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LAKE SEDIMENT AND WATER GEOCHEMISTRY, LAC AYLMER, QUEBEC

Canada

GEOCHEMISTRY OF LAKE SEDIMENTS AND WATERS, LAC AYLMER, QUEBEC

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Résumé

Les prélèvements sonar et l'échantillonnage des sédiments démontrent que le fond des lacs Aylmer et St-François est recouvert de 5 à 10 m de silt et d'argile proglaciaires couvrant le socle rocheux ou un till. Dans les bassins de plus de 6 m de profondeur, ces sédiments proglaciaires sont recouverts par 5 m de sédiments organiques (3-5% C) saturés en eau. Puisque le niveau du lac fut augmenté artificiellement de quelques mètres(?), les zones de moins de 5 m de profondeur consistent en du sable, till ou de silt et argile proglaciaires, partiellement recouverts de sédiments organiques. Dans le bassin sud du lac Aylmer et dans les autres lacs environnants (Elgin, Maskinongé, des Îles, baie Sauvage, Équerre), les sédiments ont les concentrations les plus élevées de carbone (7-27%). Des nodules de manganèse ont été seulement retrouvés dans les sédiments de surface à moins de 6 m de profondeur, le long du côté est de la baie Ward.

Les comparaisons préliminaires des données géochimiques de 128 échantillons de sédiment du lac Aylmer avec 38 autres provenant de lacs avoisinants confirment que le lac Aylmer est affecté par les ruisseaux s'écoulant des régions minières et de leurs déchets miniers situés à quelques kilomètres à l'est du lac. Les métaux entrant dans le lac Aylmer par le ruisseau Troisième et la rivière Maskinongé semblent se fixer aux sédiments de fond près de l'embouchure de ces effluents (de 0,5 à 10,0 km de leur entrée dans le lac). D'ailleurs, ceux-ci ne sont pas concentrés dans les sédiments riches en matières organiques du bassin sud du lac Aylmer, ce qui suggère peu de transport en solution pour ces métaux. Le pH quasi neutre (~7.0) du lac pourrait restreindre la mobilité des cations associés à l'activité minière.

Une suite de métaux (Ni, Cr, Co, Mg) est enrichie dans les roches ultramafiques et dans les sédiments glaciaires transportés au sud-est des affleurements ultramafiques situés au nord de la région étudiée. Cette même série de métaux se retrouve enrichie dans les sédiments de la partie nord du lac Aylmer, la baie Moose, et aussi dans la partie nord du lac St-François. Cet enrichissement pourrait être relié au remaniement anthropogénique des sédiments glaciaires et/ou à des effets naturels, comme l'érosion et la météorisation des dépôts glaciaires, riches en ces métaux.

Près de 100 échantillons d'eau ont été prélevés dans le bassin hydrologique du lac Aylmer en plus des lacs environnants. Les échantillons ont été filtrés et acidifiés directement sur le terrain et des données telles que le pH, la salinité et la température furent mesurées à chaque site. Les résultats préliminaires indiquent des concentrations de SO_4^{-2} relativement élevées dans toute la région étudiée pouvant refléter l'effet de l'érosion agissant sur les roches et les sédiments glaciaires riches en pyrite. Des concentrations élevées en Al, Ba, Ca, Cd, Co, Cu, Fe, Ni, Pb et Zn ont été mesurées dans les ruisseaux qui drainent la propriété des mines Solbec et Cupra de même que celui du parc à résidus du site Solbec. Cependant, ces enrichissements de cations dans la phase dissoute des échantillons d'eau ne peuvent être tracés jusqu'au lac Aylmer. Les analyses par microscope électronique à balayage de particules fines sur les papiers utilisés dans le procédé de filtration des échantillons d'eau pour la région étudiée indiquent la présence d'un chargement en suspension composé de métaux primaire et secondaire.

Des niveaux élevés de métaux dans les sédiments de la baie Ward, le bassin le plus profond du lac Aylmer, sont attribués à des procédés géochimiques naturels dans les sédiments du lac ou reliés à des activités anthropogéniques le long de ses rives et dans la communauté de Beaulac. Les métaux (Cu, Pb, Zn) reliés a l'activité minière de la région sont aussi enrichis dans les sédiments de la partie la plus profonde de la baie Ward, à des niveaux comparables à ceux mesurés à l'embouchure du ruisseau Troisième et de la rivière Maskinongé. Par contre, plusieurs métaux qui ne sont pas reliés à l'activité minière (i.e., Hg, Ni, Ag, Mn, Fe, As et Sb) sont enrichis dans les sédiments de la baie Ward. Ceci suggère que des processus naturels d'échange de cations et/ou d'autres sources anthropogéniques ou naturelles pourraient être en partie responsables des hautes teneurs de métaux dans les sédiments de la baie Ward.

La disponibilité biologique et la stabilité de ces métaux dans les sédiments du lac Aylmer n'ont pas été établies.

Introduction

In summer of 1994, a comprehensive program of lake sediment and water sampling was undertaken in lac Aylmer and its drainage basin. The primary objective of the sampling is to provide a geochemical database from which patterns related to anthropogenic metal inputs into lac Aylmer can be separated from those resulting from natural processes. It is known that a primary source of metals in the lake is the base-metal mining activity in the hills along the eastern side of its drainage basin, but it is also important to assess the contributions of metals related to: (1) activities in the three towns on its shores; (2) asbestos mining in the north part of its basin; (3) farming and residence development around the lake; (4) sand and gravel exploitation near the lake; (5) the effects of linking the three original lakes into one by artificially raising lake level by 5-7 metres; and, (6) natural weathering and erosional processes acting on glacial deposits. It is anticipated that the analyses reported here and future lake sediment coring, sampling, and sequential leaching analyses will permit meaningful assessment of the complex interactions among all these potential anthropogenic and natural sources of metals in sediments and water of the upper rivière St-François drainage basin, which includes lacs Aylmer and St-François.

Geology

The bedrock lithologies of the study area comprise a series of northeasterly trending, steeply dipping, low-grade metasedimentary and volcanic strata intruded or displaced by igneous rocks of granitic and ultramafic composition (Slyvitsky and St. Julien, 1987). The south and central basins of lac Aylmer were formed on an impure limestone which is flanked to the southeast by metavolcanic rocks ranging from felsic tuffs to basalt.

It is within the volcanic complex that the base-metal mines that impact lac Aylmer, as well as other sites of uneconomic sulphide mineralization, are found. Major granodioritic intrusions with contact metamorphic aureoles lie across lac Elgin to the south of lac Aylmer and between the southern ends of lac Aylmer and lac St-François. The north half of lac St-François and baie Moose of lac Aylmer are underlain by pyrite-rich carbonaceous slates and greywacke sandstones. Basalt and associated ultramafic rocks of the Thetford Mines ophiolite complex crop out extensively north of lac Aylmer.

The lac Aylmer basin was glaciated at least three times by separate glaciers that advanced, in succession, southeastward (Johnville), southwestward (Chaudière), and southeastward (Lennoxville) (McDonald and Shilts, 1971). Considerable quantities of debris were transported southeastward during the final Laurentide (Lennoxville) glaciation, but in its final phases, remnants of the Lennoxville glacier were isolated in this part of the Appalachians and flowed northward, then westward. Little glacial transport was associated with the northward flow because the area is situated very close to an ice divide (Gadd, et al., 1972), but the Ni, Cr, Co, Mg-rich till that covers most of the drainage basin of the upper rivière St-François basin attests to extensive erosion and southeastward dispersal of debris from ultramafic outcrops in the west and north part of the lac Aylmer basin during the earlier phases of Lennoxville glaciation (Shilts and Smith, 1989).

Human alteration of the natural environment of lac Aylmer

Settlement

Early settlements around lac Aylmer were established in the late 1800s and include the communities of Disraeli, Beaulac and Stratford. One of the first important anthropogenic effects on lac Aylmer and surrounding lakes was the damming of the discharge channels of lac Aylmer and of lac St-François to facilitate floating of logs to the mills on the lower St. François. The dam at the mouth of lac Aylmer was built in the late 1880s and rebuilt during the middle of the 20th century. Water levels are presently controlled by these dams at approximately 5-7 m above the natural level.

Until the mid 1980s septic tanks were rare, and municipal sewage treatment plants did not exist in the lac Aylmer region. Until 1984, waste water from Disraeli drained directly into lac Aylmer, and it was not until 1985 that the municipality of Beaulac acquired a water treatment plant (Drolet et Morais, 1985). Stratford Center indirectly drained waste water into lac Aylmer via rivière Bernier/Maskinongé (Drolet et Morais, 1985). Also, cottages around lac Aylmer and lac St-François drained waste water directly into the lake. Another source of waste water in lac Aylmer's drainage basin comes from present and past agricultural activities, such as pig, cattle, turkey and chicken farming, the exploitation of sugar bushes, and grain farming. For example, high inputs of organic matter into ruisseau Troisième were identified by the Ministry of Natural Resources (1976) to come from a turkey farm still in operation in 1985 (Drolet et Morais, 1985).

Base-metal mining

Polymetallic volcanogenic massive sulfide deposits hosted in chlorite schist, sericite schist and black slate were exploited from 1962 to 1977. In 1959, geologists from Solbec Copper Mines Ltd., part of the Sullivan Mining Group, discovered the mineralization that became the Solbec mine approximately 2.5 km north of Stratford and 3 km east of lac Aylmer. The mine operated as a cut-and-fill and open pit excavation, producing about 1,500,000 t of ore from 1962 to 1970 (Robert and Desmarais, 1987). The processing plant at the Solbec site treated ores from other nearby mining sites until the end of 1977, for a total of 4 885 000 t of ore (ib.). The waste material accumulated within this 15 year period was pumped to a waste site on the peat-covered alluvial plain of a tributary of ruisseau Troisi me, approximately 2 km northeast of the treatment plant. The tailings are mainly composed of silica, iron, aluminum and calcium, with 20% sulfur and 2 to 5% other metals, including As, Cd, Cr, Cu, Hg, Pb and Zn (Drolet et Morais, 1985). The sulphide phases are dominantly pyrite, but minor amounts of sphalerite, galena and chalcopyrite are also present in the tailings. The differential gravity setting method for separation of the ore (Cu, Pb, Zn) also used reagents such as Carbonate z-200, Xanthate z-6, Zn-sulphate, Cu-sulfate, Na-cyanide, and slaked lime (ib.). Every year, approximately 260 000 tonnes of waste material were pumped to the waste site along with waste water used during mining operations (ib.). At the Cupra mine, located 2.5 km southwest of Stratford, waste water flowed into Rivière Bernier, which eventually flows westward into lac Aylmer via rivière Maskinongé.

In 1983 the Solbec and Cupra mine sites were classified by GERLED (Groupe d'étude et de restoration des lieux d'élimination des déchets dangereux) of the Ministry of the Environment of Quebec (MENVIQ) as category I sites, sites with high risk for human health and the environment (Desrochers et al., 1990). Since 1974, the government of Quebec has been monitoring pH, salinity and metal concentrations in mining effluents and has carried out some water sampling in lac Aylmer and lac St-François (Association des mines et des métaux du Québec, 1974; INRS-Eau, Ministère de l'Environnement du Québec, 1984, 1985; Ministère des Loisirs, de la Chasse et de la Pêche, 1985). Lake sediment sampling surveys were also carried out in lac Aylmer with the aim of establishing metal concentration at the mouths of rivers draining mine effluents (Réseau de surveillance des substances toxiques dans le milieu aquatique, 1979, 1980, 1981, INRS-Eau).

In 1987, Cambior, Ltd. became the owner of Sullivan Mines Ltd. and inherited the Solbec-Cupra mining sites. An agreement was reached with the Ministry of the Environment in which Cambior stated their intention to restore the mine and tailings sites (Desrochers et al., 1990). The Solbec and Cupra mine sites have been remediated, and the Solbec tailings were being restored by flooding of the tailings area in the fall of 1994. The remediation strategies were developed through several studies financed under the MEND (Mine Environment Neutral Drainage) program of CANMET, Department of Natural Resources, Ottawa.

Asbestos mining

In the northern part of the lac Aylmer drainage basin, a small asbestos mine and tailings are a possible source of Ni, Cr, Co, Mg, and other metals associated with the ultramafic rocks that host the asbestos. However, the terrain in the northern part of the study area is covered by glacial drift rich in those components, and the geochemical influence of the erosion and weathering of this glacially transported sediment probably far exceeds that of the asbestos mining residues.

Sand and gravel exploitation

Sand and gravel deposits of glacial and fluvial origin have been exploited at the few places they occur in the lac Aylmer area. The extensive exploitation of fluvial gravel terraces and possible ice-contact deposits at the inflow of rivière St-François into lac Aylmer may have contributed considerable fine-grained clastic sediment with geochemical affinity to ultramafic rocks (Ni, Co, Cr, Mg, etc.) to the northern basin of lac Aylmer. The geological source of much of the material that makes up the sand and gravel was the ultramafic-rich debris glacially transported southeastward from the source outcrops in the north and northwest part of the study area. Other major exploited gravel deposits of ice-contact stratified drift lie along the southeast side of ruisseau Troisième, just north of lac Elgin on the east side of rivière Maskinongé, and on rivière Bernier, just south of Stratford.

Methods

(1) Sonar surveys: Using a Raytheon RTT-1000 subbottom acoustic profiling system (Sonar) operating at frequencies of 200 KHz, and 7 KHz, a detailed survey of the bathymetry, bottom sediment facies, and thickness of sediments in lac Aylmer and lac St François was made. Records made during preliminary projects in the early 1980s supplement this work. From these surveys, it can be seen that the bedrock that forms the lac Aylmer depression is in most cases directly overlain by acoustically laminated glacial lake clays that average 5 m to 10 m in thickness. These clays are overlain in deeper parts of the lake by up to 5 m of acoustically non-laminated modern sediment that was found to be rich in organic matter when sampled. In water depths of less than 5-7 m, the approximate amount that the lake has been raised artificially, sand, till, bedrock, or the above-mentioned inorganic laminated clay forms the lake bottom. The map of sediment types that form the present lake's bottom is used as the base for plotting geochemical data because of the strong relationship between sediment type (facies) and metal concentrations.

Records from a sonar survey carried out on lac St François in 1983 show that lac St François occupies a single, elongate basin and has a sediment stratigraphy very similar to that of lac Aylmer. However, unlike lac St François which consists of a single, elongated basin, lac Aylmer is divided into three distinct basins, representing the original sites of natural lakes formerly connected by rivière St François and separated by land that was flooded by damming in the late 19th century.

(2) Sediment grab sampling and geochemical analyses: Using a "Petite Ponar" sampler, grab samples of the upper 10-15 cm of bottom sediment were collected at 128 sites distributed on a regular grid in lac Aylmer. Similar sampling was carried out at 10 sites in lac St François and at 3-4 sites each in lac Elgin, lac des Isles, lac Maskinongé, lac Équerre, lac à la Barbue, and baie Sauvage of lac St François. The other lakes were chosen from different geological environments to provide a range of background geochemical characteristics against which those of lac Aylmer could be compared.

All samples were homogenized in the field, which in some cases involved disrupting and "folding in" obvious horizontal, chemically contrasting layers. A five-gram split was obtained from each sample after approximately one month of storage at temperatures between 2° and 5° C (samples were packed in ice for shipment to Ottawa). Each split was digested with 30 ml, 3-1-2 HCl-HNO_3- H_2O at 95° C for one hour and diluted to 100 ml with water. The solution was analyzed directly at Acme Laboratories, Vancouver using an Inductively Coupled Plasma (ICP) technique for Mn, Fe, Sr, Ca, P, La, Cr, Mg, Ba, Ti, B, W, Na, K, Ga, and Al. Mo, Cu, Pb, Zn, Ag, As, Au, Cd, Sb, Bi, Tl, Se, Te, and Ga were extracted with MIBK-Aliquot 336 and analyzed by ICP. Hg was similarly extracted and analyzed by cold-vapour atomic absorption spectroscopy (AAS). Total carbon was determined using a Leco carbon analyzer. Ten duplicate samples of lake sediment of known composition that were collected from a lake in the Huntsville, Ontario area were inserted randomly among the Aylmer samples and repeat analyses of the Quebec samples were carried out once in every 30 samples for quality control. Interlaboratory standards were also analyzed after every 35th sample.

(3) Water sampling and analysis: Surface and bottom water samples were collected in lac Aylmer and in adjacent lakes and inflowing streams. A one-kilometre grid was used for surface water samples in lac Aylmer, itself. Samples were collected near the sediment/water interface at several sites for comparison with sediment and surface water geochemistry. Surface lake water samples were collected approximately 20 cm below the air/water interface, whereas bottom water samples were collected at 1-2 m above the sediment/water interface. The pattern of stream water sampling was chosen to evaluate compositional variations before and after confluence of tributaries carrying contaminated effluents. At each site, 3 x 175 ml nalgene water bottles were rinsed and filled to the top. Water was then tested immediately on site for pH, conductivity, and temperature. The apparatus was rinsed using de-ionized water. Water samples were also kept cool until sent to the laboratories.

The three water samples at each site were filtered in the field through a 0.45 µm millipore filter, using a hand pump. Filtered and filtered-acidified samples were kept refrigerated in 175 ml nalgene bottles. The extra 175 ml water sample was used in the filtering procedure to rinse the apparatus and the sampling bottles. Double distilled HNO_3 was used to acidify the samples in the field to a 0.4% solution of pH~2. Acidifying the samples sent for cation analysis slows down bacterial activity, limiting post-sampling alteration of water chemistry.

Filtered, unacidified samples were shipped to Barringer Laboratories for analysis of the anions F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{-3} and SO_4^{-2}. Filtered acidified samples were analyzed for a suite of cations in the research laboratories at the Geological Survey of Canada.

(4) Till Sampling: Till was sampled from artificial and natural exposures at various times throughout the past 22 years. The <250-mesh (<63 µm) fractions of recently collected samples were analyzed for a wide range of elements using techniques similar to those described for lake sediments. The older samples were analyzed for Cu, Pb, Zn, Ni, Cr and Co by AAS after a hot, 1-hour HNO_3- HCl leach. The values determined by the different analytical methods are thought to be comparable.

Results and Discussion

Variations in bedrock geology and in the composition of glacial sediments dispersed from various types of bedrock outcrops clearly influence the chemistry of individual smaller lakes and certain basins or sectors of the larger lakes (Aylmer and St-François). For instance, lakes lying on granite have sediments and water enriched in uranium; lakes receiving streams draining glacial sediments rich in the asbestos-bearing bedrock of the Thetford Mines Ophiolite Complex are enriched in Fe, Ni, Mg, Cr, and Co. In both cases, these bedrock types (granite and ultramafic rock) are typically enriched in the element suite noted in the lake sediments. Anomalously high Mn and Mo in sediments of lac Elgin may be related to mineralization, since the bedrock environment favorable for hosting economically viable deposits of Mo elsewhere in the region (i.e., Mt St-Sébastien) exists under and beside this lake.

Metallic species that were extracted as ore from the Cupra and Solbec base-metal mines are found in patterns in lake sediments that suggest enrichment above natural levels in some parts of lac Aylmer. The greatest enrichments appear to be confined largely to the deepest part of baie Ward and to areas just offshore from rivière Maskinongé and ruisseau Troisième, the latter streams known to have carried effluents from the mine sites for the past 30+ years. It should be noted that a wide range of metals is enriched in baie Ward, whereas a suite limited mainly to those metals associated with mining is found offshore from inflowing streams from the base-metal mining areas. The environmental significance of the enrichments is not known, because the type of analyses performed to date provide only a guide to total metal in the sediment and give no indication of a metal's bio-availability or of its potential for dissolution into the water column.

The pattern of metal concentration is also strongly related to the type of bottom sediment mapped from the sonar surveys. Samples from sandy bottoms or from bottoms underlain by inorganic, proglacial lake clays have low metal concentrations, regardless of location. Metals of all types are generally concentrated in the deepest basins in gyttja, modern sediment that is rich in organic carbon. However, the most carbon-rich sediments (8-18 dry weight %) at the south end of lac Aylmer, and in the smaller lakes sampled within its drainage basin, are relatively impoverished in metals compared to sediments with only 3-6% carbon in baie Ward and baie Moose. Because organic matter is prone to scavenge metals, the lack of metal in the carbon-rich sediments at the outlet end of lac Aylmer suggests that the metals entering the lake elsewhere are being fixed in the sediment close to their point of entry or are entering as clastic particles that settle to the bottom quickly. Fixation of disolved metals may be enhanced by the relatively high pH (~7.0) of lac Aylmer, which is related to the carbonate bedrock basin in which it is located. High pH causes precipitation, i.e. decreases mobility of many cations. This implies that the lake, in its present form, is a sink for metals and is not exporting them in any quantity. Further study is required to evaluate this hypothesis, however.

Baie Moose bears strong sedimentological but little geochemical resemblance to baie Ward. A glacial dispersal train of Co-Mg-Ni-Fe-Cr-rich debris extends southward from the asbestos-bearing ridge between Disraeli and Thetford Mines, covering the land between northern lac Aylmer and lac St-François. Sediments in the northern ends of both of these lakes, particularly near the mouth of rivière St-François in lac Aylmer are rich in these metals compared to baie Ward, which is rich in Cu, Pb, Zn, Hg and other metals. This suggests that anthropogenic activities — construction, excavation, farming, asbestos mining, gravel extraction, etc. — that disturb the glacial cover, or natural weathering and erosional processes are responsible for the lake sediment geochemistry of baie Moose.

Conclusion

The results of the sediment sampling program indicate that, as anticipated, there are patterns of geochemical enrichment related to both natural processes and to anthropogenic activity within the drainage basin of lac Aylmer. The interaction and relative importance of anthropogenically generated metals from mines, from the towns and farms on the lakeshore, and from naturally occurring metals in the surrounding geological materials cannot be determined confidently without further laboratory tests and fieldwork. In particular, geochemical analyses to date show only patterns of total metal in the sediment and shed no light on the potential for dissolution or bioavailability. Deep sediment coring, sequential leaching experiments, and lead isotope tracing will be carried out to further explain the geochemical patterns and data that have resulted from this preliminary work.

References

Desrochers, Clément J. et Associés Inc.
1990: Restauration du site de la mine Solbec; Solbec Rapport, CJDA, mars 1990, Sainte-Foy, Québec, 27 p.

Drolet, C. et Morais, L.
1985: Parc à résidus des mines Solbec et Cupra; Rapport de caractérisation; Lieu 05-22. Ministère de l'environnement du Québec, Direction des Substances dangereuses, octobre 1985, 73 p.

Gadd, N.R., McDonald, B.C., and Shilts, W.W.
1972: Deglaciation of southern Quebec; Geological Survey of Canada, Paper 71-47, 19 p.

McDonald, B.C. and Shilts, W.W.
1971: Quaternary stratigraphy and events in southeastern Quebec; Geological Society of America, Bulletin, v. 82, p. 683-698.

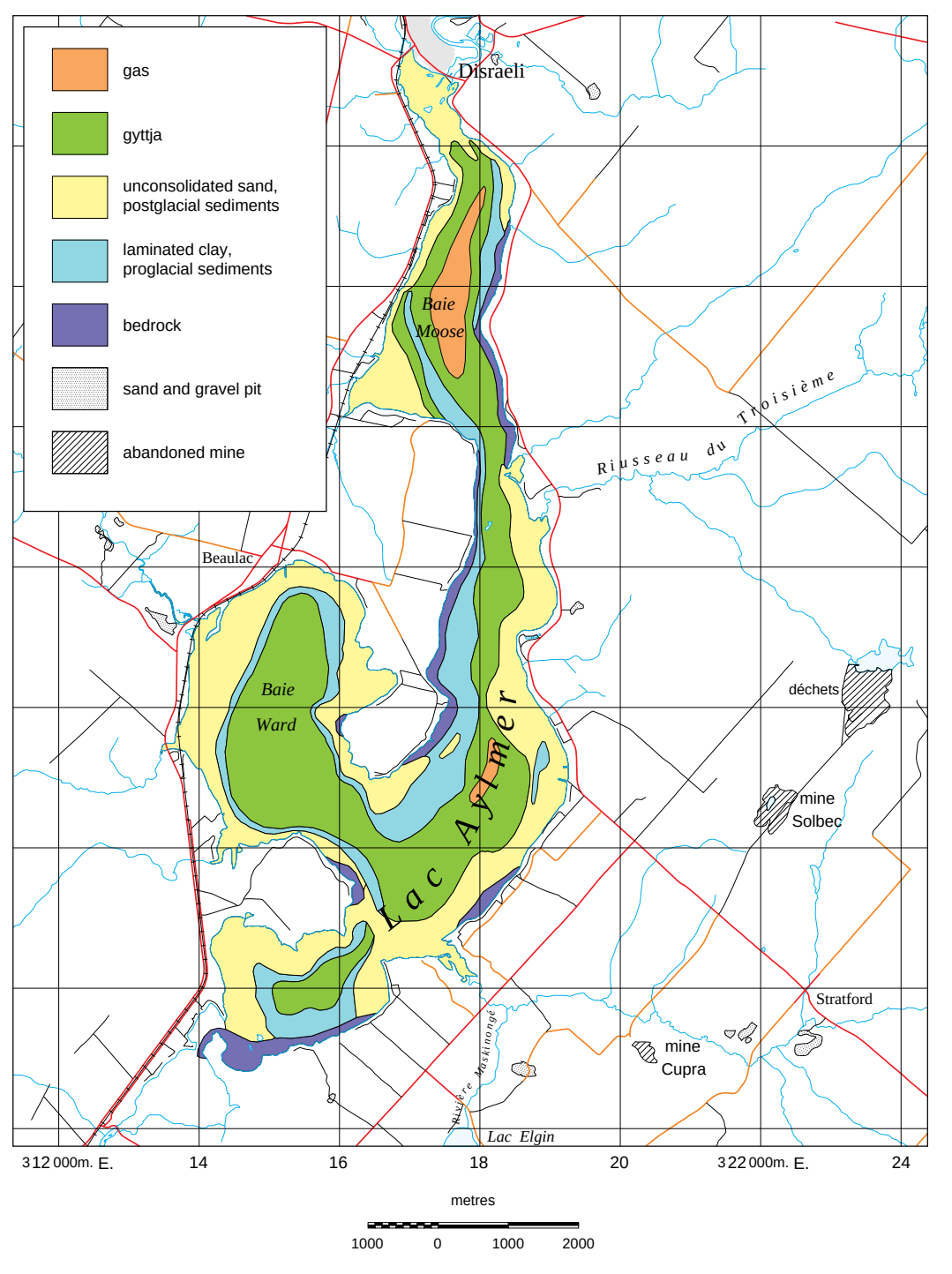
Ministère des Richesses naturelles
1976: Lac Aylmer; Direction générales des Eaux, 126 p.

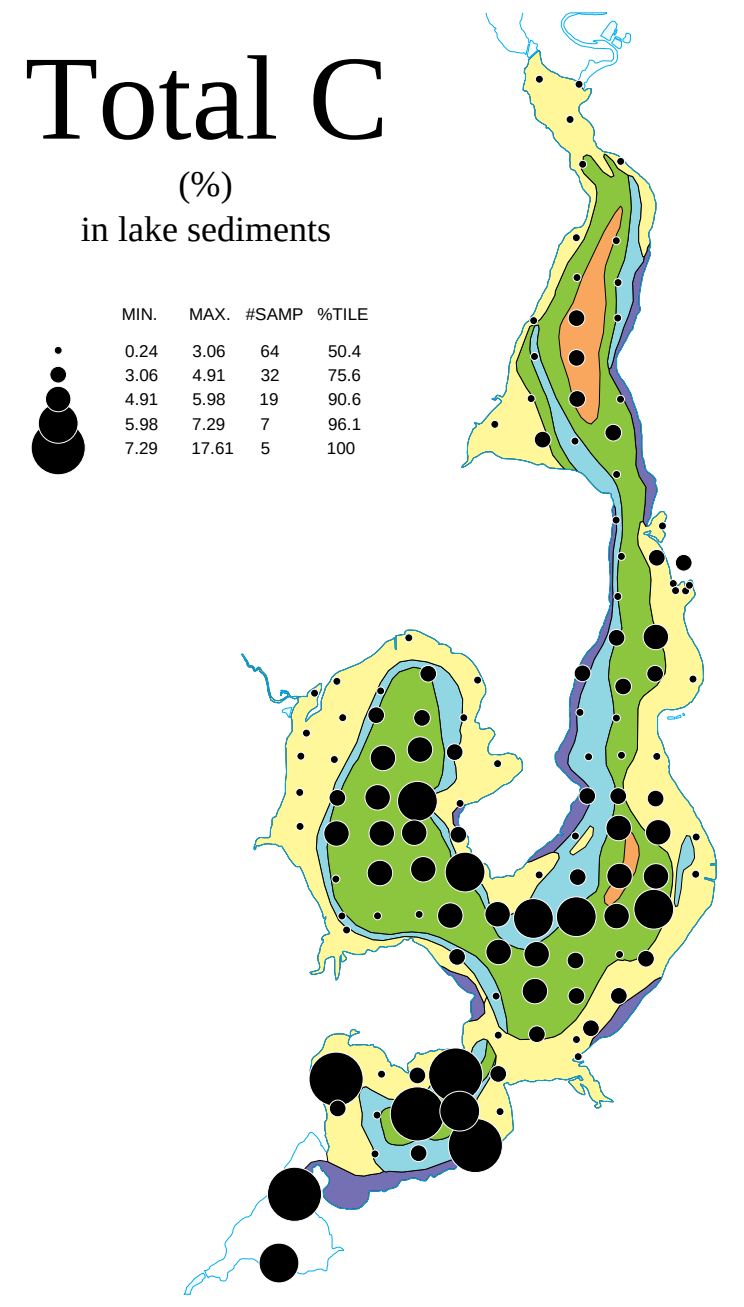
Robert, J.M. et Desmarais, G.
1987: Assainissement et revitalisation du parc à résidus sulfureux des anciennes mines Solbec et Cupra — solutions possible; 40ième Conférence canadienne de géotechnique, octobre 19-21, 1987, Régina, Saskatchewan, p. 89-99.

Shilts, W.W. and Smith, S.L.
1989: Drift prospecting in the Appalachians of Estrie-Beauce, Québec; Geological Survey of Canada, Paper 89-20, p. 41-59.

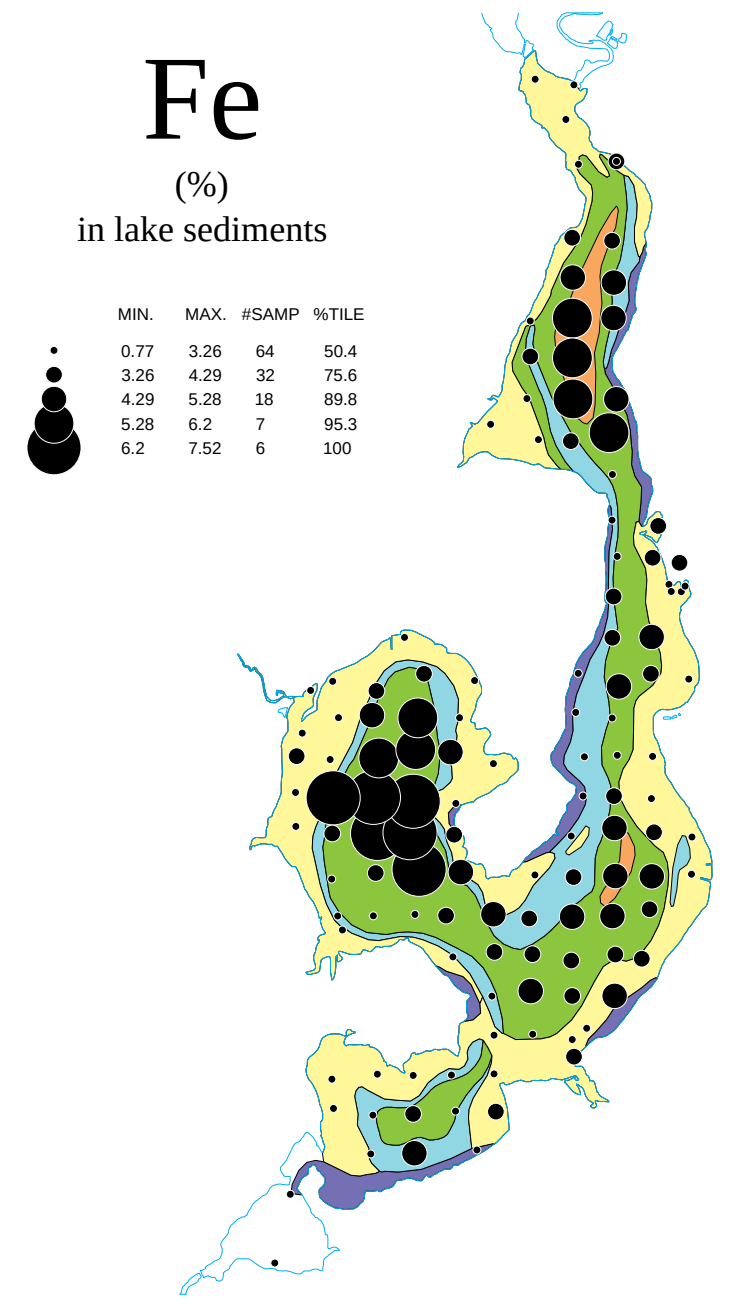
Slivitsky, A. and St Julien, P.
1987: Compilation géologique de la région de l'Estrie-Beauce; Ministère de l'Énergie et des Ressources du Québec, MM85-04, 40 p.

Index Map

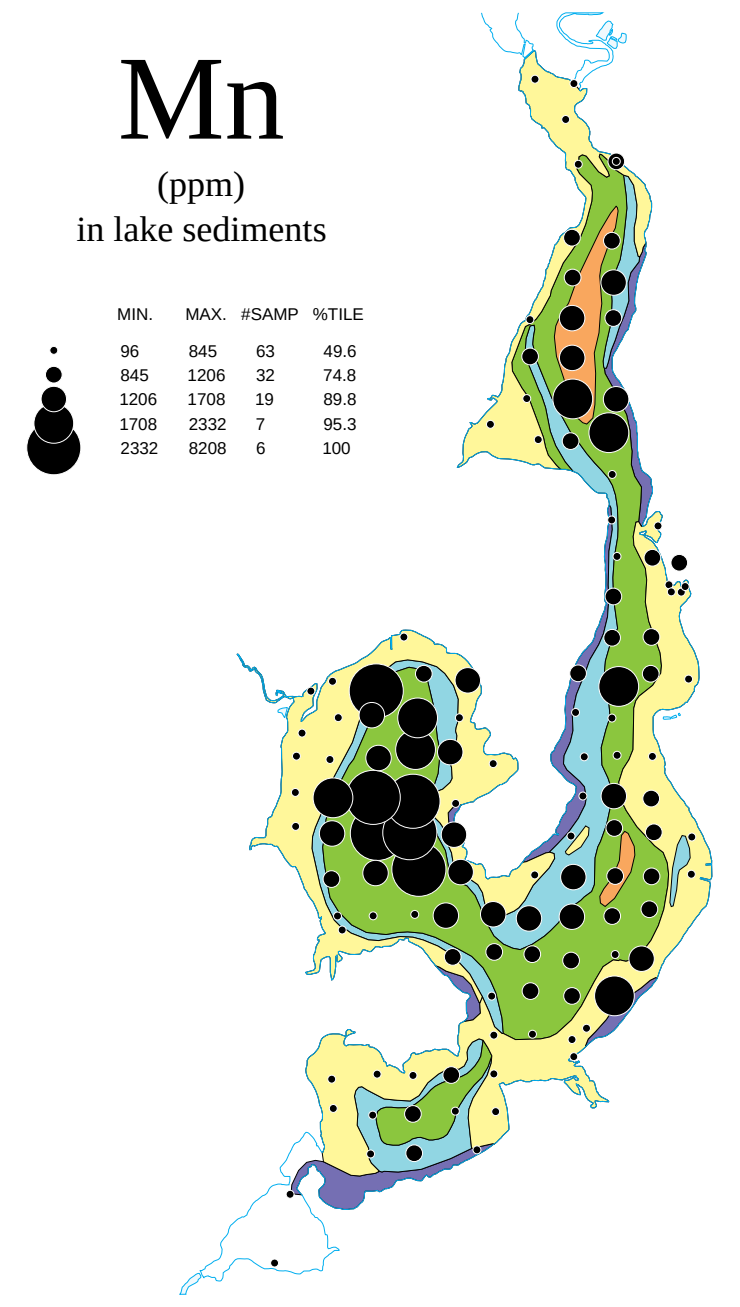



Total C
(%)
in lake sediments

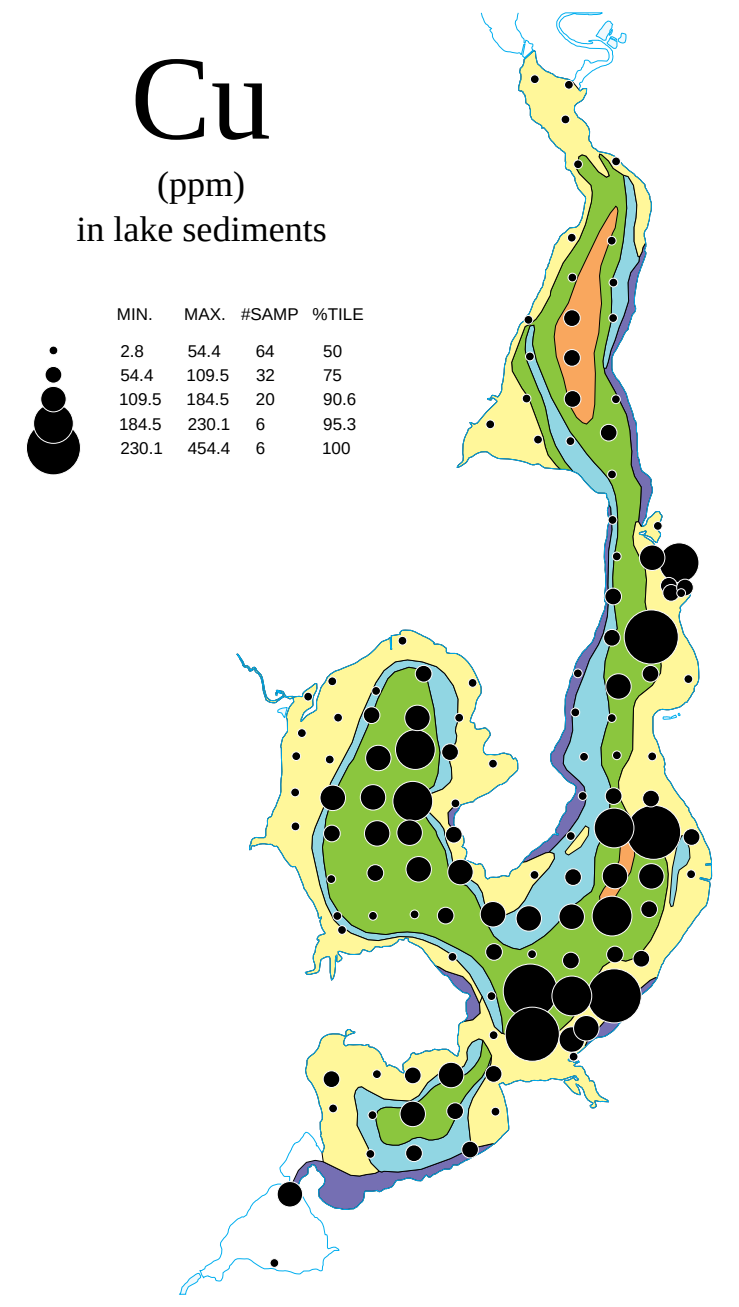
MIN.	MAX.	#SAMP	%TILE
0.24	3.06	64	50.4
3.06	4.91	32	75.6
4.91	5.98	19	90.6
5.98	7.29	7	96.1
7.29	17.61	5	100


Fe
(%)
in lake sediments

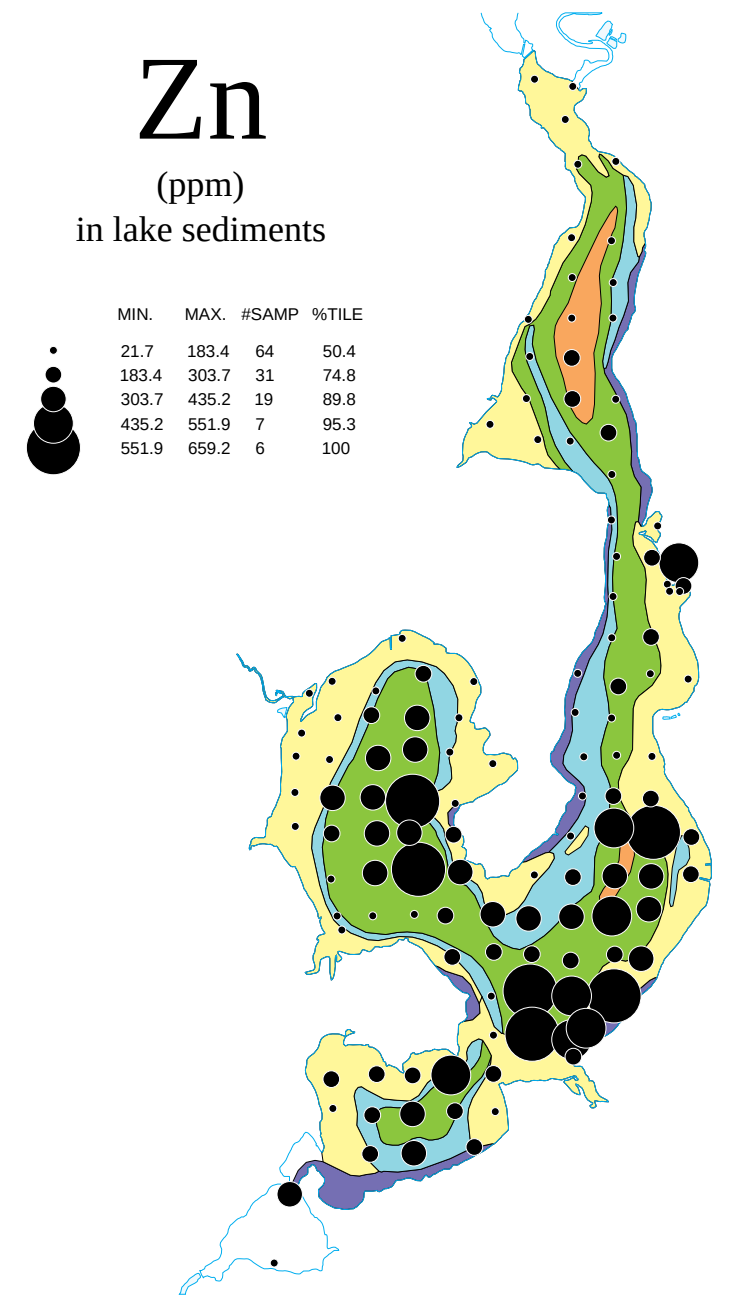
MIN.	MAX.	#SAMP	%TILE
0.77	3.26	64	50.4
3.26	4.29	32	75.6
4.29	5.28	18	89.8
5.28	6.2	7	95.3
6.2	7.52	6	100


Mn
(ppm)
in lake sediments

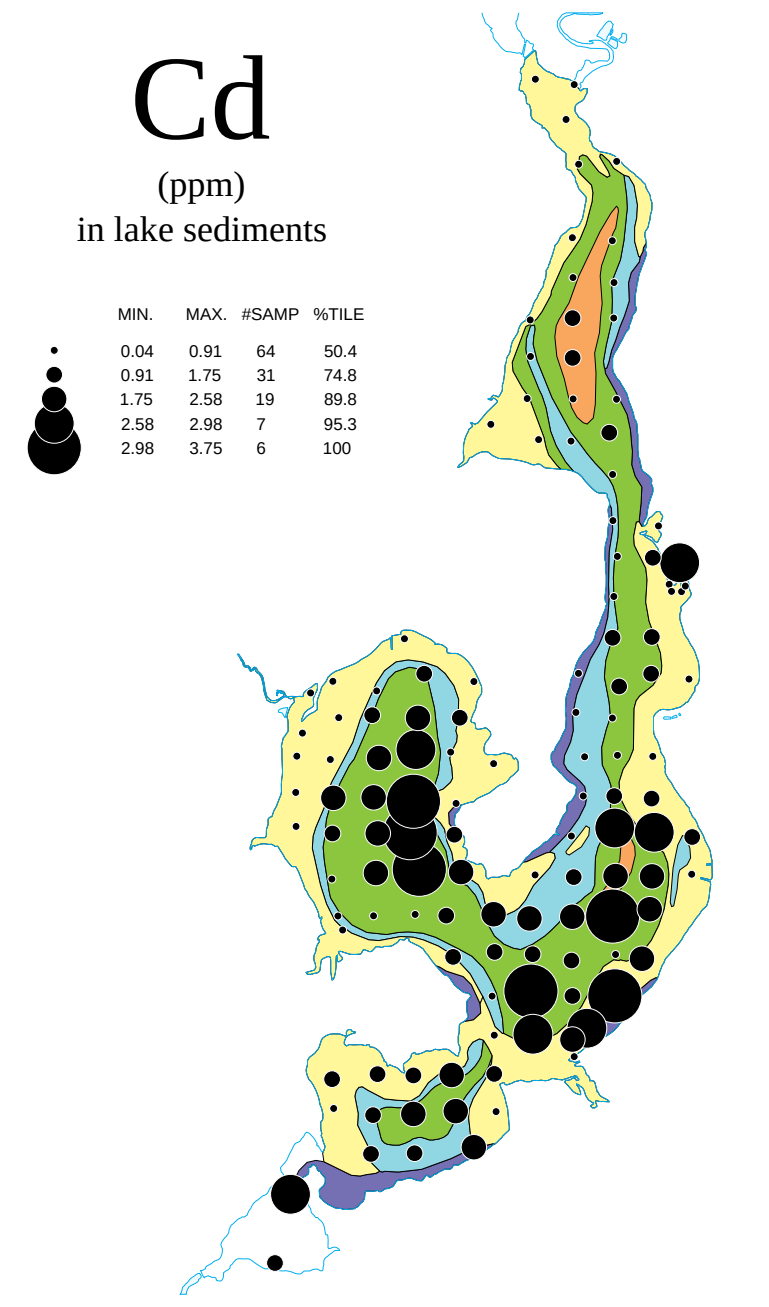
MIN.	MAX.	#SAMP	%TILE
96	845	63	49.6
845	1206	32	74.8
1206	1708	19	89.8
1708	2332	7	95.3
2332	8208	6	100


Cu
(ppm)
in lake sediments

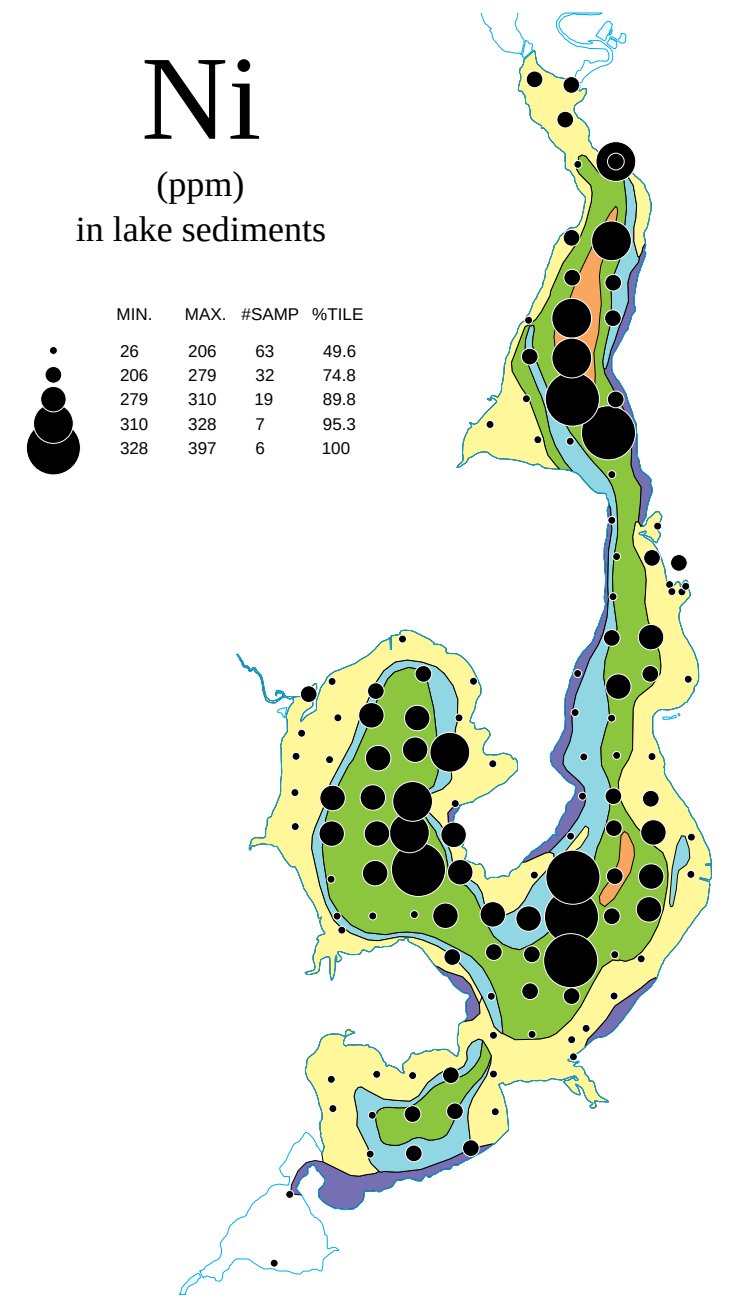
MIN.	MAX.	#SAMP	%TILE
2.8	54.4	64	50
54.4	109.5	32	75
109.5	184.5	20	90.6
184.5	230.1	6	95.3
230.1	454.4	6	100


Zn
(ppm)
in lake sediments

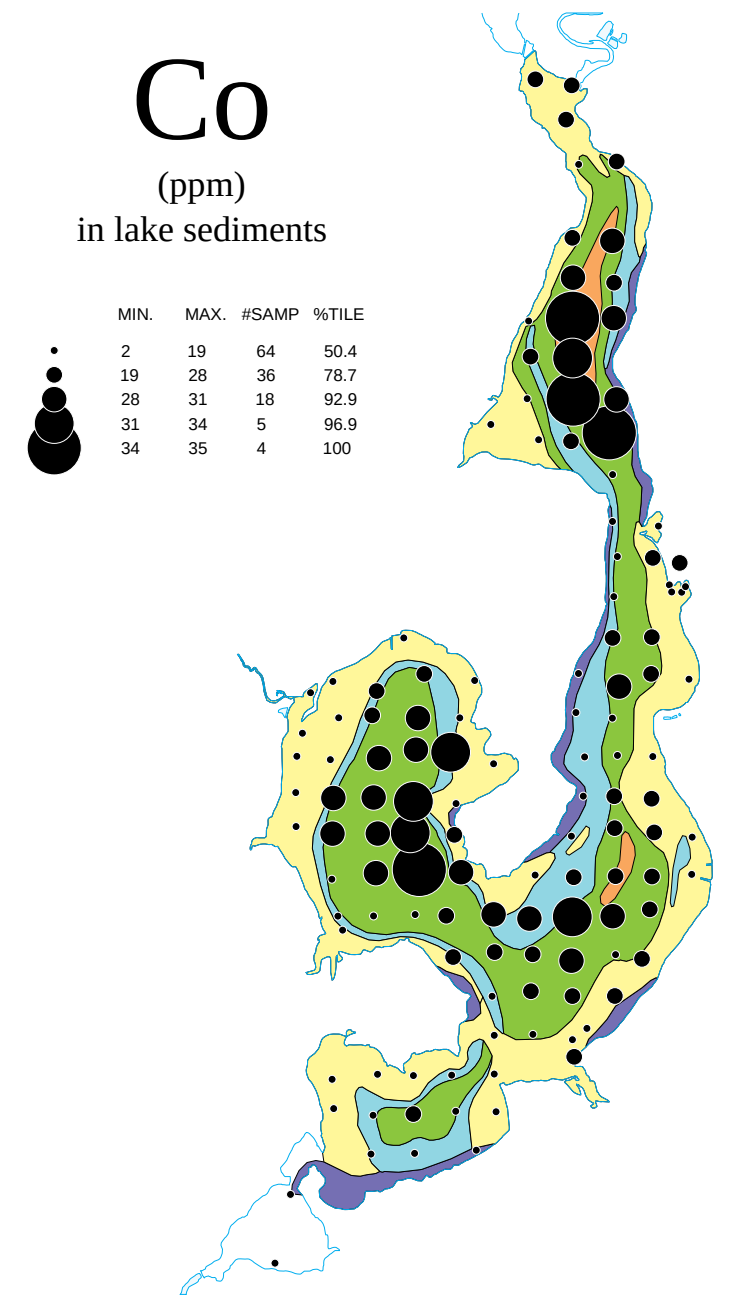
MIN.	MAX.	#SAMP	%TILE
21.7	183.4	64	50.4
183.4	303.7	31	74.8
303.7	435.2	19	89.8
435.2	551.9	7	95.3
551.9	659.2	6	100


Cd
(ppm)
in lake sediments

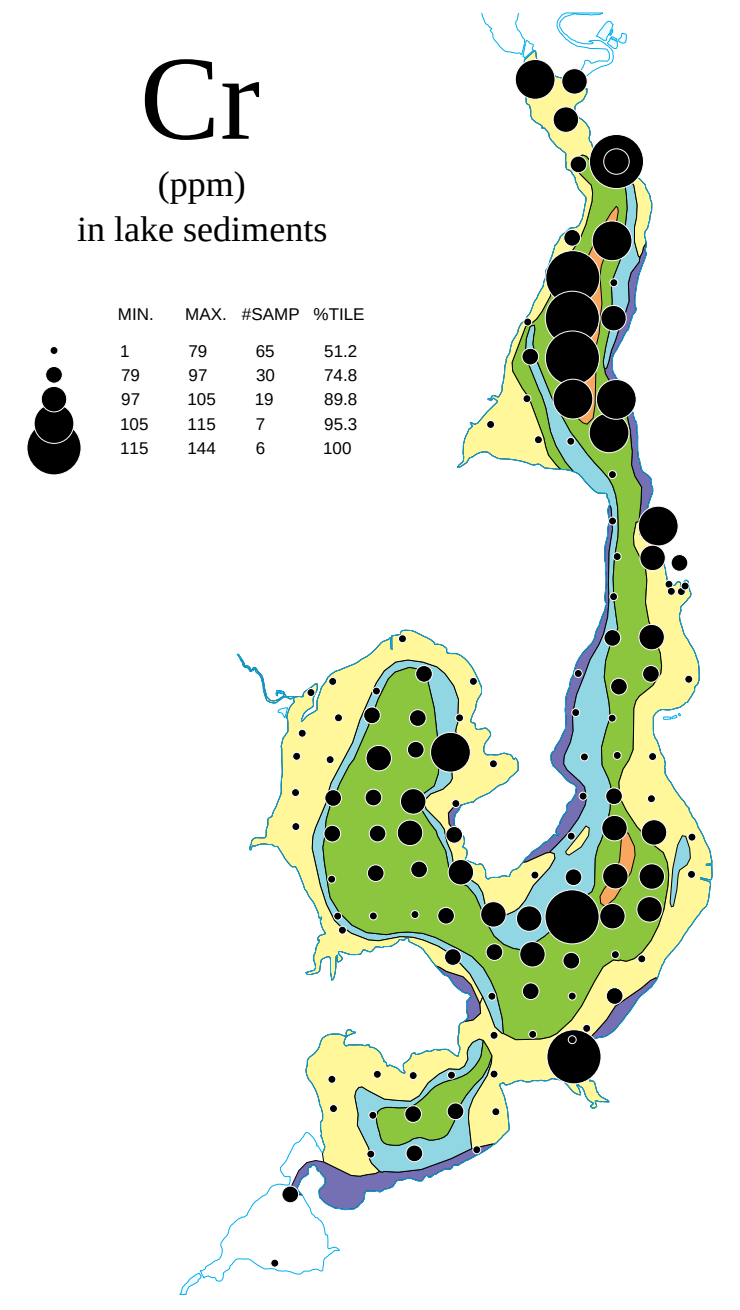
MIN.	MAX.	#SAMP	%TILE
0.04	0.91	64	50.4
0.91	1.75	31	74.8
1.75	2.58	19	89.8
2.58	2.98	7	95.3
2.98	3.75	6	100


Ni
(ppm)
in lake sediments

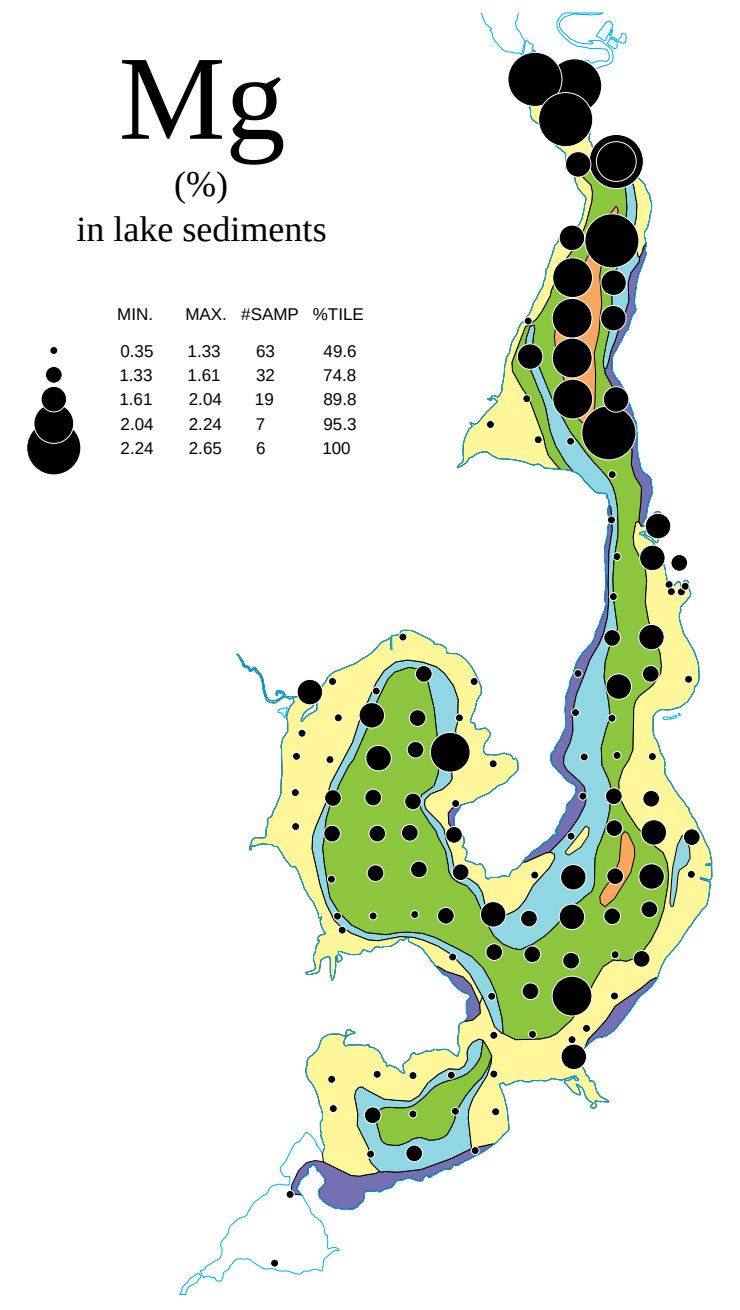
MIN.	MAX.	#SAMP	%TILE
26	206	63	49.6
206	279	32	74.8
279	310	19	89.8
310	328	7	95.3
328	397	6	100


Co
(ppm)
in lake sediments

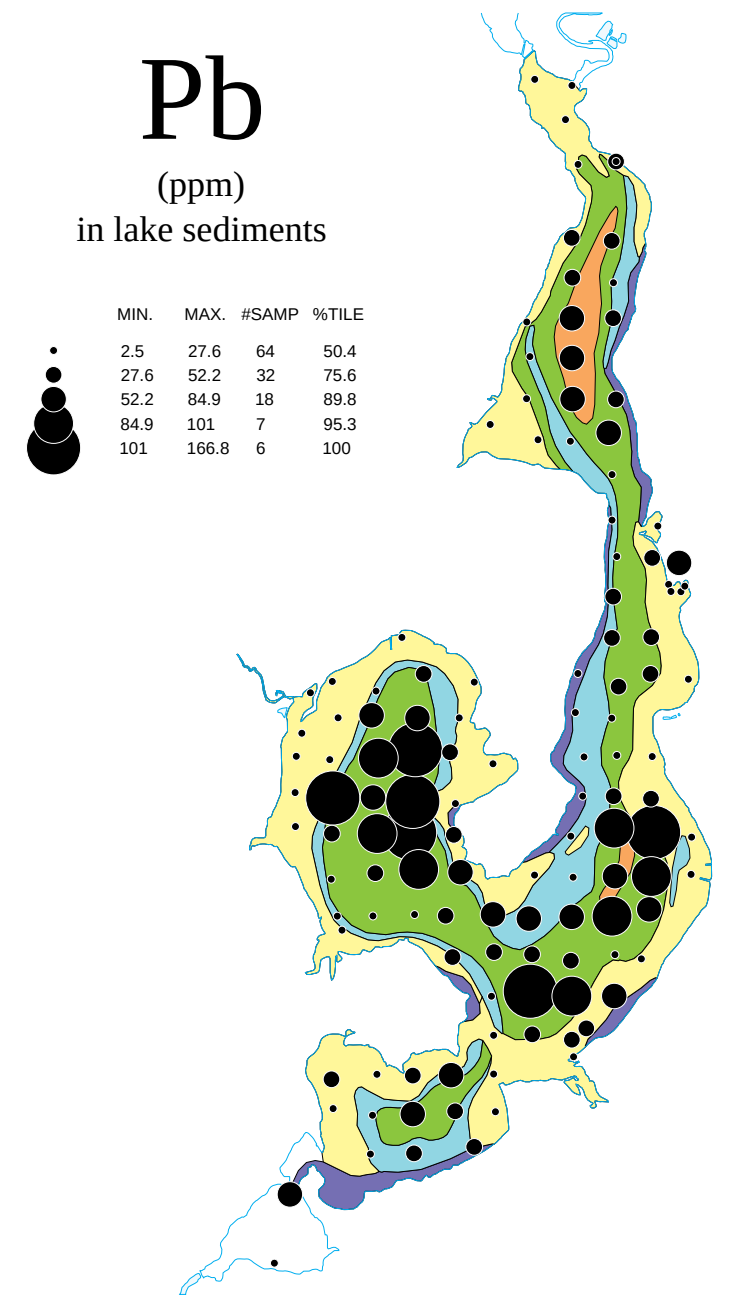
MIN.	MAX.	#SAMP	%TILE
2	19	64	50.4
19	28	36	78.7
28	31	18	92.9
31	34	5	96.9
34	35	4	100


Cr
(ppm)
in lake sediments

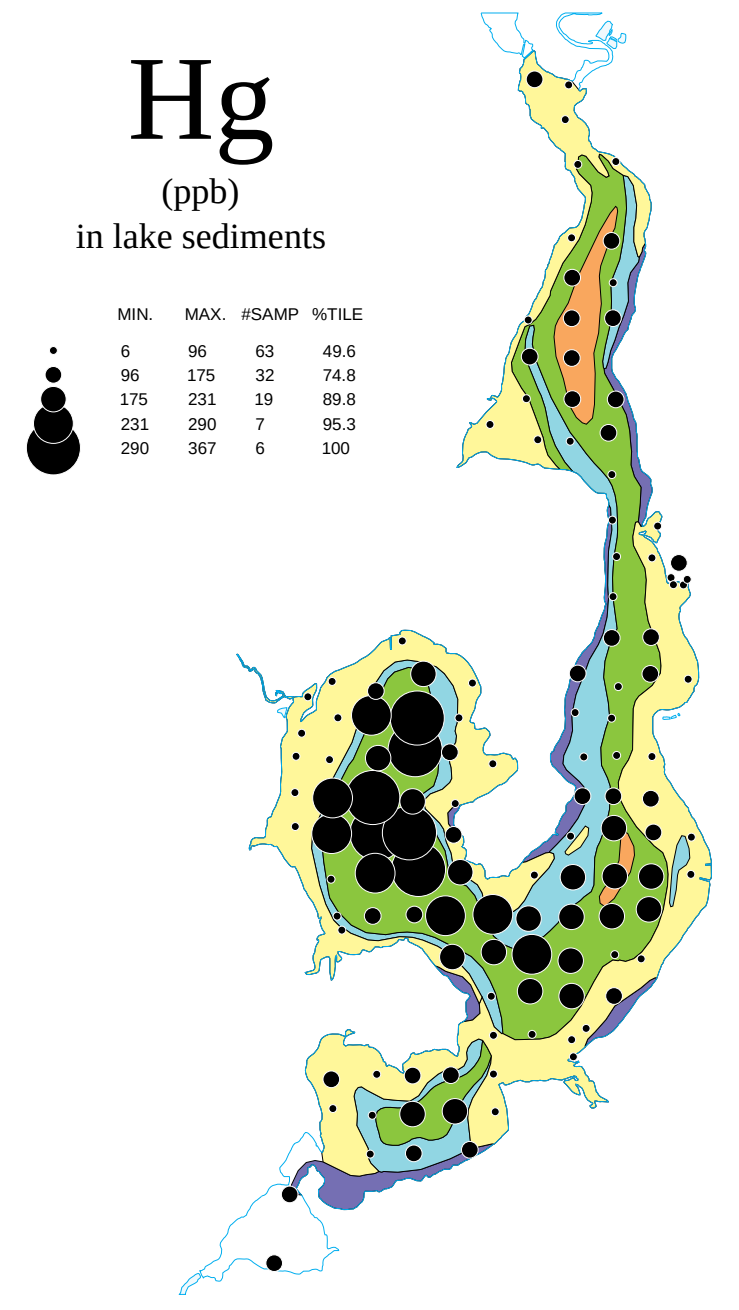
MIN.	MAX.	#SAMP	%TILE
1	79	65	51.2
79	97	30	74.8
97	105	19	89.8
105	115	7	95.3
115	144	6	100


Mg
(%)
in lake sediments

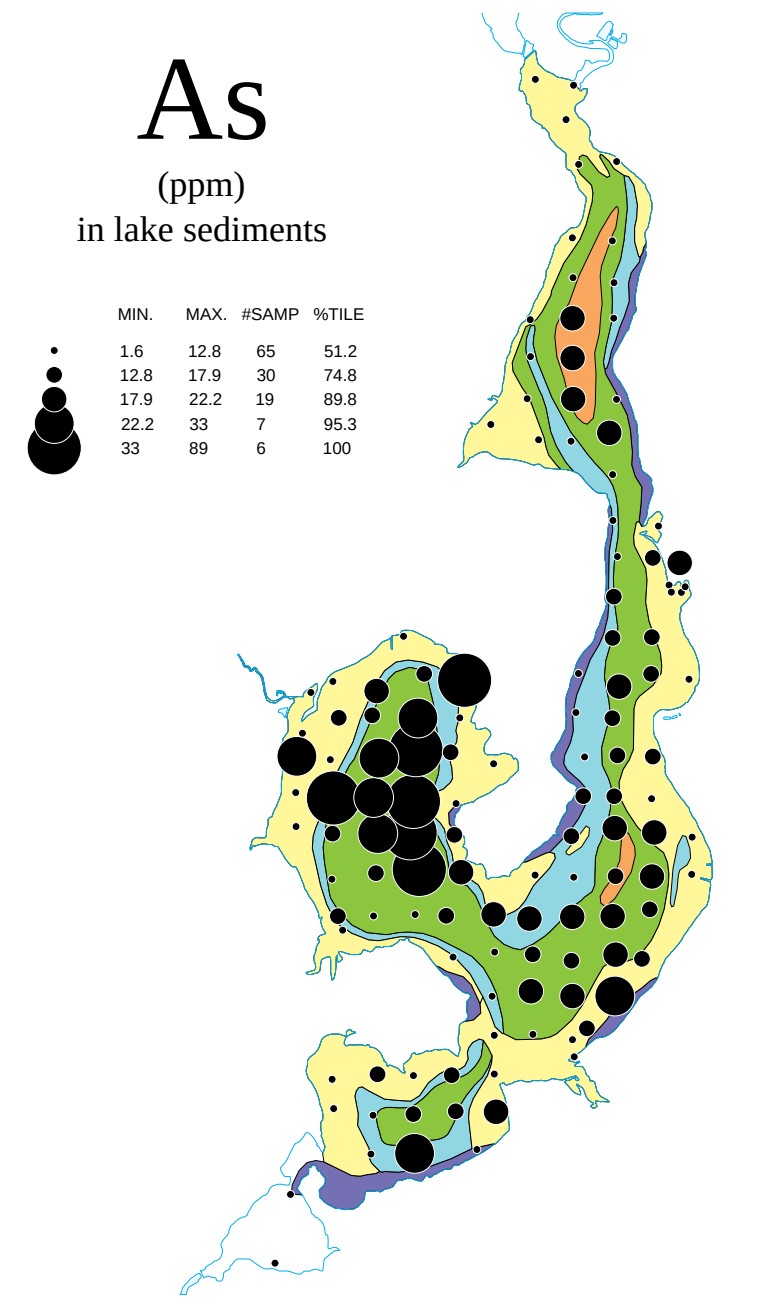
MIN.	MAX.	#SAMP	%TILE
0.35	1.33	63	49.6
1.33	1.61	32	74.8
1.61	2.04	19	89.8
2.04	2.24	7	95.3
2.24	2.65	6	100


Pb
(ppm)
in lake sediments

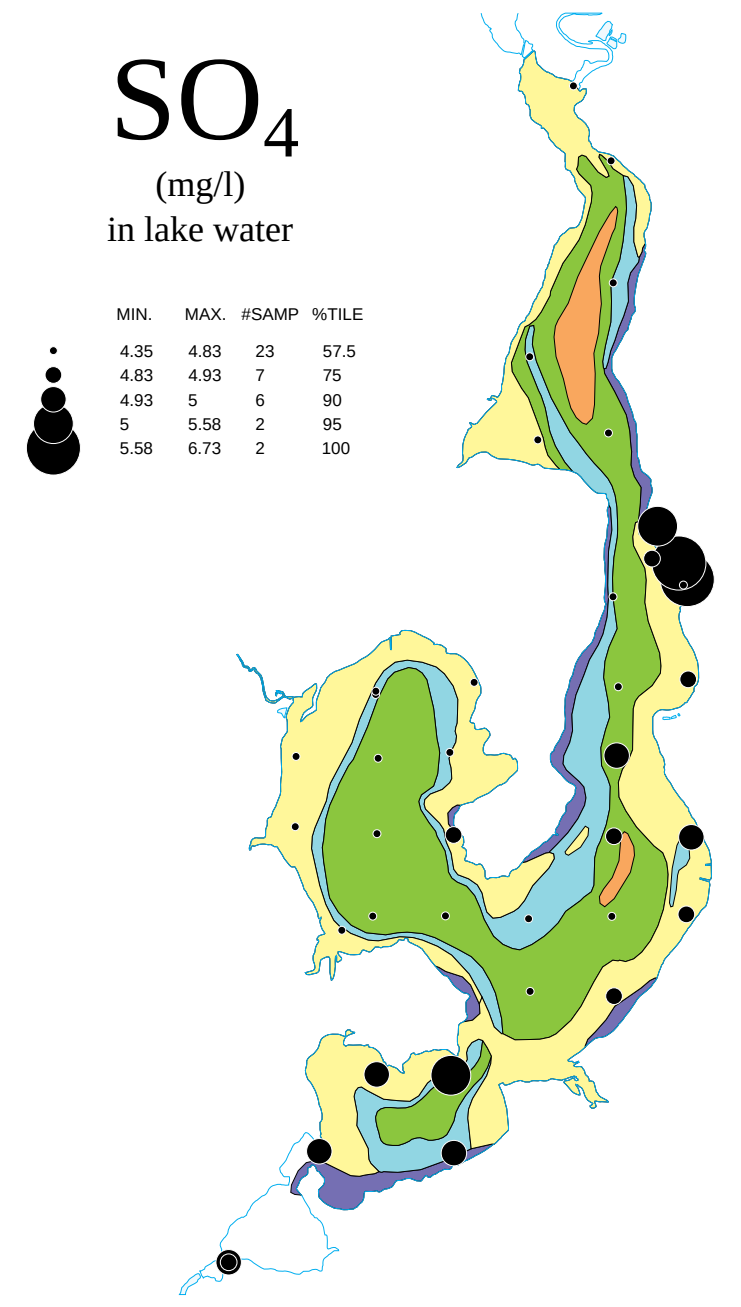
MIN.	MAX.	#SAMP	%TILE
2.5	27.6	64	50.4
27.6	52.2	32	75.6
52.2	84.9	18	89.8
84.9	101	7	95.3
101	186.8	6	100


Hg
(ppb)
in lake sediments

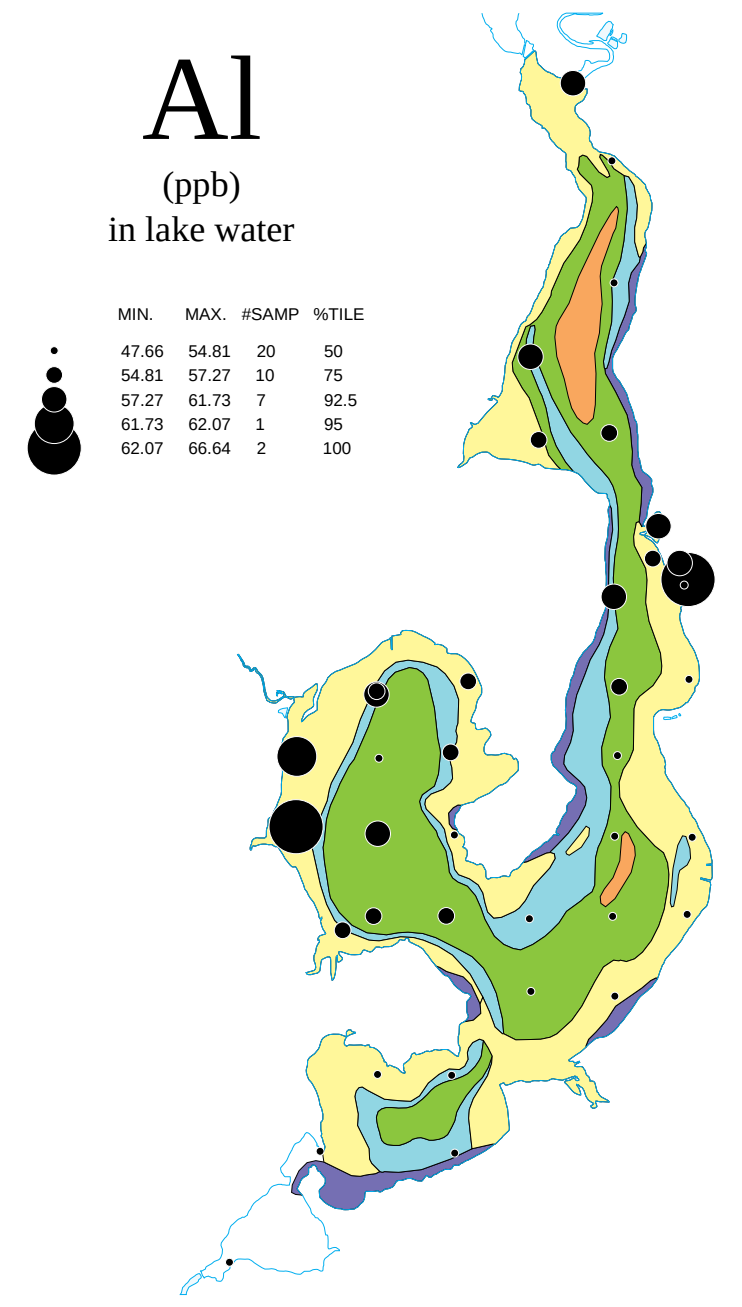
MIN.	MAX.	#SAMP	%TILE
6	96	63	49.6
96	175	32	74.8
175	231	19	89.8
231	290	7	95.3
290	367	6	100


As
(ppm)
in lake sediments

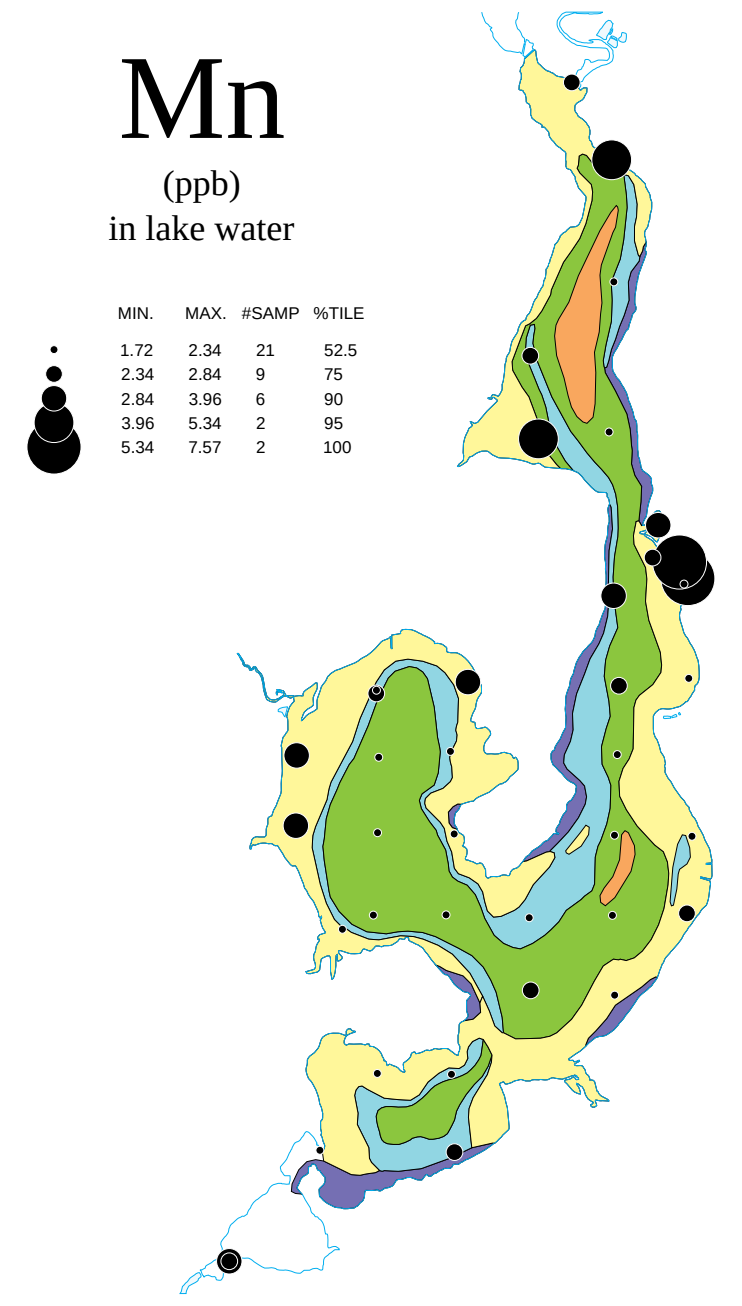
MIN.	MAX.	#SAMP	%TILE
1.6	12.8	65	51.2
12.8	17.9	30	74.8
17.9	22.2	19	89.8
22.2	33	7	95.3
33	89	6	100


SO_4
(mg/l)
in lake water

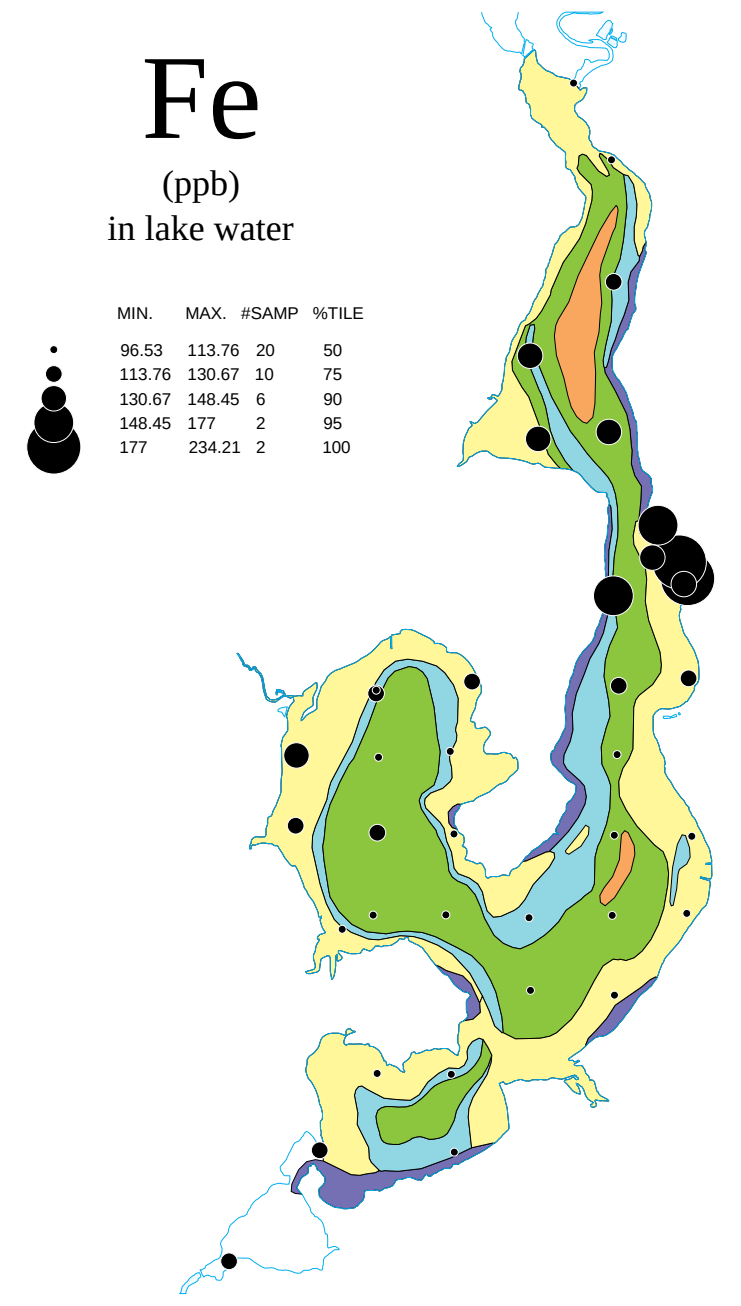
MIN.	MAX.	#SAMP	%TILE
4.35	4.83	23	57.5
4.83	4.93	7	75
4.93	5	6	90
5	5.58	2	95
5.58	6.73	2	100


Al
(ppb)
in lake water

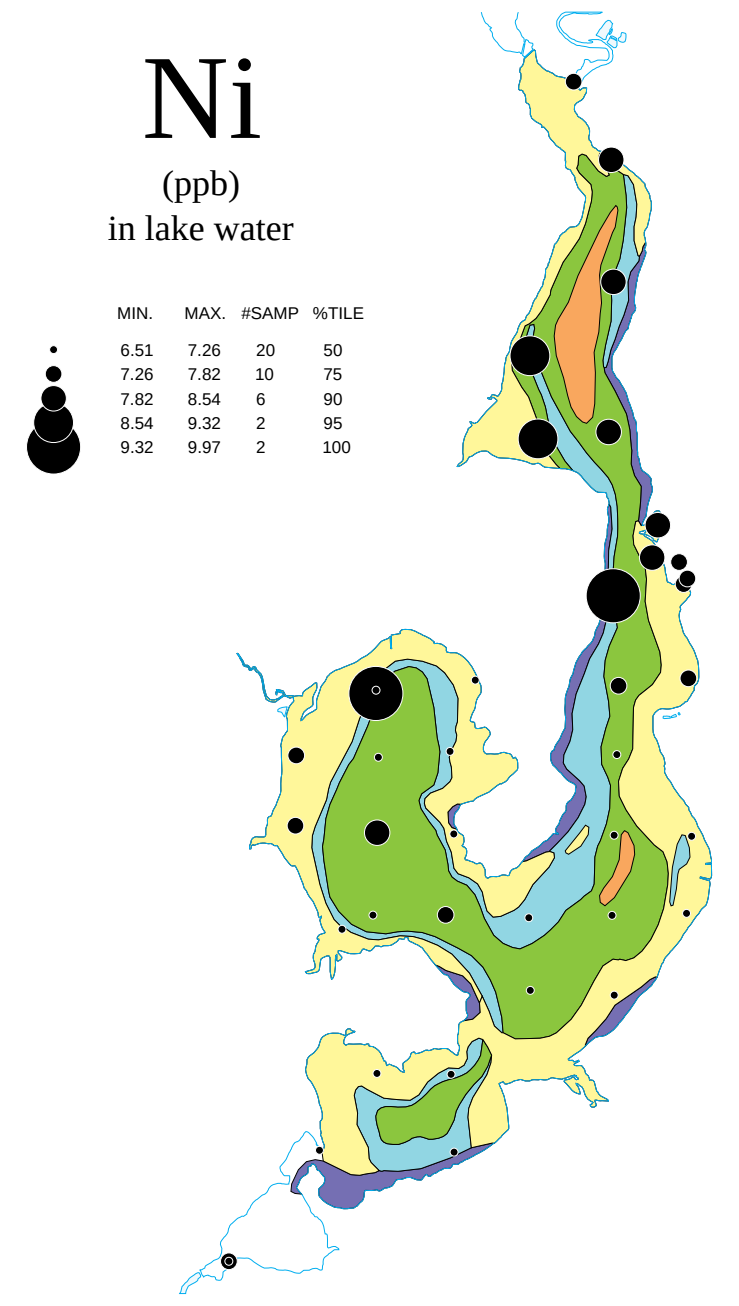
MIN.	MAX.	#SAMP	%TILE
47.66	54.81	20	50
54.81	57.27	10	75
57.27	61.73	7	92.5
61.73	62.07	1	95
62.07	66.64	2	100


Mn
(ppb)
in lake water

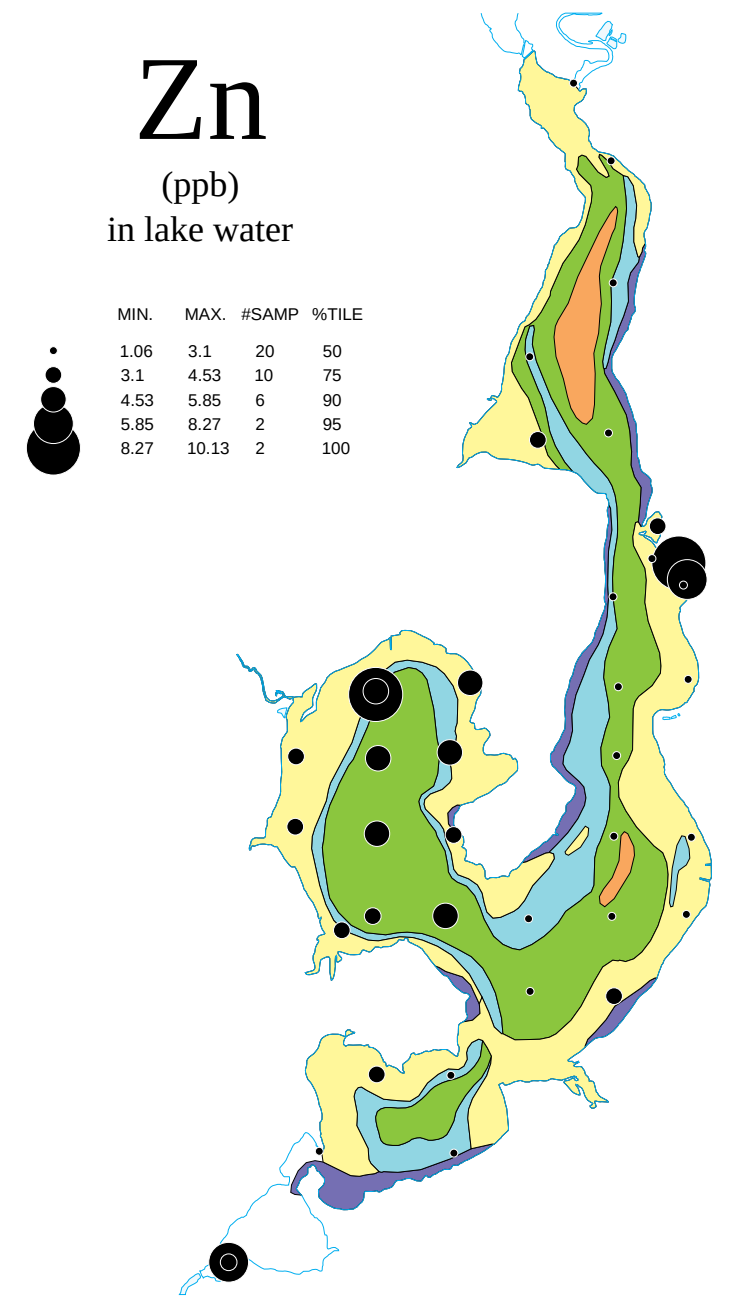
MIN.	MAX.	#SAMP	%TILE
1.72	2.34	21	52.5
2.34	2.84	9	75
2.84	3.96	6	90
3.96	5.34	2	95
5.34	7.57	2	100


Fe
(ppb)
in lake water

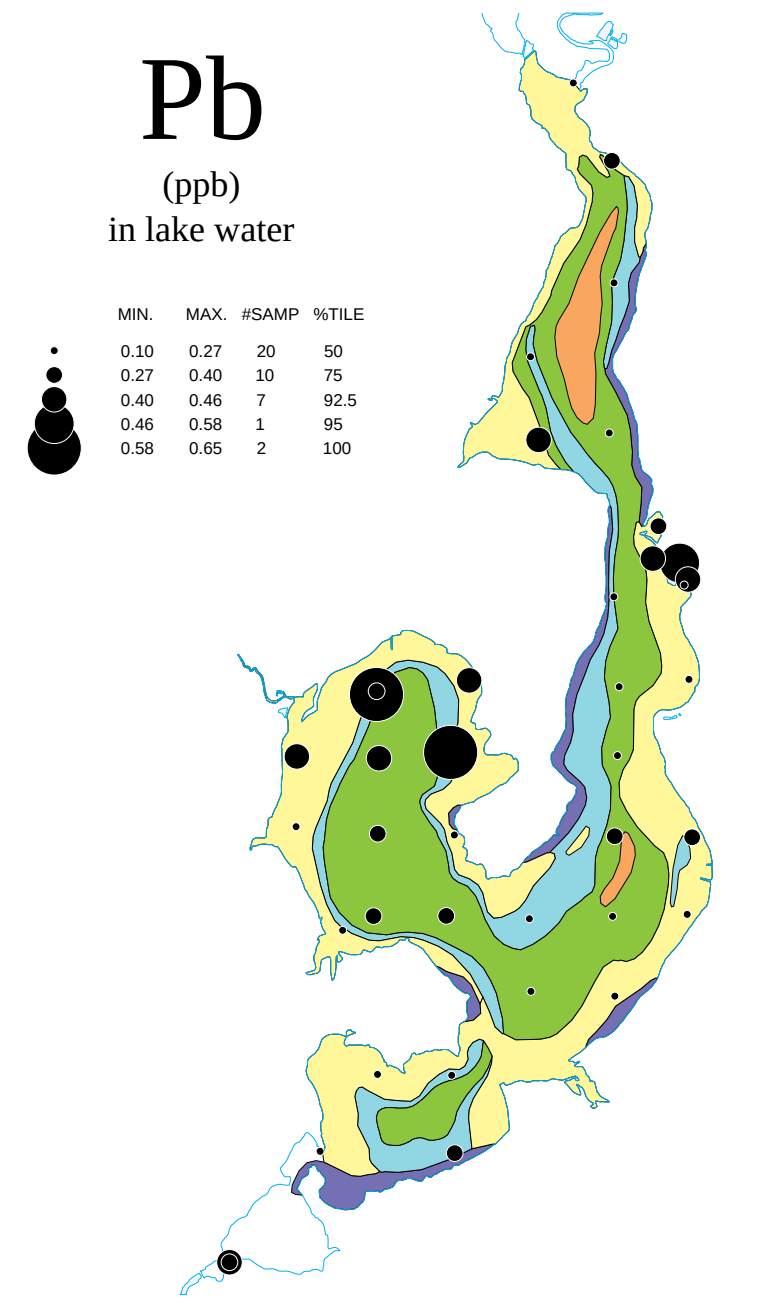
MIN.	MAX.	#SAMP	%TILE
96.53	113.76	20	50
113.76	130.67	10	75
130.67	148.45	6	90
148.45	177	2	95
177	234.21	2	100


Ni
(ppb)
in lake water

MIN.	MAX.	#SAMP	%TILE
6.51	7.26	20	50
7.26	7.82	10	75
7.82	8.54	6	90
8.54	9.32	2	95
9.32	9.97	2	100

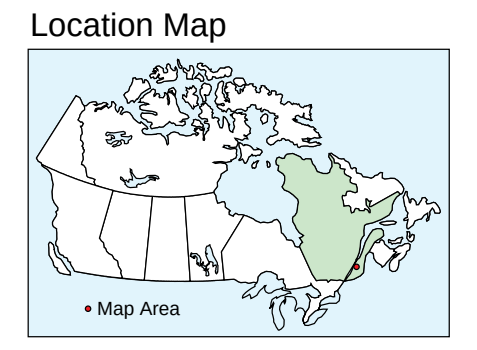

Zn
(ppb)
in lake water

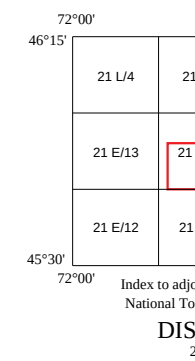
MIN.	MAX.	#SAMP	%TILE
1.06	3.1	20	50
3.1	4.53	10	75
4.53	5.85	6	90
5.85	8.27	2	95
8.27	10.13	2	100


Pb
(ppb)
in lake water

MIN.	MAX.	#SAMP	%TILE
0.10	0.27	20	50
0.27	0.40	10	75
0.40	0.46	7	92.5
0.46	0.58	1	95
0.58	0.65	2	100

Location Map





Index to adjoining Maps of the National Topographic System
DISRAELI
21 E/14

Scale Échelle

Miles 1 0 1 2 3 Milles

Metres 1000 0 1000 2000 3000 4000 Mètres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION
ZONE 19 NAD 1927

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