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By
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Cover:
Soil sampling pit illustrating reddish brown glaciolacustrine clay intruded by grey till.

Georeference:
NTS area(s): 64C/9

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Multimedia Geochemical Signatures of a REE-enriched Britholite-Allanite Zone in the Eden Lake Aegirine-Augite Syenite, Lynn Lake Area, Northwestern Manitoba (NTS 64C/9)

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ABSTRACT

Rock, soil and vegetation geochemical samples were collected from transects adjacent to and crosscutting fracture-controlled rare-earth element (REE)-enriched britholite and allanite mineralization in the aegirine-augite syenite phase of the Eden Lake intrusion. Multielement analysis of these materials indicates preferential acquisition and storage in the twigs of alders (*Alnus rugosa*) of light rare-earth elements (LREEs) and elements diagnostic of the syenite host rocks. Rock geochemical haloes are narrow, effectively confined to the immediate area of the mineralized zone and, thus, offer no advantage over detailed radiometric or magnetometer surveys. Geochemical exploration for this style of mineralization is not impeded by clay-rich overburden and therefore, in the absence of alder, can proceed using enzyme leach^{sm} selective extraction of b-horizon soil samples. Analysis of alder twigs (*Alnus rugosa*) and b-horizon soil samples was particularly effective for REE exploration in overburden-filled lineaments within the Eden Lake intrusion. This type of analysis would also be effective for REE exploration in other overburden-covered terranes.

INTRODUCTION

The Eden Lake syenite, a multiphase alkaline intrusion, occurs 60 km southeast of the mining town of Lynn Lake in northwestern Manitoba (Fig. 1). This intrusion forms part of a 15 km^2 granitoid intrusive complex situated between the Lynn Lake and Leaf Rapids tectonic domains in the Reindeer Zone of the Trans-Hudson Orogen. The Eden Lake syenite has a marked airborne radiometric signature, has been intruded by fluorite-enriched pegmatite and contains intrusive phases with high concentrations of REEs, uranium and thorium. The zones of REE enrichment, up to 50,000 times chondrite, are associated with: (1) rusty weathered north- and west-trending fractures with pyrite, magnetite, allanite (a cerium-bearing epidote group mineral with the formula $(Ce,Ca,Y)(Al,Fe)_3(SiO_4)_3(OH)$) and britholite (an apatite group mineral with the formula $(Ca,Ce)_5(SiO_4,PO_4)_3(OH,F)$); (2) red weathered aplite dykes; and (3) areas or zones of coarse-grained granite and fluorite-bearing pegmatite. Despite a long history of mining and exploration in the Lynn Lake area and more recent mining activity in the Leaf Rapids area 40 km to the southeast, the general area of the Eden Lake syenite has remained dormant in terms of exploration activity. Accordingly, anthropogenic contamination is absent and the area represents an ideal and pristine geological environment in which to examine the REE contents of bedrock, soil and vegetation growing over and adjacent to mineralized zones.

Despite a well developed regional airborne radiometric signature to the Eden Lake syenite, ground radiometric surveys are hampered by overburden cover. McRitchie (1989) documented a reduction in radiometric readings between exposed outcrop and outcrop covered with a 10 to 20 cm veneer of overburden. The potential for common species of vegetation to acquire and store REEs as part of the process of nutrient acquisition indicates the possibility for rapid and cost-effective vegetation geochemical surveys to assist in the delineation of additional REE-enriched mineralization in the Eden Lake area.

There are few studies of REE uptake by vegetation in the literature. Dunn and Hoffman (1986) documented areally restricted La, Ce, Sm, Ba and Sr enrichment in a wide range of vegetation types growing over fracture-controlled apatite and allanite mineralization near Uranium City, Saskatchewan. Yliruokanen (1975) concludes, in a study of REE-enriched pegmatites in Finland, that mosses and lichen growing on the pegmatites are capable of concentrating REEs whereas uptake by trees from the same area was low.

The REEs and other elements associated with the britholite and allanite mineralized zones in the Eden Lake aegirine-augite syenite present an opportunity to document metal uptake by vegetation and to compare vegetation, soil and rock geochemical results in a pristine geological environment. The aims of this survey were to: (1) assess the applicability of rock, soil and vegetation geochemical methods to REE exploration in the Eden Lake area by geochemically characterizing the mineralization and its host rocks; (2) identify the vegetation species or organs that concentrate rare earth and related elements; (3) determine the areal extent of any geochemical anomalies; and (4) determine the effectiveness of the enzyme leach^{sm} in the analysis of b-horizon soils for application to REE exploration.

PREVIOUS WORK

Prior to this soil and vegetation geochemical study an airborne gamma-ray spectrometer survey undertaken by the Geological Survey of Canada in 1977 detected anomalous potassium, equivalent thorium and equivalent uranium in the Eden Lake area. Geological mapping by Cameron (1988) in 1978 and 1979 identified the aegirine-augite syenite. McRitchie (1988) undertook field examinations of the Eden Lake syenite. The following year McRitchie (1989) conducted a ground scintillometer survey of the same area and provided a mineralogical description of the syenite as well as major and trace element analyses, including REE, for the syenite and a britholite-allanite mineralized zone (Table 1). In 1989, the Geological Survey of Canada (Schmitt et al., 1989) reported high uranium and fluorine in lake waters and uranium in lake sediments from the Eden Lake area. These regional lake sediment and lake water geochemical surveys delineated a uranium and fluorine geochemical anomaly with dimensions of 40 km east-west and 20 km north-south. A detailed ground scintillometer survey by Young and McRitchie (1990) more closely defined areas of anomalous radioactivity and delineated localized radioactive “hot spots” that corresponded to: (1) individual or clustered radioactive minerals; (2) narrow (1–3 mm) disseminated, fine-grained pyrite or magnetite; (3) 3 m long fractures trending 284° to 352° and larger 30 m by

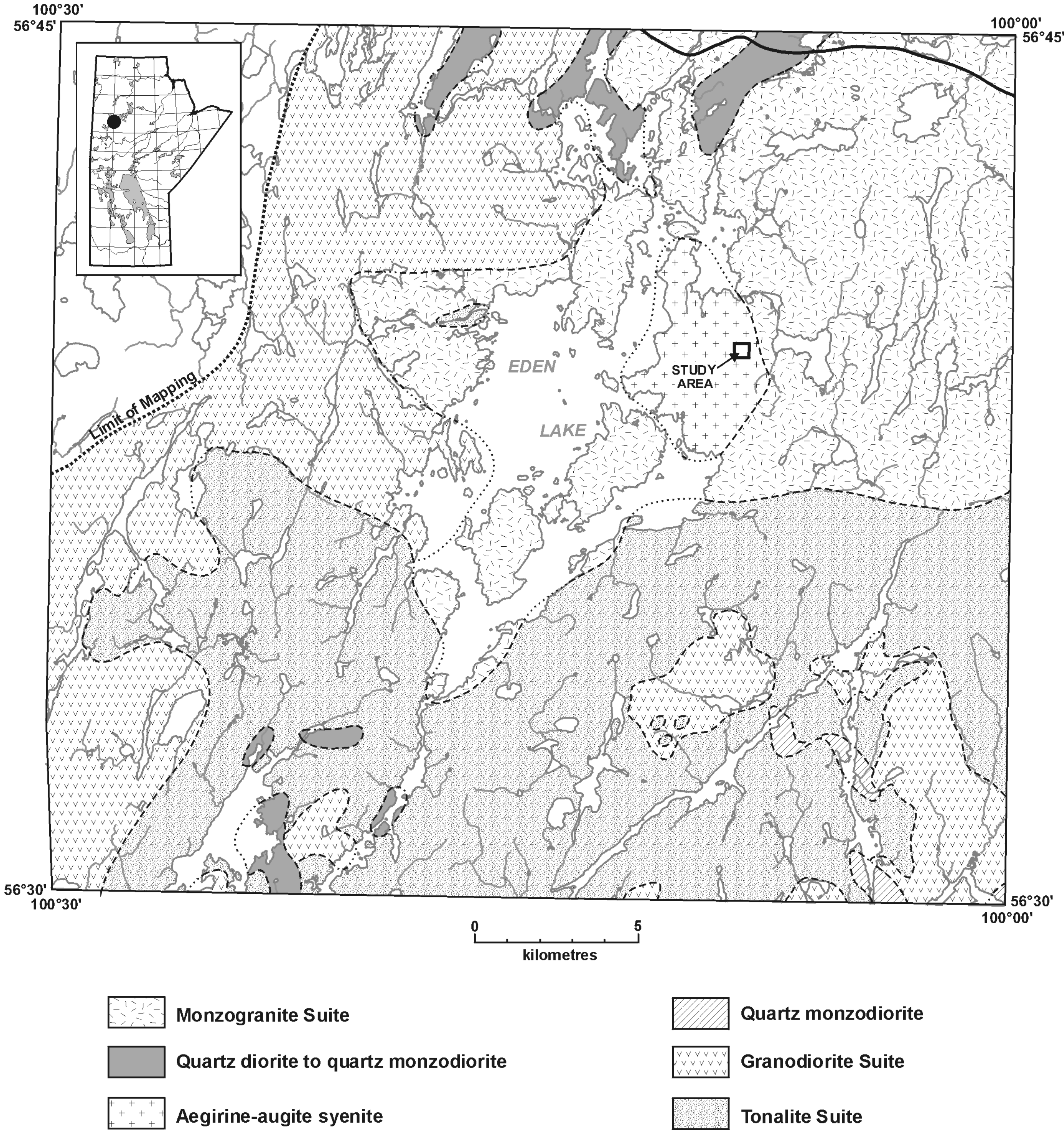

Figure 1: Location map and regional geological setting for the Eden Lake vegetation geochemical survey area. Geology after Cameron (1988).

2 m fractures with concentrations of magnetite or disseminated pyrite; and (4) larger zones of radioactive response with a northerly trend up to 70 m long and 20 m wide with associated pyrite and magnetite. Results from this study indicate that anomalous radioactive responses were not isolated to one specific phase of the Eden Lake intrusive suite nor were they entirely structurally-controlled. Young and McRitchie (1990) also present chemical analyses of britholite and allanite that demonstrate significant LREE enrichment (Table 2). Halden and Fryer (1999), using major and trace element data, geochemically characterize the Eden Lake syenite as an A-type granitoid (Eby, 1990; Clemens et al., 1986) and suggest a mafic, juvenile arc source region for this intrusion. Fedikow et al. (1993, 1994) describe ground scintillometer survey and preliminary vegetation geochemical results from the britholite-allanite mineralized area. In these studies a Scintrex-Broadband gamma-ray scintillometer (model GSB-ISL with a 1.5" by 1.5" thallium activated sodium iodide crystal) was used to take

Table 1: Trace element geochemical analyses of a britholite-allanite mineralized zone, Eden Lake. Data from McRitchie (1989). All values in ppm.

Sample	Sc	Th	U	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu
04-89-31-1	2.90	3500	1180	13 700	36 500	20 700	3060	600	180	54	21
04-89-08-1	2.90	1800	880	17 700	45 900	22 900	3300	680	180	68	16
04-89-08-4C	1.90	2100	1400	13 800	39 600	24 300	3150	670	180	27	14
04-89-06-5	2.47	775	690	12 100	15 000	6140	1840	247	66	56	5

Table 2: Summary of mineral chemical analyses (weight %) for britholite and allanite from the Eden Lake aegirine-augite syenite. Samples from McRitchie (1989); analyses from Young and McRitchie (1990). n.d. - not detected

	Britholite (1 analysis)	Allanite (3 analyses)
SiO_2	11.31	30.30 to 30.54
TiO_2	n.d.	0.81 to 0.86
P_2O_5	4.77	n.d.
Al_2O_3	0.18	10.99 to 11.13
MgO	n.d.	0.86 to 0.98
MnO	0.78	0.58 to 0.62
FeO	0.20	11.37 to 11.86
Fe_2O_3	n.d.	6.15 to 7.53
CaO	2.08	10.31 to 10.47
Y_2O_3	1.20	n.d.
La_2O_3	9.15	5.96 to 6.46
Ce_2O_3	27.06	13.70 to 13.99
Pr_2O_3	7.26	1.48 to 1.67
Nd_2O_3	17.53	2.85 to 3.13
Sm_2O_3	2.43	0.00 to 0.27
Gd_2O_3	0.89	n.d.
ThO_2	3.28	n.d.
H_2O	0.81	1.50 to 1.51
Total	88.93	98.65 to 99.12

measurements at ground level from a grid with 10 m stations on lines 25 m apart. This grid included each of the vegetation sampling sites in the area. Contoured total counts per second (c.p.s.) at 183 stations, recording potassium, equivalent uranium and equivalent thorium, effectively delineated the britholite- and allanite-bearing fractures as well as the smaller rusty-weathered, pyrite-bearing fractures in the study area. The highest responses in the survey (1150–3900 c.p.s.) correlated with northeast-trending, fracture-controlled pods, lenses, veinlets and disseminated grains of britholite and allanite.

Arden (1995) studied the mineralogy and chemistry of constituent minerals in the Eden Lake britholite-allanite zone. This study identified britholite, titanite, apatite and allanite as the mineral phases that concentrate REE, uranium and thorium. A study of the physical beneficiation of an Eden Lake britholite sample was undertaken by Lakefield Research Ltd. in 1996. The coarse fraction (+150 mesh) of a britholite sample that assayed 2.37% Ce, 1.64% Nd and 1.2% La was concentrated by gravity separation. This concentrate assayed 8.98% Ce, 4.92% Nd and 3.23% La.

TOPOGRAPHY AND VEGETATION

The Eden Lake study area is characterized by mature boreal forest growing on isolated outcrop, outcrop ridges and low-lying areas of swamp and muskeg developed upon glaciolacustrine clay and sandy till. Small boulder ridges and remnants of dissected eskers occur throughout the general area. Fault bounded granitic ridges are characterized by steep cliffs that rise up to 60 m above the surrounding terrain. Trees growing from these outcrops are partially stunted; more vigorous growth is observed in overburden covered areas.

Vegetation in the survey area is characterized by ubiquitous black spruce (*Picea mariana*) and lesser stands of Jack pine (*Pinus banksiana*). White spruce (*Picea glauca*), birch (*Betula papyrifera*), poplar (*Populus tremuloides*) and willow (*Salix spp.*) occur sporadically in the area. Alder (*Alnus rugosa*) and labrador tea (*Ledum groenlandicum*) predominate amongst the shrubs. Outcrop ridges are locally covered by lichen (*Cladina mitis*) and blueberry (*Vaccinium augustifolium*).

GEOLOGY AND GEOCHEMISTRY OF THE EDEN LAKE INTRUSION

The Eden Lake aegirine-augite syenite is part of a post-orogenic intrusive complex that comprises monzogranite, pegmatite, megacrystic monzodiorite and porphyritic granodiorite. The syenite, which is locally intruded by fine-grained, pink aplitic leucosyenite, typically contains several granitoid phases including a pink to cream colored monzosyenite phase with 15 to 30% ferromagnesian minerals. The leucosyenite is intruded by pink and white granite dykes that are intruded by pink pegmatites containing interstitial and vug-filling purple fluorite as well as graphically intergrown quartz and potassium feldspar, plagioclase and lenses of white, non-mineralized quartz.

The medium-grained, equigranular syenite and monzosyenite is characterized by pink potassium feldspar, aegirine-augite, hornblende, sphene, minor apatite and trace zircon. Weakly to non-foliated syenite locally contains centimetre-scale layers of ferromagnesian minerals and centimeter to millimeter wide pyroxene-rich veinlets with cores of feldspar and apatite. Coarse-grained leucosyenite phases rarely contain 2 to 3 m long pyroxene crystals. Brecciated fine- to medium-grained, amphibolite fragments in the syenite were observed in the area of the vegetation geochemical survey. Chemically, the syenite is marked by high alkali and low CaO, high F and relatively constant Y/Nb and Yb/Ta trace element ratios. The various phases of the syenite, including the aegirine-augite phase which is the focus of this multimedia geochemical study, contain high concentrations of REEs (Halden and Fryer, 1999). Pink pegmatite dykes

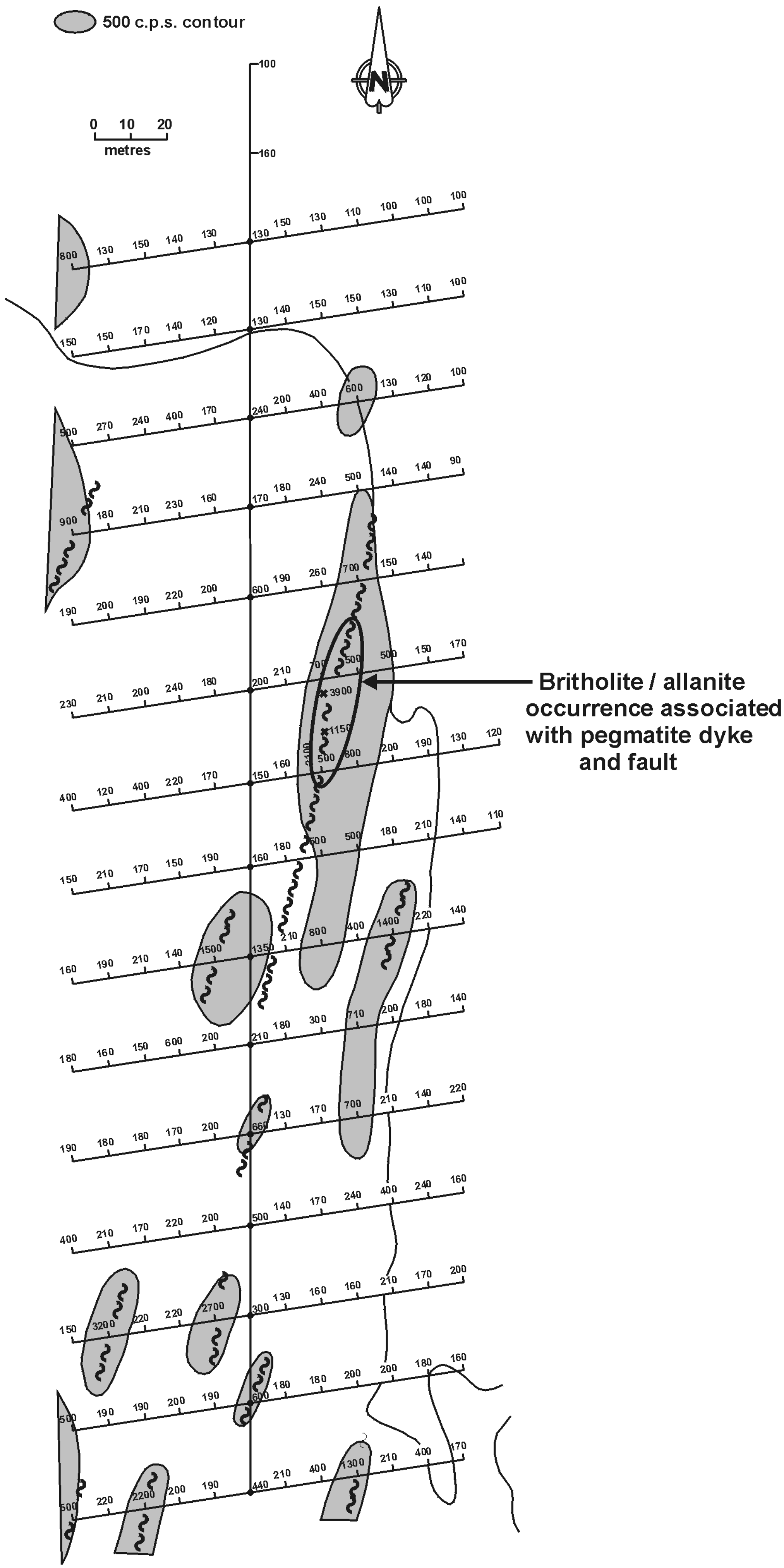

Figure 2: Scintillometer survey results from the area of the vegetation geochemical survey, Eden Lake area. All radiometric measurements taken at ground level.

trending 024° with near vertical dips are present in the survey area. Faults in the survey area strike 014°, are generally rusty weathered and show a marked increase in radioactive response relative to the surrounding rock (Fig. 2).

Allanite, a cerium-bearing epidote group mineral, and britholite, an apatite group mineral, occur as intermittent zones of irregularly distributed massive 10 cm wide veins and up to 3 cm^2 individual grains or agglomerates of grains spatially associated with the 014° trending faults. In the britholite-allanite mineralized zone the lighter REEs are concentrated in the order:

britholite: Ce>Nd>La>Pr>Sm
allanite: Ce>La>Nd>Pr>Sm

In addition to being highly enriched in Ce (27.06%) and Nd (17.53%) britholite also concentrates Th (3.28%). High concentrations of U (1960 ppm), Ni (4400 ppm), Ta (36 ppm), Cr (10 ppm), Sb (6.2 ppm) and Cs (4.7 ppm) were also detected in mineralized samples (Table 3).

Table 3: Multielement neutron activation analysis of a representative sample of the britholite-allanite mineralization, Eden Lake. Data in parts per million unless otherwise indicated. Analyses by Activation Laboratories Ltd., Ancaster, Ontario.

Element	Concentration
Co	14
Cr	10
Cs	5
Fe (%)	1.87
Hf	3
Na (%)	1.07
Ni	4400
Sb	6.2
Sc	1.2
Sr (%)	0.22
Th	2220
U	1960
La	21 000
Ce	48 900
Nd	28 700
Sm	3200
Eu	1190
Tb	320
Yb	138
Lu	15

In a study of the mineralized zones in the Eden Lake syenite, Halden et al. (work in progress, 2001) demonstrate that U, Th, Y and REEs are concentrated along grain boundaries, cleavages and fractures in minerals surrounding metamict britholite.

The source of the REEs, U, Th and F in the Eden Lake syenite are unknown. Petrogenetic modelling by Halden and Fryer (1999) suggest the syenite may be derived from partial melting of a granite-peridotite mantle or from lower crust with a predominantly mafic composition.

SAMPLE COLLECTION, PREPARATION AND ANALYSIS

Vegetation Samples

Vegetation tissue samples from a variety of species growing adjacent to the britholite and allanite mineralized zone were collected for analysis as part of an orientation program. Samples were collected from a 5 m^2 box centered on the occurrence and from one transect across the outcrop ridge and one transect in overburden-covered ground north of the occurrence (Fig. 3). Tissues collected adjacent to the mineralized zone included needles, twigs, outer bark, inner bark and trunkwood from black spruce and Jack pine, twigs and leaves of birch and alder and lichen. Samples from the outcrop "ridge" and "overburden" transects were collected at 10 m station intervals and represent the outer bark, twigs and needles from black spruce and Jack pine.

One black spruce crown sample, representing the needles, twigs and cones from the top 45 cm of the tree, was also collected from within the sampling box. The analysis of the crown sub-sample will permit an initial assessment of the acropetal tendency for accumulation of REE and other elements in black spruce tissues at the mineralized site.

Approximately 350 g of 8 year old black spruce twigs were collected at each sampling station from the north, south, east and west sides of the tree. This "peripheral" sampling procedure was adopted for all species to integrate possible chemical variations around the perimeter of the tree (Fedikow, 1993). For Jack pine, alder and birch the most recent 45 cm of twig growth was sampled.

The possibility of downslope leakage-type vegetation geochemical anomalies in overburden-covered terrain was also investigated during this study. A total of 57 alder twig samples were collected over a distance of 200 m from the outcrop-overburden interface and from locations scattered over the outcrop ridge (Fig. 3). These samples represent the top 45 cm of alder branches and were of consistent diameter so as to minimize variation in metal content due to age differences between shrubs.

All samples were dried in brown paper bags and needles separated from twigs; alder and birch leaves were separated from stems prior to drying. Dry vegetation samples were ashed incrementally at temperatures not exceeding 475°C, weighed into high purity, polyethylene vials and analyzed by instrumental neutron activation for a total of 36 elements. Analyses were undertaken by Activation Laboratories Ltd. (Ancaster, Ontario).

Soil Samples

Soil samples were collected from 25 locations corresponding to alder twig sampling sites (Fig. 3). B-horizon soils were collected at each site from shallow pits dug with a clean spade. Samples consisted of approximately 0.5 kg of material that was stored in a medium-sized ZIPLOC bag. Six replicate field samples were collected approximately 0.75 m apart for the assessment of reproducibility for enzyme leach^{sm} geochemical analyses. This site was characterized by high REE contents in alder twigs. Soil samples were air dried, sieved and the -60 mesh portion analysed using the enzyme leach^{sm} with an ICP-MS finish. Analyses were undertaken by Activation Laboratories Ltd. (Ancaster, Ont.).

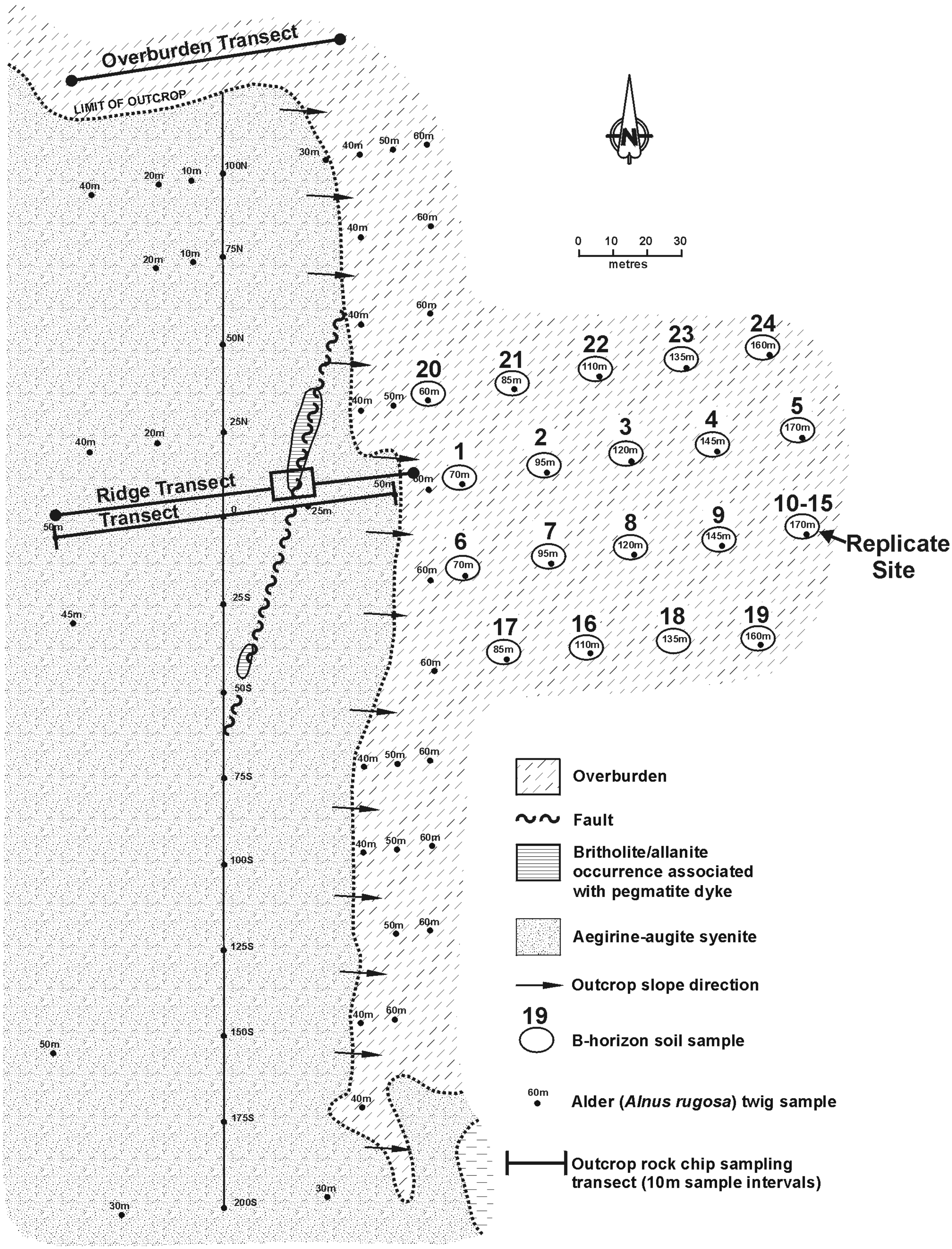

Figure 3: Geological map of the survey area with alder (Alnus rugosa) twig, b-horizon soil and outcrop rock chip sample locations at the britholite-allanite mineralized zone.

Outcrop Chip Samples

Rock chip samples were collected at 10 m intervals along a transect that crosscuts and is perpendicular to the strike of the fracture-controlled britholite-allanite mineralized zone (Fig. 3). Samples were jaw-crushed and pulverized in the laboratories of the Manitoba Geological Survey. Sample powders were then analysed by neutron activation for 33 elements by Activation Laboratories Ltd. (Ancaster, Ont.). A silicate whole rock analysis was performed on these rock samples in the laboratories of the Manitoba Geological Survey.

SOIL PROFILE

A typical soil profile from the sampling grid at Eden Lake comprises forest litter topping 1 to 5 cm of sphagnum overlying 6 to 8 cm of brown, poorly decomposed humus with root mat. This overlies a 1 to 5 cm thick, fine-grained, black, well decomposed humus which rests on varicoloured and variably oxidized sandy to silty glaciolacustrine clay. Pebbles to boulders of aegirine-augite syenite and a variety of exotic lithologies including granite, gabbro and fine-grained mafic volcanic rocks are mixed with the clay. Britholite-allanite mineralization was not observed in these boulders.

VEGETATION GEOCHEMISTRY

Britholite-Allanite Mineralized Zone

Rare-earth elements (REEs)

Table 4 summarizes geochemical data for the vegetation species and tissues sampled within the 5 m^2 sampling box centered on the britholite and allanite mineralized zone (Fig. 3). The enrichment of the LREEs La, Ce and Nd in the allanite and britholite (Fedikow et al., 1993) are reflected in the analyses of some of the tissues sampled for the orientation survey. The highest concentration of La, Ce, Nd and, to a lesser degree Sm, are present in alder twigs. Total rare-earth element (∑REE) content of the alder twigs is 757.5 ppm which exceeds that of lichen (415.3 ppm), the next most efficient tissue for concentrating these elements at this site. Alder leaves also contain highly elevated LREE concentrations with 93 ppm La, 120 ppm Ce and 66 ppm Nd. The heavy REEs (HREEs) are present in low concentrations in almost all tissues sampled (Table 4), however, lichen contains higher concentrations of the HREEs including Eu, Tb, Yb and Lu.

Geochemical Partitioning

Geochemical partitioning studies for REEs within two species at the orientation site was undertaken with the collection of samples of all available tissues from single black spruce and Jack pine trees. For black spruce, samples were collected at both chest height and from the crown or upper 40 cm of the tree. Six tissue types for the Jack pine were collected (Table 4). LREE contents in black spruce needles are comparable for both chest height and crown samples whereas chest height twigs contain higher LREE and ∑REE concentrations (∑REE= 57.2 ppm) than their crown counterparts (∑REE = 14.6 ppm). Crown cones have comparable LREE and ∑REE concentrations to both crown needles and twigs. In chest height tissue samples, black spruce twigs contain approximately twice the ∑REE contents (57.2 ppm) and higher LREE concentrations than other black spruce tissues from this tree.

Significant concentrations of REEs have been recorded from all tissues of the Jack pine sampled for geochemical partitioning (Table 4). The analytical data confirms the highest REE contents occur in outer bark (∑REE = 165.0 ppm). Jack pine twigs, needles, cones, trunkwood and inner bark have a lower range in ∑REE of 9.8 to 25.6 ppm. Since the sampling area is considered to be free of anthropogenic particulate contamination, the observation of higher REE concentrations in the outer bark is considered to be significant.

The most significant tissues sampled in order of highest to lowest LREE contents at the orientation sampling site were: alder twigs (740 ppm), lichen (396 ppm), alder leaves (279 ppm), Jack pine outer bark (165 ppm), birch twigs (136 ppm), birch leaves (61 ppm) and black spruce twigs (40 ppm). Although lichen contains the second highest LREE contents of all tissues sampled, the collection of a single lichen sample required 37 minutes and is considered labour intensive and time consuming. Additionally, inorganic mineral particulate from the growth substrate acquired during sample collection could easily contaminate this tissue type, although ash content reported from the lichen sample (1.08%) is low and does not indicate particulate contamination from the underlying outcrop.

Other Elements

Base and precious metal contents of all vegetation tissues are low with the exception of a single analysis of 2.0% Zn in birch (*Betula papyrifera*) twigs. Exceptionally high contents of Ba and Sr are contained in tissues of the black spruce, alder and birch. Chest height black spruce tissues range from 2050 to 4300 ppm for Ba and 5100 to 6400 ppm for Sr. Alder twigs contain both the highest Ba (6900 ppm) and Sr (1.2%) measured in the orientation survey. The source for Ba and Sr, as well as the LREEs, is twofold. McRitchie (1989) determined the range 1300 to 3300 ppm Ba and 1400 to 2200 ppm Sr in rock samples from the Eden Lake syenite. These analyses are confirmed by Halden and Fryer (1999), who quote Ba and Sr analyses from samples of the Eden Lake syenite in the range 1089 to 4736 ppm and 1057 to 3820 ppm, respectively. The aegirine-augite syenite and the thin soil veneer developed upon this bedrock represents one source of the Ba and Sr in the vegetation. A second source for Ba and Sr may also be the britholite-allanite mineralization.

U and Th contents for the Eden Lake syenite are in the range 690 to 1400 ppm and 775 to 3500 ppm, respectively (McRitchie, 1989). Young and McRitchie (1990) document 3.28% ThO_2 in britholite from Eden Lake. Despite this high background level for U and Th, all tissues sampled at the orientation site, with the exception

Table 4: Summary of neutron activation analyses for ashed (470°C) tissues collected adjacent to the britholite and allanite mineralized survey site, Eden Lake area. Analyses in ppm unless otherwise indicated. For the purposes of this study the values quoted as the lower limits of determination (<) for REEs have been utilized for the calculation of total REE (∑REE).

Species	Tissues	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	∑REE	Ba	Sr	Sc	Th	U	Zn	Ash (%)
Black spruce	Outer bark	7	13	6	0.9	0.2	<0.5	0.4	0.06	28.5	3950	5100	1.4	0.9	0.4	1800	2.59
(*Picea mariana*)	Inner bark	3	5	<5	0.2	<0.02	<0.5	<0.05	<0.05	13.9	4300	5800	<0.1	<0.1	<0.1	2500	3.18
	Twigs	12	22	6	1.5	0.4	<0.5	0.7	0.12	57.2	3800	5800	2.3	1.4	1.2	3100	2.08
	Trunkwood	6	8	<5	0.2	<0.02	<0.5	<0.05	<0.05	19.3	3800	6400	0.1	<0.1	<0.1	3100	0.36
	Needles	2	3	<5	0.2	<0.01	<0.5	<0.05	<0.05	10.8	2050	6050	0.2	<0.1	<0.1	2250	5.27
Black spruce	Cones	1	<3	<5	0.2	<0.03	<0.5	<0.05	<0.05	9.9	330	780	0.4	<0.1	<0.1	1800	0.62
(*Picea mariana*)	Twigs	3	6	<5	0.3	<0.03	<0.5	<0.05	<0.05	14.6	5700	7100	0.5	0.2	<0.1	2200	1.95
Crown	Needles	1	<3	<5	0.2	<0.02	<0.5	0.1	<0.05	10.2	920	3300	0.3	<0.1	<0.1	1200	2.44
Jack pine	Outer bark	33	74	49	5.6	1.3	0.6	1.2	0.19	165	950	1600	3.5	4.5	2.4	4200	1.61
(*Pinus banksiana*)	Inner bark	3	7	<5	0.5	<0.02	<0.5	<0.05	<0.05	16.2	640	1600	0.1	<0.1	<0.1	3900	2.36
	Twigs	2	5	<5	0.3	<0.02	<0.5	0.2	<0.05	13	120	1000	0.3	0.2	0.5	3500	1.66
	Trunkwood	9	11	<5	0.2	<0.01	<0.5	<0.05	<0.05	25.6	640	2100	0.1	<0.1	<0.1	6200	0.3
	Cones	1	<3	<5	0.2	<0.03	<0.5	<0.05	<0.05	9.8	<50	<300	0.2	0.1	<0.1	5100	1.51
	Needles	2	5	<5	0.3	<0.02	<0.5	0.2	<0.05	13	120	1000	0.3	0.2	0.5	1500	3.84
Alder	Twigs	270	320	150	13	3.3	1.1	<0.05	<0.05	757.5	6900	12 000	0.3	<0.1	<0.2		
(*Alnus rugosa*)	Leaves	93	120	66	5.4	1.2	<0.5	<0.05	<0.05	286.2	1300	4700	<0.1	1	1		
Birch	Twigs	45	61	30	3.2	0.8	<0.5	<0.05	<0.05	140.6	5700	7100	0.5	<0.1	<0.1	20 000	1.09
(*Betula papyrifera*)	Leaves	16	26	19	1.6	0.4	<0.5	<0.05	<0.05	63.6	1400	2400	0.1	0.4	<0.1	6000	3.23
Lichen (*Cladonia spp.*)		86	190	120	13	3	0.9	2.1	0.31	415.3	1000	1500	6	8.1	4.5	2700	1.08

Species	Tissues	Au (ppb)	As	Br	Ca (%)	Co	Cr	Cs	Fe (%)	Hf	K (%)	Mo	Na	Ni	Rb
Black spruce	Outer bark	6	3	14	34.5	5	9	1.6	0.48	1.5	1.9	2	1750	<50	56
(*Picea mariana*)	Inner bark	<5	<0.5	24	30	4	<1	2.6	0.06	<0.5	11.2	<2	401	<50	200
	Twigs	18	5.7	27	23.8	7	16	4.4	0.84	1.7	10.9	<2	2550	<50	170
	Trunkwood	<5	4.2	190	33.9	8	50	2.7	0.07	<0.5	7.4	<2	296	<50	220
	Needles	<5	<0.5	38	29.9	2	3	1.2	0.06	<0.5	5.6	<2	145	<50	70
Black spruce	Cones	<5	2.7	36	4	10	5	22	0.23	<0.5	24.7	<2	758	160	940
(*Picea mariana*)	Twigs	16	2.6	23	21.5	17	8	1.9	0.23	<0.5	22.3	<2	746	<50	320
Crown	Needles	<5	2.8	48	20.9	2	6	8.2	0.12	<0.5	14.4	<2	347	64	320
Jack pine	Outer bark	17	6.1	11	24.2	8	23	4	1.16	2.1	4	<2	4530	190	66
(*Pinus banksiana*)	Inner bark	13	<0.5	46	24.6	3	<1	4.2	0.07	<0.5	18.5	<2	2600	<50	230
	Twigs	5	2.2	55	15.2	5	3	2.1	0.16	<0.5	18.9	<2	377	<50	180
	Trunkwood	6	<0.5	32	27.1	4	3	3.9	0.05	<0.5	13.3	<2	304	<50	220
	Cones	<5	1.9	51	2	6	<1	19	0.24	<0.5	21.4	<2	261	120	780
	Needles	5	2.2	55	15.2	5	3	2.1	0.16	<0.5	18.9	<2	377	<50	180
Alder	Twigs	9	1.5	12	26.1	10	3	7	0.15	<0.5	14.3	6	492	<50	310
(*Alnus rugosa*)	Leaves	<5	<0.5	30	17.2	9	4	17	0.2	<0.5	25.1	<2	253	<50	1000
Birch	Twigs	16	2.6	23	21.5	17	8	1.9	0.23	<0.5	22.3	<2	746	<50	320
(*Betula papyrifera*)	Leaves	<5	<0.5	21	15.4	8	<1	3.2	0.13	<0.5	28.9	<2	184	80	530
Lichen (*Cladonia spp.*)		22	12	130	7	13	51	14	1.67	4.2	20.6	5	7310	<50	500

of lichen and Jack pine outer bark, are below 1 ppm for both Th and U (Table 4). Lichen contains 8.1 and 4.5 ppm Th and U, respectively whereas Jack pine outer bark contains 4.5 ppm Th and 2.4 ppm U. Alder twigs, although conspicuous by their LREE contents, do not contain measurable Th or U (<0.1 ppm Th and <0.2 ppm U).

Black spruce and Jack pine cones, collected as part of the geochemical partitioning study, contain the highest Cs (black spruce = 22 ppm, Jack pine = 19 ppm) of all tissues. Alder leaves (17 ppm) and lichen (14 ppm) have comparable concentrations of Cs.

Ridge and Overburden Transects

Needle, twig and outer bark samples from black spruce and Jack pine were collected through the mineralized zone from a 110 m long transect (Ridge Transect) oriented perpendicular to the strike of the mineralization-hosting pegmatite. A second transect (Overburden Transect), with the same length and orientation as the Ridge Transect, was established in overburden-covered terrain approximately 25 m north of the end of the outcrop ridge. This transect, which was designed to intersect the extrapolated position of the mineralized fault beneath overburden, was sampled for black spruce needles and twigs. The location of both transects relative to known mineralization is illustrated in Figure 3. Analytical data from neutron activation analysis of these samples is presented in Table 5. Plots of analytical results for both transects are given in Appendix 1.

Results

Ridge Transect

Data from the Ridge Transect indicates restricted, narrow vegetation geochemical haloes developed in

Table 5: Summary of neutron activation analytical data for ashed (470°C) tissues from black spruce and Jack pine, britholite-allanite occurrence, Eden Lake area. All analyses in ppm unless otherwise indicated.

Species/Tissues	Grid Reference	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	ΣREE	Ba	Sr	Sc	Th	U	Zn	Au (ppb)
Black spruce *(Picea mariana)*																	
Outer bark	0+10E	10	19	8	1.3	0.3	<0.5	0.7	0.09	39.5	4500	2900	2.2	1.2	0.9	2700	7
	0+40E	5	10	<5	0.6	<0.01	<0.5	0.3	0.05	21.4	4200	4100	1.0	0.6	<0.1	2700	<5
	0+50E	5	9	<5	0.5	<0.02	<0.5	0.3	<0.05	19.9	5000	3000	0.8	0.3	<0.1	2400	6
	0+70E	4	6	<5	0.4	<0.02	<0.5	0.2	<0.05	16.0	5800	2600	0.7	0.4	<0.1	1800	<5
	0+40W	4	10	<5	0.7	0.2	<0.5	0.4	0.09	22.6	5200	3400	1.3	0.9	<0.1	2100	6
	0+50W	6	10	6	0.8	0.2	<0.5	0.4	0.09	24.1	5300	2900	1.3	1.0	<0.1	2800	<5
Twigs	0	9	17	<5	1.2	0.2	<0.5	0.7	0.10	33.8	3600	3600	2.2	1.2	0.7	3500	10
	0+10E	9	17	<5	1.2	0.2	<0.5	0.5	0.13	33.5	3400	4200	1.8	0.9	0.6	5200	11
	0+40E	8	16	<5	1.0	<0.02	<0.5	0.5	0.08	30.6	2800	4900	2.0	1.0	0.6	3300	11
	0+50E	11	22	8	1.5	0.5	<0.5	0.8	0.15	44.5	2800	2600	2.9	1.5	0.6	3500	13
	0+70E	12	21	11	1.3	<0.03	<0.5	0.8	0.13	46.8	3100	2700	2.8	1.5	1.1	2200	8
	0+10W	7	14	<5	0.9	<0.02	<0.5	0.5	0.09	28.1	3100	2900	1.5	1.0	<0.1	4600	9
	0+20W	12	23	10	1.4	0.3	<0.5	0.7	0.16	48.1	3100	3400	2.5	1.7	0.8	4400	14
	0+30W	9	17	8	1.1	0.3	<0.5	0.5	0.09	25.8	4700	3600	1.8	1.2	0.5	3100	7
	0+40W	13	25	13	1.5	0.3	<0.5	0.7	0.10	54.1	4900	4300	2.5	1.8	<0.1	4500	9
	0+50W	11	20	<5	1.5	0.4	<0.5	0.8	0.12	43.8	3700	4200	2.6	1.7	<0.1	4000	10
	100S	11	18	7	1.2	<0.02	<0.5	0.7	0.12	38.5	4800	5200	2.2	1.4	<0.1	4800	14
	150N	6	10	<5	0.8	0.2	<0.5	0.4	0.08	22.8	4900	1500	1.6	0.7	<0.1	2600	12
	150N+10E	4	9	<5	0.5	<0.03	<0.5	0.4	0.11	19.1	2700	1700	1.2	0.5	<0.1	5100	14
	150N+20E	4	9	<5	0.6	<0.02	<0.5	0.3	<0.05	20.0	3300	2100	1.2	0.6	<0.1	3700	7
	150N+30E	3	5	<5	0.4	<0.02	<0.5	0.3	<0.05	14.7	2700	2100	0.9	0.3	<0.1	2900	10
	150N+40E	6	11	<5	0.7	0.2	<0.5	0.4	0.10	23.5	1800	1800	1.6	0.9	<0.1	2500	11
	150N+50E	5	6	<5	0.6	<0.02	<0.5	0.4	0.07	17.2	1900	1700	1.3	0.8	<0.1	2700	9
	150N+60E	5	9	<5	0.6	<0.02	<0.5	0.4	0.05	20.4	1200	1400	1.3	0.7	<0.1	3300	9
	150N+10W	4	8	<5	0.4	<0.02	<0.5	<0.05	0.07	17.8	2300	1300	1.0	0.4	<0.1	4300	<5
	150N+20W	5	9	<5	0.7	<0.02	<0.5	0.4	0.10	21.1	4400	2300	1.5	0.9	<0.1	5200	12
	150N+30W	4	9	<5	0.6	<0.02	<0.5	0.3	<0.05	19.8	3700	2400	1.2	0.5	<0.1	4200	11
	150N+40W	6	11	<5	0.8	<0.02	<0.5	0.4	0.13	23.8	2400	2500	1.6	0.9	<0.1	4100	9
	150N+50W	12	22	14	1.6	0.4	<0.5	0.8	0.16	51.5	3000	3400	3.0	2.0	1.4	5800	18

Table 5: Summary of neutron activation analytical data for ashed (470°C) tissues from black spruce and Jack pine, britholite-allanite occurrence, Eden Lake area. All analyses in ppm unless otherwise indicated. (continued)

Species/Tissues	As	Br	Ca (%)	Co	Cr	Cs	Fe (%)	Hf	K (%)	Mo	Na	Ni	Rb	Sb	Ash (%)
Black spruce ***(Picea mariana)***															
Outer bark	7.1	30	30.0	6	15	2.2	0.84	2.1	2.5	<2	2910	<50	52	1.4	2.27
	6.8	19	33.5	6	8	2.4	0.32	1.2	2.3	<2	1640	<50	63	0.7	2.67
	4.9	22	32.9	5	6	2.3	0.30	1.5	1.9	<2	1130	<50	62	0.6	2.08
	3.4	15	31.9	6	5	6.4	0.22	1.2	3.5	<2	984	<50	170	0.4	2.14
	4.2	17	33.4	4	8	1.7	0.41	1.8	1.8	<2	1790	<50	48	0.8	3.12
	6.2	17	33.9	4	11	1.8	0.51	1.3	2.7	<2	2080	<50	56	1.0	2.68
Twigs	5.5	62	23.2	9	14	3.3	0.82	1.7	12.8	<2	2460	<50	190	0.7	1.71
	5.0	35	27.8	7	9	3.6	0.70	1.3	10.8	<2	2240	170	140	0.8	1.89
	4.6	38	25.7	11	14	4.3	0.61	1.4	9.4	<2	2260	<50	170	0.6	2.14
	5.5	31	24.6	7	20	5.3	0.98	1.6	11.2	<2	3430	100	170	1.0	1.97
	7.0	64	23.1	9	21	5.6	0.99	1.9	13.6	<2	3500	<50	320	1.0	1.63
	4.5	34	25.4	7	11	5.1	0.58	1.2	14.5	<2	1900	70	190	0.6	1.81
	5.4	37	23.7	10	15	7.1	0.87	1.3	10.9	<2	2850	150	230	0.7	1.72
	3.4	26	26.5	6	13	5.4	0.61	1.7	9.6	<2	1990	<50	190	0.6	2.03
	5.9	69	22.5	7	16	5.2	0.90	2.2	13.0	<2	3120	<50	210	0.8	1.92
	6.3	27	27.0	6	18	5.5	0.94	2.1	9.5	<2	2900	<50	160	0.8	2.06
	5.7	32	23.2	10	13	5.3	0.79	2.1	10.9	<2	2380	130	180	0.6	1.99
	4.3	51	23.8	6	11	2.6	0.57	1.5	15.9	3	1980	<50	420	0.6	1.86
	4.4	130	17.3	8	11	2.2	0.41	<0.5	25.4	<2	1440	<50	580	0.4	1.39
	3.0	40	19.1	7	10	2.3	0.48	1.2	22.4	<2	1440	<50	510	0.4	1.44
	3.2	42	20.5	12	5	3.2	0.34	0.8	22.9	<2	1140	89	770	0.4	1.65
	3.8	25	25.3	10	13	2.1	0.58	0.9	13.1	<2	2040	<50	420	0.6	1.87
	3.2	64	21.7	13	9	1.4	0.48	1.0	21.8	<2	1490	<50	650	0.4	1.50
	5.2	57	19.8	12	10	1.9	0.49	0.8	19.6	<2	1510	<50	610	0.6	1.40
	3.9	110	18.3	7	8	3.3	0.36	0.9	24.9	<2	1130	<50	540	0.4	1.47
	4.0	37	22.1	8	14	2.6	0.59	1.2	18.3	<2	1840	100	360	0.5	1.63
	3.7	47	18.9	11	7	7.3	0.47	1.0	23.5	5	1350	<50	680	0.4	1.60
	3.9	44	23.1	10	10	6.0	0.59	1.1	11.7	<2	2020	150	340	0.6	1.94
	6.9	52	20.3	8	22	6.8	1.00	1.9	14.2	<2	3090	<50	240	0.8	1.66

Table 5: Summary of neutron activation analytical data for ashed (470°C) tissues from black spruce and Jack pine, britholite-allanite occurrence, Eden Lake area. All analyses in ppm unless otherwise indicated. (continued)

Species/ Tissues	Sample No.	Grid Reference	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	∑REE	Ba	Sr	Sc	Th	U	Zn	Au (ppb)
Black spruce *(Picea mariana)*																		
Needles	El-20	0	1	<3	<5	<0.1	<0.01	<0.5	<0.05	<0.05	9.4	1400	2500	0.2	<0.1	<0.1	2200	6
	EL-25	0+10E	1	3	<5	<0.1	<0.01	<0.5	<0.05	<0.05	9.8	1500	2900	0.2	<0.1	<0.1	3400	6
	EL-33	0+40E	1	<3	<5	0.1	<0.02	<0.5	<0.05	<0.05	9.9	1300	3200	0.2	<0.1	<0.1	2300	<5
	EL-36	0+50E	1	<3	<5	0.1	0.1	<0.5	<0.05	<0.05	9.7	1000	1600	0.2	0.1	<0.1	2500	<5
	EL-40	0+70E	1	4	<5	0.1	0.02	<0.5	<0.05	<0.05	10.0	840	1200	0.3	0.3	<0.1	900	<5
	EL-45	0+10W	1	<3	<5	<0.1	0.1	<0.5	<0.05	<0.05	9.7	1200	2000	0.2	<0.1	<0.1	2700	<5
	EL-48	0+20W	2	<3	<5	0.2	<0.02	<0.5	<0.05	<0.05	10.4	1300	2300	0.2	<0.1	<0.1	2600	<5
	EL-55	0+30W	1	<3	<5	0.1	<0.02	<0.5	<0.05	<0.05	9.7	2200	2600	0.1	<0.1	<0.1	2000	<5
	EL-58	0+40W	1	<3	<5	0.1	<0.02	<0.5	<0.05	<0.05	9.9	1900	3000	0.2	<0.1	<0.1	2700	<5
	EL-62	0+50W	1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.5	1500	3300	0.2	<0.1	<0.1	2400	<5
	EL-72	100S	1	3	<5	<0.1	0.1	<0.5	<0.05	<0.05	9.9	1700	3700	0.2	0.3	<0.1	2500	<5
	EL-92	150N	<1	<3	<5	<0.1	<0.02	<0.5	0.1	<0.05	9.2	2100	870	0.2	<0.1	<0.1	2000	<5
	EL-222	150N+10E	<1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.3	810	660	0.2	0.5	<0.1	3000	<5
	EL-223	150N+20E	<1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.3	1400	1100	0.1	0.6	<0.1	2200	<5
	EL-224	150N+30E	<1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.2	1300	1400	0.2	0.3	<0.1	1200	<5
	EL-225	150N+40E	<1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.4	820	1200	0.2	0.9	<0.1	1200	<5
	EL-226	150N+50E	<1	<3	7	<0.1	<0.02	<0.5	0.1	<0.05	11.3	730	800	0.1	0.8	<0.1	1400	<5
	EL-227	150N+60E	<1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.3	290	650	0.2	0.7	<0.1	1400	<5
	EL-217	150N+10W	<1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.2	840	600	0.1	0.2	<0.1	2800	<5
	EL-218	150N+20W	<1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.2	1600	1200	0.2	<0.1	<0.1	2700	<5
	EL-219	150N+30W	<1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.1	1400	1700	0.2	0.5	<0.1	2500	<5

Table 5: Summary of neutron activation analytical data for ashed (470°C) tissues from black spruce and Jack pine, britholite-allanite occurrence, Eden Lake area. All analyses in ppm unless otherwise indicated. (continued)

Species/Tissues	As	Br	Ca (%)	Co	Cr	Cs	Fe (%)	Hf	K (%)	Mo (%)	Na	Ni	Rb	Sb	Ash (%)
Black spruce *(Picea mariana)*															
Needles	<0.5	25	31.8	2	<1	1.3	0.07	<0.5	7.0	<2	135	<50	87	0.1	3.96
	2.0	66	27.6	3	<1	2.3	0.10	<0.5	10.2	<2	193	<50	110	0.2	3.06
	1.0	37	27.2	2	<1	2.7	0.08	<0.5	11.5	<2	218	<50	150	0.3	2.67
	1.3	57	27.6	2	<1	2.4	0.09	<0.5	8.8	<2	297	<50	120	0.2	2.86
	1.9	97	22.5	3	4	3.1	0.12	<0.5	14.8	<2	361	<50	310	0.3	2.28
	<0.5	67	26.0	3	1	3.2	0.13	<0.5	13.2	<2	277	57	160	0.2	2.46
	7.1	36	23.1	2	<1	4.3	0.14	<0.5	7.5	<2	207	<50	120	0.8	3.11
	0.9	47	30.0	2	<1	3.6	<0.05	<0.5	8.8	<2	141	<50	140	0.2	3.29
	<0.5	75	24.8	3	<1	3.0	0.15	<0.5	14.8	<2	179	61	160	0.2	3.00
	1.0	41	32.2	2	<1	1.5	0.13	<0.5	6.9	<2	139	<50	78	0.1	4.10
	1.8	64	27.3	2	1	2.3	0.06	<0.5	8.0	<2	149	<50	110	0.2	4.10
	<0.5	64	29.9	2	2	1.1	0.07	<0.5	8.2	<2	116	<50	220	0.3	4.04
	<0.5	66	23.0	3	<1	<0.5	0.10	<0.5	14.7	<2	157	<50	290	0.4	2.27
	<0.5	35	24.9	2	<1	1.2	0.07	<0.5	13.1	3	115	<50	280	0.4	2.41
	1.1	55	24.9	3	1	2.1	0.06	<0.5	18.0	<2	148	<50	580	0.1	2.64
	0.7	22	26.4	2	<1	0.8	0.08	<0.5	14.1	<2	160	<50	320	<0.1	3.34
	<0.5	34	26.3	2	<1	1.1	0.08	<0.5	17.0	<2	134	<50	460	0.1	2.32
	1.1	51	26.5	4	<1	1.3	0.08	<0.5	12.8	<2	187	<50	370	0.3	2.45
	<0.5	92	24.2	3	1	1.2	0.08	<0.5	13.4	<2	125	<50	250	0.2	2.67
	<0.5	130	23.1	4	1	1.6	0.08	<0.5	12.9	<2	141	<50	250	0.1	2.86
	<0.5	70	23.8	3	3	4.3	0.08	<0.5	13.5	<2	83	<50	340	0.2	2.89

Table 5: Summary of neutron activation analytical data for ashed (470°C) tissues from black spruce and Jack pine, britholite-allanite occurrence, Eden Lake area. All analyses in ppm unless otherwise indicated. (continued)

Species/ Tissues	Sample No.	Grid Reference	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	∑REE	Ba	Sr	Sc	Th	U	Zn	Au (ppb)
Black spruce *(Picea mariana)*																		
Needles	EL-220	150N+40W	1	<3	<5	<0.1	<0.02	<0.5	<0.05	<0.05	9.23	910	1600	0.1	<0.1	<0.1	2100	<5
	EL-221	150N+50W	1	<3	<5	0.1	<0.02	<0.5	<0.05	<0.05	9.6	1000	2200	0.2	0.2	1.1	2600	<5
Jack pine *(Pinus banksiana)*																		
Outer bark	EL-17	0	9	17	9	1.2	0.4	<0.5	0.6	0.11	37.4	880	960	1.8	1.2	0.7	2900	8
	EL-22	0+10E	11	21	10	1.6	0.4	<0.5	0.7	0.16	45.4	700	1700	2.1	1.6	0.7	3900	8
	EL-28	0+30E	12	21	7	1.5	0.4	<0.5	0.7	0.16	43.3	1400	2400	2.7	1.3	0.1	4000	<5
	EL-31	0+40E	9	16	8	1.0	0.3	<0.5	0.4	0.07	35.1	1300	2300	1.5	0.8	<0.1	3500	9
	EL-38	0+60E	12	22	10	1.5	0.4	<0.5	0.7	0.10	46.6	990	1200	2.4	1.3	0.9	2600	6
	EL-42	0+70E	15	23	10	1.3	0.3	<0.5	0.2	<0.05	50.4	770	1700	2.2	1.1	0.8	1200	6
	EL-47	0+20W	9	14	7	0.9	0.2	<0.5	0.4	0.08	32.3	990	1200	1.3	1.0	<0.1	3200	6
	EL-52	0+30W	8	12	<5	0.8	0.1	<0.5	0.3	0.07	26.3	1100	2500	1.1	0.7	0.4	2800	6
	EL-60	0+40W	6	11	<5	0.7	0.2	<0.5	0.4	0.06	23.4	440	910	1.4	0.9	0.6	2200	<5
Twigs	EL-18	0	6	11	10	0.8	<0.02	<0.5	0.4	<0.05	29.0	450	1000	1.2	0.6	<0.1	4000	14
	EL-23	0+10E	9	16	10	1.2	0.3	<0.5	0.5	0.09	37.1	560	1800	1.7	1.2	0.6	4700	13
	EL-29	0+30E	14	21	<5	1.1	0.3	<0.5	0.4	0.08	42.4	820	1500	1.6	0.9	<0.1	3800	13
	EL-43	0+10W	7	14	<5	0.9	<0.03	<0.5	0.5	0.07	28.0	540	1100	1.5	1.0	0.6	4300	14
	EL-50	0+20W	8	13	<5	0.9	<0.02	<0.5	0.4	0.09	28.3	580	1100	1.4	0.7	0.5	3600	10
	EL-53	0+30W	10	17	8	0.9	<0.02	<0.5	0.4	0.09	36.6	650	2100	1.5	0.9	0.2	3500	10
	EL-65	0+50W	8	14	<5	0.9	0.2	<0.5	0.4	0.09	28.6	430	1300	1.6	0.8	<0.1	4100	5
	EL-73	100S	12	19	10	1.3	0.3	<0.5	0.7	0.11	43.6	770	2000	2.2	1.4	0.7	3500	9
	EL-76	150S	11	17	<5	0.9	0.3	<0.5	0.4	0.07	35.1	830	3300	1.4	0.8	<0.1	3400	6
Needles	EL-18	0	1	4	<5	0.2	<0.02	<0.5	<0.05	<0.05	10.7	170	640	0.4	0.2	<0.1	3700	<5
	EL-23	0+10E	2	<3	<5	0.2	<0.02	<0.5	0.2	<0.05	10.6	110	7900	0.4	<0.1	0.6	3100	<5
	EL-29	0+30E	3	5	<5	0.3	<0.02	<0.5	<0.05	<0.05	13.4	160	700	0.4	0.5	<0.1	2600	5
	EL-43	0+10W	1	3	<5	0.2	<0.02	<0.5	<0.05	<0.05	10.2	190	<300	0.4	<0.1	<0.1	3000	14
	EL-50	0+20W	2	5	<5	0.3	<0.02	<0.5	0.2	<0.05	13.5	200	770	0.4	0.3	<0.1	2900	<5
	EL-53	0+30W	3	6	5	0.3	<0.02	<0.5	<0.05	<0.05	14.7	250	1200	0.4	0.3	<0.1	2800	<5
	EL-65	0+50W	2	<3	<5	0.2	<0.02	<0.5	<0.05	<0.05	10.4	150	600	0.3	0.2	<0.1	3100	6
	EL-73	100S	3	5	<5	0.3	<0.02	<0.5	0.2	<0.05	13.5	260	1400	0.5	0.5	<0.1	3600	5
	EL-76	150S	2	<3	<5	0.2	<0.02	<0.5	<0.05	<0.05	10.6	280	2100	0.3	<0.1	0.4	2800	<5o

Table 5: Summary of neutron activation analytical data for ashed (470°C) tissues from black spruce and Jack pine, britholite-allanite occurrence, Eden Lake area. All analyses in ppm unless otherwise indicated. (continued)

Species/Tissues	As	Br	Ca (%)	Co	Cr	Cs	Fe (%)	Hf	K (%)	Mo (%)	Na	Ni	Rb	Sb	Ash (%)
Black spruce *(Picea mariana)*															
Needles	0.7	50	25.5	2	3	3.0	0.06	<0.5	9.4	<2	126	<50	240	0.3	3.68
	0.8	40	26.7	2	2	2.6	0.11	<0.5	9.0	<2	139	<50	120	0.3	2.70
Jack pine *(Pinus banksiana)*															
Outer bark	7.2	18	31.9	5	12	1.3	0.73	1.1	2.0	3	2350	53	53	1.3	1.82
	4.2	14	28.5	5	13	2.1	0.82	1.0	2.8	2	2590	150	65	1.1	1.35
	5.7	21	25.3	7	15	15	0.93	1.5	5.0	<2	3080	<50	170	1.4	1.19
	5.3	25	31.2	5	8	2.4	0.54	0.9	2.8	<2	1710	<50	73	1.2	1.86
	12	31	26.4	6	17	7.1	0.87	1.4	4.7	<2	2870	<50	150	1.8	1.10
	7	18	28.9	4	13	3.3	0.72	1.0	4.1	<2	2370	<50	160	1.7	1.36
	3.3	14	31.7	4	8	1.0	0.50	1.0	1.7	<2	1650	<50	42	0.7	1.92
	4.3	20	33.0	4	9	1.9	0.46	0.6	1.9	<2	1550	<50	55	0.7	1.70
	3.3	16	33.7	3	8	1.1	0.47	0.8	1.9	2	1530	<50	41	0.8	2.82
Twigs	2.9	43	24.4	4	8	1.7	0.47	0.6	12.7	<2	1390	<50	190	0.6	1.78
	3.3	30	20.8	5	11	2.6	0.65	1.0	16.0	<2	1980	100	160	0.6	1.22
	3.3	26	21.7	6	12	11	0.64	0.7	13.4	<2	1950	<50	240	0.8	1.39
	3.4	43	25.0	5	11	3.7	0.56	0.6	16.3	<2	1720	<50	200	0.6	1.24
	3.6	64	20.0	6	11	5.8	0.53	0.7	16.7	<2	1600	<50	340	0.6	1.59
	3.3	44	23.5	5	10	4.8	0.56	<0.5	15.5	<2	1730	<50	230	0.7	1.53
	3.8	21	23.7	4	13	3.8	0.57	0.9	15.3	<2	1780	<50	250	0.7	1.48
	5.2	31	23.3	5	13	4.5	0.81	1.2	12.0	<2	2450	87	200	0.9	1.73
	2.7	19	26.2	5	7	3.5	0.52	0.8	13.9	<2	1530	<50	220	0.5	1.75
Needles	<0.5	65	18.8	4	4	0.7	0.19	<0.5	16.2	<2	371	<50	140	0.2	1.93
	2.0	61	18.8	4	3	1.1	0.20	<0.5	15.1	<2	401	<50	110	0.3	2.08
	2.5	81	18.2	6	3	6.1	0.17	<0.5	14.7	<2	412	<50	220	0.6	1.93
	2.9	77	23.9	4	5	1.8	0.16	<0.5	13.3	<2	567	<50	130	0.3	2.36
	2.5	47	20.7	5	4	2.1	0.15	<0.5	14.5	<2	383	<50	210	0.4	2.26
	2.5	74	21.9	5	5	2.3	0.19	<0.5	13.6	3	442	<50	150	0.4	2.19
	1.6	29	22.6	2	1	1.4	0.14	<0.5	11.8	<2	341	<50	140	0.3	2.77
	1.5	58	23.7	4	5	1.7	0.19	<0.5	13.1	<2	425	67	150	0.4	2.35
	1.8	46	20.7	4	4	1.7	0.18	<0.5	15.1	<2	293	<50	200	0.3	2.35

black spruce outer bark for ∑REE and individually, La and Ce over known mineralization. These enrichments are restricted to within 10 to 20 m of the mineralized zone and are of low geochemical contrast. Total REE contents vary from 28.5 and 39.5 ppm within 10 m of the mineralized zone and between 16 and 24.1 ppm for the remainder of the transect. There are no distinct patterns for ∑REE, La and Ce in black spruce twigs and needles near the mineralized zone. Some enrichment in ∑REE occurs in twigs collected downslope from the mineralized zone.

Jack pine needle and twig samples collected outside the britholite-allanite mineralized zone display an absence of high concentrations of rare earth and other elements. Contents of Zn and Ni in Jack pine outer bark form narrow but discrete haloes about the mineralized fracture. Zn varies from 3500 to 4200 ppm for 10 m on either side of the zone. The remainder of the samples from the transect vary between 1200 and 3200 ppm Zn. Ni contents vary between 53 and 190 ppm over the same distance and are below the limits of detection (50 ppm) for the remaining samples.

Overburden Transect

Black spruce needle and twig ∑REE, La and Ce data are not anomalous over the extrapolated position of the britholite-allanite mineralized zone in overburden-covered syenite. This observation is also true for other elements determined during this study. The concentrations of ∑REE and Ba and Sr in twigs and outer bark are lower than equivalent tissues collected from the Ridge Transect. Needles from both transects are equally depleted in ∑REE, La and Ce. Uranium and Th contents are also lower in Overburden Transect black spruce twigs, albeit tissues from both transects contain low concentrations of these elements. The conclusion is that either the britholite-allanite mineralized fracture system is not present in the extrapolated direction or that it is not being reflected due to the thicker overburden.

Leakage (Down-Slope) Anomalies: Alder study

The vegetation geochemical orientation survey identified alder (*Alnus rugosa*) twigs as the most efficient tissue type for acquisition and storage of LREEs (Table 4). An ashed sample of this tissue from the area of LREE-enriched britholite-allanite mineralization contains 757.5 ppm ∑REE and clearly reflects an enrichment of these elements in the mineralization. Lichen (*Cladina mitis.*; 415.3 ppm) and the outer bark of Jack pine (*Pinus banksiana*; 165 ppm) represent possible alternative tissue types for sampling. Collection of lichen samples, however, may be prohibitively labour intensive and time consuming for an exploration-oriented survey. On the basis of these vegetation geochemical orientation results, 57 alder (*Alnus rugosa*) twig samples were collected over the aegirine-augite syenite and off of the outcrop to the east in an overburden-covered north-south-trending lineament (Fig. 3). Data from the neutron activation analysis of these tissues is summarised in Table 6 and descriptive statistics for these data are given in Table 7.

Figures 4 through 7 illustrate three distinctive types of geochemical patterns for alder twig data. Samples collected from the outcrop ridge are characterized by low concentrations of REEs distributed without obvious spatial association to the mineralized zone. Those that abut or are within 25 m of the outcrop-overburden interface display a series of areally restricted, single-sample anomalies. This latter response is typified by the results for Cs (Fig. 7), one of the elements enriched in the mineralization (Table 3). The third, and most significant, pattern type is characterized by areally extensive La, Ce and ∑REE multisample, high contrast geochemical anomalies in overburden samples collected over and downslope from the REE-enriched mineralization. The La and Ce anomalies extend to the limits of sampling and are open to the east. A further suite of 10 alder twig samples were collected at 25 m spacings east of the La and Ce anomaly by Strider Resources Ltd. (Ziehlke, 1999). Further LREE anomalous responses were documented along this transect.

Areally extensive La and Ce anomalies documented in alder twigs growing adjacent to the REE-enriched outcrop ridge are likely a product of downslope migration of REE-enriched meteoric waters. These REEs were contributed to the soil profile and then possibly to the tissues of alder twigs. Alternatively, the anomalous LREE contents may represent the signature of overburden-covered structures that also host britholite-allanite mineralization. A “gap”, characterized by low REEs, which exists between the edge of the outcrop and the anomalous vegetation geochemical response in overburden-covered terrain, is more consistent with the latter interpretation.

ROCK GEOCHEMISTRY

Geochemical data from neutron activation analysis of 11 outcrop chip samples collected from the transect through the britholite-allanite mineralized zone (Fig. 3) are summarized in Table 8. Silicate whole rock analyses are presented in Table 9. The elements Ag, Hg, Ir and Se were all below the lower limit of determination and are not included in Table 8. Low abundances of As, Br, Mo, Ni and Sb are typical of these samples.

Host rocks to the REE mineralized zone are marked by elevated CaO (14.12%), P_2O_5 (6.30%), MnO (0.30%) and volatile elements (loss on ignition 1.9%) as well as by depleted SiO_2 (42.2%), Al_2O_3 (6.83%), Na_2O (2.41%) and K_2O (2.12%). The mineralized host rocks are also characterized by the highest percentage of insoluble residue (0.92%). Distinctive bilobate or doubly peaked patterns for major and trace elements are present along the transect (Figs. 8, 9, 10); this pattern is displayed by REEs, U, Th, Fe, Hf, Ca, Cr, Sc and Zn. This bilobate pattern corresponds with the location of the britholite-allanite mineralized zone as well as a subparallel zone 40 m west of the main zone. The subsidiary mineralization is represented by weak, rusty weathered zones associated with an intermittent fracture system without

Table 6: Summary of neutron activation analytical data for ashed alder twigs, britholite-allanite occurrence. Analyses by Activation Laboratories Ltd., Ancaster, Ont.

Sample	As PPM	Ba PPM	Br PPM	Ca %	Co PPM	Cr PPM	Cs PPM	Fe %	K %	Mo PPM	Na PPM	Rb PPM	Sb PPM	Sc PPM	Sr PPM	Zn PPM	La PPM	Ce PPM	Nd PPM	Sm PPM	Eu PPM	Ash %
125S+50E	1.3	1900	27	31.5	8	5	14	0.16	6.45	26	591	370	0.2	0.2	20000	1300	31	26	15	1	0.34	1.9
150S+40E	1.2	2700	25	33.3	17	4	9.7	0.14	7.87	16	2500	370	0.3	0.2	7700	2100	110	74	33	2.9	0.48	1.8
75S+60E	1.3	4200	47	27.8	14	1	53	0.38	13.1	9	1070	870	0.7	0.5	10000	520	81	57	28	1.2	0.05	1.06
200S+30E	1	2700	22	35.2	8	1	4.6	0.1	5.32	10	807	160	0.2	0.2	24000	1800	24	19	10	0.8	0.22	2.83
100S+60E	1.1	2700	16	34.8	9	1	14	0.14	7.4	5	611	270	0.3	0.3	11000	270	25	17	11	0.8	0.23	1.78
50S+60E	1.3	5300	31	31.7	12	1	10	0.19	12.2	4	1190	460	0.4	0.4	14000	3000	50	42	21	0.9	0.34	1.27
125S+60E	0.5	2000	21	34.8	6	1	21	0.14	6.05	10	1270	360	0.4	0.2	21000	810	23	20	11	0.7	0.02	2.12
25S+60E	1.7	2700	10	34	8	1	10	0.14	11.5	2	352	390	0.3	0.1	12000	630	37	22	11	0.6	0.03	1.68
100S+50E	0.6	2300	9	34.6	6	1	21	0.11	6.33	6	286	370	0.3	0.2	10000	510	31	21	15	0.9	0.26	2.2
175S+40E	0.8	2300	10	30.4	19	1	7.3	0.14	7.61	17	2190	260	0.3	0.3	14000	3100	45	39	19	1.6	0.03	1.98
100S+40E	0.5	2000	17	34.1	2	4	10	0.1	5.41	32	616	230	0.2	0.2	10000	880	46	28	24	1.9	0.38	2.47
150S+50E	0.9	1100	20	37.7	6	1	9.9	0.12	4.06	61	1090	280	0.2	0.2	18000	840	13	12	7	0.4	0.02	2.72
75S+40E	1.6	2500	35	30.7	6	1	15	0.27	11.3	6	1140	440	0.3	0.3	9200	1800	72	55	13	1.5	0.04	1.44
200S+30W	1.7	4000	20	31.7	10	4	13	0.18	8.97	2	730	240	0.3	0.2	22000	2800	40	35	15	1.2	0.03	1.83
0+50W	4.7	9800	40	21.4	24	1	3.3	0.22	21.2	2	640	430	0.5	0.5	7000	29000	5.9	9	5	0.4	0.06	0.67
25S+45W	0.5	4000	20	30.7	5	1	3.6	0.13	13.6	9	341	260	0.2	0.2	33000	4300	72	41	37	2.9	0.5	1.78
75S+50E	1.7	3100	12	30.2	8	3	33	0.2	9.44	2	1150	600	0.5	0.3	11000	710	300	210	69	5.2	1.06	1.51
25S+70E	2.6	3000	12	28.4	12	2	14	0.14	9.33	8	760	540	0.4	0.3	12000	480	92	75	28	2	0.4	1.84
150S+50W	2.2	4600	11	30	14	2	12	0.2	13.4	6	400	460	0.4	0.3	22000	3800	56	51	20	2.1	0.38	1.3
75N+20W	2.5	5100	28	25.9	66	32	25	0.33	19.4	2	499	1100	0.7	0.4	6900	3600	70	68	28	1.9	0.04	1.24
100N+60E	2.2	2900	32	29.8	30	16	3.5	0.23	12.4	10	505	670	0.2	0.4	6300	1300	44	36	10	0.9	0.28	1.35
75N+60E	2	4200	34	29.1	26	26	4.9	0.2	14.5	2	433	980	0.3	0.3	7700	2500	28	21	19	0.6	0.03	1.31
50N+60E	2.4	3600	25	32.1	14	2	6.9	0.29	15.8	2	426	910	0.1	0.4	6400	1400	100	88	31	2.3	0.46	1.39
25N+160E	2.1	2600	24	31.9	38	3	4.2	0.23	13.7	2	559	680	0.3	0.4	5600	800	110	110	36	4.2	0.83	1.31
25N+85E	2.5	6800	26	26	33	19	7.4	0.29	12	2	542	900	0.3	0.4	12000	2200	90	72	30	1.5	0.04	1.31
100N+40W	2.4	3200	9	30.1	19	9	9.5	0.22	8.99	3	397	310	0.3	0.3	21000	4900	160	110	39	1.9	0.44	1.75
50N+40E	2.5	1800	9	19.1	7	7	37	0.11	6.82	5	253	320	0.5	0.2	5600	1200	32	21	17	0.9	0.04	1.96
25N+60E	4.2	4100	23	28.3	27	18	8.4	0.29	13.5	2	440	850	0.3	0.4	8400	1500	150	130	34	3.1	0.56	1.63
100N+20W	2.8	6800	24	26.5	69	8	32	0.25	18.4	5	420	1200	0.6	0.3	7500	2600	110	80	30	1.4	0.05	1.16
25N+40E	1.4	2800	20	30.3	10	18	37	0.16	11.7	6	325	540	0.5	0.3	7300	1900	49	43	20	2	0.38	1.4
75N+40E	1.6	4000	31	29.9	16	6	20	0.18	16.1	7	423	990	0.3	0.2	6000	780	220	220	85	7.3	1.46	1.2
25N+110E	2.8	4300	19	26.4	35	16	13	0.27	17.7	12	438	1300	0.3	0.4	8600	1300	120	96	24	2.2	0.31	1.12
100N+30E	2.4	2900	13	30.4	19	14	13	0.21	12.5	6	376	550	0.4	0.3	6700	3600	62	51	21	1.8	0.44	1.56
25N+135E	3.4	2300	16	31.2	46	3	1.4	0.22	11.1	4	522	450	0.2	0.5	4500	1600	72	68	17	2.2	0.46	1.46
25N+50E	4.7	4500	14	26.4	29	19	41	0.22	13.9	17	375	1100	0.8	0.4	7900	1000	110	100	38	2.7	0.47	1.22
25N+40W	2.9	3100	8	31.2	5	27	3.9	0.19	6.34	10	375	170	0.3	0.3	24000	1700	60	52	26	2.2	0.49	2.15
25S+120E	1.2	3000	11	17.3	11	11	11	0.18	8.68	2	337	750	0.2	0.3	8700	420	26	21	10	0.4	0.04	1.7
50S+110E	2.3	4400	20	31.1	18	14	30	0.26	13	5	344	1400	0.5	0.4	11000	1200	110	90	28	1.6	0.04	1.34
0+145E	2.1	3000	24	29.2	20	2	11	0.22	12.1	2	943	1000	0.1	0.5	4700	1100	150	140	42	4.4	0.93	1.38
100N+40E	2.2	2800	22	30.8	7	4	61	0.16	12.8	2	477	970	1	0.4	7200	490	82	55	20	0.8	0.04	1.2
100N+10W	2.6	4800	16	28	33	23	27	0.33	16.4	2	593	910	0.4	0.6	7000	3800	61	52	20	1.6	0.34	1.31
0+120E	2.3	4200	20	25.7	19	14	36	0.38	16.5	12	745	1300	0.5	0.7	5300	870	370	300	95	8.6	2.07	1.08
0+70E	3.3	4800	18	26	15	11	6.6	0.2	18.5	13	533	940	0.1	0.4	8100	1100	280	260	86	8.1	1.52	1.2
50S+85E	0.8	890	9	6.8	5	4	13	0.09	3.06	2	127	220	0.2	0.1	1900	370	19	13	7	0.4	0.03	2.69
0+50E	3.3	2800	14	15.5	13	12	13	0.17	9.66	2	363	310	0.5	0.3	4400	5500	24	23	17	0.8	0.03	2.06
50S+135E	4.5	4900	16	26.4	27	3	8.9	0.35	9.42	2	923	620	0.6	0.7	12000	600	270	200	61	3.5	0.67	1.12
25S+95E	2.2	4700	22	25.9	16	17	15	0.29	14.7	16	635	990	0.3	0.4	11000	1000	230	180	51	3.8	0.75	1.11
0+170E	4	3000	17	27.7	21	18	14	0.25	12.2	7	440	940	0.1	0.3	7600	950	370	290	92	8.3	1.65	1.37
25N+20W	1	2600	12	35	5	4	5.7	0.12	6.15	5	219	170	0.2	0.2	14000	3000	26	23	10	1	0.03	2.37
100N+50E	3.6	2500	19	25.9	14	2	8	0.19	13.8	13	395	700	0.1	0.3	5000	1300	83	74	25	2	0.41	1.2
75N+10W	3.2	3400	19	25.6	33	5	14	0.28	9.89	2	458	530	0.3	0.4	7800	5700	41	39	15	1.3	0.03	1.42
25S+170E	2.8	3100	28	26.9	30	2	7.5	0.26	15.3	2	437	780	0.4	0.3	6600	1500	320	240	72	4.9	0.73	1.19
0+95E	2.5	3100	13	28.3	18	3	8	0.16	15.4	10	392	950	0.1	0.2	8900	650	56	51	16	1.3	0.25	1.22
0+25E	2.3	3800	7	33.6	7	10	11	0.11	9.55	3	252	260	0.3	0.1	13000	2400	48	46	25	2.1	0.54	2.37
25S+145E	3.2	3700	12	28.2	22	3	20	0.25	12.1	2	680	790	0.4	0.4	11000	990	210	170	45	3.6	0.74	1.33
50S+160E	3.6	3100	36	22	26	8	32	0.34	18.8	2	684	1100	0.6	0.5	9000	1800	270	220	61	4.3	0.4	0.94
0+60E	3.9	6000	30	27.8	13	2	31	0.21	19.4	2	626	790	0.6	0.4	11000	2200	66	51	25	1.1	0.05	0.92

Table 7: Summary of descriptive statistics for geochemical analyses of alder twigs. Statistics based on 57 samples except where indicated. Analyses in ppm or as indicated.

Element	Range	Mean	Standard Deviation	Median
La	5.9-370	103	94	70
Ce	9-300	84	76	52
Nd (n=56)	7-95	31	22	25
Sm	0.4-8.6	2.3	2	1.8
Eu (n=36)	0.2-2.1	0.6	0.4	0.5
Tb (n=3)	0.6-0.9	0.8	0.2	0.8
Yb	0.16-0.4	0.3	0.1	0.3
Lu (n=9)	0.05-0.12	0.08	0.03	0.06
∑REE	21.0-776.7	220	193	144
As (n=54)	0.6-4.7	2.4	1.0	2.3
Ash, %	0.67-2.80	1.60	0.50	1.39
Au, ppb (n=23)	5-13	8	2	9
Ba	890-9800	3553	1486	3100
Br	7-47	20	9	20
Ca	6.8-37.7	28.6	5.2	29.8
Co	2-69	19	14	15
Cr (n=45)	2-32	10	8	7
Cs	1.4-61.0	16	13	13
Fe, %	0.09-0.38	0.21	0.07	0.2
K, %	3.06-21.2	11.8	4.3	12.1
Mo (n=35)	3-61	11	11	9
Na	127-2500	625	423	499
Rb	160-1400	646	339	600
Sb	0.2-1.0	0.4	0.2	0.3
Sc	0.1-0.7	0.3	0.1	0.3
Zn	270-29000	2271	3835	1300
Zn*	270-5700	1794	1324	1300

*** Statistics calculated without the single analysis of 29000 ppm.**

visible britholite and allanite mineralization. Single sample anomalies for Ag, As, Sb, Ni, Ta, U, Th, Br, Cs, La, Ce, Nd and Yb occur in the britholite-allanite mineralized zone but are absent from the subsidiary zone to the west. A two-sample Au response occurs over the mineralized zone. The relative abundances of REEs along the sampling transect are illustrated as a series of profiles in Figures 11, 12 and 13. The sample from the mineralized zone at 0 + 20E contains highly elevated REE contents (note that the scale on the graph is logarithmic).

ENZYME LEACH^{sm} SOIL GEOCHEMICAL SURVEY

Enzyme leach^{sm} dissolution is a phase-specific leach that preferentially attacks amorphous manganese dioxide coatings on mineral grains thereby liberating trace metals that are trapped in this material. Amorphous manganese dioxide is an efficient chemical sieve or trap for cations, anions and polar molecules because of its large surface area and the random distribution of positive and negative charges on this surface. Mineral grains within the b soil horizon tend to be coated with a film of hygroscopic water and amorphous manganese dioxide and represent the target for dissolution with the enzyme leach.

Metals trapped or complexed with the amorphous manganese dioxide are interpreted to represent the chemical signatures of oxidizing bedrock-hosted mineralization at depth. Notwithstanding this observation, buried mineralized boulders resident in a dispersion train may also contribute trace metals to the b-horizon. These signatures, in the form of metal-enriched volatiles (Hg-vapour, halides, halogens), move upwards through fracture systems or induced zones of permeability in bedrock and overburden under the influence of electrochemical cells, groundwater flow, capillary flow, evapotranspiration pumping, or as in the case of Hg-vapour the partial pressure of the gaseous compounds generated by oxidation.

Of some concern is the potential that subtle additions from oxidizing mineralization to the b-horizon may be concealed or “swamped” by downward movement from the “a” soil horizon of metal-enriched compounds from weathering of till and/or organo-metallic humate or fulvate compounds. Despite these concerns the anomalies delineated by the enzyme leach generally occur directly over the mineralized target in the form of high contrast “oxidation” or lower contrast “apical” anomalies, each with their own unique element associations. The oxidation anomalies are developed for elements such as Cl, Br, I, As, Sb, Mo, W, Re, Se, Te, V, U and Th with the form of doubly-peaked or “rabbit-ear” anomalies with low concentrations of metals directly over the deposit and peak concentrations on either side of the mineralization. Apical anomalies result from diffusion of commodity elements along an electrochemical gradient moving from an area of high concentration to one of lower concentration and are characterised by a series of high concentrations directly over the target zone. In the latter anomaly type, the metals present are representative of those in the mineralized source. Apical anomalies are of lower contrast than comparable oxidation anomalies. Variability in the morphology of the anomalies can be attributed to the depth of burial of the source.

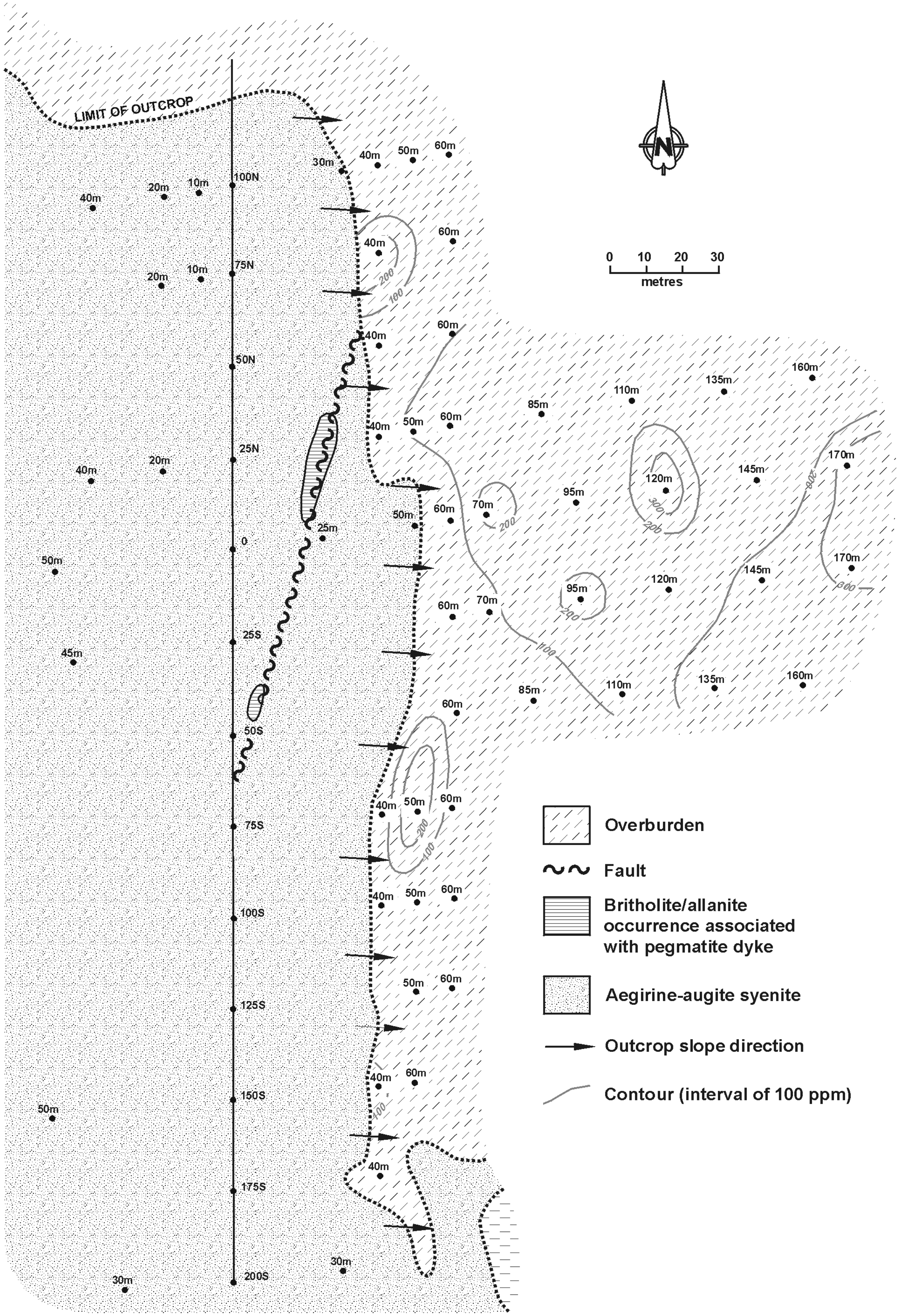

Figure 4: Contoured La concentrations in alder twigs.

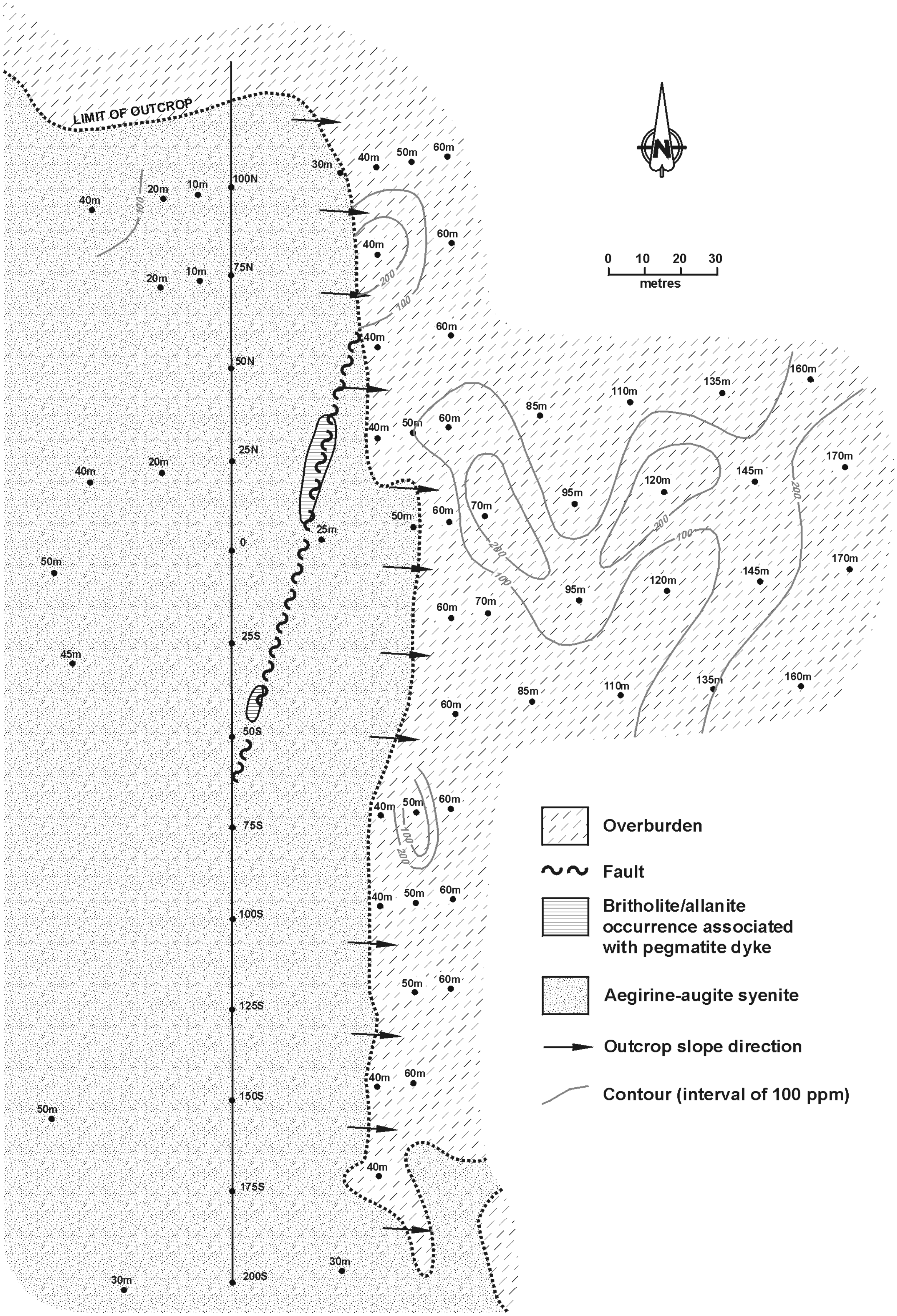

Figure 5: Contoured Ce concentrations in alder twigs.

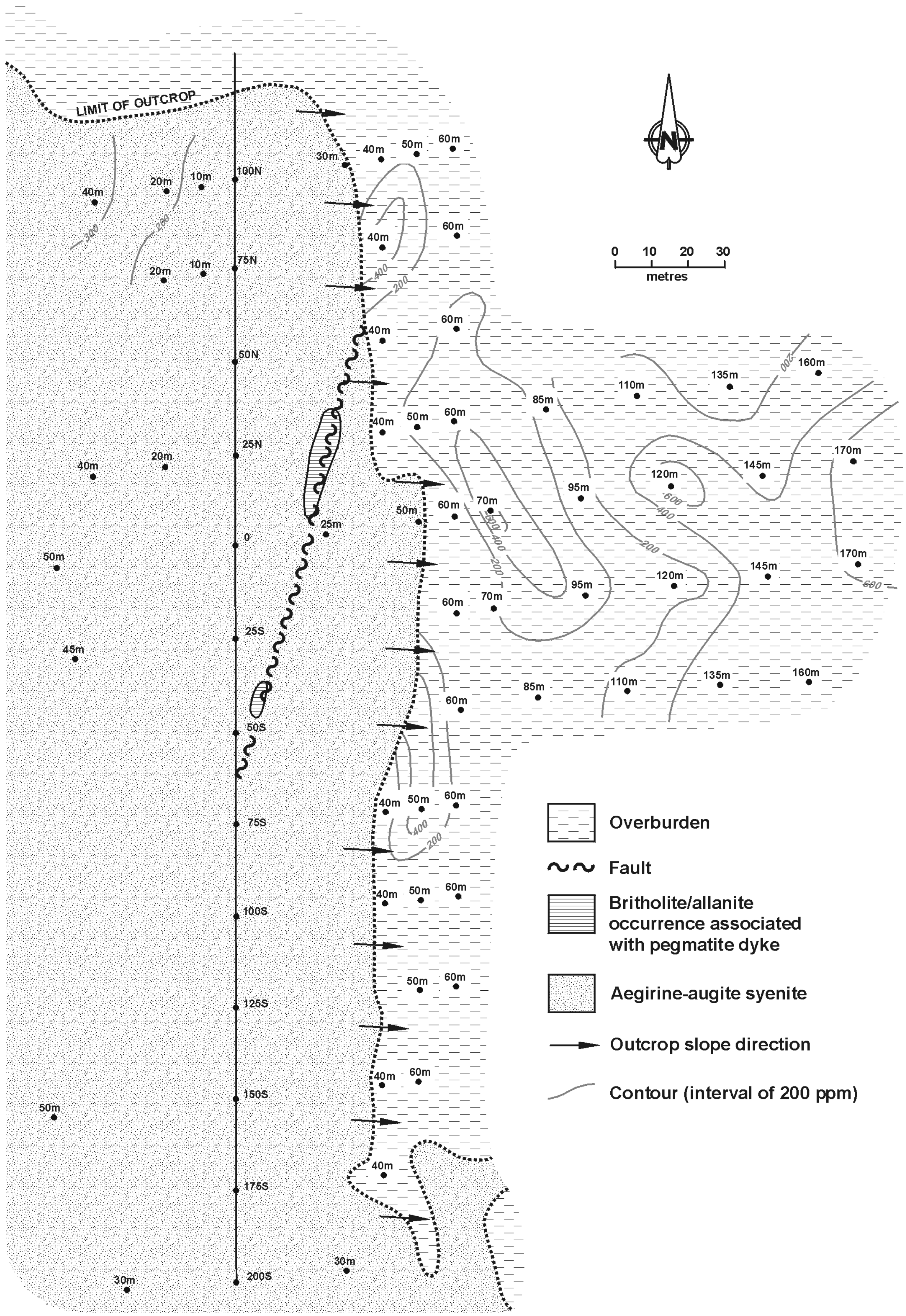

Figure 6: Contoured ∑REE concentrations in alder twigs.

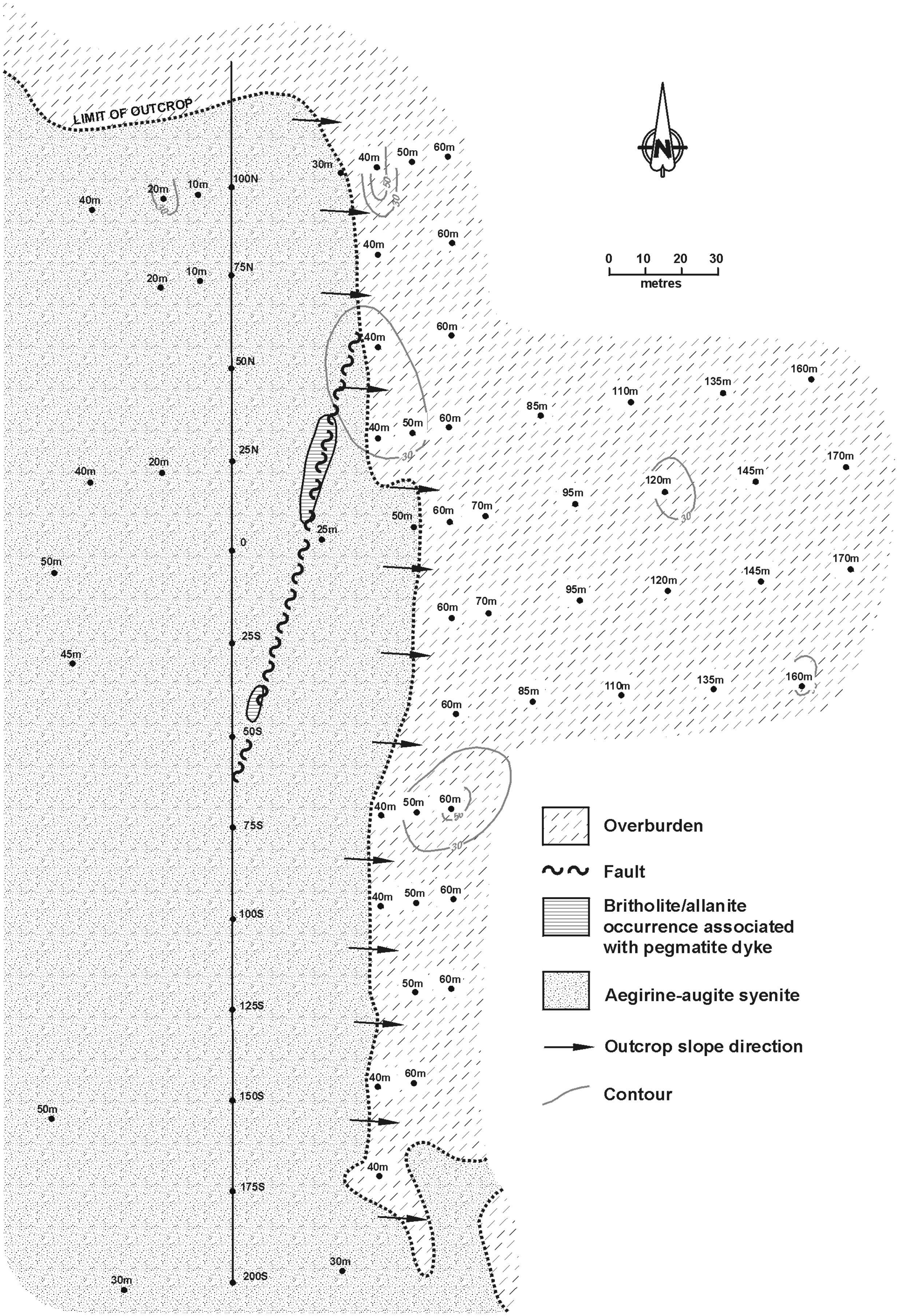

Figure 7: Contoured Cs concentrations in alder twigs.

Table 8: Multielement neutron activation analyses of 11 rock chip samples across the britholite-allanite mineralized zone. Data in parts per million unless otherwise indicated. Analyses by Activation Laboratories Ltd., Ancaster, Ont.

SAMPLE	Au	Ag ppb	As	Ba	Br	Ca %	Co	Cr	Cs	Fe %	Hf	Na	Ni	Rb	Sb	Sc
50 m E	2	2	1	3340	0.5	1	29.7	1.5	1.1	1.2	4.1	33500	<50	158	<0.1	0.8
40 m E	2	2	1	2290	0.5	0.6	22.6	0.5	0.6	1.17	6.5	32900	<50	151	<0.1	1.1
30 m E	38	2	16	2140	0.6	7	30.4	0.5	1.3	5.73	8.5	41300	316	45	<0.1	4.6
20 m E	<50	<35	<10	nd	<6.1	<14	14	9.7	4.7	1.87	2.9	10700	4400	<30	6.2	1.2
10 m E	5	2	1	2800	0.5	1.2	31.2	1.4	1.1	0.91	3.3	36700	<50	156	<0.1	0.3
0	5	2	1	366	0.5	0.6	55.3	2	0.4	0.32	0.7	44800	<50	31	<0.1	1.3
10 m W	2	2	1	1230	0.5	0.6	43.7	2.2	1	0.621	2.7	32100	<50	146	<0.1	0.4
20 m W	2	2	1	3530	0.5	4.2	18.4	7.7	0.9	2.9	6.2	27000	<50	175	<0.1	2.6
30 m W	10	2	4	845	0.5	0.8	45.9	0.9	0.5	0.74	5.3	44100	<50	66	<0.1	2
40 m W	18	2	5	1530	0.5	1.2	57	1.7	0.7	0.841	2.4	42100	<50	84	<0.1	1.2
50 m W	9	2	6	1410	0.5	0.8	48.4	1.8	0.6	0.7	1.5	28500	61	127	0.1	0.4

SAMPLE	Sr %	Ta	Th	U	W	Zn	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu
50 m E	0.2	3	9.2	2.9	989	76	62.1	135	78	11.6	2.7	1	0.85	0.11
40 m E	0.13	1.8	7.8	3.2	421	60	47.4	135	77	13.4	3.4	1.1	1.08	0.15
30 m E	0.26	2.5	43.1	11.5	197	160	842	1610	690	85.7	21.5	6.2	4.52	0.43
20 m E	0.22	36	2220	1960	300	<60	21000	48900	28700	3200	1190	320	138	15
10 m E	0.18	1.6	13.1	2.6	418	29	43.6	87	43	6.91	1.68	0.5	0.64	0.09
0	0.1	2.6	0.9	0.7	721	29	1.9	6	6	1.28	0.39	0.2	0.49	0.05
10 m W	0.04	2	5.6	3.4	646	31	6	13	7	1.1	0.39	0.2	0.63	0.08
20 m W	0.21	1.8	25.8	6.6	324	124	133	319	173	26.2	6.25	2.1	2	0.27
30 m W	0.06	2.6	37	5.5	763	40	91.8	153	61	8.07	1	0.8	1.81	0.21
40 m W	0.07	3.5	4.3	2.3	1270	45	11.6	23	12	2	0.63	0.3	0.68	0.07
50 m W	0.06	2	5.6	2.4	650	81	55.9	120	56	7.97	1.68	0.6	0.69	0.08

Table 9: Silicate whole rock analyses of 11 rock chip samples across the britholite-allanite mineralized zone. Analyses in weight %. Analyses by Manitoba Geological Survey.

SAMPLE	SiO_2	Al_2O_3	Fe_2O_3T	CaO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Insolubles	LOI	TOTAL
0+50W	74.2	13.23	0.95	0.53	0.22	3.98	5.48	0.11	0.04	0.03	0.27	0.2	99.24
0+40W	71.7	15.18	1.17	1.41	0.39	6.11	3.54	0.18	0.04	0.03	0.29	0.3	100.34
0+30W	74.0	14.84	0.99	1.09	0.18	6.26	2.62	0.12	0.03	0.02	0.18	0.2	100.53
0+20W	61.5	14.93	4.23	4.42	1.13	4.01	7.41	0.65	0.48	0.13	0.74	0.4	100.03
0+10W	73.8	13.94	0.89	0.88	0.12	4.97	4.64	0.10	0.00	0.02	0.23	0.2	99.79
0	75.2	14.18	0.51	0.79	0.12	6.85	1.89	0.10	0.00	0.01	0.15	0.1	99.90
0+10E	64.8	17.92	1.34	1.35	0.28	5.49	7.53	0.15	0.06	0.04	0.60	0.7	100.26
0+20E	42.2	6.83	4.32	14.12	1.19	2.41	2.12	0.20	6.30	0.30	0.92	1.9	82.81
0+30E	56.0	12.05	8.45	9.19	2.82	5.32	2.40	1.00	1.25	0.19	0.67	0.6	99.94
0+40E	67.8	16.23	1.73	1.51	0.41	5.13	6.90	0.32	0.06	0.05	0.44	0.3	100.88
0+50E	65.6	16.75	1.83	1.76	0.58	5.21	7.12	0.27	0.22	0.05	0.67	0.3	100.36

The leachate from b-horizon soil was analyzed by ICP-MS at detection limits in the parts per billion range. The enzyme leach does not detect elemental Au or Hg in the b-horizon.

Details of the enzyme leach are provided in Clark et al. (1990), and Clark (1993, 1995).

Geochemical data from the enzyme leach^{sm} analysis is summarized in Table 10 and descriptive statistics presented in Table 11. Figure 14 gives the location of the replicate soil samples and Figure 15 shows the location of soil samples relative to the alder sample locations as well as the variation in concentration of Ba and Sr in alder twigs. Bubble plots show the geochemical variation of data on the survey grid (Figs. 16-18).

Data Reproducibility

Samples collected for the assessment of reproducibility of enzyme leach^{sm} analyses were prepared in precisely the same manner as the other samples on the grid. Table 12 summarizes the replicate analyses of all elements above the lower limits of determination.

The LREEs (La, Ce and Nd) are interpreted to be reproducible (± 15–20%) at concentration levels in the hundreds of parts per billion (ppb). The remainder of the REEs, although present in concentrations less than the LREEs, (i.e. tens of ppb), are also reproducible. This is also valid for Ba, Sr, U, Th, Ni, Co, I and Y. Variability for the elements Cu, Pb, Zn, Ga, V, Nb, Zr, Mn and Rb tends to exceed ±25% and to be as high as ±40% in semi-quantitatively determined Sc. Some of these elements, particularly the base metals, are present in concentrations of a few tens of ppb or less.

Rare-Earth Elements (REEs)

The REEs La, Ce, Nd, Pr, Dy, Gd and Sm are present in the manganese oxide coatings of b-horizon soil particles at concentration ranges that are useful in delineating geochemical contrast in the dataset. The remainder of the REEs are at or below the lower limit of detection and as such are not considered further. The

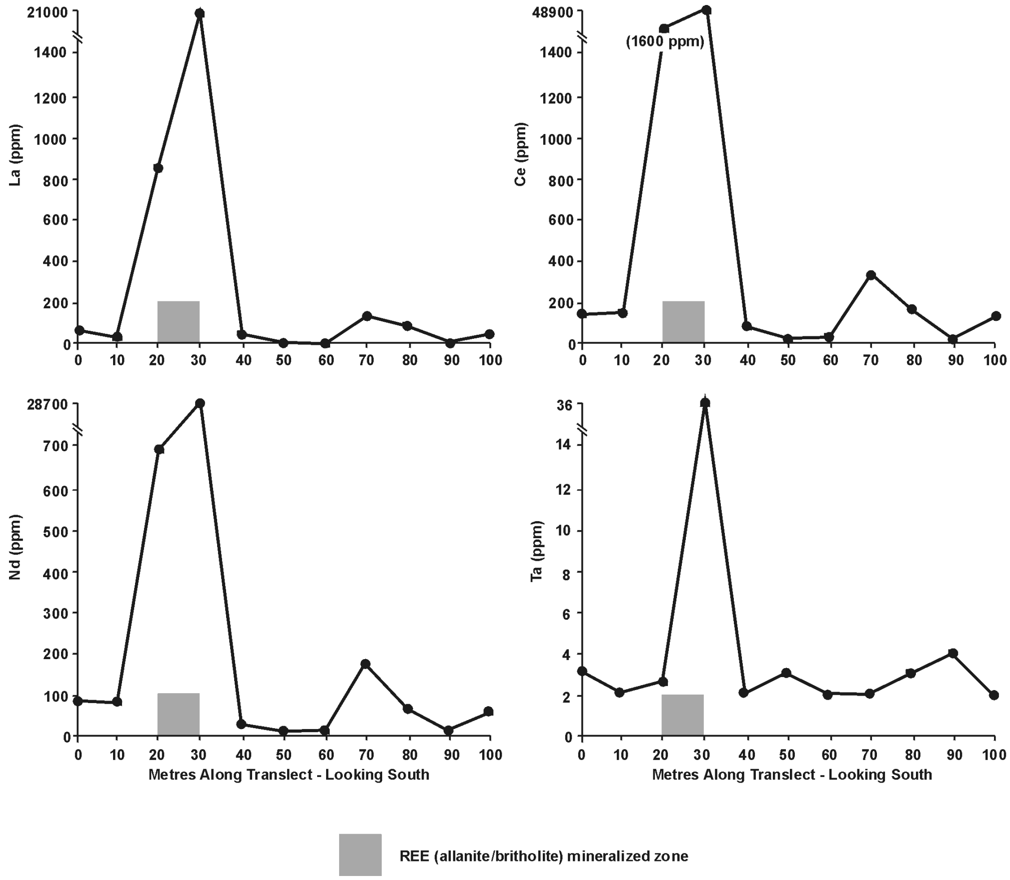

Figure 8: Variation in concentration of La, Ce, Nd and Ta in outcrop chip samples from an east-west transect through the britholite-allanite mineralized zone.

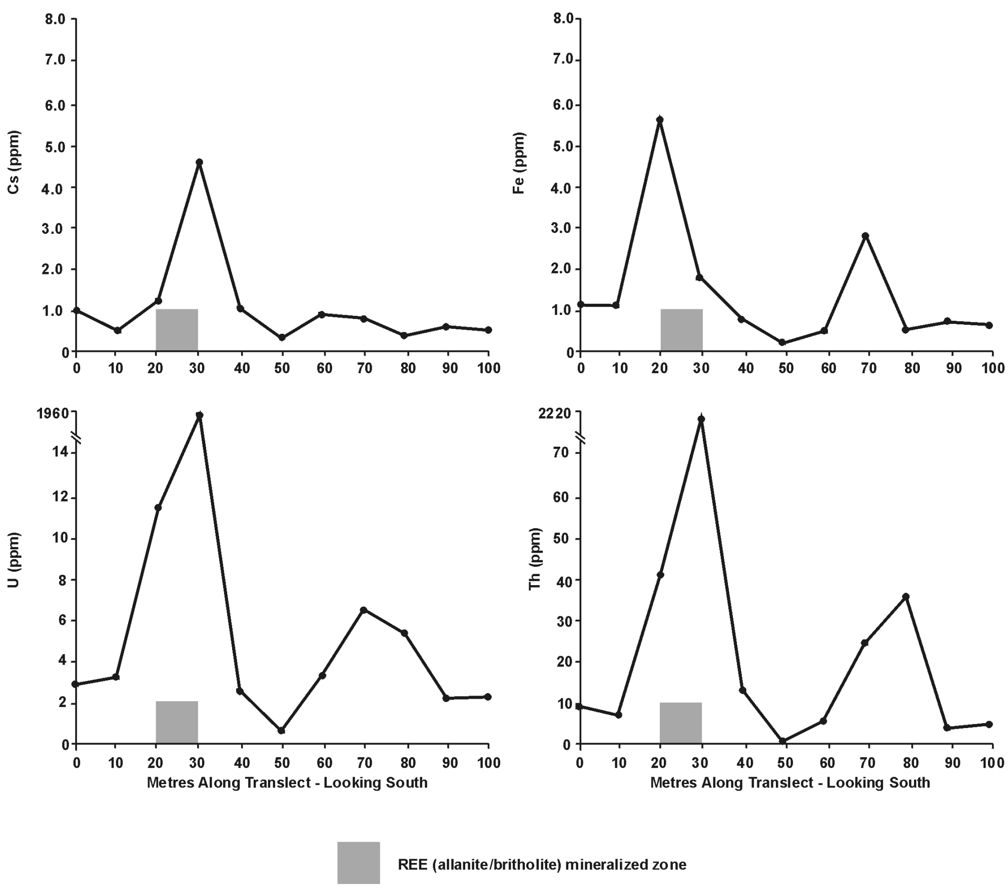

Figure 9: Variation in concentration of Cs, Fe, U and Th in outcrop chip samples from an east-west transect through the britholite-allanite mineralized zone.

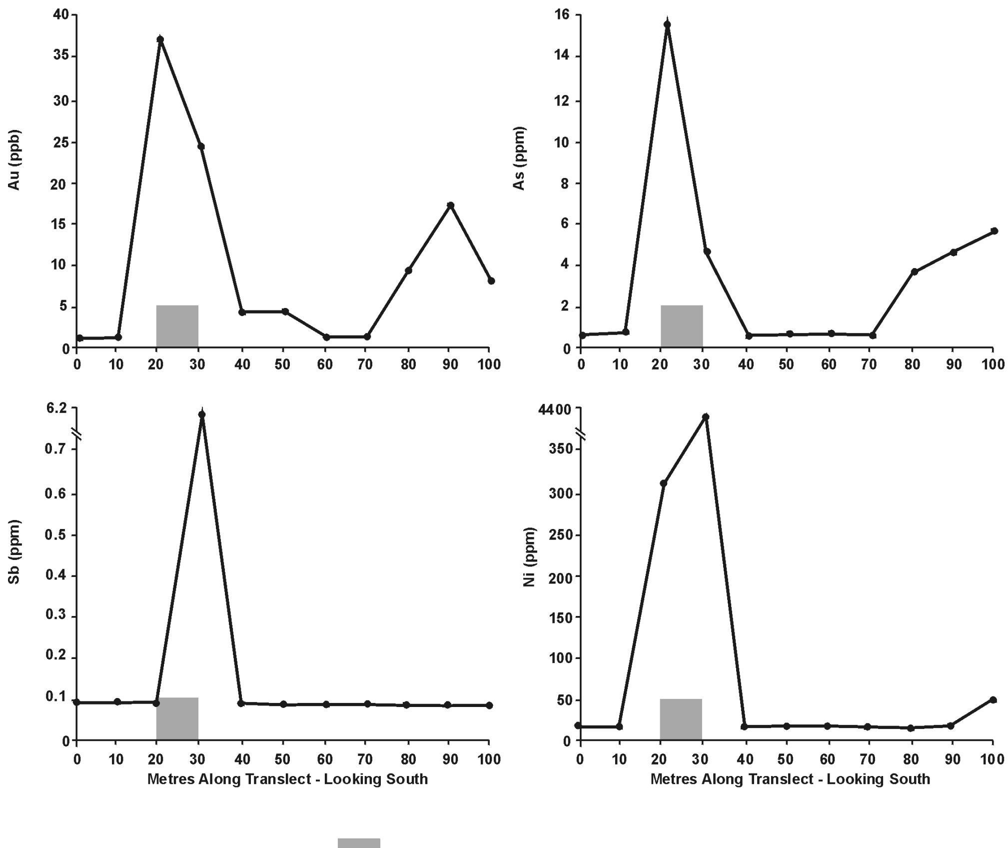

Figure 10: Variation in concentration of Au, As, Sb and Ni in outcrop chip samples from an east-west transect through the britholite-allanite mineralized zone.

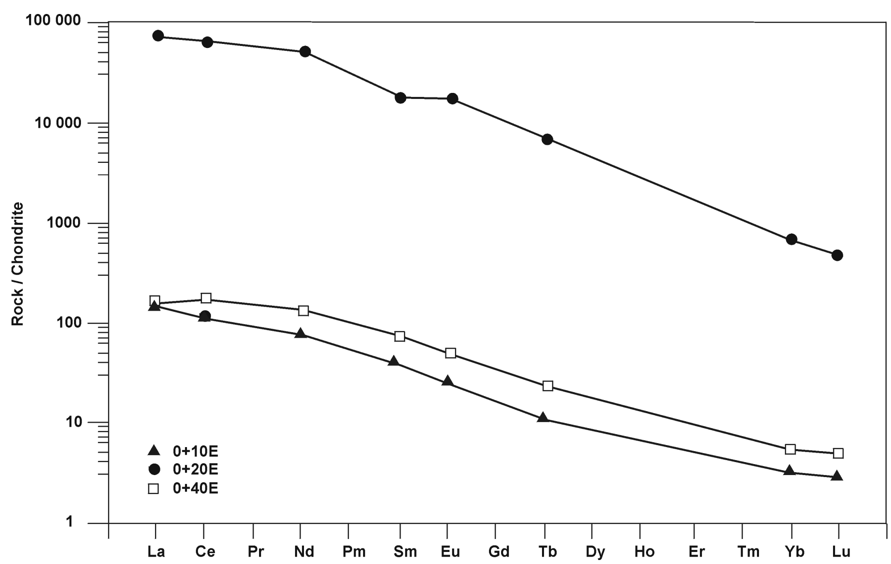

Figure 11: Rare earth element rock geochemical profiles (samples 0+10E, 0+20E, 0+40E) through the britholite-allanite mineralized zone, Eden Lake.

seven REEs considered in the following discussion are also determined to be reproducible on the basis of the enzyme leach^{sm} analysis of six field replicate samples (Table 12).

The LREEs Ce, La and Nd are the most abundant of the REEs in the soil geochemical results. Cerium with a mean of 225 ppb is much more abundant than La and Nd (La=110 ppb, Nd=104 ppb). Interestingly, Ce predominates over the rest of the REEs in the mineralized zone (cf. Table 1). The remainder of the REEs are present in concentrations that vary from 2 to 55 ppb. These elements are also enriched in the mineralized zone (Tables 1, 2, 3) in vegetation species growing adjacent to the mineralization (Table 4) and in alder twigs collected from two distinct areas in overburden covered terrain. Figures 16, 17 and 18 show the variation in concentration of the REEs in the b-horizon soils and indirectly demonstrate the geochemical coherence of REEs. This coherence is reflected in covariance of these elements such that high contents of REEs are located in soils adjacent to the outcrop/soil interface and at the eastern extremity of the sampling grid. In these two areas high contrast

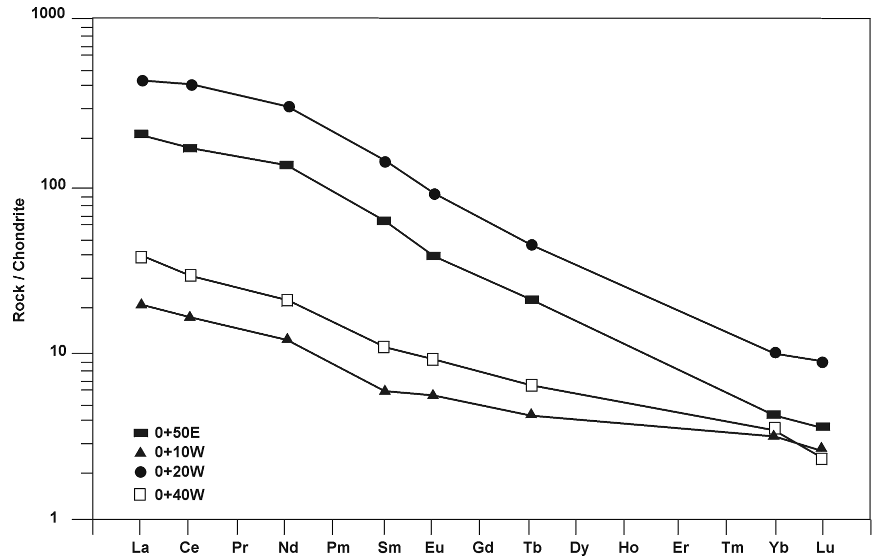

Figure 12: Rare earth element rock geochemical profile (sample 0+50E, 0+10W, 0+20W, 0+40W) through the britholite-allanite mineralized zone, Eden Lake.

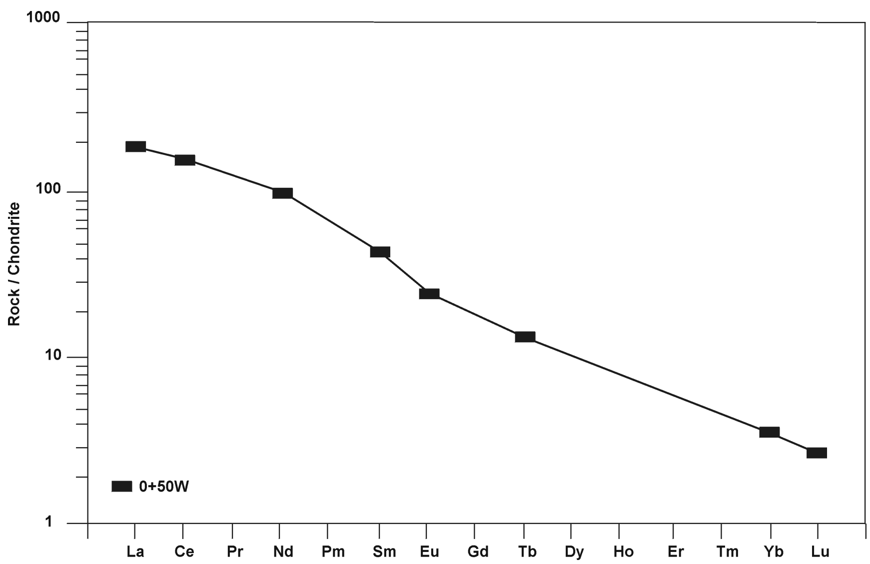

Figure 13: Rare earth element rock geochemical profiles (samples 0+50W) through the britholite-allanite mineralized zone, Eden Lake.

geochemical anomalies for Ce, La and Nd occur. The remainder of the REEs are also covariant in these two areas, albeit at much lower concentration levels (Table 10).

Other Elements

Ba and Sr

Ba and Sr, which respectively vary from 1300 to 3300 ppm and 1400 to 2200 ppm, are diagnostic trace elements for the aegirine-augite syenite that hosts the britholite-allanite mineralized zone. High Ba and Sr concentrations are present in most vegetation tissues analysed during the orientation survey (Table 4), including 6900 ppm Ba and 1.2% Sr in ashed alder twigs.

Soil geochemical results (enzyme leach^{sm}) for Ba vary from 511 to 4423 ppb and for Sr from 485 to 3200 ppb and are the most abundant elements determined in this sample set. The distribution of Ba in the b-horizon at Eden Lake is generally non-descript with somewhat higher values located adjacent to the outcrop and in the northern portion of the grid. Sr results are significantly different with two main areas of enrichment. High Sr contents occur adjacent to the syenite outcrop on the west side of the grid and at the eastern extremity of the grid in an area devoid of outcrop.

U and Th

The mineral britholite has been identified as a concentrator of U and Th in the Eden Lake mineralized zone (Arden, 1995). Accordingly, the covariance of either of these elements with the REEs in overburden-covered terrain would be significant in terms of prioritizing geochemical anomalies. Uranium distribution in the b-horizon indicates decreasing concentrations away from the syenite outcrop-overburden interface whereas Th distribution is more variable. Thorium is covariant with U at the outcrop/soil interface but also at the eastern extremity of the sampling grid where high REE contents were identified in both b-horizon soils and in alder twigs.

Reproducibility of Cu, Pb, Zn, Ga, SQSc, V, Zr, Rb, Nb, Br and Mn is suspect. This is based on the collection and analysis of 6 field replicate samples with reproducibilities exceeding ±25%, albeit at relatively low levels of concentration. Accordingly, interpretations

Table 10: B-horizon enzyme leach^{sm} soil geochemical data, britholite-allanite mineralized area, Eden Lake. Analyses in parts per billion. Analyses by Activation Laboratories Ltd., Ancaster, Ont.

Sample	Grid Reference	S.Q.Li	S.Q.Cl	S.Q.Sc	S.Q.Ti	V	Mn	Co	Ni	Cu	Zn	Ga	Br	Rb	Sr	Y	Zr	Nb	Cd	I	Cs	Ba	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Er	Yb	Pb	Th	U
1	0+70E	71	9715	32	1606	53	291	22	48	5	90	15	106	195	1039	51	59	11	1	37	4	4423	203	402	55	191	25	7	21	5	12	4	5	29	79	31
2	0+95E	27	<3000	<10	805	27	116	14	26	5	35	4	30	159	1543	24	19	4	0.8	19	1	2403	92	184	28	98	12	3	12	3	6	2	3	14	37	21
3	0+120E	51	<3000	<10	871	37	261	22	38	5	106	5	105	147	558	32	<1	7	2.2	21	2	2680	87	172	23	79	12	3	10	3	7	2	3	19	32	13
4	0+145E	23	4833	<10	1147	30	228	36	39	5	86	4	30	163	1016	15	47	10	0.3	<10	2	1666	49	103	13	44	6	2	6	2	4	1	2	20	36	9
5	0+170E	51	8440	90	2376	78	506	29	57	18	57	16	58	169	2195	54	79	14	0.3	29	4	2526	203	378	43	154	21	4	18	3	10	4	4	24	57	13
6	25S, 70E	39	<3000	<10	490	56	169	10	28	5	66	2	47	120	3200	46	29	8	0.7	37	3	2613	169	338	48	181	23	6	21	3	11	3	4	21	48	46
7	25S, 95E	48	<3000	<10	901	31	208	17	28	5	50	7	38	142	1002	33	4	5	1.3	18	2	2582	145	273	39	140	17	5	19	2	8	2	3	16	41	27
8	25S, 120E	43	4612	15	1552	89	271	20	29	5	153	7	43	113	999	21	<1	16	1	<10	1	1183	63	130	17	62	8	2	9	1	4	1	1	31	28	22
9	25S, 145E	46	<3000	<10	650	22	356	21	37	5	76	3	66	140	2131	17	<1	6	1.2	<10	1	2901	62	121	16	56	8	2	8	2	4	1	1	27	26	17
10	25S, 170E	108	<3000	190	3624	136	419	28	75	27	75	27	40	247	1610	51	198	28	<0.2	20	6	1964	174	435	53	194	25	6	23	3	13	5	5	39	105	18
11	25S, 170E	149	3399	272	1916	200	605	30	101	52	100	11	32	248	1417	63	291	38	<0.2	32	8	2037	207	532	64	233	33	7	28	4	17	7	6	50	113	19
12	25S, 170E	142	<3000	261	2062	196	727	34	107	50	125	9	31	301	1502	64	281	39	<0.2	28	10	2140	211	523	68	240	33	7	28	4	16	6	7	61	116	21
13	25S, 170E	129	3253	202	2648	151	580	38	87	37	102	14	32	271	1623	54	195	34	0.5	26	7	2182	187	457	52	198	25	6	23	3	13	4	5	50	98	18
14	25S, 170E	209	4101	412	3150	244	850	48	132	69	147	14	84	359	1528	70	404	55	<0.2	32	11	2626	247	647	74	262	36	7	30	4	16	6	7	75	163	24
15	25S, 170E	140	4145	125	1435	107	309	28	70	25	61	8	<30	145	1172	48	190	17	<0.2	22	3	1415	156	367	50	175	24	5	21	3	12	4	4	28	97	17
16	50S, 110E	38	3787	32	3673	168	312	12	32	12	131	10	30	83	1590	27	47	50	0.8	16	2	1426	110	257	32	119	15	4	14	2	7	3	2	70	61	33
17	50S, 85E	55	3221	24	2093	82	256	10	27	5	95	9	38	89	1020	14	15	16	0.3	<10	2	1418	60	121	17	62	9	2	6	1	4	1	1	34	36	21
18	50S, 135E	36	<3000	<10	2180	88	259	10	22	5	81	9	65	76	947	12	<1	19	0.7	<10	<1	843	47	101	14	48	6	2	7	<1	3	1	<1	34	30	23
19	50S, 160E	15	3954	<10	2144	56	303	7	14	5	160	6	30	71	485	7	4	37	1.3	<10	2	511	26	53	7	26	3	1	3	<1	2	<1	<1	35	19	14
20	25N, 60E	38	<3000	<10	865	41	196	21	31	5	47	5	49	164	1853	30	11	6	0.3	14	2	3032	115	235	29	108	14	4	13	2	8	2	2	22	42	17
21	25N, 85E	89	4271	<10	1111	31	262	24	60	5	73	6	63	229	1291	27	28	6	0.8	17	2	2497	136	257	34	121	16	4	13	2	6	2	2	13	46	26
22	25N, 110E	86	6751	<10	904	27	287	43	67	5	64	4	46	200	889	27	17	6	1.5	19	2	3279	101	191	25	95	12	3	12	2	6	2	2	19	47	22
23	25N, 135E	195	<3000	86	1716	79	656	63	105	14	161	9	125	246	935	33	70	19	0.8	28	5	4320	121	263	29	108	17	4	13	2	8	3	3	37	64	13
24	25N, 160E	151	5762	72	1247	59	1253	82	82	9	78	7	51	231	1063	32	114	13	1	24	3	2997	130	262	28	97	13	3	13	2	8	2	2	27	94	12

Table 11: Summary of descriptive statistics for enzyme leach^{sm} geochemical data, Eden Lake b-horizon, soil samples. Analyses based on 19 samples unless otherwise indicated. All analyses in parts per billion.

Element	Range	Mean	Standard Deviation
La	26-203	110	53
Ce	53-435	225	109
Nd	26-194	104	50
Pr	7-55	29	14
Dy	2-13	7	3
Gd	3-23	13	6
Sm	3-25	14	6
Ba	511-4423	2382	1050
Sr	485-3200	1335	655
U	9-46	21	9
Th	19-105	49	23
Cu	5-27	8	6
Pb	13-70	28	13
Zn	35-161	89	38
Ni	14-105	44	24
Ga	2-27	8	6
Co	7-82	26	19
SQLi	15-195	64	46
SQSc(n=8)	15-190	68	57
Y	7-54	29	14
V	22-168	63	39
Zr(n=15)	4-198	49	52
Nb	4-50	15	12
I(n=13)	14-37	23	8
Mn	116-1253	348	251
Rb	71-247	157	57
Br	30-125	56	28

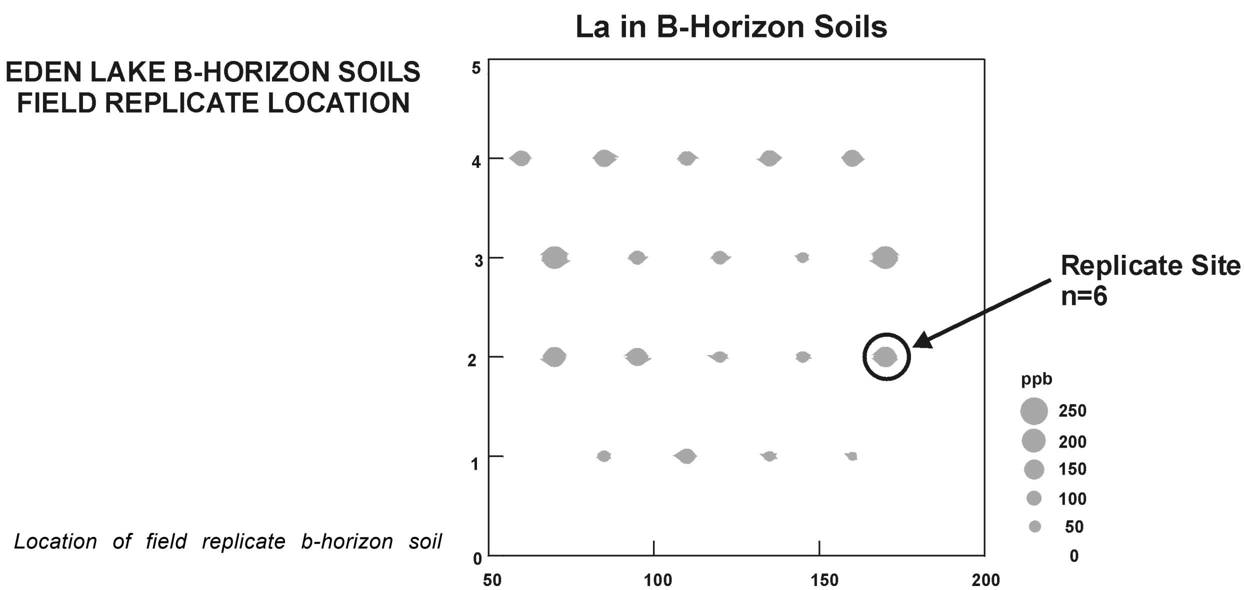

Figure 14: Location of field replicate b-horizon soil samples.

based on these elements were not undertaken. The remaining elements, including I, Ni, Co, SQLi and Y, have reproducibilities of <± 25% (Table 12). The highest concentrations of I occur adjacent to the syenite outcrop on the western edge of the grid as well as on the eastern and northeastern parts of the grid. The range for I in the dataset is small (14–37 ppb). The elements Ni, Co and SQLi are somewhat covariant with I with the highest concentrations from the northeast portion of the grid. High Y concentrations have similar spatial distributions as I and the LREEs. Samples with 40 to 60 ppb Y occur adjacent to the syenite outcrop and at the eastern extremity of the sampling grid. In contrast, samples collected from the central portion of the grid contain 10 to 30 ppb Y.

Hydrogen Ion and Specific Conductance

The pH and specific conductance of b-horizon soil samples collected for enzyme leach analysis were measured and results are tabulated in Table 13. The pH and conductivity measurements were corrected and converted to H^+ and specific conductance using the formula from Govett (1976) and reproduced with examples in Govett et al. (1984). The data indicate elevated H+ and *K* in a select number of samples (Figs.19, 20) and are moderately correlated to high REE contents in soils and vegetation.

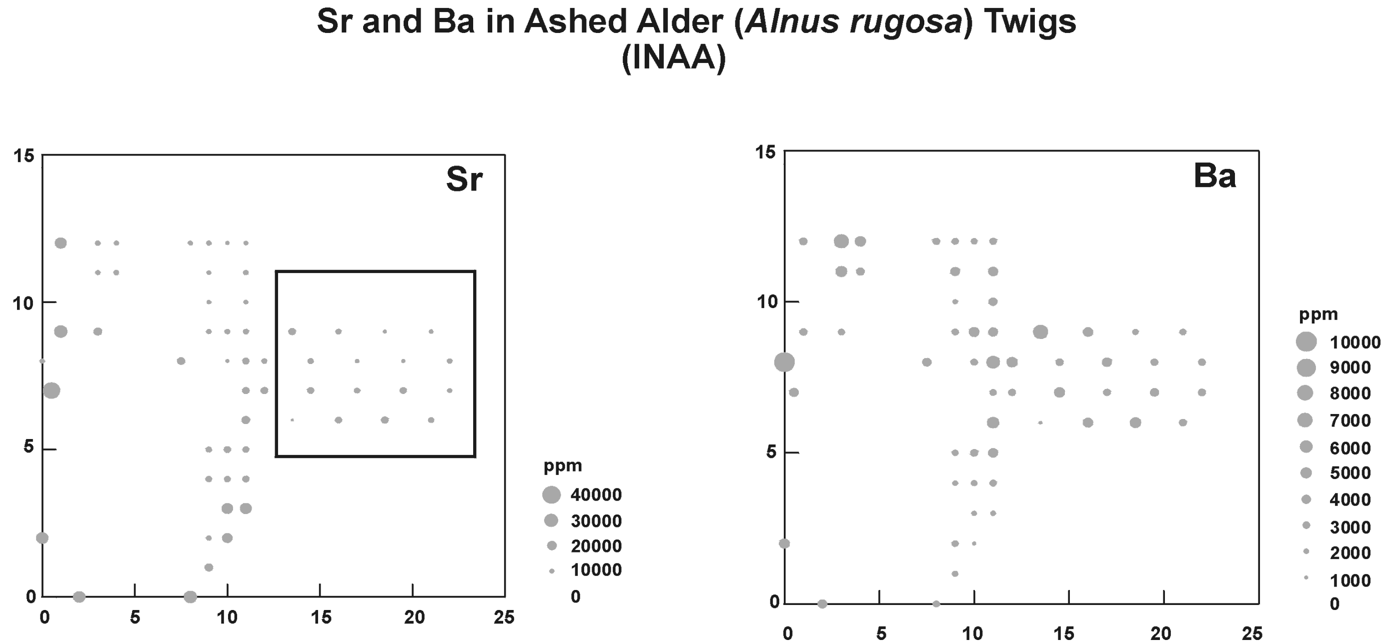

Figure 15: Bubble plots of Sr and Ba contents in ashed alder twigs, Eden Lake britholite-allanite mineralized area.

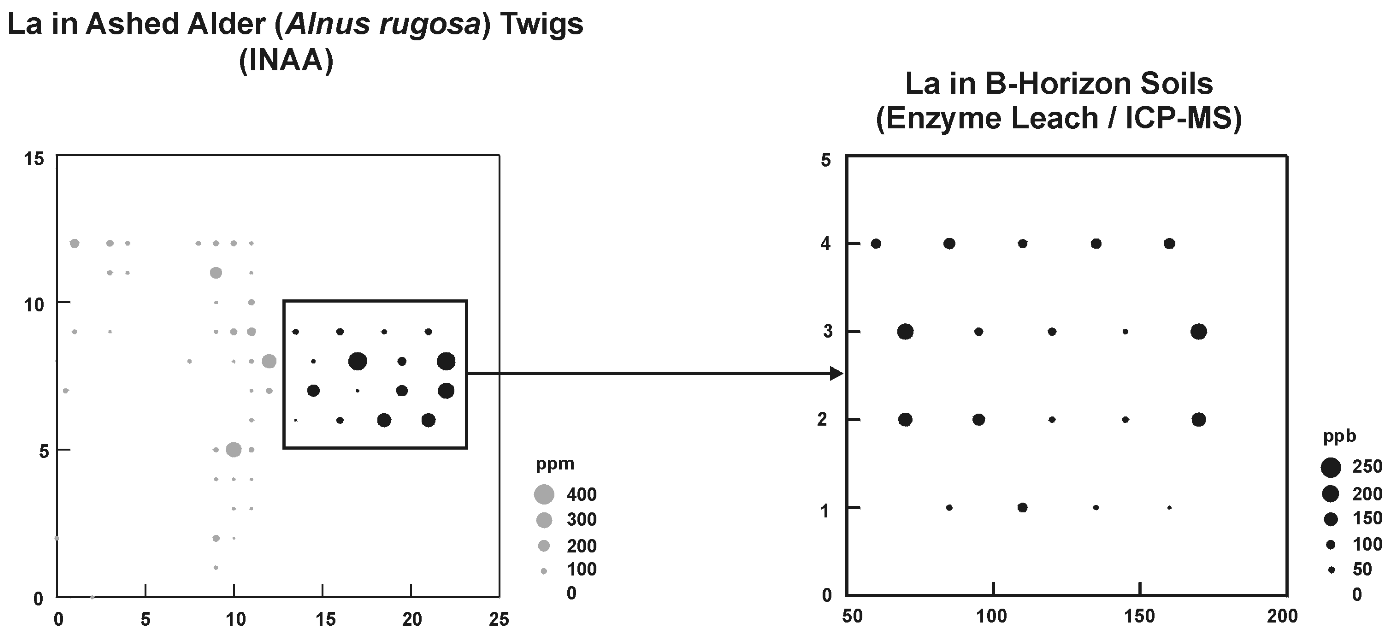

Figure 16: Bubble plots depicting the variation in concentration of La contents in b-horizon soils (enzyme leach^{sm}) and alder twigs, Eden Lake britholite-allanite mineralized area.

CONCLUSIONS

Definitive statements regarding the applicability of rock, soil and vegetation geochemical surveys to REE exploration in the Eden Lake area can be made on the basis of this study. The host rocks to the britholite-allanite REE mineralized zone are characterized by greatly elevated REE contents as well as distinctively high Ta, Cs, Fe, U, Th, Au, As and Sb. This combination of REEs and associated elements should permit prioritization of soil and/or vegetation geochemical anomalies during routine exploration in the area. Rock geochemical haloes are developed adjacent to the britholite-allanite mineralized zone for a variety of major and trace elements, however, they are characterized by low geochemical contrast and narrow areal extent. Typically, haloes are confined to within 10 to 20 m of the mineralized zone and offer little practical advantage over hand-held scintillometer surveys for property-scale evaluations. Rock geochemical variability can be attributed to mineralogical changes in the host rocks as a result of the formation of the mineralized zones (Arden, 1995). Elevated TiO_2, CaO and Nd, Ce, La, Y and Sm (titanite), P, As, Ba, Ce, La, Nd, Sm, Gd, Dy, Er, Yb and Pb (apatite), MgO and Fe_2O_3 (aegirine-augite), and Sr, Zn, Pb and REEs (allanite) reflect these mineralogical changes.

Soil geochemical surveys based on enzyme leach^{sm} dissolutions of the b-horizon offer an excellent geochemical exploration tool in the Eden Lake area. Areally extensive,

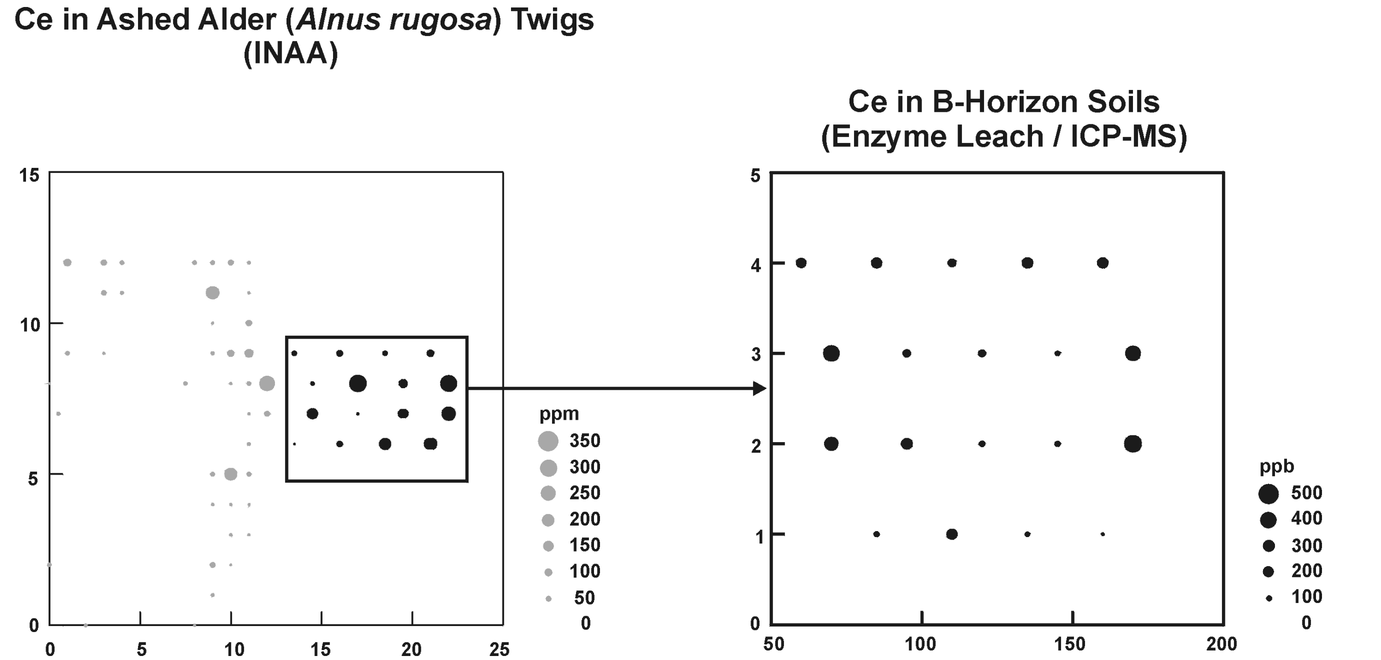

Figure 17: Bubble plots depicting the variation in concentration of Ce contents in b-horizon soils (enzyme leach^{sm}) and alder twigs, Eden Lake britholite-allanite mineralized area.

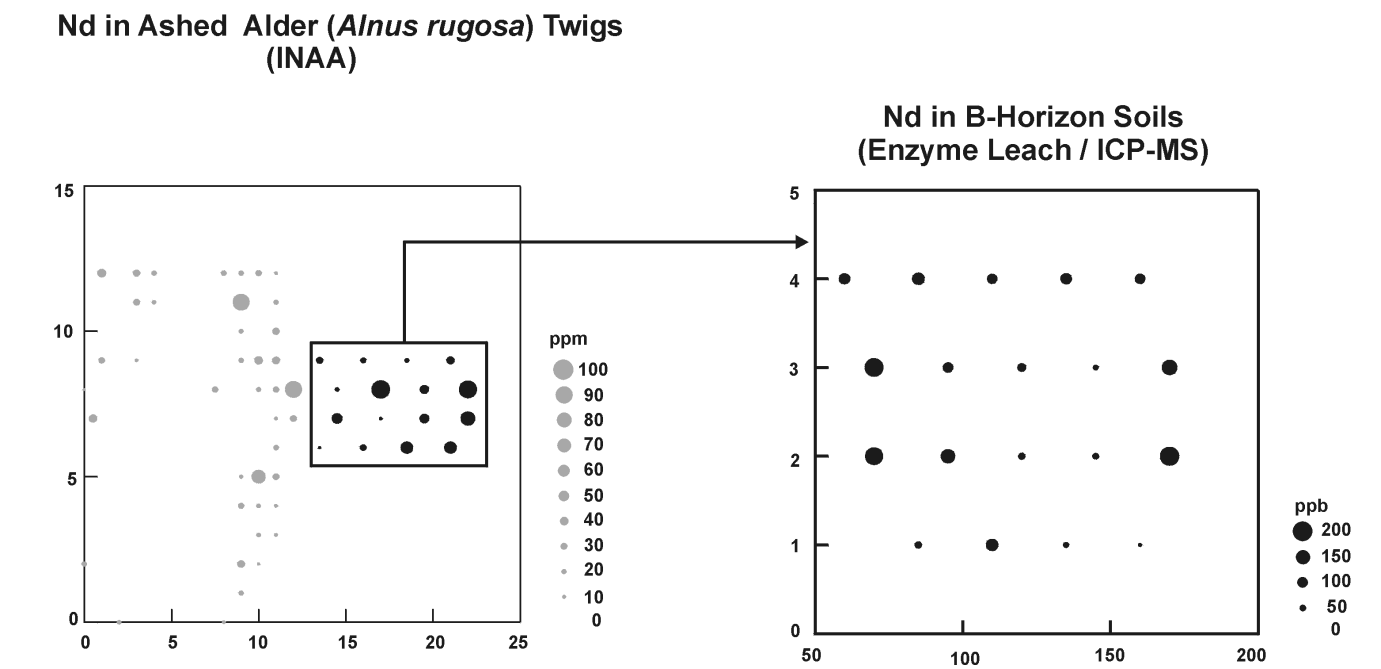

Figure 18: Bubble plots depicting the variation in concentration of Nd contents in b-horizon soils (enzyme leach^{sm}) and alder twigs, Eden Lake britholite-allanite mineralized area.

high contrast LREE anomalies were detected in an overburden-covered lineament downslope of the britholite-allanite mineralized zone. Soil geochemical data are reproducible and amenable to interpretation without data transformation. A second zone of high LREE concentrations in b-horizon soils has been recognized during the course of this survey. This anomaly is open to the east and may reflect a second zone of REE-enriched mineralization mantled by overburden. Of some concern in the sampling area is the nature of the overburden. Boulder alluvium represents a serious impediment to sample acquisition and, although not insurmountable, requires a significant time investment.

Critical to rapid, cost-effective and successful REE exploration in the Eden Lake area is the recognition of a number of vegetation tissues that have the ability to acquire and store high concentrations of REEs and particularly LREEs. Alder twigs collected adjacent to the britholite-allanite occurrence contain hundreds of ppm of LREEs in ashed sample and represent a readily available sampling medium. This is true for both outcrop dominated and overburden-covered terrain, both of which were assessed in this survey. Downslope leakage-type geochemical anomalies were identified for LREEs in alder twig samples collected adjacent to the outcrop-overburden interface and at the eastern extremity of the

Table 12: Summary of descriptive statistics for enzyme leach^{sm} analytical data from replicate (n=6) b-horizon soil samples, britholite-allanite area.

Element	Range	Mean	Standard Deviation
La	156-247	197	32
Ce	367-647	494	97
Nd	175-262	217	33
Pr	50-74	60	9
Dy	12-17	15	2
Gd	21-30	26	4
Sm	24-36	29	5
Ba	1415-2626	2061	392
Sr	1172-1623	1475	167
U	17-24	20	3
Th	97-163	115	25
Cu	25-69	43	17
Pb	28-75	51	16
Zn	61-147	102	32
Ni	70-132	95	23
Ga	8-27	14	7
Co	28-48	34	8
SQLi	108-209	146	34
SQSc(n=8)	125-412	244	98
Y	48-70	58	9
V	107-244	172	50
Zr(n=15)	190-404	260	84
Nb	17-55	35	13
I(n=13)	20-32	27	5
Mn	309-850	582	197
Rb	145-359	262	71
Br	30-84	42	21

The elements Er, Eu, Ge, Hf, Ho, In, Ir, Lu, Mo, Nd, Os, Pd, Pt, Re, Rh, Ru, Sb, Se, Sn, SQBe, SQCl, SQHg, Ta, Tb, Te, Tl, Tm, W and Yb are at or below the lower limit of determination.

“SQ”: semi-quantitive determination.

All analyses in parts per billion.

Table 13: Corrected pH (hydrogen ion) and conductivity (specific conductance) measurements, b-horizon soil samples, britholite-allanite area.

SAMPLE	Specific Conductance	H+ (Hydrogen Ion) ppb
E.L.-1	8	29
E.L.-2	4	16
E.L.-3	5	18
E.L.-4	1	6
E.L.-5	1	8
E.L.-6	1	6
E.L.-7	7	25
E.L.-8	14	44
E.L.-9	8	24
E.L.-10	10	32
E.L.-11	3	12
E.L.-12	3	14
E.L.-13	3	13
E.L.-14	6	23
E.L.-15	6	21
E.L.-16	16	52
E.L.-17	17	54
E.L.-18	13	40
E.L.-19	8	25
E.L.-20	3	13
E.L.-21	12	41
E.L.-22	11	39
E.L.-23	9	36
E.L.-24	12	43

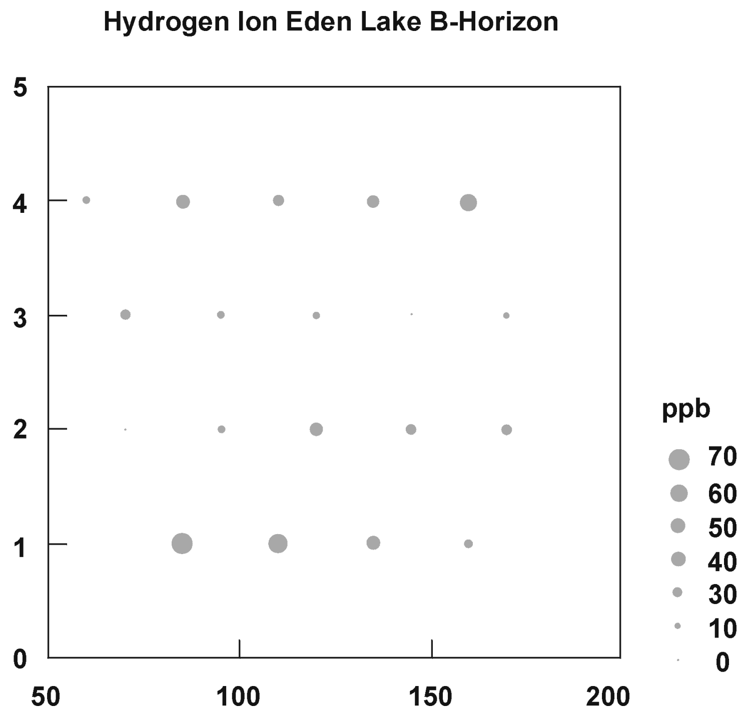

Figure 19: Bubble plot depicting the variation in concentration of hydrogen ion (H+) concentration in b-horizon soils, Eden Lake britholite-allanite mineralized area.

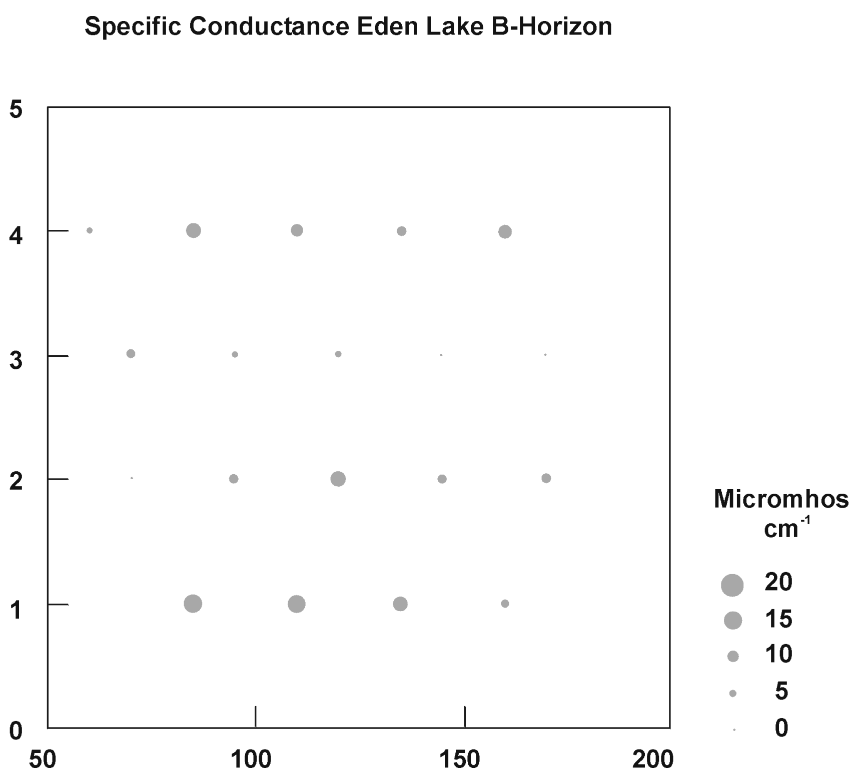

Figure 20: Bubble plot depicting specific conductance in b-horizon soils, Eden Lake britholite-allanite mineralized area.

sampling grid. The LREE alder twig geochemical anomaly from the eastern portion of the grid displays a high degree of correlation with the enzyme leach^{sm} soil geochemical LREE anomalies. This reflects the ability of the alders to approximate the REE content of the substrate.

Alder twigs are capable of acquiring and storing REEs at significant concentration levels that are easily determined by routine analytical approaches. In particular, LREE (La and Ce) contents in alder twigs identify high contrast, multisample anomalies that are areally larger than the observed mineralized zone. Rare-earth element exploration of the Eden Lake area can be facilitated by the collection and analysis of alder twigs. The twigs represent the most cost-effective sampling medium due to their ease of collection and relatively ubiquitous presence in this area. If alders are not available for sampling then b-horizon soils can be collected and analysed using the enzyme leach^{sm}.

Subsequent (Ziehlke, 1998, 1999) alder twig geochemical prospecting along the north-south-trending lineament adjacent and parallel to the trend of the known britholite-allanite REE mineralized zone by Strider Resources Ltd. has resulted in the discovery of highly elevated REE contents in ashed samples of alder

(Ziehlke, 1998). Overall, a strike length of approximately 1 km is indicated by this anomaly. Prospecting in the eastern portion of the intrusion along additional north-south-trending lineaments has uncovered extraordinary concentrations of the HREEs Dy, Ho, Er, Yb and Lu within coarse-grained black andradite zones of indeterminate extent. Prospecting in the westernmost north-south lineament in the intrusion has also identified anomalous Ce (2880 ppm) and Nd (840 ppm) in association with a late pegmatite and micropegmatite intrusion (Ziehlke, 1999). These developments are indicative of a REE-enriched intrusion with significant potential for extensive zones of REE mineralization. A recently completed (September 2000) enzyme leach geochemical orientation program conducted by Strider Resources Ltd. over selected lineaments in the Eden Lake intrusion indicate extraordinary enrichments of both light and heavy rare earth elements in b-horizon soils. These previously undocumented anomalies are further evidence for REE mineral deposit potential in this intrusion. Elevated zones of Au, As, Sb and Ag in the britholite-allanite zone suggest a potential for structurally-controlled precious metal mineralization in the Eden Lake intrusion.

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All vegetation geochemical analyses in this report are based upon ashed vegetation samples. Ashing was undertaken in the laboratories of the Geological Survey of Canada under the direct supervision of Dr. Colin Dunn. We acknowledge the contribution of Dr. Dunn to this study.

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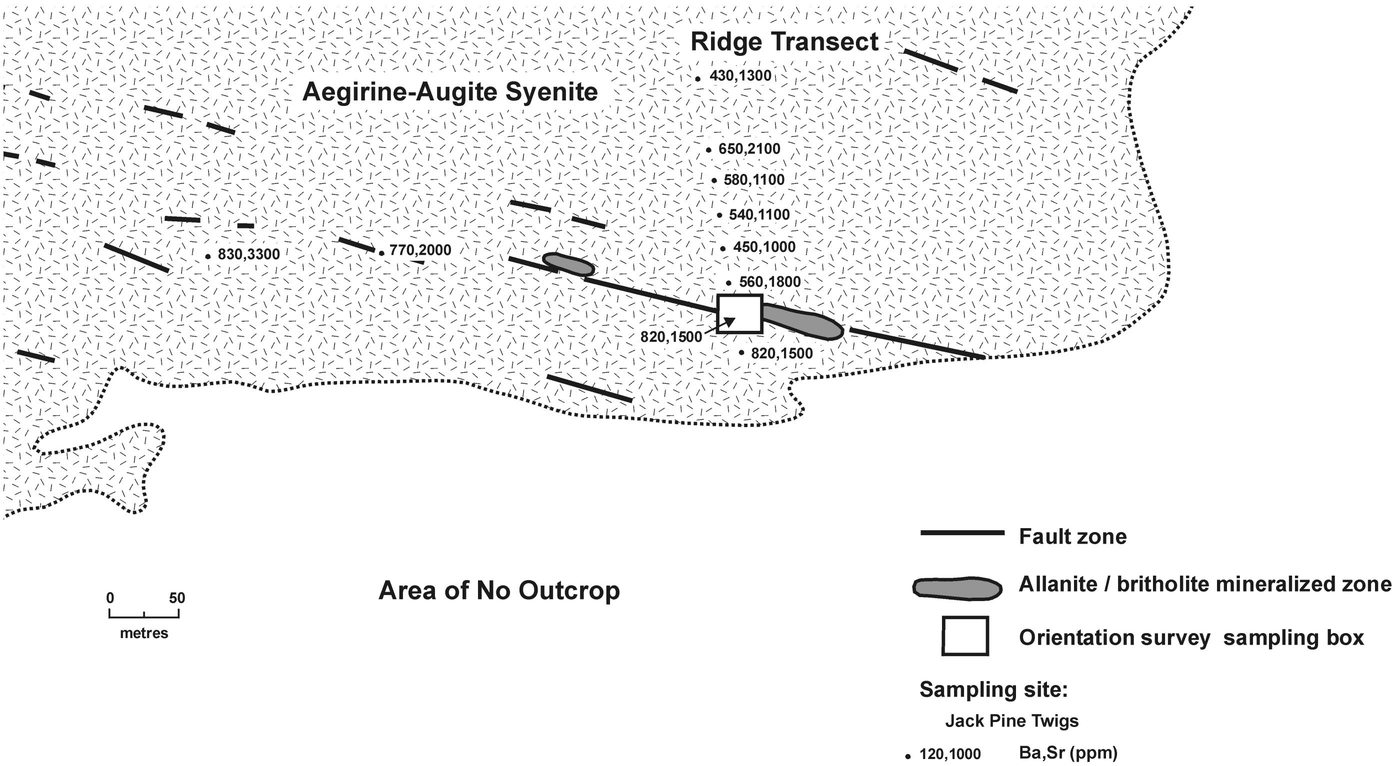
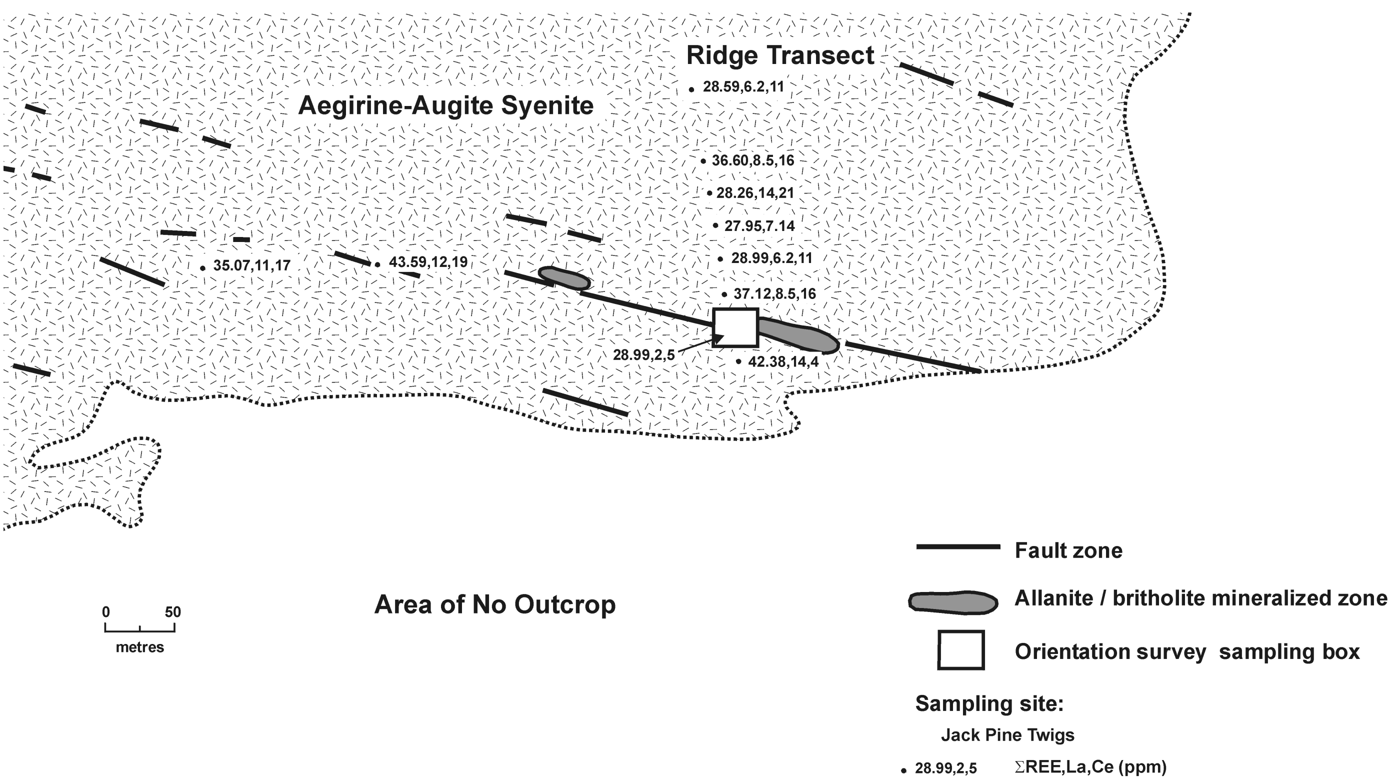
Appendix 1: Black spruce (*Picea mariana*) and Jack pine (*Pinus banksiana*) vegetation geochemical results from the Ridge and Overburden transects, britholite-allanite mineralized area, Eden Lake.

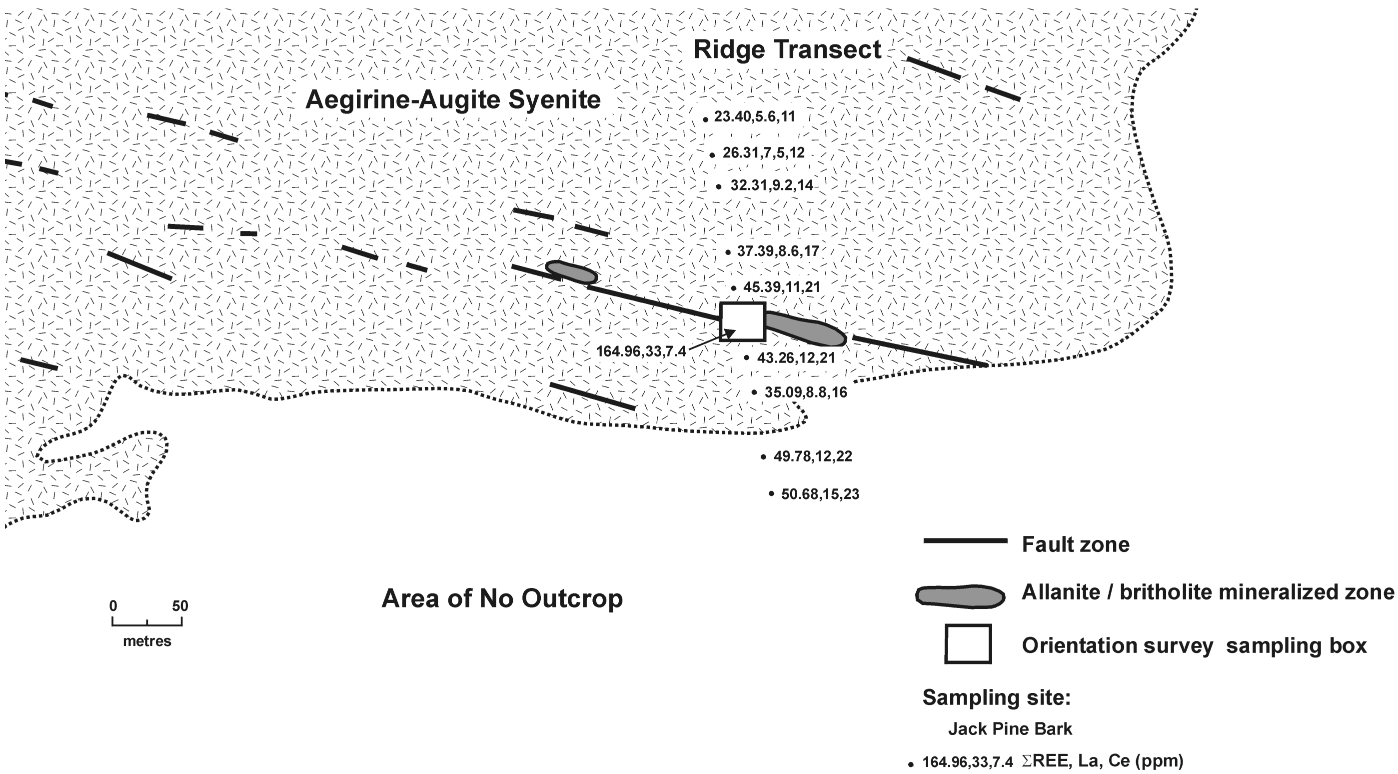


Barium and Sr concentrations in ashed samples of Jack pine (Pinus banksiana) twigs, Ridge Transect.

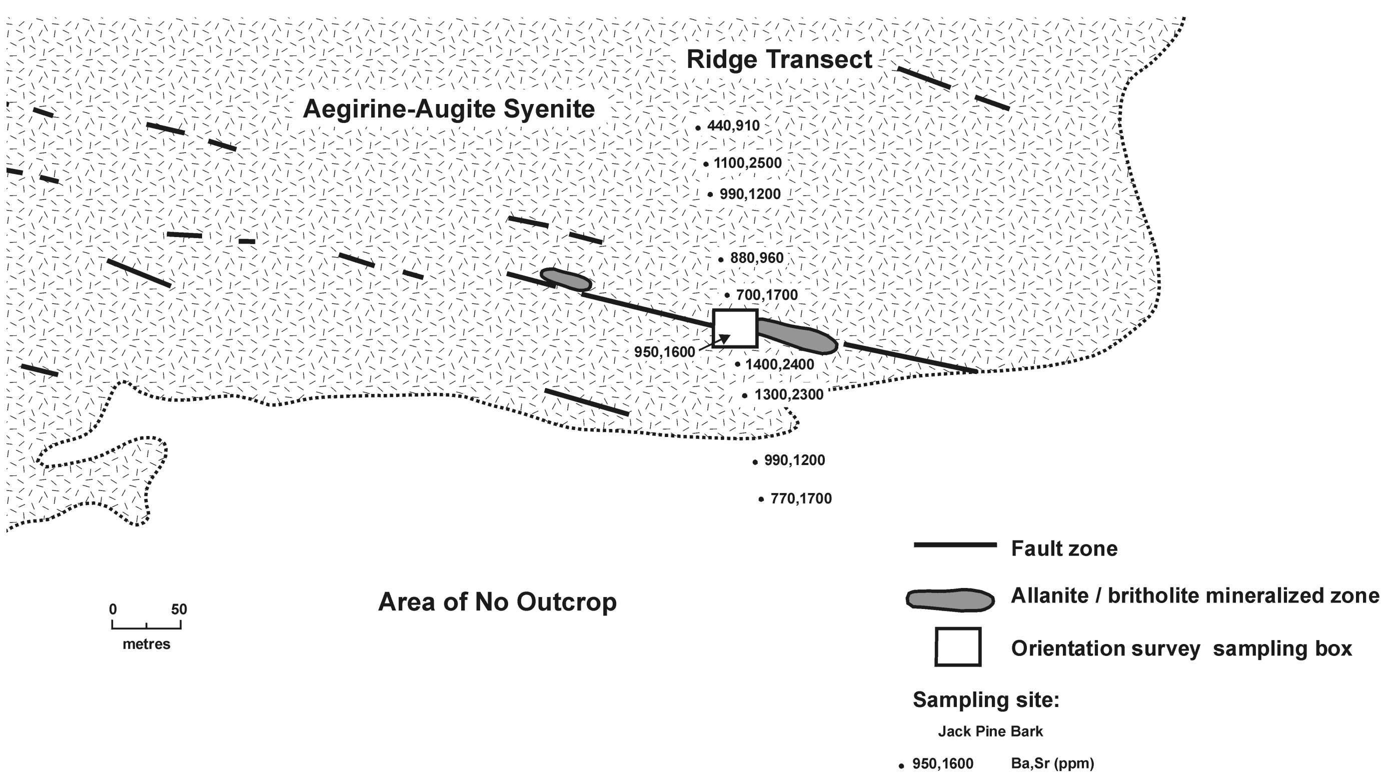


Total REE, La and Ce concentrations in ashed samples of Jack pine (Pinus banksiana) twigs, Ridge Transect.

Appendix 1: Black spruce (*Picea mariana*) and Jack pine (*Pinus banksiana*) vegetation geochemical results from the Ridge and Overburden transects, britholite-allanite mineralized area, Eden Lake. (continued)



Total REE, La and Ce concentrations in ashed samples of Jack pine (Pinus banksiana) bark, Ridge Transect.



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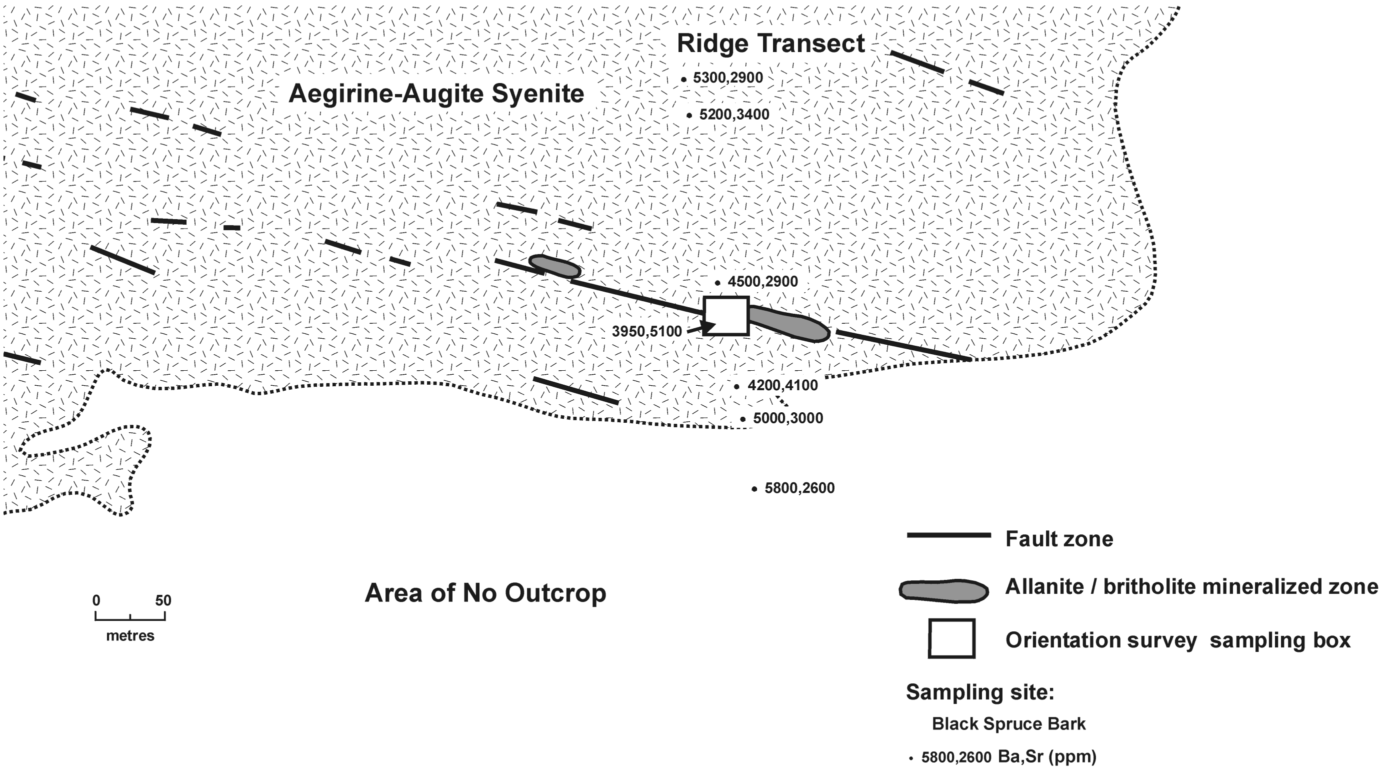
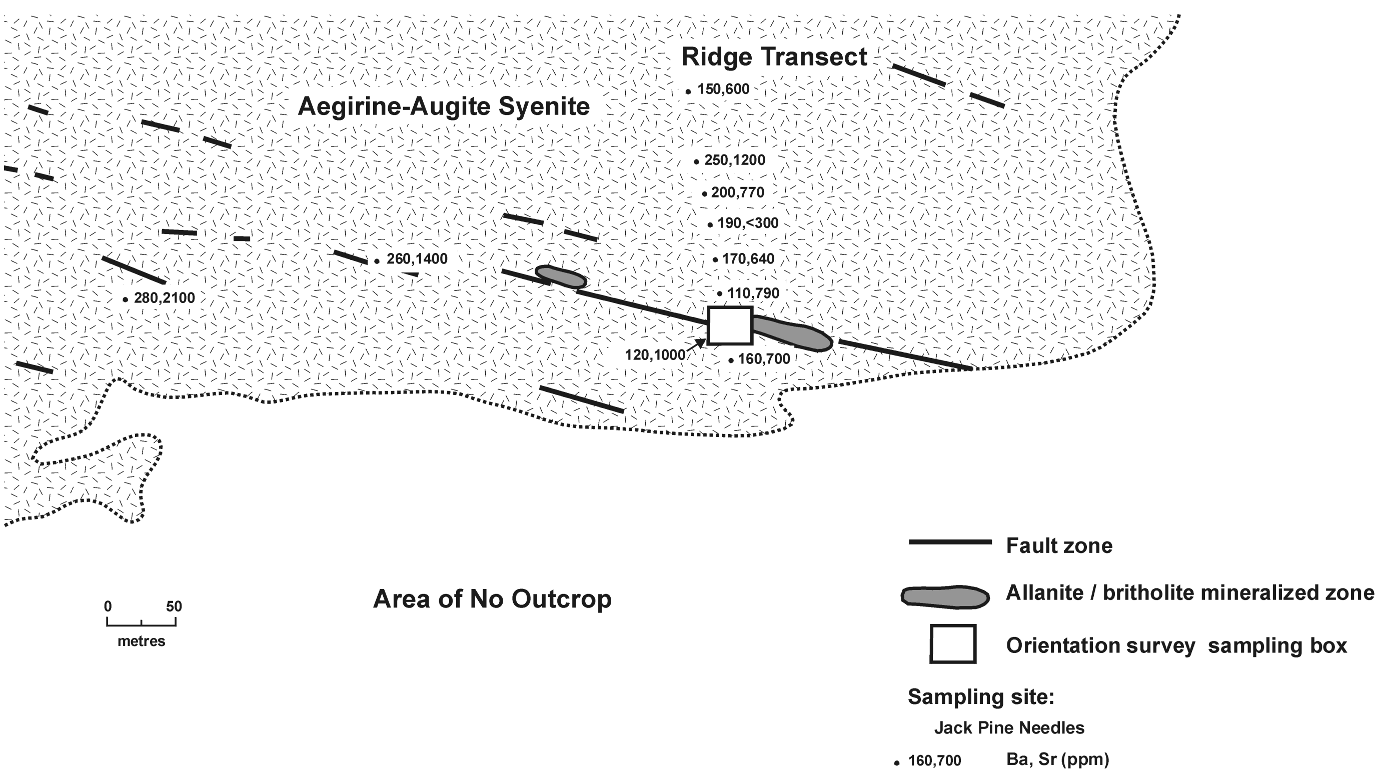
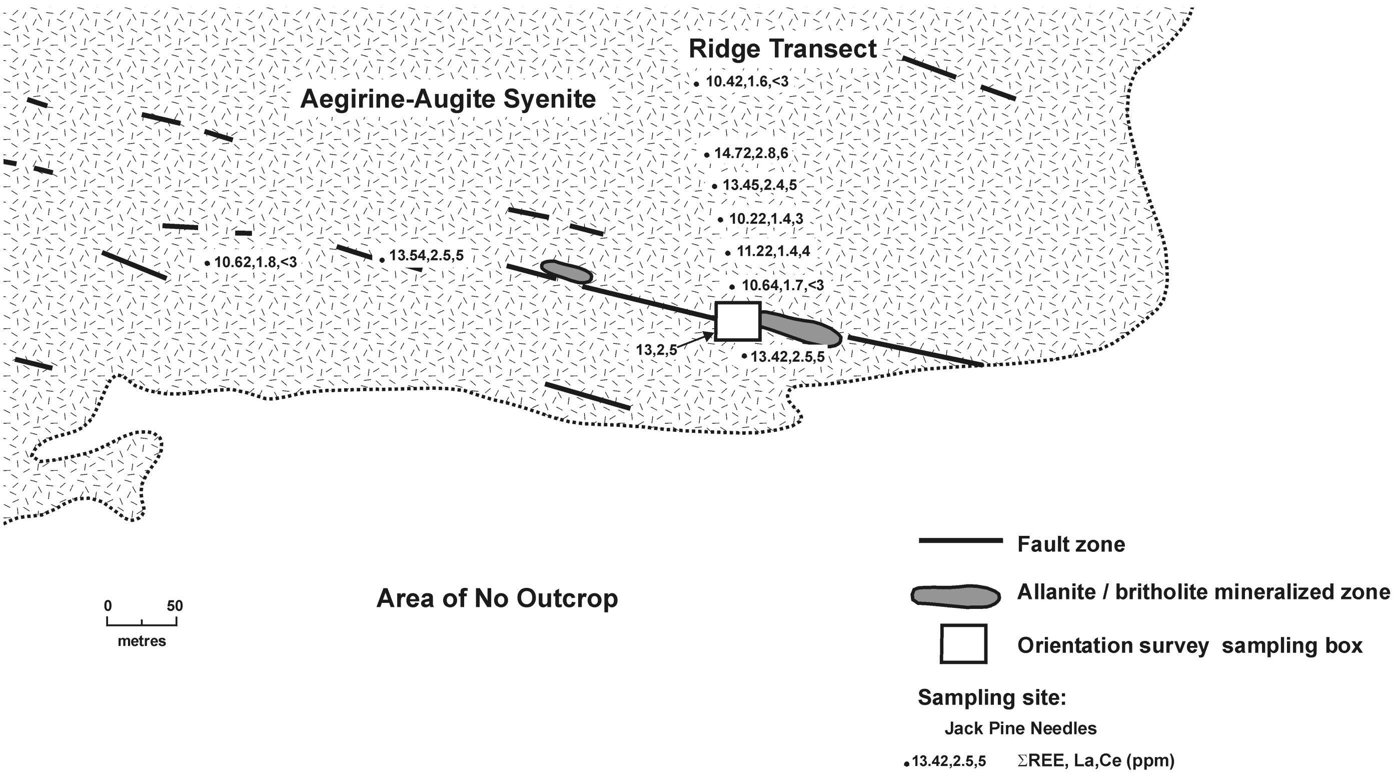


Barium and Sr concentrations in ashed samples of black spruce (Picea mariana) bark, Ridge Transect.

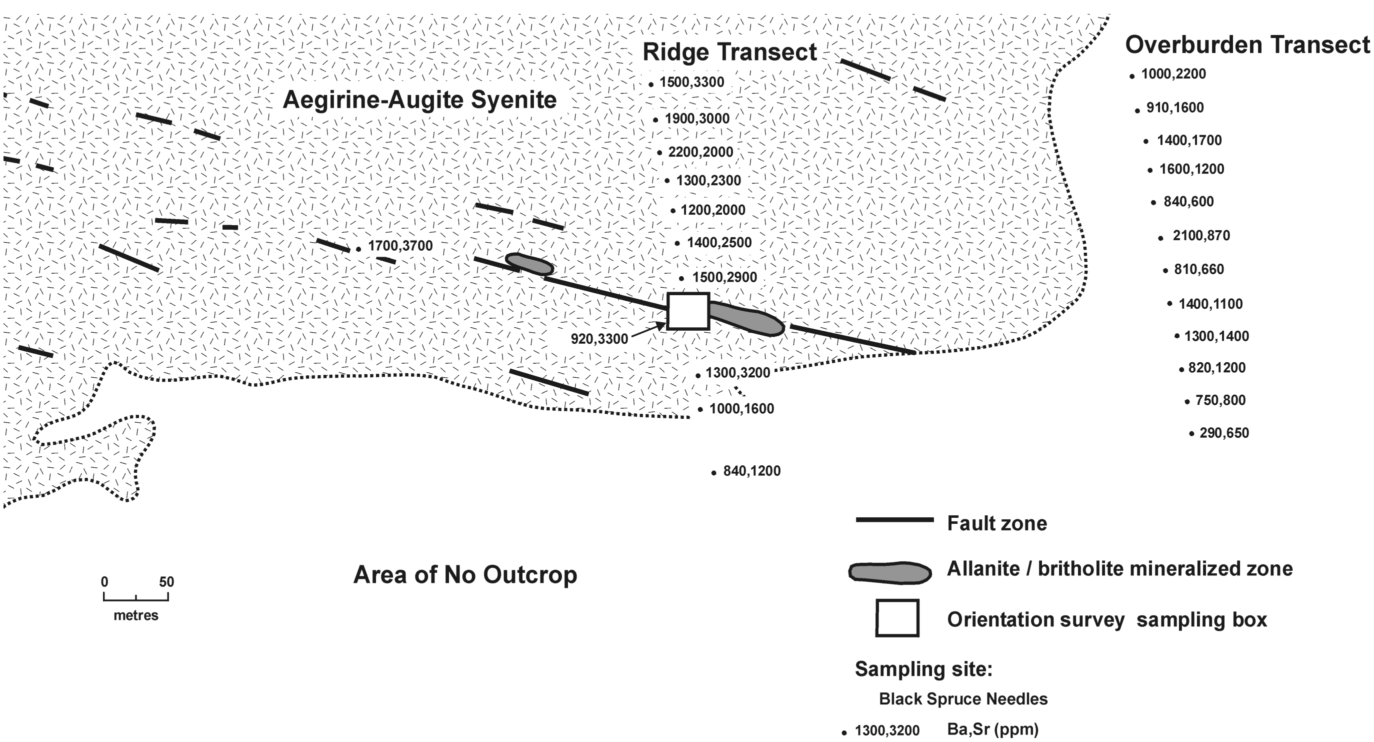


Barium and Sr concentrations in ashed samples of Jack pine (Pinus banksiana) needles, Ridge Transect.

Appendix 1: Black spruce (*Picea mariana*) and Jack pine (*Pinus banksiana*) vegetation geochemical results from the Ridge and Overburden transects, britholite-allanite mineralized area, Eden Lake. (continued)



Total REE, La and Ce concentrations in ashed samples of Jack pine (Pinus banksiana) needles, Ridge Transect.



Barium and Sr concentrations in ashed samples of black spruce (Picea mariana) needles, Ridge and Overburden Transect.

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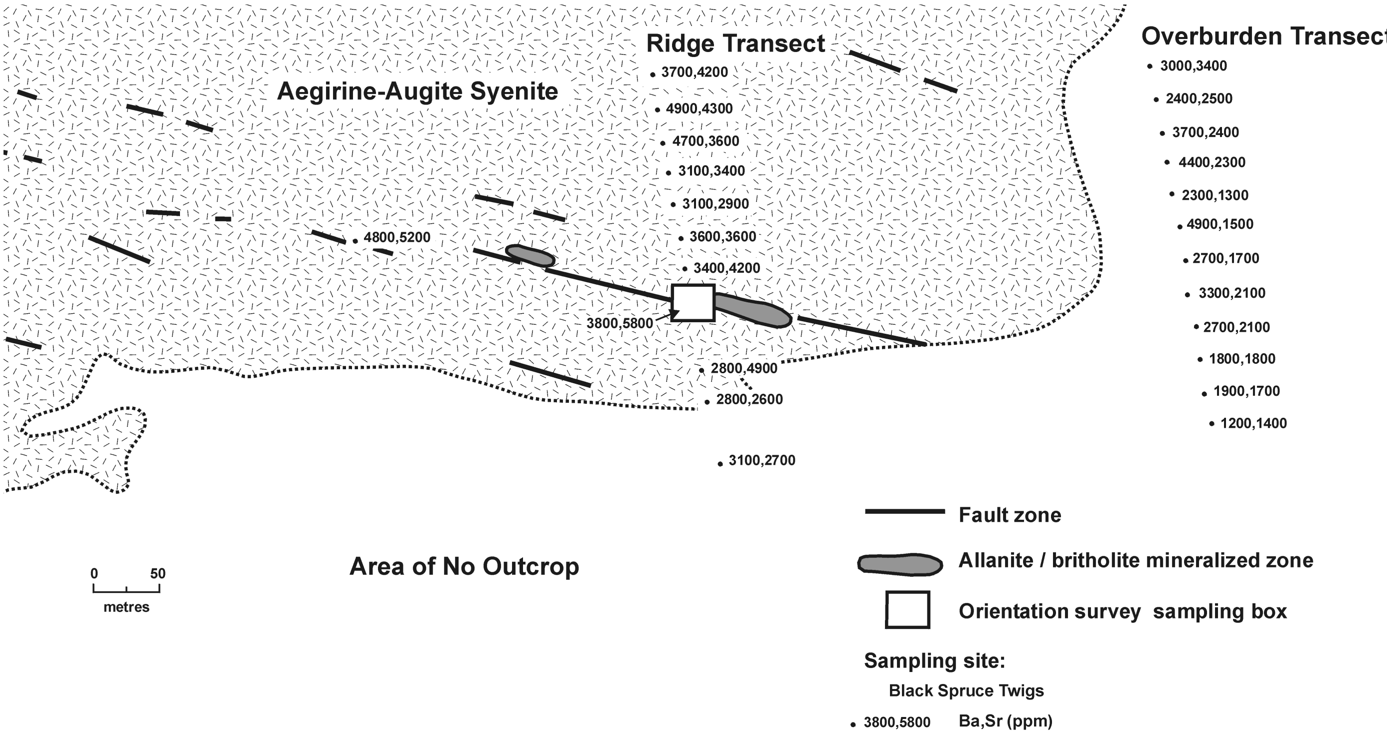
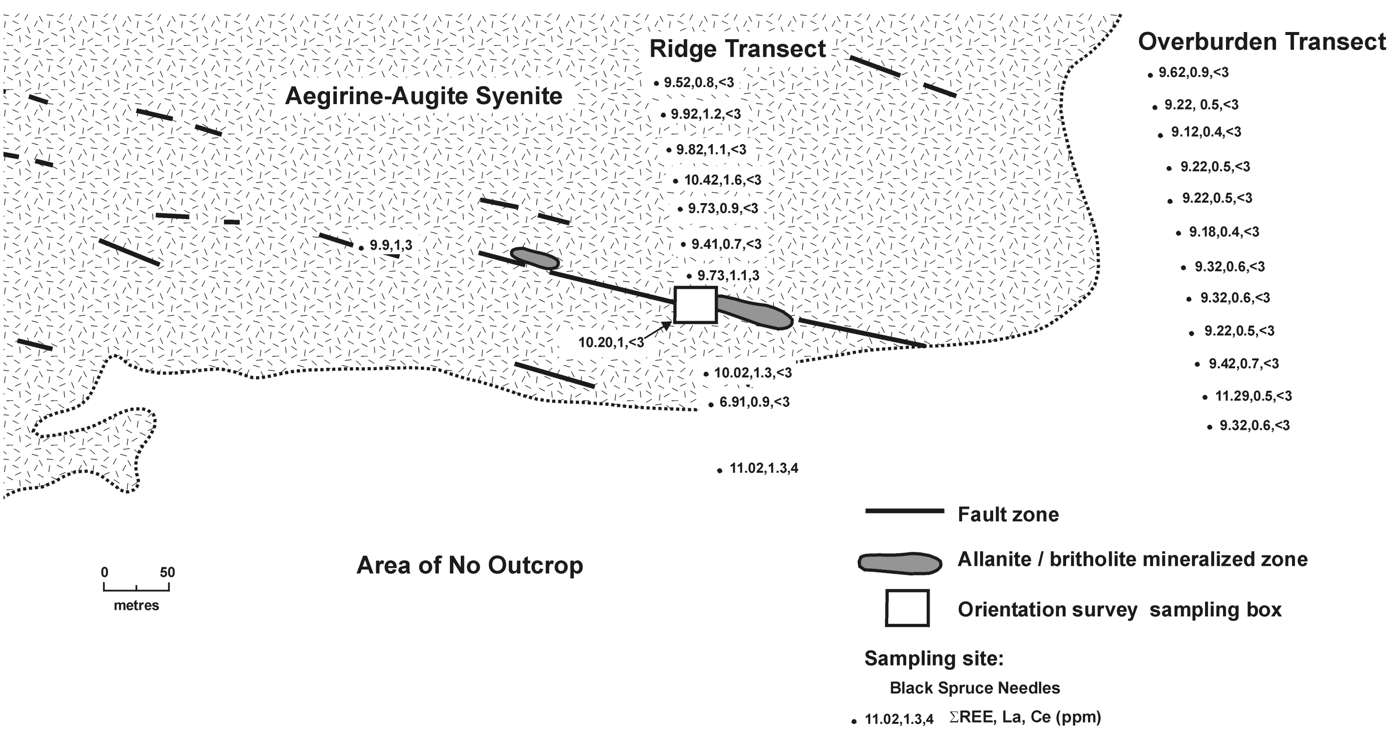
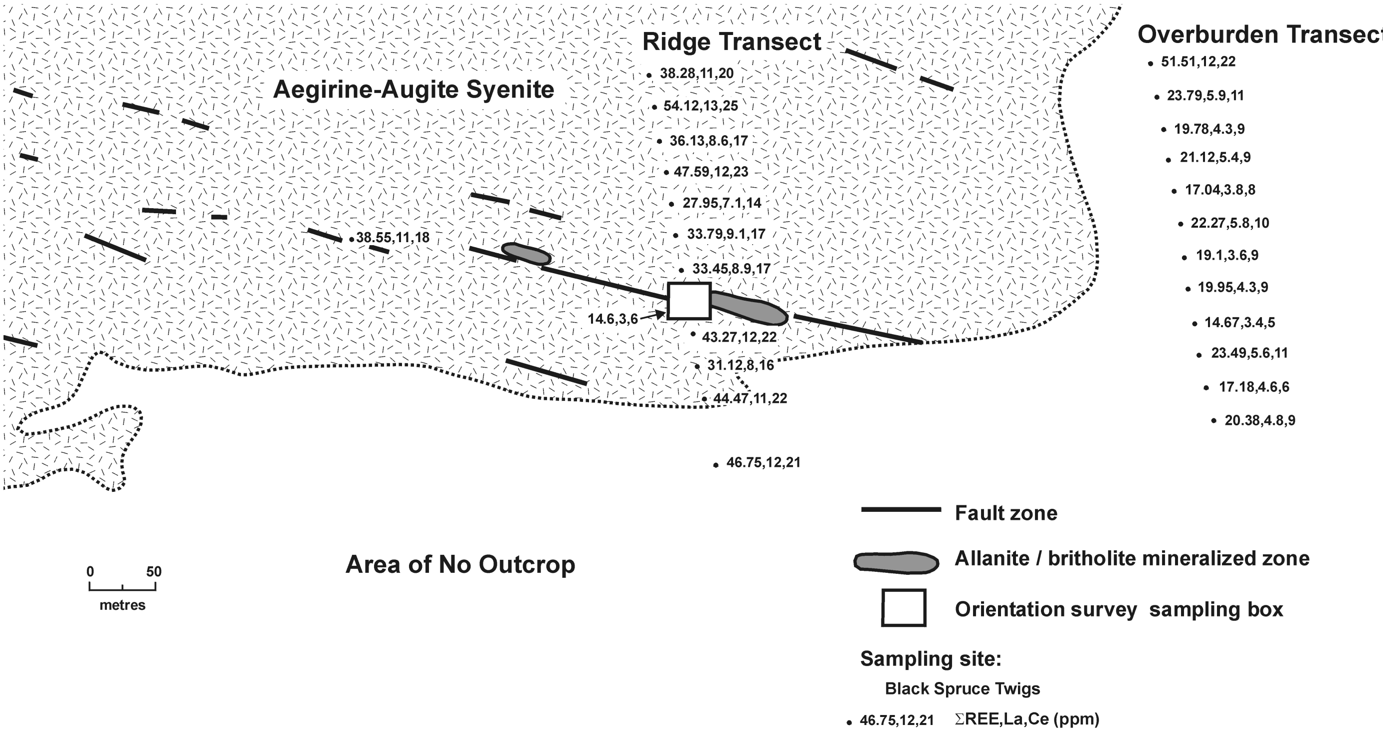


Barium and Sr concentrations in ashed samples of black spruce (Picea mariana) twigs, Ridge and Overburden Transects.



Total REE, La and Ce concentrations in ashed samples of black spruce (Picea mariana) needles, Ridge and Overburden Transects.

Appendix 1: Black spruce (*Picea mariana*) and Jack pine (*Pinus banksiana*) vegetation geochemical results from the Ridge and Overburden transects, britholite-allanite mineralized area, Eden Lake. (continued)



Total REE, La and Ce concentrations in ashed samples of black spruce (Picea mariana) twigs, Ridge and Overburden Transects.