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Biogeochemical survey over kimberlites in the Kirkland Lake area, northeastern Ontario

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INTRODUCTION

In 1992, the Geological Survey of Canada began a four year project in the Kirkland Lake area of northeastern Ontario designed to increase knowledge of the genesis of kimberlite, the principal host rock for diamonds, to improve techniques for kimberlite exploration and to evaluate the potential for the discovery of additional kimberlite occurrences in the region. Part of this project included the study of the geochemical and mineralogical character of known kimberlitic intrusions and determining associated geochemical signatures in various sample media that are routinely used in mineral exploration (e.g.. till, humus, soil and vegetation).

Most bedrock in the Kirkland Lake area is covered by glacial sediments, from a few metres to 100 m thick. By applying a combination of geophysical and drift prospecting methods several kimberlite pipes and dikes have been discovered in the Kirkland Lake area within the last 10 years (Brummer et al., 1992a; McClenaghan, 1993).

This report describes the geochemical results for tree tissue samples that were collected over two kimberlite pipes and one kimberlite dike in the Kirkland Lake area: the Diamond Lake and C14 pipes and the Buffonta dike. Pin cherry twigs, balsam fir twigs, black spruce twigs and black spruce bark samples were collected in order to evaluate their effectiveness in detecting the presence of kimberlite beneath the glacial sediments and to evaluate their potential use in diamond exploration. A series of overburden holes were subsequently drilled by the GSC on the two kimberlite pipes to determine the glacial stratigraphy of each site and to examine dispersal patterns in till down-ice. These results will be published at a later date. Biogeochemical data will be compared to geochemical results from till and soil on which the plants were living.

Location and Access

The Kirkland Lake kimberlite field is in northeastern Ontario, approximately 10 km to the north and east of Kirkland Lake and 100 km southeast of Timmins (Figure 1). The Diamond Lake pipe is the most easterly in the cluster, located at 48°06'20"N and 79°45'30" W, in the southwest corner of McVittie Township. It underlies the east bank of the Misema River and is accessed via the Fork Lake Road, running north from Highway 66. The Buffonta kimberlite dike is located in central Garrison Township at 48°28'02"N and 79°56'52" W on the old Buffonta Mines property, just west of the old Buffonta pit. The property is accessed via a gravel road, extending southeast from Highway 101. The C14 kimberlite pipe is located in south central Clifford Township, at 48°16'30"N and 79°48'W. The property is accessed via an old logging road running east from Highway 564, towards Kennedy Lake.

Geology

The Kirkland Lake kimberlite field is in the western part of the Archean Abitibi Greenstone Belt and is underlain by a typical assemblage of greenstone rocks dominated by mafic and felsic metavolcanics. Kimberlitic intrusions were emplaced in the area during the Late Jurassic, approximately 155 to 160 Ma (Brummer et al., 1992b) and consist of tuffisitic kimberlite breccia.

The Diamond Lake area is underlain by two kimberlite pipes, the north pipe is approximately 150 m in diameter and the south pipe is approximately 50 m diameter (Figure 2). The pipes intrude metasedimentary rocks, mainly greywacke and conglomerate. The bedrock surface is covered by a thick sequence of glaciofluvial sand and gravel of the Misema River Esker, on average 40 m thick (Averill and McClenaghan, 1994).

The Buffonta area (Figure 3) is underlain by mafic volcanic rocks and the Garrison monzonite stock (Jensen, 1982). Gold mineralization, with minor galena, molybdenite,

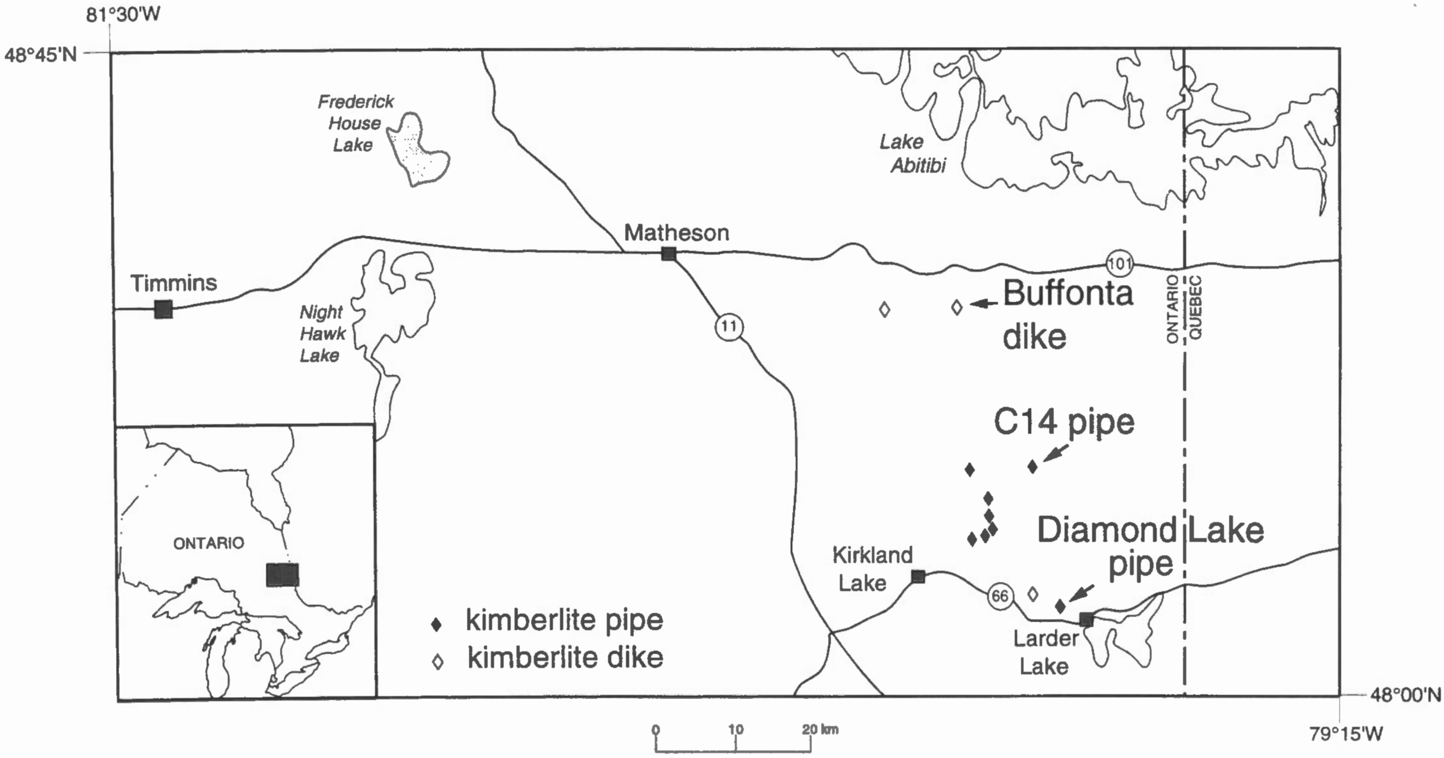

Figure 1. Location of the C14, Diamond Lake and Buffonta kimberlite intrusions in the Kirkland Lake kimberlite field, northeastern Ontario.

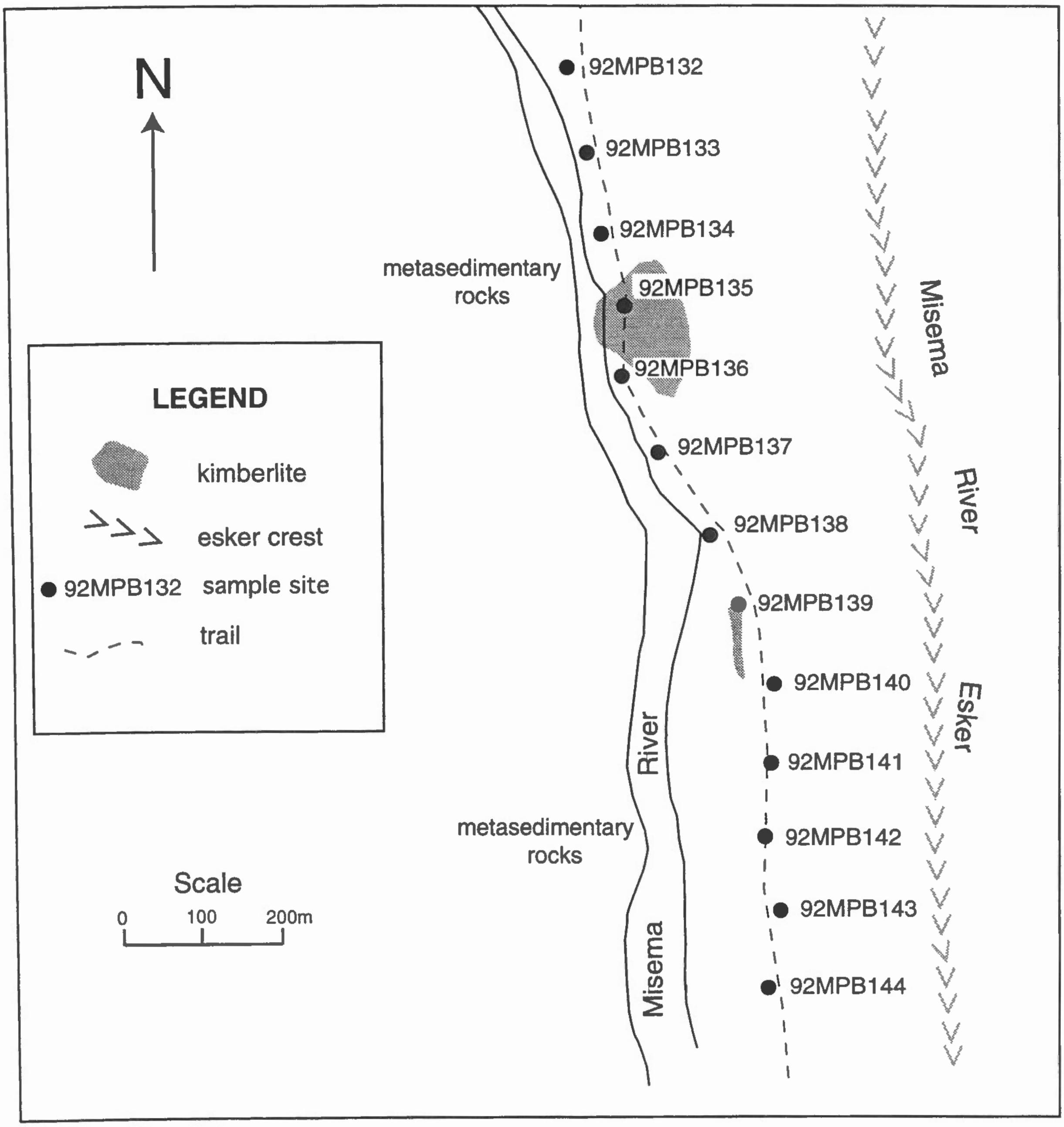

Figure 2. Diamond Lake bedrock geolgy and location of balsam fir sample sites.

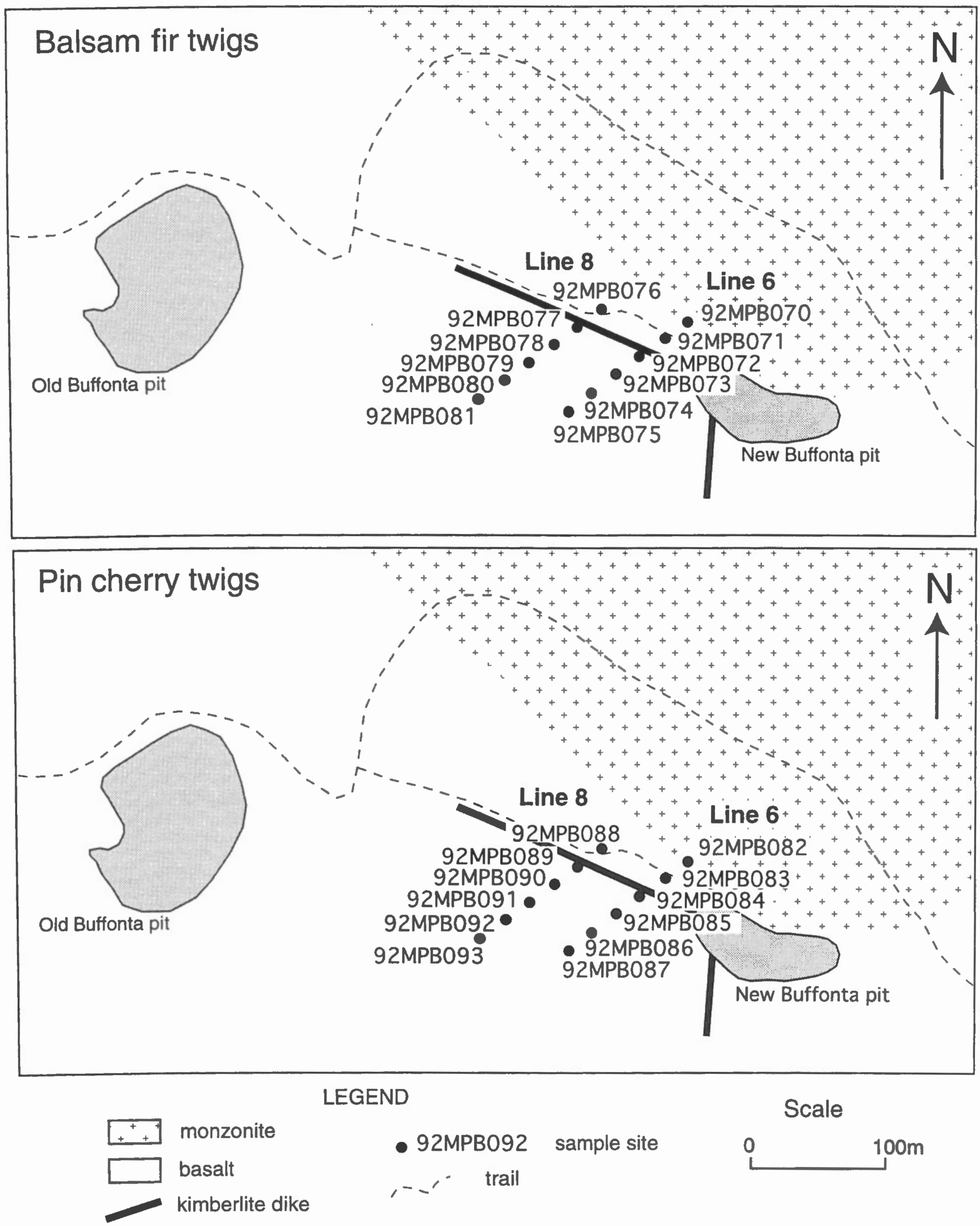

Figure 3. Buffonta bedrock geology and location of pin cherry and balsam fir sample sites.

argentite and chalcopyrite, occurs in quartz veins hosted by foliated volcanic rocks within the 1 km wide contact metamorphic aureole of the stock (Bath, 1990). The Buffonta kimberlite dike has intruded one of several northwestward shear zones related to the earlier intrusion of the Garrison stock. The dike is approximately 1 m wide where it subcrops and consists of kimberlitic breccia with angular quartz vein and pyritized felsic intrusive fragments within a kimberlite matrix (Barron and Barnett, 1993). On the west side of the new Buffonta pit, the dike has intruded along the margin of a 0.4 m wide quartz vein. Bedrock is covered by a thin blanket (up to 3 m) of Matheson Till.

The C14 pipe is approximately 200 m in diameter and intrudes felsic metavolcanic rocks (Figure 4). Mafic intrusive rocks lie 50 m to the south (Jensen, 1975). Several mineralized occurrences of pyrite, chalcopyrite, gold, sphalerite, molybdenite and galena which occur in felsic intrusive and felsic volcanic rocks northeast of the pipe may explain some of the biogeochemical metal enrichment in this area (Jensen, 1975). The C14 pipe is covered by approximately 20 m of glaciolacustrine clay and silt overlying 5 m of Matheson Till. Mafic intrusive rocks south of the pipe are covered by a thin, discontinuous veneer of Matheson Till (Figure 4).

METHODS

Sample Collection

Tree tissues were collected along transects over the kimberlite bodies during a two day period in August, 1992. The composition of forest cover was different over each kimberlite. At each location tissues of the dominant species were collected: twigs of balsam fir (*Abies balsamea*) at Diamond Lake; twigs and outer bark of black spruce (*Picea mariana*) at the C14 pipe; and twigs of both balsam fir and pin cherry (*Prunus pennsylvanica*) at Buffonta.

Samples of twig and foliage were snipped using standard anvil-type, teflon-coated, garden pruning snips, and placed in heavy duty brown paper hardware bags

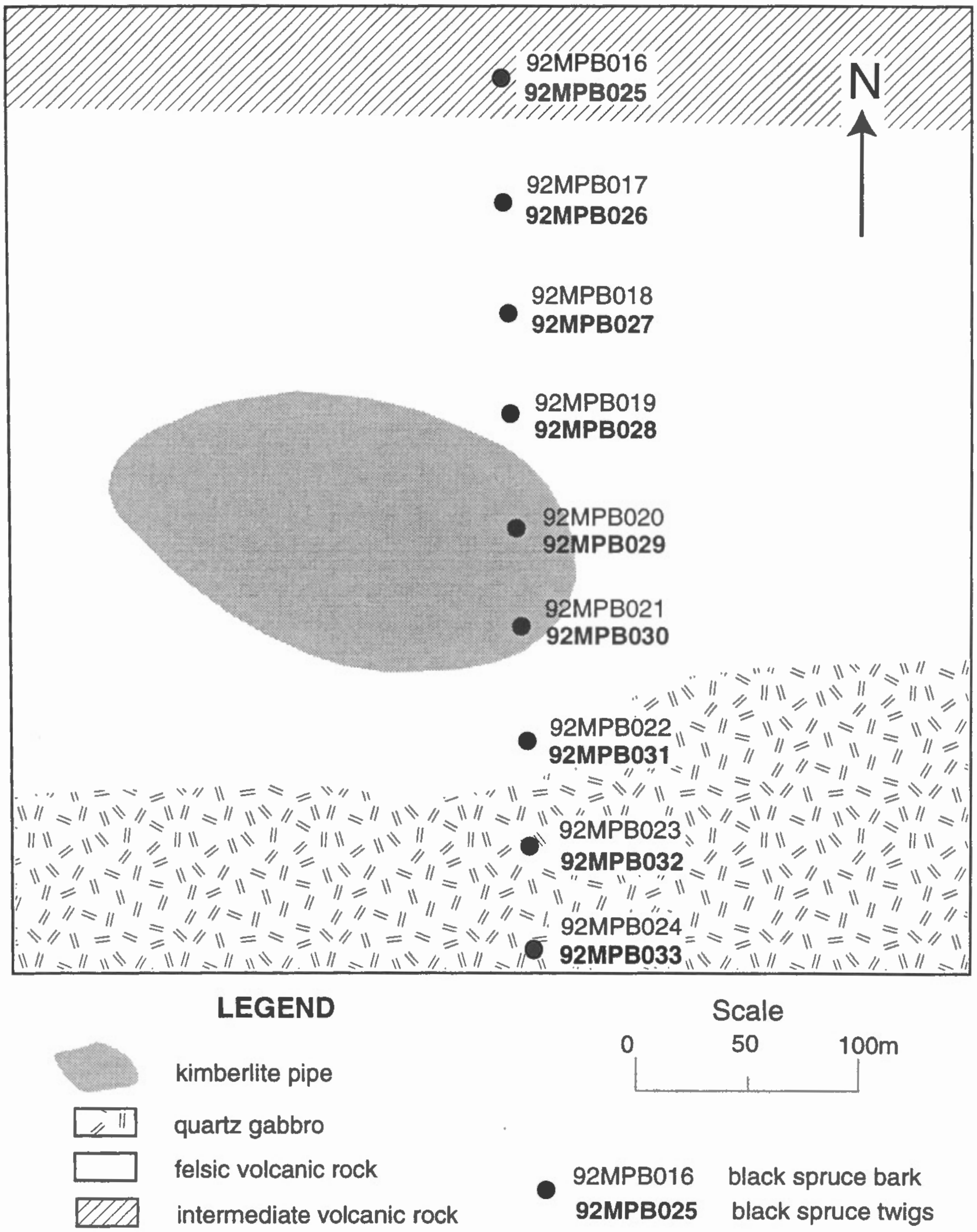

Figure 4. C14 bedrock geology and location of black spruce sample sites.

(approximately 25 x 35 cm) and secured with masking tape. Usually 5 to 7 twigs, each comprising 5 to 7 years of growth, provided the required amount of material (approximately 200 g fresh weight). Within the survey area this amount of growth was commonly 35 to 40 cm of twig. Where growth was more spindly and annual growth increments were shorter, up to 10 years of growth was collected. Although there is annual variation in the metal uptake and storage of many chemical elements (some accumulating near the twig ends), the over-riding factor for consideration in a biogeochemical sampling program is the *diameter* of the twig. It is important to maintain a consistent ratio of twig bark to twig wood, because many of the heavy metals are located in the bark of the twig rather than its woody tissue. If this ratio changes substantially, then variations in element content may be attributable to mixing thick with thin twigs, providing false anomalies. For the Kirkland Lake surveys the twig diameter at most locations was approximately 5 mm where twigs were 5 to 7 years old.

There are fewer variables that need to be considered during collection of black spruce bark. The only factor of importance is that only the loose, dead tissue comprising the scaly outer bark should be collected because its composition is substantially different from that of the inner bark. Most heavy metals accumulate in tree extremities (outer bark, twig ends and tree tops). Approximately 50 g of bark scales was scraped from each spruce tree using a hardened steel paint scraper and either a large hardware bag or a dust-pan to collect the scrapings. The bark scales were then placed into standard `kraft' paper soil bags. More details of sampling procedures and precautions are given in Dunn *et al.* (1993), and Brooks *et al.* (1995).

At Diamond Lake, balsam fir twigs were collected from 13 sample sites spaced 100 m apart along a 1200 m north to south transect (Figure 2). At the Buffonta property, pin cherry and balsam fir twigs were collected from 12 sites at 30 m intervals along two transects (Lines 6 and 8, Figure 3). At the C14 pipe, black spruce bark and twig samples were collected along a 400 m transect over the kimberlite from nine sites spaced at 50 m intervals (Figure 4). Sample locations are listed in Appendix A.

Sample Preparation and Analysis

Samples were left to dry for several weeks in a greenhouse, after which foliage was separated from the twigs because there are differences in the composition of the two tissue types (lower levels of most heavy and base metals in the foliage). The ratio of foliage to twig may vary substantially among sample locations, therefore if twigs are not separated from foliage some false anomalies may be generated which are simply a function of different ratios of twig to foliage.

Approximately 50 g of dry twig or bark was weighed into aluminum trays. The trays were placed in a pottery kiln, and the temperature slowly raised (over 2 - 3 hours) to 470 C. After a further 12 hours no charcoal remained, and the tissues were reduced to approximately 1 g of ash. Ash yields for individual samples are listed in Appendix A. Half was weighed accurately and compacted into small polyethylene vials for INAA (instrumental neutron activation analysis) of 35 elements at Activation Laboratories Ltd., Ancaster, Ontario. Lower detection limits for elements relevant to this study are listed in Table 1 and the analytical results are listed in Appendix B.

The remaining half of the ash sample was submitted for multi-element analysis by ICP-ES (inductively-coupled plasma emission spectrometry), following an aqua regia digestion, at Acme Analytical Laboratories Ltd., Vancouver, B.C.. Relevant elements are listed in Table 1 and the results are listed in Appendix C. For most elements in plant ash this extraction is near `total', although for some (e.g. Al, B, Na, K) it is only partial. Analytical precision was good for most elements, such that the relative element distribution patterns are meaningful even if the absolute concentrations are only partial.

Table 1. Analytical methods and lower detection limits

Element	Method	Method	Lower Detection Limit
Ag ppm	ICP-ES		0.2 ppm
Al%	ICP-ES		0.02%
As ppm		INAA	0.5 ppm
Au ppb		INAA	5 ppb
B ppm	ICP-ES		1 ppm
Ba ppm		INAA	100 ppm
Be ppm	ICP-ES		0.3 ppm
Br ppm		INAA	1 ppm
Ca %		INAA	0.10%
Ce ppm		INAA	1 ppm
Cd ppm	ICP-ES		0.2 ppm
Co ppm		INAA	1 ppm
Cr ppm		INAA	1 ppm
Cs ppm		INAA	0.5 ppm
Cu ppm	ICP-ES		1 ppm
Fe %		INAA	0.05%
K %		INAA	0.01%
La ppm		INAA	0.1 ppm
Li ppm	ICP-ES		2 ppm
Mg %	ICP-ES		10%
Mn ppm	ICP-ES		1 ppm
Mo ppm	ICP-ES		2 ppm
Na ppm		INAA	100 ppm
Ni ppm	ICP-ES		1 ppm
P %	ICP-ES		10%
Pb ppm	ICP-ES		1 ppm
Rb ppm		INAA	20 ppm
Sb ppm		INAA	0.1 ppm
Sc ppm		INAA	0.1 ppm
Sr ppm		INAA	300 ppm
Th ppm		INAA	0.1 ppm
Ti %	ICP-ES		0.01%
V ppm	ICP-ES		2 ppm
Zn ppm		INAA	20 ppm

Ash standard samples and duplicate splits of field samples were inserted at random intervals to monitor analytical quality control. Results for standards and duplicates are listed in Appendix D.

RESULTS

For each element, profile plots for the Diamond Lake, Buffonta and C14 areas were combined in one diagram to compare concentrations between areas and between tree species. Data for Diamond Lake are plotted from north to south starting with sample 92MPB132 (Figure 2). Data for Buffonta are plotted from northeast to southwest along lines 6 and 8, beginning with samples 92MPB070/082 (Figure 3) and 92MPB076/088 (Figure 3), respectively. C14 data are plotted from north to south, starting with samples 92MPB016/025 (Figure 4). Seven samples, not analyzed by ICP-ES because of insufficient volume, are represented on the plots by small black dots. Values reported as less than detection limit were assigned values of half the detection limit for constructing the profile plots. Plots are presented in Appendices E (INAA) and F (ICP-ES).

Differences among species and tissue types

Every species of plant and tissue type has a different requirement for, and tolerance to metals: for example, the composition of balsam fir is different from that of black spruce, and the composition of black spruce twigs differs from that of its bark. Some are able to concentrate high levels of certain metals, whereas others create barriers to metal uptake at low concentrations. The profile plot of As concentration (Appendix E) shows that at the C14 pipe black spruce concentrates more As in bark than in twigs; conversely there are higher concentrations of Au in the twigs than the bark.

Of the species and tissues discussed in this report, the relative sensitivity and ability of each to accumulate base and heavy metals is: black spruce twigs > black spruce bark > balsam fir twigs > pin cherry twigs. There are exceptions to this pattern (e.g. As and Sb are higher in the spruce bark than the twigs; Ba and Sr are higher in the pin cherry twigs than in the balsam fir twigs, etc.). Some metals (e.g. Au) may have volatilized from the pin cherry during the ashing process: this species contains cyanogenic glycosides with which Au may combine to volatilize as a Au cyanide below the ashing temperature of 470°C. Except for Br which is partially lost during ashing, other element losses due to volatilization are insignificant.

These differences in element accumulation show the importance of being consistent in the collection of a single species, tissue type, and amount of growth (as discussed earlier) within a survey area unless it can be established that a normalization factor among species/tissues can be applied. For the present study the element distribution patterns over each kimberlite body should be considered separately, because it is the element distribution *patterns* which are of more significance than the absolute values. The exception is balsam fir twigs which were collected at two locations (Diamond Lake and Buffonta), and therefore their absolute values can be compared.

Element Variations Over Kimberlite

Brief notes are provided on each element in the order of maps in Appendix E (INAA), followed by those in Appendix F (ICP-ES). The data are compared to normal or background values for balsam fir twigs and black spruce bark defined by Dunn et al. (1989) and Dunn et al. (1992).

Elements Determined by INAA

Arsenic (As)

Weak response except for spruce bark over the intermediate volcanic rocks at C14 and very subtle enrichment over the kimberlite.

Gold (Au)

Unusually high concentrations in most balsam fir samples from Buffonta, and also in the spruce from C14. Background levels in these species are usually <10 ppb Au in ash.

Barium (Ba)

Balsam fir is enriched in Ba relative to its usual concentrations of 1000 - 1500 ppm Ba in twigs. The high concentrations in samples from Buffonta suggest local enrichment of Ba in the substrate.

Bromine (Br)

Some Br always volatilizes during ashing, but there is commonly residual Br enrichment in vegetation from zones of Au enrichment. At C14, relatively high concentrations occur in spruce twigs also enriched in Au.

Calcium (Ca)

Calcium is a basic `building block' element in plants (much as silica is in most rocks). Variations in the study areas are of no exploration significance. Calcium levels in spruce bark suggest enrichment of carbonates in the substrate in the area of the C14 pipe.

Cerium (Ce)

Normal background concentrations.

Cobalt (Co)

Normal background concentrations, except weak enrichment in association with Au over the C14 kimberlite, and increasing Co concentrations southward along the Diamond Lake profile, perhaps reflecting progressive enrichment in base metals.

Chromium (Cr)

Usual background levels. Weak enrichment in spruce twigs over the C14 kimberlite.

Cesium (Cs)

1 - 3 ppm Cs is common in twigs and bark of conifers. Weak enrichment associated with Au enrichment in vegetation is common (cf. C14).

Iron (Fe)

Normal range of concentrations.

Potassium (K)

Normal range of concentrations. Potassium is a `building block' element essential to plants.

Lanthanum (La)

Normal range of concentrations

Sodium (Na)

Normal range in concentrations.

Rubidium (Rb)

Background concentrations are commonly in the range of 200 - 300 ppm Rb in conifer twigs, therefore there is enrichment at Diamond Lake and C14. A biogeochemical study of the Sturgeon Lake kimberlite in Saskatchewan noted enrichment of Rb in aspen twigs near the kimberlite (Dunn, 1993).

Antimony (Sb)

Normal background concentrations except for elevated levels at C14.

Scandium (Sc)

Commonly, scandium closely follows Fe in plants. The distribution patterns of the two elements are very similar for Diamond Lake, Buffonta and C14.

Samarium (Sm)

Concentrations are close to those typical of these species, and distribution patterns closely follow those of the other rare earth elements (cf. La, Ce).

Strontium (Sr)

High concentrations of Sr occur in the pin cherry, whereas in the fir and spruce the levels are typical for these species. Note the Sr enrichment over the Diamond Lake, Buffonta and C14 kimberlites. Studies in Saskatchewan (Dunn, 1993) recorded relatively high Sr concentrations in several plant species growing adjacent to kimberlite.

Thorium (Th)

Normal background concentrations.

Zinc (Zn)

Concentrations are usually about 2000 ppm Zn in balsam fir twigs (Dunn et al., 1989) and 1500 ppm Zn in black spruce bark (Dunn et al., 1992). There is, therefore, some enrichment in the areas surveyed, notably at Buffonta. Above the C14 pipe the black spruce twigs are enriched in Zn. There is progressive enrichment of Zn southward along the Diamond Lake transect.

Elements Determined by ICP-ES

Silver (Ag)

Typical background levels of silver in conifer twigs and bark are <1 ppm Ag. Consequently, the Ag content of spruce twigs at the C14 pipe is strongly anomalous, and indicates enrichment of Ag in the substrate.

Aluminum (Al)

Normal range of concentrations.

Boron (B)

Normal range of concentrations. Boron is an essential element for plant metabolism.

Beryllium (Be)

Plants usually contain <0.2 ppm Be, and 1 ppm Be is uncommon. Several sites over and adjacent to kimberlite at Diamond Lake and Buffonta are enriched in Be. Two samples of the kimberlite dike at Buffonta yielded 2 ppm Be.

Cadmium (Cd)

Background concentrations in conifer twigs and bark are typically <3 ppm Cd in ash. Cadmium is highly mobile in the surficial environment and high concentrations in plant ash commonly occur over base metal (especially Zn) enrichment in the substrate. The profile of Cd in balsam fir twigs at Diamond Lake suggests progressive base metal enrichment toward the south. At Buffonta the balsam fir data indicate similar base metal enrichment, especially over the kimberlite.

Copper (Cu)

Normal range of concentrations, except at C14 where the spruce twigs indicate Cu enrichment over and around the pipe.

Lithium (Li)

Normal range of concentrations

Magnesium (Mg)

Normal range of concentrations except unusually low levels in spruce bark at C14.

Manganese (Mn)

Normal range in concentrations, except for unusually low levels in spruce bark at C14. Several of the kimberlite sites have relatively low concentrations of Mn, which is in accord with biogeochemical data obtained from the Sturgeon Lake kimberlite in Saskatchewan (Dunn, 1993).

Molybdenum (Mo)

None of the species collected are particularly sensitive to the presence of Mo. Levels of a few ppm Mo are common. Weak enrichment over the kimberlite at Buffonta may indicate traces of molybdenite in the substrate.

Nickel (Ni)

Background levels of Ni in conifer twigs and bark are typically <50 ppm in ash, except over mafic and ultramafic rocks where concentrations may be substantially higher. Over the Sturgeon Lake kimberlite, Ni concentrations in dogwood twigs were substantially higher than in the surrounding area (Dunn, 1993), although other species did not show this trend. Weak enrichment occurs in balsam fir at Buffonta.

Phosphorus (P)

Normal concentrations of this essential element in conifer twigs are <2% P. There is notable enrichment at Buffonta which may reflect the typically enhanced concentrations of P associated with kimberlites.

Lead (Pb)

Lead concentrations in conifer twigs are mostly <200 ppm. Concentrations in spruce from the vicinity of the C14 pipe suggest Pb enrichment in the substrate.

Titanium (Ti)

Normal range of concentrations.

Vanadium (V)

Normal range of concentrations.

SUMMARY

1. Biogeochemical transects across the three kimberlite bodies show that of the species and tissues collected, their relative sensitivity and ability to accumulate base and heavy metals is: black spruce twigs > black spruce bark > balsam fir twigs > pin cherry twigs. There are, however, some exceptions to this pattern.

2. Strontium and rubidium are enriched in most tissues from sites over and adjacent to the kimberlites. This observation is in accord with results obtained from a biogeochemical study of the Sturgeon Lake kimberlite in Saskatchewan. Most other elements in the plant tissues did not show sufficient geochemical contrast to provide consistent help in locating the kimberlite bodies. The element enrichments/depletions over each kimberlites were:

a) **Diamond Lake:** *Balsam fir twigs*- Sr, Rb, Be, Mo, (Mn depletion);

b) **Buffonta:** *Balsam fir twigs* - Sr, Rb, Be, Mo, (Mn depletion), Au, Cr, Na, Cd, Ni, Al;

Pin Cherry twigs- Sr, Rb, Au;

c) **C14:** *Black spruce twigs* - Sr, Rb, (Mn depletion), Au, Cr, Na, Cd, Co, Cu, Ba, Cs, REE, Zn;

Black spruce bark - Sr, Ba, Zn.

3. Gold is enriched in balsam fir twigs from Buffonta and in spruce twigs and bark from C14. At the C14 pipe there is coincident enrichment of Ag, As, Sb and, to a lesser degree, Cu and Br.

4. At Diamond Lake there is a progressive southward increase in Cd, Zn, and Co, and to a lesser degree Pb, Ni, Cr, V, Fe, Sc, Mn and REE.

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Appendix A. Sample locations

Appendix A: Sample locations

SAMPLE	MATERIAL	TM ZONE	EASTING	NORTHING	TOWNSHIP	LOCATION	GRID LOCATION	ASH YIELD %	COMMENTS
92MPB016	Black spruce bark	17	588750	5348050	Clifford	C-14 pipe	4+25E, 0+100N	2.00	
92MPB017	Black spruce bark	17	588750	5348100	Clifford	C-14 pipe	4+25E, 0+050N	2.00	
92MPB018	Black spruce bark	17	588750	5348150	Clifford	C-14 pipe	4+25E, 0+000N	2.90	
92MPB019	Black spruce bark	17	588750	5348200	Clifford	C-14 pipe	4+25E, 0+050S	1.90	
92MPB020	Black spruce bark	17	588750	5348250	Clifford	C-14 pipe	4+25E, 0+100S	2.20	overlies kimberlite pipe
92MPB021	Black spruce bark	17	588750	5348300	Clifford	C-14 pipe	4+25E, 0+150S	1.70	overlies kimberlite pipe
92MPB022	Black spruce bark	17	588750	5348350	Clifford	C-14 pipe	4+25E, 0+200S	2.10	
92MPB023	Black spruce bark	17	588750	5348400	Clifford	C-14 pipe	4+25E, 0+250S	1.70	
92MPB024	Black spruce bark	17	588750	5348450	Clifford	C-14 pipe	4+25E, 0+300S	2.00	
92MPB025	Black spruce twigs	17	588750	5348050	Clifford	C-14 pipe	4+25E, 0+100N	1.62	
92MPB026	Black spruce twigs	17	588750	5348100	Clifford	C-14 pipe	4+25E, 0+050N	1.60	
92MPB027	Black spruce twigs	17	588750	5348150	Clifford	C-14 pipe	4+25E, 0+000N	1.75	
92MPB028	Black spruce twigs	17	588750	5348200	Clifford	C-14 pipe	4+25E, 0+050S	1.50	
92MPB029	Black spruce twigs	17	588750	5348250	Clifford	C-14 pipe	4+25E, 0+100S	1.42	overlies kimberlite pipe
92MPB030	Black spruce twigs	17	588750	5348300	Clifford	C-14 pipe	4+25E, 0+150S	1.56	overlies kimberlite pipe
92MPB031	Black spruce twigs	17	588750	5348350	Clifford	C-14 pipe	4+25E, 0+200S	1.90	
92MPB032	Black spruce twigs	17	588750	5348400	Clifford	C-14 pipe	4+25E, 0+250S	1.64	
92MPB033	Black spruce twigs	17	588750	5348450	Clifford	C-14 pipe	4+25E, 0+300S	1.70	
92MPB070	Balsam fir twigs	17	577460	5369780	Garrison	Buffonta pit	6+00W, 2+00N	2.12	
92MPB071	Balsam fir twigs	17	577440	5369760	Garrison	Buffonta pit	6+00W, 1+00N	2.17	
92MPB072	Balsam fir twigs	17	577400	5369740	Garrison	Buffonta pit	6+00W, 0+00N	2.27	overlies kimberlite dike
92MPB073	Balsam fir twigs	17	577375	5369725	Garrison	Buffonta pit	6+00W, 1+00S	2.82	
92MPB074	Balsam fir twigs	17	577350	5369700	Garrison	Buffonta pit	6+00W, 2+00S	2.12	
92MPB075	Balsam fir twigs	17	577325	5369675	Garrison	Buffonta pit	6+00W, 3+00S	2.43	
92MPB076	Balsam fir twigs	17	577360	5369790	Garrison	Buffonta pit	8+00W, 0+00N	2.40	
92MPB077	Balsam fir twigs	17	577330	5369765	Garrison	Buffonta pit	8+00W, 1+00S	2.35	overlies kimberlite dike
92MPB078	Balsam fir twigs	17	577310	5369750	Garrison	Buffonta pit	8+00W, 2+00S	2.48	
92MPB079	Balsam fir twigs	17	577280	5369730	Garrison	Buffonta pit	8+00W, 3+00S	2.49	
92MPB080	Balsam fir twigs	17	577250	5369705	Garrison	Buffonta pit	8+00W, 4+00S	2.49	
92MPB081	Balsam fir twigs	17	577225	5369680	Garrison	Buffonta pit	8+00W, 5+00S	2.56	

SAMPLE	MATERIAL	TM ZONE	EASTING	NORTHING	TOWNSHIP	LOCATION	GRID LOCATION	ASH YIELD %	COMMENTS
92MPB082	Pin cherry twigs	17	577460	5369780	Garrison	Buffonta pit	6+00W, 2+00N	3.12	
92MPB083	Pin cherry twigs	17	577440	5369760	Garrison	Buffonta pit	6+00W, 1+00N	2.81	
92MPB084	Pin cherry twigs	17	577400	5369740	Garrison	Buffonta pit	6+00W, 0+00N	2.65	overlies kimberlite dike
92MPB085	Pin cherry twigs	17	577375	5369725	Garrison	Buffonta pit	6+00W, 1+00S	2.77	
92MPB086	Pin cherry twigs	17	577350	5369700	Garrison	Buffonta pit	6+00W, 2+00S	3.28	
92MPB087	Pin cherry twigs	17	577325	5369675	Garrison	Buffonta pit	6+00W, 3+00S	3.82	
92MPB088	Pin cherry twigs	17	577360	5369790	Garrison	Buffonta pit	8+00W, 0+00N	3.17	
92MPB089	Pin cherry twigs	17	577330	5369765	Garrison	Buffonta pit	8+00W, 1+00S	3.58	overlies kimberlite dike
92MPB090	Pin cherry twigs	17	577310	5369750	Garrison	Buffonta pit	8+00W, 2+00S	3.18	
92MPB091	Pin cherry twigs	17	577280	5369730	Garrison	Buffonta pit	8+00W, 3+00S	2.95	
92MPB092	Pin cherry twigs	17	577250	5369705	Garrison	Buffonta pit	8+00W, 4+00S	2.76	
92MPB093	Pin cherry twigs	17	577225	5369680	Garrison	Buffonta pit	8+00W, 5+00S	3.01	
92MPB132	Balsam fir twigs	17	592300	5330500	McVittie	Diamond Lake pipe	7+00N, 0+00E	2.81	
92MPB133	Balsam fir twigs	17	592325	5330400	McVittie	Diamond Lake pipe	6+00N, 0+25E	2.60	
92MPB134	Balsam fir twigs	17	592350	5330300	McVittie	Diamond Lake pipe	5+00N, 0+50E	2.74	
92MPB135	Balsam fir twigs	17	592362	5330205	McVittie	Diamond Lake pipe	4+05N, 0+62E	2.53	overlies kimberlite pipe
92MPB136	Balsam fir twigs	17	592373	5330103	McVittie	Diamond Lake pipe	3+03N, 0+73E	3.00	
92MPB137	Balsam fir twigs	17	592400	5330000	McVittie	Diamond Lake pipe	2+00N, 1+00E	2.61	
92MPB138	Balsam fir twigs	17	592455	5329900	McVittie	Diamond Lake pipe	1+00N, 1+55E	2.42	
92MPB139	Balsam fir twigs	17	592512	5329800	McVittie	Diamond Lake pipe	0+00N, 2+12E	0.60	
92MPB140	Balsam fir twigs	17	592580	5329700	McVittie	Diamond Lake pipe	1+00S, 2+80E	2.53	
92MPB141	Balsam fir twigs	17	592555	5329600	McVittie	Diamond Lake pipe	2+00S, 2+55E	2.61	overlies kimberlite dike?
92MPB142	Balsam fir twigs	17	592550	5329500	McVittie	Diamond Lake pipe	3+00S, 2+50E	2.39	
92MPB143	Balsam fir twigs	17	592565	5329407	McVittie	Diamond Lake pipe	4+07S, 2+65E	2.31	
92MPB144	Balsam fir twigs	17	592562	5329300	McVittie	Diamond Lake pipe	5+00S, 2+62E	2.49	

Appendix B. INAA data

Sample	Material	Location	As ppm	Au ppb	Ba ppm	Br ppm	Ca %	Ce ppm	Co ppm	Cr ppm	Cs ppm	Fe %	K %	La ppm	Na ppm	Rb ppm	Sb ppm	Sc ppm	Sm ppm	Sr ppm	Th ppm	Zn ppm
92MPB132	balsam fir twig	Diamond Lake pipe	1.2	18	2400	44	16	<3	3	32	<0.5	0.32	21.7	1.6	863	260	0.5	0.5	0.2	990	<0.1	1500
92MPB133	balsam fir twig	Diamond Lake pipe	2.4	29	2400	44	21	7	3	24	<0.5	0.55	18.7	2.7	1020	270	0.6	0.9	0.4	860	0.5	1600
92MPB134	balsam fir twig	Diamond Lake pipe	1.5	12	3000	44	19	4	5	40	1.7	0.54	22.0	2.4	1680	350	0.5	1.2	0.4	<300	<0.1	2300
92MPB135	balsam fir twig	Diamond Lake pipe	2.2	30	2500	49	19	5	4	26	1.6	0.45	22.0	2.3	1920	450	0.5	0.8	0.3	<300	<0.1	1800
92MPB136	balsam fir twig	Diamond Lake pipe	1.6	17	2500	47	16	<3	4	21	<0.5	0.19	25.7	1.3	780	370	0.4	0.5	0.2	750	<0.1	1600
92MPB137	balsam fir twig	Diamond Lake pipe	1.9	22	2000	46	16	6	4	36	<0.5	0.46	19.8	2.7	1620	390	0.4	1.2	0.4	<300	0.4	1900
92MPB138	balsam fir twig	Diamond Lake pipe	2.8	35	2400	47	18	7	6	55	1.9	0.82	19.5	3.9	2350	580	0.5	1.9	0.6	1100	0.6	2300
92MPB139	balsam fir twig	Diamond Lake pipe	2.0	20	2200	23	16	6	6	24	1.9	0.38	20.2	2.2	1150	490	0.2	0.9	0.3	1100	0.2	2200
92MPB140	balsam fir twig	Diamond Lake pipe	3.0	23	2900	39	15	8	9	45	5.0	0.81	21.2	3.6	2040	440	0.7	1.8	0.6	690	0.2	2700
92MPB141	balsam fir twig	Diamond Lake pipe	2.9	14	2200	35	13	8	9	51	2.2	0.65	19.7	3.1	2040	270	0.5	1.8	0.5	690	0.3	2100
92MPB142	balsam fir twig	Diamond Lake pipe	2.1	15	2000	43	13	7	9	41	2.1	0.75	22.8	3.0	2070	330	0.5	1.7	0.5	670	<0.1	2400
92MPB143	balsam fir twig	Diamond Lake pipe	3.1	14	3600	33	14	6	7	40	2.5	0.54	21.5	3.2	1410	400	0.4	1.3	0.5	<300	0.2	2600
92MPB144	balsam fir twig	Diamond Lake pipe	3.9	16	3000	32	17	6	9	51	2.3	0.75	20.3	3.7	1960	250	0.7	1.7	0.6	860	0.4	2900
92MPB070	balsam fir twig	Buffonta pit	2.0	45	4000	26	17	6	4	24	1.4	0.29	21.2	2.2	859	290	0.4	1.0	0.3	1000	0.3	2800
92MPB071	balsam fir twig	Buffonta pit	1.5	134	4300	22	16	<3	4	27	1.5	0.39	20.4	2.7	1040	330	0.3	1.1	0.4	1000	0.2	2600
92MPB072	balsam fir twig	Buffonta pit	2.2	78	3600	24	18	6	6	30	1.6	0.45	21.0	3.4	1290	290	0.5	1.5	0.6	1100	0.1	3000
92MPB073	balsam fir twig	Buffonta pit	2.6	42	4600	21	18	5	5	27	1.6	0.36	18.4	2.4	1000	220	0.6	0.9	0.4	860	0.2	2800
92MPB074	balsam fir twig	Buffonta pit	1.6	22	4700	30	14	<3	5	27	1.3	0.32	23.1	1.5	755	200	0.3	0.8	0.2	<300	0.4	3500
92MPB075	balsam fir twig	Buffonta pit	4.0	48	4800	30	17	8	5	21	1.2	0.46	20.2	3.1	1190	250	0.8	1.3	0.5	1400	0.2	2800
92MPB076	balsam fir twig	Buffonta pit	2.5	40	5400	32	19	5	5	35	1.6	0.42	19.3	2.6	1010	250	0.6	1.2	0.4	940	0.8	3500
92MPB077	balsam fir twig	Buffonta pit	2.3	46	4300	29	18	6	6	34	2.1	0.33	22.8	2.4	825	310	0.4	1.1	0.3	1100	0.2	3100
92MPB078	balsam fir twig	Buffonta pit	1.9	32	3900	33	19	6	8	23	1.2	0.34	19.0	2.4	773	230	0.4	1.0	0.3	1200	<0.1	2700
92MPB079	balsam fir twig	Buffonta pit	1.7	22	4200	37	15	4	5	25	1.5	0.31	21.5	1.8	744	150	0.4	0.7	0.3	<300	<0.1	3100
92MPB080	balsam fir twig	Buffonta pit	1.6	17	4500	48	15	<3	5	<1	2.7	0.23	24.9	1.5	692	280	0.3	0.4	0.2	1300	<0.1	3500
92MPB081	balsam fir twig	Buffonta pit	1.5	74	3000	38	16	<3	5	25	<0.5	0.27	20.6	1.7	628	310	0.4	0.5	0.3	1200	<0.1	2800
92MPB082	pin cherry twig	Buffonta pit	<0.5	<5	3200	17	25	<3	2	4	<0.5	0.05	13.3	1.1	139	220	<0.1	<0.1	<0.1	2300	<0.1	1500
92MPB083	pin cherry twig	Buffonta pit	<0.5	8	4200	13	22	<3	2	<1	<0.5	0.06	13.3	0.6	158	280	<0.1	<0.1	<0.1	2200	<0.1	2200
92MPB084	pin cherry twig	Buffonta pit	0.9	15	3000	14	21	<3	2	5	0.7	0.1	15.0	1.1	251	300	0.1	0.2	<0.1	2900	<0.1	1800
92MPB085	pin cherry twig	Buffonta pit	1.2	<5	3000	13	25	<3	1	6	2.2	0.06	12.9	0.6	217	270	<0.1	0.1	<0.1	2600	<0.1	2000
92MPB086	pin cherry twig	Buffonta pit	0.5	<5	3500	14	26	<3	1	<1	3.2	<0.05	10.5	0.9	154	180	<0.1	<0.1	<0.1	2500	<0.1	1500
92MPB087	pin cherry twig	Buffonta pit	<0.5	<5	3100	12	24	<3	1	6	<0.5	0.06	13.8	0.6	100	190	<0.1	<0.1	<0.1	2100	<0.1	1600
92MPB088	pin cherry twig	Buffonta pit	<0.5	7	4600	22	24	<3	2	7	0.7	0.08	11.7	1.2	210	170	<0.1	<0.1	<0.1	2900	<0.1	3500
92MPB089	pin cherry twig	Buffonta pit	<0.5	<5	3500	20	26	<3	2	6	0.6	<0.05	10.1	0.4	145	160	<0.1	<0.1	<0.1	2800	<0.1	1500
92MPB090	pin cherry twig	Buffonta pit	0.7	<5	3200	16	22	<3	1	6	<0.5	<0.05	14.3	0.4	163	240	<0.1	<0.1	<0.1	2300	<0.1	2300
92MPB091	pin cherry twig	Buffonta pit	<0.5	6	3700	33	19	<3	2	<1	<0.5	0.08	18.4	0.7	191	300	<0.1	<0.1	<0.1	1700	<0.1	2200
92MPB092	pin cherry twig	Buffonta pit	<0.5	<5	2700	19	20	<3	1	6	0.7	<0.05	18.7	0.4	134	440	<0.1	<0.1	<0.1	1700	<0.1	1300
92MPB093	pin cherry twig	Buffonta pit	<0.5	<5	2700	28	23	<3	3	6	<0.5	0.11	10.3	0.6	226	250	<0.1	0.1	<0.1	2700	<0.1	2100

Sample	Material	Location	As ppm	Au ppb	Ba ppm	Br ppm	Ca %	Ce ppm	Co ppm	Cr ppm	Cs ppm	Fe %	K %	La ppm	Na ppm	Rb ppm	Sb ppm	Sc ppm	Sm ppm	Sr ppm	Th ppm	Zn ppm
92MPB025	black spruce twig	C14 pipe	5.5	58	1200	44	18	13	10	24	2.3	1.07	11.7	6.4	1710	220	1.5	1.6	1	<300	0.8	2900
92MPB026	black spruce twig	C14 pipe	4.6	49	1200	57	18	10	6	26	3.2	0.73	11.9	4.6	1460	210	1.2	1.2	0.8	<300	0.4	2800
92MPB027	black spruce twig	C14 pipe	4.8	34	1000	61	18	8	6	20	2.8	0.7	14.1	4.4	1410	250	0.9	1.2	0.7	<300	1.1	2800
92MPB028	black spruce twig	C14 pipe	4.4	78	1200	49	16	8	7	24	3.9	0.81	17.7	4.9	1540	290	0.9	1.4	0.7	<300	0.9	3000
92MPB029	black spruce twig	C14 pipe	5.5	88	2000	50	14	11	16	42	4.6	0.85	15.6	5.6	1700	460	1	1.5	0.9	1600	1.0	3400
92MPB030	black spruce twig	C14 pipe	6.6	90	2400	50	22	13	6	16	3.2	0.87	11.5	6.3	2020	320	1.2	1.7	0.9	1800	1.0	3500
92MPB031	black spruce twig	C14 pipe	3.5	50	1200	43	20	7	5	23	2.3	0.69	12.5	4.3	1490	230	1	1.2	0.7	1400	0.7	2500
92MPB032	black spruce twig	C14 pipe	3.7	85	1200	93	16	6	6	35	3.4	0.71	15.6	4.5	2000	420	0.7	1.3	0.7	<300	0.7	2900
92MPB033	black spruce twig	C14 pipe	4.7	77	1500	92	15	10	8	31	3.2	0.62	15.4	5.1	1640	410	0.9	1.3	0.7	710	0.9	2900
92MPB016	black spruce bark	C14 pipe	38.0	39	3600	28	26	9	3	22	2.2	1.22	1.8	5.4	1660	53	3.9	1.7	0.9	1000	1.0	1000
92MPB017	black spruce bark	C14 pipe	34.0	33	3700	22	26	11	4	24	1.3	1.38	1.6	6.4	1800	44	4.5	2.0	1.1	630	1.0	900
92MPB018	black spruce bark	C14 pipe	20.0	18	2500	17	29	7	2	13	<0.5	0.68	1.0	3.2	984	20	2	1.0	0.5	890	0.4	1200
92MPB019	black spruce bark	C14 pipe	21.0	32	4200	32	29	10	5	19	0.8	1.19	1.4	5.1	1530	27	3.2	1.7	0.8	980	0.8	1300
92MPB020	black spruce bark	C14 pipe	27.0	28	5000	20	28	7	4	14	1.3	0.82	1.6	3.8	1220	37	2.4	1.2	0.6	2300	0.5	1500
92MPB021	black spruce bark	C14 pipe	20.0	21	3500	24	28	9	4	17	1.5	0.94	1.3	4.2	1230	33	3	1.3	0.6	1400	0.5	2400
92MPB022	black spruce bark	C14 pipe	18.0	29	3900	32	28	8	3	17	1.7	0.97	1.7	4.3	1290	45	3.1	1.3	0.7	850	0.6	1500
92MPB023	black spruce bark	C14 pipe	19.0	55	3700	27	27	11	5	19	1.1	1.33	2.2	5.7	1770	41	3.2	1.8	0.9	<300	0.8	1900
92MPB024	black spruce bark	C14 pipe	24.0	31	5200	39	28	9	4	19	1.6	0.95	1.5	4.6	1290	46	3.4	1.4	0.7	640	0.8	1300

Appendix C. ICP-ES data

APPENDIX C ICP-ES data

Sample	Material	Location	Ag ppm	Al %	B ppm	Be ppm	Cd ppm	Cu ppm	Li ppm	Mg %	Mn ppm	Mo ppm	Ni ppm	P %	Pb ppm	Ti %	V ppm
93MPB132	balsam fir twig	Diamond Lake pipe	1.1	0.77	372	0.4	6.2	181	<2	2.67	9247	<2	55	2.34	52	0.01	4
93MPB133	balsam fir twig	Diamond Lake pipe	0.4	0.30	354	<0.3	4.1	215	2	1.98	2290	<2	45	1.77	72	0.01	5
93MPB134	balsam fir twig	Diamond Lake pipe	0.2	0.64	315	0.5	11.0	169	2	2.30	4586	<2	53	1.63	49	0.03	6
93MPB135	balsam fir twig	Diamond Lake pipe	1.3	0.32	379	0.6	6.8	192	2	2.39	2233	3	35	1.93	63	0.02	6
93MPB136	balsam fir twig	Diamond Lake pipe	0.8	0.29	298	<0.3	5.2	165	<2	2.07	3548	<2	53	1.82	26	0.01	3
93MPB137	balsam fir twig	Diamond Lake pipe	1.0	0.40	356	<0.3	9.6	198	3	2.24	1502	6	34	1.59	74	0.04	8
93MPB138	balsam fir twig	Diamond Lake pipe	1.2	0.58	362	<0.3	18.6	180	3	2.46	5222	<2	46	1.62	90	0.04	10
93MPB139	balsam fir twig	Diamond Lake pipe	0.6	0.44	380	<0.3	10.0	174	2	2.86	9948	<2	64	1.90	64	0.02	4
93MPB140	balsam fir twig	Diamond Lake pipe	0.8	0.84	338	<0.3	21.4	162	2	3.34	13202	<2	84	1.80	92	0.02	8
93MPB141	balsam fir twig	Diamond Lake pipe	0.8	0.82	392	<0.3	16.8	170	<2	3.04	19194	<2	82	1.88	76	0.02	8
93MPB142	balsam fir twig	Diamond Lake pipe	0.6	0.88	378	<0.3	25.0	182	2	2.60	14826	<2	68	2.47	78	0.02	8
93MPB143	balsam fir twig	Diamond Lake pipe	0.8	0.84	316	<0.3	33.8	186	<2	2.50	19386	<2	70	2.48	110	0.02	6
93MPB144	balsam fir twig	Diamond Lake pipe	1.2	0.92	382	<0.3	19.8	216	2	2.40	16868	<2	68	1.95	114	0.02	8
93MPB070	balsam fir twig	Buffonta pit	0.9	0.57	382	0.4	17.0	222	2	2.59	19885	3	52	3.71	72	0.01	4
93MPB071	balsam fir twig	Buffonta pit	0.9	0.68	426	0.4	12.6	223	3	2.42	19885	3	63	3.32	88	0.01	4
93MPB072	balsam fir twig	Buffonta pit	0.8	0.86	386	0.5	33.4	212	<2	2.51	15950	6	88	3.27	110	0.02	5
93MPB073	balsam fir twig	Buffonta pit	0.9	0.58	352	0.3	25.7	205	<2	1.99	22611	2	55	3.35	124	0.01	4
93MPB074	balsam fir twig	Buffonta pit		insufficient sample													
93MPB075	balsam fir twig	Buffonta pit	0.7	0.56	386	0.4	28.5	255	<2	1.64	38077	<2	60	3.30	162	0.01	5
93MPB076	balsam fir twig	Buffonta pit	0.8	0.86	429	0.4	26.3	225	2	2.57	18622	2	76	3.99	69	0.01	3
93MPB077	balsam fir twig	Buffonta pit		insufficient sample													
93MPB078	balsam fir twig	Buffonta pit		insufficient sample													
93MPB079	balsam fir twig	Buffonta pit	0.8	0.64	485	0.3	27.6	234	<2	2.23	22486	<2	70	3.74	115	0.02	3
93MPB080	balsam fir twig	Buffonta pit		insufficient sample													
93MPB081	balsam fir twig	Buffonta pit	1.0	0.62	489	0.3	27.7	186	<2	2.12	24242	2	57	3.03	83	0.01	3
93MPB082	pin cherry twig	Buffonta pit	0.3	0.02	450	<0.3	0.6	67	<2	1.98	1620	<2	22	2.34	14	0.01	<2
93MPB083	pin cherry twig	Buffonta pit	0.5	0.02	562	<0.3	1.2	95	<2	2.42	3265	<2	26	2.37	10	0.01	<2
93MPB084	pin cherry twig	Buffonta pit	0.3	0.04	565	<0.3	0.8	98	<2	2.00	1935	2	28	2.36	52	0.01	<2
93MPB085	pin cherry twig	Buffonta pit	<0.2	0.03	482	<0.3	0.3	94	<2	1.78	2027	3	25	2.01	14	0.01	<2
93MPB086	pin cherry twig	Buffonta pit	<0.2	0.02	492	<0.3	0.9	74	<2	1.74	1203	2	23	1.88	9	0.01	<2
93MPB087	pin cherry twig	Buffonta pit	0.3	<0.02	435	<0.3	0.4	76	<2	1.59	1343	<2	15	2.35	2	0.01	<2
93MPB088	pin cherry twig	Buffonta pit	0.2	0.05	505	<0.3	1.4	111	<2	2.27	3169	<2	24	2.41	16	0.01	<2
93MPB089	pin cherry twig	Buffonta pit	0.2	0.02	407	<0.3	0.4	73	<2	1.63	1194	<2	14	1.98	4	0.01	<2
93MPB090	pin cherry twig	Buffonta pit	<0.2	0.02	529	<0.3	0.7	92	<2	2.17	2344	<2	15	2.34	9	0.01	<2

APPENDIX C ICP-ES data

Sample	Material	Location	Ag ppm	Al %	B ppm	Be ppm	Cd ppm	Cu ppm	Li ppm	Mg %	Mn ppm	Mo ppm	Ni ppm	P %	Pb ppm	Ti %	V ppm
93MPB091	pin cherry twig	Buffonta pit	<0.2	<0.02	606	<0.3	0.6	110	<2	2.37	2449	<2	14	3.17	2	0.01	<2
93MPB092	pin cherry twig	Buffonta pit	0.3	<0.02	558	<0.3	0.3	88	<2	2.18	1026	<2	11	3.28	3	0.01	<2
93MPB093	pin cherry twig	Buffonta pit	<0.2	0.03	488	<0.3	0.6	87	<2	2.33	3074	<2	22	2.48	18	0.01	<2
93MPB025	black spruce twig	C14 pipe	5.3	0.57	503	<0.3	7.0	434	3	2.84	20233	<2	127	2.59	393	0.02	14
93MPB026	black spruce twig	C14 pipe	3.8	0.51	510	<0.3	6.2	441	3	2.97	17832	2	123	2.58	330	0.02	12
93MPB027	black spruce twig	C14 pipe	3.3	0.46	475	<0.3	5.9	389	3	3.29	13848	<2	110	2.89	219	0.02	10
93MPB028	black spruce twig	C14 pipe			insufficient sample												
93MPB029	black spruce twig	C14 pipe			insufficient sample												
93MPB030	black spruce twig	C14 pipe	3.7	0.56	555	<0.3	9.4	516	5	3.37	14713	2	100	2.96	324	0.03	14
93MPB031	black spruce twig	C14 pipe	3.1	0.42	468	<0.3	5.8	382	4	3.73	14052	2	69	2.16	238	0.02	11
93MPB032	black spruce twig	C14 pipe			insufficient sample												
93MPB033	black spruce twig	C14 pipe	4.8	0.59	534	<0.3	7.6	409	4	3.24	15223	2	159	3.24	194	0.02	12
93MPB016	black spruce bark	C14 pipe	1.2	0.38	218	<0.3	5.4	226	<2	0.30	5856	<2	60	0.37	278	0.02	14
93MPB017	black spruce bark	C14 pipe	1.2	0.40	192	<0.3	5.4	236	<2	0.24	3764	4	56	0.43	378	0.02	14
93MPB018	black spruce bark	C14 pipe	0.4	0.22	166	<0.3	5.0	136	<2	0.22	5272	<2	34	0.27	228	0.01	8
93MPB019	black spruce bark	C14 pipe	1.6	0.36	186	<0.3	7.8	230	<2	0.28	6354	<2	60	0.45	332	0.02	12
93MPB020	black spruce bark	C14 pipe	1.2	0.22	196	<0.3	8.4	210	<2	0.30	4404	<2	46	0.35	222	0.01	8
93MPB021	black spruce bark	C14 pipe	1.0	0.28	212	<0.3	8.0	244	<2	0.32	4066	<2	38	0.43	292	0.01	10
93MPB022	black spruce bark	C14 pipe	0.8	0.32	164	<0.3	10.4	226	<2	0.30	4522	<2	50	0.42	292	0.02	12
93MPB023	black spruce bark	C14 pipe	1.8	0.44	182	<0.3	8.0	232	<2	0.32	4868	2	76	0.45	344	0.02	12
93MPB024	black spruce bark	C14 pipe	1.4	0.32	200	<0.3	6.8	210	<2	0.26	4586	<2	50	0.37	264	0.02	10

Appendix D. Analytical quality control data

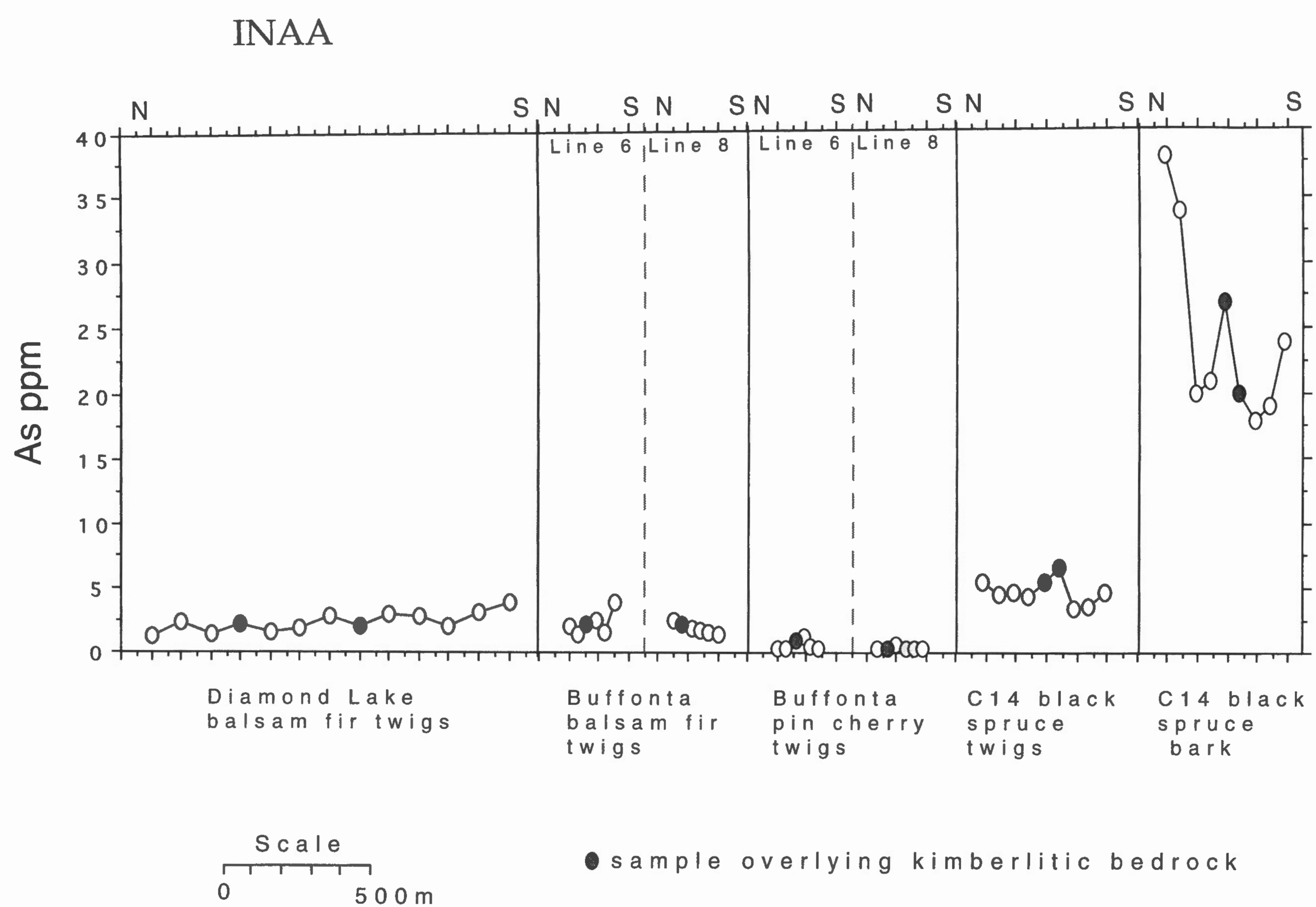
INAA

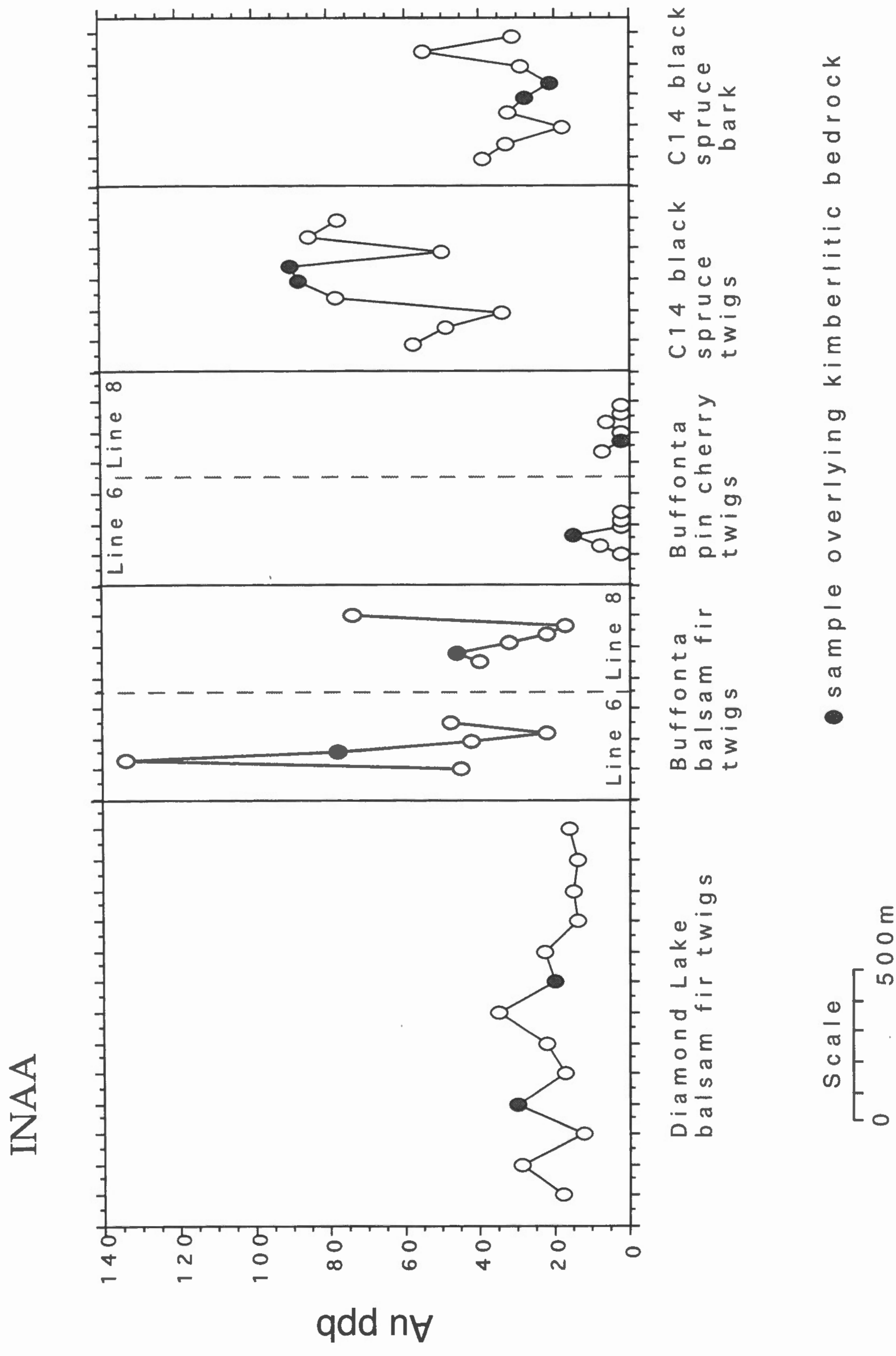
Sample	Type	Au ppb	As ppm	Ba ppm	Br ppm	Ca %	Ce ppm	Co ppm	Cr ppm	Cs ppm	Fe %	K %	La ppm	Na ppm	Rb ppm	Sb ppm	Sc ppm	Sm ppm	Sr ppm	Th ppm	Zn ppm
92MPB087	original	<5	<0.5	3100	12	24.1	<3	1	6	<0.5	0.06	13.8	0.6	100	190	<0.1	<0.1	<0.1	2100	<0.1	1600
92MPB087	duplicate	<5	0.7	3000	13	22.3	<3	2	6	0.6	<0.05	13.3	0.5	108	210	<0.1	<0.1	<0.1	2300	<0.1	1600
92MPB091	original	6	<0.5	3700	33	19.3	<3	2	<1	<0.5	0.08	18.4	0.7	191	300	<0.1	<0.1	<0.1	1700	<0.1	2200
92MPB091	duplicate	<5	<0.5	4300	31	20.9	<3	3	<1	<0.5	<0.05	19.0	0.5	161	350	<0.1	<0.1	<0.1	2300	<0.1	2400
V6a standard	GSC standard	15	6.2	480	29	19.7	46	10	74	2.1	2.21	3.8	23	10800	59	1.2	4.8	3.7	1200	3.1	1000
V6a standard	GSC standard	10	5.7	430	28	13.5	41	8	59	<0.5	1.76	3.4	21	9660	55	1.2	4.4	3.2	690	3.5	820
V6a standard	GSC standard	10	5.1	440	25	14	38	8	60	<0.5	1.81	3.0	19	9270	49	1.2	4.4	3.0	1200	3.9	750
V6a standard	GSC standard	15	5.3	440	26	15.2	41	8	70	2.2	1.82	3.7	20	9370	48	1.2	4.5	3.3	1200	2.8	850
V6a standard	GSC standard	14	6.6	430	30	14.8	42	9	68	1.4	1.9	2.9	20	9220	34	1.1	4.5	3.2	970	2.7	830

ICP-ES

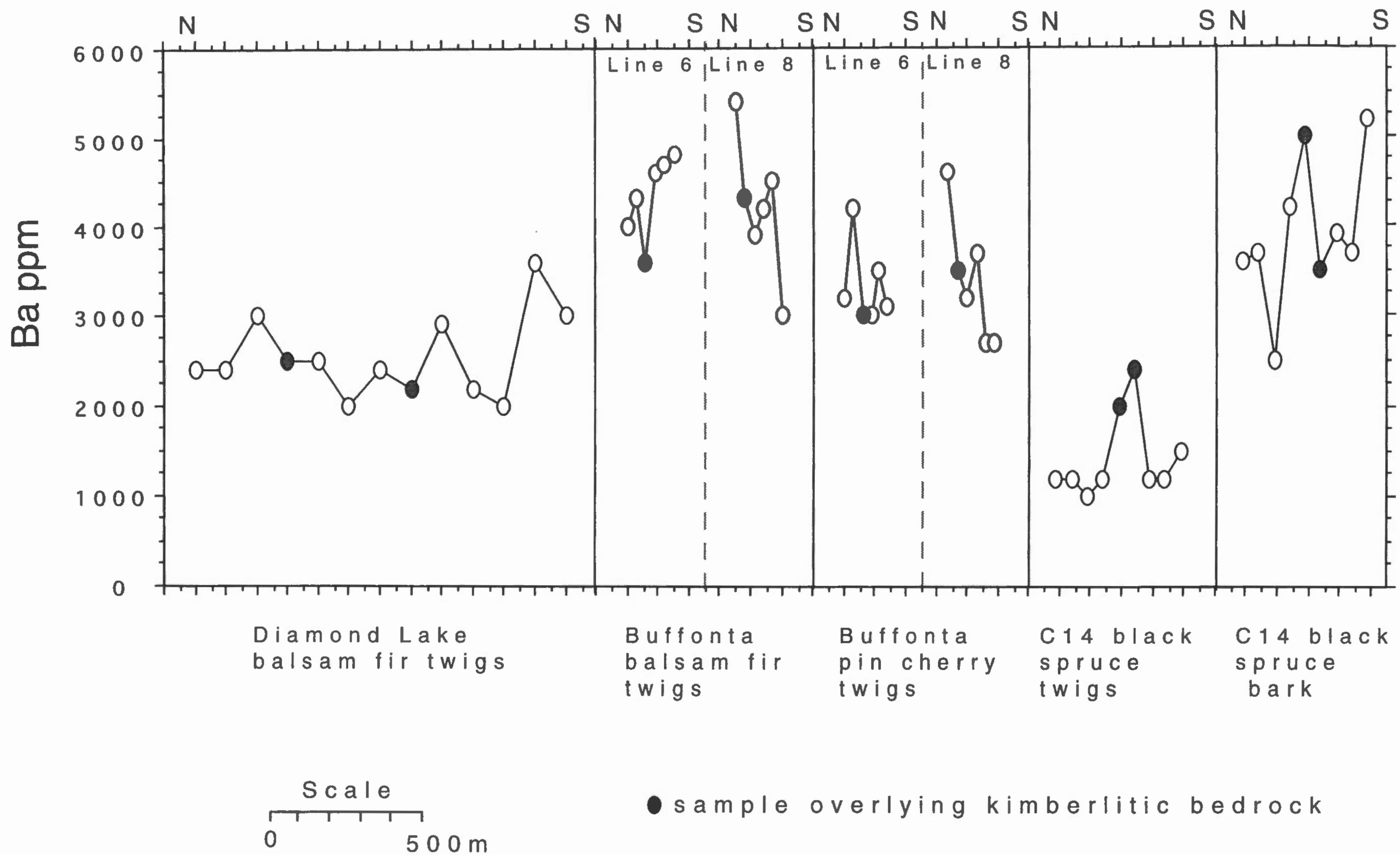
Sample	Type	Ag ppm	Al %	B ppm	Be ppm	Cd ppm	Cu ppm	Li ppm	Mg %	Mn ppm	Mo ppm	Ni ppm	P %	Pb ppm	Ti %	V ppm
93MPB087	original	0.3	<0.02	435	0.2	0.4	76	<2	1.59	1343	<2	15	2.35	2	0.01	<2
93MPB087	duplicate	0.2	<0.02	448	0.2	0.3	76	<2	1.63	1386	<2	16	2.43	5	0.01	<2
93MPB089	original	0.2	0.02	407	0.2	0.4	73	<2	1.63	1194	<2	14	1.98	4	0.01	<2
93MPB089	duplicate	<0.2	0.02	425	0.2	0.5	72	<2	1.74	1268	<2	16	2.12	4	0.01	<2
93MPB091	original	<0.2	<0.02	606	0.2	0.6	110	<2	2.37	2449	<2	14	3.17	2	0.01	<2
93MPB091	duplicate	<0.2	0.02	576	0.2	0.3	108	<2	2.27	2334	<2	14	3.04	2	0.01	<2
V6a standard	GSC standard	0.5	1.06	215	0.2	2.7	127	8	2.38	749	5	42	0.62	218	0.05	27
V6a standard	GSC standard	<0.2	1.04	211	0.2	2.5	106	7	2.23	740	5	42	0.62	257	0.04	25
V6a standard	GSC standard	0.8	1.03	214	0.2	2.3	121	7	2.18	770	4	44	0.61	197	0.04	26
V6a standard	GSC standard	<0.2	1.10	212	0.2	2.8	100	6	2.14	812	4	42	0.60	200	0.04	26
'6a standard	GSC standard	0.6	0.98	214	0.2	2.4	124	4	2.02	752	4	42	0.61	210	0.04	26
V6a standard	GSC standard	<0.2	0.94	216	0.2	2.0	90	4	1.80	640	4	36	0.49	178	0.04	22
STANDARD C	ACME lab standard	7.3	1.88	35	0.5	18.9	59	21	0.94	1052	18	72	0.08	39	0.09	57
STANDARD C	ACME lab standard	7.5	1.85	35	0.7	19.0	58	22	0.91	1036	21	72	0.09	39	0.08	61

Appendix E. INAA profile plots

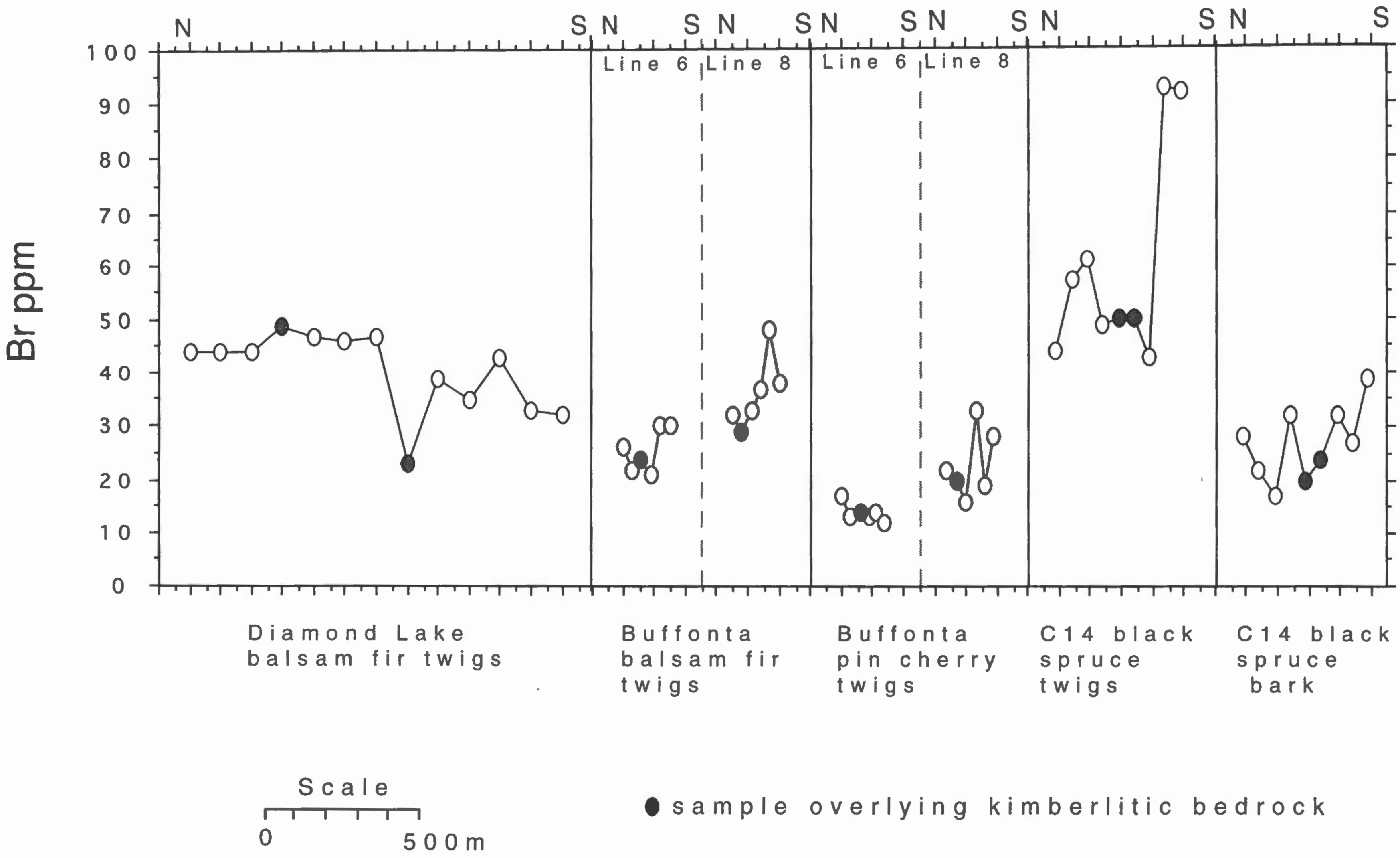

INAA
As ppm
0
5
10
15
20
25
30
35
40
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock

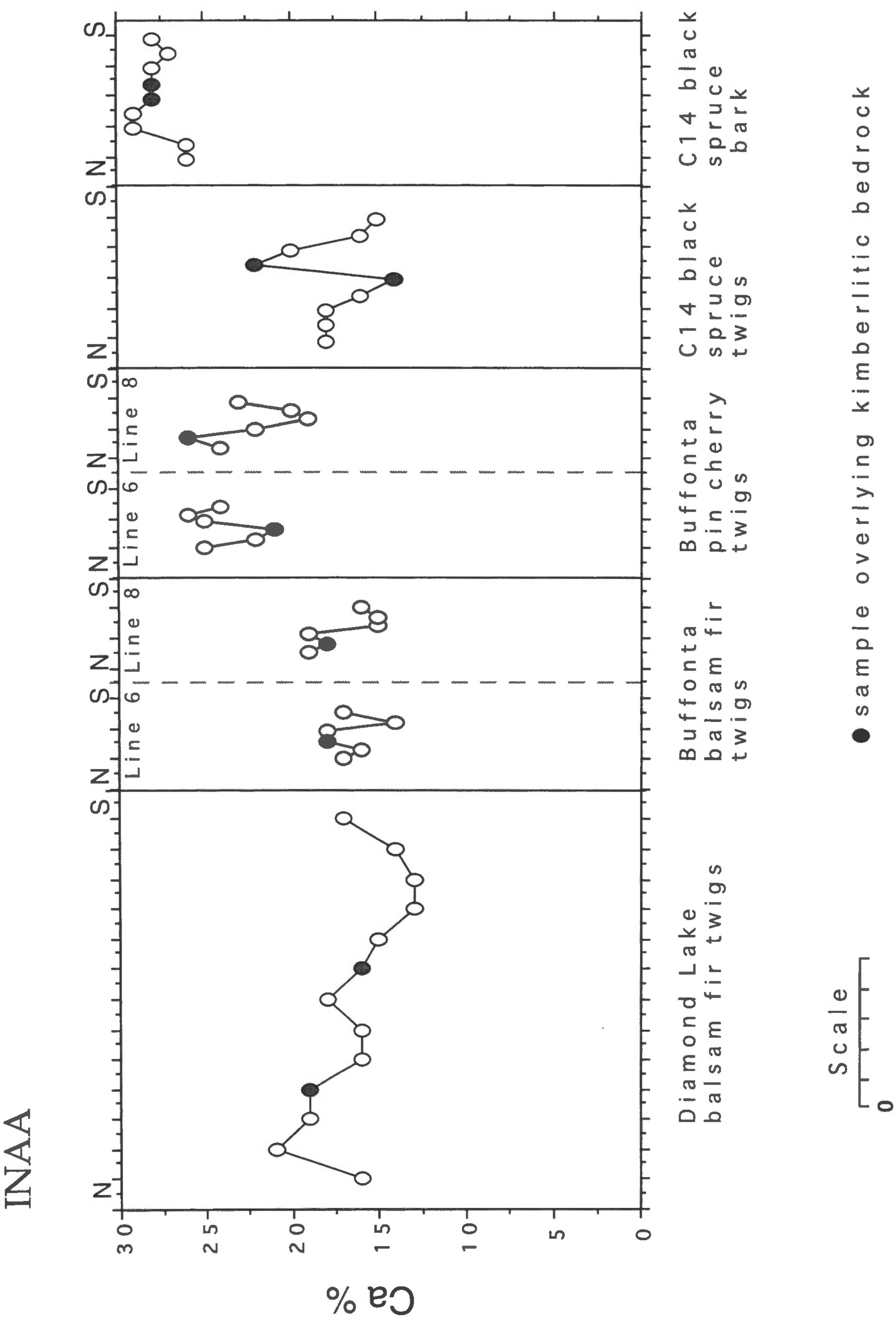

INAA
Au ppb
140
120
100
80
60
40
20
0
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Line 6
Line 8
Buffonta pin cherry twigs
Line 6
Line 8
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock

INAA

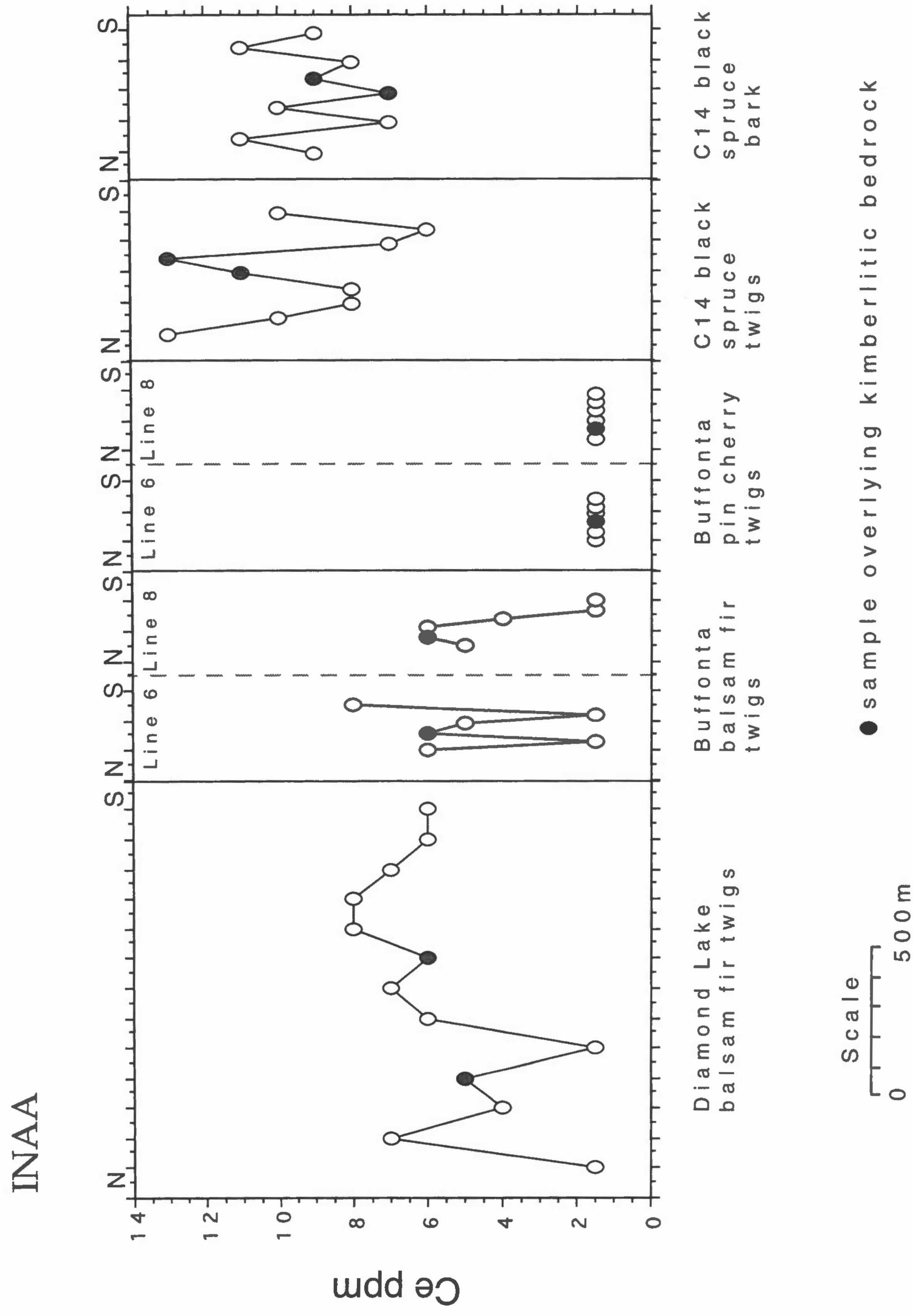

Ba ppm
6000
5000
4000
3000
2000
1000
0
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock

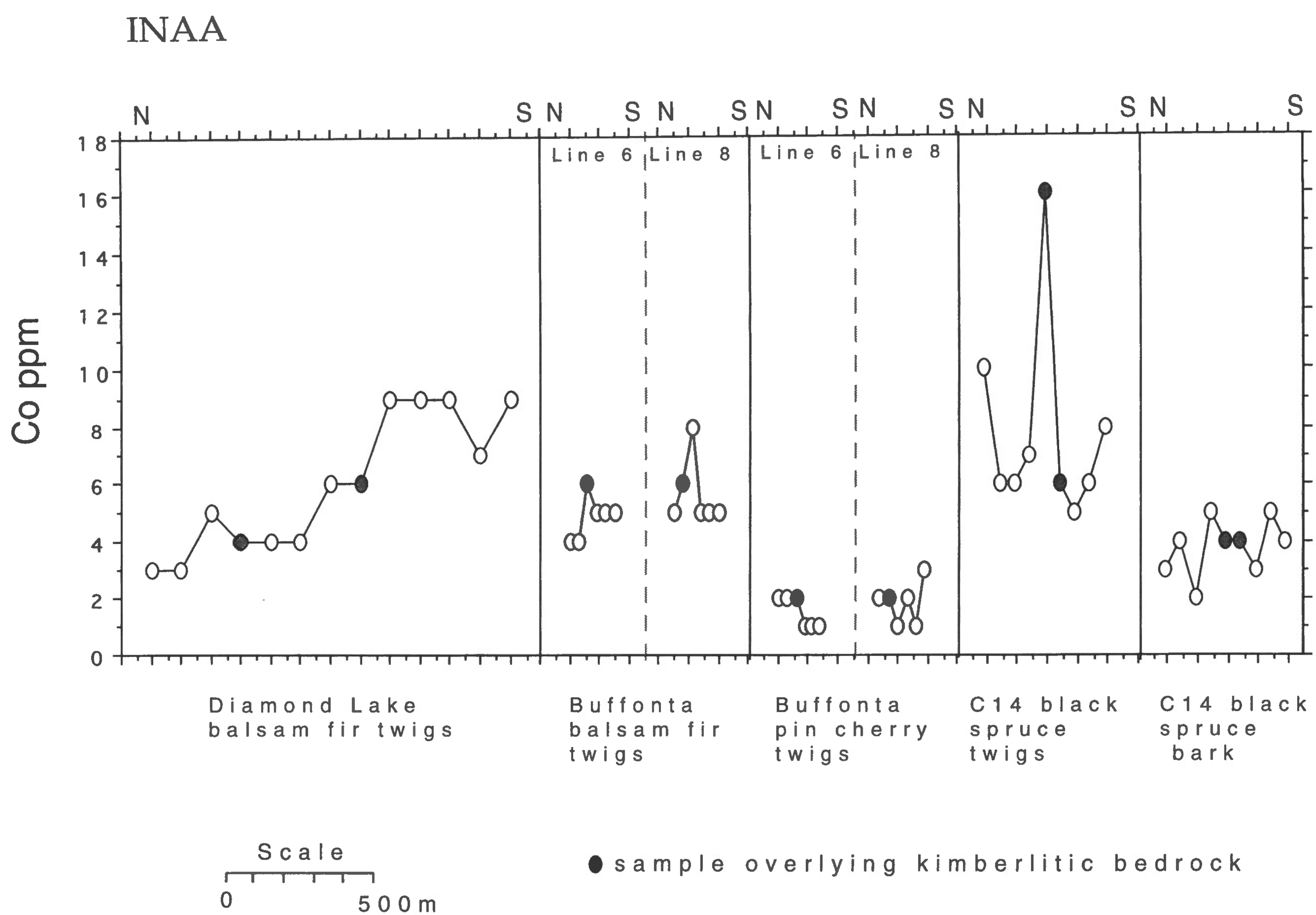
INAA

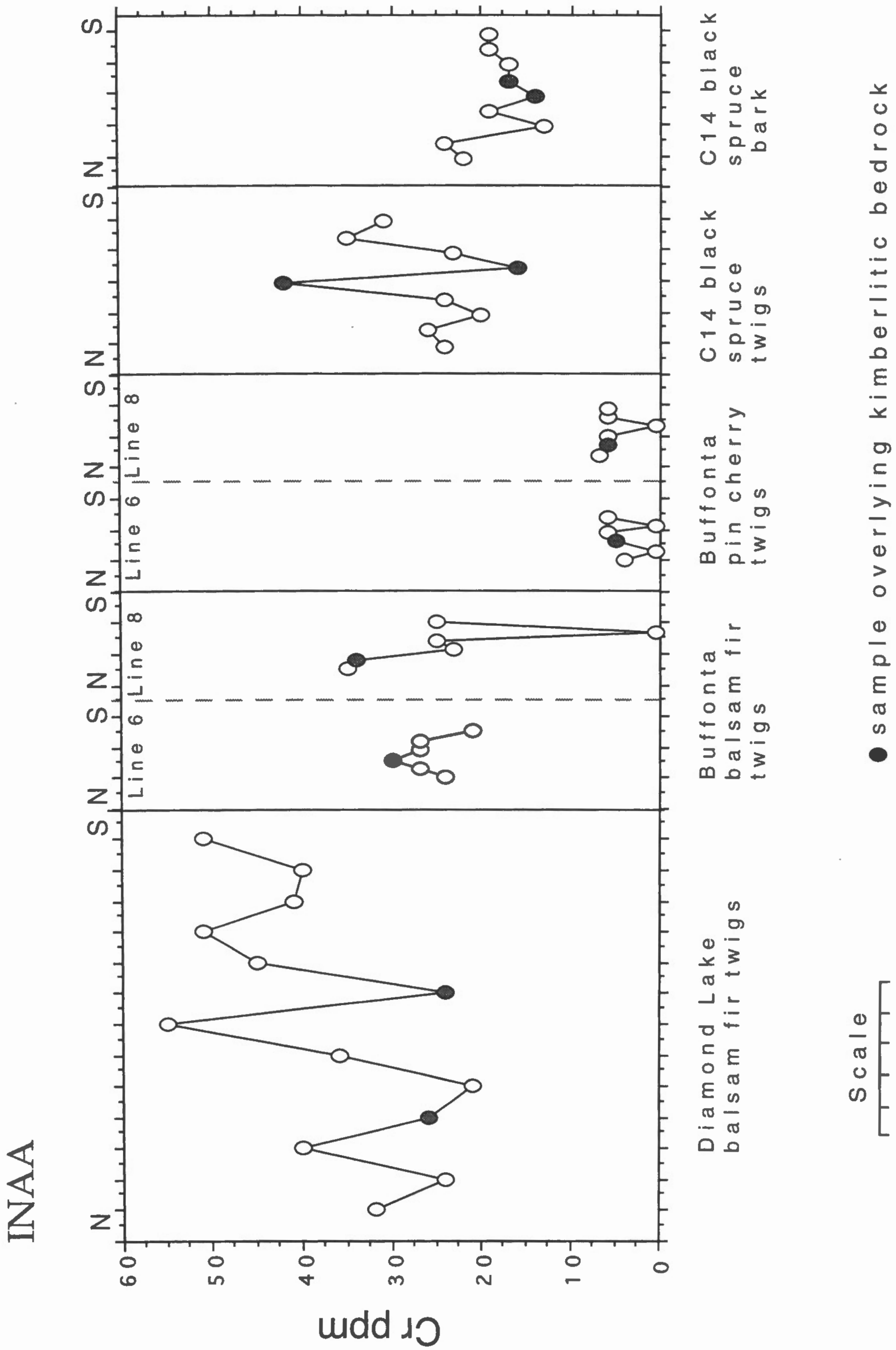

N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Br ppm
100
90
80
70
60
50
40
30
20
10
0
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock



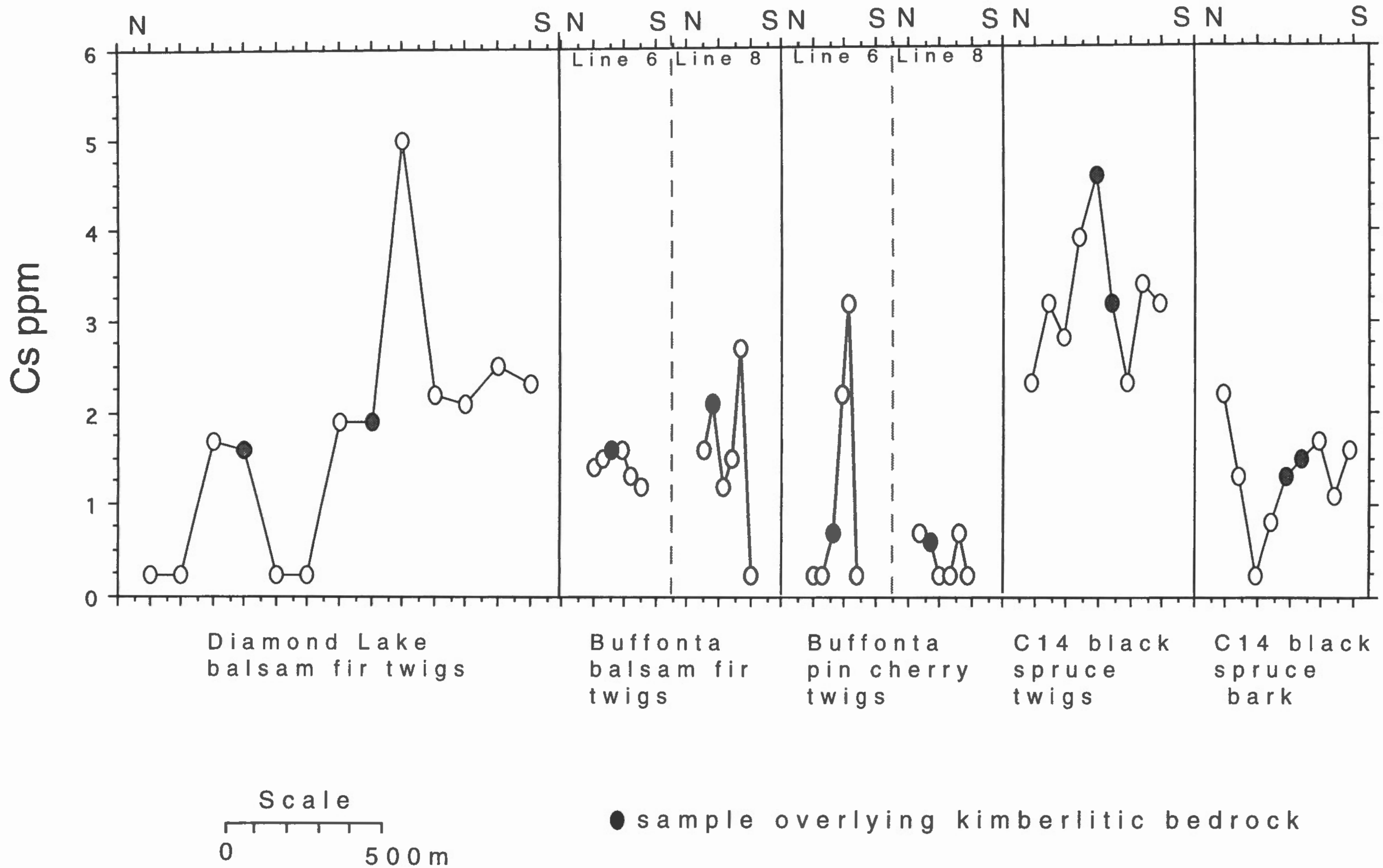
INAA
Ca %
30
25
20
15
10
5
0
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
● sample overlying kimberlitic bedrock


INAA
Ce ppm
14
12
10
8
6
4
2
0
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
sample overlying kimberlitic bedrock
Scale
0
500m

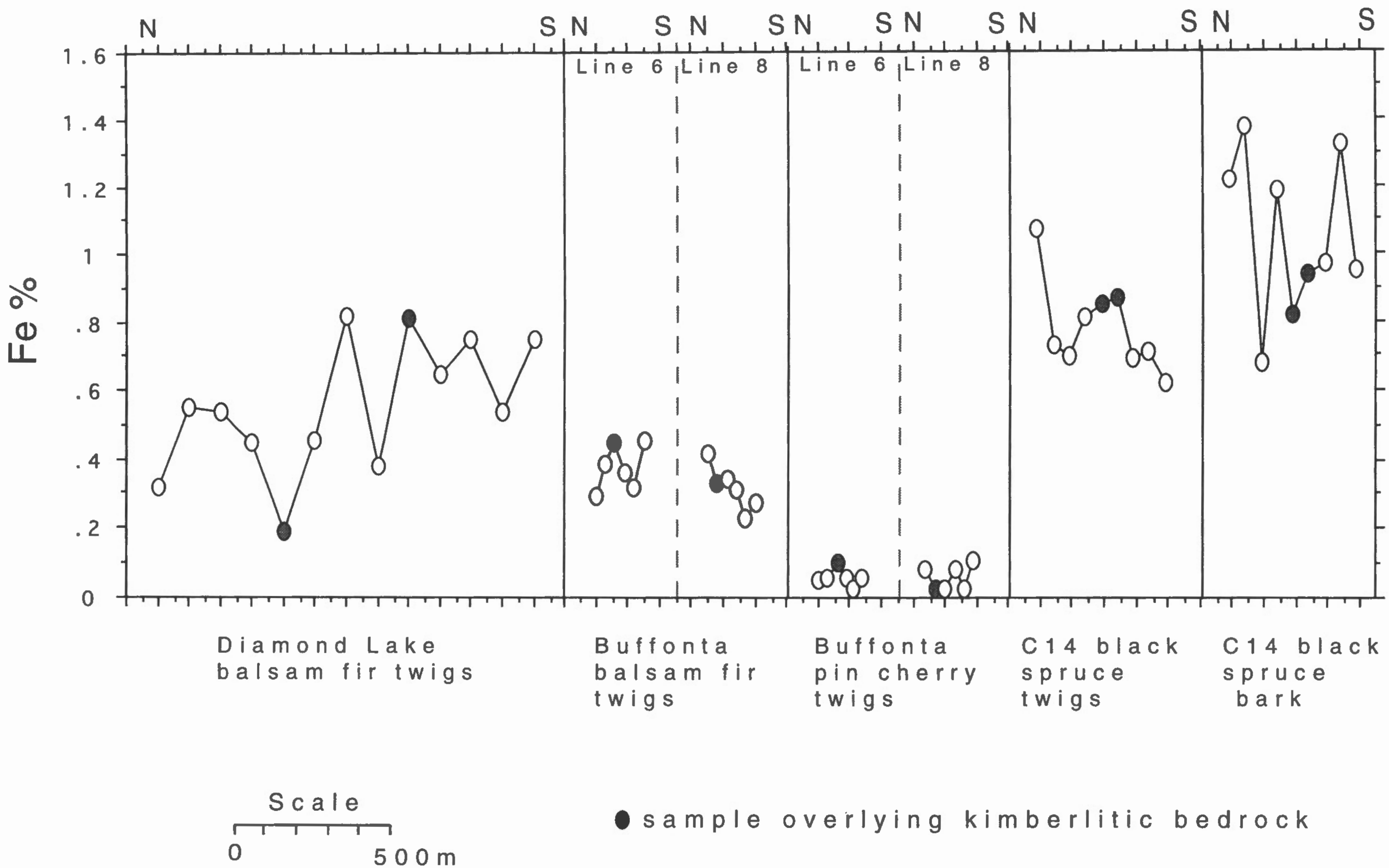

INAA
Co ppm
0
2
4
6
8
10
12
14
16
18
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock


INAA
Cr ppm
60
50
40
30
20
10
0
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
sample overlying kimberlitic bedrock
Scale
0
500m

INAA

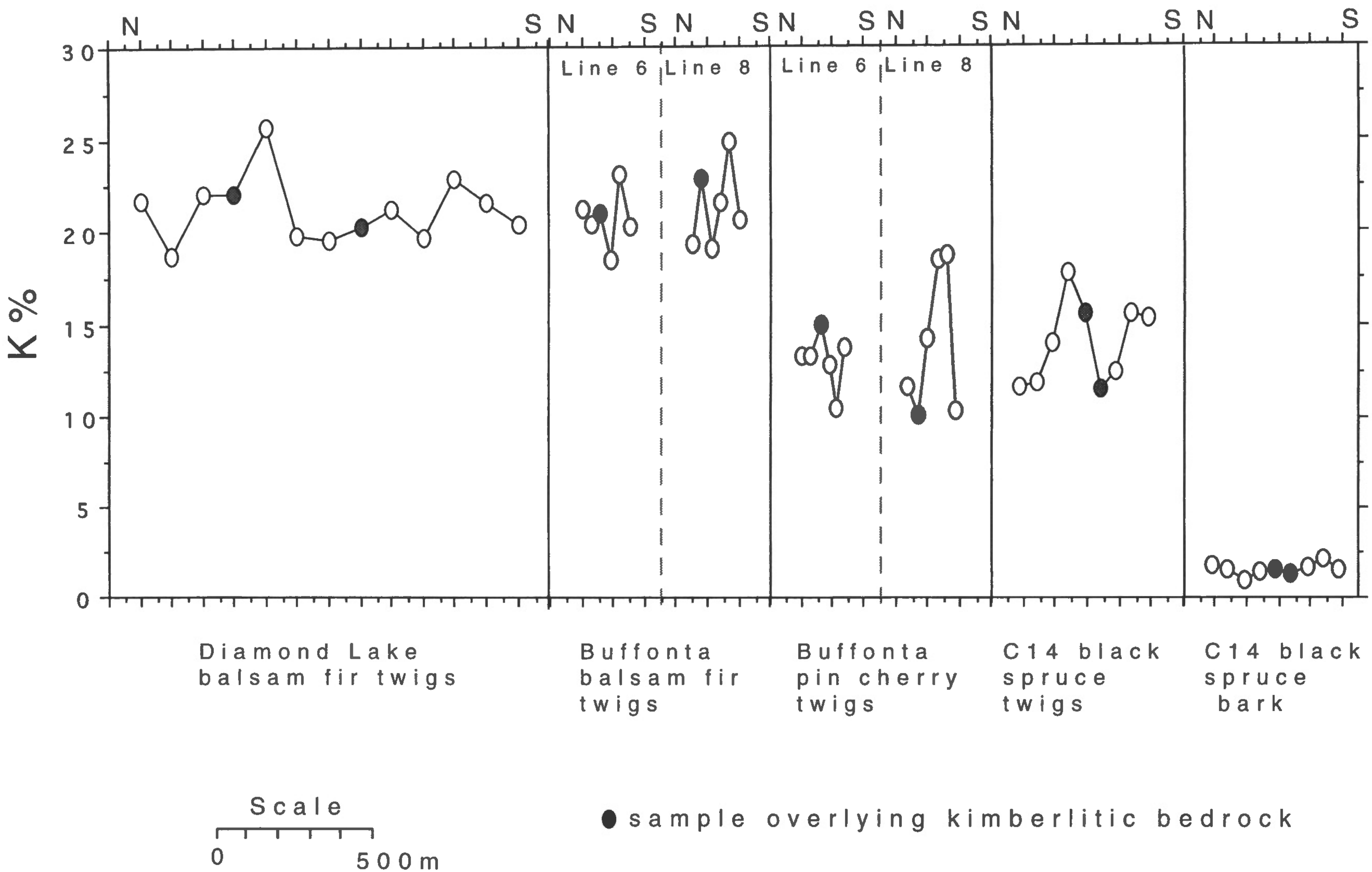

Cs ppm
0
1
2
3
4
5
6
N
S
Line 6
Line 8
Diamond Lake
balsam fir twigs
Buffonta
balsam fir
twigs
Buffonta
pin cherry
twigs
C14 black
spruce
twigs
C14 black
spruce
bark
Scale
0
500m
sample overlying kimberlitic bedrock

INAA

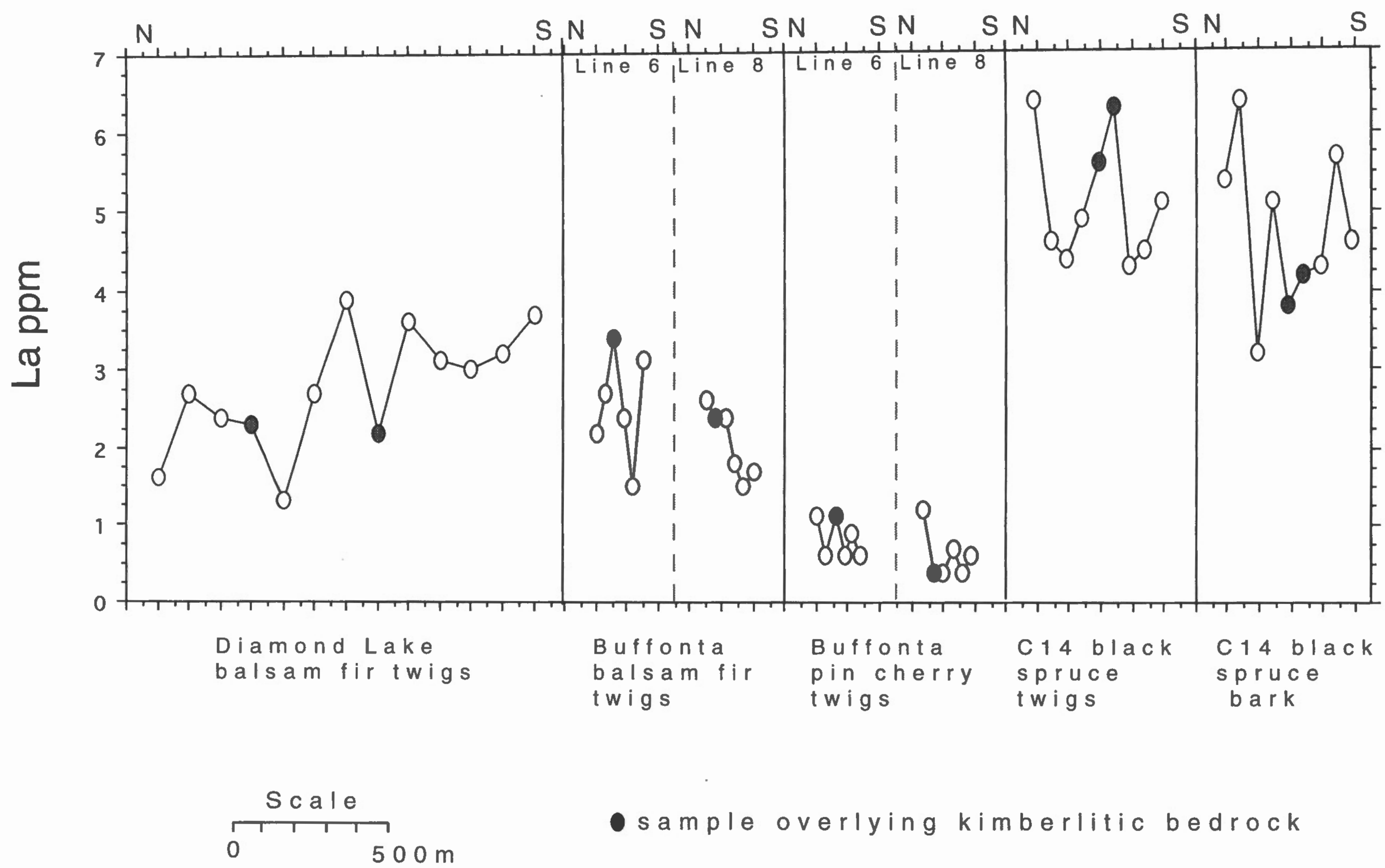


N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Fe %
1.6
1.4
1.2
1
.8
.6
.4
.2
0
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock

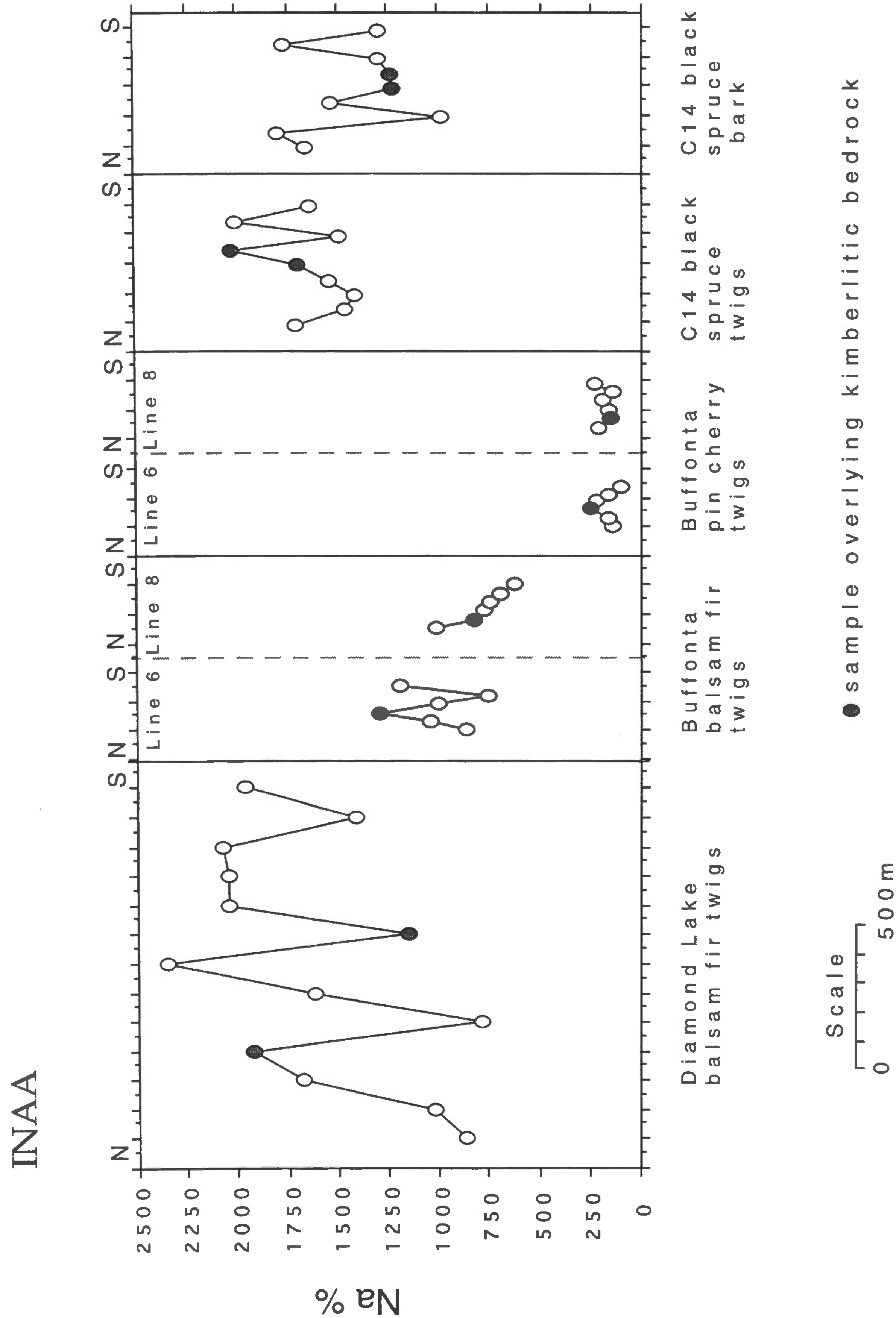
INAA


N S N S N S N S N S N S N S
Line 6
Line 8
Line 6
Line 8
30
25
20
15
10
5
0
K %
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock

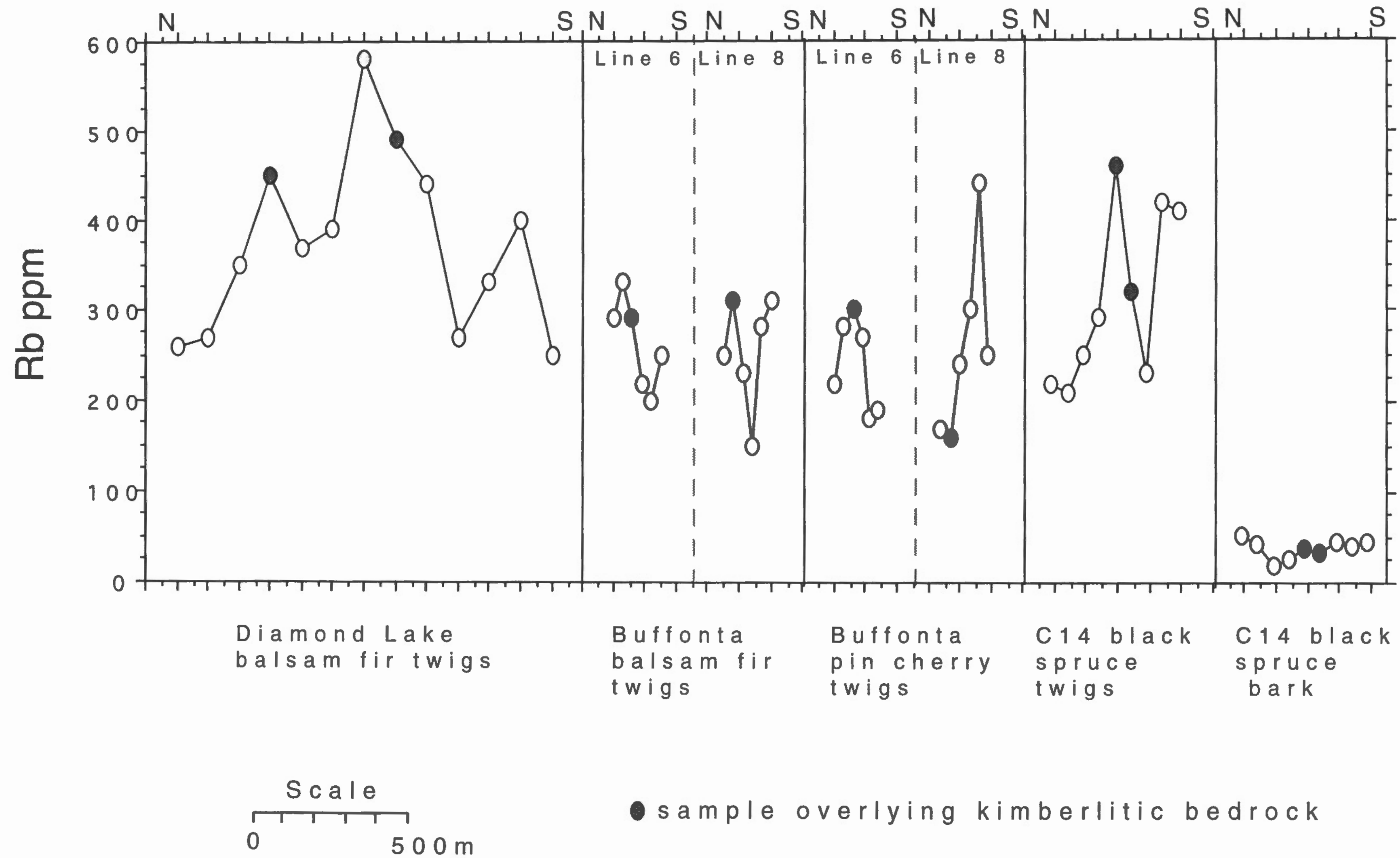
INAA

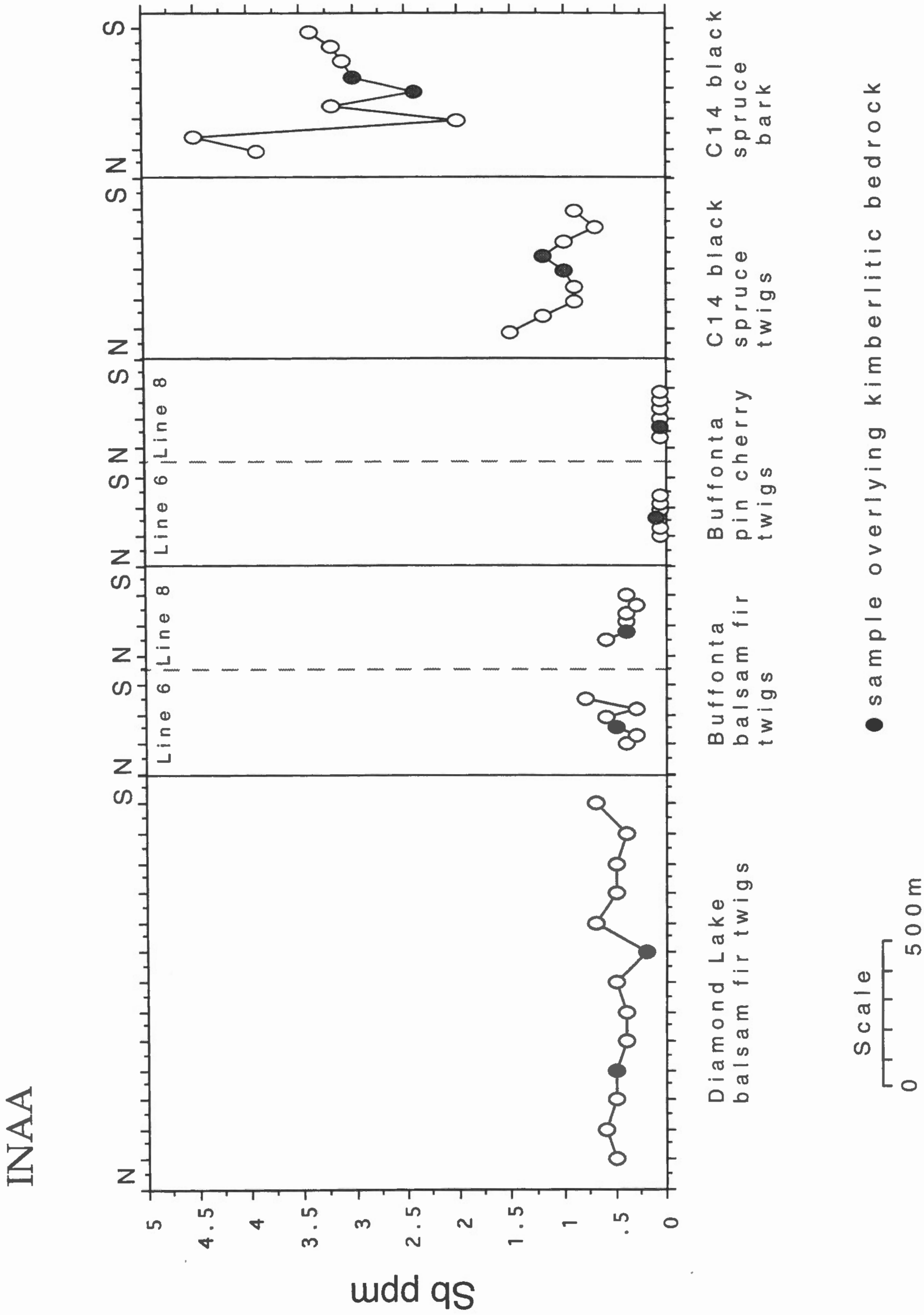


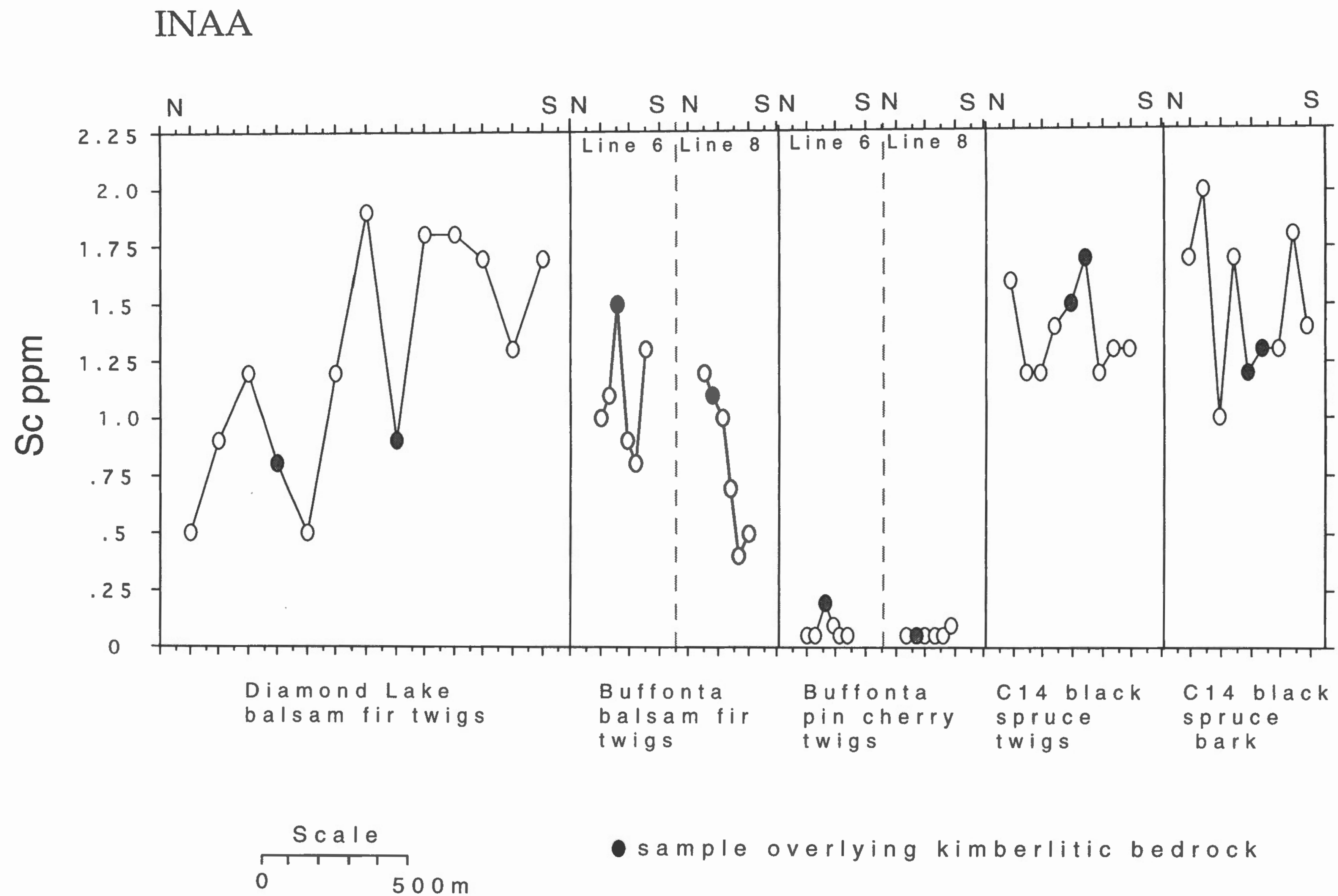
La ppm
0
1
2
3
4
5
6
7
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock


INAA
Na %
2500 2250 2000 1750 1500 1250 1000 750 500 250 0
N S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
sample overlying kimberlitic bedrock
Scale
0 500m

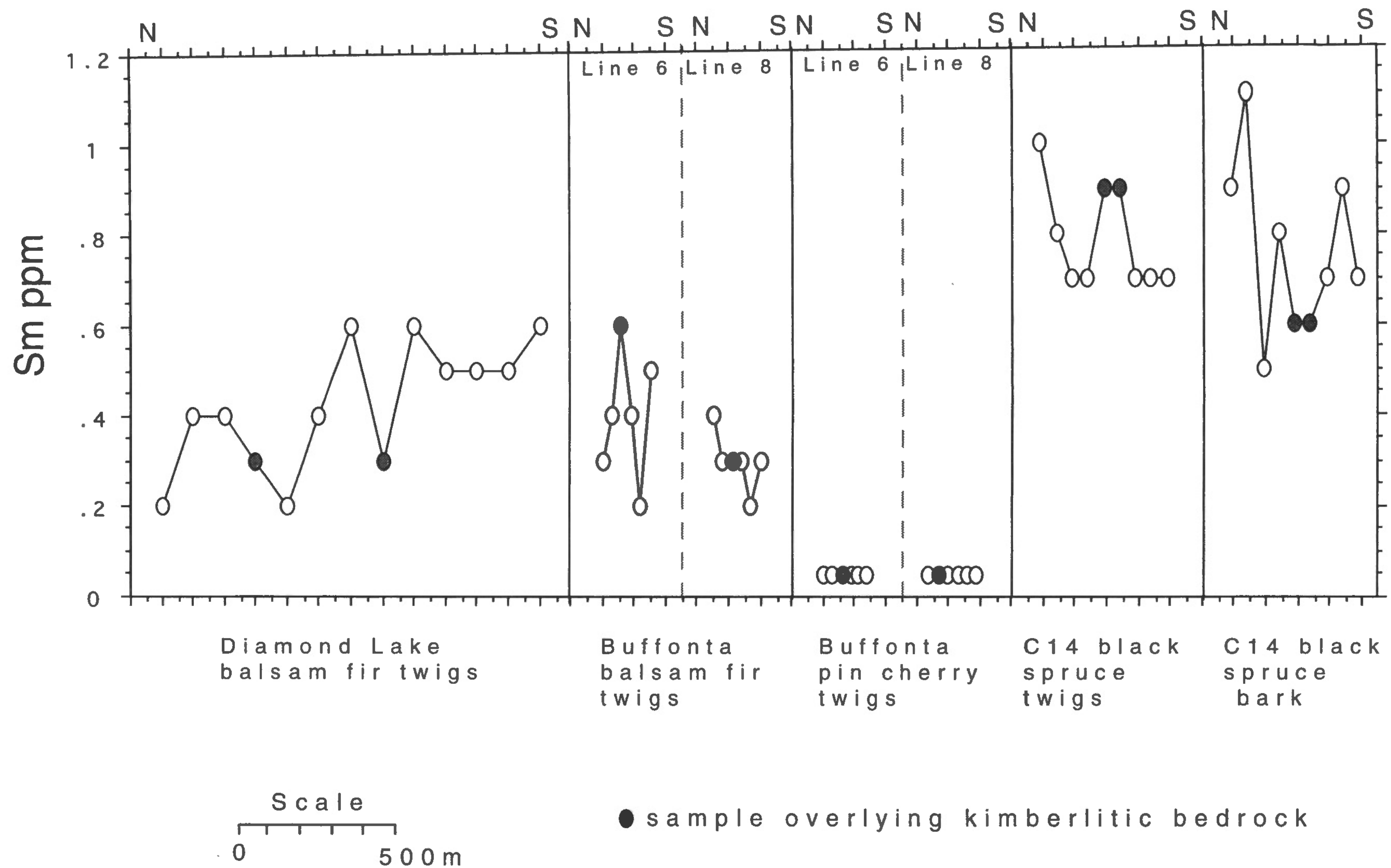
INAA


Rb ppm
600
500
400
300
200
100
0
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock

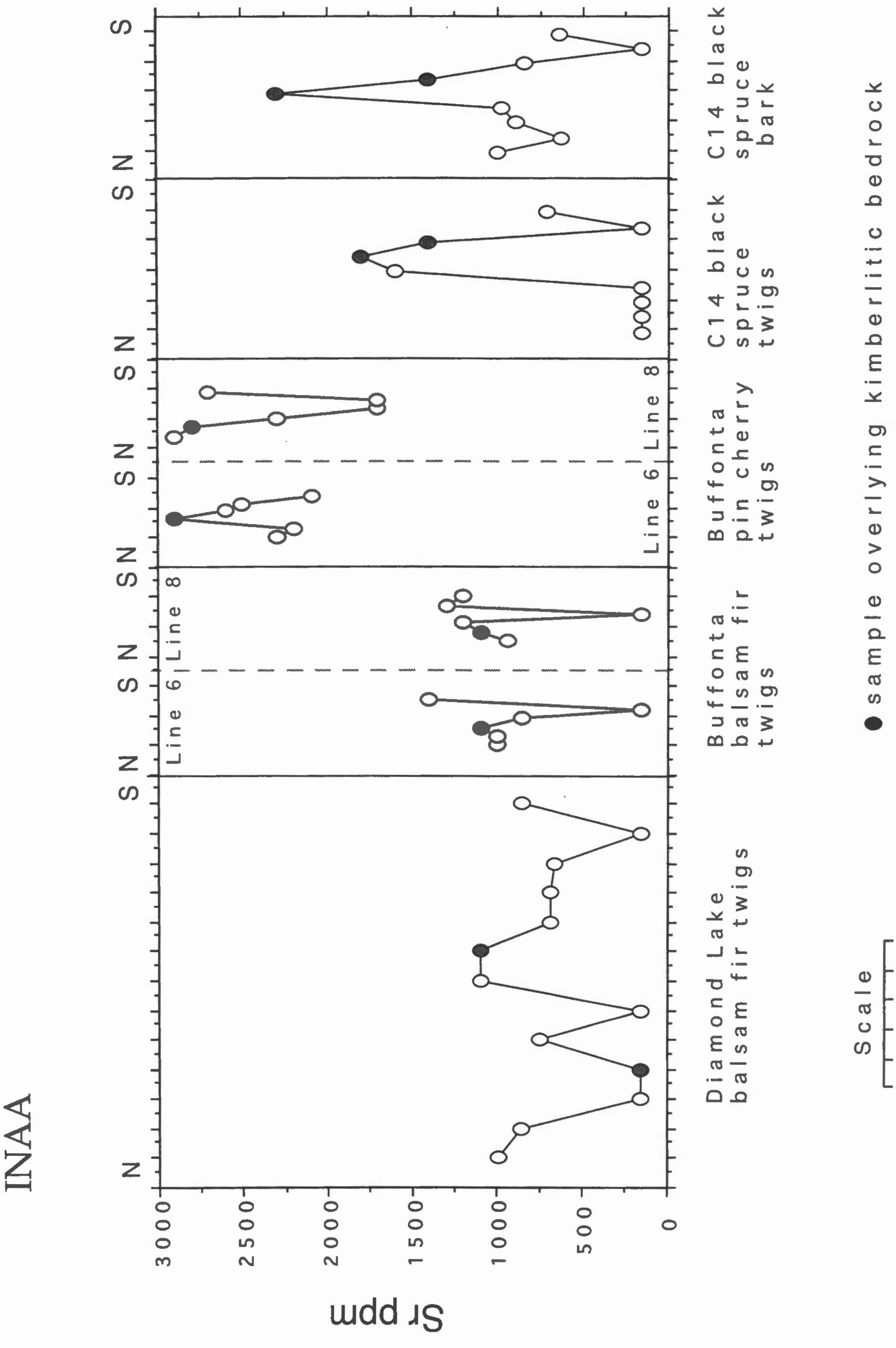

INAA
Sb ppm
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock


INAA
Sc ppm
2.25
2.0
1.75
1.5
1.25
1.0
.75
.5
.25
0
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock

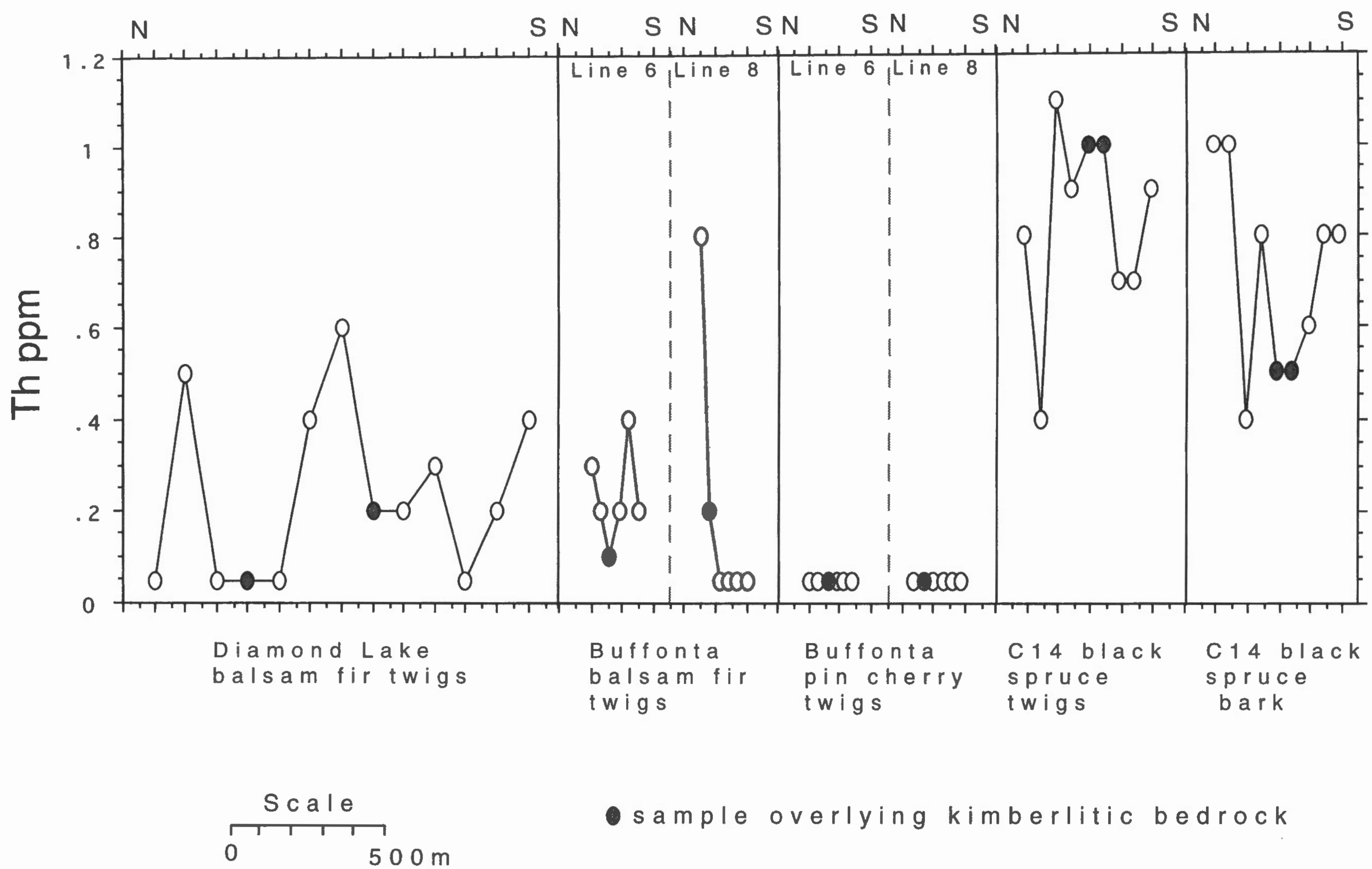
INAA



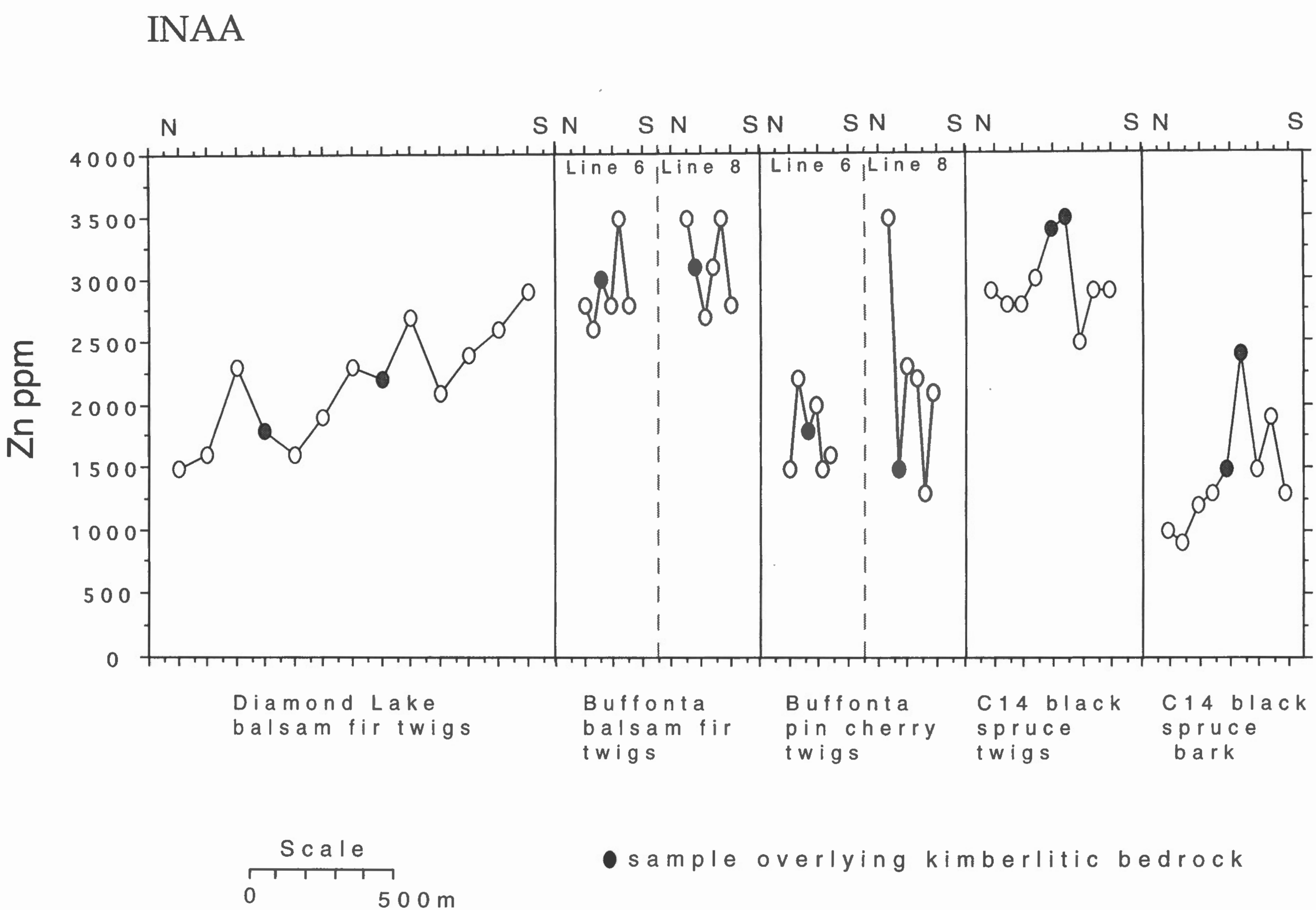
Sm ppm
1.2
1
.8
.6
.4
.2
0
N S N S N S N S N S N S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock


INAA
Sr ppm
3000
2500
2000
1500
1000
500
0
N
S
Diamond Lake balsam fir twigs
Line 6
Line 8
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
sample overlying kimberlitic bedrock
Scale
0
500m

INAA



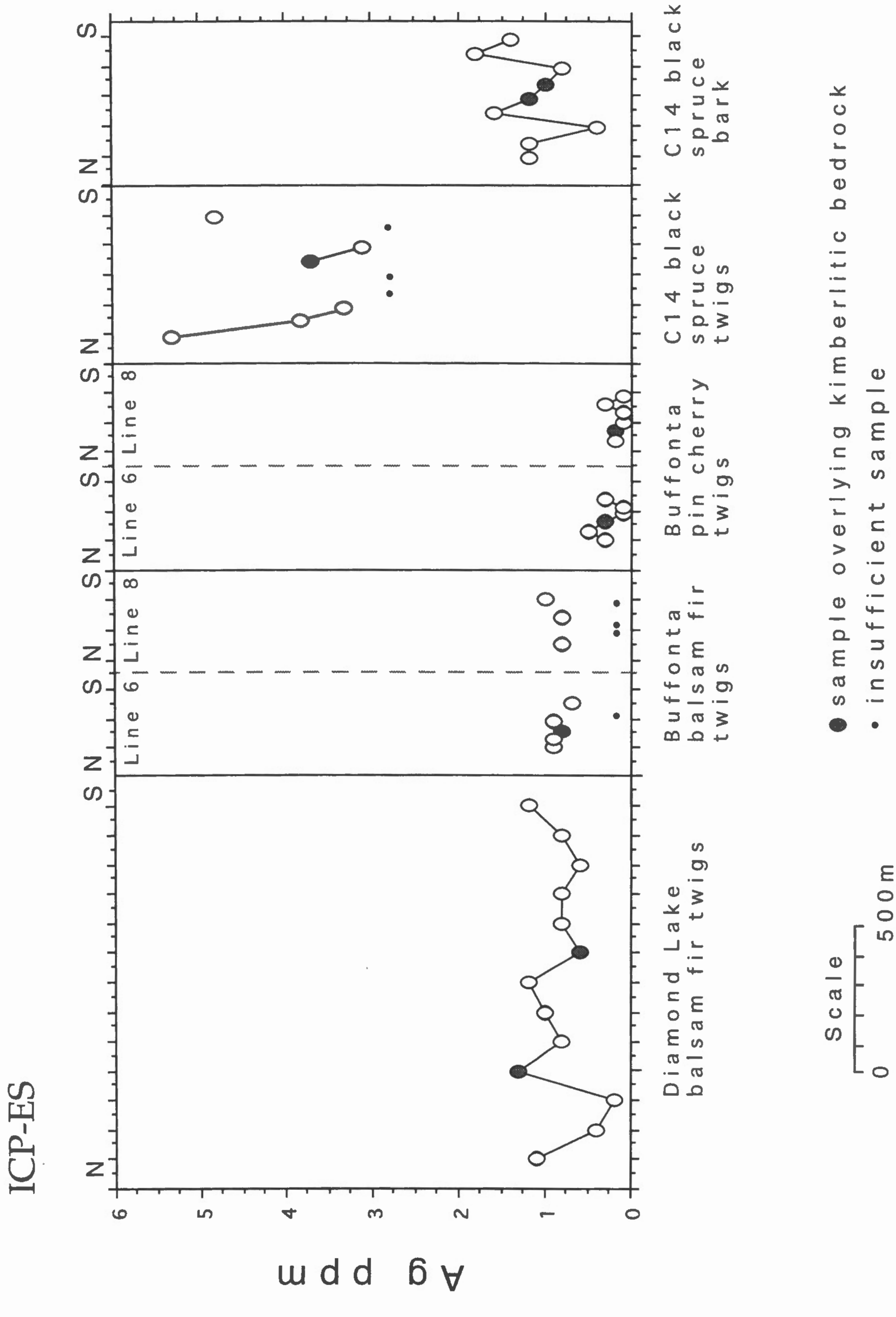
Th ppm
1.2
1
.8
.6
.4
.2
0
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock



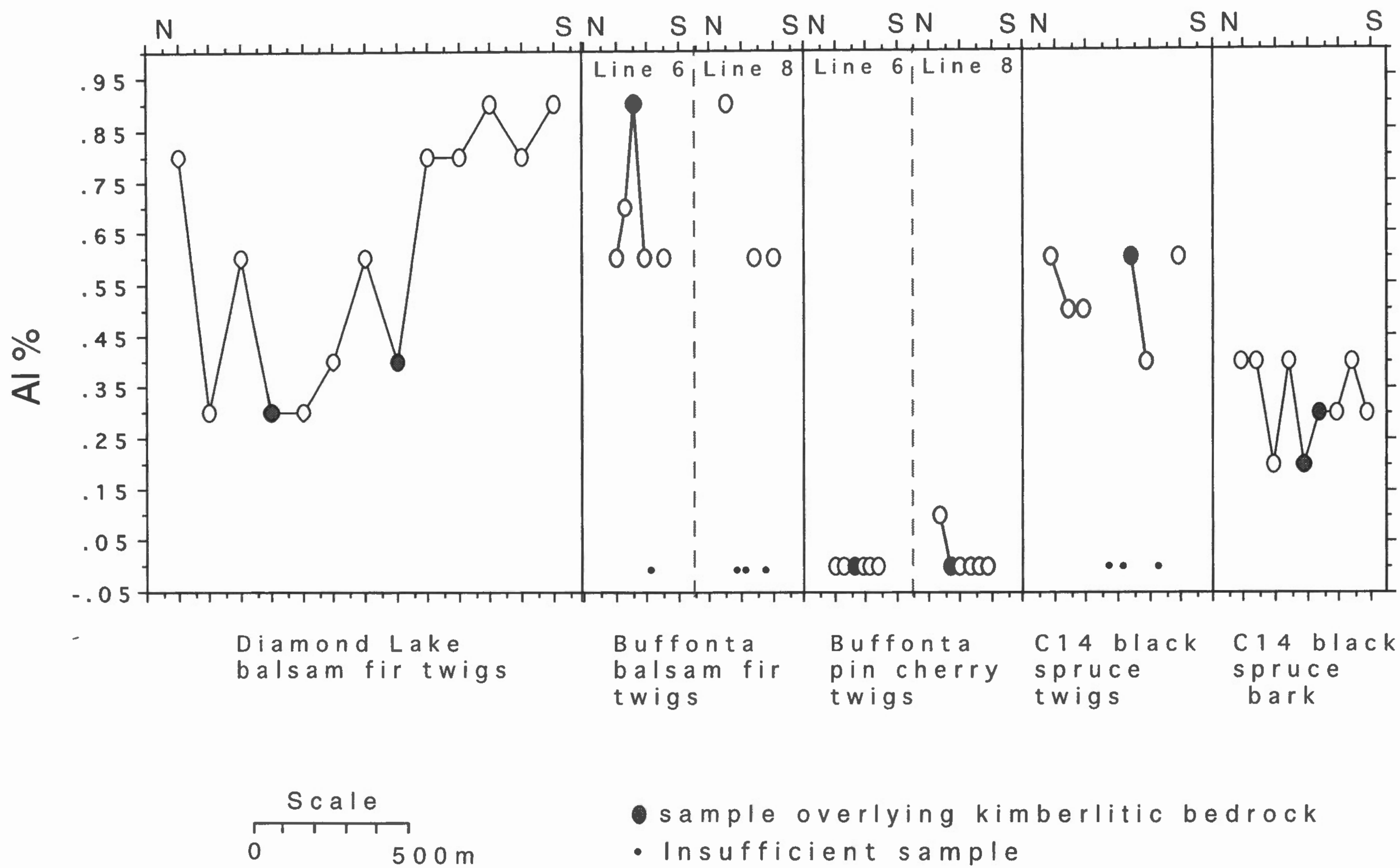
INAA
Zn ppm
4000
3500
3000
2500
2000
1500
1000
500
0
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock

Appendix F. ICP-ES profile plots

Element **Page**

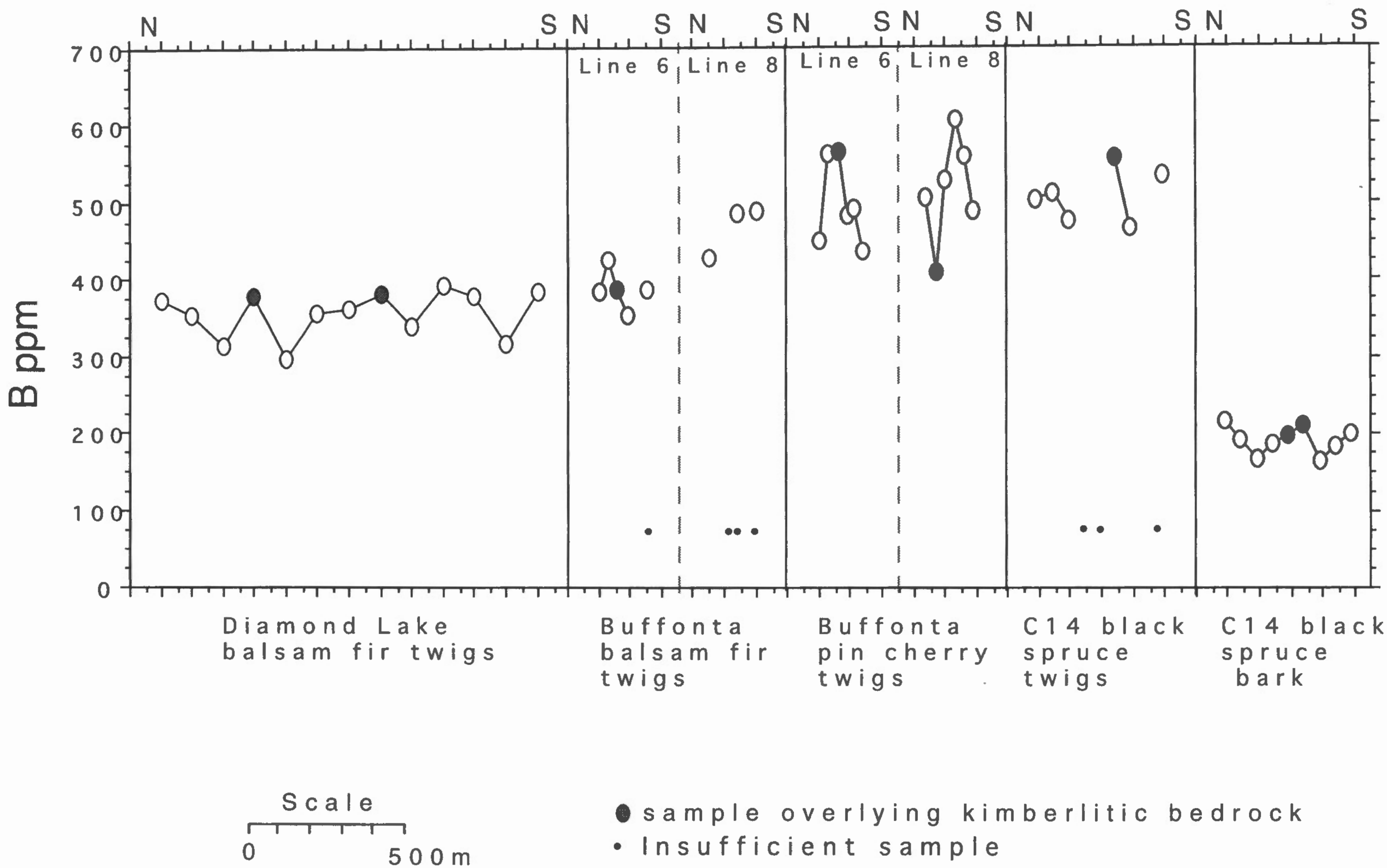

ICP-ES
Ag ppm
0
1
2
3
4
5
6
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
sample overlying kimberlitic bedrock
insufficient sample
Scale
0
500m

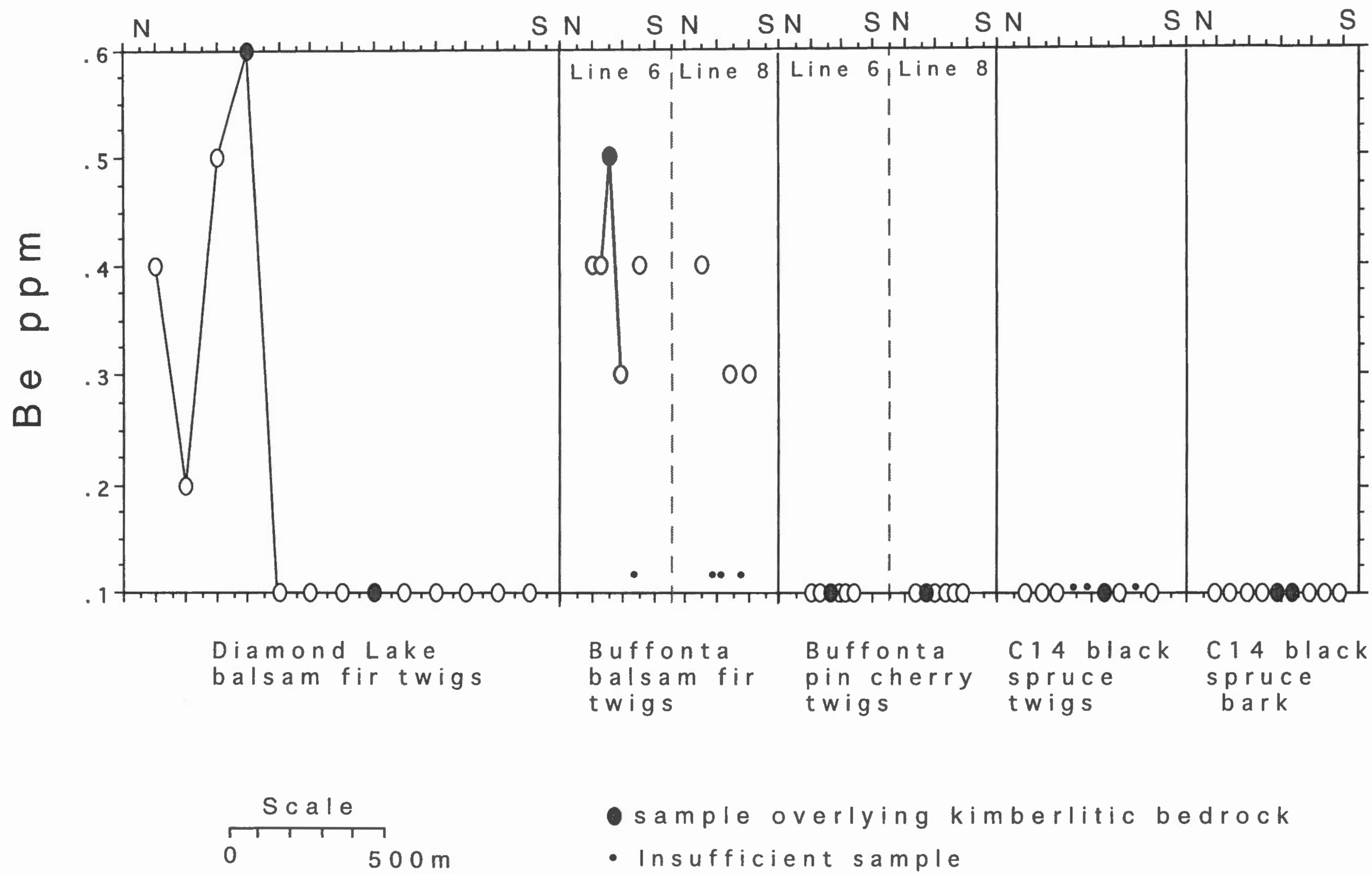
ICP-ES



N
S
Line 6
Line 8
.95
.85
.75
.65
.55
.45
.35
.25
.15
.05
-.05
Al %
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample

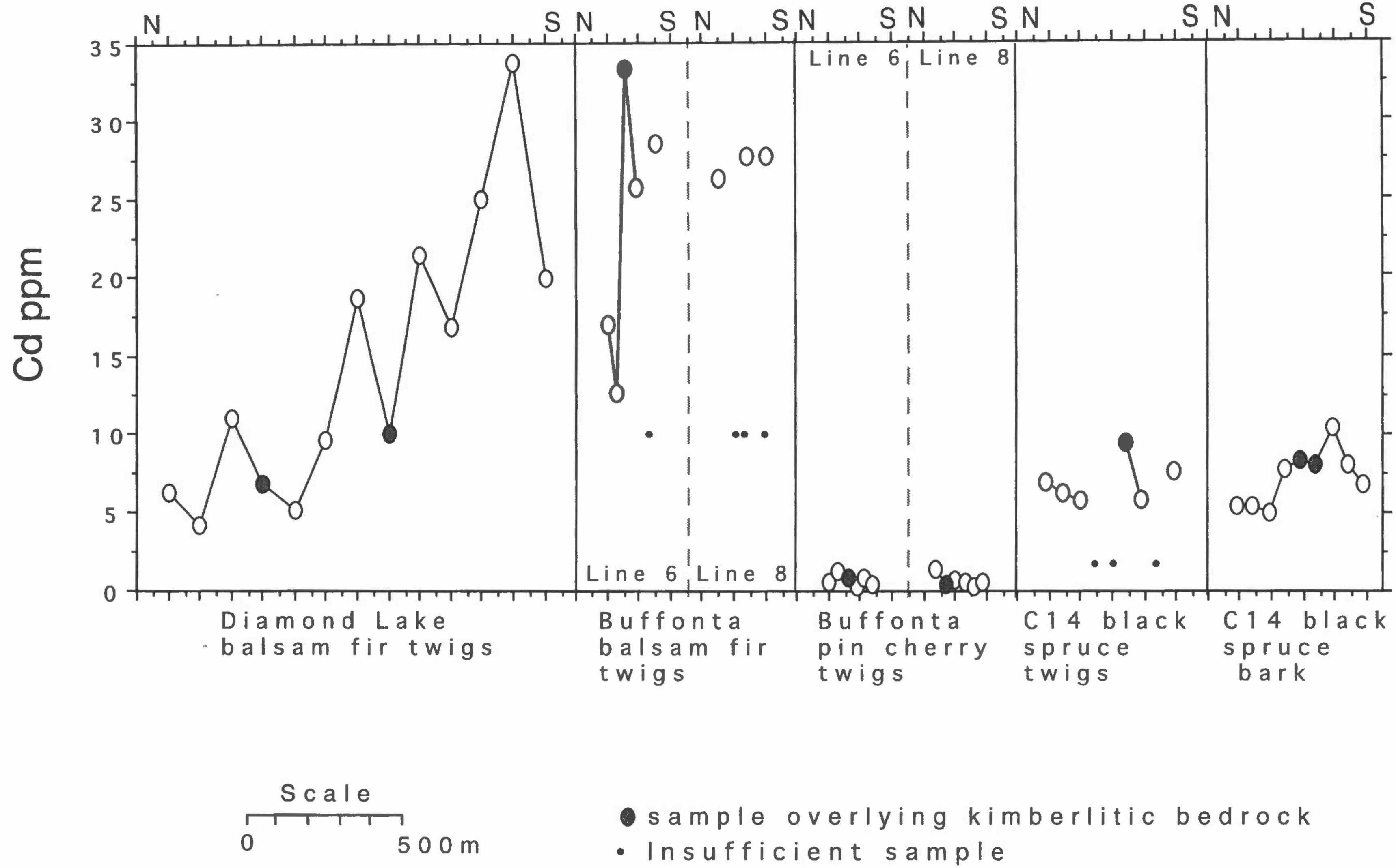
ICP-ES


B ppm
0
100
200
300
400
500
600
700
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample

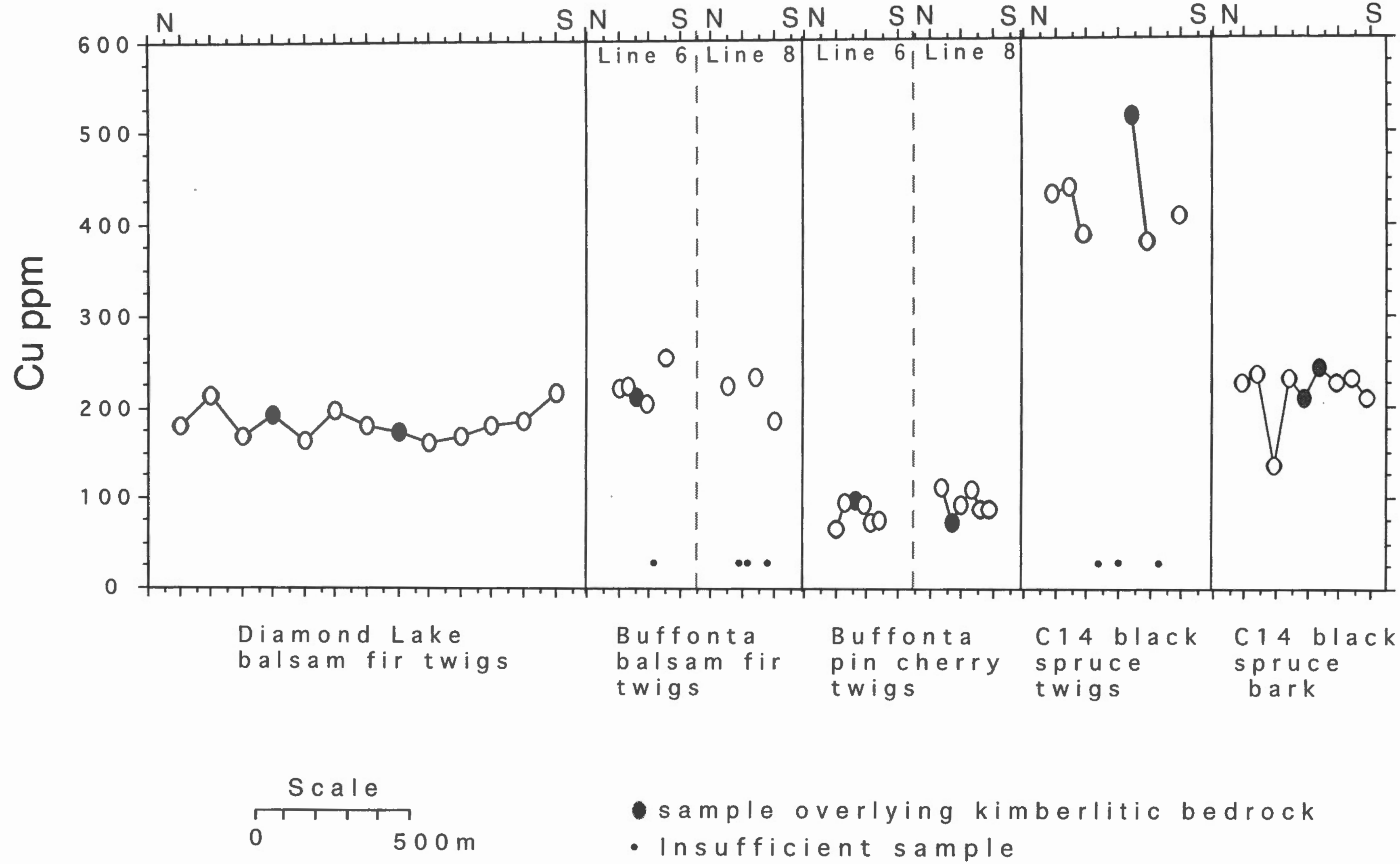


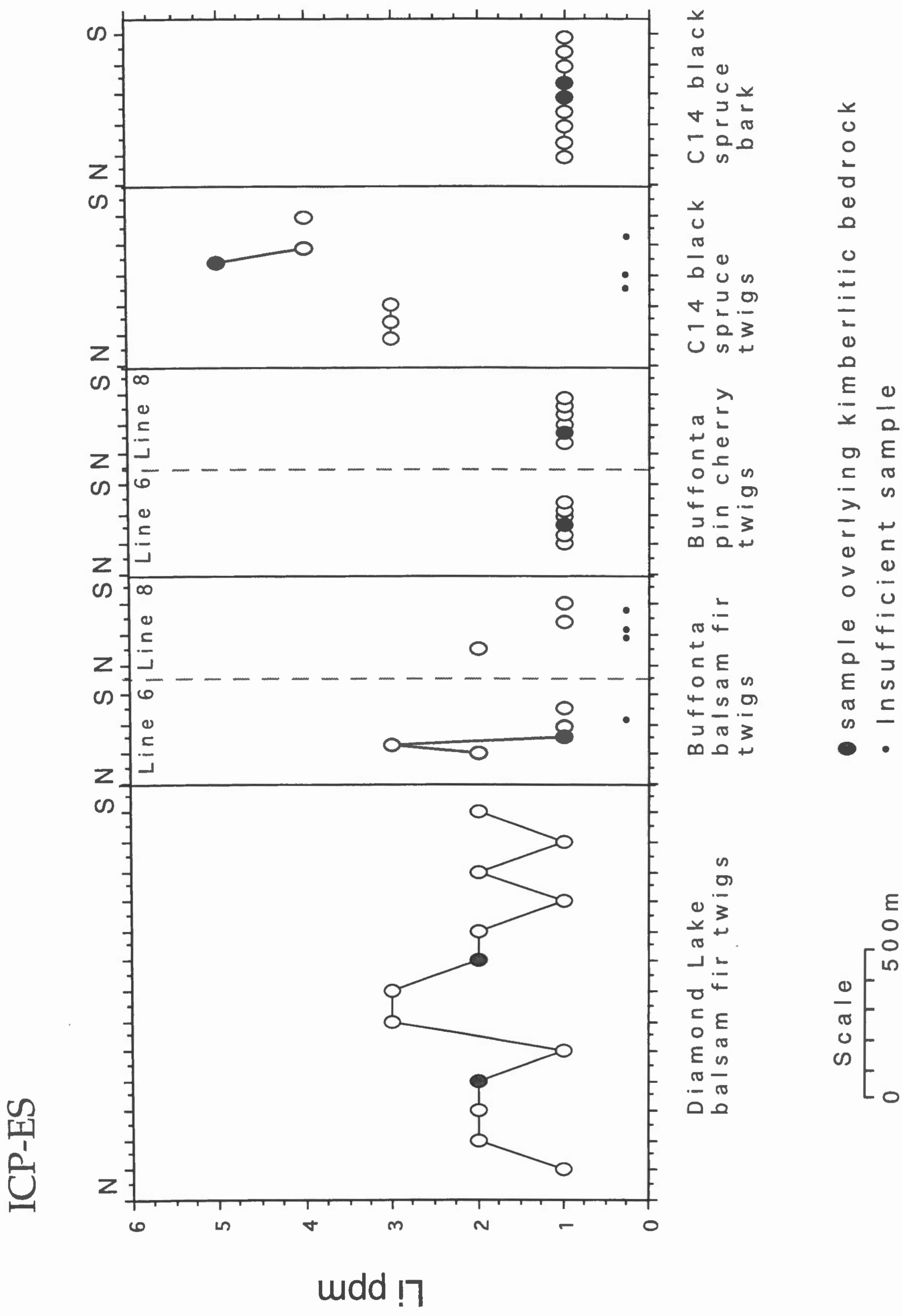
Be ppm
.6
.5
.4
.3
.2
.1
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample

ICP-ES


Cd ppm
35
30
25
20
15
10
5
0
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample

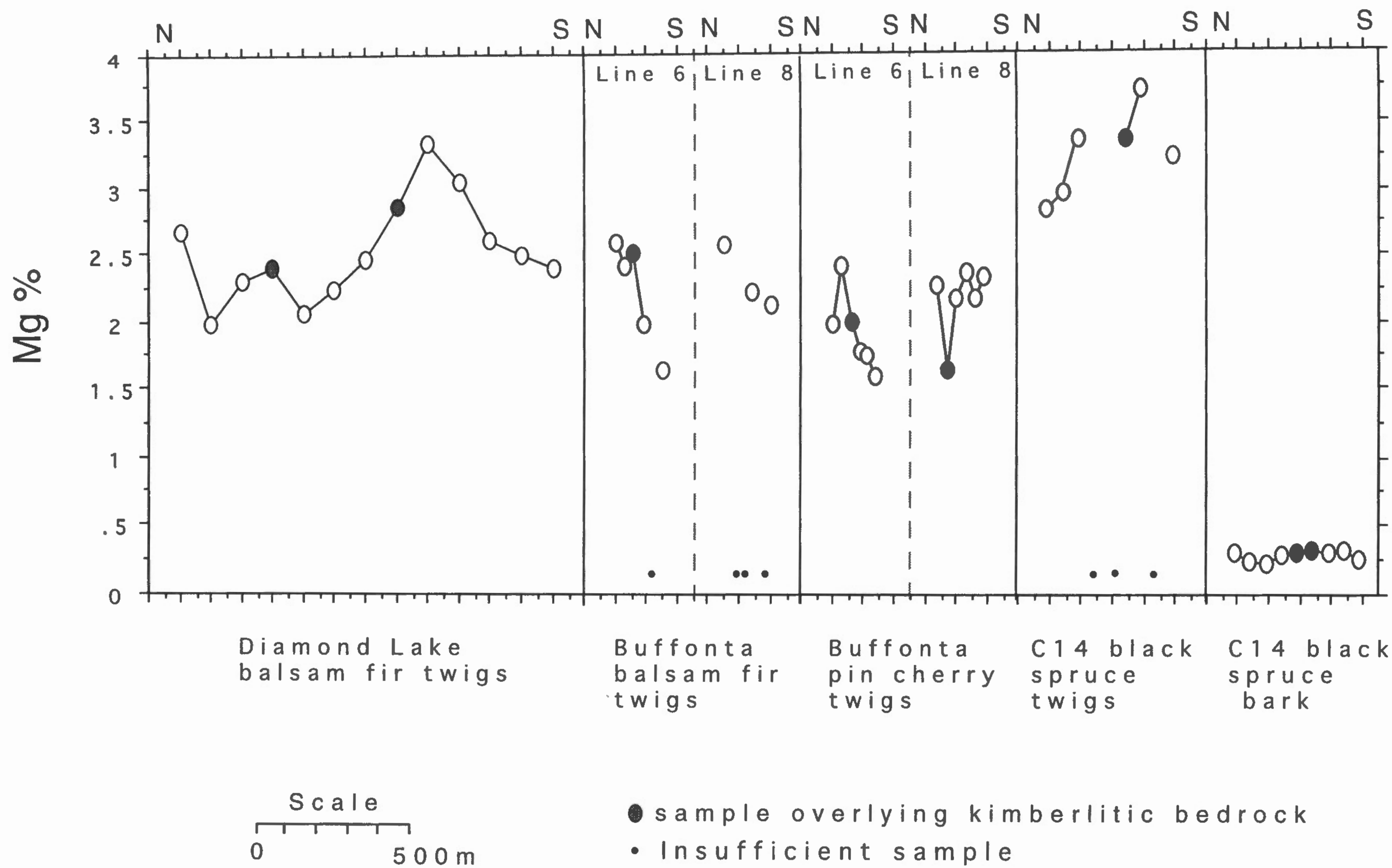
ICP-ES


Cu ppm
600
500
400
300
200
100
0
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample



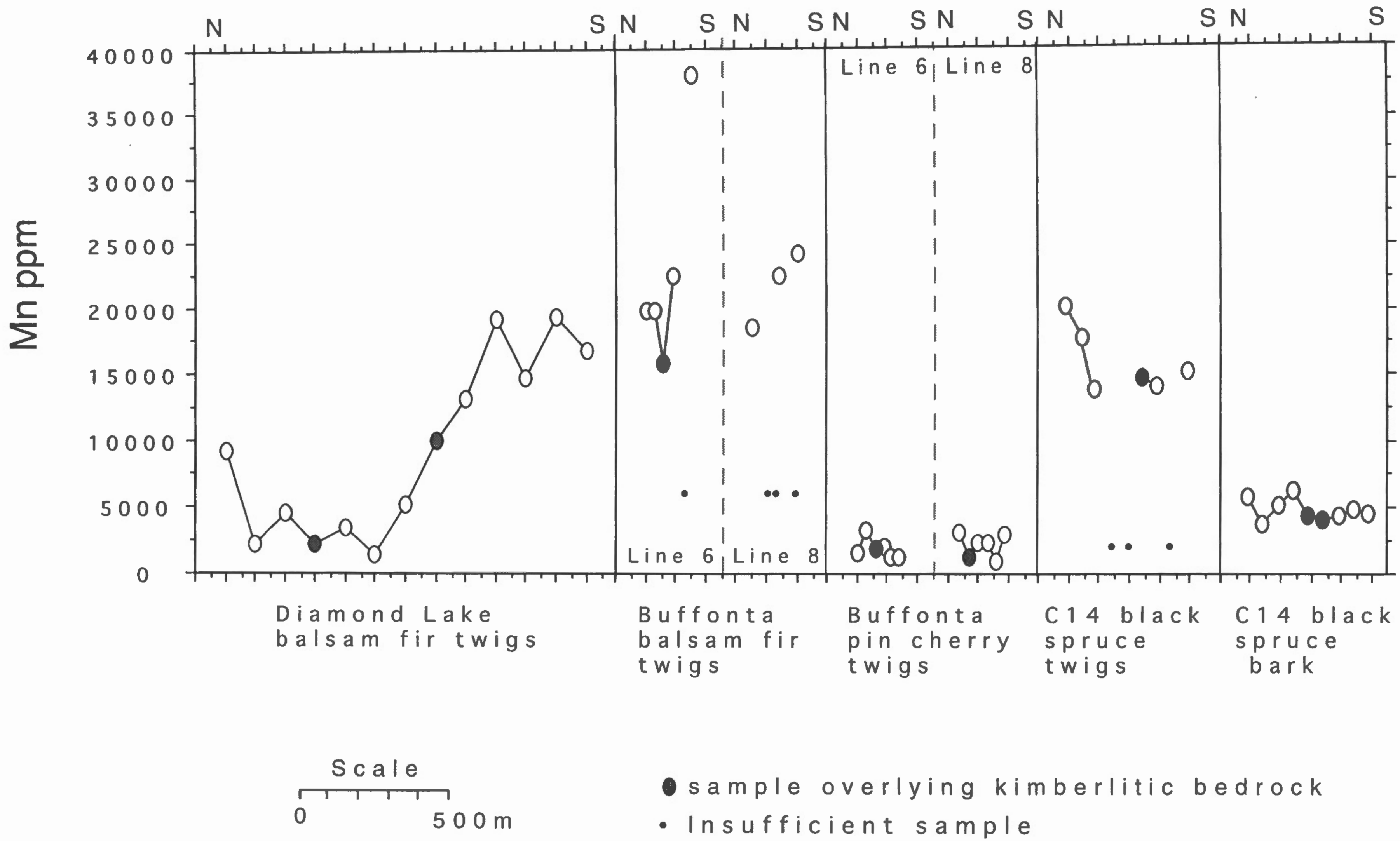
ICP-ES
Li ppm
0
1
2
3
4
5
6
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
sample overlying kimberlitic bedrock
Insufficient sample
Scale
0
500m

ICP-ES



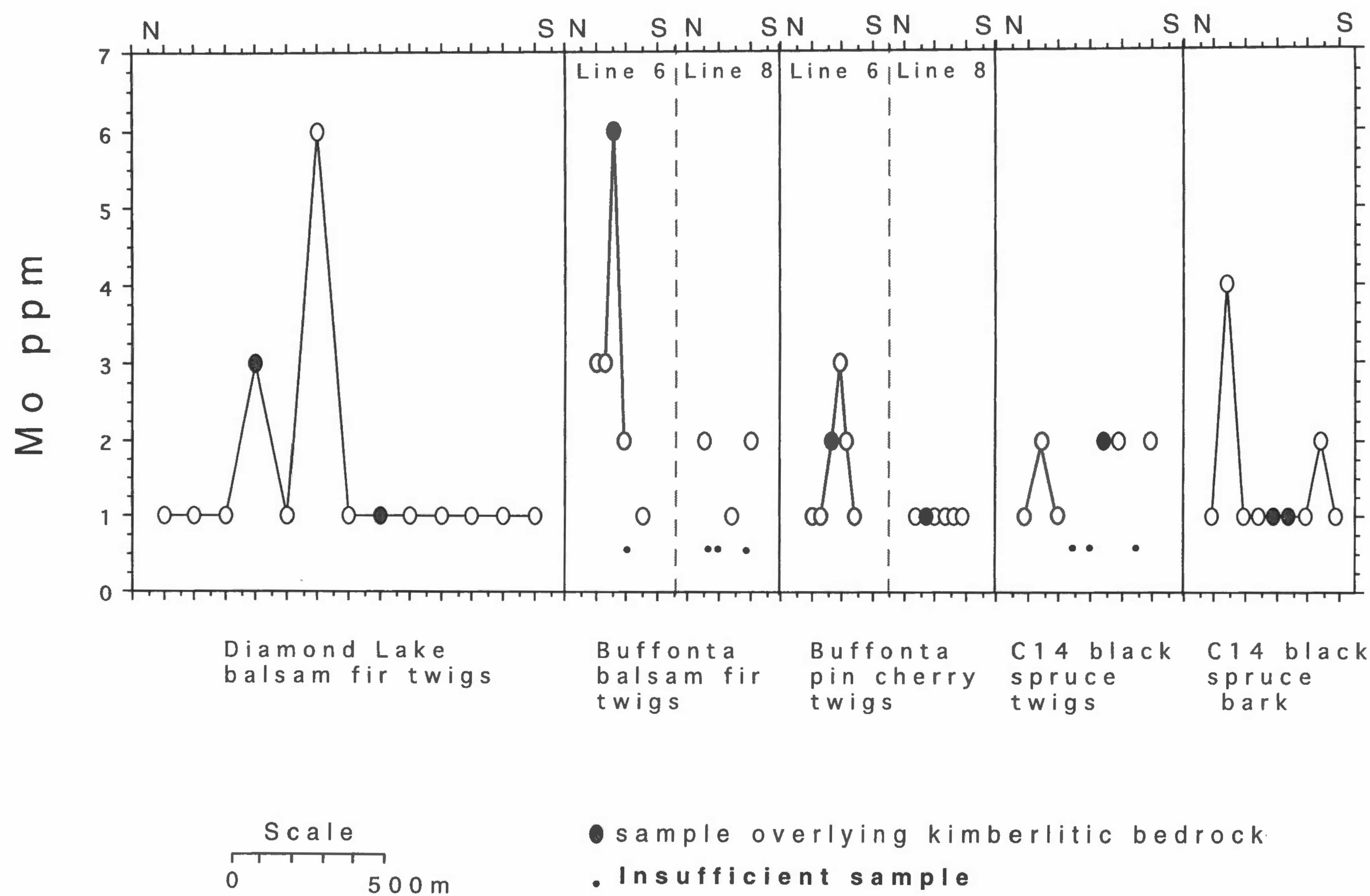
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Mg %
4
3.5
3
2.5
2
1.5
1
.5
0
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample

ICP-ES

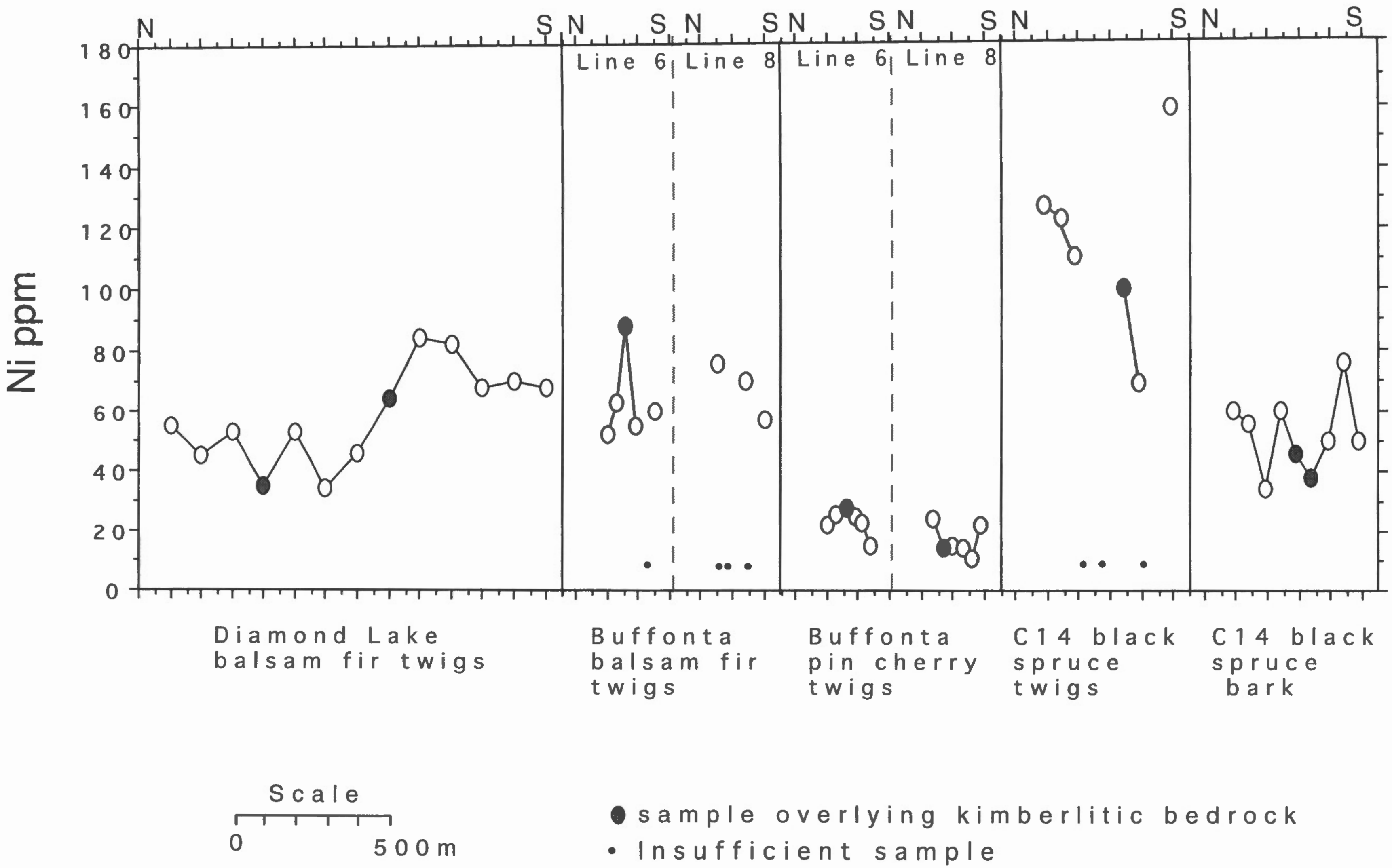


Mn ppm
40000
35000
30000
25000
20000
15000
10000
5000
0
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample

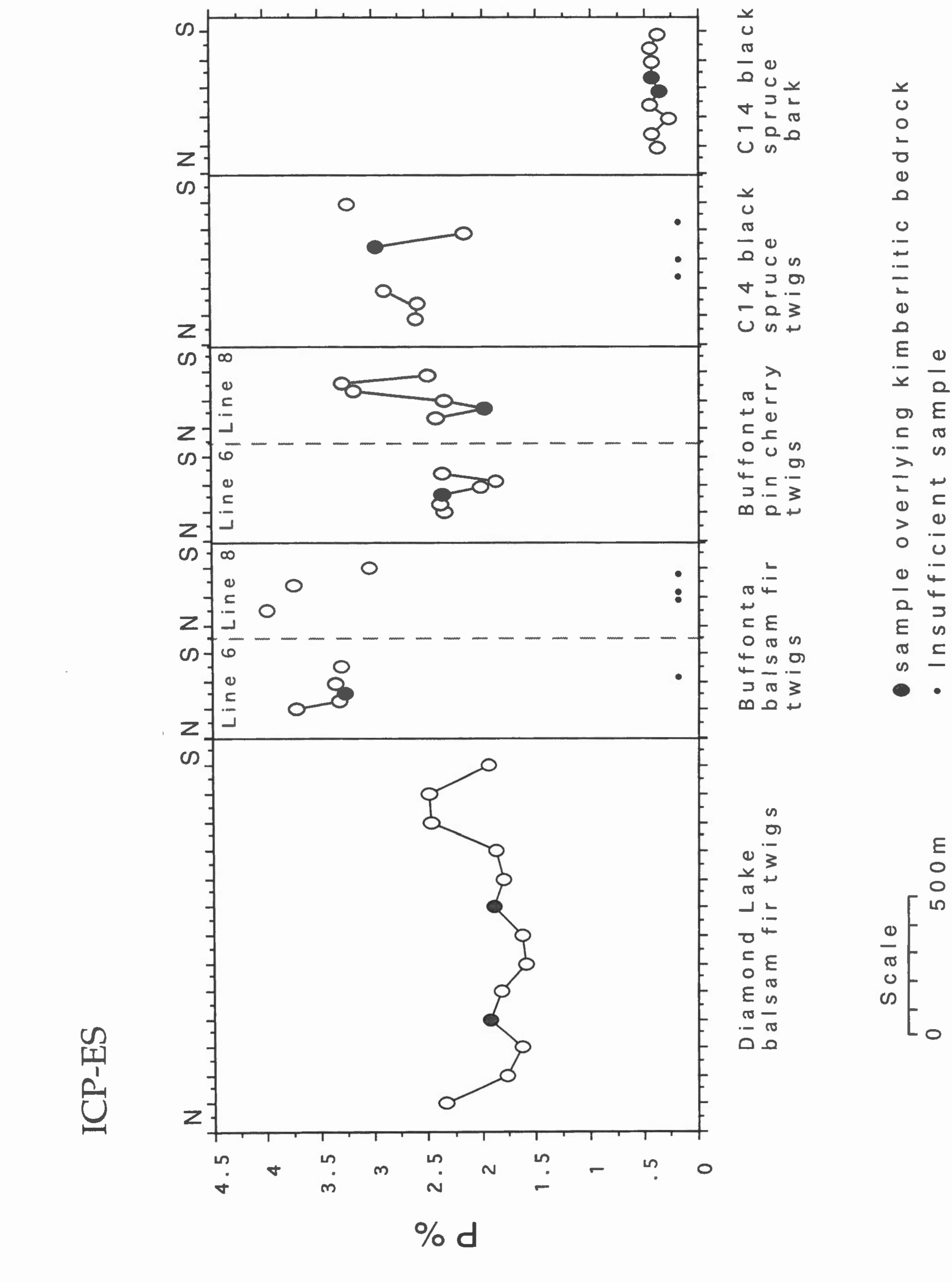
ICP-ES


Mo ppm
7
6
5
4
3
2
1
0
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
. Insufficient sample

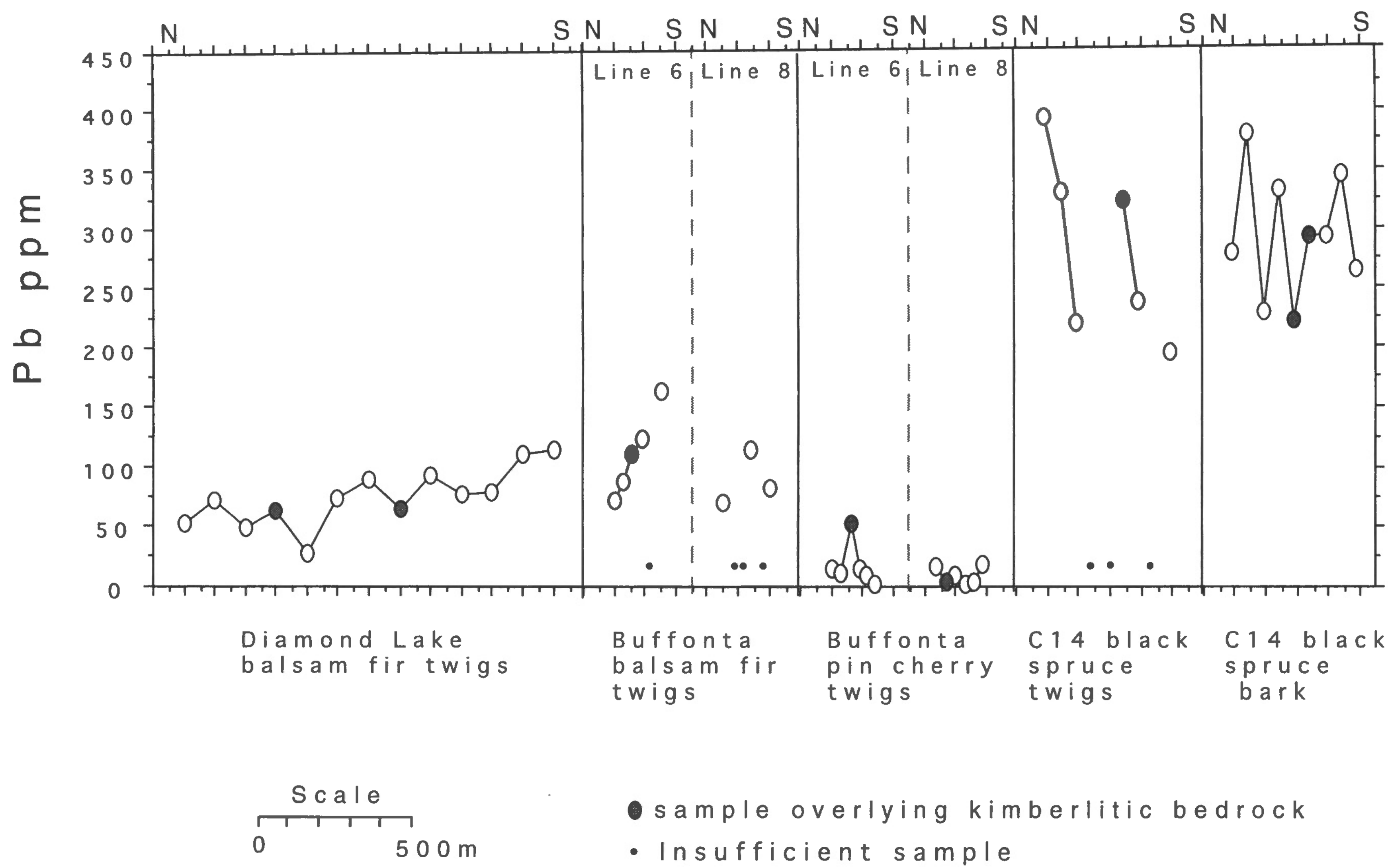
ICP-ES



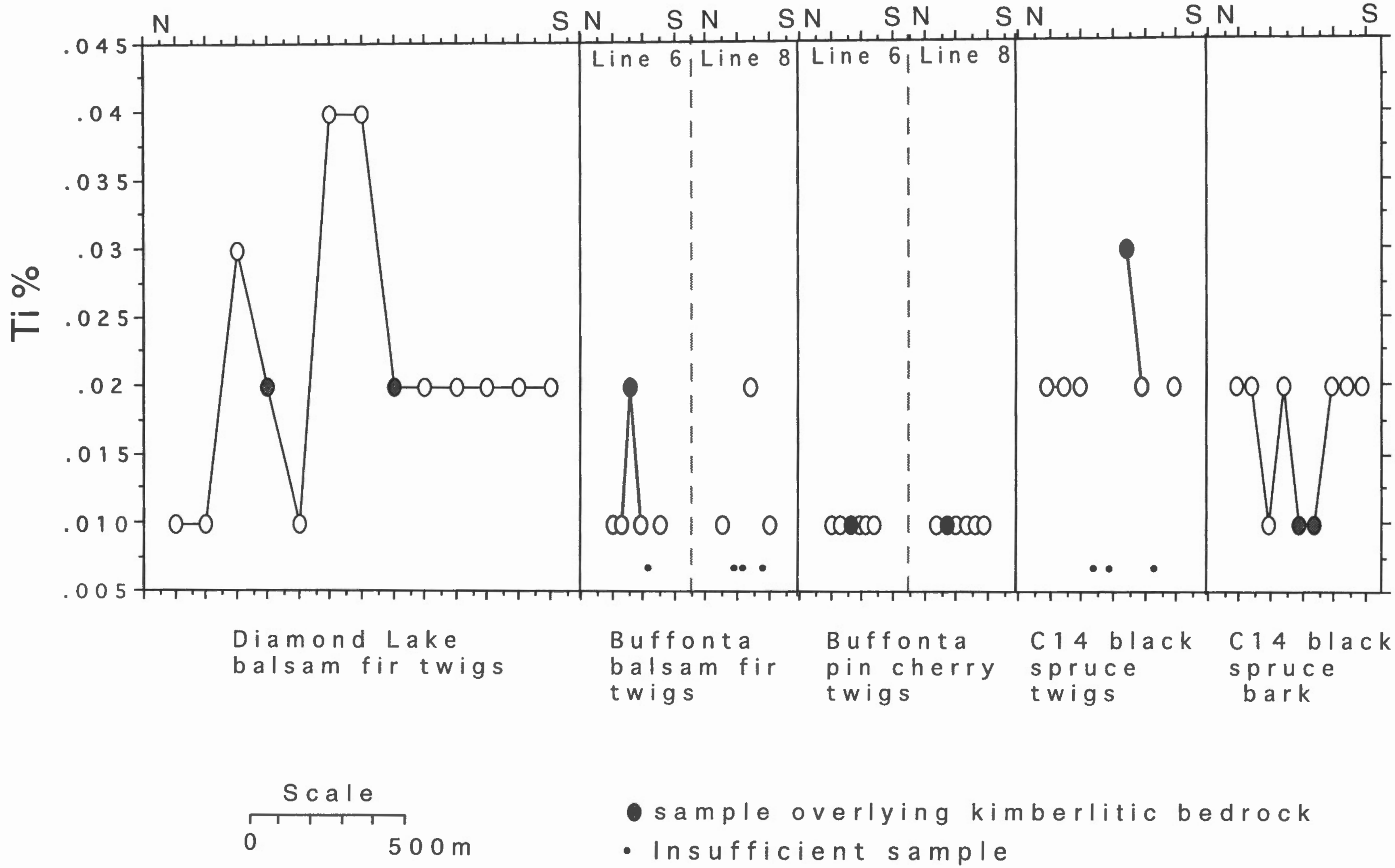
Ni ppm
180
160
140
120
100
80
60
40
20
0
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample


ICP-ES
P %
4.5
4
3.5
3
2.5
2
1.5
1
.5
0
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample

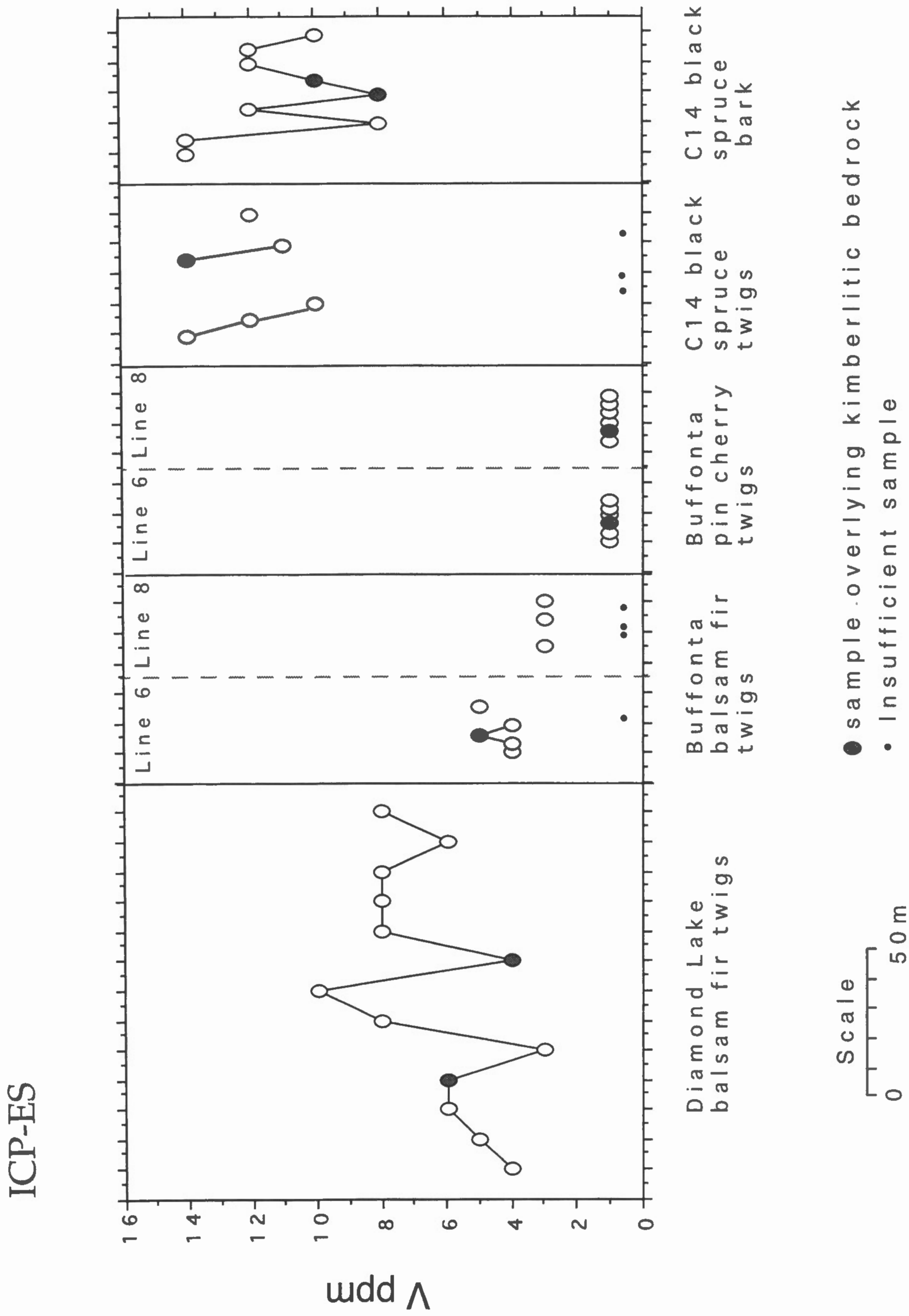
ICP-ES


Pb ppm
450
400
350
300
250
200
150
100
50
0
N
S N
S N
S N
S N
S N
S N
S
Line 6
Line 8
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample

ICP-ES



Ti %
.045
.04
.035
.03
.025
.02
.015
.010
.005
N
S
Line 6
Line 8
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Scale
0
500m
sample overlying kimberlitic bedrock
Insufficient sample


ICP-ES
V ppm
0
2
4
6
8
10
12
14
16
Diamond Lake balsam fir twigs
Buffonta balsam fir twigs
Buffonta pin cherry twigs
C14 black spruce twigs
C14 black spruce bark
Line 6
Line 8
Line 6
Line 8
Scale
0
50m
sample overlying kimberlitic bedrock
Insufficient sample