40. DETAILED GEOCHEMICAL STUDIES, SOUTHEASTERN ONTARIO

Project 760044

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Abstract

Detailed geochemical studies were carried out in 1977 in the Grenville Province of southeastern Ontario to follow up the reconnaissance lake sediment geochemical and airborne radiometric surveys of 1976. Preliminary interpretation of the U data from the detailed geochemical studies indicates that the levels of concentration of U in lake waters and sediments are controlled by a variety of natural processes which on occasion can adversely distort the geochemical distribution patterns of U.

Introduction

As part of the Federal-Provincial Uranium Reconnaissance Program (U.R.P.) (Darnley et al., 1975) regional geochemical and airborne radiometric surveys were carried out in southeastern Ontario during the summer of 1976.

The geochemical surveys covered map sheets 31F and 31C (N1/2) within Ontario (Fig. 40.1) and consisted of the collection of lake sediments at a density of one sample per 13 km^2. The lake sediment samples were anlayzed for Zn, Cu, Pb, Ni, Co, Ag, Mn, As, Mo, Fe, Hg, U and L.O.I. (loss on ignition) and these data were released in the spring of 1977 (Geological Survey of Canada, 1977a, b).

The airborne gamma-ray spectrometry, flown at five km line spacings, covered map sheets 31F and 31C. These data were presented as (1) contour maps of the integral count, the potassium, equivalent uranium and equivalent thorium concentrations, and the eU/eTh, eU/K and eTh/K ratios; and (2) stacked profiles of the seven radiometric parameters plotted for each flight line from each of the two map sheets. These data were also released in the spring of 1977 (Geological Survey of Canada, 1977c, d).

Detailed geochemical studies were carried out in the summer of 1977 over nine areas selected on the basis of the regional geochemical and geophysical data (Fig. 40.1) (Closs and Coker, 1977). Five of the areas are characterized by elevated concentrations of U in lake sediments and generally, complementary airborne radiometric highs (Fig. 40.1, areas 1, 4, 5, 7 and 8, (9); Table 40.1). Discussion will be limited to the detailed geochemical studies carried out in these areas.

Regional Geology

The survey area is typically underlain by a variety of plutonic rocks, including widespread anorthosite, mixed gneisses of igneous and metamorphic origin, and numerous remnants of rocks of superficial origin (i.e. metasediments, amphibolites of unknown origin, and metavolcanics)

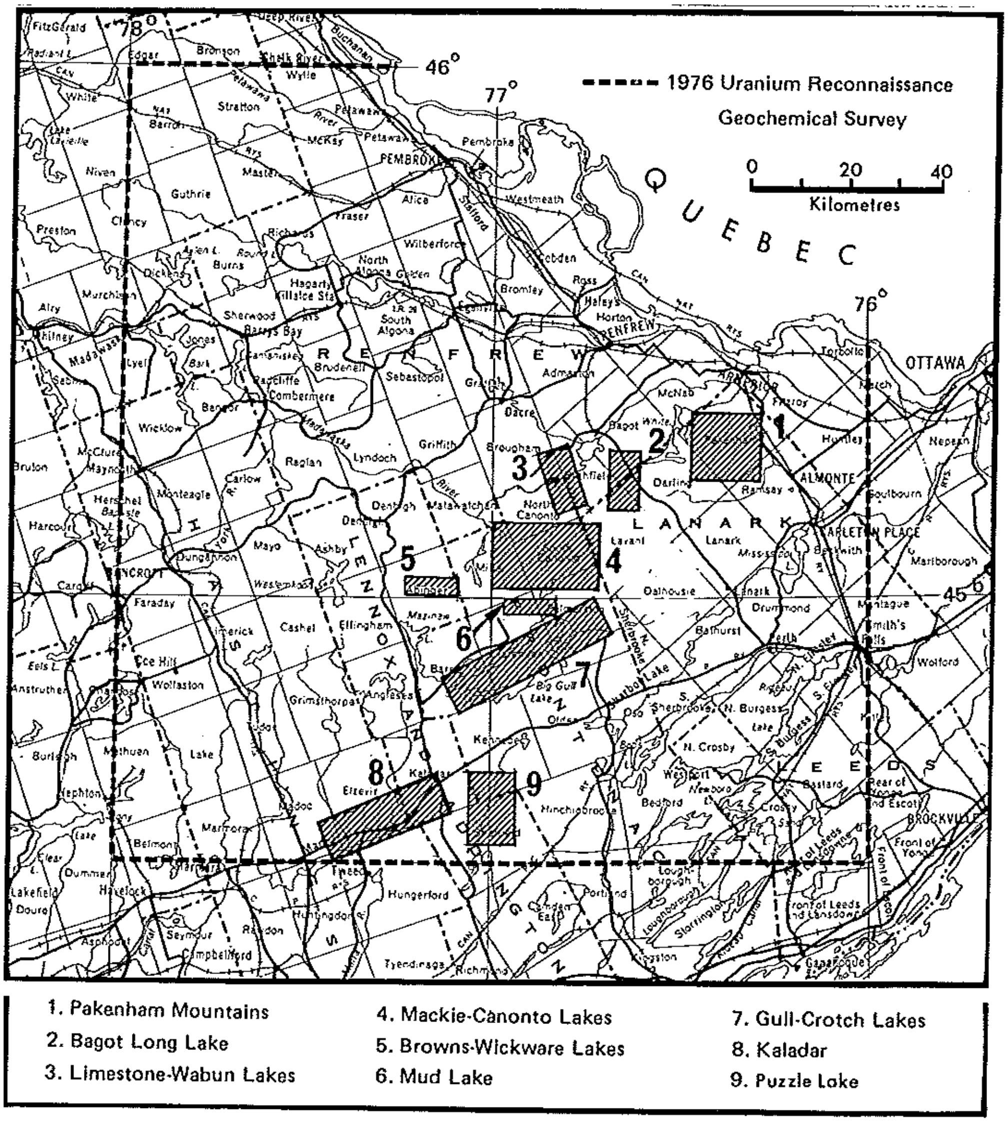

Figure 40.1. Areas of detailed geochemical studies, southeastern Ontario (from Closs and Coker, 1977).

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Table 40.1

Detailed geochemical studies – Uranium, southeastern Ontario

Area (Fig. 40.1)	Name	N.T.S.	Significant Metals	Type of Work performed
1	Pakenham Mts.	31 F 8	U, Hg	2 3 4
4	Mackie-Canonto L.	31 F 2	U	1 3 4
5	Browns-Wickware L.	31 F 3	U	1 3 4
7	Gull-Crotch L.	31 C 14/15	U	1 3 4
8	Kaladar	31 C 11	U	1 3 4
(9)	Puzzle L.	31 C 10/11	Zn(U)	1

1 Detailed lake water and sediment sampling
2 Stream water and sediment sampling
3 Bedrock sampling
4 Ground scintillometer measurements

(Lumbers, 1964). These remnant superficial rocks and mixed gneisses constitute the rocks of the Grenville Province. Although geological mapping has been carried out for many years in the Grenville Province by both the Ontario Department of Mines and the Geological Survey of Canada some regions remain essentially unmapped. Some of the geological mapping related to the areas in which detailed geochemical investigations were undertaken includes: Harding, 1944; Peach, 1958; Liberty, 1963; Hewitt, 1964; Lumbers, 1964; and Hill, 1974.

A large variety of metallic mineral occurrences, some of economic significance, are present. These include: gold, arsenic, iron, nickel, copper, lead, zinc, molybdenum, uranium and rare earth minerals, and some industrially useful rock and nonmetallic minerals described in summary by Lumbers, 1964.

Detailed Geochemical Studies

Sampling techniques and analytical procedures

Lake sediment samples were collected using a Geological Survey sampler from a float-equipped Hughes 500-C turbo-helicopter. Organic-rich sediments (generally brown-thixotropic gels) were collected from the profundal basins of permanent lakes, ponds and swamps. In some instances, intermittent swamps, flooded marshes and beaver-dammed ponds were sampled although the nature of the material obtained (i.e. containing coarse organics – wood, bark, leaves etc.) was not optimum.

Surface lake waters, which were generally clear or brown in colour, were collected directly into polyethylene bottles and acidified (250 μL of HNO_3 per 125 mL of water) on the day of collection. At each sample site measurements of surface water pH, dissolved oxygen content, temperature, and conductivity were made using the Martek Mark V Water Quality Analyser.

Stream waters, collected and acidified as were lake waters, and stream sediments were collected from active streams in the Pakenham Mountains area.

Bedrock samples were collected from the various lithologies present in the area. The average radioactivity over the exposed extent of the outcrop was measured using a McPhar TV-1A scintillometer.

The lake sediment, lake water, stream sediment, stream water and bedrock related field observations were recorded on field data cards, with some modifications, as described by Garrett (1974).

Lake sediment samples were prepared to pass a minus 80-mesh (180 μ) sieve by the staff of Golder Associates, Ottawa. Bedrock samples were ground to approximately 100-mesh (150 4 μ) at the Geological Survey.

The fluorometric method of analysis of the lake and stream water samples for acid-extractable U was based on the method described by Smith and Lynch (1969). These anlayses were performed by A.J. MacLaurin in the laboratories of the Geochemistry Subdivision, Geological Survey of Canada.

The delayed neutron activation method of analysis, by which the lake sediment, stream sediment, and bedrock samples were analyzed for total U, was developed by Atomic Energy of Canda Ltd., Commercial Products Division, and is described in some detail by Boulanger et al. (1975).

Results

Pakenham Mountains (area 1, Figure 40.1) Insufficient lake density for a detailed survey dictated that stream waters and sediments be utilized in this area. In most instances inorganic-clastic sediments and clear waters were obtained, although some sediments did contain minor organics and some waters were yellow-brown (humic rich) in colour. Neither the stream waters ($\bar{x}$ = 0.32 ppb, range = 0.05 to 0.66 ppb; n = 13) nor stream sediments ($\bar{x}$ = 2.3 ppm, range = 1.4 to 4.8 ppm; n = 11) contain significant levels of U. The higher concentrations are generally related to the presence of organics.

Bedrock in the area contains little U (Table 40.2) and although the area has been mapped as a plutonic complex (Hill, 1974) the possibility of being of remnant superficial origin should be considered. The area was primarily of interest geologically and of marginal interest on the basis of the reconnaissance geochemistry. The geochemical data obtained in the detailed study give little indication of any uranium potential.

Mackie – Canonto lakes (area 4, Fig. 40.1) Lake waters are somewhat enriched in U in the east part of this area, as depicted by 34 water samples having a mean U content of 0.45 ppb and range of 0.26 to 1.02 ppb. Lake sediments, however, are enriched in the west and central parts of the area, as indicated by 25 sediment samples with an overall mean U content of 38.4 ppm and range of 26.4 to 72.1 ppm. This variation reflects the measured chemical differences existing in the lake waters within this area. Lakes in the east, with U enriched waters, generally have more alkaline waters with pH > 7.0 and conductivities > 100 μmhos compared to the neutral to acid waters in lakes in the west, with U enriched sediments, and with pH < 7.0 and conductivities < 50 μmhos.

Pegmatites in the area were found to be generally conformable with their host rock, frequently tourmaline bearing and somewhat enhanced radioactively, although only slightly enriched in U (see Table 40.2). The high degree of bedrock exposure and the trace amounts of U available in the pegmatites and gneisses in this area (Table 40.2) most probably account for the levels of U that occur in the waters and sediments of lakes in this area.

Browns – Wickware lakes (area 5, Fig. 40.1) Elevated concentrations of U exist in lake sediments in the south half of this area. There is no U response in lake waters. The main area of elevated U in lake sediments consists of three grouped samples in the west-central part of the area containing 30.2, 30.0 and 52.1 ppm U. Although exposed bedrock is plentiful, this area has not been geologically mapped to date. The bedrock lithologies encountered consisted of biotite and/or amphibole gneisses, quartzo-feldspathic rocks, and simple pegmatites (quartz, potassium feldspar, ± biotite). Only minor amounts of U were detected in the bedrock of this area (Table 40.2). The geochemical response in the lake sediments is likely due to a mass bedrock effect of little economic significance.

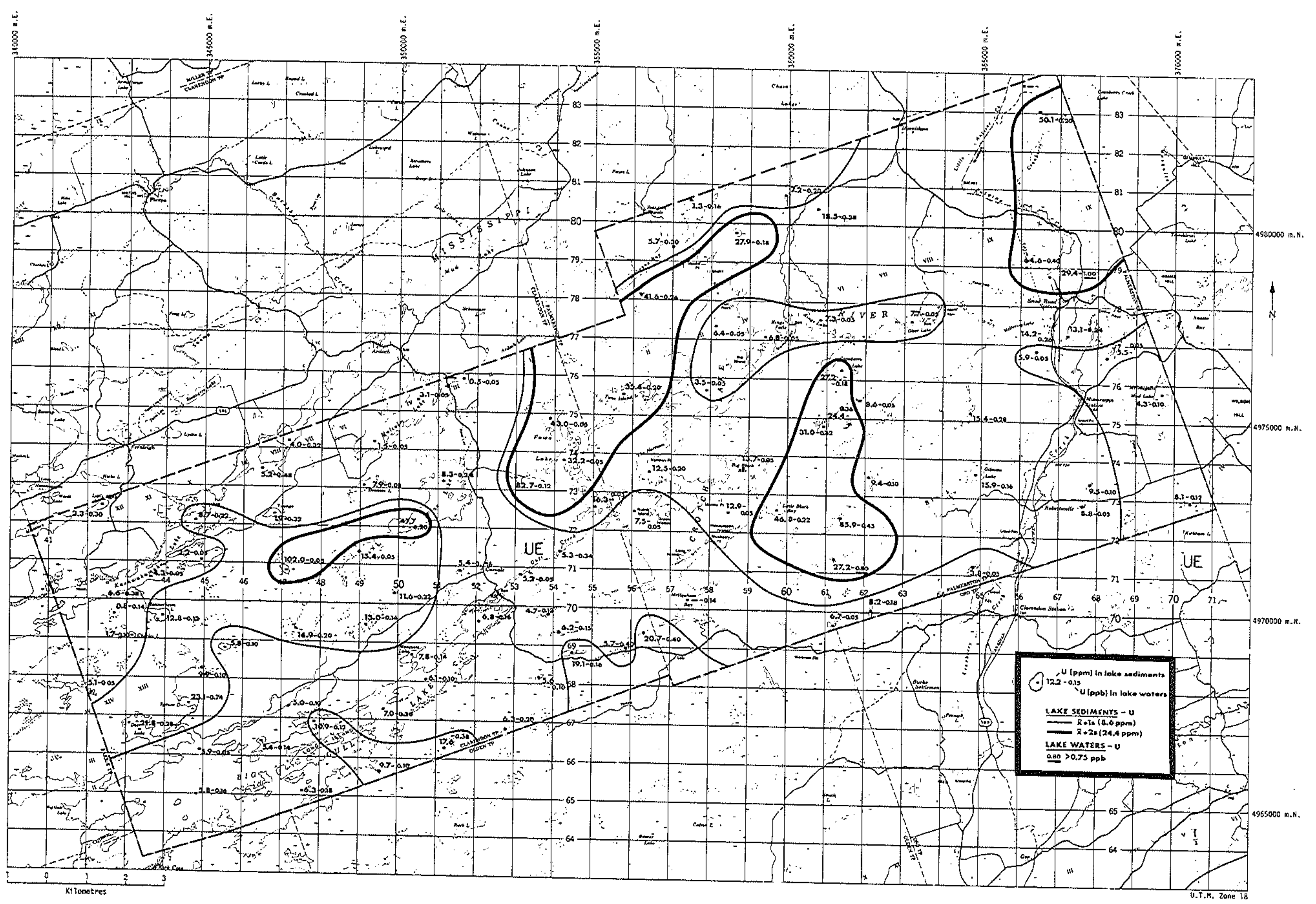

Figure 40.2. Distribution of uranium in lake sediments and lake waters, Gull-Crotch lakes (31C/14, 15) area, southeastern Ontario.

Gull – Crotch lakes (area 7, Fig. 40.1) Presentation of the distribution patterns of U in lake sediments from within this detailed study area, as well as within the Kaladar area, is based on the log-normalized distribution of U in the reconnaissance lake sediment samples (i.e. geometric $\bar{x}$ = 3.0 ppm, $\log_{10} \sigma = 0.482$; therefore $\bar{x}+1\sigma = 8.6$ and $\bar{x}+2\sigma = 24.4$ (number of reconnaissance samples = 1254)). As no reconnaissance data were available for U in lake waters a threshold value of 0.75 ppb was chosen on the basis of previous work carried out in the Grenville province (Renfrew area, 31/F/7) by Coker and Jonasson (1977).

The distributions of U in the lake waters and sediments within this area are illustrated in Figure 40.2. There is general coincidence between the distribution patterns of U in both sample media. The large area of enhanced U in lake sediments, and to a lesser extent in lake waters, southeast of Crotch Lake is a reflection of U enriched mineralized pegmatites in that locality. Other areas of similar enrichment of U in lake sediments and/or waters occur coincident with the grey granite-granodioritic bedrock unit. Pegmatites sampled within this unit show enrichment in U (Table 40.2). There are at least two, and possibly three, types of pegmatites, all mineralogically simple (quartz, potassium feldspar, ± biotite, with traces of tourmaline), of either the conformable or unconformable type within this area. The most significant enhancement of U in lake waters and/or sediments generally occurs in conjunction with the grey granite – granodioritic unit in this area, and pegmatites (conformable?) within this unit show the highest enrichment in U.

Kaladar (area 8, Fig. 40.1) Uranium is enriched in the waters and sediments of lakes within a band trending from the northeast to the southwest of the Kaladar area (Fig. 40.3). This band of U enrichment roughly corresponds to the area mapped as grey granite – granodiorite containing some slightly U-enriched simple pegmatites (Table 40.2). Exposed bedrock constitutes approximately 70 to 75 per cent of this band. Intervening spaces between bedrock outcrops are occupied by intermittent swamps, marshes, streams, and ponds, as well as some true lakes, the drainage of which is largely controlled by the action of beavers. These waters are invariably acid (pH < 6.0) and organic-rich. The large volume of exposed bedrock, containing minor U (Table 40.2), subjected to these organic-rich acid waters, results in enhancement of the natural leaching processes and probably causes the extreme levels of enrichment of U in both the waters and sediments sampled within this band.

Puzzle Lake (area (9), Fig. 40.1) On the basis of the reconnaissance geochemical data this area was primarily of interest for Zn, and of only secondary interest for U.

Table 40.2

Distribution of uranium in bedrock samples, southeastern Ontario

Rock type \ Area	Pakenham Mt.	Mackie-Canonto Lakes	Browns-Wickware Lakes	Gull-Crotch Lakes	Kaladar
Amphibolite gneiss		0.9 (0.5-1.4)-(2)			1.9 (0.3-4.0)-(6)
Amphibolite				1.7 (0.5-3.7)-(4)	
Basic metavolcanic					0.8 (0.4-1.3)-(2)
Granodioritic rock	1.2			2.9 (1.3-5.5)-(8)	1.4 (1.0-1.9)-(5)
Granitic gneiss		1.8 (0.3-4.0)-(5)	3.1 (1.1-5.3)-(11)	2.4 (1.7-3.1)-(4)	3.5 (2.2-4.9)-(8)
Granitic rock	1.9 (0.8-3.1)-(8)				
Intermediate metavolcanics				1.0	
Marble		0.8 (0.1-2.1)-(6)			1.6 (0.3-4.2)-(5)
Pegmatite		6.0 (0.5-18.8)-(8)	2.1	26.7 (2.1-121.0)-(11)	15.5 (9.2-29.0)-(9)
Paragneiss		2.8 (0.6-4.9)-(2)			3.0 (2.6-3.4)-(2)
Syenitic rock				2.0	

Arithmetic mean
0.4
(0.2-0.8) - (10) – number of samples
Range (minimum - maximum)

However, the detailed geochemical studies indicate significant enrichment of U in lake waters (1.20 and 0.98 ppb) and sediments (26.3, 153.0, 85.5, and 32.7 ppm) associated with Mo occurrences in the southeastern part of the area. Perhaps these Mo occurrences should be examined for their U potential as has been suggested in other parts of the Grenville (Coker and Jonasson, 1977). In addition an isolated lake sediment sample containing 52.4 ppm U taken from a lake at the Precambrian-Paleozoic contact is perhaps indicative that this contact should be more closely examined for possible depositional environments for U.

Discussion and Conclusions

Interpretation of the distribution of U in lake waters and sediments within the detailed study areas, as presented, should be viewed as only preliminary in nature. Interelement relationships can significantly clarify certain limnologic, chemical and geological phenomena and add greatly to the final interpretation. The detailed geochemical studies of areas (2, 3, 6 and 9 – Fig. 40.1) characterized by elevated base metal concentrations will also be outlined later.

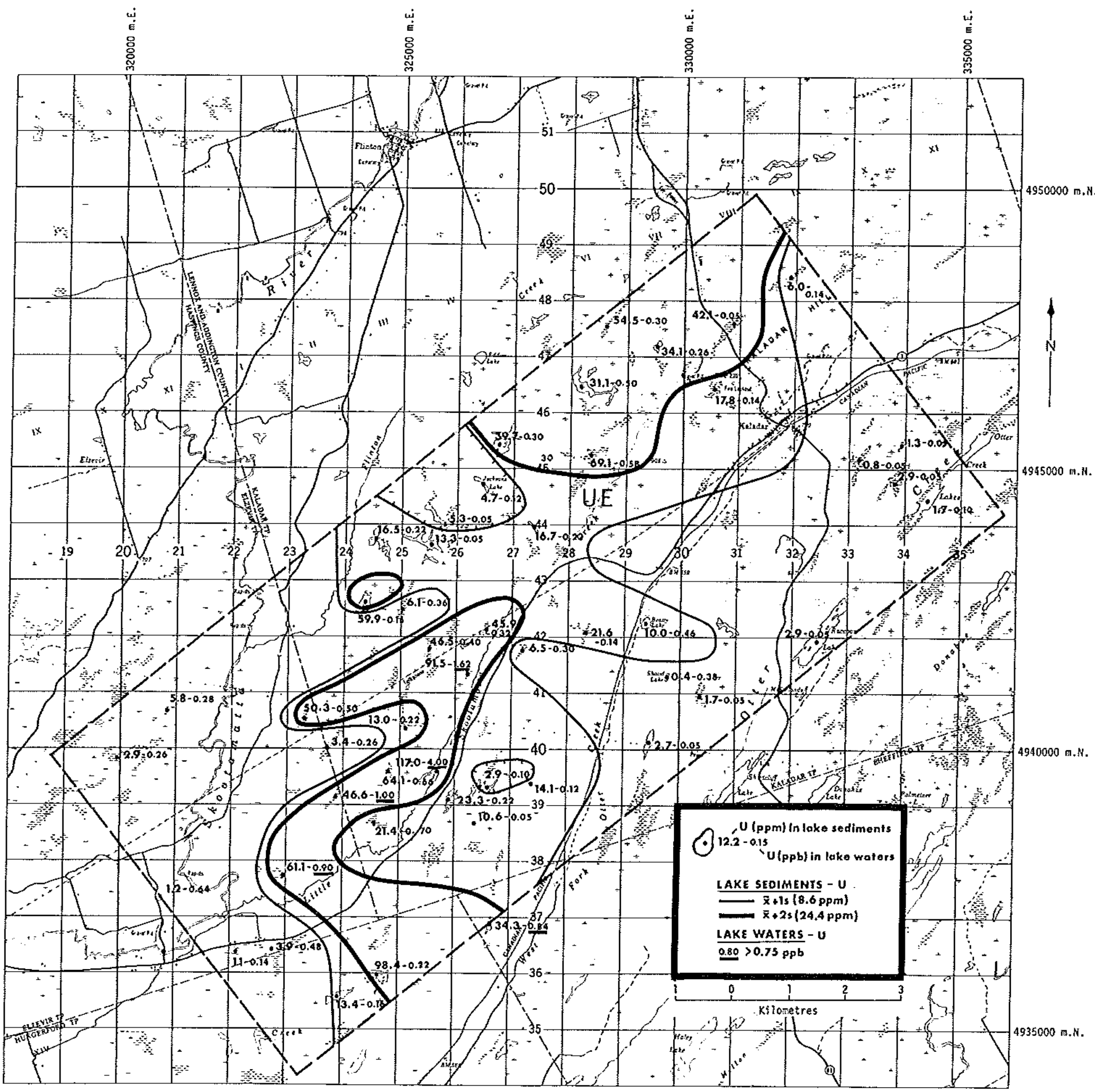

Figure 40.3. Distribution of uranium in lake sediments and lake waters, Kaladar (31C/11) area, southeastern Ontario.

In some cases, such as in the Mackie-Canonto lakes, Browns-Wickware lakes, and, possibly, the Pakenham Mountains areas the levels of U that occur in the waters and sediments are a reflection of a mass bedrock effect probably enhanced by organic activity. Lack of correspondence between the distribution patterns of U in lake waters and sediments can result from variations in the chemical conditions as indicated by variations in pH and alkalinity in the Mackie-Canonto lakes area.

In the Gull-Crotch lakes area elevated levels of U in lake waters and sediments are a reflection of mineralized pegmatites. Elevated levels of U in the lake waters and sediments of the Puzzle Lake area are associated with known Mo occurrences.

Unusual surficial chemical conditions, very acid and extremely organic-rich waters, have probably resulted in some enhancement of natural leaching processes causing relatively higher concentrations of U than would normally be expected to occur in both the waters and sediments within the drainage courses of the Kaladar area.

In general lake water and sediment geochemistry can be of value in the search for U mineralization within the Grenville Province. Caution, however, must be exercised in the interpretation of such geochemical data as the surficial chemistry within the Grenville Province is complex and can greatly distort the geochemical distribution patterns produced.

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