TRACE ELEMENTS IN VEGETATION AND SOILS OVER THE KEY LAKE URANIUM-NICKEL OREBODY NORTHERN SASKATCHEWAN, CANADA

N. C. Walker
Department of Mineral Resources
Regina, Saskatchewan (Canada)

ABSTRACT

Plant and soil samples collected over the Key Lake uranium-nickel orebody were analysed for U, Ni, Co, Cu, Pb, Zn, Cd, V, Mo, Fe, Mn, and Ca. The plants sampled were jack pine *(Pinus banksiana)*, black spruce *(Picea mariana)*, blueberry *(Vaccinium myrtilloides)* and labrador tea *(Ledum groenlandicum)*; the soils were A_0, A_1 and B horizons. Conifer samples were split into twigs, needles, cones, bark and wood, and shrubs into stems, leaves and roots.

Concentrations of uranium in plant and organic soil ash are generally greater than those in the B soil horizon. Cobalt in roots and Pb in leaves of blueberry show positive correlation with the trace of the ore zone. Uranium correlates with Pb and Co in the ash of conifer twigs growing over an area of glacially transported, buried radioactive boulders 4 km from the ore zone. Uranium profiles (from three lines spaced 50 m apart) for needles, twigs and wood of jack pine, stems, leaves and roots of blueberry and also for A_0 (forest litter) and A_1 (humus) showed, in two or more of these media, anomalies over the trace of the Deilmann ore zone, even where the ore is overlain by 75m of overburden. Over the ore-body most plant parts have anomalous uranium concentrations. Preliminary investigations indicate that the trunk wood may be the most useful sampling medium. Uranium is concentrated most efficiently by ashing trunk wood, because wood has a higher loss on ignition than other organic material. Wood is the component most likely to survive the frequent burns which in many localities limit the availability of plant and organic soil material. Samples can be collected in winter and summer permitting a rapid preliminary evaluation of an area.

INTRODUCTION

The major objective of this study was to determine if the uranium content of plants would aid uranium mineral exploration in glaciated boreal forest regions of Saskatchewan. A secondary objective was to discover whether or not other metals associated with the orebody could also be used as exploration guides.

Published data on this method of uranium exploration in Canada are limited. Wolfe (1971) suggests that uranium may show moderate to high anomaly contrast in the common deep-rooted tree species of the Canadian Shield. Brooks (1972) and Malyuga (1964) give reviews of the principles of and case histories in biogeochemistry as applied to exploration for various metalliferous deposits. Brooks (1973) and Timperley *et al.* (1970) conclude that the biogeochemical method is less effective for elements which are essential in plant nutrition, in particular for copper and zinc. Non-essential elements such as nickel and uranium tend to give much more satisfactory results. A review of the recent literature on biogeochemistry is given by Brooks (1977, in prep.).

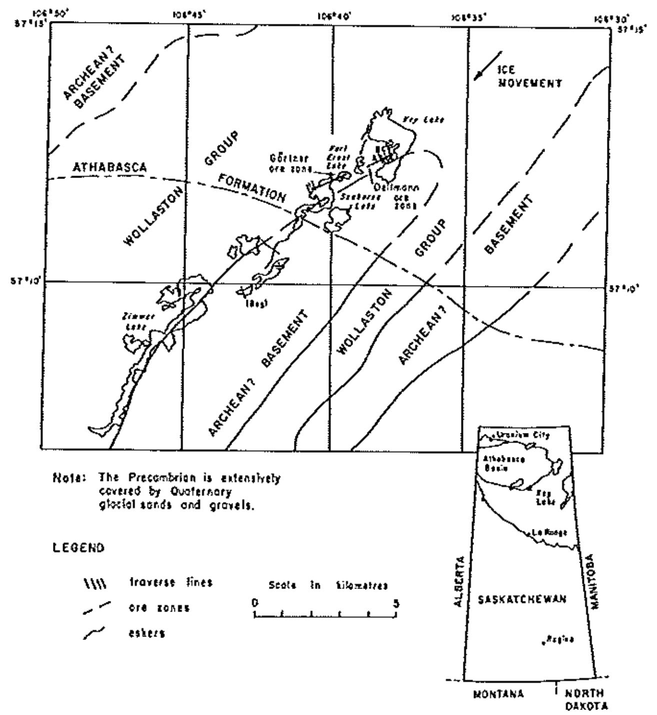

FIGURE 1. Location and generalized geology of the Key Lake area. Geology after Ray (1977).

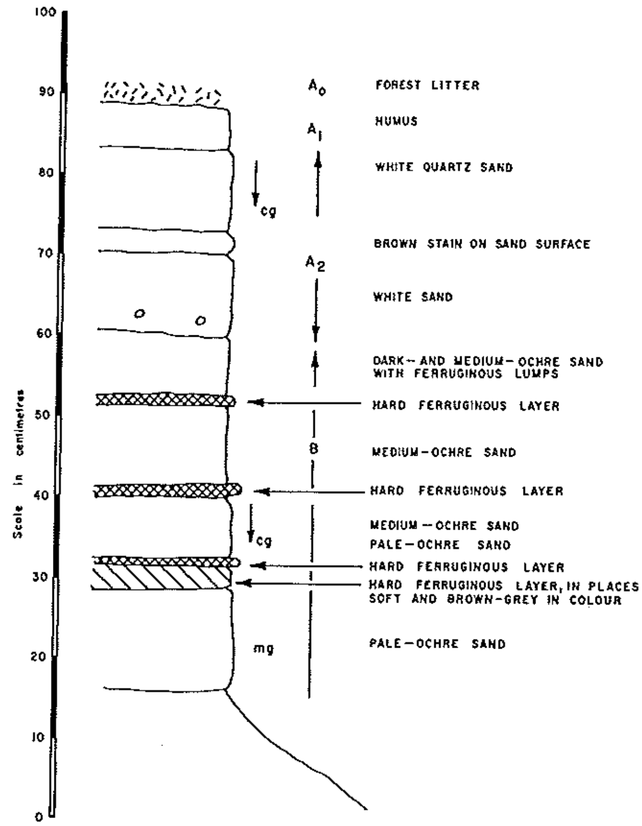

FIGURE 2. Soil and weathering horizons, east side Seahorse Lake, 4 m from shore, 3 m above lake level, June 1976.

AREA OF STUDY

The Key Lake uranium-nickel orebody located 230 km north of La Ronge was selected for the survey (Figure 1).

Uranium in lake water and in radioactive boulders were early clues to the Key Lake deposit. Various exploration techniques including lake water and sediment geochemistry (Tan, 1976), radon emanometry, soil geochemistry, TRACK ETCH surveys, electromagnetic surveys, scintillometry and diamond drilling were used to locate the ore zones. Apart from a few tree top samples in which uranium was not detected (B. Tan pers. comm., 1976) no biogeochemical sampling was done.

PHYSIOGRAPHY AND SOILS

The area is part of a pitted outwash plain trending northeast-southwest at an elevation of approximately 535 m above sea level with linear till ridges or drumlins, eskers and numerous lakes. The direction of ice movement and glaciofluvial flow was toward the southwest.

Subsurface drainage flows from Seahorse Lake northeast along a line of lakes to Key Lake. Surficial deposits are mostly glaciofluvial sand and sandy gravel. Sandy till, with a low clay content, is exposed in till ridges and drumlins and presumably underlies much of the outwash deposits.

Organic soils (forest litter (A_0) and undecomposed humus (A_1)) are generally thin (3–5 cm) or nonexistent. Figure 2 shows a soil and weathering profile typical of the area, comprising A_0, A_1, A_2 and B horizons.

GEOLOGY

The area of study lies within the Wollaston lithostructural domain. The geological succession as described by Ray (1977) at Key Lake from oldest to youngest is: Granitoid basement (presumed Archean); Aphebian metasediments comprising the Wollaston Group; unmetamorphosed Helikian sandstone (Athabasca Formation). The rocks of the area are poorly exposed and extensively covered by Pleistocene deposits (Figure 1).

The uranium-nickel orebodies occur in highly altered biotite gneiss and graphitic schist of the lower unit of the Wollaston Group, as well as in orthoquartzite of the Athabasca Formation which un-

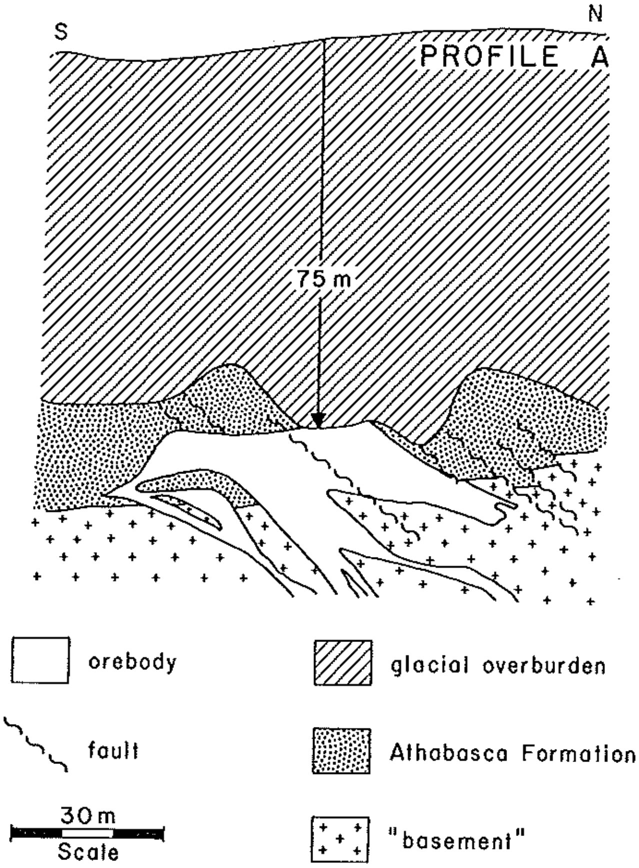

FIGURE 3. Cross section Deilmann orebody, adapted from Dahlkamp and Tan (1977).

conformably overlies the Wollaston Group. The ore appears localised near the unconformity along part of a northeast-trending fault zone which dips between 50° and 70° to the northwest. This fault conforms to the footwall of the major graphitic horizon in the Aphebian strata and displaces the unconformity between the Aphebian metasediments and the Helikian sandstone. Two orebodies have been recognized, the Gärtner to the southwest and the Deilmann (Figure 3) to the northeast, the two exceeding a total length of 2800 m.

Grades of up to 45% U_3O_8 and 45% Ni have been indicated by diamond drilling in the Gärtner orebody from 50 m to 80 m below surface, whereas the Deilmann orebody, at depths of 65 m to 140 m, grades up to 59% U_3O_8 and 30% Ni. The width of the Gärtner orebody averages 50 m and that of the Deilmann ranges between 10 and 100 m. The ore mineralogy, described by Watkinson *et al.* (1975), is dominated by pitchblende, millerite and gersdorffite.

Glacial streams have separated the deposits, which may once have been continuous over a length of 3600 m, and have transported mineralized boulders up to 6.5 km to the southwest of the ore zone. Mineralized boulders also occur within the overburden above parts of the Gärtner orebody.

SAMPLING AND ANALYTICAL TECHNIQUES

In June 1976, samples were collected along three lines that crossed the Deilmann orebody. The lines were 250, 280 and 320 m long and spaced 50 m apart. The sampling interval on each line varied from 2 m to 50 m with greatest sampling density over the projected trace of the mineralization. Line A corresponds to the geological section of Figure 3. Line D (Figure 1), 380 m to the east of line A, was sampled at intervals of 50–70 m, along a length of 800 m.

An esker, which extends southwesterly from the Gärtner zone, includes radioactive sandstone boulders removed from the ore zone. This esker was sampled approximately 4 km southwest of the ore zone.

SAMPLE COLLECTION

Vegetation

All dominant plant species were sampled, with greatest attention given to *Pinus banksiana* (jack pine), Picea mariana (black spruce), *Ledum groenlandicum* (labrador tea), and *Vaccinium myrtilloides* (blueberry). The plant parts sampled were twigs, needles, wood, bark, cones and roots of the trees; and stems, leaves and roots of the shrubs (Table 1).

The most recent 20 cm of branch growth (twigs and needles) were collected at heights between 2.5 to 3.0 m. Wood and bark were blazed from the trunk at 1.25 m above ground and cones were collected from tree tops. Sufficient material was collected to provide 1g of ashed sample. Between 60g and 350g of plant material was required, depending upon plant part (see ash content column, Table 2).

Soils

Samples from each of 3 different soil horizons (Figure 2), forest litter (A_0), humus (A_1), and B horizon, were taken at each vegetation sample site within a radius of 25–45 cm of the tree sampled.

SAMPLE PREPARATION

The tree samples were separated into needles, twigs, cones, bark, wood, flowers (male cones) and roots, and the shrubs separated into leaves, stems and

TABLE 1

NUMBER OF SAMPLES BY PLANT TYPE, PLANT PART, AND SOIL HORIZON. ALL SAMPLES ANALYZED FOR U: NUMBERS IN PARENTHESES INDICATE THE NUMBER OF SAMPLES SUBSEQUENTLY ANALYZED FOR OTHER TRACE METALS

Trees	Needle	Twig	Old Twig	Cone	Bark	Wood	Old Needle	Flower	Totals
Jack Pine	63 (33)	87 (51)	45 (21)	13 (6)	23 (10)	22 (10)	3	7	263 (131)
Spruce	8 (8)	9 (8)	8 (6)		1 (1)	1 (1)			27 (24)
Shrubs		**Leaf**	**Stem**	**Old Stem**	**Root**	**Seed**			
Labrador Tea		8 (8)	9 (9)	5 (4)	5 (2)	3 (3)			30 (26)
Blueberry		23 (23)	18 (17)	1 (1)	14 (12)				56 (53)
Soils		A_0		A_1		B			
		109 (45)		110 (54)		105 (46)			324 (145)

roots. They were then ground, oven dried at 120°C, and ashed at 500°C. Soils were dried, ashed, and the A_1 and B horizons sieved to minus 80-mesh.

SAMPLE ANALYSIS

Samples were analysed for uranium, nickel, cobalt, copper, lead, zinc, cadmium, vanadium, molybdenum, iron, manganese and calcium. Neutron activation analysis (NAA) was chosen for the U, while atomic absorption spectrophotometry was used to determine the other eleven elements on the same ash sample after the NAA.

RESULTS

URANIUM IN VEGETATION

Uranium is found in the ash of all parts of jack pine and spruce sampled with median concentrations ranging from 0.6 to 5.5 ppm (Table 2). The variations in the amount of ash produced from different parts of the plant affects the relative order of the U content. On calculating the median U contents back to a dry weight of plant the decreasing order is now flower, twig, old twig, bark, wood, needle then cone. It appears that flowers (although only a small population) concentrate U to the greatest degree. From a practical point of view however, wood or twigs are easier to collect and because the U is more concentrated by the ashing of wood, than by ashing of twigs, wood appears to be the most appropriate sample medium.

Uranium detectable in the ash of blueberry and labrador tea (Table 3) varies from one part of the plant to another. The maximum values shown for each species relate to their similar sites on the radioactive boulder area and demonstrate the ability of these shrubs to concentrate uranium.

Plots of uranium in vegetation collected along lines crossing the Deilmann ore zone reveal anomalies over the trace of the zone. Two of the profiles (A and B) are illustrated in Figures 4 and 5.

The anomaly to background ratio for both twigs and needles on profiles A and B is about 2.5 to 1 and the values for twig ash are higher than those for needle ash. The high value for twigs collected from the lakeshore on profile B is possibly a reflection of a) the subjacent Archean/Aphebian unconformity (Ray,

TABLE 2

URANIUM CONTENT OF JACK PINE PARTS, FROM KEY LAKE AND BOULDER AREA

Part	No. of Samples	U(ppm) in ashed material					Median Ash content (%)	Median U in dry plant (ppm)
		Min.	Max.	Mean	Std. dev.	Median		
Wood	(23)	0.8	41.2	7.1	8.1	5.5	0.3	0.0165
Flower	(6)	2.3	18.0	6.4	5.4	3.4	1.0	0.0340
Twig	(94)	0.1	162.0	6.5	21.0	1.9	1.7	0.0323
Cone	(13)	0.3	8.8	2.5	2.2	1.8	0.3	0.0054
Old Twig	(66)	0.1	63.0	4.2	9.3	1.6	1.3	0.0208
Bark	(24)	0.5	11.5	1.7	2.3	1.0	1.8	0.0180
Needle	(65)	0.1	135.0	5.6	22.0	0.6	2.6	0.0156

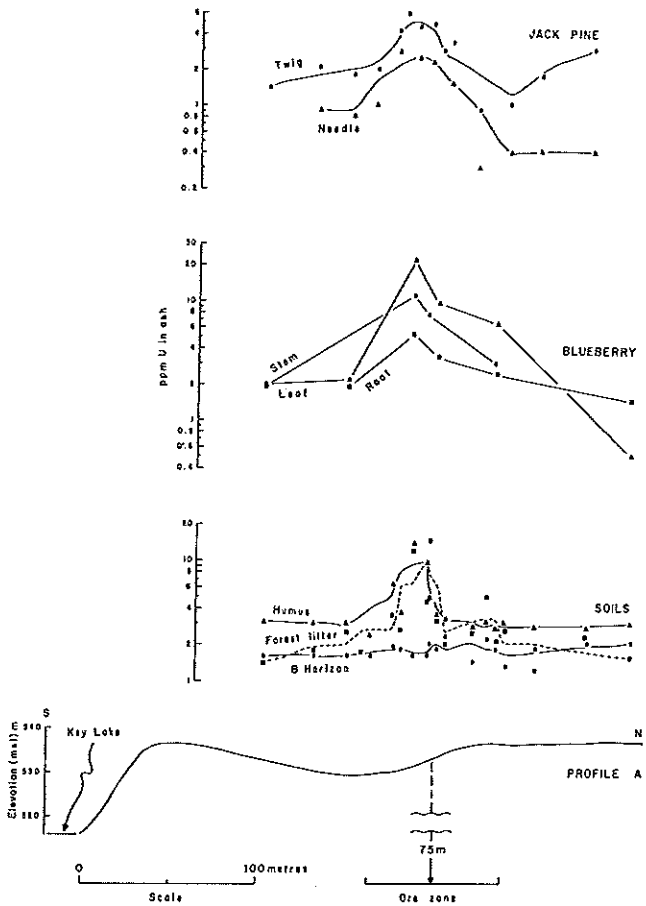

FIGURE 4. Plot of uranium in ashed jack pine, blueberry and soils; profile A, Deilmann ore zone; values in ppm. Jack pine and soil plots smoothed by moving average technique.

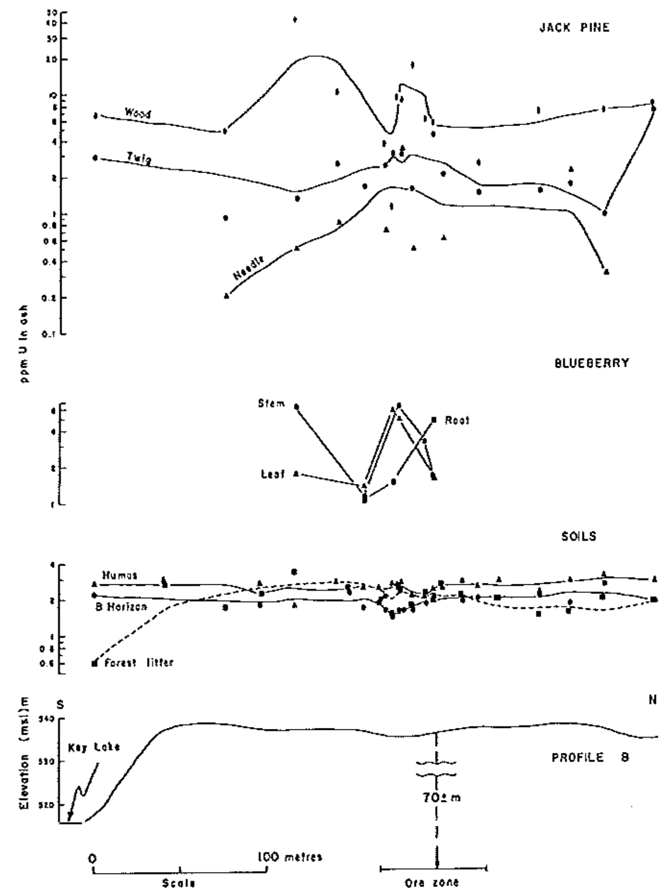

FIGURE 5. Plot of uranium in ashed jack pine, blueberry and soils; profile B, Deilmann ore zone; values in ppm. Jack pine and soil parts smoothed by moving average technique.

1977) or b) proximity to uraniferous groundwater discharge at the base of the slope. The reason for the high twig value to the north (on profile B) is not known; it may reflect the presence of a buried radioactive boulder.

The plot of uranium in trunk wood ash has an anomaly to background ratio of 6 to 1, i.e. higher than either the twigs or the needles, and the smoothed profile is distinguished by twin peaks flanking a depression over the trace of the ore zone. The form of the peak and its displacement relative to the ore zone may be explained by the electrochemical dispersion models of Govett (1973) and others.

URANIUM IN SOILS

Uranium was detected in the three soil horizons sampled (Tables 3 and 4). The ashed organic soils, A_0 and A_1 generally contained more uranium than the ignited B horizon soil. Soil above and surrounding buried radioactive boulders is higher in uranium than soil in the Key Lake area.

Plots of uranium in the soils of profile A (Figure 4) show peaks in the A_0 and A_1 horizons but a corresponding depression in the B horizon. This depression is similar to that in the plot for the wood. Moreover the peaks displayed in the plots for the organic soils in profile A are not reflected by profile B only 50 to 120 m away, in which little contrast is seen between the three soil plots.

Uranium in trees is generally independent of uranium in B horizon soil and is related to uranium in the B horizon only in the area of radioactive boulders. The contribution of uranium from the vegetation to the organic soils is obvious and is part of the cycle of uranium distribution in the area.

TRACE ELEMENTS

Tables 3 and 4 present a summary of results of analyses for Ni, Co, Cu, Pb, Zn, Cd, V, Mo, Fe, Mn and Ca with corresponding U values on selected samples. Since there was no significant difference in trace

TABLE 3

TRACE ELEMENT STATISTICS, VEGETATION AND SOILS, FROM KEY LAKE AREA. COLUMN "n" IS THE NUMBER OF SAMPLES; THE NUMBERS IN PARENTHESES REFER TO SPRUCE

Species	n	U ppm Min.	Max.	Mean	S.D.	Med.	Ni ppm Min.	Max.	Mean	S.D.	Med.	Co ppm Min.	Max.
Jack Pine or spruce													
Needle	18 (2)	0.1	9.1	1.4	2.0	0.6	36	148	61	26	50	12	26
Twig	34 (2)	0.5	8.5	2.2	1.6	1.8	43	162	84	26	73	14	34
Bark	7 (1)	0.7	11.5	3.2	3.2	1.3	34	68	49	13	46	18	32
Wood	9 (1)	2.5	41.2	9.5	10.8	6.8	42	84	58	14	50	10	24
Cone	6	0.6	4.1	2.0	1.4	1.2	136	460	314	110	280	9	23
Blueberry													
Leaf	20	0.5	32.4	5.7	9.3	1.2	28	690	187	160	120	7	25
Stem	17	0.6	14.7	5.1	5.1	2.9	30	102	64	22	56	7	25
Root	12	0.5	5.2	2.0	1.4	1.4	32	190	79	40	60	8	30
Labrador tea													
Leaf	8	0.7	47.9	7.7	15.3	1.0	38	115	74	28	65	14	20
Stem	9	0.7	71.6	9.9	21.9	2.4	26	143	65	36	59	15	32
Old Stem	5	0.5	8.2	2.5	2.9	1.5	48	100	78	21	83	13	23
Seed	3	0.5	4.1	2.3	1.5	2.4	10	70	38	25	34	15	20
Root	2	0.8	3.1	2.0			17	100	58			12	17
Soil Horizon													
A_0	39	0.6	12.3	3.0	2.2	2.4	16	100	54	15	54	5	99
A_1	47	1.6	14.2	3.2	2.1	2.8	8	64	34	12	36	2	14
B	41	0.9	7.6	2.0	1.1	1.8	1	43	8	7	7	1	12

Species	n	Cd ppm Min.	Max.	Mean	S.D.	Med.	V ppm Min.	Max.	Mean	S.D.	Med.	Mo ppm Min.	Max.
Jack Pine or spruce													
Needle	18 (2)	4.0	15.2	9.6	3.0	9.5	2	22	14	4	14	1	12
Twig	34 (2)	1.3	40.5	12.1	9.3	8.0	16	82	37	16	30	1	20
Bark	7 (1)	5.9	35.0	21.0	8.9	21.1	6	24	15	5	16	1	12
Wood	9 (1)	6.8	24.0	11.4	5.1	8.6	2	12	5	4	4	1	6
Cone	6	5.5	17.3	11.0	4.6	9.1	6	20	13	4	12	1	8
Blueberry													
Leaf	20	0.4	5.8	3.3	1.4	3.0	4	22	9	4	8	1	50
Stem	17	2.0	10.0	6.7	1.9	7.1	5	26	15	5	14	1	10
Root	12	2.7	12.6	8.2	3.0	8.0	5	66	19	16	14	1	12
Labrador tea													
Leaf	8	1.3	7.4	4.6	1.8	4.9	4	14	10	3	8	1	10
Stem	9	3.8	9.1	5.8	1.5	5.6	4	18	9	4	10	1	10
Old Stem	5	7.2	25.0	11.5	6.8	8.0	4	40	21	13	20	1	10
Seed	3	3.8	5.2	4.3	0.6	4.0	8	20	12	6	8	1	4
Root	2	5.3	10.0	7.6			20	35	28			1	1
Soil Horizon													
A_0	39	1.6	18.0	7.9	2.9	8.3	12	60	34	11	36	1	14
A_1	47	0.2	12.1	5.1	2.0	5.0	4	44	25	10	24	1	8
B	41	0.1	3.0	0.5	0.7	0.2	2	22	10	7	8	1	8

element content found between jack pine and spruce twigs, the data for the two species have been combined although for the needles, on the basis of 4 sample pairs, more Cu was found in jack pine and more Mn in spruce.

The following elements show some interesting relations in the various parts of the vegetation above the Deilmann ore zone. Ni and Pb, and Zn and CaO show positive correlation in the wood (Figure 6) and duplicate the double peak shown by U in Figure 5. On the other hand, Zn and Cd are inversely correlated in the wood but show a positive correlation in the bark (Figure 7). For the jack pine twigs, Cd, Pb and Ni rise to maxima on the one line analysed and Zn a minimum (on two lines). Likewise, Co in roots and leaves, and Pb and Cd in blueberry leaves show maxima.

High values of Ni, Co and Pb were found in the vegetation sampled over the area of buried radioactive boulders on the esker 4 km southwest of the ore zones. High nickel and lead may well indicate the presence of boulders near surface and could possibly be used in the Key Lake area to distinguish uranium mineraliza-

Co ppm (Cont'd.)			Cu ppm					Pb ppm					Zn ppm				
Mean	S.D.	Med.	Min.	Max.	Mean	S.D.	Med.	Min.	Max.	Mean	SD.	Med.	Min.	Max.	Mean	S.D.	Med.
18	4	18	37	113	73	16	73	37	71	51	10	49	900	3640	2766	621	2840
21	5	20	144	470	224	70	198	51	370	129	62	108	1420	5020	3125	914	3150
25	4	23	90	144	118	9	106	48	84	62	12	60	1460	4900	3352	980	3250
18	4	17	124	490	220	100	191	48	102	71	18	66	2620	6200	4533	1125	4430
18	5	21	224	1000	562	268	409	24	111	61	32	55	2320	4600	3452	768	3470
14	4	13	18	255	129	56	127	3	99	35	23	32	160	920	581	229	700
15	4	16	155	420	284	65	287	10	103	58	21	62	950	2780	2201	497	2330
15	6	12	150	511	297	96	277	35	100	61	22	48	740	3250	1531	709	1280
17	2	17	113	185	150	26	144	36	76	52	14	51	690	1040	839	106	780
20	5	17	170	360	262	62	262	34	136	66	30	58	900	1840	1378	257	1410
18	4	20	220	480	344	87	360	64	150	99	31	85	1400	2200	1754	310	1580
17	2	16	220	250	251	13	224	30	72	46	18	37	1240	1440	1360	86	1400
14			280	330	305			16	34	25			1200	2140	1670		
15	14	12	10	145	81	30	75	72	372	222	63	231	130	2400	1334	510	1330
8	3	8	5	72	37	15	37	4	216	128	46	132	220	900	548	168	561
3	2	2	1	41	4	6	3	1	129	11	20	6	10	1010	113	186	40
Mo ppm (Cont'd)			**Fe %**					**Mn %**					**CaO %**				
Mean	**S.D.**	**Med.**	**Min.**	**Max.**	**Mean**	**S.D.**	**Med.**	**Min.**	**Max.**	**Mean**	**SD.**	**Med.**	**Min.**	**Max.**	**Mean**	**S.D.**	**Med.**
6	3	6	0.1	0.4	0.2	0.1	0.2	0.7	6.3	3.8	1.4	3.8	17.8	37.3	25.6	5.0	25.7
6	5	6	0.2	2.3	1.1	0.5	0.9	0.2	3.0	1.5	0.6	1.5	14.8	39.9	25.0	6.3	24.0
7	5	6	0.1	0.3	0.2	0.1	0.2	0.3	2.1	1.4	1.4	1.4	37.4	47.4	43.2	3.2	42.6
2	2	1	0.1	0.4	0.2	0.1	0.2	0.7	5.1	3.0	1.2	2.9	23.1	35.2	30.5	3.6	31.0
4	3	2	0.4	3.4	1.1	1.0	0.7	0.4	0.8	0.6	0.1	0.6	2.5	6.6	4.3	1.7	3.0
14	12	12	0.2	1.0	0.5	0.2	0.4	0.6	12.0	6.6	3.3	6.5	1.8	20.7	12.2	5.4	11.1
5	3	6	0.2	2.9	0.8	0.8	0.5	3.7	12.0	7.7	2.3	7.9	13.2	35.4	26.2	5.0	26.6
4	4	2	0.5	1.9	0.9	0.5	0.7	1.6	10.5	5.6	2.7	5.4	11.8	27.0	18.2	4.1	17.2
6	3	4	0.2	0.9	0.4	0.2	0.3	1.2	3.9	2.1	0.8	1.6	25.9	33.0	28.1	2.3	26.7
3	3	2	0.2	1.6	0.5	0.4	0.4	3.0	8.6	5.3	1.8	4.9	17.3	31.0	23.6	4.1	23.8
4	4	1	0.3	1.8	1.0	0.5	1.1	4.9	7.4	6.5	0.9	6.8	18.3	26.0	21.2	2.7	19.8
2	1	1	0.2	0.3	0.2	0.1	0.2	0.9	8.6	4.2	3.2	3.0	1.9	17.3	11.9	7.1	16.4
1			0.8	0.1	1.0			2.8	11.5	7.2			14.2	22.0	18.1		
4	4	1	0.5	2.1	1.5	0.4	1.6	0.11	2.47	1.10	0.60	0.90	2.6	31.3	12.4	6.0	12.0
2	2	1	0.4	2.0	1.4	0.4	1.5	0.06	0.66	0.33	0.15	0.33	0.1	6.3	3.7	1.4	3.9
2	2	1	0.2	2.2	0.8	0.5	0.6	0.00	0.60	0.03	0.09	0.01	0.1	4.7	0.4	0.7	0.2

tion at depth (U + low Ni and low Pb) from mineralized boulders (U + high Ni and high Pb).

CONCLUSIONS

The study at Key Lake indicates that uranium is taken up by jack pine *(Pinus banksiana)*, black spruce *(Picea mariana)*, blueberry *(Vaccinium myrtilloides)* and labrador tea *(Ledum groenlandicum)* and that the uranium content is different for different parts of the plant. The ashed woody parts of the plants, such as the twigs and trunks of jack pine and stems of blueberry and labrador tea contain the most uranium. The ashed wood of jack pine contains the most uranium because it has the greatest weight loss on ignition.

Plots of uranium in the ash of twig or wood samples show peaks that correlate with the position of the ore body at depth. Other trace elements: Zn, Ni and Pb in wood ash and Zn in bark also show the position of the ore body.

Because there is little variation in trace metal contents of spruce and jack pine samples collected from

TABLE 4
TRACE ELEMENT STATISTICS, VEGETATION AND SOILS, FROM AREA OF BURIED RADIOACTIVE BOULDERS. COLUMN "n" IS THE NUMBER OF SAMPLES; THE NUMBERS IN PARENTHESES REFER TO SPRUCE

Species	n	U ppm Min.	Max.	Mean	S.D.	Med.	Ni ppm Min.	Max.	Mean	S.D.	Med.	Co ppm Min.	Max.
Jack pine or spruce													
Needle	4 (6)	0.5	418	64.2	125.4	2.2	45	176	108	38	110	20	32
Twig	6 (6)	1.5	162	22.3	43.5	3.6	63	251	136	60	104	19	29
Soil Horizon													
A_0	5	6.2	2540	767.2	963.2	178.0	46	650	293	262	99	11	87
A_1	6	8.2	5745	1342.7	2089.3	97.6	30	3700	839	1329	86	3	200
B	6	9.0	1440	461.5	573.1	23.9	6	676	169	247	9	1	86

Species	n	Cd ppm Min.	Max.	Mean	S.D.	Med.	V ppm Min.	Max.	Mean	S.D.	Med.	Mo ppm Min.	Max
Jack pine or spruce													
Needle	4 (6)	1.4	12.1	7.6	3.1	6.2	8	24	14	5	12	4	16
Twig	6 (6)	0.1	27.1	10.2	8.4	6.4	16	46	36	8	38	1	12
Soil Horizon													
A_0	5	1.6	11.0	5.2	3.3	4.2	26	70	40	16	34	1	10
A_1	6	1.0	6.6	3.1	1.9	2.0	6	66	26	21	14	1	4
B	6	0.1	0.4	0.3	0.1	0.2	12	40	23	11	16	1	2

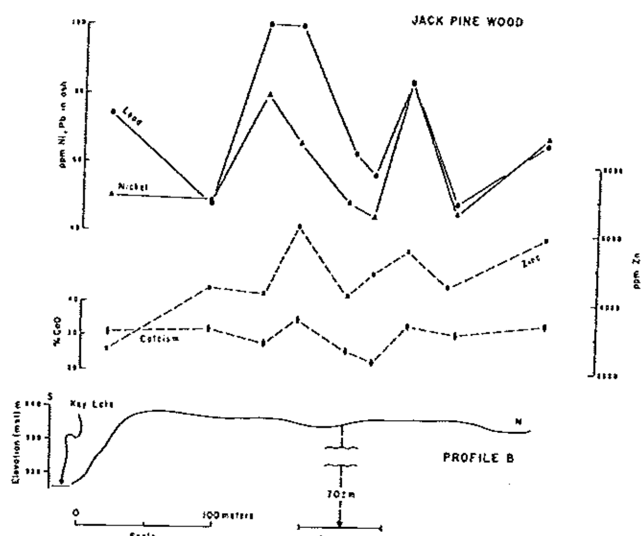

FIGURE 6. Comparison of Ni, Pb, Zn and CaO in ashed jack pine wood; values in ppm except for CaO which are percentages.

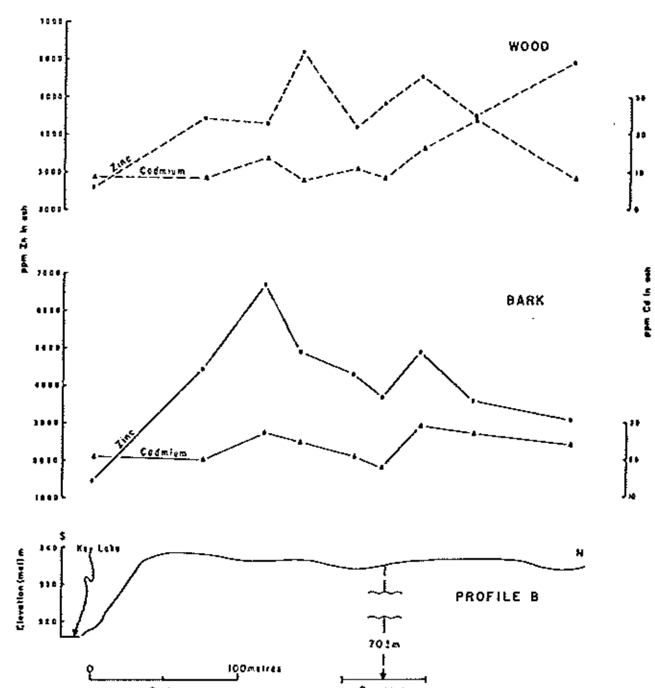

FIGURE 7. Comparison of Zn and Cd in ashed bark and wood of jack pine, values in ppm.

the same location, it appears that data from either or both species may be used for tracing U anomalies in this area.

Wood samples may be collected year round, using unskilled help, permitting a rapid and inexpensive preliminary evaluation of an area.

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Co ppm (Cont'd.)			Cu ppm					Pb ppm					Zn ppm				
Mean	S.D.	Med.	Min.	Max.	Mean	S.D.	Med.	Min.	Max.	Mean	S.D.	Med.	Min.	Max.	Mean	S.D.	Med.
26	4	25	37	101	65	18	60	48	99	67	14	66	2060	3370	2664	495	2480
23	3	22	127	276	190	43	175	76	246	139	50	122	2800	4450	3551	457	3470
28	29	13	25	188	89	59	64	121	610	267	179	234	380	1900	1122	592	1010
48	70	11	10	420	94	147	29	54	425	194	135	114	130	810	347	233	180
26	33	4	2	51	17	20	3	8	245	65	83	23	20	500	178	179	20
Mo ppm (Cont'd.)			**Fe %**					**Mn %**					**CaO %**				
Mean	S.D.	Med.	Min.	Max.	Mean	S.D.	Med.	Min.	Max.	Mean	S.D.	Med.	Min.	Max.	Mean	S.D.	Med.
9	4	8	0.1	0.3	0.2	0.1	0.2	1.4	4.3	3.1	0.9	3.1	18.3	37.4	29.0	6.2	27.9
6	4	6	0.4	1.8	1.0	0.4	0.9	0.7	3.2	1.7	0.9	1.2	21.0	32.7	27.1	3.6	27.6
4	4	1	1.1	1.9	1.4	0.3	1.3	0.25	0.86	0.60	0.30	0.80	2.6	14.1	8.0	3.9	8.9
2	1	1	0.6	2.0	1.1	0.4	0.9	0.03	0.20	0.10	0.08	0.07	0.8	4.0	1.6	1.1	1.1
1	0.5	1	0.6	1.8	1.0	0.4	0.9	0.01	0.06	0.03	0.02	0.02	0.1	1.5	0.4	0.5	0.1

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