. Early reconnaissance-scale surveys have above average levels of these elements (Friske *et al.*, 1994a, b). Conversations with Charles Gower of the Geological Survey regarding his several years of field work and bedrock mapping in the area gave further encouragement. Finally, a new highway network running from north to south, and most recently to the west, will provide industry with the necessary infrastructure to facilitate exploration.

LOCATION, ACCESS AND PHYSIOGRAPHY

The survey area is located in southeastern Labrador (Figure 1). Most of the area is accessible to roads. A highway runs from the Québec–Labrador border in the south to Cartwright in the north with several branch roads serving coastal towns. The south Labrador coast is accessible by vehicle by seasonal ferry service from the Island of Newfoundland that runs between St. Barbe and Blanc Sablon, QC. Roads in the area now also connect to Happy Valley-Goose Bay and the Canadian road network. Most of the terrain is moderately rugged and is either tree covered or consists of wetlands except for an approximately 20-km-wide coastal fringe of near barren conditions.

PREVIOUS GEOCHEMICAL SURVEYS

The area was included in the Labrador reconnaissance-scale surveys which had a sample density of 1 per 14 km^2 (Friske *et al.*, 1994a, b). Sediment analyses included 39 to 43 elements, as well as U, F and pH analyses of water. Additionally, a regional till survey was completed immediately to the west of the lake survey in NTS map areas 13A/10,14 and 15 (McCuaig, 2002).

Median values of copper, nickel and molybdenum in this survey are 12, 9, and 0.5 ppm respectively. Eleven samples from the regional survey have copper values ranging from 81–125 ppm. They are found overlying a variety of rock types and are geographically dispersed. There are twenty-seven samples with nickel values in the range of 29–73 ppm. Twelve of these are from lakes overlying the White Bear Arm Suite, a complex composed of gabbronorite, leucogabbronorite, anorthosite and monzonite. Eighteen samples have molybdenum values in the 11–78 ppm range. Three of these are from lakes about 6 km south to southwest of the only molybdenite occurrence known in the survey area in NTS map area 12P/16. Bedrock mapping indicates that the lakes and the mineralization are underlain by metamorphosed felsic volcanoclastic rocks. A cluster of seven sediment samples that have high uranium values 40–239 ppm is located in NTS map areas 12P/16, 13A/01 and 3D/04. Another sample with 51 ppm U1 is found in NTS map area 13H/10. The median uranium value in the current survey is 2 ppm.

GEOLOGY AND MINERALIZATION

The surveyed area is underlain primarily by rocks of the Grenville Province (Figures 2, 3, 4 and 5). The geology and following descriptions are derived from the 1:1 000 000-scale geological map of Labrador (Wardle *et al.*, 1997) and on the 1:100 000 mapping of Gower (2005). The Grenville Province is subdivided into a northern exterior thrust belt and a southern interior magmatic belt. In the survey area, the boundary between the two extends approximately west-northwest from Mary's Harbour. South of this is the interior magmatic belt.

The exterior thrust belt is a Grenvillian tectonic feature but composed predominantly of crust formed during the Labradorian Orogeny (*ca.* 1710 to 1620 Ma). The belt is divided into four thrust-bound terranes in the survey area. Three of these, the Groswater Bay, the Hawke River and the Lake Melville terranes are comprised of mixed assemblages of calc-alkalic tonalitic–granodioritic gneiss, mafic and granitoid intrusions and metasedimentary gneiss. The fourth, the Mealy Mountains terrane, includes weakly deformed anorthosite–monzonite–charnokite–granite (AMCG) suite and pre-Labradorian and Labradorian gneissic and granitoid crust.

The interior magmatic belt is characterized by abundant Grenvillian (*ca.* 1080 to 960 Ma) magmatism and consists of rocks of the Pinware terrane in the survey area. Plutons were emplaced into an assemblage of quartzofeldspathic gneiss and granitic intrusions during Pinwarian orogenesis (1520–1460 Ma) that were themselves intruded into Labradorian crust.

Three types of base metal mineralization are reported from the survey area – nickel (Ni), copper (Cu) and molybdenum (Mo) (Mineral Occurrence Data System (MODS), 2009). Seven occurrences of nickel (Ni) classified as indications are known from mafic rocks in the Hawke River terrane. Thirty-nine examples of Cu mineralization are listed in the survey area. Of these one is classified as a showing and the remainder as indications. Two molybdenum (Mo) occurrences are known. One is located about 11 km east of Cartwright and one in NTS map area 12P/16 about 30 km northeast of Red Bay. One hundred and thirteen pyrite occurrences are identified. Of these ten occur in the interior magmatic belt, and one hundred and three are found in the exterior thrust belt. Many of the Cu and pyrite occurrences are found near or on the coast where exposure is best, suggesting that many undetected mineral occurrences remain further inland.

The MODS records identify only one thorium–uranium showing, located in NTS map area 13H/02.

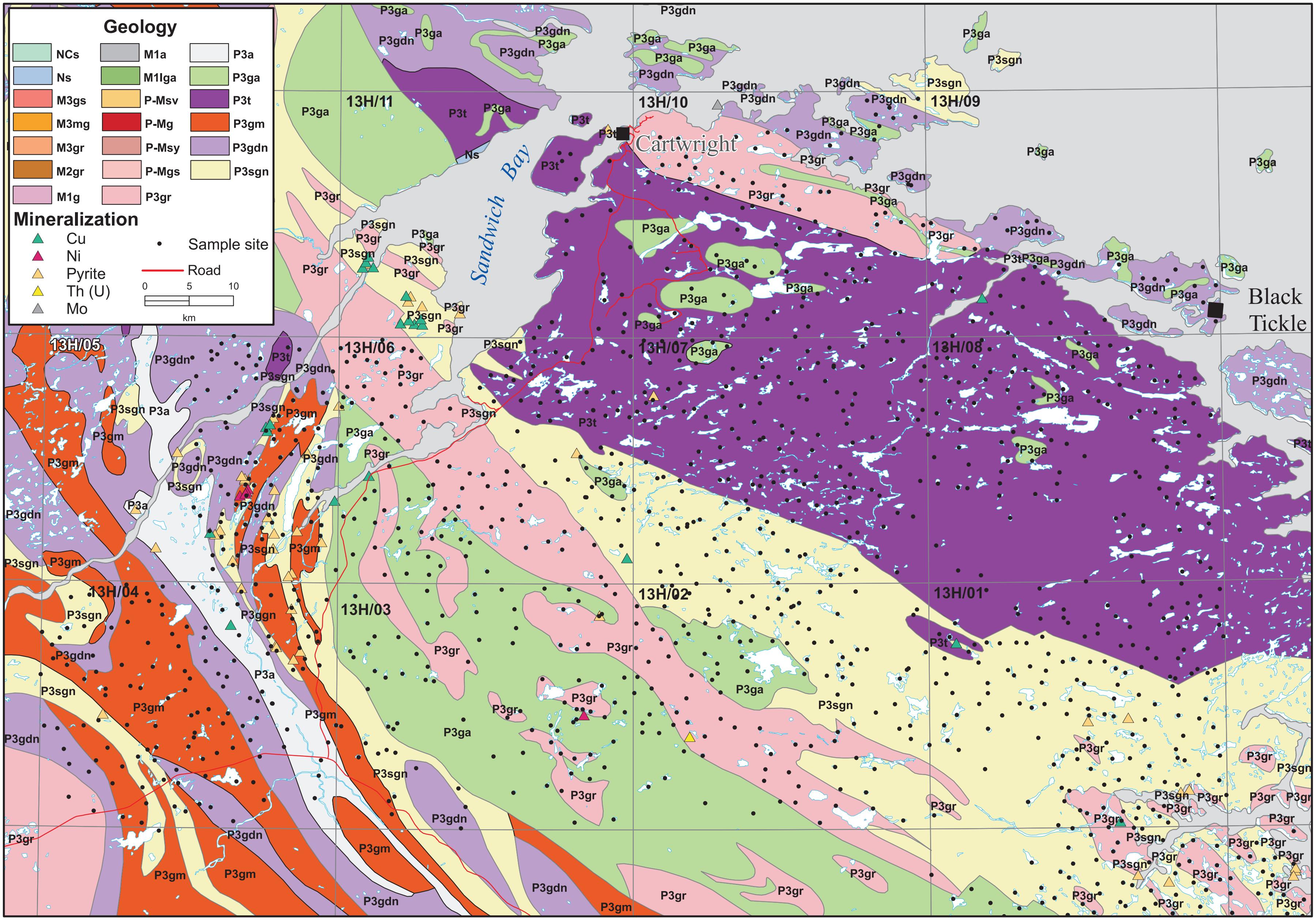

Figure 2. *Geology of the northern part of survey area.*

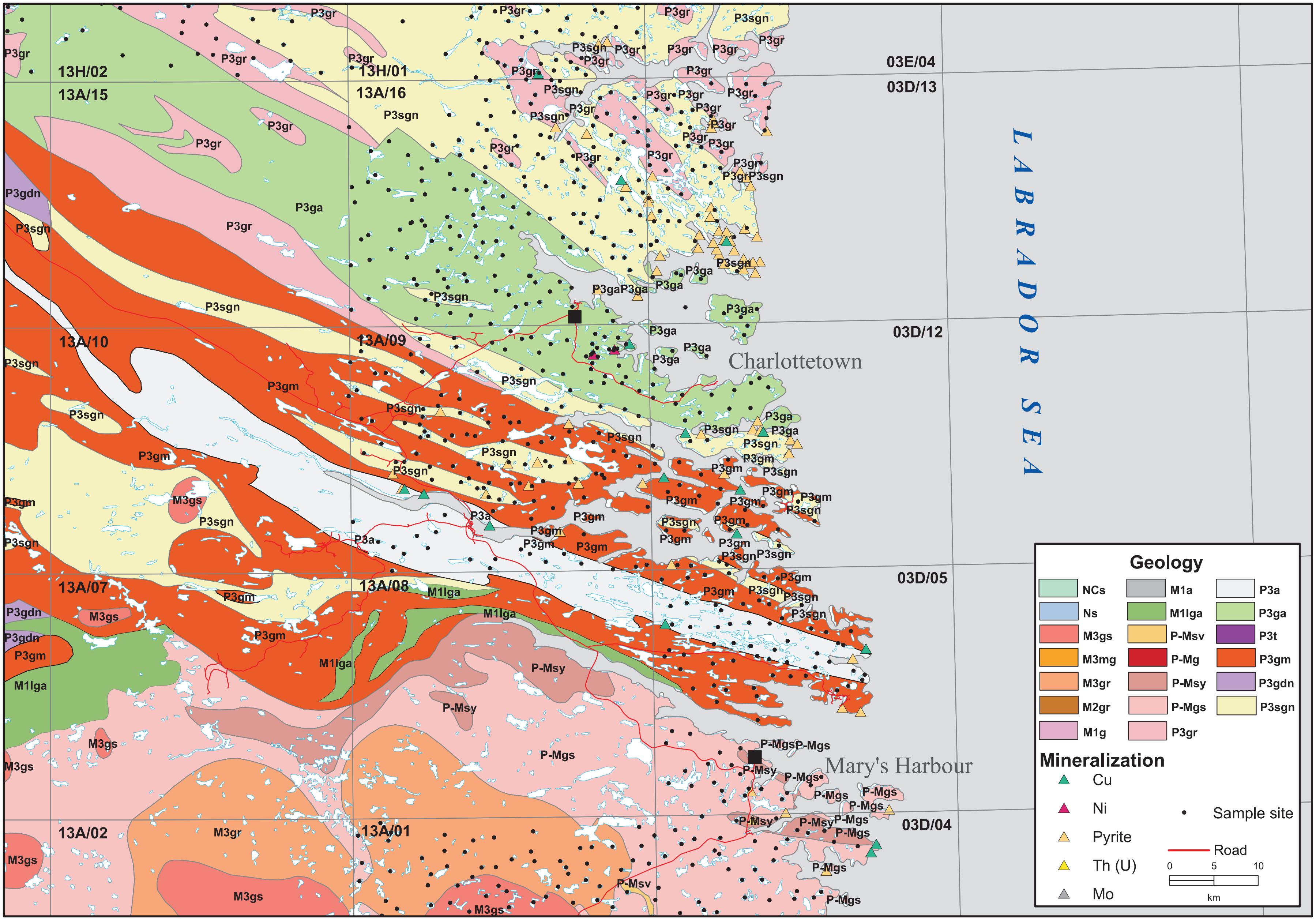

Figure 3. *Geology of the central part of survey area.*

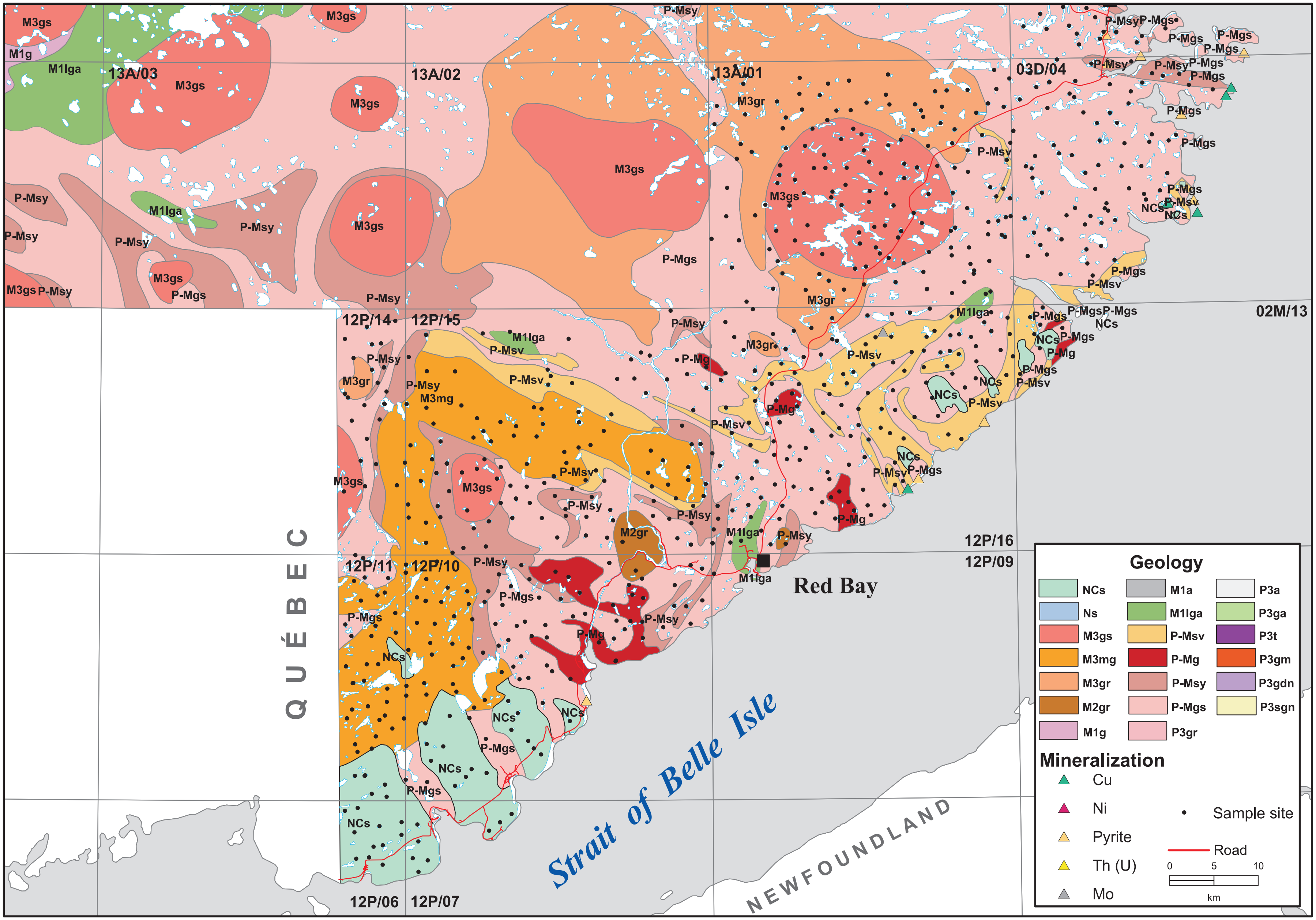

Figure 4. *Geology of the southern part of survey area.*

SUPRACRUSTAL ROCKS

NEOPROTEROZOIC

NCs	Sandstone and nodular limestone (Labrador Gp.)
Ns	Sandstone and nodular limestone (Labrador Gp.)

MESOPROTEROZOIC

PALEO- AND/OR MESO- PROTEROZOIC

P-Msv	Metasedimentary and felsic volcanic rocks [1650 to 1450 Ma, Pinware terrane, southeastern GP]

PALEOPROTEROZOIC

P3sgn	Pelitic, migmatitic metasedimentary gneiss and minor psammitic gneiss at amphibolite to granulite facies

PLUTONIC ROCKS

M3gs	Late- to post- tectonic granite and syenite plutons [1080 to 956 Ma, southern GP]
M3mg	Monzonite to granite [Pinware terrane, southeastern GP]
M3gr	Syenite to granite [Pinware terrane, southeastern GP]
M2gr	Granite plutons [e.g. Upper North River pluton, ca. 1296 Ma, GP]
M1g	Granitoid rocks [1500 to 1420 Ma]
M1a	Anorthosite and other, locally layered, mafic rocks
M1lga	Layered gabbro-anorthosite-ultramafic intrusions [e.g., Kyfanan Lake intrusion]
P-Mg	K-feldspar-megacrystic granitoid plutons
P-Msy	Syenite, monzonite and diorite
P-Mgs	Granite, syenite, monzonite, diorite and derived gneiss [1650 to 1450 Ma]
P3gr	Granite, quartz monzonite, granodiorite, syenite and minor quartz diorite [e.g., ca.1650 Ma; Trans-Labrador batholith and coeval rocks in GP and MP]
P3a	Anorthosite and other, locally layered, mafic components [1645 to 1625 Ma]
P3ga	Mafic intrusive suites (gabbronorite, lesser diorite), some metamorphosed at amphibolite to granulite facies
P3t	Quartz diorite to granodiorite plutons
P3gm	K-feldspar-megacrystic granite and other granitoid plutonic rocks
P3gdn	Granodioritic orthogneiss (lesser quartz dioritic and granitic orthogneiss), commonly migmatitic; may include some Mesoproterozoic rocks in areas mapped only at reconnaissance scale

Figure 5: *Expanded geologic legend for figures 3, 4, and 5 (GP - Grenville Province, MP - Makkovik Province).*

There is one instance of zirconium mineralization, the Fox Harbour occurrence, located in NTS map area 3D/05. This is of interest as it may be associated with rare earth mineralization.

SURFICIAL GEOLOGY

The most recent surficial geology map that covers the survey area is at 1:1 000 000-scale (Klassen *et al.*, 1992). The northern part (NTS map areas 13H, 3E/5, 12 and 13) was mapped at 1:50 000 (Fulton and Hodgson, 1974). Klassen *et al.* (*op. cit.*) indicates that most of the inland area is covered by undifferentiated till. In contrast, much of the coastal area, extending generally from 2–20 km inland, features thin till or exposed bedrock. Of secondary importance are glaciofluvial deposits found generally along some of the modern drainages and a few occurrences of glaciomarine and marine deposits found near the coast. There also a few minor occurrences of hummocky till indicating areas of ice stagnation.

The mapping by Fulton and Hodgson (1974), consisting of photo interpretation with limited ground checking, provides a few striae which offers clues to ice movement directions in the northern portion of the survey area. In the area to the west, southwest and south of Sandwich Bay (NTS map areas 13H/5, 6, 11 and 12), the ice-flow indicators are predominantly oriented northeastward and a few, eastward. In the south, towards the coast, Klassen's (1992) mapping of drumlins and flutes suggests a predominantly southeastward flow.

Marine limit in the area is 150 m at Red Bay and 100 m at Cartwright.

SAMPLE COLLECTION

Samples of organic lake sediment were collected from 2129 sites and water samples were obtained from 2234 sites. Additionally, approximately one site in 20 was sampled in duplicate. These duplicate samples were collected about 50 m apart. Generally, smaller lakes were sampled in this survey than was the case for the reconnaissance survey, in which the objective had been to obtain a more regional geochemical perspective. Normally, the centre of the lake (or if apparent from the air, the central basinal portion of the lake) was sampled. On some deep lakes (>25 m), no sample was retrieved in lake centres and a sample from a shallower site closer to shore was obtained. The collection procedure involves landing a float-equipped 206-B Jet Ranger helicopter on the lake surface and dropping a weighted tubular sampler fitted with a nylon rope for retrieval. A butterfly valve in the bottom of the tube opens upon impact with the sediment and closes upon retrieval, trapping the contained sediment. Samples are stored in water-resistant Kraft paper bags. Markings on the rope permit determination of the sample depth. Other observations made during sampling include GPS coordinates of the site, the nature of vegetation surrounding the lake, sediment colour, texture and composition and water colour.

Samples of lake water were collected before the sediment sampler was dropped to avoid water contamination. Samples were collected in purified, 125 mL Nalgene bottles. These were filled by immersing the bottles about 40 cm below the lake surface. Prior to sampling, the bottles were acid leached in the laboratory, and washed with distilled and deionized water. Sampling of a typical site took about one minute between touchdown and takeoff.

SAMPLE PREPARATION AND ANALYSES

Preparation

Lake sediments were partially air-dried in the field prior to shipping to the Geological Survey's laboratory for final oven-drying at 40°C. The samples were then disaggregated using a mortar and pestle before being screened through a 180 micron stainless steel sieve. The fine fraction was retained for chemical analyses. To monitor analytical precision, five percent of the samples were randomly selected, split and included as blind duplicates in all analytical procedures. Water samples were stored in a cool environment prior to shipping to St. John's. At the laboratory, waters were filtered using a 0.45 µm millipore filtration apparatus.

Analyses

Lake sediment was analyzed using four methods for 48 unique elements plus loss-on-ignition (Table 1). In addition, 13 of these elements were analyzed using a second method for a total of 62 separate determinations. Some additional elements were analyzed by INAA but were either below detection limit or were so unrepeatable as to be of no use. Elements which are analyzed using two methods, one of which gives preferable results for reasons of improved detection limit or preci-

Table 1. Analytical methods for lake-sediment samples

ELEMENTS and LOI	METHOD	DIGESTION/ PREPARATION
As, Au, Ba, Br, (Ca), Ce, Co, Cr Cs, Eu, Fe, Hf, La, Lu, Mo, Na, Nd, (Rb), Sb, Sc, Sm, Ta, Tb, Th, U, W, Yb, (Zn), (Zr)	Instrumental Neutron Activation Analysis (INAA)	5 to 10 g in shrink-wrapped vial (total analysis)
Al, As, Ba, Be, Ca*, Cd, Ce, Co, Cr, Cu, Dy, Fe, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb*, Sc, Sr, Ti, V, Y, Zn*, Zr*	Inductively Coupled Plasma-Emission Spectrometry (ICP-ES)[1]	Hf-$HClO_4$-HCl (total digestion)
Ag	Atomic Absorption Spectrometry (AA)[2]	HNO_3
F	Fluoride-ion specific electrode with digital ion analyzer[2]	2:1 Na_2CO_3:KNO_3 flux, fusion
Loss-on-ignition (LOI)	Gravimetric using muffle furnace raised to 500°C	

* Indicates preferable method of analysis
Brackets ( ) enclosing element name indicate less favoured method of analysis; use alternative method indicated by an asterick

[1] Finch, 1998; [2] Wagenbauer *et al.*, 1983

sion, are distinguished by an asterisk in Table 1. All analyses except INAA were performed in the Geological Survey's laboratory. The INAA analyses for samples collected in 2006 were performed by Becquerel Laboratories and for samples collected in 2007, by ActLabs. Results from these two labs are not strictly comparable and this issue is discussed below under *Data Quality*. To enable the user to readily distinguish the method of analysis for a given element, a suffix is attached to the element symbol when used in most tables and figures. The key to the suffixes is as follows:

1. Instrumental neutron activation analysis (INAA), *e.g.*, Au1.
2. Inductively coupled plasma-emission spectroscopy (ICP-ES after HF-$HClO_4$-HCl digestion, *e.g.*, Cu2
6. Silver by atomic absorption spectrometry (AA after HNO_3 digestion, *i.e.*, Ag6.
9. Fluoride-ion selective electrode, *i.e.*, F9.

Lake water was analyzed for conductivity, pH, SO_4 and 26 elements using the methods noted in Table 2. Uranium in water was analyzed by SGS Lakefield Research Limited using ICP-mass spectrometry. All other analyses were performed by the Geological Survey's laboratory. The key to the suffixes is as follows:

1. ICP-emission spectroscopy, *e.g.*, Few1.
2. ICP-emission spectroscopy with ultrasonic nebulizer, *e.g.*, Cuw2.
3. ICP-mass spectrometry, *e.g.*, Uw3.
9. Fluoride-ion selective electrode with digital ion analyser, *e.g.*, Fw9.

Analytical and field data are provided in Appendix 1.

Table 2. Analytical methods for lake-water samples

ANALYSIS	METHOD	PREPARATION
pH	Combination pH electrode	None
Conductivity	Conductivity sensor	None
Ca, Fe, K, Mg, Mn, Na, Si, SO_4	ICP-emission spectroscopy[1]	Filtration (0.45 µm) and HNO_3 acidification
Al, Ba, Be, Co, Cr, Cu, Li, Mo, Ni, P, Pb, Sr, Ti, V, Y, Zn	ICP-ultrasonic nebulizer[1]	Filtration (0.45 µm) and HNO_3 acidification
As	ICP-ultrasonic nebulizer[1]	Filtration (0.45 µm) and HNO_3 acidification; H-H_2O_2
F	Fluoride-ion specific electrode with digital ion analyzer	
U,	ICP-mass spectrometry	Filtration (0.45 µm) and HNO_3 acidification

[1] Finch, 1998

DATA QUALITY

To ensure the reliability of the analytical data, three means of determining data accuracy and precision were employed. First, during sample collection, pairs of sediment samples and pairs of water samples were obtained from lakes. Analyses of these site duplicates give an appreciation of within-lake data variation. Eighty-six lakes were sampled for sediment and water duplicates. The duplicate samples were taken about 50 m apart. Second, at the analytical stage, a standard of known composition was inserted within every batch of 20 samples. For sediment, international reference standards composed of lake sediment material were used, notably LKSD-1, LKSD-2, LKSD-3 and LKSD-4. For water, standards used were both naturally occurring water and synthetic standards created in the laboratory to predetermined compositions. The results of these standards were monitored to ensure analytical accuracy and precision. Third, a sample split, or laboratory duplicate, was included in every batch of 20 samples. These duplicates were compared to ensure adequate precision.

The sediment samples collected in 2006 and those collected in 2007 were analyzed using INAA by two different laboratories. Those from 2006 were analyzed by Becquerel Laboratories and those from 2007 by ActLabs. Evaluation of the LKSD standards for the INAA analyses indicates a problem in directly comparing some of the analyses from the two laboratories. Tables 3a and b present the recommended values, the mean and standard deviations and the ranges for elements analysed by both laboratories. This table permits the user to compare the accuracy and precision of the analyses by the different laboratories. 'Accuracy' is the closeness to which the value of the mean analysis of a given element comes to the recommended value. 'Precision' is a measure of the reproducibility of an analysis. This can be evaluated by comparing the standard deviations for an element by the two laboratories. The smaller the standard deviation, the better the precision. A value of zero would indicate perfect precision. If a method is accurate (*i.e.*, the mean analysis is close to the recommended value) but has poor precision, the analysis may be of limited use because one cannot place confidence in the reproducibility of the result. In LKSD-3, for example, thorium (Th1) has mean values of 11.1 ppm and 11.2 ppm for Becquerel and ActLabs respectively, both near the recommended value of 11.4 ppm. The standard deviations, however, vary considerably. Becquerel has a value of 0.59 whereas that of ActLabs is 1.96 indicating that the Becquerel data are more precise. Examining the range also gives a sense of the precision. A small range suggests good precision and a wide range suggests poor precision.

There were 96 standard deviations calculated for the four standards for each lab. Of these, Becquerel had 93 standard deviations that were smaller than the corresponding value for ActLabs' analyses and ActLabs had 3 standard deviations that were smaller than the corresponding Becquerel value. From this it is apparent that for nearly all elements, Becquerel had more precise analyses.

Site duplicates are useful because they give an appreciation of overall data variance occurring at both the sampling and analytical stages. Since they consist of samples from the survey itself, they may reveal limitations in the data that are specific to the area and which may not show up in the reference standards. Scatter plots of 62 variables for sediment analyses along with the Spearman correlation coefficient (r) are shown in Figures 6, 7 and 8. The higher the absolute

Table 3a. Summary statistics of recommended values, Becquerel analyses and ActLab analyses of lake sediment control samples, LKSD-1 and LKSD-2. Values in ppm unless otherwise indicated

	Recom-mended Value	Becquerel Mean	ActLabs Mean	Becquerel Standard Deviation	ActLabs Standard Deviation	Becquerel Minimum	Range Maximum	ActLabs Minimum	Range Maximum
LKSD-1									
As1	40	37	32	1.0	3.5	35	39	27	39
Au1, ppb	5	5	3	1.6	2.8	3	11	0.5	7
Ba1	430	409	392	13	59	380	440	310	540
Br1	11	10	8	0.5	1.3	10	11	7	11
Ce1	27	31	23	2.5	4.2	25	35	17	31
Co1	11	12	9	0.7	1.2	11	14	6	11
Cr1	31	31	26	5.7	4.3	21	41	16	34
Cs1	1.5	0.8	0.3	0.08	0.24	0.6	0.9	0.2	1
Fe1, %	2.8	3.1	2.4	0.15	0.23	2.9	3.4	2.1	2.8
Hf1	3.6	4.0	3.5	0.00	0.96	4	4	2	6
La1	16	16	13	0.6	1.4	15	18	11	16
Lu1	0.4	0.3	0.3	0.07	0.10	0.22	0.46	0.17	0.5
Mo1	10	11	10	0.8	4.3	10	13	0.2	15
Rb1	24	23	12	2.8	13.9	16	29	2	40
Sb1	1.2	1.1	1.0	0.03	0.61	1.1	1.2	0.7	3.7
Sc1	9	9	6	0.52	0.63	8.4	10.1	5.5	7.5
Sm1	4	3	3	0.30	0.66	2.8	3.8	1.6	3.8
Ta1	0.3	0.3	0.2	0.07	0.23	0.2	0.5	0.1	1
Tb1	0.6	0.6	0.3	0.08	0.16	0.2	0.7	0.2	0.6
Th1	2.2	2.1	2.2	0.09	0.39	1.9	2.3	1.6	3.3
U1	9.7	9.3	10.7	0.41	2.65	8.7	10	8.7	21.8
W1	< 4	0.9	0.4	0.60	0.44	0.2	2	0.2	2
Yb1	2	2	2	0.18	0.28	2.1	2.7	1.7	2.7
Zr1	134	139	114	58	113	50	210	100	400
LKSD-2									
As1	11	10	10	0.5	1.6	9.3	11	7.9	14.8
Au1, ppb	3	3	2	1.0	2.3	0.5	6	0.5	7
Ba1	780	761	701	24	116	720	810	580	1110
Br1	18	17	13	0.7	2.9	16	19	11	24
Ce1	108	120	91	9.8	23.4	100	140	60	170
Co1	17	19	15	1.5	2.0	16	22	13	22
Cr1	57	60	48	8.1	8.2	38	73	35	70
Cs1	3	2.9	1.7	0.12	0.55	2.6	3.1	0.2	2
Fe1, %	4.3	4.5	3.5	0.20	0.51	4.1	4.9	3.0	5.6
Hf1	7	7.9	6.8	0.44	1.89	7	9	5	11
La1	68	68	57	3.5	8.0	60	73	48	88
Lu1	0.6	0.6	0.7	0.10	0.16	0.42	0.75	0.53	1.17
Mo1	<5	1	3	0.6	2.9	0.2	2.2	0.2	10
Rb1	85	80	57	3.2	17.3	75	88	2	100
Sb1	1.1	1.0	1.0	0.05	1.02	0.9	1.1	0.5	5.4
Sc1	13	13	10	0.86	1.48	11.5	14.7	8.6	16
Sm1	11	11	8	0.32	2.40	10	11.5	5	15
Ta1	0.8	0.8	0.3	0.12	0.52	0.6	1.2	0.1	1.8
Tb1	1.4	1.3	0.6	0.09	0.51	1.1	1.5	0.2	2
Th1	13.4	12.5	12.8	0.47	2.26	11.8	13.5	9.6	20
U1	7.6	7.4	8.1	0.25	1.09	7	8	6.1	11.4
W1	< 4	1.0	0.2	0.61	0.00	0.2	2	0.2	0.2
Yb1	4	4	4	0.39	0.78	3.4	5	3.1	7
Zr1	254	295	143	63	170	210	460	100	700

Table 3b. Summary statistics of recommended values, Becquerel analyses and ActLab analyses of lake sediment control samples, LKSD-3 and LKSD-4. Values in ppm unless otherwise indicated

	Recom-mended Value	Becquerel Mean	ActLabs Mean	Becquerel Standard Deviation	ActLabs Standard Deviation	Becquerel Minimum	Range Maximum	ActLabs Minimum	Range Maximum
LKSD-3									
As1	27	26	22	3.4	3.9	10	31	12.1	32.4
Au1, ppb	3	5	1	0.9	2.0	3	7	0.5	9
Ba1	680	681	572	34	89	640	770	380	770
Br1	16	15	11	0.8	1.8	13	17	9	17
Ce1	90	96	74	5.5	13.5	83	110	55	113
Co1	30	32	24	3.4	2.7	17	37	15	30
Cr1	87	86	72	9.8	9.2	57	110	51	92
Cs1	2.3	2.4	1.4	0.16	0.74	2	2.8	0.2	3
Fe1, %	4.0	4.2	3.3	0.31	0.36	3.9	5.6	2.1	4.2
Hf1	4.8	5.4	5.2	0.69	1.45	5	8	3	8
La1	52	51	41	3.7	4.6	44	64	27	52
Lu1	0.4	0.4	0.4	0.05	0.09	0.33	0.55	0.29	0.7
Mo1	<5	1	2	0.5	3.3	0.2	1.5	0.2	14
Rb1	78	75	49	4.5	19.1	69	89	2	83
Sb1	1.3	1.2	1.0	0.08	0.12	1	1.4	0.8	1.2
Sc1	13	13	10	0.96	1.12	10.5	15.7	6.4	12
Sm1	8	8	5	0.63	1.38	7.6	10.8	3.5	8.5
Ta1	0.7	0.8	0.1	0.11	0.15	0.6	1	0.1	0.8
Tb1	1	0.9	0.3	0.10	0.21	0.7	1.2	0.2	0.9
Th1	11.4	11.1	11.2	0.59	1.96	10.6	13	7.7	16.8
U1	4.6	4.6	4.7	0.56	1.00	4.2	7.2	2.6	7.4
W1	< 4	0.6	0.2	0.55	0.00	0.2	2	0.2	0.2
Yb1	2.7	3	3	0.36	0.43	2	3.5	1.9	3.6
Zr1	178	166	107	90	120	50	300	100	500
LKSD-4									
As1	16	15	17	1.0	2.3	14	17	14.3	24
Au1, ppb	2	3	1	1.5	1.0	0.5	5	0.5	5
Ba1	330	312	349	19.6	115.7	270	350	25	520
Br1	49	50	41	1.7	8.4	46	53	33	71
Ce1	48	53	44	4.0	11.4	42	59	32	84
Co1	11	12	10	1.4	1.8	9	15	9	17
Cr1	33	32	33	7.5	7.8	20	51	23	59
Cs1	1.7	1.5	1	0.1	0.6	1.3	1.8	0.2	2
Fe1, %	2.8	3.2	2.6	0.2	0.4	2.6	3.6	2.24	3.99
Hf1	2.8	3	3	0.5	1.2	2	4	2	6
La1	26	27	24	1.5	3.3	21	29	20	36
Lu1	0.5	0	0	0.2	0.2	0.12	0.7	0.18	0.93
Mo1	<5	3	16	0.8	10.7	1.5	4.5	0.2	28
Rb1	28	24	14	2.9	19.1	18	30	2	65
Sb1	1.7	2	2	0.1	4.6	1.5	1.8	1.1	22.5
Sc1	7	8	6	0.6	0.9	5.7	8.5	5.2	9.3
Sm1	5	4	4	1.0	1.1	1.3	4.5	2.7	7.2
Ta1	0.4	0	0	0.1	0.2	0.1	0.5	0.1	1.1
Tb1	1.2	1	0	0.1	0.3	0.2	0.8	0.2	0.8
Th1	5.1	5	6	0.2	1.0	4.5	5.6	4.7	9.2
U1	31	31	35	1.0	5.7	28.9	32.6	28.8	56.5
W1	< 4	0	0	0.4	0.2	0.2	2	0.2	1
Yb1	2	2	2	0.3	0.5	1.4	2.8	1.6	4.1
Zr1	105	87	229	68.2	241.0	50	240	100	1000

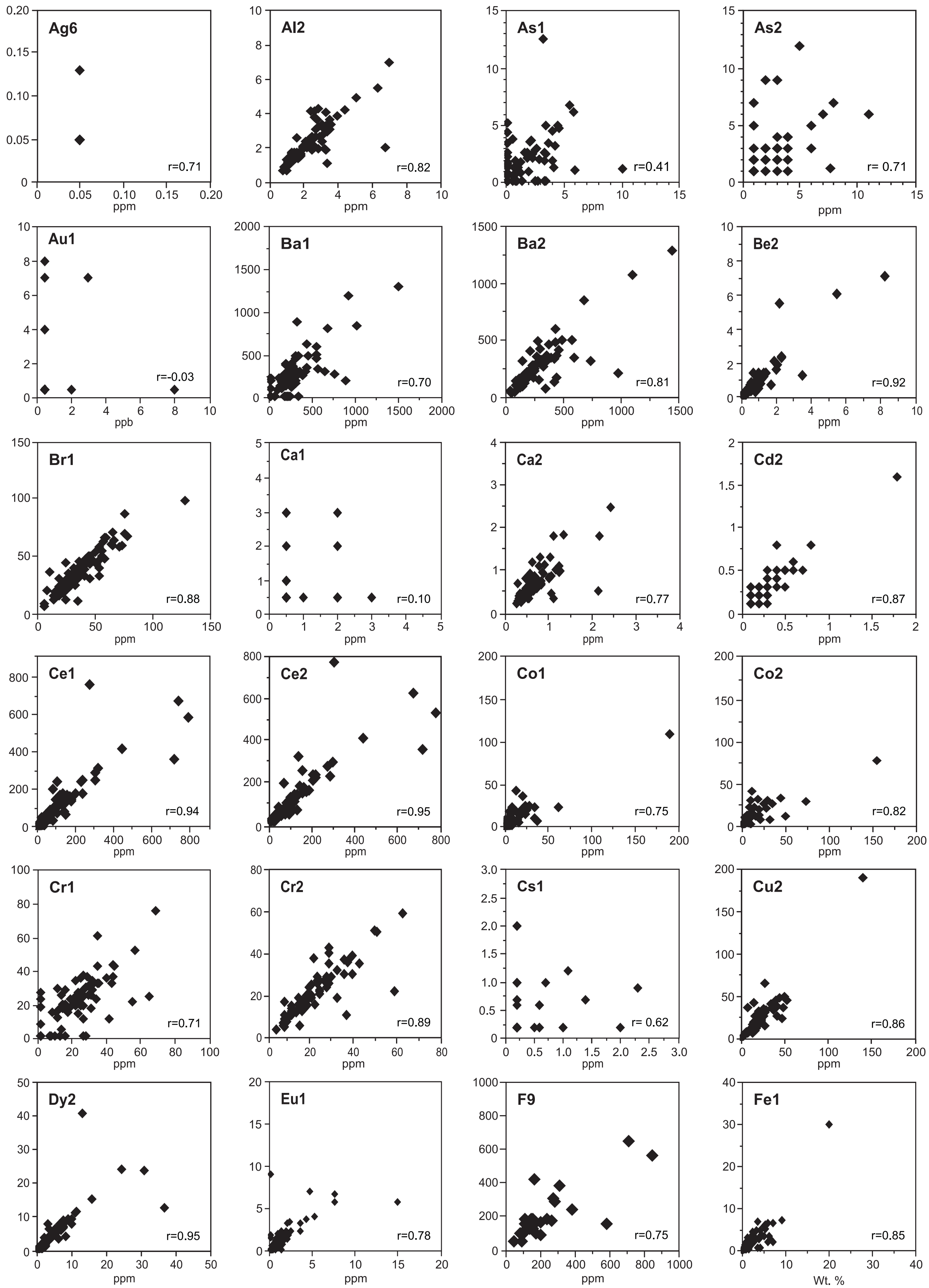

Figure 6. *Scatter plots of Ag6, A12, As1, As2, Au1, Ba1, Ba2, Be2, Br1, Ca1, Ca2, Cd2, Ce1, Ce2, Co1, Co2, Cr1, Cr2, Cs1, Cu2, Dy2, Eu1, F9 and Fe1 in site duplicates of lake sediment.*

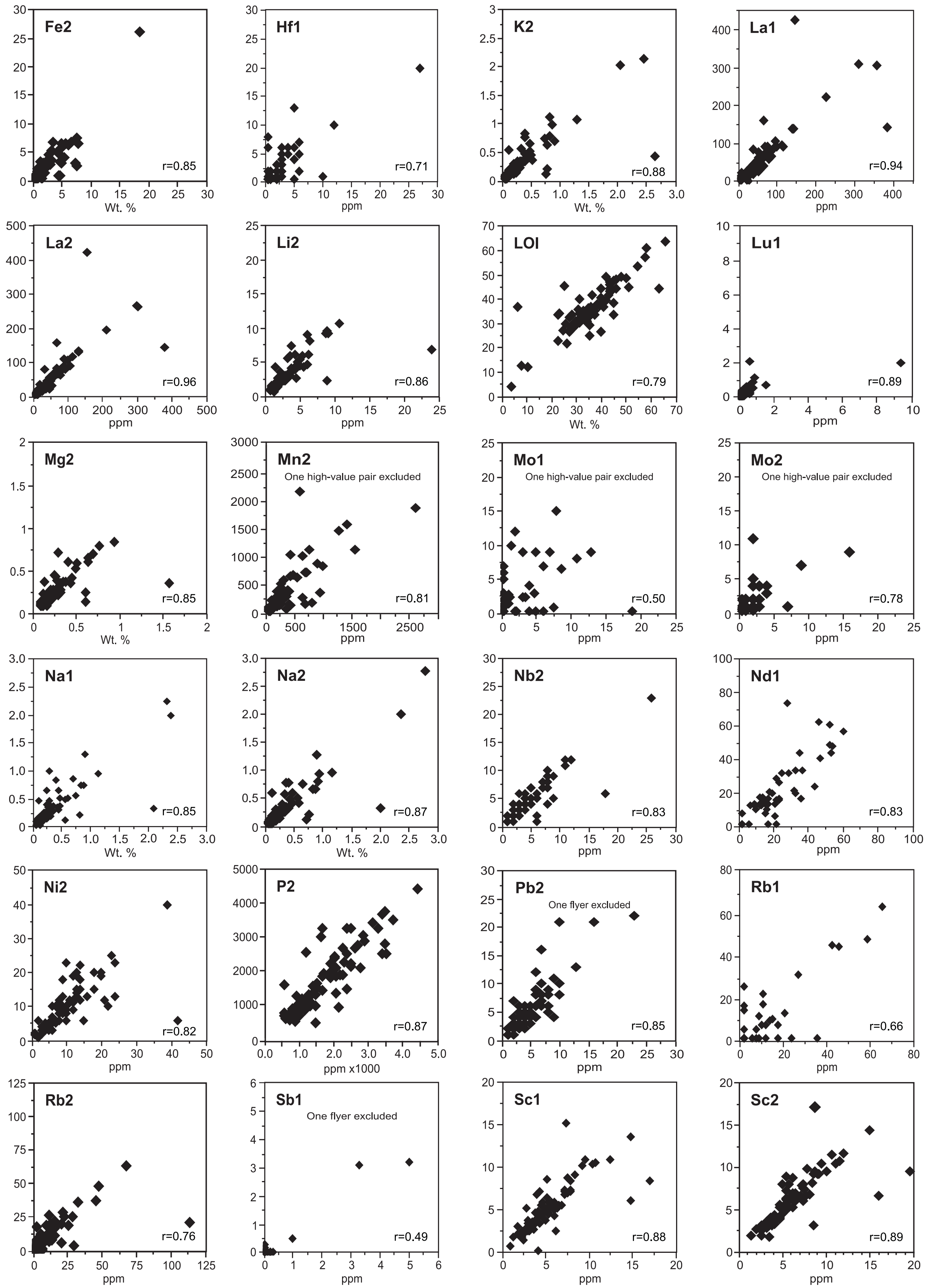

Figure 7. *Scatter plots of Fe2, Hf1, K2, La1, La2, Li2, LOI, Lu1, Mg2, Mn2, Mo1, Mo2, Na1, Na2, Nb2, Nd1, Ni2, P2, Pb2, Rb1, Rb2, Sb1, Sc1 and Sc2 in site duplicates of lake sediment.*

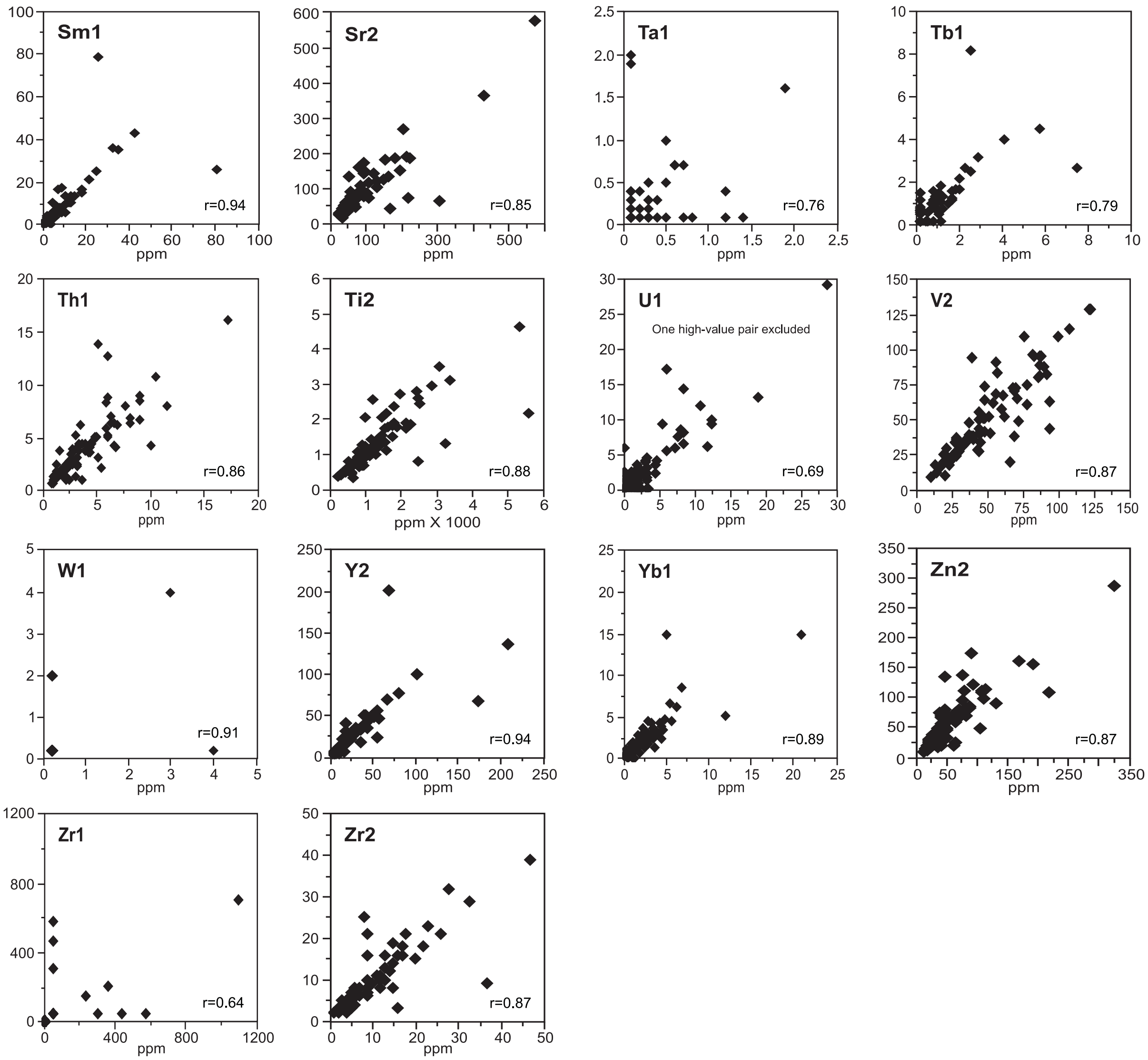

Figure 8. *Scatter plots of Sm1, Sr2, Ta1, Tb1, Th1, Ti2, U1, V2, W1, Y2, Yb1, Zn2, Zr1 and Zr2 in site duplicates of lake sediment.*

value, the better the correlation with ± 1.00 being a perfect correlation. A comparison of coefficients for the same element by different methods is a useful way to select the more reliable method. For example, As2, Ba2, Ca2, Cr2, Mo2, Rb2 and Zr2 by ICP give preferable results to results given by INAA. For other elements, the two methods give similar reproducibility, *e.g.*, Co, Cr, Fe, La, Na and Sc.

Scatter plots of 27 variables from site duplicates in water are shown in Figures 9 and 10. In general, the correlations are stronger between water duplicates than between sediment duplicates. This is not surprising because water is a more homogeneous medium than sediment and, unlike sediment, is not prone to compositional modifications within a lake due to variations in depth, LOI, Fe/Mn oxide scavenging and bottom currents. Many elements have very strong correlations (r>0.9). Analyses of Be, Co, Mo, Ni and Pb appear to be of little use in this area, particularly for values near the detection limits.

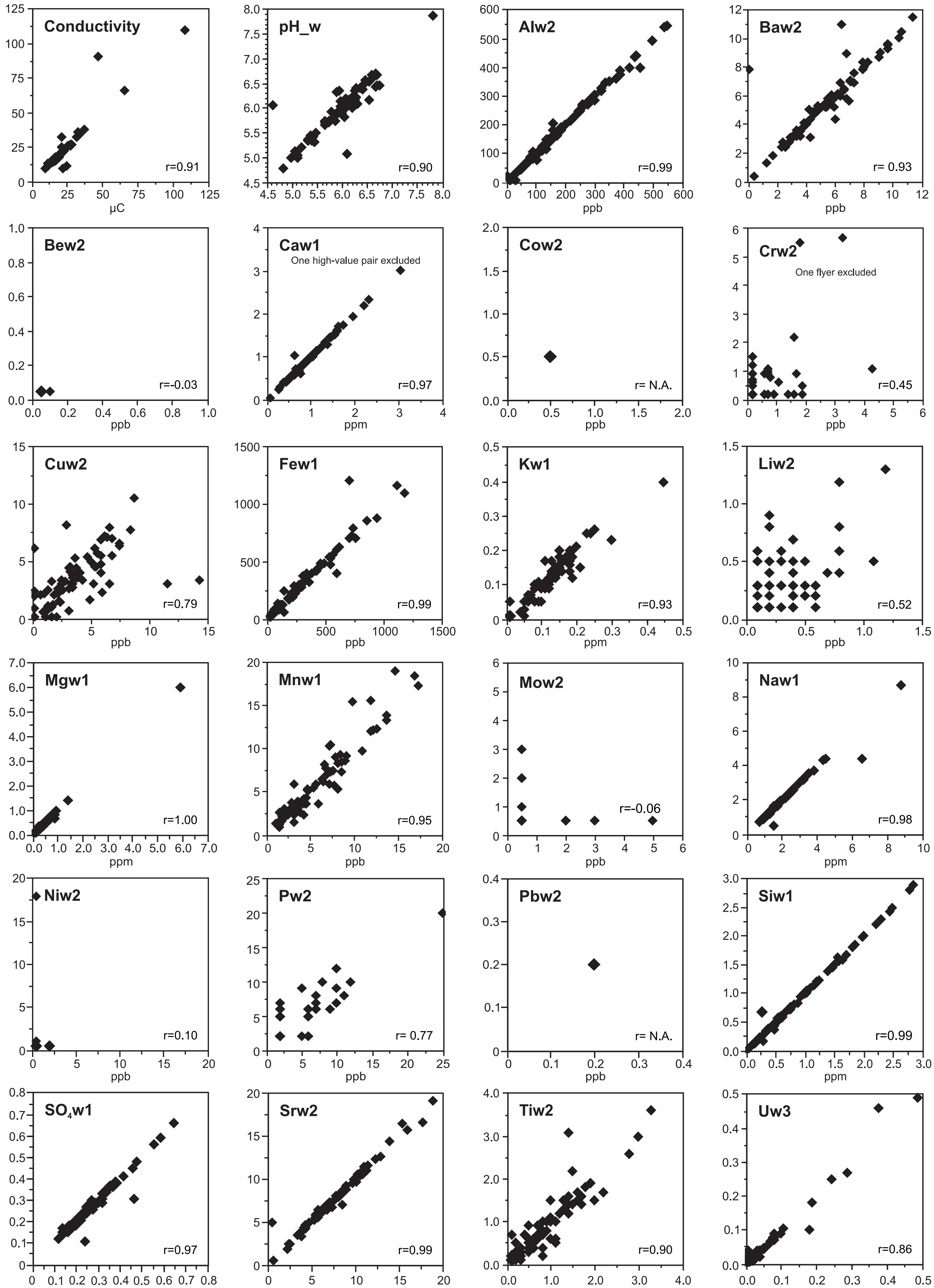

Figure 9. *Scatter plots of conductivity, pH, A1, Ba, Be, Ca, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Si, SO4, Sr, Ti and U in site-duplicates of lake water.*

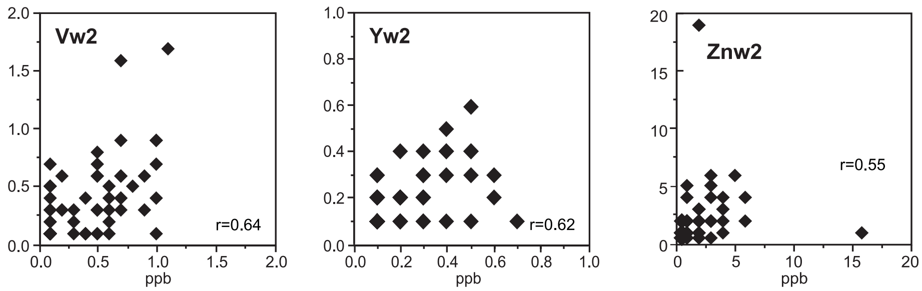

Figure 10. *Scatter plots of V, Y and Zn in site-duplicates of lake water.*

DESCRIPTION AND DISCUSSION OF RESULTS

STATISTICAL ANALYSIS

Summary Statistics

To quantify the range and distribution characteristics of the element populations, summary statistics have been calculated for the sediment (Table 4) and water data (Table 5). Analyses of the second sample of site-duplicate pairs are excluded. Statistics tabulated include the median, arithmetic mean, geometric mean, arithmetic standard deviation, logarithmic standard deviation, minimum and maximum. Because the distributions of most element populations are more log-normal than normal, the geometric means as well as arithmetic means are given.

Histograms and Cumulative Frequency Curves

Histograms of the lake sediment and water variables are included in the symbol plot maps showing the distributions of the variables. These figures show the shape of the population distributions and may be useful when interpreting the distribution maps of these variables. Cumulative frequency curves are also incorporated into these maps. The curves show the percentage of data accounted for by the progressive range of variable values.

Correlation Analysis of Sediment Data

Table 6 provides a matrix of Spearman correlation coefficients of selected elements and variables that may be associated with uranium, gold or base-metal mineralization. Coefficients for which $r \geq |0.80|$) are coloured red to emphasize element pairs with strong correlations. Of the variables in the vertical columns, iron (Fe1), depth and loss-on-ignition (LOI) may be considered environmental parameters independent of bedrock composition that may influence the accumulation of elements in sediment. Of the ore metals, only cobalt (Co2), zinc (Zn2) and niobium (Nb2) show strong correlations with iron at r=0.87, r=0.84 and r=0.82 respectively, suggesting the presence of iron hydroxide scavenging. The strongest ore metal correlation with depth is copper (r=0.64). With LOI the strongest correlation is also with copper (r=0.38).

Examining correlations of ore metals with other elements, gold has no strong or moderate correlations. Copper has weak correlations with nickel (r=0.39) and molybdenum (r=0.33).

Table 4. Summary statistics for lake-sediment data; element values in ppm unless otherwise stated (N=2129)

Element/ Variable	Median	Mean Arithmetic	Mean Geometric	Standard Deviation Arithmetic	Standard Deviation Logarithmic	Minimum	Maximum
Ag6	<0.10	0.06	0.05	0.11	0.12	0.05	2.72
Al2, wt. %	2.19	2.59	2.05	1.64	0.33	0.05	8.38
As1	0.8	1.6	0.7	2.05	0.55	0.2	30
As2	<2	2.2	1.7	1.80	0.27	1	27
Au1, ppb	<1	0.7	0.6	1.06	0.21	0.5	12
Ba1	240	307	178	291	0.52	25	3000
Ba2	231	336	247	287	0.35	20	2819
Be2	0.7	0.9	0.6	0.97	0.38	0.1	19.5
Br1	30.0	34	28	23.19	0.30	1	315
Ca1, wt %	<1	0.8	0.7	0.68	0.24	0.5	5
Ca2, wt. %	0.61	0.95	0.68	1.66	0.31	0.01	31.68
Cd2	<0.1	0.2	0.1	0.19	0.38	0.1	2.1
Ce1	55	93	56	108	0.46	2	982
Ce2	60	97	62	104	0.44	1	919
Co1	5	8	5	11.9	0.46	1	220
Co2	7	10	7	12.0	0.39	1	171
Cr1	20	23	15	19.9	0.48	2	350
Cr2	18	22	17	15.5	0.33	1	134
Cs1	<1	0.4	0.3	0.66	0.30	0.2	13
Cu2	12	16	12	14.3	0.37	1	181
Dy2	2.9	4.5	2.8	5.00	0.45	0.1	86
Eu1	0.9	1.3	0.9	1.56	0.41	0.2	24
F9	197	266	203	207	0.33	14	1500
Fe1, wt.%	1.34	2.03	1.35	2.05	0.40	0.1	22.6
Fe2, wt.%	1.35	2.04	1.32	2.06	0.42	0.03	21.37
Hf1	2	3.8	1.8	5.91	0.51	0.5	66
K2, wt. %	0.27	0.57	0.30	0.75	0.50	0.01	7.19
La1	28	46	29	52.2	0.43	1	675
La2	29	47	31	50.0	0.42	1	653
Li2	3.3	4.6	3.2	4.41	0.39	0.2	61.2
LOI, wt.%	33.4	35	30	16.96	0.24	1.3	98.4
Lu1	0.24	0.33	0.21	0.37	0.44	0.02	9.34
Mg2, wt.%	0.24	0.39	0.27	0.38	0.36	0.03	3.70
Mn2	238	440	247	860	0.44	18	20049
Mo1	0.2	1.94	0.50	5.43	0.63	0.2	117
Mo2	0.50	1.45	0.87	3.80	0.35	0.5	124
Na1, wt.%	0.26	0.50	0.30	0.56	0.44	0.01	3.20
Na2, wt.%	0.27	0.53	0.30	0.60	0.47	0.02	3.26
Nb2	4	6	4	5.33	0.37	1	50
Nd1	15	17	12	13.49	0.41	2	126
Ni2	9	11	8	8.54	0.35	1	89
P2	1117	1399	1126	951	0.29	69	7617
Pb2	5	7	5	5.46	0.34	1	50
Rb1	<5	12	4.8	19.2	0.54	2	170.0
Rb2	10	18	10	21.3	0.50	1	203
Sb1	<0.5	0.2	0.03	1.84	0.51	0.02	54
Sc1	4.7	5.8	4.5	4.04	0.33	0.2	34.3
Sc2	5.5	6.7	5.3	4.39	0.34	0.1	33
Se1	<1	0.5	0.5	0.00	0.00	0.5	0.5
Sm1	4.1	7.2	4.1	9.55	0.48	0.1	170
Sr2	76	119	87	108	0.34	8	669
Ta1	<0.2	0.3	0.2	0.44	0.39	0.1	3.9

Table 4. Continued

Element/ Variable	Median	Mean Arithmetic	Mean Geometric	Standard Deviation Arithmetic	Standard Deviation Logarithmic	Minimum	Maximum
Tb1	<0.5	0.8	0.4	1.01	0.43	0.2	16
Th1	3.6	4.3	3.4	3.11	0.32	0.1	30.4
Ti2	13.49	1922	1326	1804	0.40	25	22125
U1	2	4	1	15.92	0.75	0.1	469
V2	38	44	33	29.47	0.38	1	236
W1	<1	0.3	0.2	0.40	0.17	0.2	8
Y2	16	25	16	25.70	0.41	1	387
Yb1	2	2	1	2.24	0.44	0.1	22
Zn2	40	51	39	42.39	0.32	5	535
Zr1	<100	134	76	228.44	0.37	50	2400
Zr2	9	15	9	15.42	0.43	1	122
Lake area (km^2)	0.1	0.2	0.1	0.97	0.60	0.0005	36.92
Lake depth (m)	2.5	3.7	4.2	3.31	0.33	0.2	24

Table 5. Summary statistics for lake-water data; element values in ppb unless otherwise indicated (N=2234)

Element/ Variable	Detection Limit	Percentage of samples <D.L.	Median	Mean Arithmetic	Mean Geometric	Standard Deviation Arithmetic	Standard Deviation Logarithmic	Minimum	Maximum
Al	1	0	154	184	136	131.2	0.38	1	1031
As	2	82	<2	1	1	0.8	0.17	1	8
Ba	0.1	0	5.2	6	5.0	3.99	0.29	0.1	60.6
Be	0.1	97	<0.1	<0.1	<0.1	0.02	0.07	0.05	0.4
Ca, ppm	N.A.	0	0.97	1.51	0.95	3.63	0.33	0.04	48.48
Cd	1	99.9	<1	<1	<1	0	0	0.5	0.5
Co	1	99.9	<1	<2	<2	0.02	0.01	0.5	1
Cr	0.5	73	<0.5	<0.5	<0.5	2.26	0.36	0.2	98.8
Cu	0.5	19	3.1	3.4	2	3.08	0.55	0.2	62.7
F	2	13	21	26	14	24.3	0.58	1	277
Fe	10	1	235	315	202	293	0.46	5	2905
K, ppm	0.02	11	0.13	0.14	0.10	0.1	0.43	0.01	1.66
Li	0.1	30	0.3	0.3	0.2	0.3	0.45	0.1	6.7
Mg, ppm	0.01	0	0.52	0.65	0.51	0.89	0.26	0.01	11.15
Mn	0.5	1	4.8	6	4.5	6.04	0.34	0.2	124
Mo	1	91	<1	<1	<1	0.59	0.19	0.5	6
Na, ppm	N.A.	0	1.63	<1.97	1.71	1.48	0.22	0.15	44.31
Ni	1	92	<1	<1	<1	3.42	0.19	0.5	111
P	5	64	<5	<5	<5	4.2	0.3	2	66
Pb	1	86	<1	<1	<1	1.61	0.3	0.2	51
Si, ppm	0.01	0	0.8	1.02	0.62	0.84	0.54	0.01	5.01
SO_4, ppm	0.01	0	0.26	0.30	0.26	0.19	0.21	0.03	3.86
Sr	N.A.	0	7.4	8.3	7	5.38	0.27	0.3	51.2
Ti	0.1	6	0.8	1	0.7	0.9	0.44	0.1	9.6
U	0.005	2	0.021	0.046	0.024	0.072	0.47	0.002	0.842
V	0.2	45	0.2	0.4	<0.2	0.35	0.39	0.1	7.5
Y	0.1	47	0.1	0.2	<0.1	0.2	0.40	0.1	3
Zn	1	16	2	2.4	1.6	7.3	0.33	0.5	209
Conductivity, µS	N.A.	0	19.8	24.3	20.7	25.17	0.2	7	300
pH	N.A.	0	6	5.97	N.A.	0.61	N.A.	4.3	8.46

* N.A. not applicable; ** pH is defined as a logarithmic value

Table 6. Spearman correlation coefficients (r) for selected elements and variables in lake sediment (N=2097)

	As2	Au1	Ca2	Co2	Cr1	Cu2	F9	Fe2	K2	La1	LOI	Mg2	Mn2	Mo2	Nb2	Ni2	Pb2	Sb1	Th1	U1	Y2	Zn2	Zr2
Ag6	0.01	0.04	-0.05	0.04	0.01	0.06	0.04	0.06	-0.05	-0.03	0.03	-0.03	0.05	-0.02	0.02	0.06	0.03	-0.02	-0.01	0.00	-0.03	0.01	-0.03
Al2	0.54	0.03	0.75	**0.86**	0.62	0.09	0.77	**0.82**	0.77	0.48	-0.45	**0.84**	**0.87**	0.12	**0.82**	0.58	0.48	0.09	0.57	0.23	0.58	0.78	**0.80**
As2	**1.00**	-0.03	0.29	0.45	0.26	0.16	0.35	0.53	0.37	0.63	-0.11	0.40	0.49	0.34	0.54	0.23	0.44	0.20	0.54	0.31	0.64	0.62	0.41
Au1	-0.03	**1.00**	0.08	0.06	0.10	0.11	-0.08	0.03	-0.02	-0.06	0.03	0.02	0.01	0.02	-0.03	0.13	-0.06	-0.09	-0.03	-0.02	-0.05	0.00	-0.02
Ba2	0.46	-0.02	0.75	0.65	0.39	-0.14	0.74	0.65	**0.88**	0.49	-0.45	**0.84**	0.75	-0.01	**0.80**	0.33	0.55	0.15	0.51	0.14	0.55	0.66	**0.86**
Be2	0.69	-0.05	0.39	0.63	0.31	0.10	0.47	0.71	0.57	**0.82**	-0.28	0.56	0.72	0.35	**0.81**	0.22	0.57	0.31	0.75	0.49	**0.89**	**0.81**	0.62
Br1	0.06	0.03	-0.36	-0.16	-0.06	0.55	-0.43	-0.17	-0.41	0.11	0.72	-0.33	-0.23	0.24	-0.21	-0.14	-0.18	0.07	0.00	0.11	0.00	-0.01	-0.43
Ca2	0.29	0.08	**1.00**	0.65	0.51	-0.10	0.77	0.55	0.77	0.17	-0.41	**0.86**	0.65	-0.03	0.59	0.52	0.36	0.00	0.31	0.07	0.28	0.51	0.76
Cd2	0.20	0.05	-0.16	0.26	0.15	0.46	-0.20	0.29	-0.27	0.25	0.33	-0.11	0.18	0.36	0.02	0.20	-0.03	0.10	0.04	0.27	0.29	0.37	-0.20
Ce2	0.63	-0.06	0.17	0.44	0.08	0.19	0.32	0.58	0.36	**0.98**	-0.09	0.33	0.53	0.41	0.66	0.03	0.43	0.35	0.72	0.48	**0.94**	0.71	0.41
Co2	0.45	0.06	0.65	**1.00**	0.64	0.23	0.64	**0.87**	0.60	0.40	-0.38	0.75	**0.90**	0.20	0.74	0.71	0.40	0.07	0.46	0.27	0.52	**0.81**	0.66
Cr1	0.26	0.10	0.51	0.64	**1.00**	0.34	0.34	0.51	0.39	0.07	-0.25	0.53	0.51	0.04	0.37	0.70	0.13	-0.07	0.32	0.16	0.17	0.45	0.43
Cs1	0.35	-0.11	0.08	0.18	-0.03	-0.08	0.24	0.27	0.32	0.57	-0.11	0.26	0.27	0.19	0.45	-0.13	0.44	0.45	0.43	0.36	0.58	0.40	0.31
Cu2	0.16	0.11	-0.10	0.23	0.34	**1.00**	-0.29	0.11	-0.27	0.15	0.38	-0.11	0.04	0.33	-0.08	0.39	-0.30	-0.12	0.16	0.22	0.10	0.21	-0.24
Dy2	0.64	-0.05	0.25	0.51	0.17	0.12	0.40	0.65	0.42	**0.93**	-0.18	0.40	0.61	0.39	0.72	0.12	0.49	0.38	0.70	0.53	**0.99**	0.77	0.49
F9	0.35	-0.08	0.77	0.64	0.34	-0.29	**1.00**	0.62	0.78	0.34	-0.51	**0.82**	0.68	0.07	0.78	0.58	0.53	0.24	0.29	0.09	0.41	0.63	**0.80**
Fe2	0.53	0.03	0.55	**0.87**	0.51	0.11	0.62	**1.00**	0.59	0.55	-0.38	0.69	**0.90**	0.18	**0.82**	0.55	0.49	0.16	0.50	0.27	0.66	**0.84**	0.68
Hf1	0.38	-0.05	0.68	0.56	0.32	-0.32	0.79	0.58	**0.87**	0.43	-0.53	0.79	0.66	-0.01	0.77	0.24	0.60	0.21	0.50	0.17	0.51	0.54	**0.88**
K2	0.37	-0.02	0.77	0.60	0.39	-0.27	0.78	0.59	**1.00**	0.36	-0.58	**0.91**	0.70	-0.05	0.79	0.31	0.61	0.14	0.52	0.12	0.44	0.54	**0.96**
La1	0.63	-0.06	0.17	0.40	0.07	0.15	0.34	0.55	0.36	**1.00**	-0.10	0.32	0.50	0.39	0.65	0.00	0.44	0.37	0.72	0.47	**0.93**	0.69	0.41
LOI	-0.11	0.03	-0.41	-0.38	-0.25	0.38	-0.51	-0.38	-0.58	-0.10	**1.00**	-0.53	-0.45	0.14	-0.44	-0.25	-0.29	-0.02	-0.23	-0.03	-0.20	-0.25	-0.57
Mg2	0.40	0.02	**0.86**	0.75	0.53	-0.11	**0.82**	0.69	**0.91**	0.32	-0.53	**1.00**	0.78	-0.02	0.77	0.51	0.55	0.11	0.46	0.12	0.43	0.65	**0.89**
Mn2	0.49	0.01	0.65	**0.90**	0.51	0.04	0.68	**0.90**	0.70	0.50	-0.45	0.78	**1.00**	0.16	**0.85**	0.53	0.53	0.14	0.53	0.26	0.62	**0.82**	0.76
Mo2	0.34	0.02	-0.03	0.20	0.04	0.33	0.07	0.18	-0.05	0.39	0.14	-0.02	0.16	**1.00**	0.17	0.07	0.09	0.15	0.34	0.48	0.38	0.30	-0.01
Na2	0.32	0.00	0.79	0.64	0.40	-0.24	0.75	0.59	**0.96**	0.29	-0.59	**0.91**	0.71	-0.06	0.76	0.36	0.54	0.06	0.44	0.07	0.36	0.51	**0.93**
Nb2	0.54	-0.03	0.59	0.74	0.37	-0.08	0.78	**0.82**	0.79	0.65	-0.44	0.77	**0.85**	0.17	**1.00**	0.30	0.66	0.24	0.69	0.32	0.73	0.77	**0.83**
Nd1	0.48	0.07	0.37	0.47	0.39	0.34		0.54	0.35	**0.87**	-0.17	0.35	0.48	0.26	0.55	0.30	0.18	0.01	0.71	0.33	**0.81**	0.58	0.40
Ni2	0.23	0.13	0.52	0.71	0.70	0.39	0.58	0.55	0.31	0.00	-0.25	0.51	0.53	0.07	0.30	**1.00**	0.05	-0.11	0.18	0.11	0.12	0.48	0.34
P2	0.47	0.03	0.24	0.51	0.24	0.36	0.35	0.61	0.26	0.67	0.03	0.33	0.53	0.33	0.54	0.24	0.20	0.24	0.43	0.33	0.67	0.69	0.30
Pb2	0.44	-0.06	0.36	0.40	0.13	-0.30	0.53	0.49	0.61	0.44	-0.29	0.55	0.53	0.09	0.66	0.05	**1.00**	0.31	0.51	0.23	0.50	0.44	0.64
Rb2	0.40	-0.02	0.73	0.64	0.45	-0.18	0.75	0.61	**0.93**	0.37	-0.54	**0.88**	0.72	0.00	0.79	0.36	0.60	0.14	0.57	0.18	0.46	0.57	**0.89**
Sb1	0.20	-0.09	0.00	0.07	-0.07	-0.12	0.24	0.16	0.14	0.37	-0.02	0.11	0.14	0.15	0.24	-0.11	0.31	**1.00**	0.21	0.23	0.39	0.24	0.16
Sc2	0.61	0.00	0.66	0.79	0.51	0.04	0.74	**0.83**	0.78	0.65	-0.40	**0.82**	**0.85**	0.12	**0.88**	0.44	0.59	0.22	0.64	0.27	0.75	**0.84**	**0.82**
Sm1	0.59	-0.09	0.20	0.42	0.08	0.06	0.40	0.58	0.42	**0.95**	-0.19	0.37	0.54	0.32	0.68	0.01	0.48	0.41	0.69	0.45	**0.94**	0.70	0.46
Sr2	0.34	0.01	**0.89**	0.64	0.42	-0.19	0.78	0.60	**0.90**	0.29	-0.48	**0.90**	0.71	-0.06	0.72	0.38	0.50	0.05	0.39	0.04	0.36	0.55	**0.88**
Th1	0.54	-0.03	0.31	0.46	0.32	0.16	0.29	0.50	0.52	0.72	-0.23	0.46	0.53	0.34	0.69	0.18	0.51	0.21	**1.00**	0.50	0.71	0.53	0.57
Ti2	0.42	-0.01	0.75	0.70	0.43	-0.12	0.75	0.66	**0.92**	0.46	-0.48	**0.90**	0.77	0.04	**0.87**	0.34	0.62	0.16	0.60	0.18	0.53	0.62	**0.91**
U1	0.31	-0.02	0.07	0.27	0.16	0.22	0.09	0.27	0.12	0.47	-0.03	0.12	0.26	0.48	0.32	0.11	0.23	0.23	0.50	**1.00**	0.53	0.35	0.17
V2	0.47	0.06	0.46	**0.81**	0.55	0.40	0.38	**0.82**	0.45	0.51	-0.24	0.59	0.76	0.26	0.68	0.56	0.28	0.08	0.49	0.28	0.59	0.77	0.52
Y2	0.64	-0.05	0.28	0.52	0.17	0.10	0.41	0.66	0.44	**0.93**	-0.20	0.43	0.62	0.38	0.73	0.12	0.50	0.39	0.71	0.53	**1.00**	0.77	0.51
Yb1	0.65	-0.04	0.38	0.59	0.30	0.04	0.47	0.71	0.55	**0.87**	-0.28	0.54	0.69	0.32	0.78	0.20	0.56	0.36	0.74	0.50	**0.94**	0.78	0.63
Zn2	0.62	0.00	0.51	**0.81**	0.45	0.21	0.63	**0.84**	0.54	0.69	-0.25	0.65	**0.82**	0.30	0.77	0.48	0.44	0.24	0.53	0.35	0.77	**1.00**	0.59
Zr2	0.41	-0.02	0.76	0.66	0.43	-0.24	**0.80**	0.68	**0.96**	0.41	-0.57	**0.89**	0.76	-0.01	**0.83**	0.34	0.64	0.16	0.57	0.17	0.51	0.59	**1.00**
depth_	0.14	0.08	-0.10	0.13	0.13	0.64	-0.22	0.12	-0.19	0.24	0.34	-0.12	0.07	0.34	0.01	0.12	-0.29	-0.03	0.14	0.22	0.19	0.23	-0.19

Coefficient r>|0.04| is significant at the 0.05 confidence level; Coefficient r>|0.06| is significant at the 0.01 confidence level

Molybdenum has modest correlations with uranium (r=0.48), with the REE (0.41 to 0.38), and with copper as mentioned above. Aside from those mentioned previously, correlations with nickel include cobalt (r=0.71), chromium (r=0.70) and zinc (r=0.62). These may be partly due to co-correlation with Fe2. Uranium has modest correlations with the REE, with thorium (r=0.50), and with molybdenum (r=0.48) as mentioned above.

Correlation Analysis of Water Data

Spearman correlation coefficients were calculated for those analyses for which more than 10 percent of the samples exceeded the detection limit. They are shown in Table 7. Correlations are weaker amongst the water variables compared to correlations among sediment data. Consequently, to highlight the more robust correlations, coefficients for which r≥|0.70|) are coloured red. Among the base metals, correlations are weak. Two of the strongest correlations with uranium are with yttrium (r=0.46) and fluoride (r=0.32) suggesting a granophile association. Some of the strongest correlations are among pH, calcium and magnesium, suggesting that these elements may be useful guides to magmatic differentiation of bedrock in the catchment basin.

ELEMENT DISTRIBUTION IN LAKE SEDIMENT AND WATER

The locations of sample sites, identified with the last 4 digits of a sample's field number, are shown in relation to bedrock geology and 1:50 000-scale drainage features in Figures 11-17. Referral to the corresponding .PDF file both for these figures and those of the symbol plots is recommended in order to see more detail than can be clearly illustrated in the paper copy. The bedrock polygons are from the digital 1:1 000 000 geology map of Labrador (Wardle *et al.*, 1997). References to NTS map areas are made frequently. The locations of these in relation to geology and sample sites are shown in Figure 18.

Symbol plot maps of the various elements and variables were produced for most elements using natural breaks (Jenk's Optimization) to depict naturally occurring divisions in the data in the hope of reflecting geochemical or mineralogical processes. In some cases, the intervals were adjusted manually to better display the dispersion patterns or emphasize higher values. For discussion purposes the term 'high value' will refer to the highest interval on the associated dot plot map shown by red dots, and the term "elevated value" will refer to the second highest interval shown by orange dots. Reference to the expanded geologic legend (Figure 5) may be useful when examining the symbol plots.

Histograms with overlaid cumulative frequency plots are included in each figure. These show the extent and shape of the distribution. The horizontal axes on the histograms are logarithmic because most distributions more closely approximate log distributions than arithmetic ones. The cumulative frequency curves allow the reader to determine what percentile ranges apply to each symbol class. Inflections in the curve reflect underlying breaks in the population, possibly denoting changes in bedrock composition.

Table 7. Spearman correlation coefficients (r) for selected elements and variables in lake water (N=2222)

	Conductivity	Alw2	Asw2x	Baw2	Caw1	Crw2	Cuw2	Fw9	Few1	Kw1	Liw2	Mgw1	Mnw1	Naw1	Pw2	Pbw2	SO4w1	Tiw2	Uw3	Yw2	Znw2
pH_w	0.25	-0.51	0.14	0.40	**0.73**	-0.15	0.03	0.15	-0.10	-0.01	0.14	0.54	-0.35	0.02	-0.06	-0.09	0.36	-0.48	0.06	-0.16	-0.22
Conductivity	**1.00**	0.26	0.25	0.20	0.60	-0.08	0.18	0.12	0.13	0.36	0.01	**0.85**	0.09	**0.81**	0.25	-0.08	**0.72**	0.19	0.26	0.08	0.18
Alw2	0.26	**1.00**	-0.06	-0.13	-0.08	0.14	0.09	0.23	0.33	0.16	0.03	0.12	0.44	0.48	0.29	0.02	0.09	**0.78**	0.36	0.49	0.28
Asw2x	0.25	-0.06	**1.00**	0.12	0.17	-0.02	0.18	-0.13	-0.09	0.14	0.09	0.23	-0.04	0.24	0.04	-0.09	0.20	-0.08	0.10	-0.05	0.05
Baw2	0.20	-0.13	0.12	**1.00**	0.42	-0.08	-0.05	0.03	0.16	0.07	0.05	0.40	0.01	0.06	0.20	-0.09	0.38	-0.12	-0.06	0.04	0.08
Caw1	0.60	-0.08	0.17	0.42	**1.00**	-0.07	0.04	0.24	0.21	0.08	0.03	**0.78**	-0.08	0.33	0.22	-0.08	0.59	-0.04	0.13	-0.01	-0.06
Crw2	-0.08	0.14	-0.02	-0.08	-0.07	**1.00**	0.05	0.09	0.16	-0.02	-0.00	-0.13	0.15	-0.04	0.08	0.09	-0.06	0.20	0.04	0.14	-0.05
Cuw2	0.18	0.09	0.18	-0.05	0.04	0.05	**1.00**	-0.03	-0.06	0.24	-0.03	0.12	0.02	0.23	0.02	-0.01	0.04	0.09	0.21	0.19	0.07
Fw9	0.12	0.23	-0.13	0.03	0.24	0.09	-0.03	**1.00**	0.32	-0.22	0.11	0.15	0.17	0.06	0.06	0.09	-0.01	0.30	0.32	0.44	-0.15
Few1	0.13	0.33	-0.09	0.16	0.21	0.16	-0.06	0.32	**1.00**	-0.20	-0.04	0.13	0.40	0.03	0.45	0.06	0.02	0.54	-0.12	0.24	-0.05
Kw1	0.36	0.16	0.14	0.07	0.08	-0.02	0.24	-0.22	-0.20	**1.00**	-0.09	0.33	0.04	0.52	0.07	-0.10	0.30	0.07	0.34	0.07	0.35
Liw2	0.01	0.03	0.09	0.05	0.03	-0.00	-0.03	0.11	-0.04	-0.09	**1.00**	0.05	-0.01	-0.04	-0.09	-0.02	0.02	-0.07	0.12	0.15	-0.15
Mgw1	**0.85**	0.12	0.23	0.40	**0.78**	-0.13	0.12	0.15	0.13	0.33	0.05	**1.00**	-0.00	**0.70**	0.24	-0.14	**0.76**	0.05	0.23	0.03	0.13
Mnw1	0.09	0.44	-0.04	0.01	-0.08	0.15	0.02	0.17	0.40	0.04	-0.01	-0.00	**1.00**	0.18	0.17	-0.03	-0.07	0.41	0.24	0.35	0.14
Naw1	**0.81**	0.48	0.24	0.06	0.33	-0.04	0.23	0.06	0.03	0.52	-0.04	**0.70**	0.18	**1.00**	0.19	-0.11	0.62	0.32	0.40	0.21	0.30
Pw2	0.25	0.29	0.04	0.20	0.22	0.08	0.02	0.06	0.45	0.07	-0.09	0.24	0.17	0.19	**1.00**	0.04	0.24	0.42	-0.03	0.11	0.17
Pbw2	-0.08	0.02	-0.09	-0.09	-0.08	0.09	-0.01	0.09	0.06	-0.10	-0.02	-0.14	-0.03	-0.11	0.04	**1.00**	-0.11	0.12	-0.01	0.06	-0.04
Siw1	0.24	-0.01	0.11	0.49	0.46	-0.09	0.02	0.08	-0.04	0.13	0.10	0.45	0.05	0.21	-0.01	-0.09	0.35	-0.14	0.19	0.14	0.06
SO4w1	**0.72**	0.09	0.20	0.38	0.59	-0.06	0.04	-0.01	0.02	0.30	0.02	**0.76**	-0.07	0.62	0.24	-0.11	**1.00**	-0.01	0.05	-0.06	0.10
Srw2	0.57	-0.04	0.19	0.61	**0.85**	-0.08	0.05	0.19	0.21	0.09	0.09	**0.77**	-0.06	0.34	0.26	-0.10	0.64	-0.05	0.13	0.00	-0.04
Tiw2	0.19	**0.78**	-0.08	-0.12	-0.04	0.20	0.09	0.30	0.54	0.07	-0.07	0.05	0.41	0.32	0.42	0.12	-0.01	**1.00**	0.19	0.43	0.28
Uw3	0.26	0.36	0.10	-0.06	0.13	0.04	0.21	0.32	-0.12	0.34	0.12	0.23	0.24	0.40	-0.03	-0.01	0.05	0.19	**1.00**	0.46	0.10
Vw2	0.34	0.40	0.10	0.04	0.10	0.06	0.22	-0.02	0.17	0.34	-0.21	0.28	0.17	0.44	0.24	0.02	0.21	0.45	0.10	0.10	0.35
Yw2	0.08	0.49	-0.05	0.04	-0.01	0.14	0.19	0.44	0.24	0.07	0.15	0.03	0.35	0.21	0.11	0.06	-0.06	0.43	0.46	**1.00**	0.14
Znw2	0.18	0.28	0.05	0.08	-0.06	-0.05	0.07	-0.15	-0.05	0.35	-0.15	0.13	0.14	0.30	0.17	-0.04	0.10	0.28	0.10	0.14	**1.00**
depth_m	-0.11	0.05	0.00	0.00	-0.17	0.02	-0.00	0.02	-0.23	0.13	-0.01	-0.13	0.04	0.03	-0.25	-0.02	0.02	-0.12	0.03	-0.06	-0.11
area_km	-0.08	0.01	-0.03	-0.05	-0.05	-0.01	-0.04	0.09	-0.09	0.08	0.08	-0.07	0.02	0.03	-0.01	-0.05	0.01	-0.02	0.05	-0.06	-0.08

Coefficient r>|0.07| is significant at the 0.05 confidence level; Coefficient r>|0.09| is significant at the 0.01 confidence level

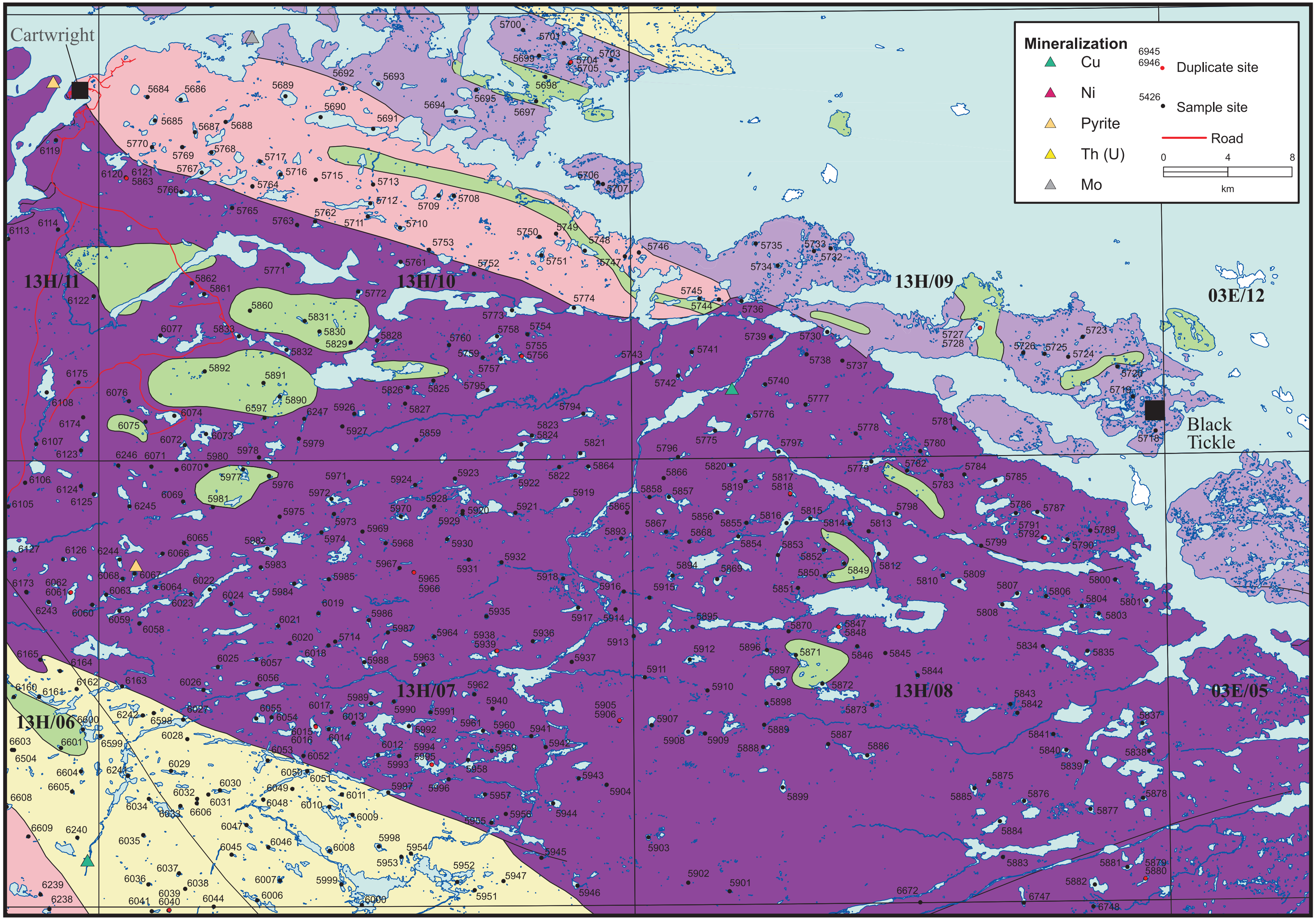

Figure 11. *Sample sites in relation to drainage and bedrock geology in NTS map areas 13H/07, 08, 09 and 10.*

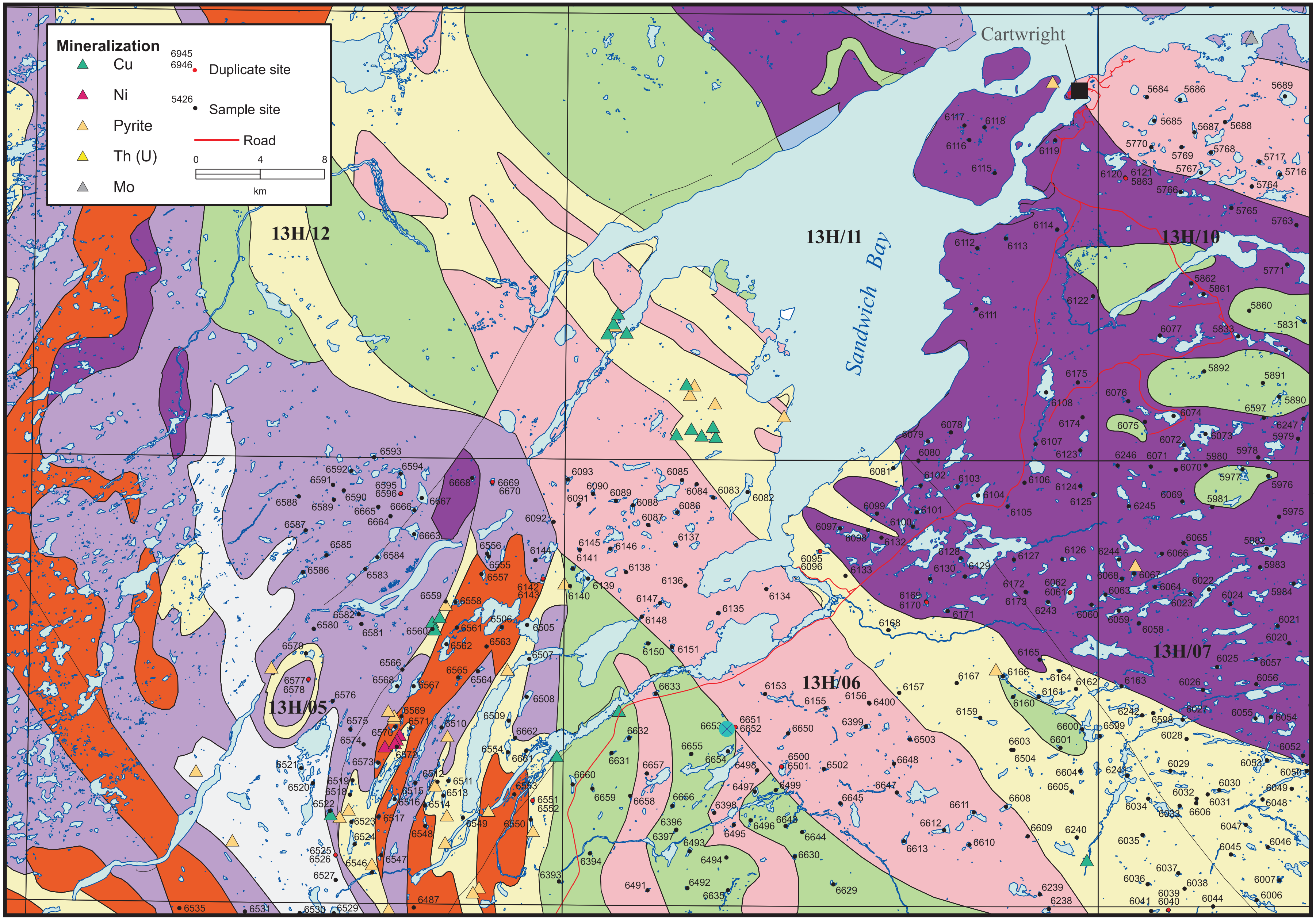

Figure 12. *Sample sites in relation to drainage and bedrock geology in NTS map areas 13H/05, 06 and 11.*

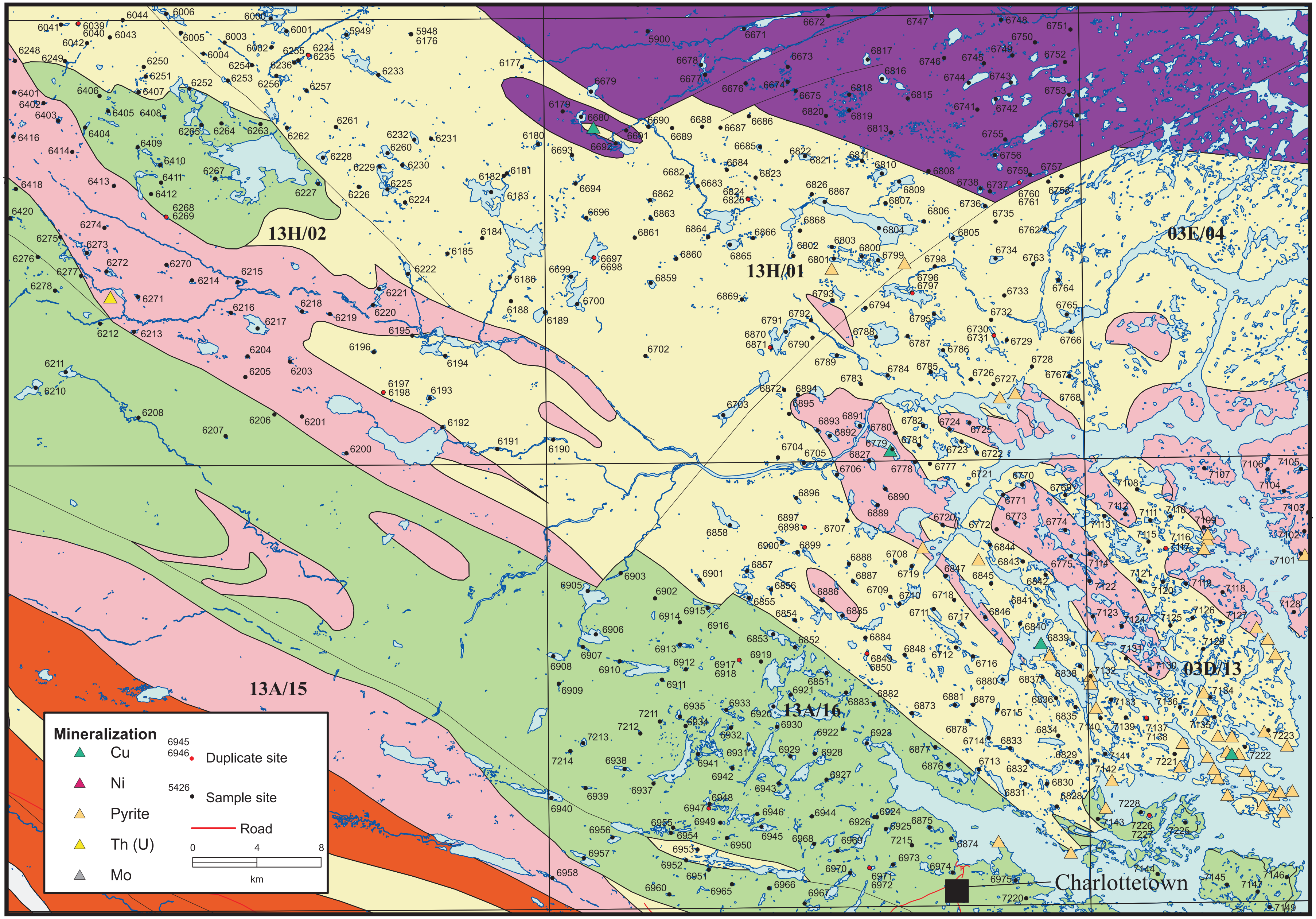

Figure 13. *Sample sites in relation to drainage and bedrock geology in NTS map areas 3D/13, 13A/16, 13H/01 and 13H/02.*

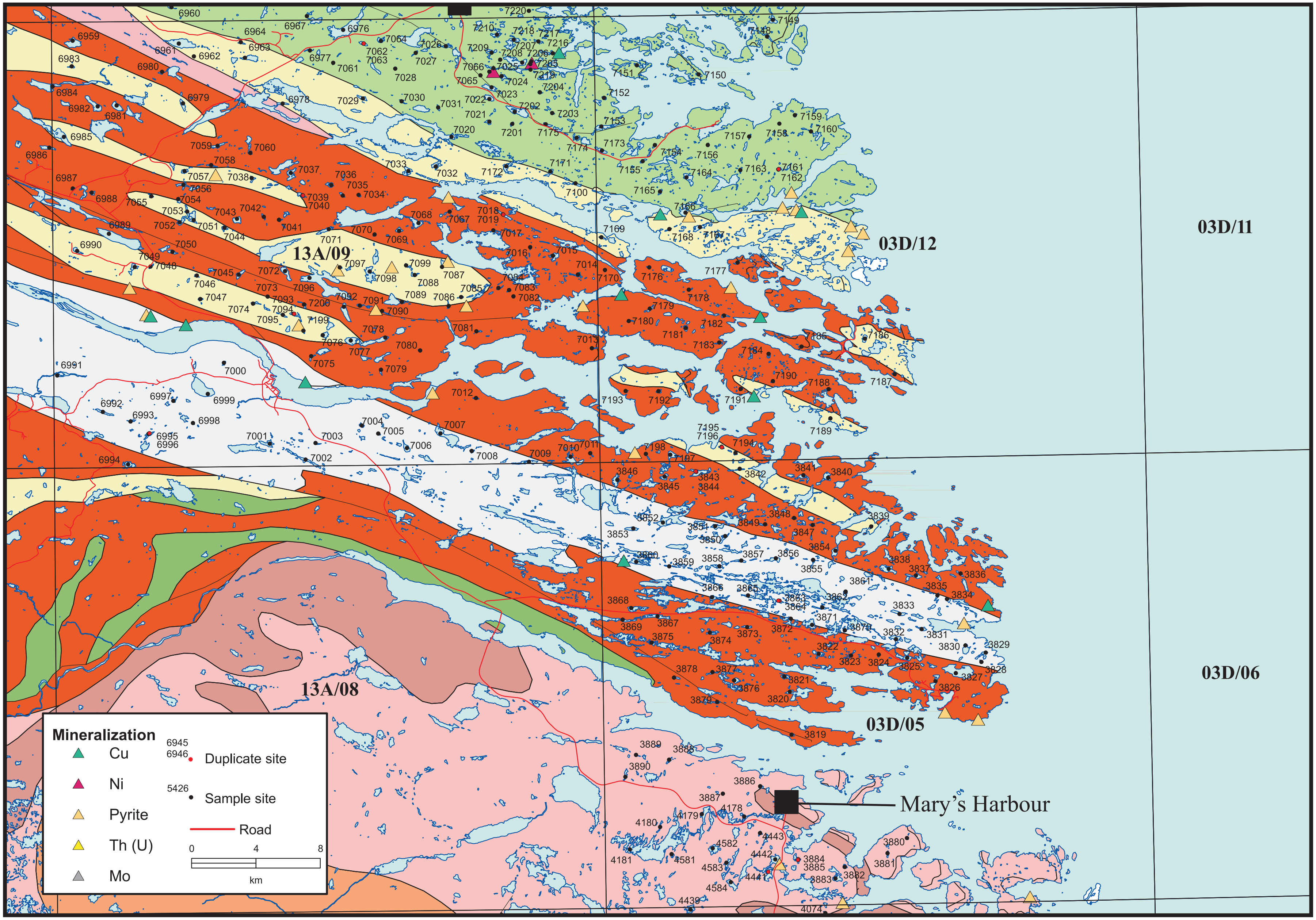

Figure 14. *Sample sites in relation to drainage and bedrock geology in NTS map areas 3D/05, 12 and 13A/09.*

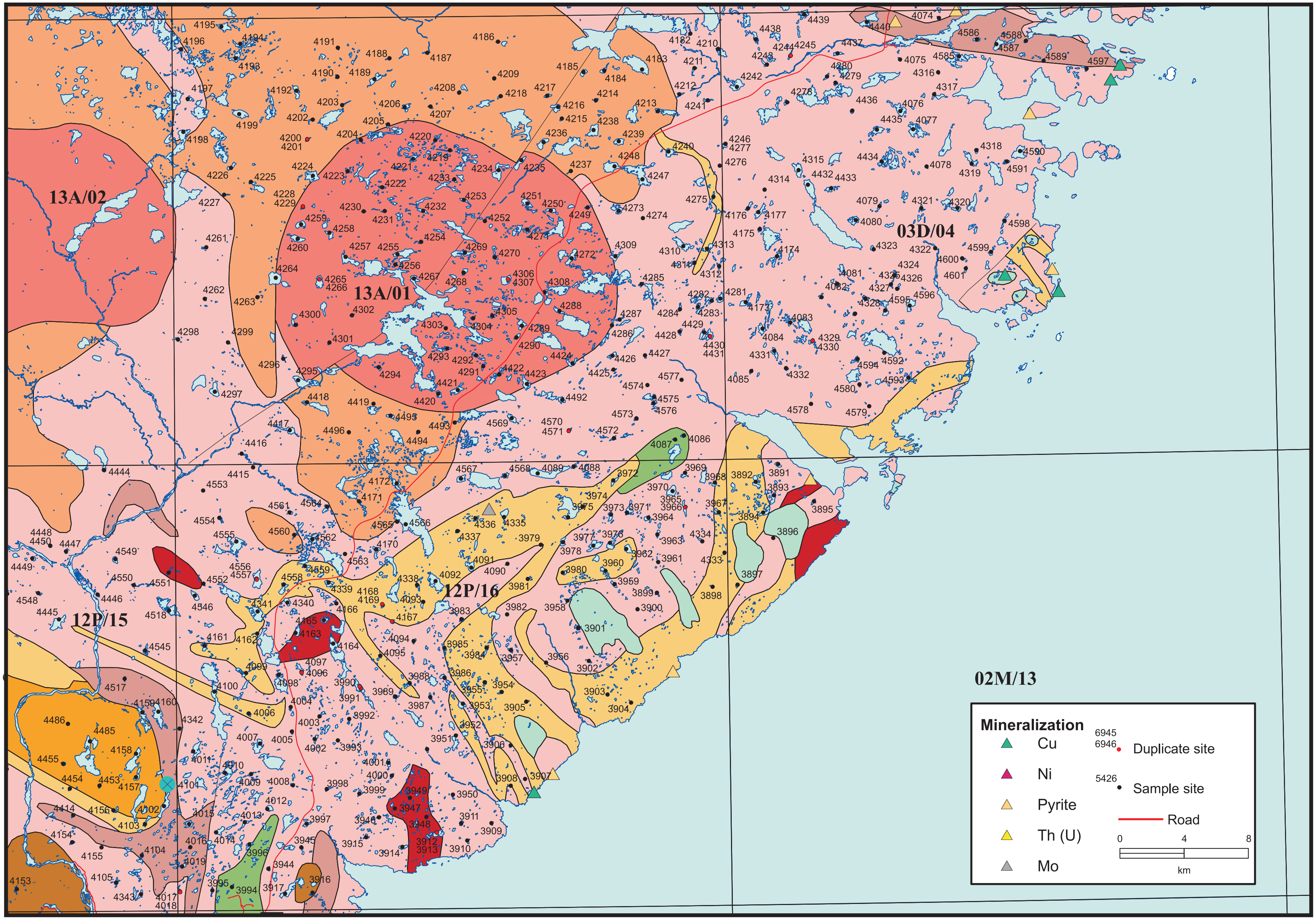

Figure 15. *Sample sites in relation to drainage and bedrock geology in NTS map areas 2M/13, 3D/04, 12P/16 and 13A/01.*

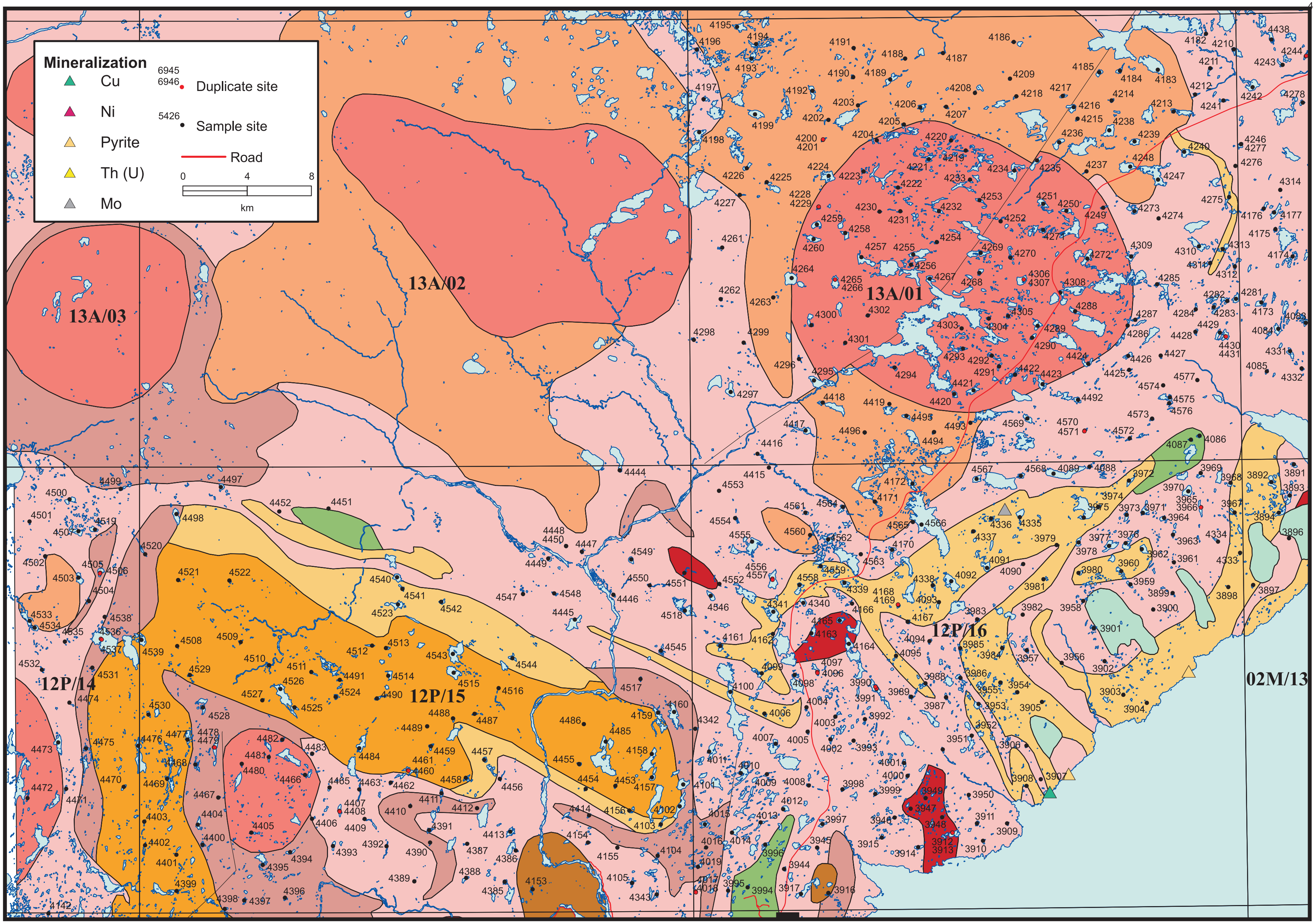

Figure 16. *Sample sites in relation to drainage and bedrock geology in NTS map areas 12P/14, 15, 16 and 13A/01.*

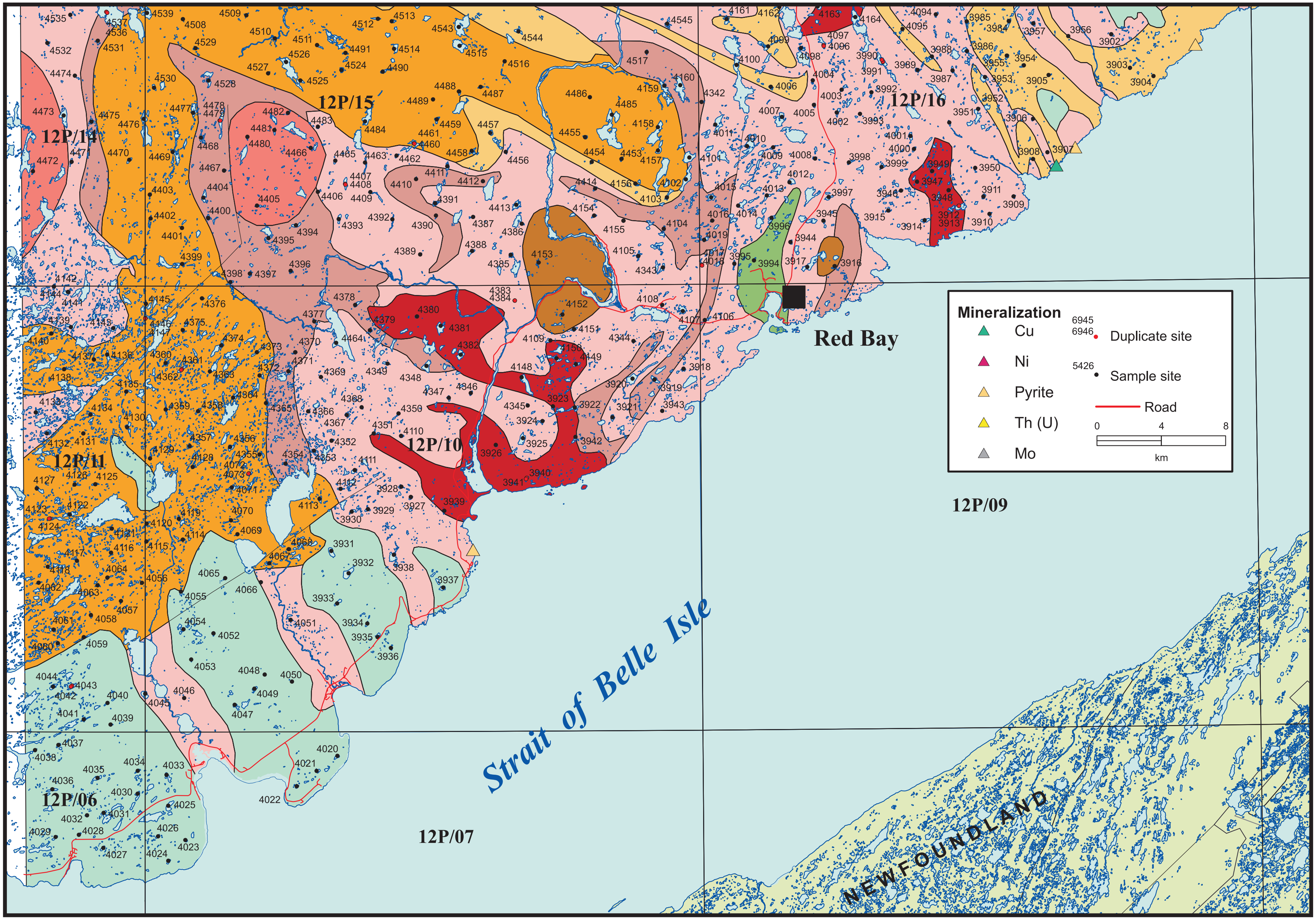

Figure 17. *Sample sites in relation to drainage and bedrock geology in NTS map areas 12P/06, 07, 09, 11, 14, 15 and 16.*

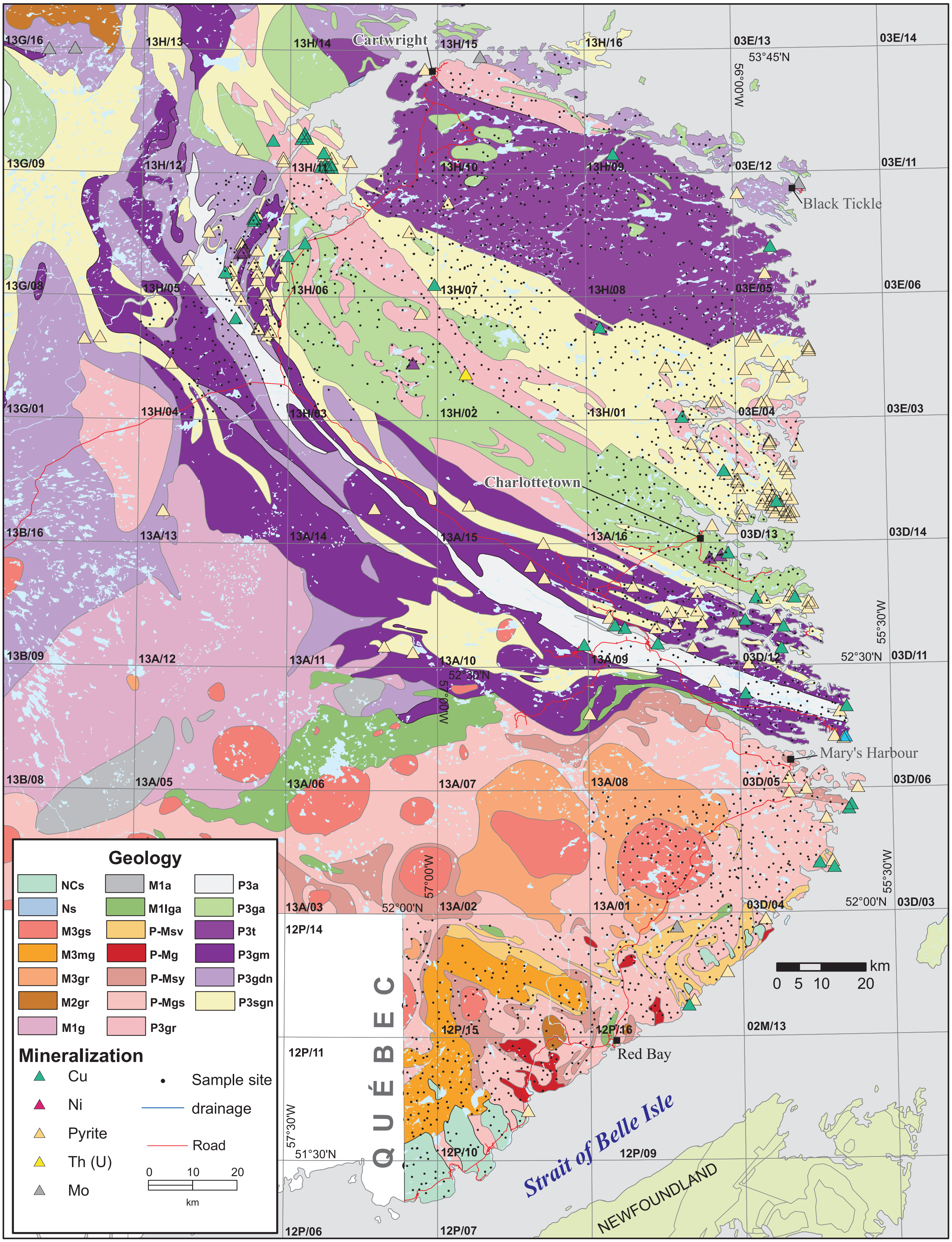

Figure 18: *Summary of geology, mineralization, sample sites and NTS maps.*

Sediment Data

Symbol plots of the distribution of LOI and iron (Fe2) are shown in Figures 19 and 20. The plot of LOI is different than the others in that the intervals are based not on the Jenk's distribution but on quantile divisions of the data. In this case each of the five symbol intervals includes 20% of the data. LOI is shown because, like iron, it can be regarded as an environmental parameter influencing the element content in sediment unrelated to bedrock source. For example, the copper (Cu2) content of sediment has a correlation coefficient of 0.38 with LOI (Table 6) and zirconium (Zr2) has a negative correlation (–0.57). These correlations may be important when ascribing significance to an anomalous value.

The distribution of iron (Fe2) in lake sediment might be regarded as a proxy for oxidizing conditions in the water column and the lake bottom. Unusually high iron likely indicates conditions that encourage precipitation of iron (hydr)oxides; these oxides often act as sinks for some metals, particularly Co and Zn. High sediment contents of metals that show a strong correlation with Fe should be interpreted in relation to the iron content of the sediment (Table 6). The distribution of Fe2 is shown in Figure 20.

Base Metals

The base metals copper, nickel, zinc and molybdenum are plotted in Figures 21-24. There are several clusters and isolated samples with elevated and high copper values (Cu2) in Figure 21 (NTS map areas 3D/12 and 13A/09). Unit P3a consisting of leuconorite and associated rocks has several such samples and also has several known Cu occurrences. Another large cluster of 13 elevated samples occurs in NTS map areas 3D/13 and 13A/16. These overlie the copper mineralized pelitic gneiss unit, P3sgn. Eight elevated and two high Cu samples are found in NTS map areas 13H/7, 8 and 10 over unit Pt3 consisting of quartz diorite, tonalite and granodiorite. Smaller clusters and isolated samples of elevated and high values are found elsewhere.

The distribution of nickel (Ni2) is shown in Figure 22. The largest grouping of elevated and high Ni2 samples is found over unit P3ga composed of gabbronorite and associated rocks. Fifteen elevated and two high samples are located over this unit in NTS map areas 3D/12 and 13, and 13A/09 and 16. A second association is found with six elevated and one high sample a few kilometres to the northeast over unit P3sgn commonly in the samples that have elevated Cu values. Several pyrite and some copper occurrences are also found in this area. Perhaps of interest are two samples with elevated and high contents of Ni2 in NTS map area 13H/08 overlying unit P3t. These samples are also high and elevated in Cu2. The high-content sample has values of 181 ppm Cu2, and 89 ppm Ni2. This sample also has a high iron content, 9.44 weight percent Fe2. Likely some of the high base metal content is due to iron oxide scavenging. One other high value Ni2 sample and several samples with elevated Ni2 are found elsewhere in the survey area.

The distribution of zinc (Zn2) is shown in Figure 23. All of the samples with high Zn2 values and most of the samples with elevated values are found in two areas in the southern part of the survey. A large group of these samples is located in NTS map areas 12P/10, 11, 15 and 16. They seem to be associated with units M3mg, M3gs and P-Mgs. The second cluster is located in NTS map area 13A/01 and is also associated with M3gs and P-Mgs.

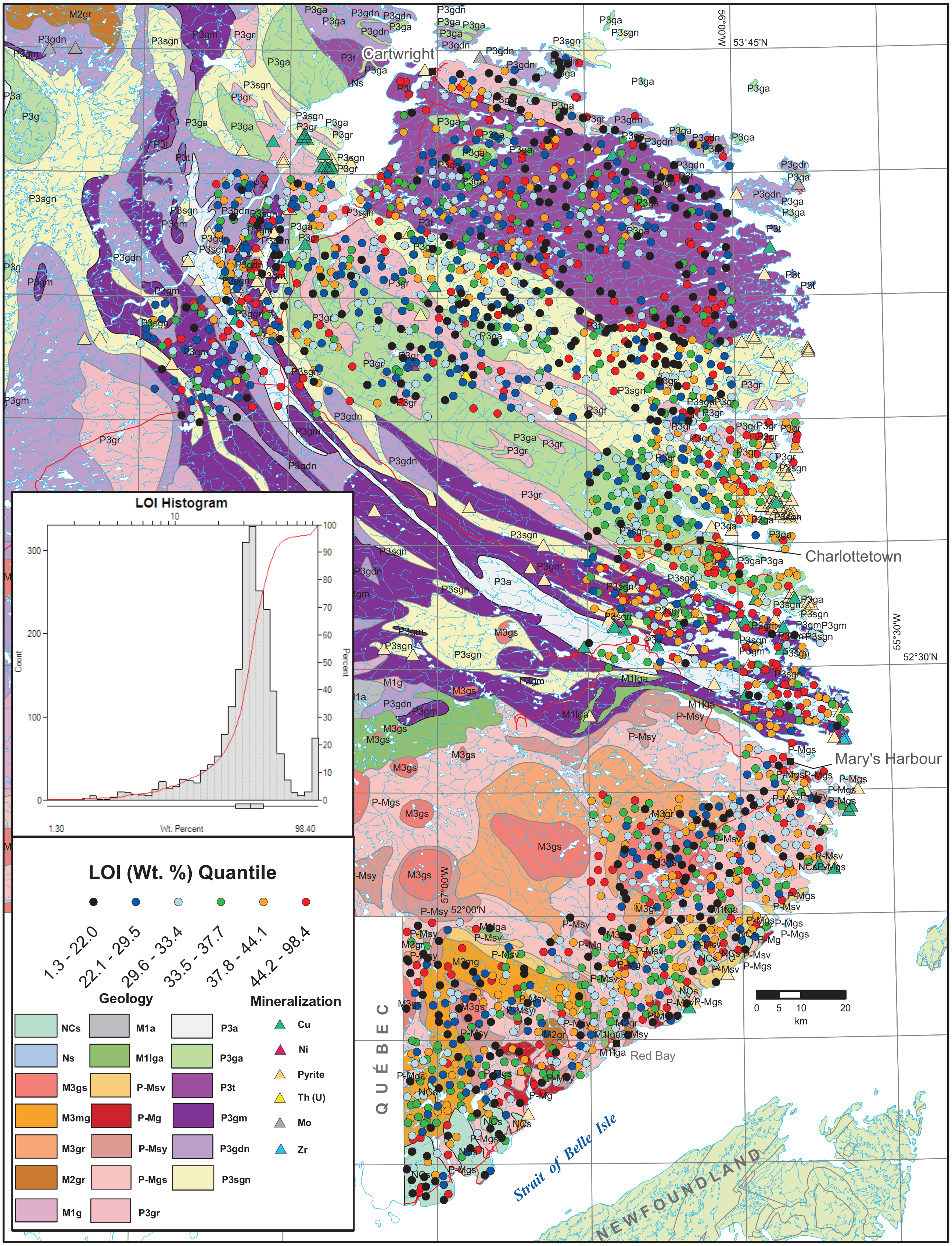

Figure 19. *Loss-on-ignition (LOI) in lake sediment.*

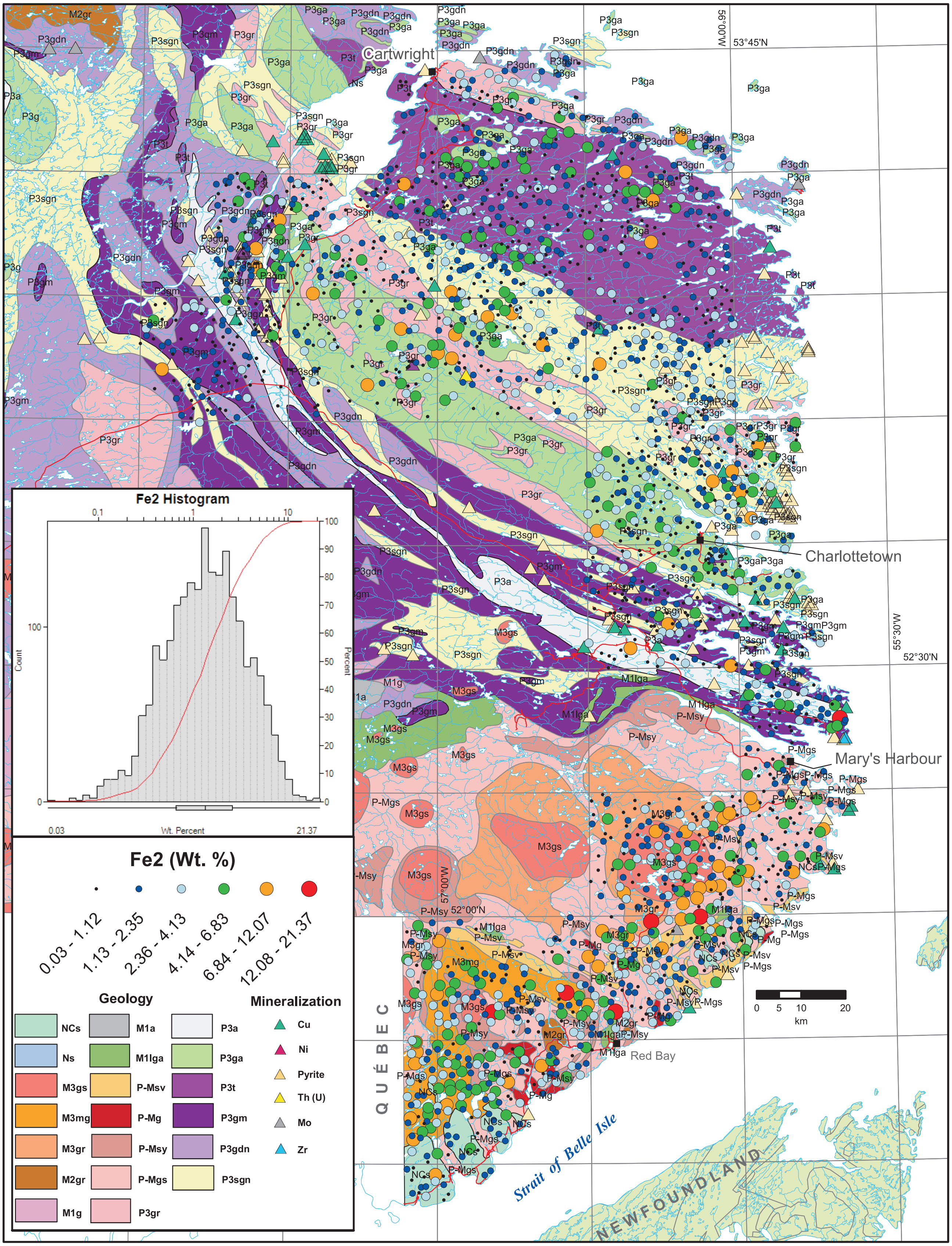

Figure 20. *Iron (Fe2) in lake sediment.*

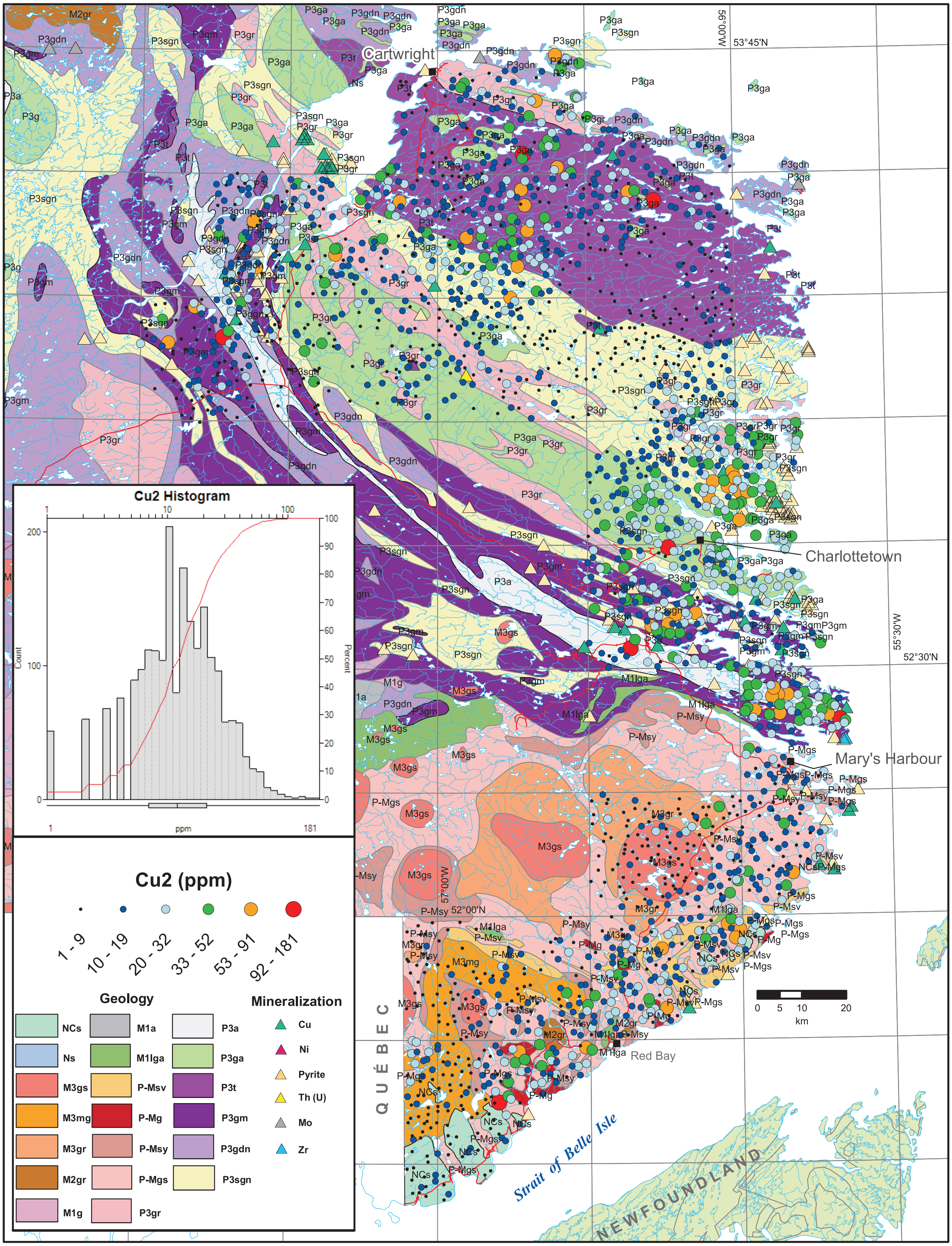

Figure 21. *Copper (Cu2) in lake sediment.*

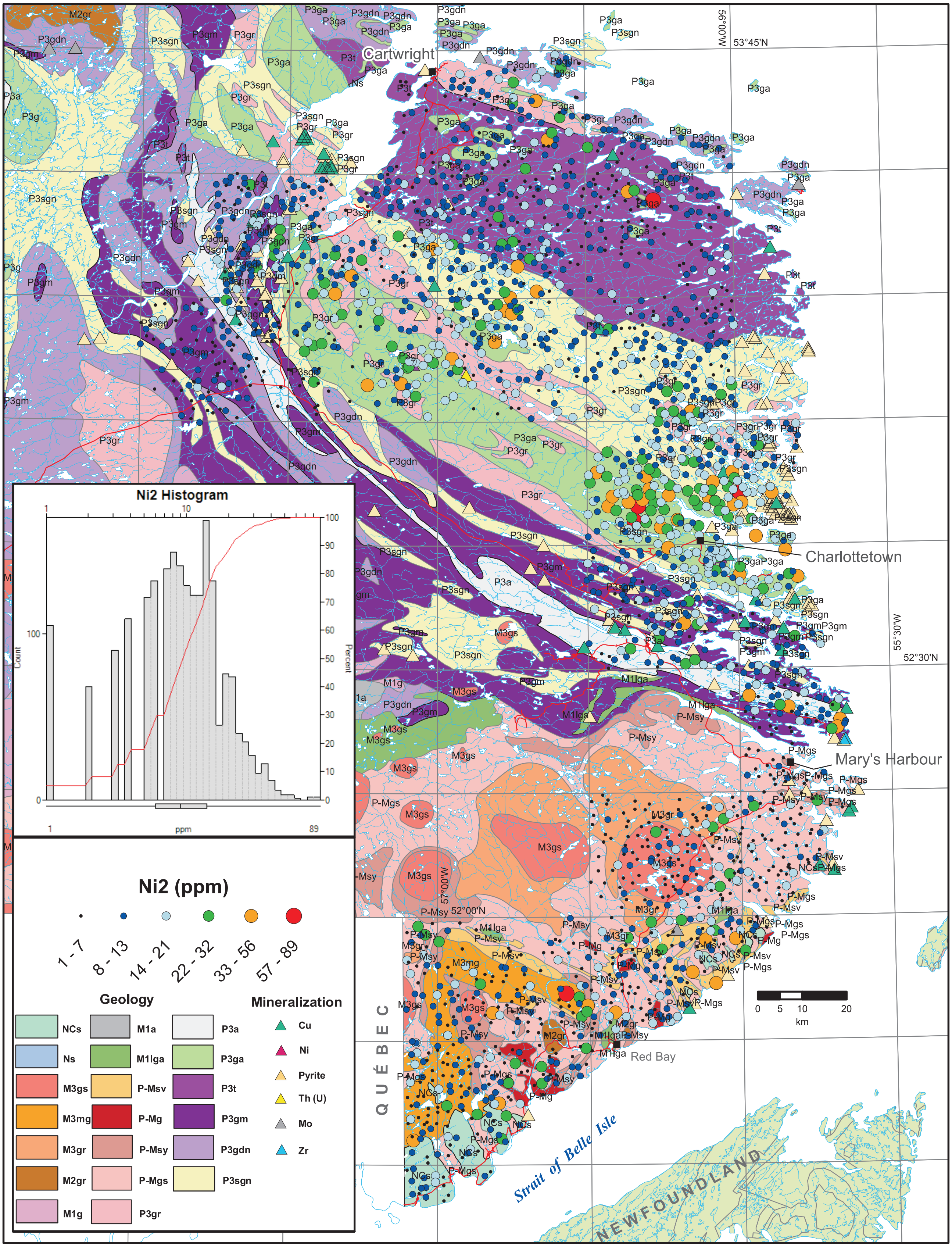

Figure 22. *Nickel (Ni2) in lake sediment.*

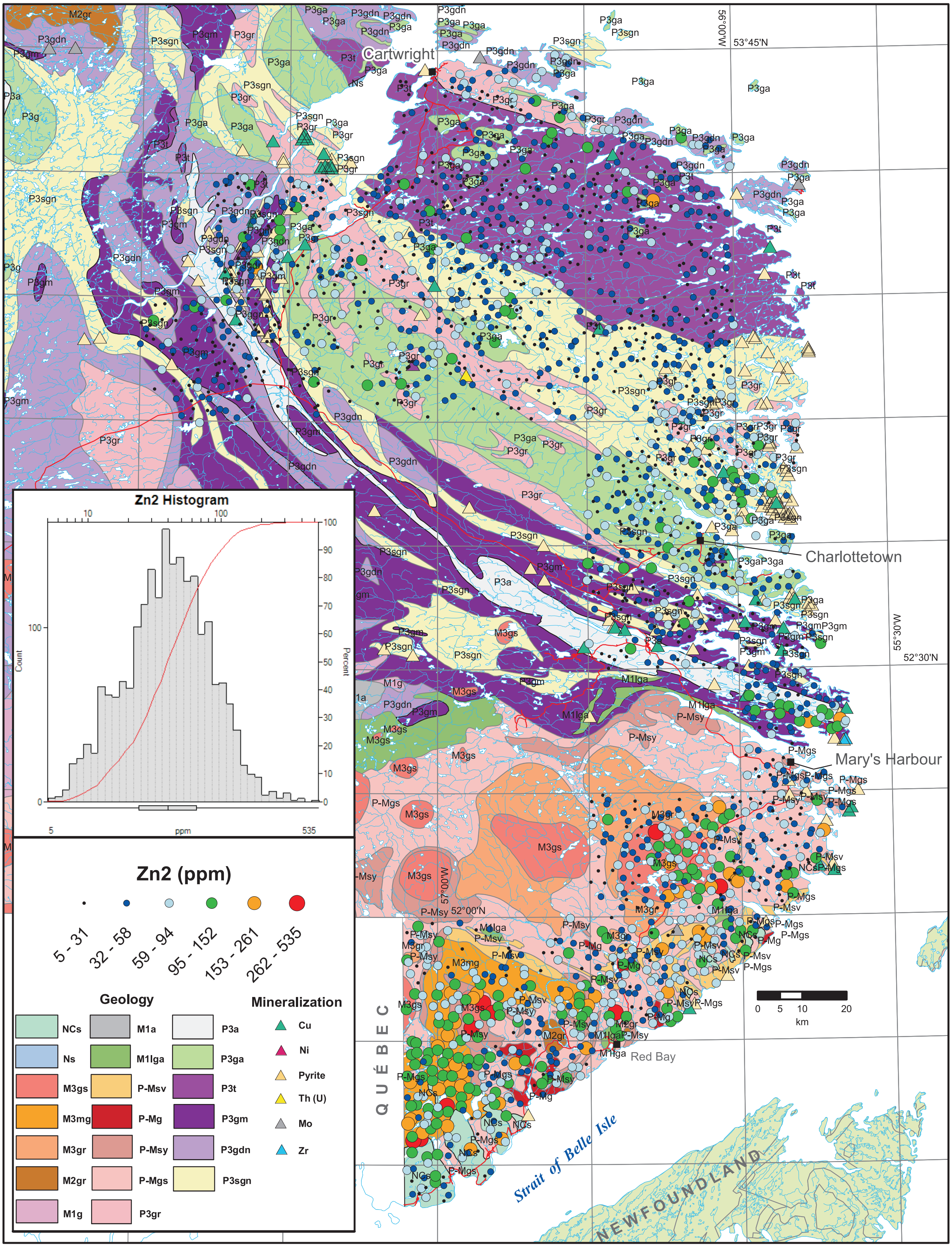

Figure 23. *Zinc (Zn2) in lake sediment.*

The distribution of molybdenum (Mo2) is shown in Figure 24. Three of the high values are isolated from other elevated values and three have a few elevated values nearby. The four most southerly samples with high values overlie granites and granitoid rocks − units P-Mgs and P3gm. The most northerly sample with high Mo2 is located over granodiorite gneiss, unit P3gdn. Surprisingly, the sixth sample is from an island in NTS map area 3D/12 mapped as gabbronorite and/or associated rocks. The only molybdenite occurrence is in NTS map area 12P/16, about 5 km from a sample with elevated Mo2.

Gold

The distribution of gold (Au1) is shown in Figure 25. Gold in lake sediment is commonly problematic to interpret. The data are characteristically noisy due to very low concentrations and perhaps the nugget effect. The Spearman correlation coefficient between pairs of site duplicate samples is –0.03, or not significant (Figure 6). The gold concentrations in the samples from the survey are quite low, with the highest interval being only 9 to12 ppb Au1.

All of the samples with high and elevated gold contents are in the north half of the survey area and are found over a variety of rock types. These samples are mostly scattered although some are within a few kilometres of each other. In some areas arsenic and/or antimony may act as pathfinders for gold mineralization. However, Table 6 indicates that there is no statistical correlation between gold and either arsenic (As2) or antimony (Sb1). Plots of these elements may be found in the appendix.

Uranium

The distribution of uranium (U1) is shown in Figure 26. With the exception of one high value and one elevated value, the samples with enriched uranium values are concentrated in NTS map areas 12P/16 and 13A/01 with three scattered samples in adjacent NTS map areas 3D/04 and 12P/16. Most of the samples are from lakes overlying granites and associated rocks of unit P-Mgs. The two other samples are from the northern part of the survey. The sample with a high U1 content (220 ppm) is from a lake very close to, and down-ice from, a granite or associated rock type in unit P3gr in NTS map area 13H/03.

REE

The distribution of the rare earth elements (REE) dysprosium (Dy2), lanthanum (La2), terbium (Tb1), yttrium (Y2) and ytterbium (Yb1) are shown in Figures 27-31. Other REE that were analysed are shown in the appendix. Because the REE have similar chemical properties in the surficial environment, they have similar distribution patterns. The biggest visual difference results from the Jenks algorithm selecting different population break points with the results that some REE have proportionally more high and elevated values than others. In all cases, the red and orange symbols are concentrated in the southern portion of the survey and in all cases, the samples are from lakes located over granites and similar rock types.

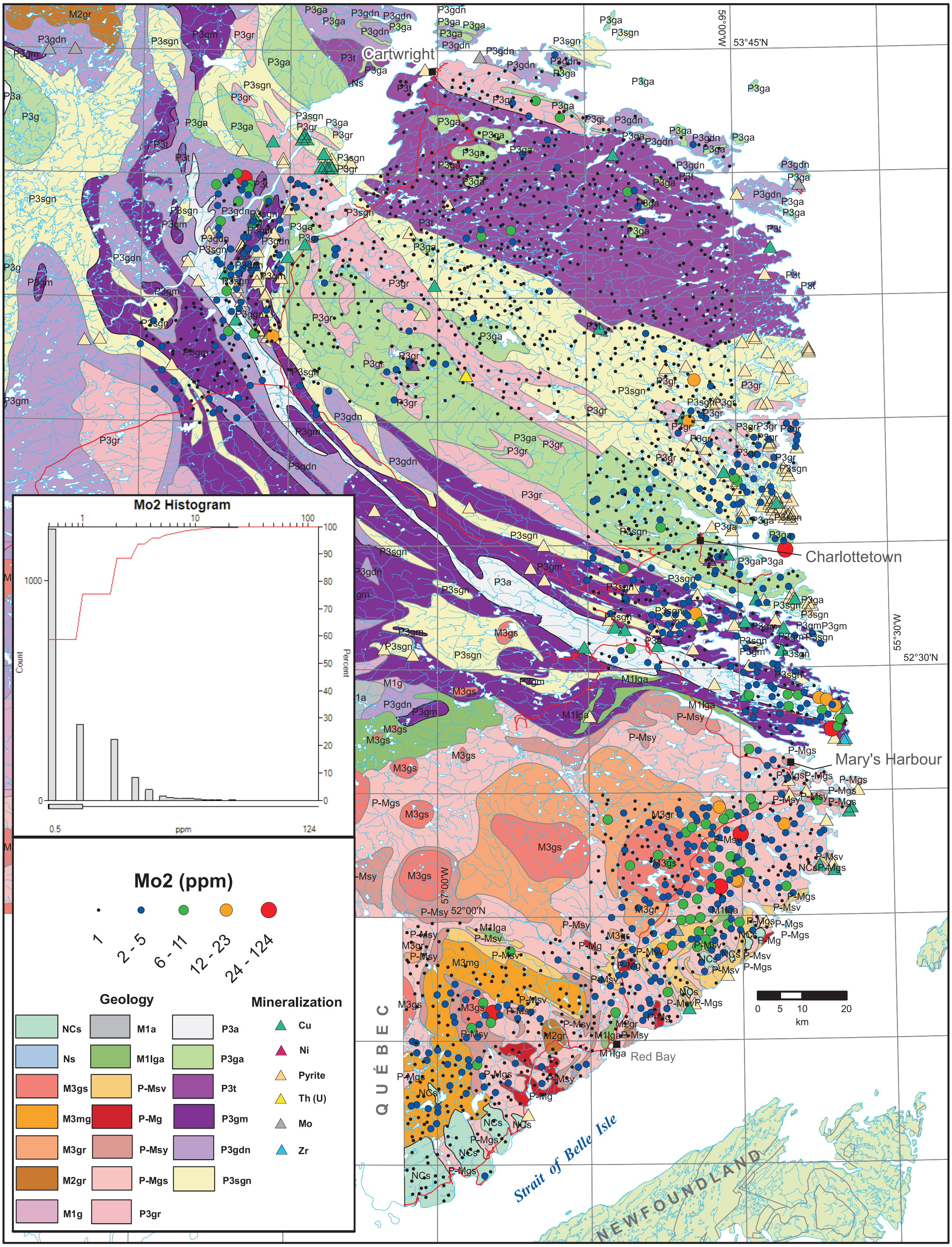

Figure 24. *Molybdenum (Mo2) in lake sediment.*

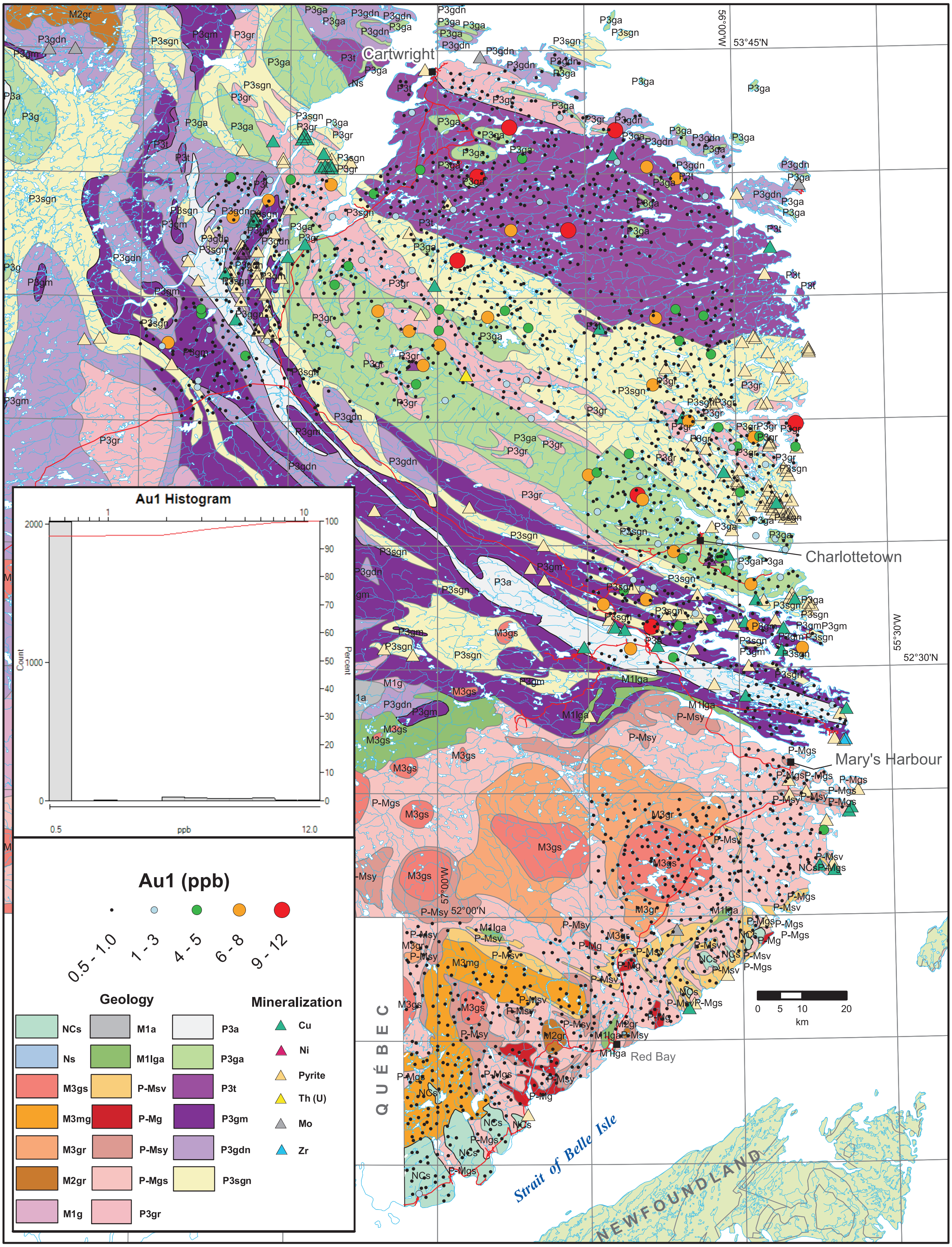

Figure 25. *Gold (Au1) in lake sediment.*

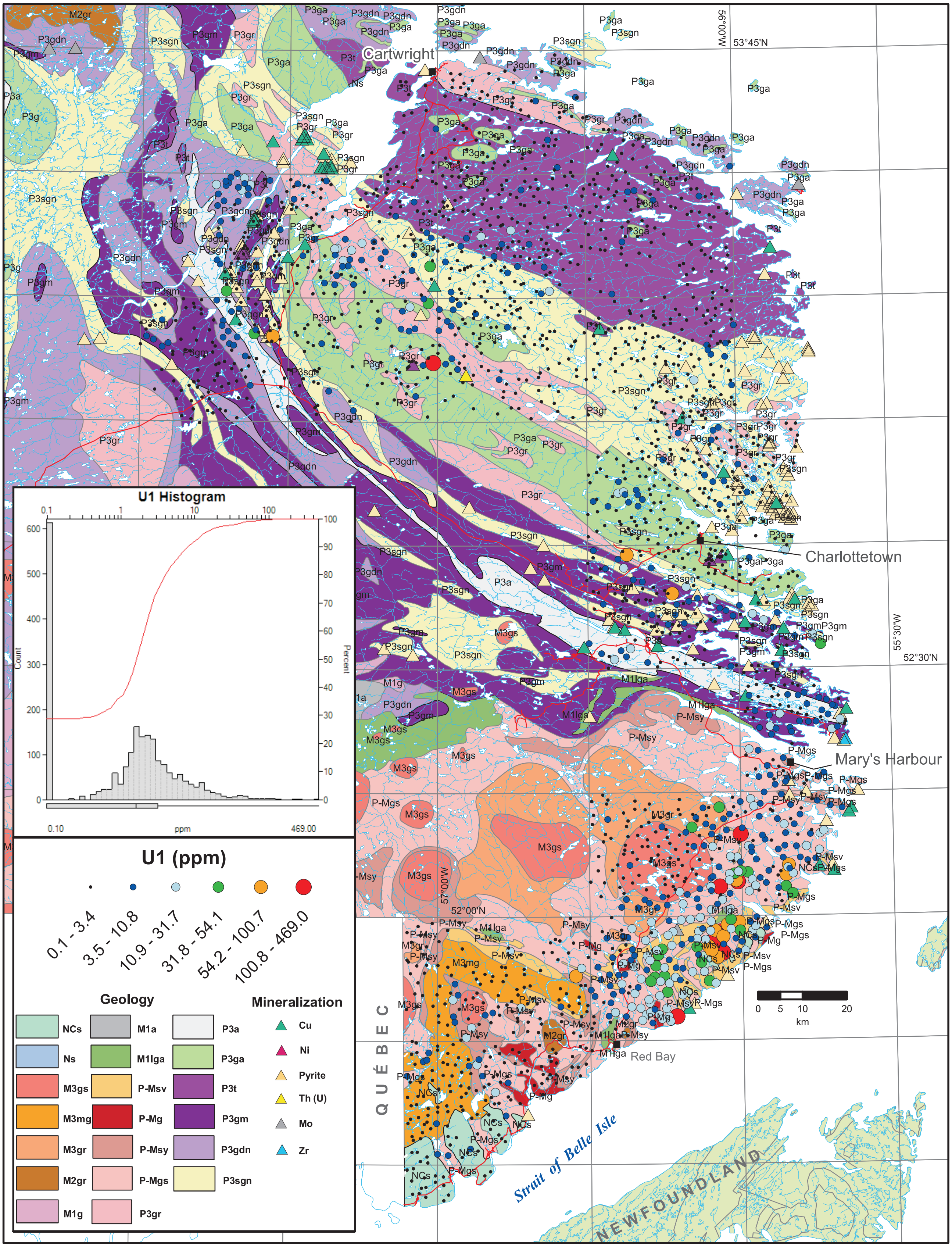

Figure 26. *Uranium (U1) in lake sediment.*

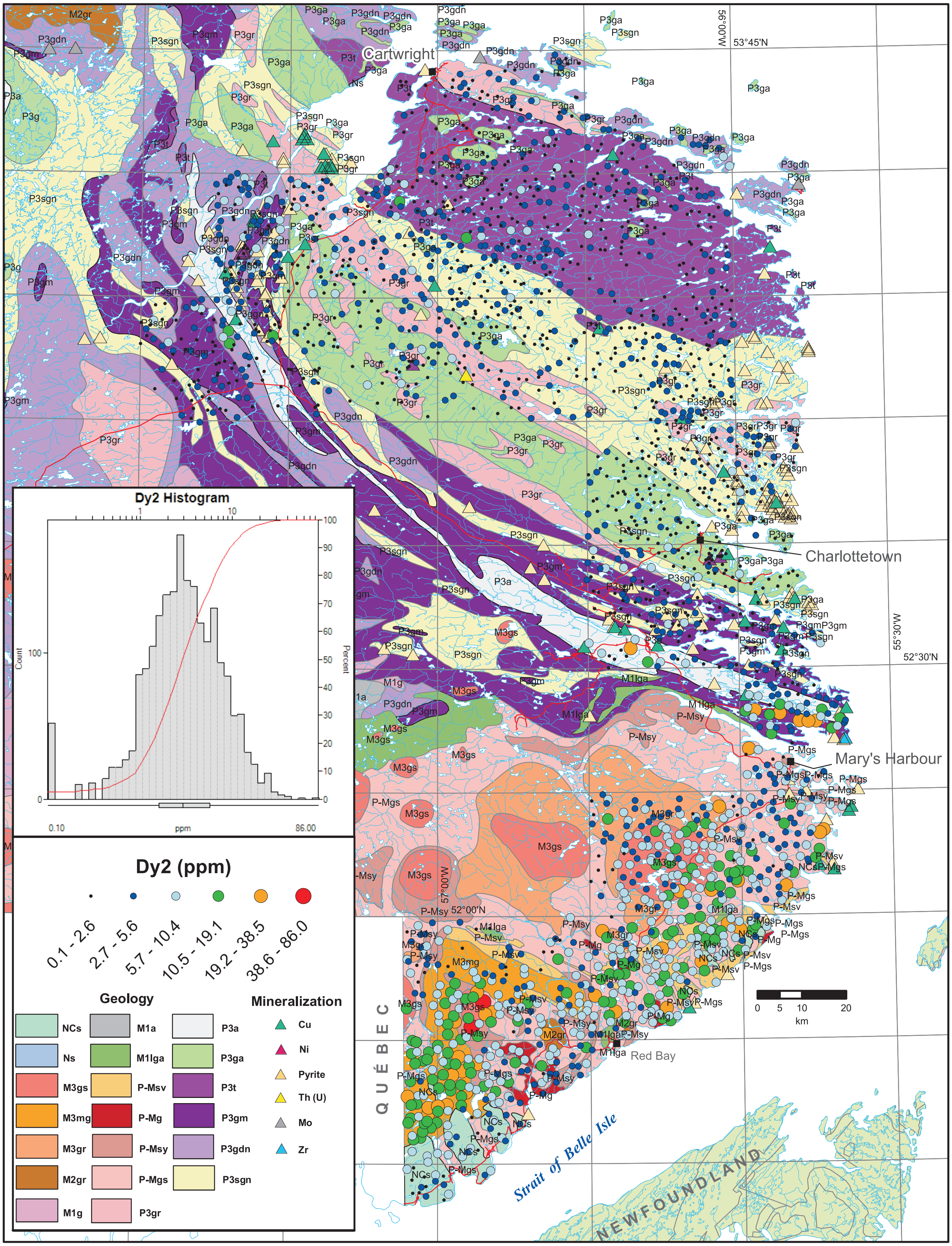

Figure 27. *Dysprosium (Dy2) in lake sediment.*

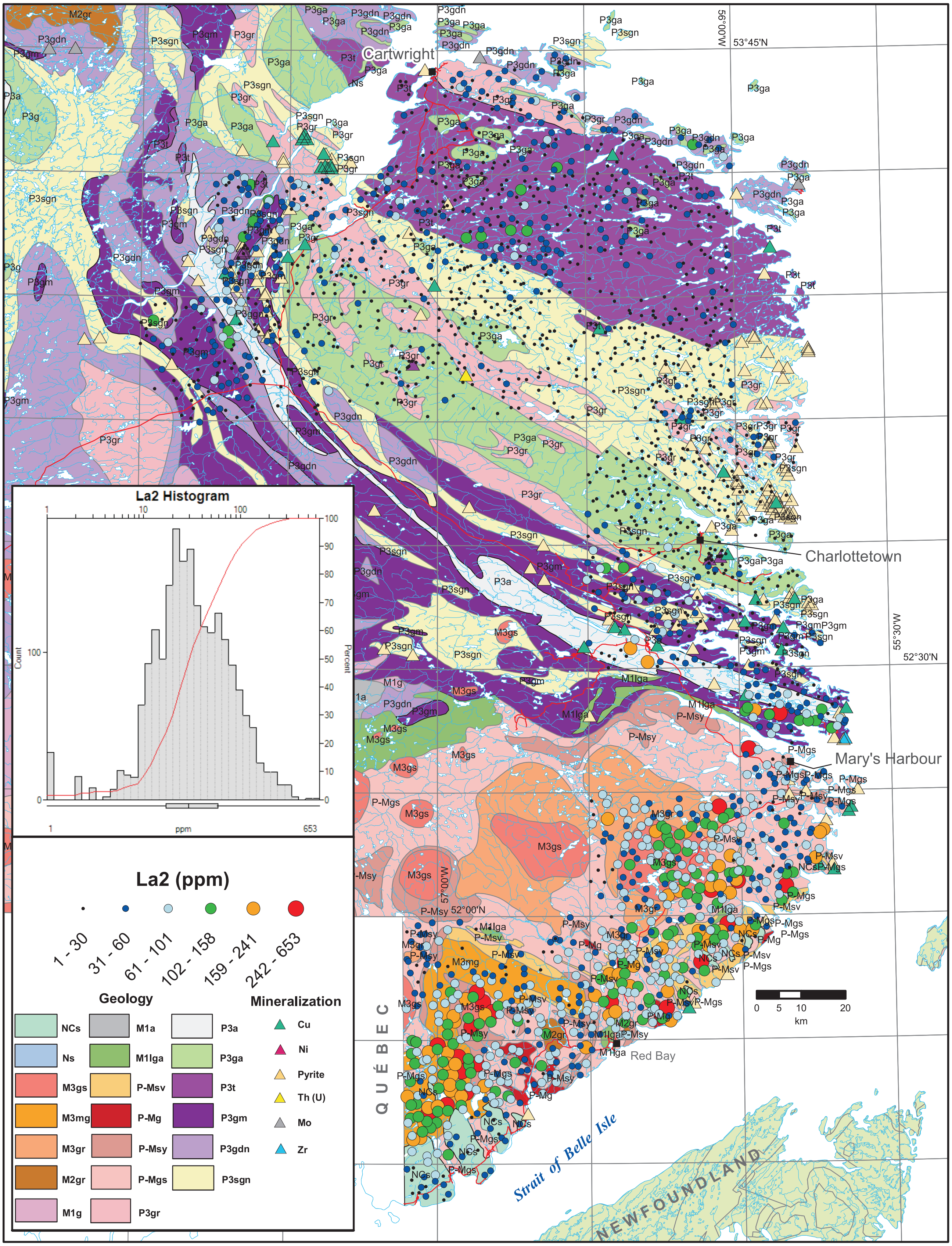

Figure 28. *Lanthanum (La2) in lake sediment.*

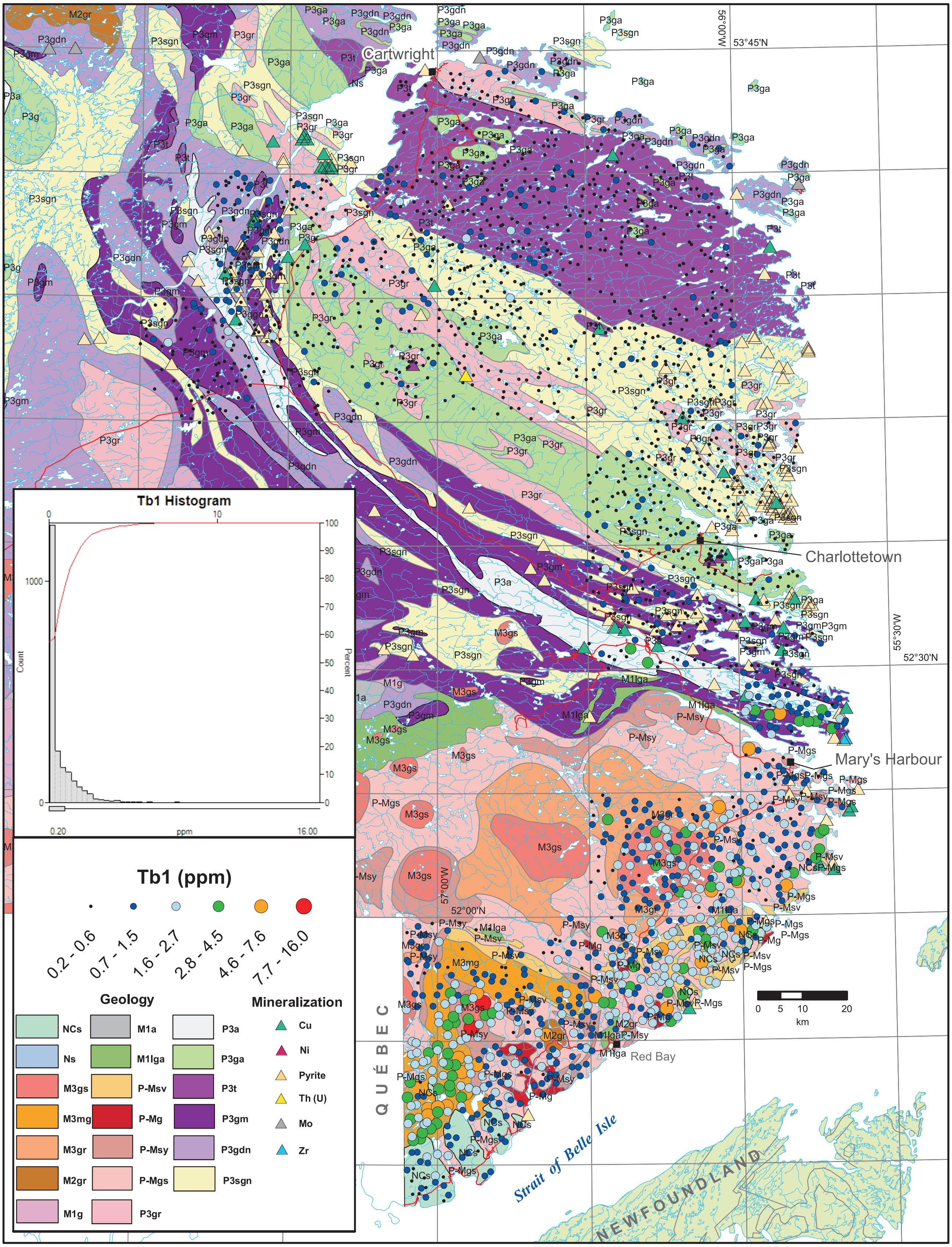

Figure 29. *Terbium (Tb1) in lake sediment.*

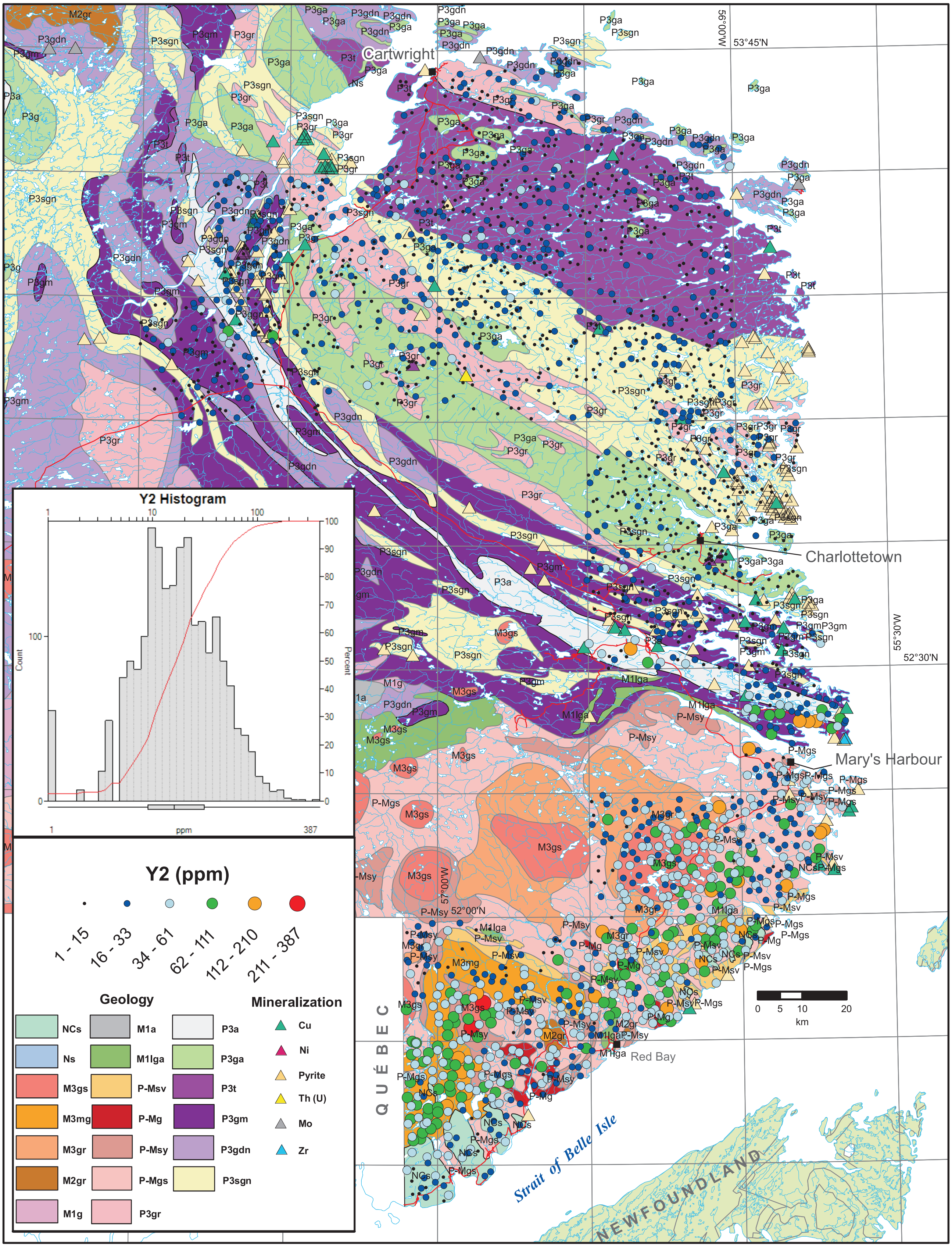

Figure 30. *Yttrium (Y2) in lake sediment.*

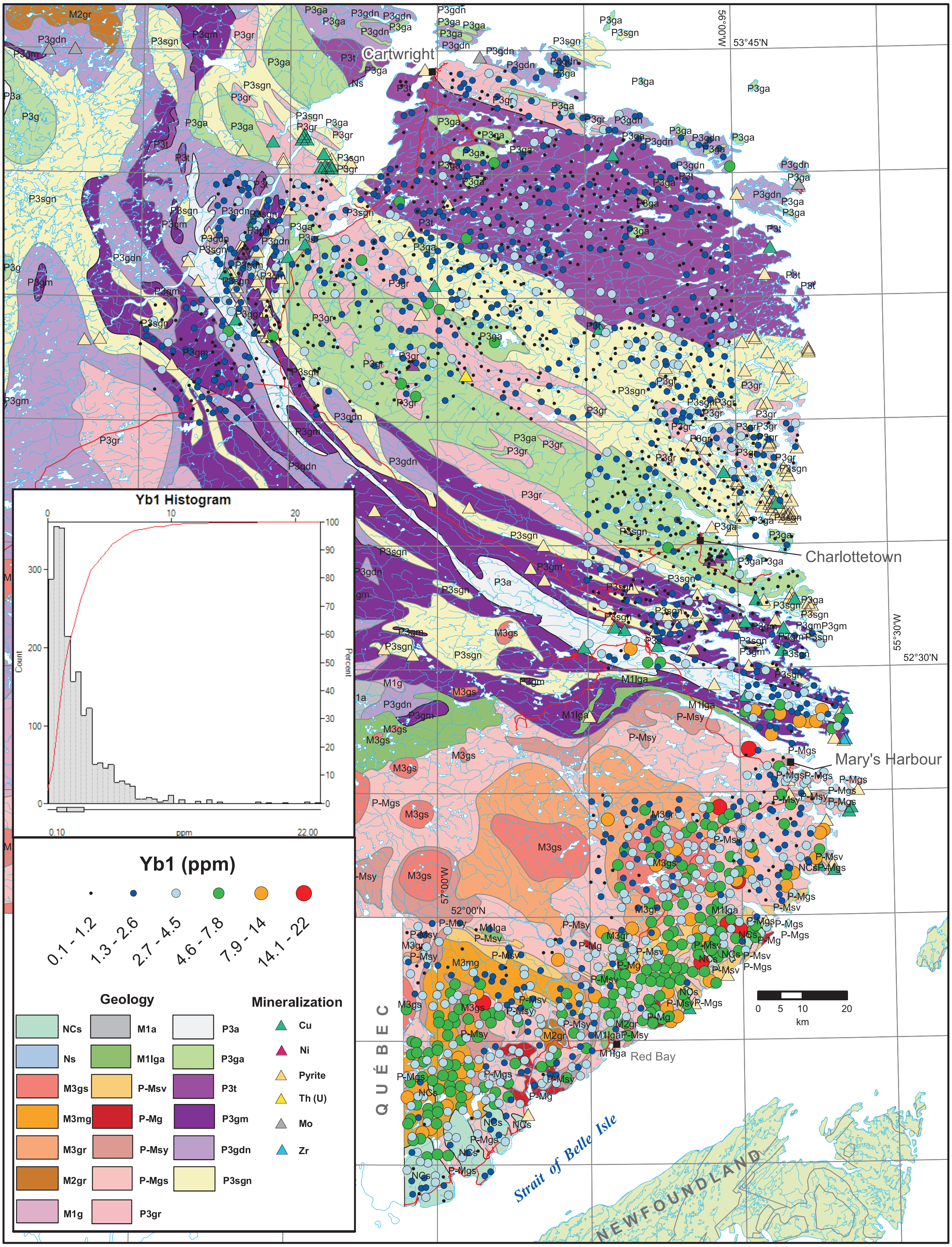

Figure 31. *Ytterbium (Yb1) in lake sediment.*

Lithophile Elements

Distribution of the lithophile elements chromium (Cr2), niobium (Nb2), tantalum (Ta1), titanium (Ti2), tungsten (W1) and zirconium (Zr2) are plotted in Figures 32-37. The distribution of Cr2 is plotted in Figure 32. It is shown primarily because it may act as a possible pathfinder element for the platinum group elements which are not analysed. Most of the samples with high and elevated chromium contents are in the northern part of the survey from lakes overlying mafic rocks of unit P3ga, quartz diorite and associated rocks of unit P3ta and pelitic gneiss of unit P3sgn.

The distribution of niobium (Nb2) is plotted in Figure 33. Samples with high and elevated contents of niobium are concentrated in the granitic terrane in the southern part of the survey. The largest anomaly is a cluster of samples located in NTS map area 13A/01 from lakes overlying granite and/or syenite of unit M3gs. Several samples with elevated contents and one with the highest niobium content in the survey (50 ppm) are found overlying the granites and monzonites of unit M3mg in NTS map area 12P/15. Other samples with high and elevated niobium contents are from lakes overlying syenites and associated rocks in units P-Msy, M3gr and P-Mgs.

The distribution of tantalum (Ta1) is plotted in Figure 34. In many respects it is similar to that of Nb2 (Figure 33). Most samples with high and elevated tantalum contents are from granitic terrane in the southern part of the survey, particularly from lakes overlying units M3gs, M3gr and P-Mgs. In contrast to that of niobium, however, one sample with a high content of tantalum and five samples with elevated contents are found from lakes overlying unit P3t in the northern part of the survey east of Sandwich Bay. Interestingly the highest tantalum analysis comes from a sample collected in NTS map area 13A/09 over map unit P3a which consists of leuconorite and related rock types; not a lithologic association one would expect for tantalum.

The distribution of titanium (Ti2) is plotted in Figure 35. Samples with high and elevated titanium contents are found in several different geological environments across the survey area. The samples, which may have the most significance from an economic viewpoint, are those found in lakes overlying mafic terrane, particularly units P3ga and P3a. There are also several samples from lakes overlying more felsic terrane including units M3mg, M3gs, M3gr, P-Mgs and P3t.

The distribution of tungsten (W1) is shown in Figure 36. All samples with high and elevated tungsten contents are found in the north half of the survey area. Nearly all are from lakes over or near granitic bedrock, notably unit P3gr. One particularly interesting cluster straddles the boundary of NTS map areas 13A/16 and 13H/01. Other such samples are found over the pelitic gneiss unit P3sgn and scattered samples are found over units P3a, P3gm and P3ga.

The distribution of zirconium (Zr2) is shown in Figure 37. Samples with high and elevated zirconium contents are found in lakes overlying a broad geographic area. However, all but one of the sixteen samples with high zirconium contents (red dots) are from sites overlying felsic igneous terrane. This is an interesting example of the Jenks algorithm effectively identifying breaks in the frequency distribution curve that reflect differing rock types.

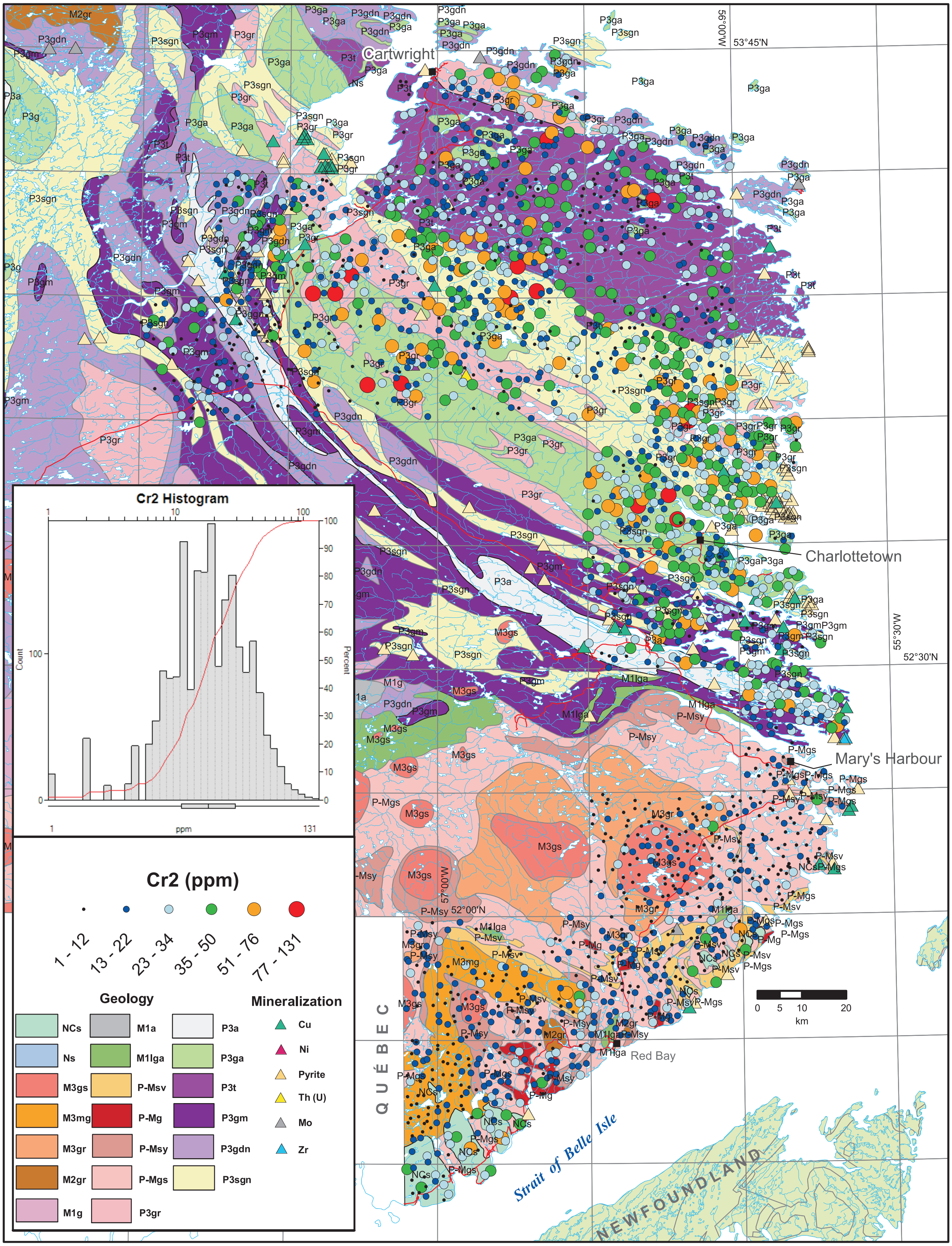

Figure 32. *Chromium (Cr2) in lake sediment.*

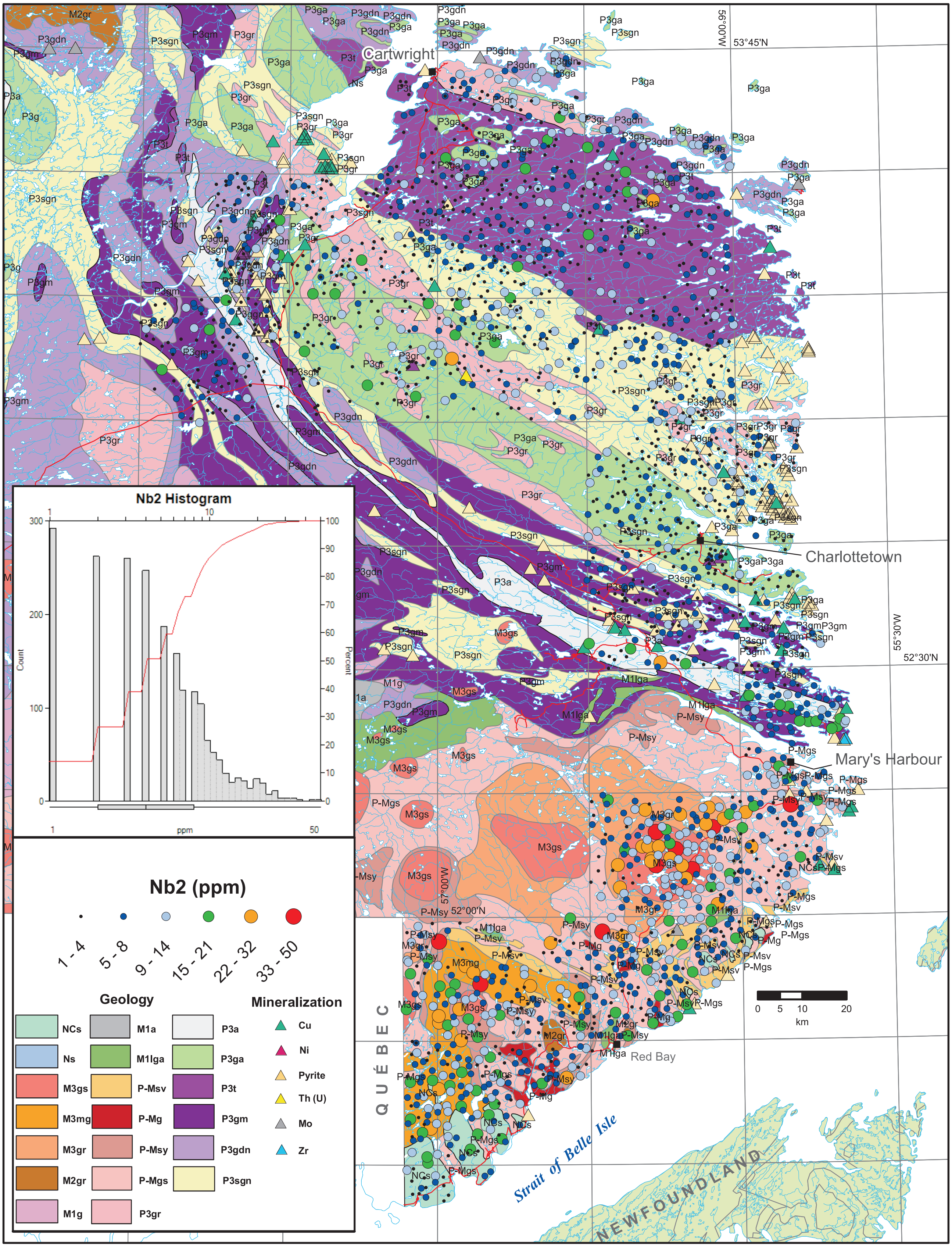

Figure 33. *Niobium (Nb2) in lake sediment.*

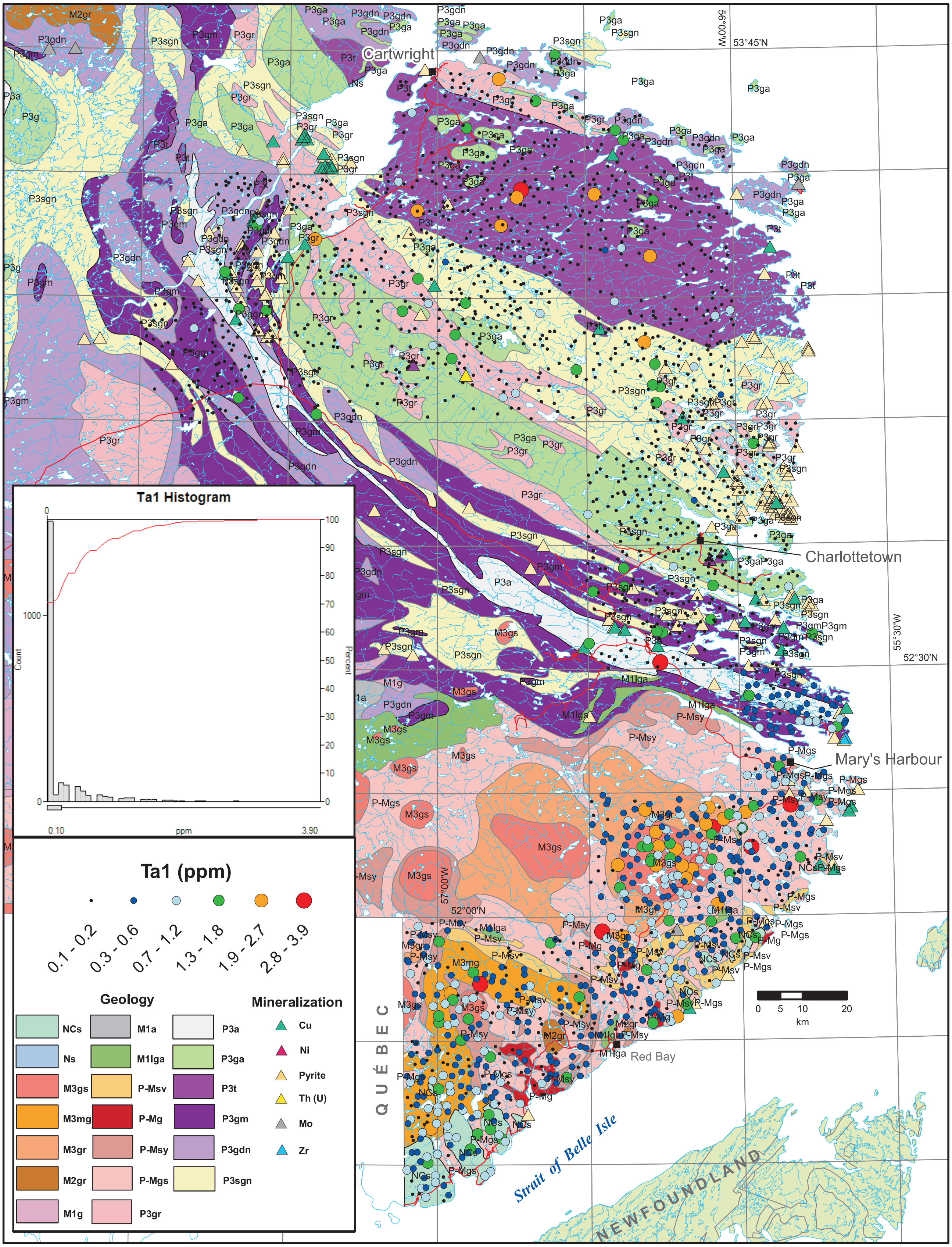

Figure 34. *Tantalum (Ta1) in lake sediment.*

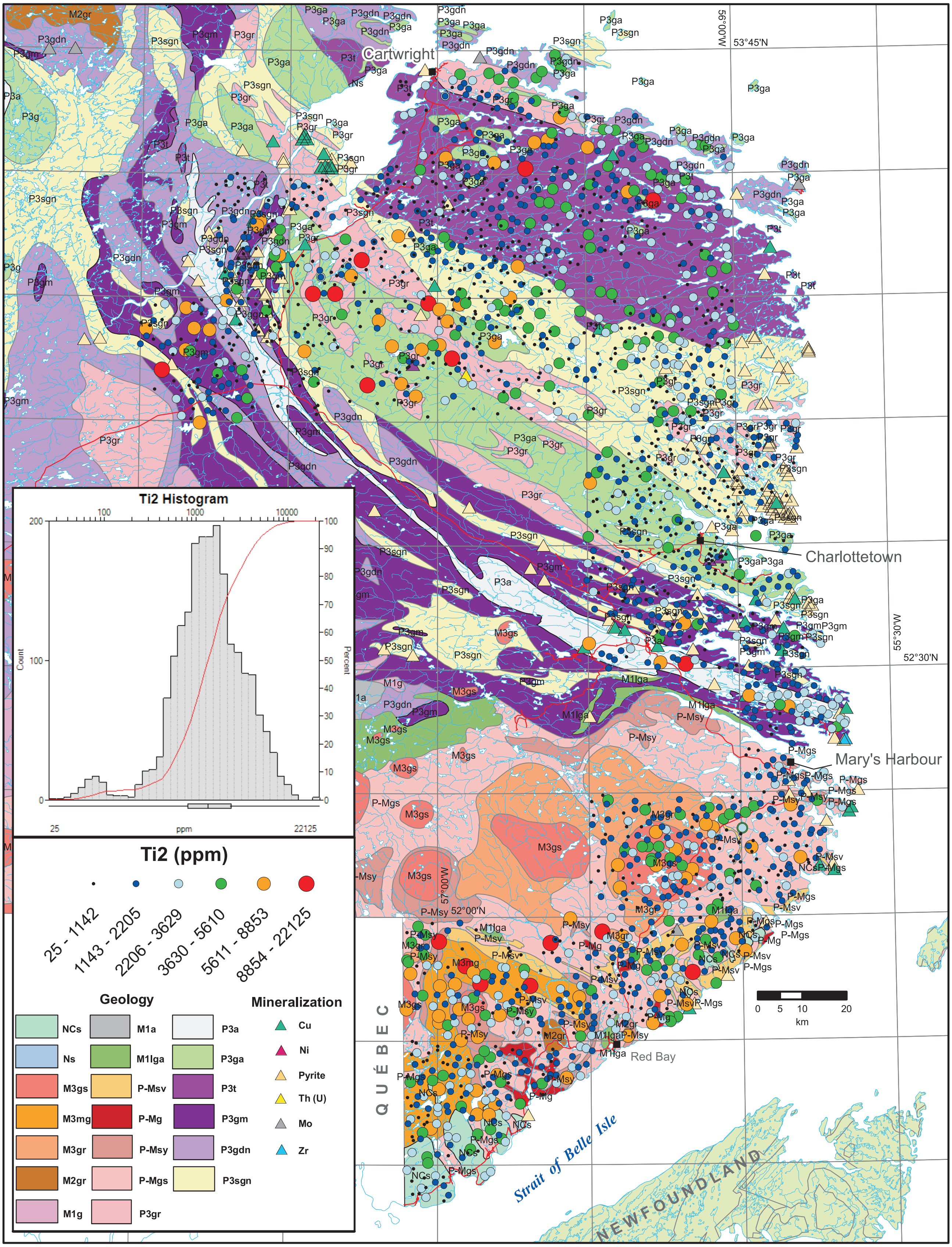

Figure 35. *Titanium (Ti2) in lake sediment.*

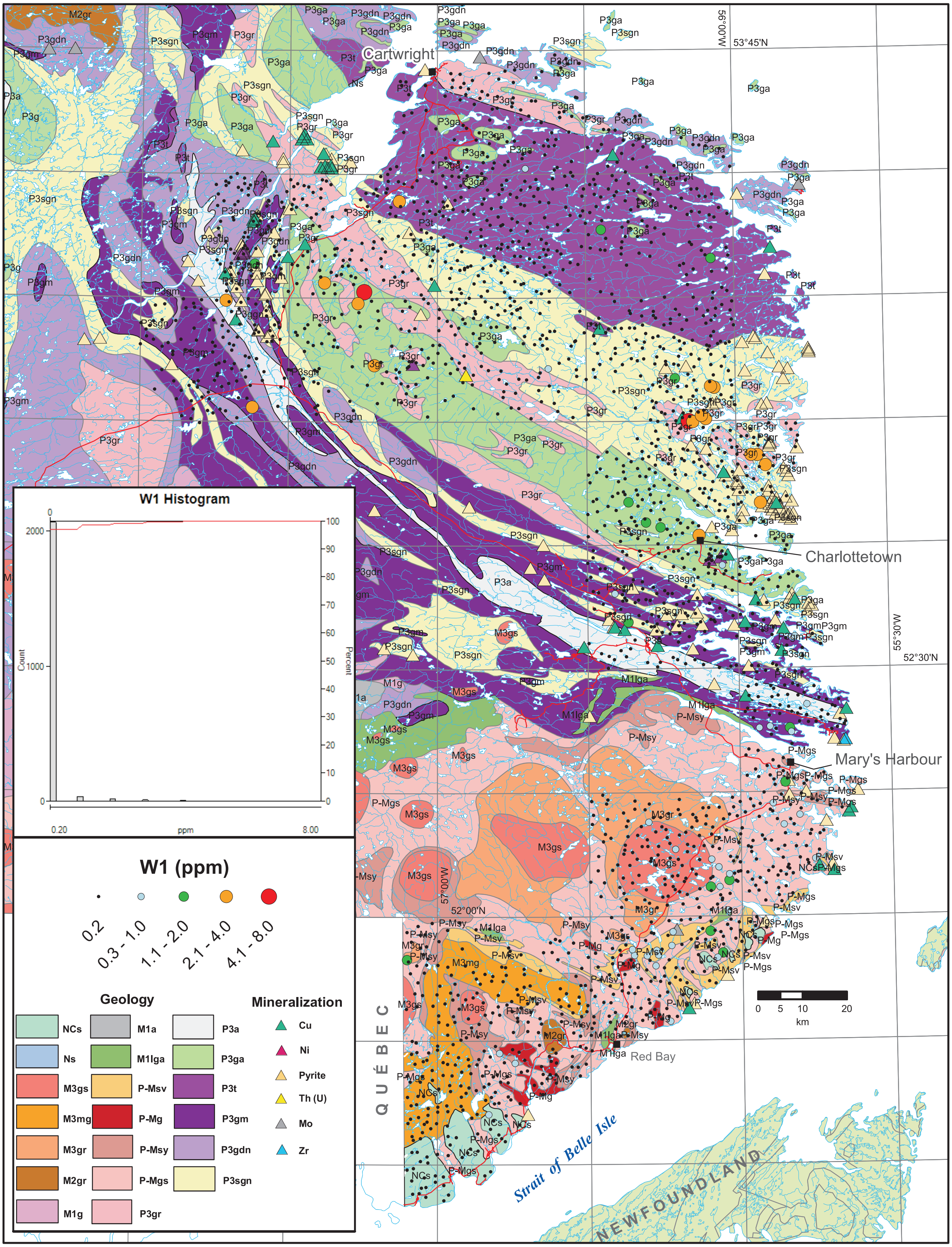

Figure 36. *Tungsten (W1) in lake sediment.*

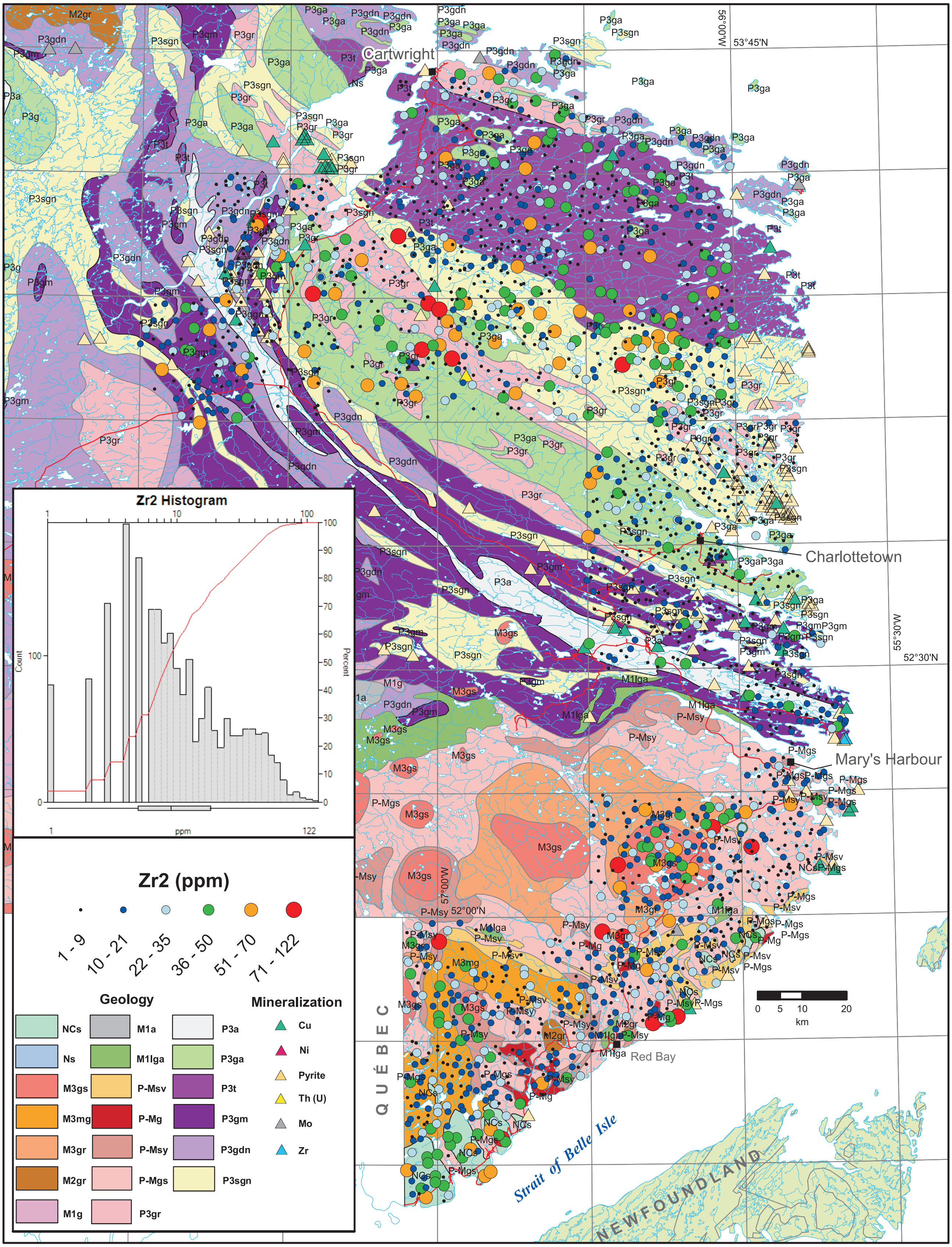

Figure 37. *Zirconium (Zr2) in lake sediment.*

Water Data

The distribution of conductivity (Figure 38) shows a strong grouping of values by rock type. The samples with the lowest conductivities are generally from granitic terrane whereas rocks with a more mafic character typically yield water samples with somewhat higher conductivities. The most conductive waters are from lakes draining the limestones and sandstones of unit NCs in the extreme south of the survey area.

The distribution of the pH of water samples is shown in Figure 39. The intervals are based on 5 quantile divisions, not the Jenks algorithm. Values in a general way reflect the nature of the bedrock underlying the catchment basins of the samples. Many of the most acidic samples (pH<5.51) are found in lakes overlying the granites and granitoids of unit P3gm. Some of the most alkaline samples (pH >6.43) are found over the limestones and sandstones of unit NCs and the mafic rocks of unit P3ga.

The distribution of beryllium (Bew2) in water is shown in Figure 40. Most samples are below detection limit. All the samples with high contents are from lakes overlying granitic terrane. The water sample from NTS map area 3D/05 with a high content of beryllium has an elevated content in the corresponding sediment sample.

The distribution of calcium (Caw1) is shown in Figure 41. This element appears to effectively delineate some rock types and may be useful as a guide to different rock compositions within a single unit. Much of the granite terrane underlain by units P-Mgs and M3gs are reflected by calcium contents in the lowest interval as shown by black dots. In contrast most of the highest contents are in waters overlying the limestones and sandstones of unit NCs.

The distribution of chromium in water (Crw2) is shown in Figure 42. It has one sample with very high chromium content, 98.8 ppb. The next highest value is 14.2 ppb. The high content sample is located in NTS map area 13A/09 near the contact of paragneiss unit P3sgn and granitic unit P3gr. Most of the samples with elevated contents are found in samples overlying the paragneiss unit.

The distribution of copper (Cuw2) is shown in Figure 43. All of the samples with high copper contents and many of the ones with elevated contents are from lakes overlying units P3gr, composed of granitic rocks, and P3gdn, composed of granitic gneiss. No copper occurrences are known in this area. Two clusters of samples with elevated contents are found in lakes overlying the paragneiss unit P3sgn. These are located in NTS map areas 3D/13 and 13A/16. Three copper occurrences are also found in this area. Another cluster of four samples with elevated copper contents is located in NTS map area 13H/03, in the vicinity of a nickel occurrence. These samples are from lakes overlying mafic rocks of unit P3ga.

The distribution of fluoride (Fw9) in water is shown in Figure 44. It appears to be a very effective indicator of bedrock type. High and elevated contents are found over highly differentiated felsic rocks such as units M3gs, M3gr, Mgs and P3gm in the south of the survey area. High and elevated contents are also found in water samples from units P3gr and P3gdn in the north. Many of

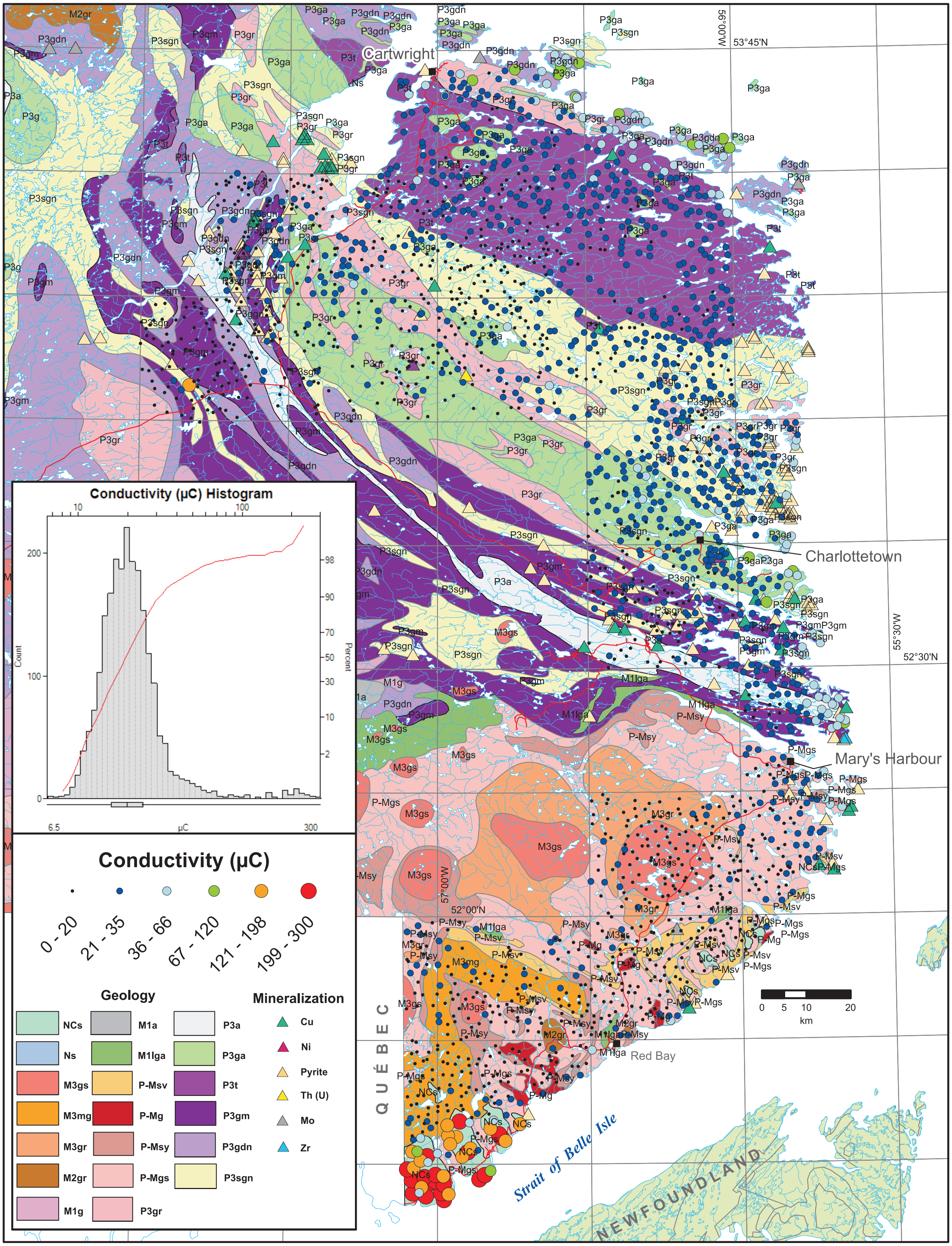

Figure 38. *Conductivity of lake water.*

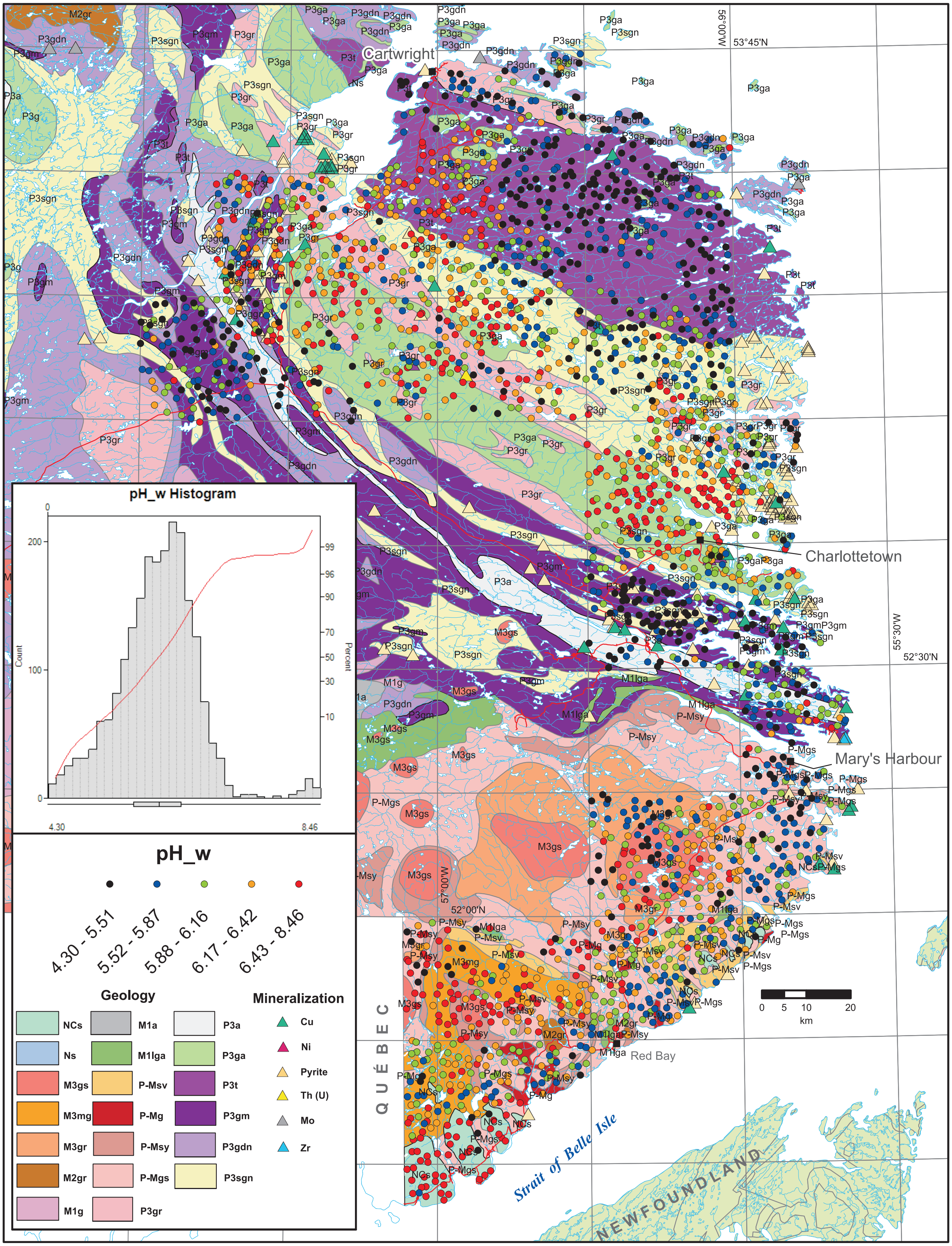

Figure 39. *Acidity (pH) of lake water.*

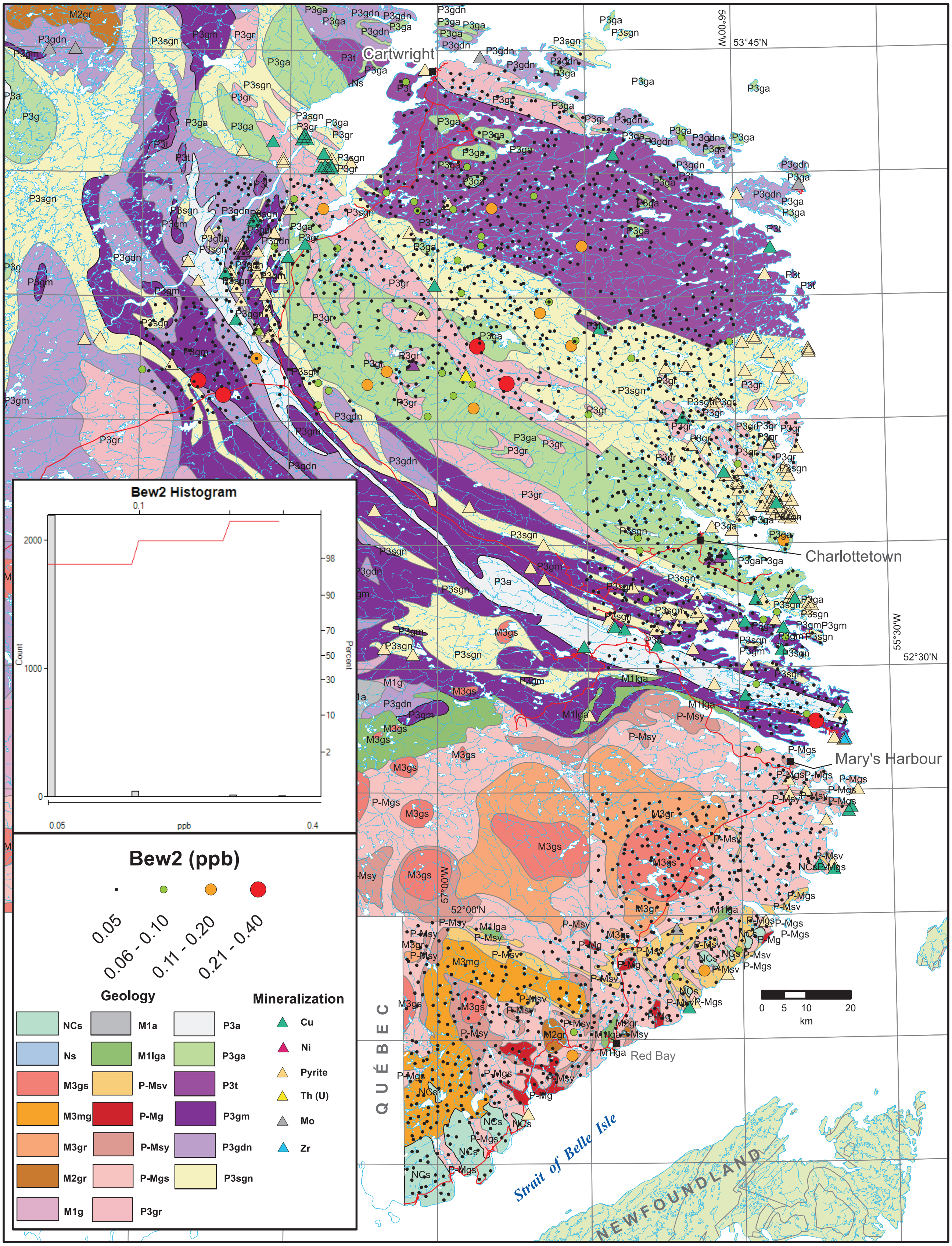

Figure 40. *Beryllium (Bew2) in lake water.*

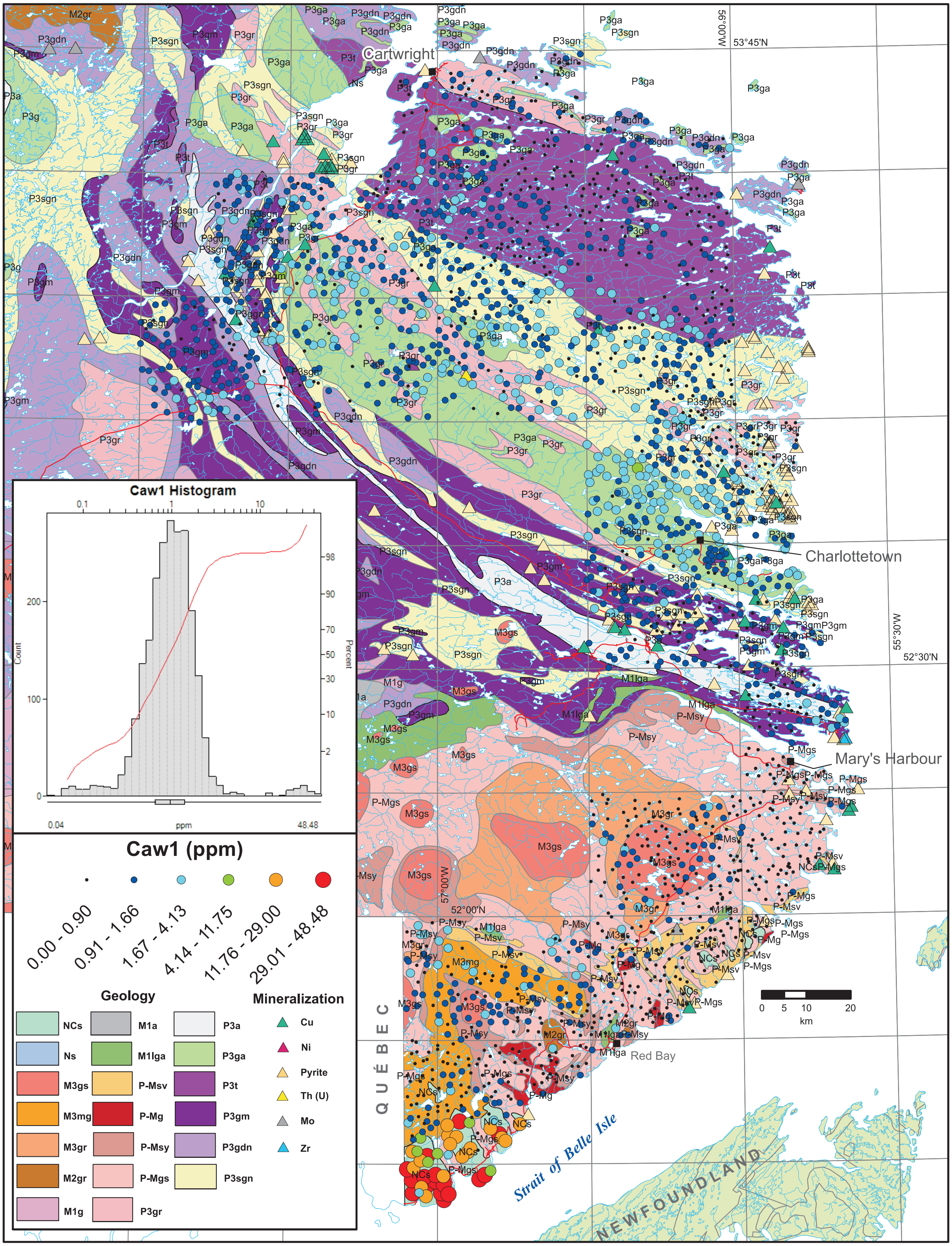

Figure 41. *Calcium (Caw1) in lake water.*

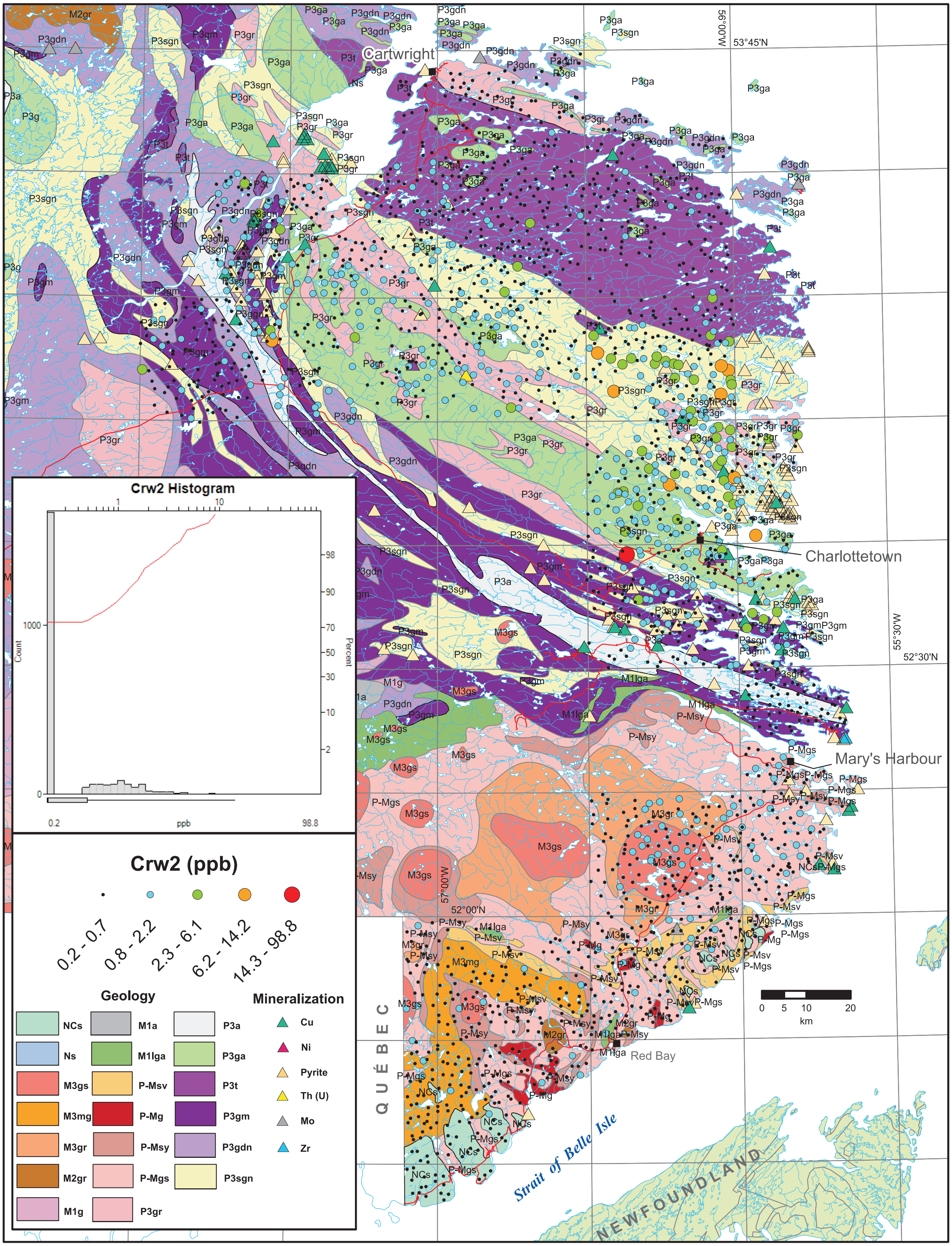

Figure 42. *Chromium (Crw2) in lake water.*

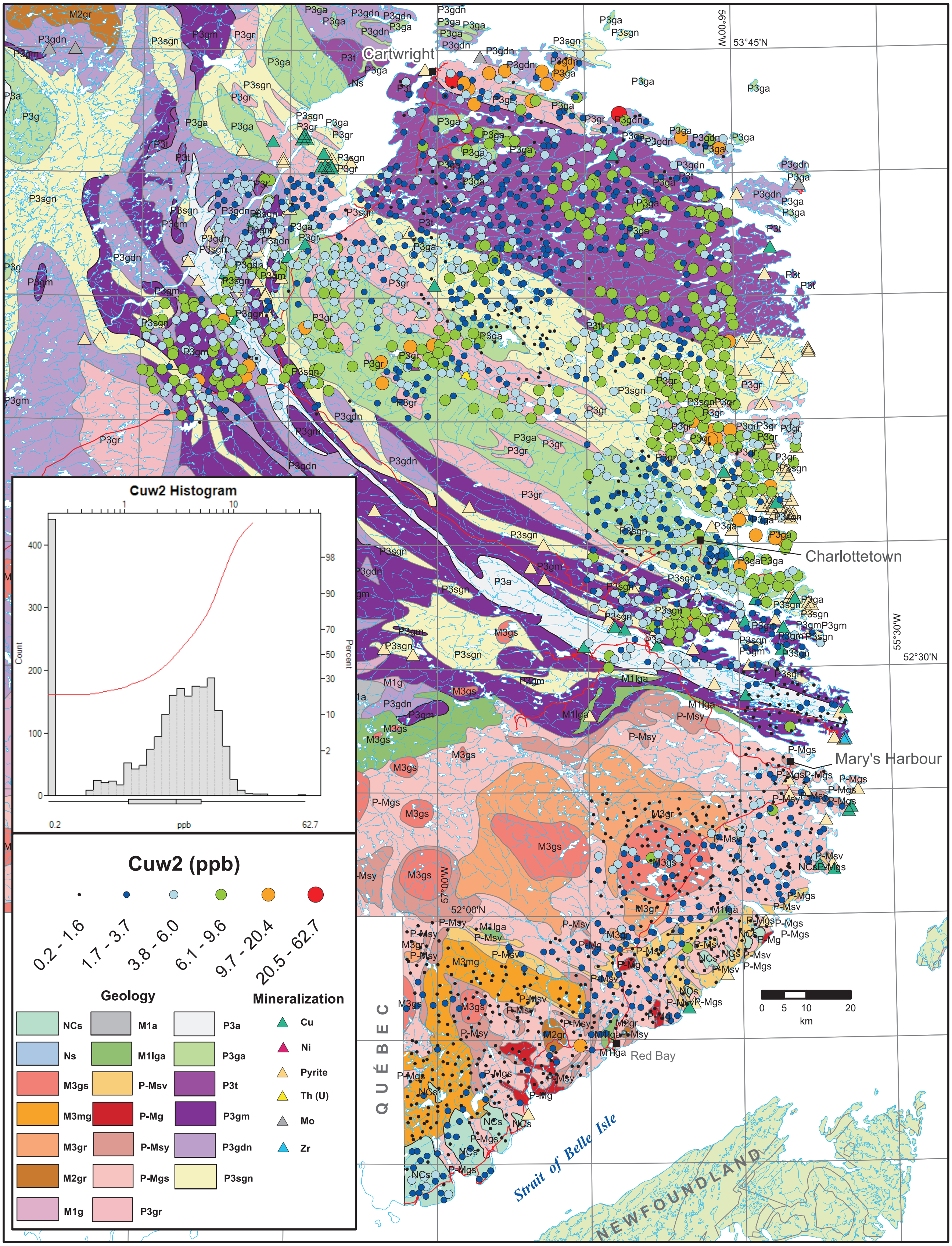

Figure 43. *Copper (Cuw2) in lake water.*

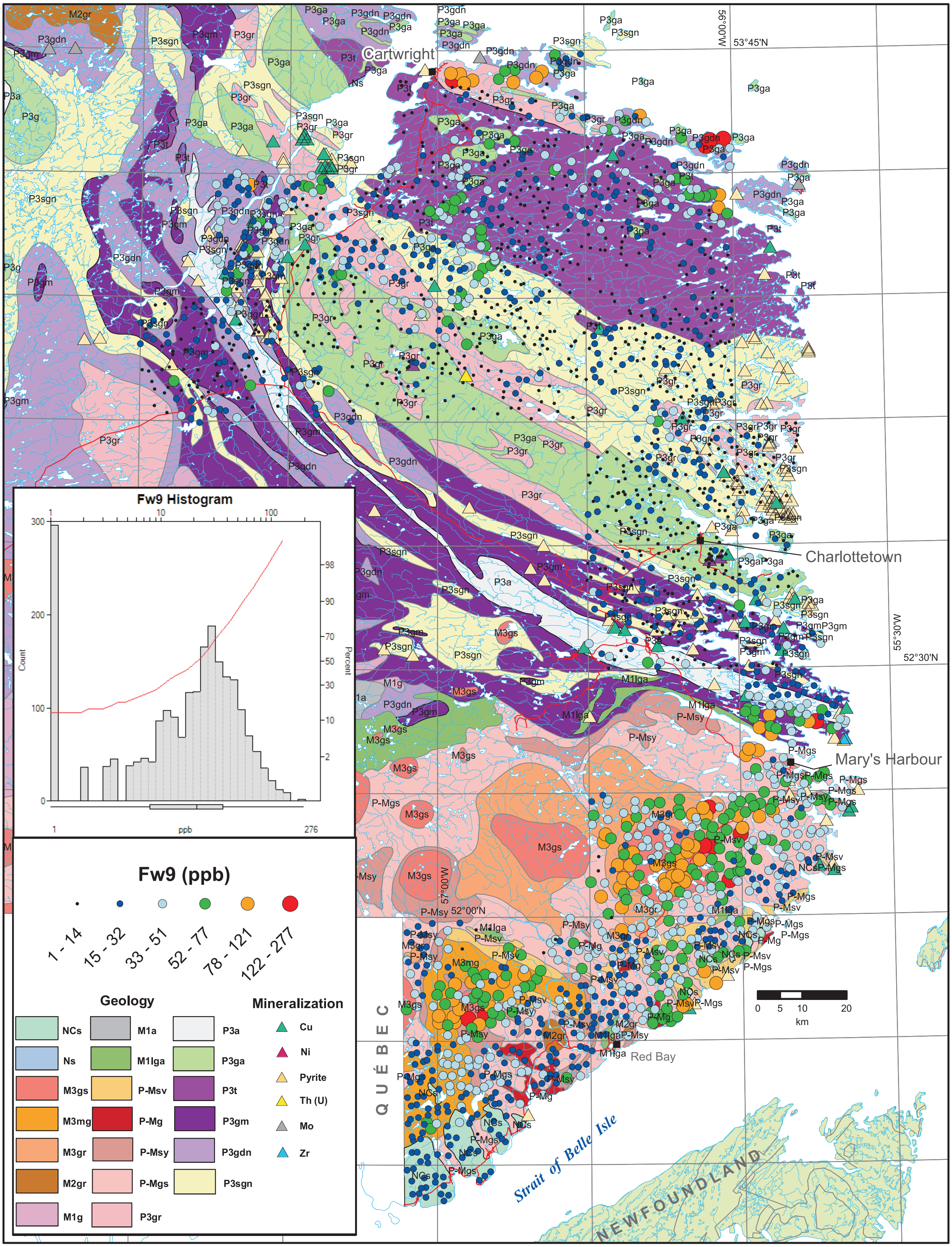

Figure 44. *Fluoride (Fw9) in lake water.*

these latter samples are close to the coast and may be affected by windblown contamination by seawater. Concentrations of elements such as sodium and strontium, which might indicate seawater contamination, are higher than average in these samples although not as proportionally high as the fluoride contents. Conversely, samples from lakes overlying mafic terrane such as unit P3ga (gabbronorite, amphibolite and mafic granulite) have universally low fluoride contents.

The distribution of iron (Few1) in water is shown in Figure 45. The concentration of Fe in surface water is largely controlled by its exposure to oxygen. Ground-water and water in bogs is effectively sealed off from atmospheric oxygen and hence can contain Fe levels in the hundreds to thousands of ppb. Such water quickly loses its Fe by oxidation when exposed to normal atmospheric oxygen in streams or lakes. Thus, the presence of high Fe levels in some lakes in Figure 45 suggests that these waters were not yet in equilibrium with atmospheric oxygen and likely entered the lakes from bogs or groundwater sources shortly before sampling.

The distribution of molybdenum (Mow2) in water is shown in Figure 46. Of the seven samples with high molybdenum contents, five are in NTS map area 3D/05 and two are in NTS map area 12P/10. Samples in the first group are from lakes overlying mafic and granitic terrane. Samples in the second group are from lakes overlying granitic and sedimentary terrane. Most of these samples do not show a correlation between molybdenum in sediment and water, although field number 6253834 in NTS map area 3D/05 has 5 ppb Mow2 and 14 ppm Mo1. As well there are four samples with high and elevated contents of Mo2 in the immediate area in NTS map area 3D/05. A loose cluster of samples with elevated contents of Mow2 is found in and near NTS map area 13H/05. These samples are from lakes that drain a variety of rock types from mafic to felsic.

The distribution of nickel (Niw2) in water is shown in Figure 47. The samples with high and elevated nickel contents do not appear to have an association with any particular rock type. Most of these samples fall within an arc extending for about 70 km from Sandwich Bay to the east and then through to the southwest.

The distribution of titanium (Tiw2) is shown in Figure 48. Most of the samples with high and elevated contents of titanium are found in lakes in the north of the survey overlying unit P3t which consists of quartz diorite, tonalite and granodiorite. Other samples with similar titanium contents are found in NTS map areas 3D/05, 3D/12 and 13A/09. Most of these samples were from lakes overlying units P3gm, P3sgn and P-Mgs.

The distribution of uranium (Uw3) in water is shown in Figure 49. Twelve samples with high uranium contents and 26 with elevated contents are found in lakes in the southern part of the survey. Nearly all of the high content lakes overlie unit P-Mgs, a felsic unit composed of granite, syenite, monzonite, granitoid gneiss, and minor diorite. The samples with high uranium contents form three distinct clusters in NTS map areas 12P/16 and 13A/01. Farther north, three other samples with high uranium contents form a cluster in lakes overlying the granite and granitoid rocks of unit P3gm in NTS map area 3D/12. Two other clusters of samples falling within the green and orange intervals are found in NTS map areas 13H/05 and 13H/06. These also overlie granitic rocks.

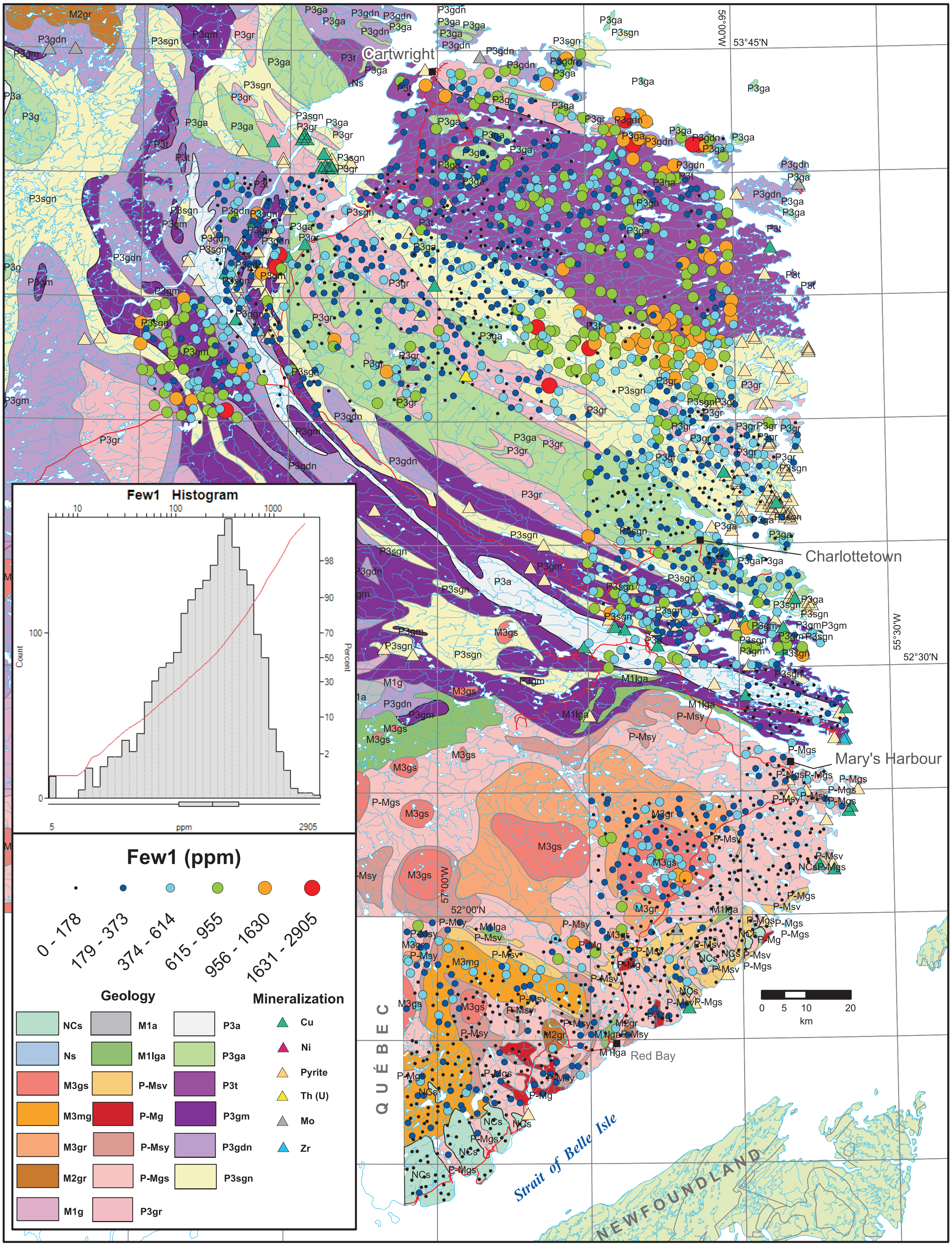

Figure 45. *Iron (Few1) in lake water.*

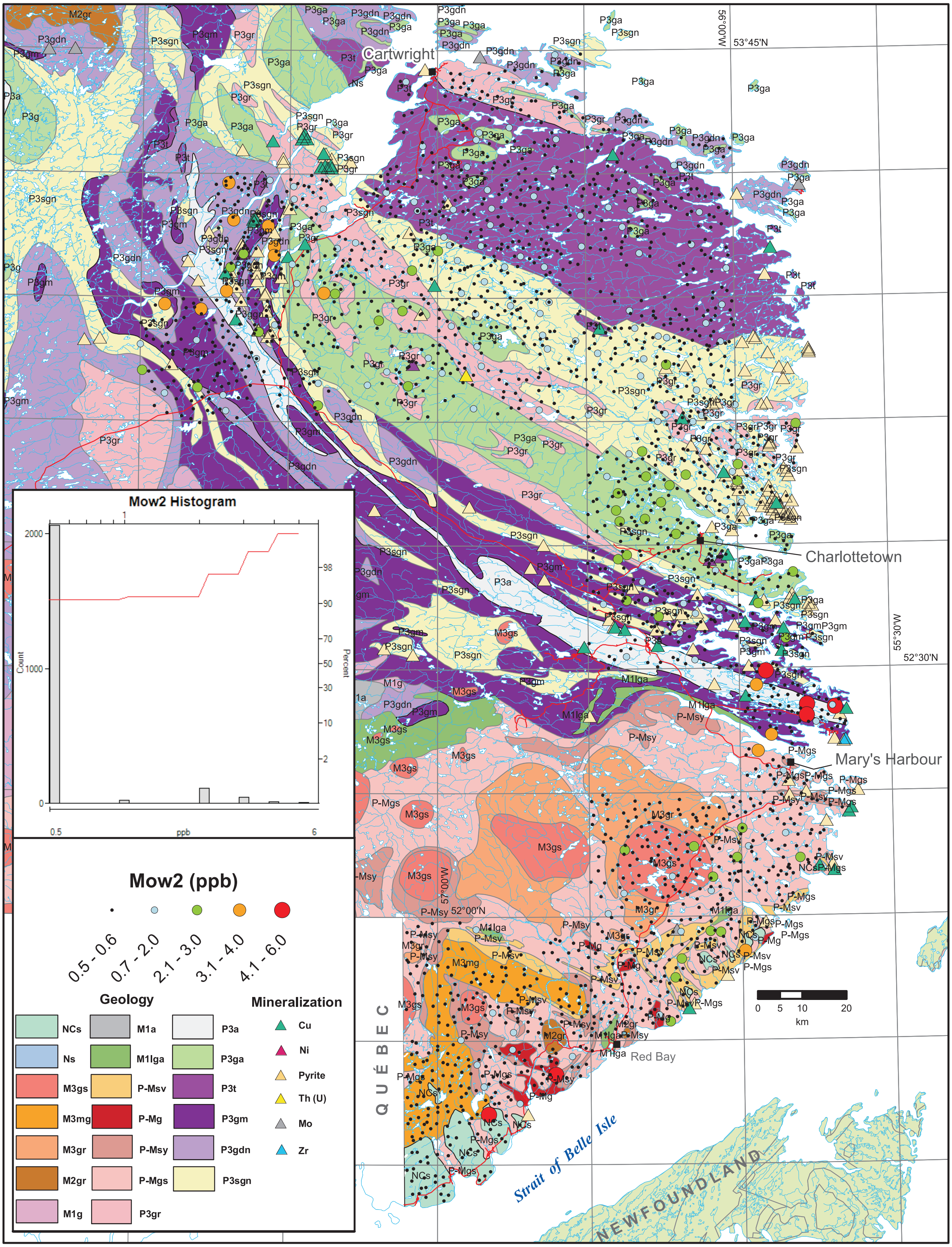

Figure 46. *Molybdenum (Mow2) in lake water.*

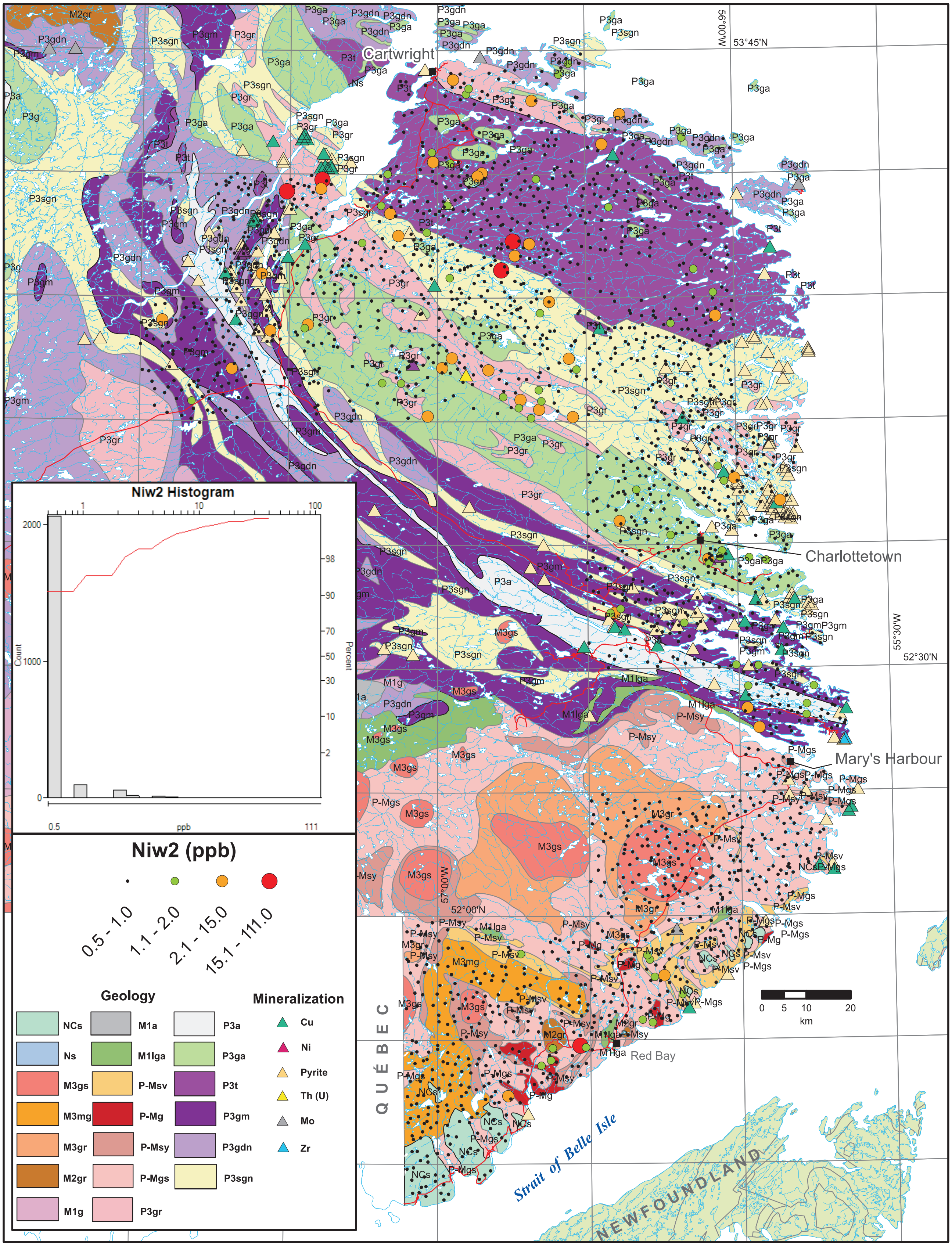

Figure 47. *Nickel (Niw2) in lake water.*

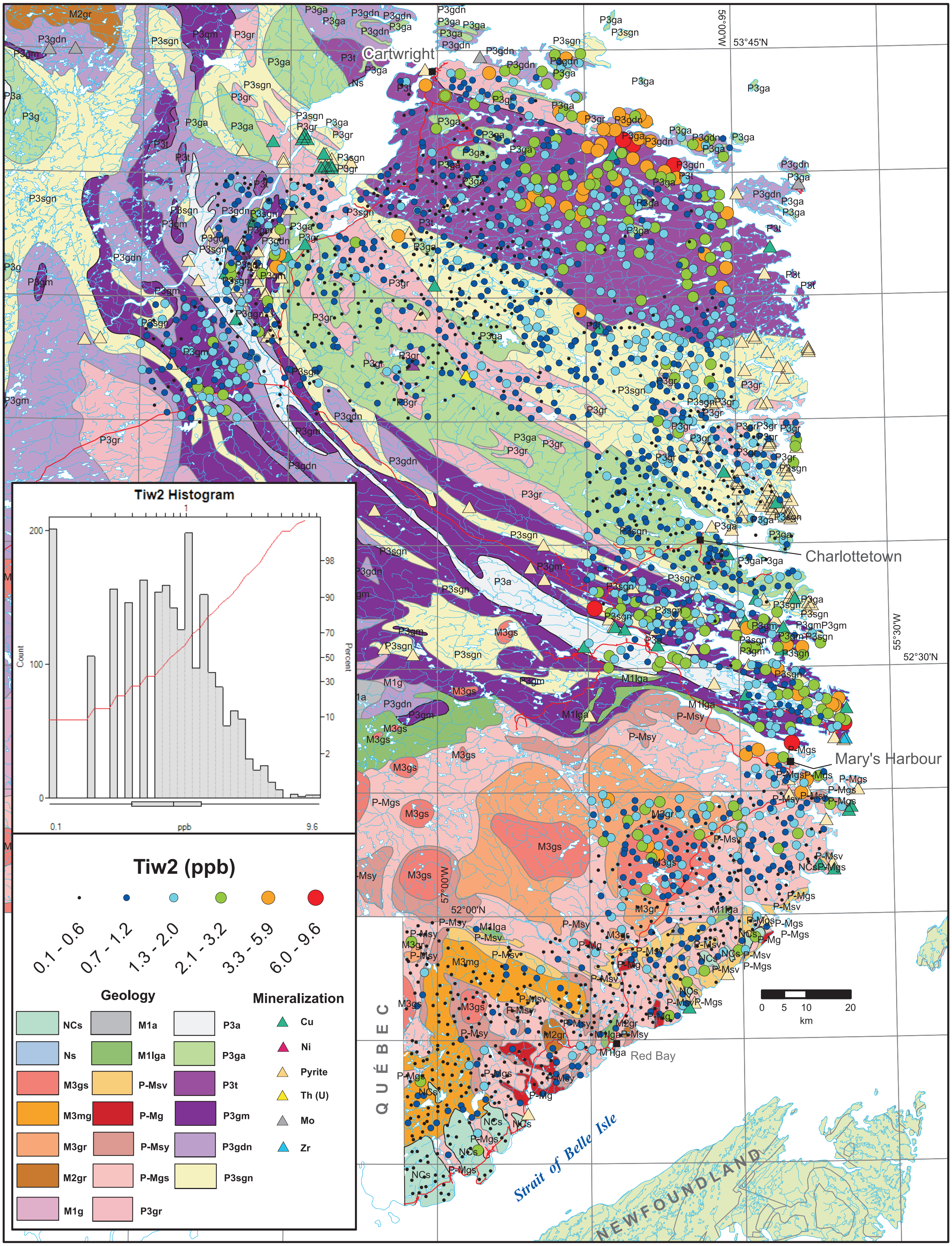

Figure 48. *Titanium (Tiw2) in lake water.*

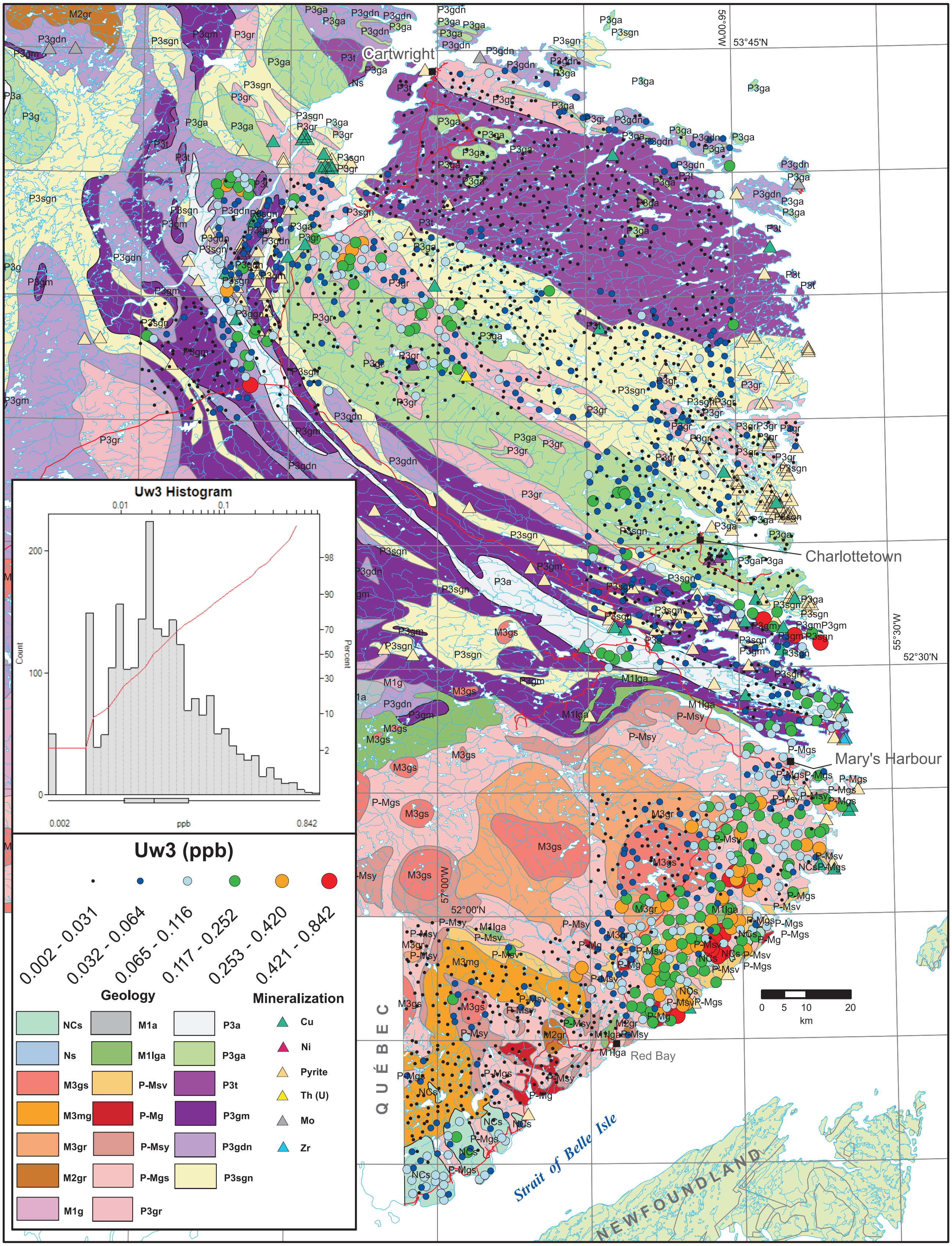

Figure 49. *Uranium (Uw3) in lake water.*

The distribution of yttrium (Yw2) in water is shown in Figure 50. The samples with high and elevated contents form both clusters and scattered occurrences. The largest group consists of two clusters overlying or near the contacts of units P3gm and P3a in NTS map areas 3D/05 and 13A/09. These prospective units extend between these two areas through NTS map area 13A/08 which has not been sampled. A small cluster of three samples, two with high yttrium contents and one with low are found in lakes overlying unit P3t in NTS map area 13H/08. Another cluster of four samples is found in NTS map area 13H/04.

The distribution of zinc (Znw2) is shown in Figure 51. Generally samples with high and elevated values are scattered. There is a very loose cluster of four samples with elevated zinc contents and one with high content in NTS map area 12P/15. The samples are from lakes which overlie granitic terrane composed of various units and rock types.

Other Geochemical Maps

The distributions of the remaining elements are shown as PDF files in Appendix 2 in alphabetical order without discussion. The distribution maps of the remaining sediment analyses are shown in Figures 52-91. The maps of the remaining water analyses are shown in Figures 92-105. Elements with all or most of the analyses below detection limit are not included.

SUMMARY AND CONCLUSIONS

1. Lake sediment and water analyses in the survey area are effective at delineating some known mineral occurrences and suggest the presence of other bedrock sources of mineralization not presently identified.

2. LOI and Fe in sediment give indications of environmental conditions at the sediment deposition site that may affect the accumulation of elements in sediment. However, correlations are not overly strong for most elements. Nonetheless, it is advisable to consider the Fe and LOI content of samples before embarking on follow-up exploration.

3. Several clusters of samples with elevated contents of the base metals Cu, Ni and Zn are found in the survey. Many of the clusters are over rock units that are elsewhere known to be mineralized in these elements.

4. Although no uranium mineralization is recorded in the MODS database, several samples with very encouraging U contents are present. Most of these are over granite or granitic rocks.

5. Several areas in the southern part of the survey, mostly granitic terrane, are distinguished by samples with high REE contents. These include, but are not limited to: dysprosium, lanthanum, terbium, yttrium and ytterbium.

6. Several lithophile elements are of interest in the survey. Samples with high niobium and tantalum contents are found primarily over granitic rocks in the southern part of the survey area.

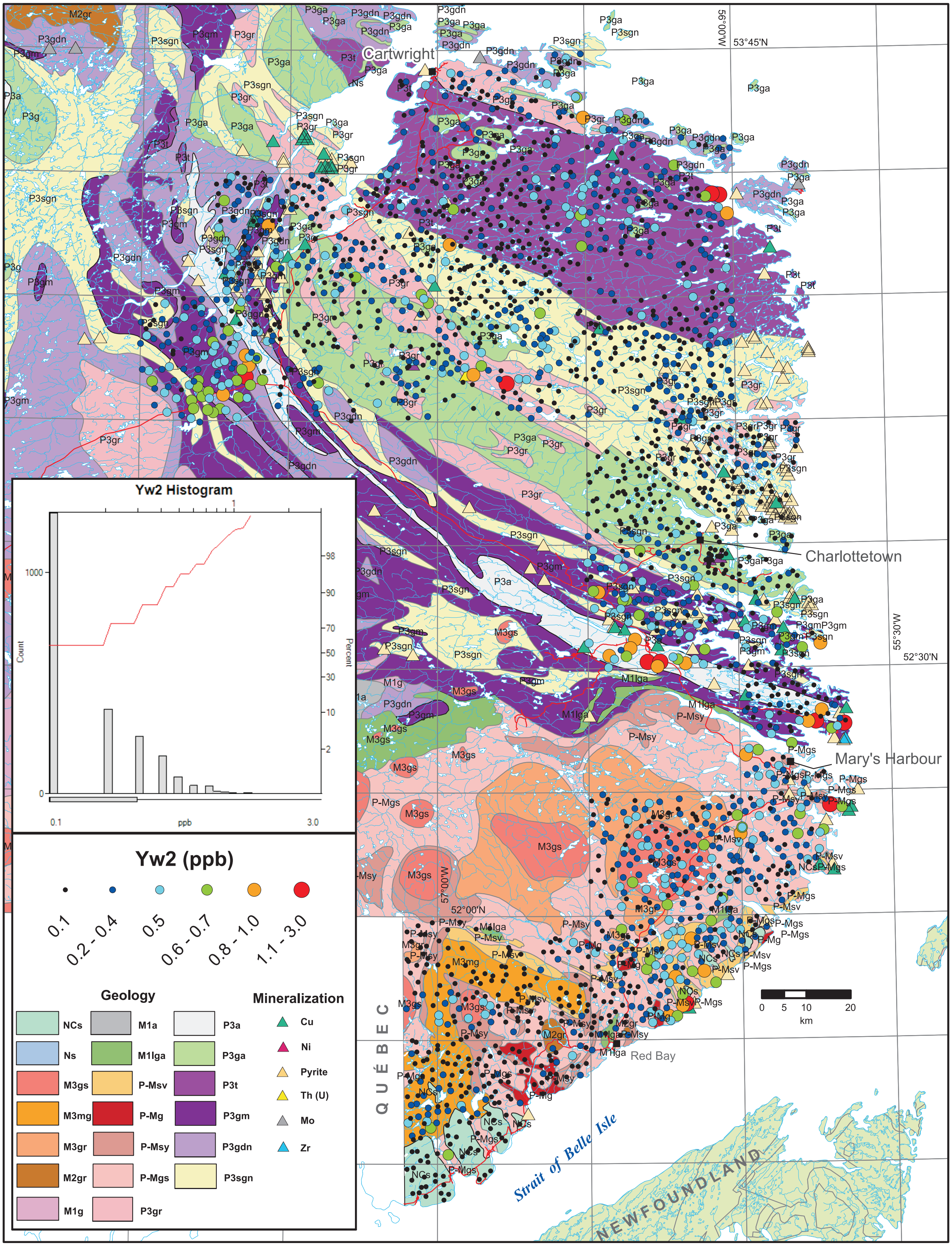

Figure 50. *Yttrium (Yw2) in lake water.*

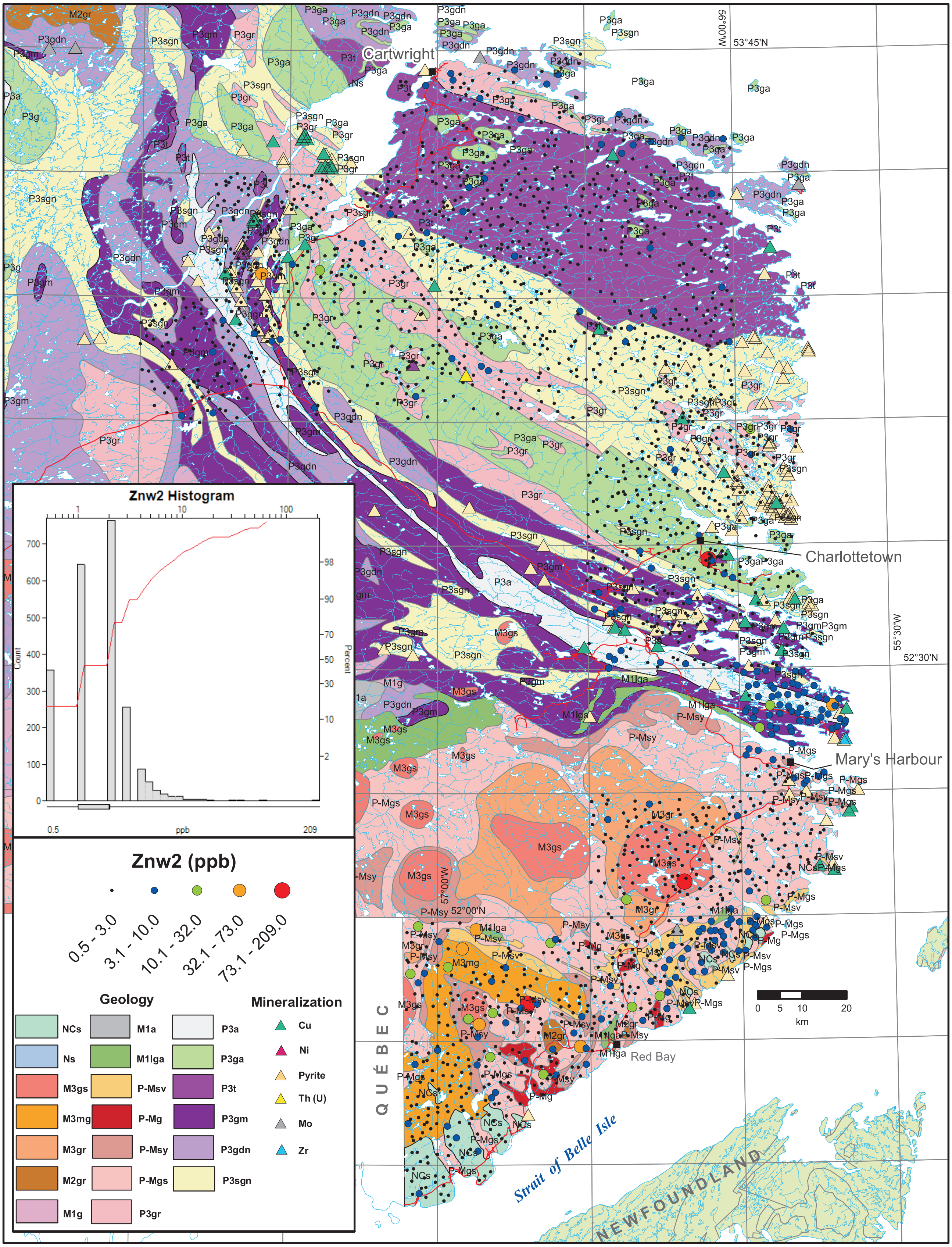

Figure 51. *Zinc (Znw2) in lake water.*

In contrast samples with high tungsten contents are mostly from granitic rocks in the northern part of the survey area.

7. Some water analyses are useful as indicators of bedrock type or for differentiating phases within an individual unit. Fluoride (Fw9) in high levels is generally found over highly differentiated or fluorite-bearing granites. Calcium distinguishes the calcareous rocks as well as some mafic units.

8. Uranium in water (Uw3) has been found elsewhere to be a useful indicator of uranium mineralization. Several areas with high contents of uranium in water are identified in the survey.

9. Yttrium in water has also been an effective indicator of rare earth mineralization elsewhere. There are several areas with high contents in water in the survey.

10. Maps of most element distributions are not discussed in the report but may offer valuable exploration information concerning bedrock composition in the drainage basins or exploration targets in their own right (*e.g.*, Au1 or Ag6).

ACKNOWLEDGMENTS

The authors wish to thank Chris Finch for his overseeing the many analytical procedures required, Charles Gower for discussions on the geology and mineral potential of the area, Terry Sears for his major contribution to preparation of the final figures, Wayne Tuttle for logistical support and the reviewers for their valuable contributions to the final draft of the manuscript - Steve Amor, Martin Batterson and Charles Gower.

REFERENCES

Finch, C.J.
1998: Inductively coupled plasma-emission spectrometry (ICP-ES) at the Geochemical Laboratory. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey, Report 98-1, pages 179-193.

Friske, P.W.B., McCurdy, M.W., Gross, H., Day, S.J., Balma, R.G., Day, H., Lynch, J.J. and Durham, C.C.
1994a: Regional lake sediment and water geochemical data, southeastern Labrador (NTS 3E/4, 3E/5, 3E/12 and 13H). Geological Survey of Canada, Open File 2473.

1994b: Regional lake sediment and water geochemical data, southeastern Labrador (NTS 3D, 13A and parts of 2M and 12P). Geological Survey of Canada, Open File 2790.

Fulton, R.J. and Hodgson, D.A.
1974: Seventeen surficial geology maps, southern Labrador. Geological Survey of Canada, Open File 201, scale 1:50,000.

Geological Survey of Newfoundland and Labrador
2005: Mineral Occurrence Data System (MODS). http://gis.geosurv.gov.nl.ca/mods/mods.asp

Gower, C.F.
2005: Kinematic evidence for terrane displacements in the Grenville Province in eastern Labrador. *In* Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 05-1, pages 73-92.

Klassen, R.A., Paradis, S., Bolduc, A.M. and Thomas, R.D.
1992: Glacial landforms and deposits, Labrador, Newfoundland and Québec. Geological Survey of Canada, Map 1814A, scale 1:100 000.

McCuaig, S.
2002: Till geochemistry of the Alexis River region (NTS areas 13A/10, 14 and 15). Newfoundland and Labrador Department of Natural Resources, Geological Survey. Open File 013A/0046, 107 pages.

Wagenbauer, H.A., Riley, C.A. and Dawe, G.
1983: Geochemical laboratory. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 133-137.

Wardle, R.J., Gower, C.F., Ryan, B., James, D.T., Nolan, L.W., Nunn, G.A.G. and Kerr, A.
1997: Digital geological map of Labrador, version 1.0. Newfoundland Department of Natural Resources, Geological Survey, Open File LAB/1226.