kiggavik Uranium Project

Baker Lake Northwest Territories Canada

Environmental Assessment

Prepared by Beak Consultants Limited

Supporting Document No. 2

Soils and Vegetation

Urangesellschaft Canada Limited

Toronto, Ontario Canada
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SUPPORTING DOCUMENT NO. 2

SOILS AND VEGETATION

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SUMMARY

A terrestrial (landforms, surficial deposits, soil and vegetation) environmental baseline resource description and mapping survey for those areas potentially affected by the proposed Kiggavik uranium development project has been prepared. Information is spatially analyzed and presented within the framework of an Ecological Land Survey (ELS) using a micro-based Geographic Information System (GIS). Individual resource component descriptions are provided as general resource background documentation.

Ecological Land Survey, because of its focus on landscape and landscape patterns, makes extensive use of remote sensing data, including satellite imagery and aerial photography. The study utilized Landsat Thematic Mapper (TM) satellite data as well as various scales of aerial photography in order to map and describe the terrestrial resources at each level of ELS generalization.

Four levels of ELS generalization have been described for the Kiggavik study area: Ecoregions, Ecodistricts, Ecosections and Ecosites. The Kiggavik study area falls within three major Ecoregions:

- o Garry Lake Plains,
- o Dubawnt Plains, and
- o Rankin Plains.

The winter road from the Kiggavik site to the limestone quarry is located in the Garry Lake Plains ecoregion, the Kiggavik site proper, and the winter road between the Kiggavik site and Aniguq Lake are located in the Dubawnt Plains ecoregion, while the dock facilities and the winter road from Aniguq Lake to Baker Lake occur in the Rankin Plains ecoregion.

Ecodistricts are subdivisions of ecoregions. Within each of the three ecoregions described for the project area, parts of four ecodistricts are included:

o	Garry Plains Ecoregion:	Deep Rose Lake (AL05)
		Marjorie Hills (AL06)
o	Dubawnt Plains Ecoregion:	Mallery Lake (DL06)
o	Rankin Plains Ecoregion:	Kaminuriak Lake (CT01)

Ecosections (subdivision of ecodistricts) and Ecosites (subdivisions of ecosections) were initially delineated and described for a 1,113 km^2 area centred on the Kiggavik site development area using 1:63,360 scale black and white aerial photographyy. A total of six ecosections for the development area are recognized. Each of the ecosections were generalized from 177 ecosites and represent distinctive land areas with recurring patterns of similar landforms, soils, vegetation and hydrology.

Surficial materials in the project area are grouped into five major classes:

- glacial till,
- glaciofluvial deposits,
- glaciolacustrine deposits,
- glaciomarine deposits, and
- peat/organic deposits.

Glacial till deposits are the most widespread of surficial materials in the project area and are represented by two major till types:

- a buff-coloured, sandy-textured till which dominates the area north of the east-west trending escarpment in the Kiggavik area, the area between the Kiggavik site and Baker Lake (where the till has been extensively modified by post-glacial marine activity), and the area north of Aberdeen Lake to the limestone quarry; and
- a reddish-coloured, coarse loamy-textured till with a relatively high silt component (17 to 37%) which dominates the area below the escarpment.

Thickness of the deposits vary from deep blankets tens of metres thick, to veneers less than one metre thick with bedrock knobs protruding. This latter condition is particularly evident in the area between the Kiggavik site and Baker Lake. In the Aberdeen Lake area, the till is moulded into east-west trending drumlins which were subsequently modified through glaciolacustrine activity. The till in the area between Baker Lake and the Kiggavik site has been extensively modified by a post-glacial marine transgression (up to 180 m above sea level). Sandy foreshore and beach deposits are commonly associated with the till in this area.

Patterned ground such as striping and stone circles are common periglacial features associated with the till. Surface relief of the till is typically gently undulating, with numerous scattered lakes, ponds and streams occupying shallow, basin-like depressions.

The coarse, loamy-textured till occurs primarily in the Kiggavik area south of the escarpment. In the Kiggavik area, the till has been moulded into drumlins. Permafrost features associated with the till include sorted circles, earth/moss hummocks and striping.

Glaciofluvial Deposits

Glaciofluvial deposits occur most extensively on the east end of Aberdeen Lake and the south and west shores of Skinny Lake. Small, scattered deposits are found in the vicinity of the Lone Gull camp and southeast of the Kiggavik site. Thickness of the deposits has been accurately determined; however, surface coring in most deposits reached at least 3 m. Active layer depths typically reach 1.0 m ± 0.2 m. Ice wedge polygon surface patterns are typical of these landforms.

Glaciolacustrine Deposits

Glaciolacustrine deposits occur primarily as the result of modification of previously developed landforms along the shores of Aberdeen and Squiggly Lakes. Terraces developed in the sandy glaciofluvial deposits at the east end of Aberdeen Lake and the wave-washed surfaces of the drumlins along the north shore of the lake are evidence of this activity.

Glaciomarine Deposits

Glaciomarine deposits in the form of sandy beach and foreshore deposits, and sandy-gravelly raised shorelines around bedrock hills are characteristic of the terrain between Aniguq Lake and Baker Lake. Deposits are typically thin, and feature ice wedge polygon patterns.

Organic Deposits

Organic deposits occur frequently throughout the project area, but are particularly significant in the Kiggavik site area where they are associated with seepage zones along the escarpment. Poorly-drained depressions and drainageways between lakes and ponds are other typical locations for peat deposits to occur. The area between Aniguq Lake and Baker Lake, particularly west of the Qinguq River, exhibits extensive development of poorly-drained peaty terrain.

Three vegetation complexes dominate the area: Moss-heath/lichen-heath (17,181 ha), lichen-heath/low shrub (15,708 ha) and lichen steppe/lichen-heath (13,019 ha). Lichen heath and lichen steppe complexes dominate to the north and west of the study area while the moss-heath and low shrub communities dominate in the south and east. These vegetation trends are generally related to the surficial deposits of the area, where the moss-heath and low shrub communities are associated with the finer-textured, imperfectly-drained tills in the south and east, and the lichen-dominated communities associated with the sandy-textured, well-drained soils to the north and west.

1.0 INTRODUCTION

An Ecological Land Survey (ELS) has been prepared as part of the baseline resource description and environmental impact assessment for the Kiggavik uranium development project near Baker Lake, N.W.T. (Figure 1.1).

ELS has been described as an approach to land survey which provides a "balanced and integrated information base" (Environment Canada 1980), particularly for those projects which have multiple development aspects; are located in remote areas for which limited information exists and where the dynamics of land, water and climate are incompletely understood. ELS uses a hierarchical approach to land classification, so that information can assembled and spatially portrayed at various levels of detail according to the needs of the proponent. ELS information is readily incorporated into a Geographic Information System (GIS) environment thereby facilitating spatial data and impact assessment analyses.

The proposed Kiggavik development is particularly suited to the ELS approach by virtue of its remote geographic location; general paucity of natural resource information, and need to examine the integrated nature of the resource components at a variety of information levels. For example, as part of the proposed Kiggavik project, a number of site development and operational support options have been identified including: winter road connections between the Kiggavik site and Baker Lake, and the proposed limestone quarry site approximately 75 km northwest of the main development site. In addition, a permanent dock facility for trans-shipment of materials and supplies has been proposed for the Baker Lake vicinity. Potential environmental impacts from both site and support development activities have both regional and local implications which can be effectively addressed through an ELS.

This report presents results of a terrestrial (landforms, surficial deposits, soil and vegetation) environmental baseline resource description and mapping for those areas potentially affected by the proposed Kiggavik development. Information is spatially presented within the context of an ELS framework using analytical capabilities of a micro-based GIS. Individual resource component descriptions are provided as general resource background documentation.

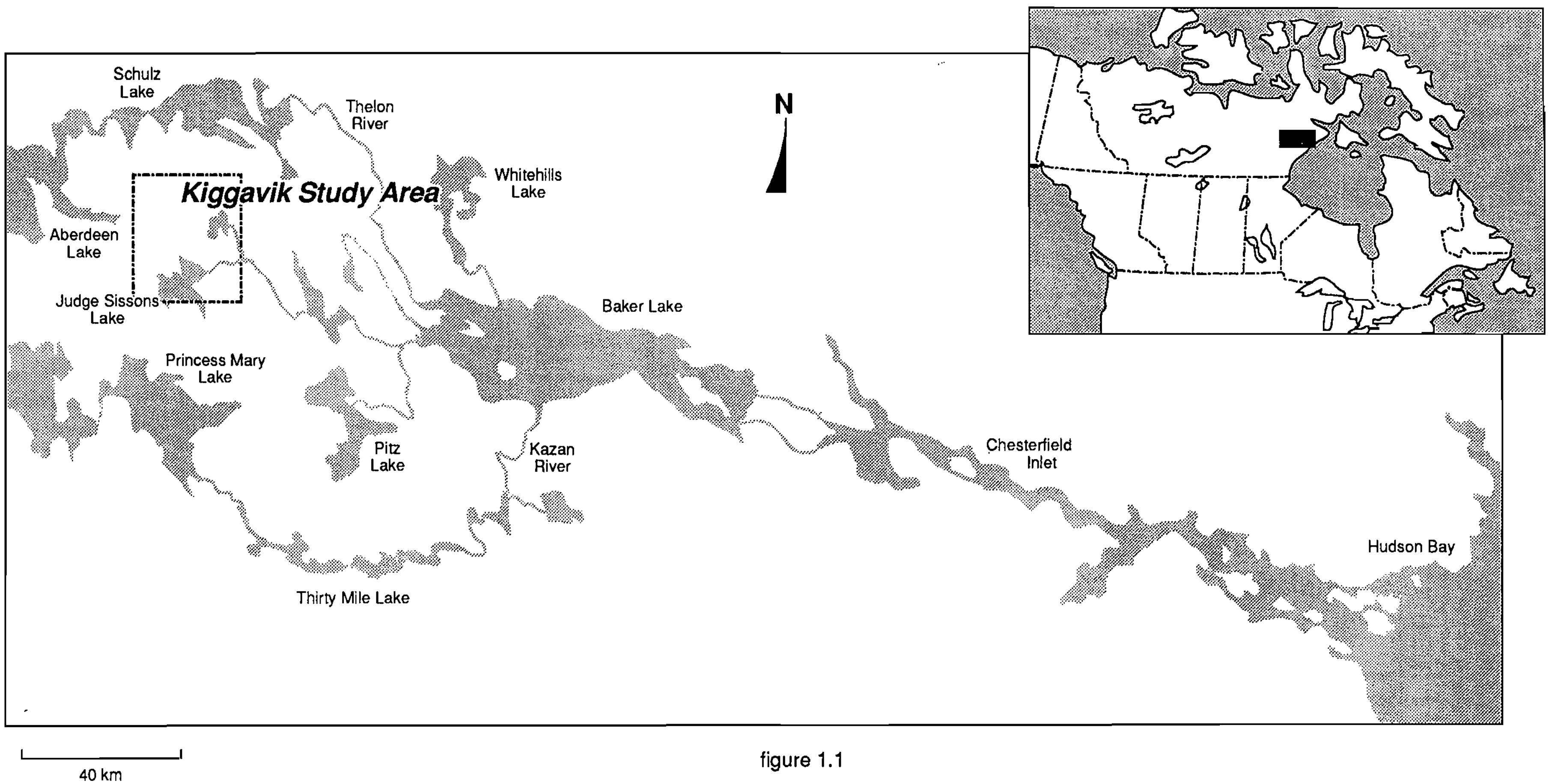


figure 1.1

Project Location Map ***District of Keewatin, Northwest Territories***

Although a number of reconnaissance field surveys were carried out in support of the ELS, most of the information used in the study has been obtained through the interpretation of satellite imagery, aerial photographs, and existing reports and other documentation. This existing information includes data for the Kiggavik site and local area collected during studies in the late 1970's and early 1980's by Urangesellschaft Canada Limited; from relevant reports prepared for the Polar Gas study in the Baker Lake area, and other information obtained from studies in similar environments in the northern Keewatin.

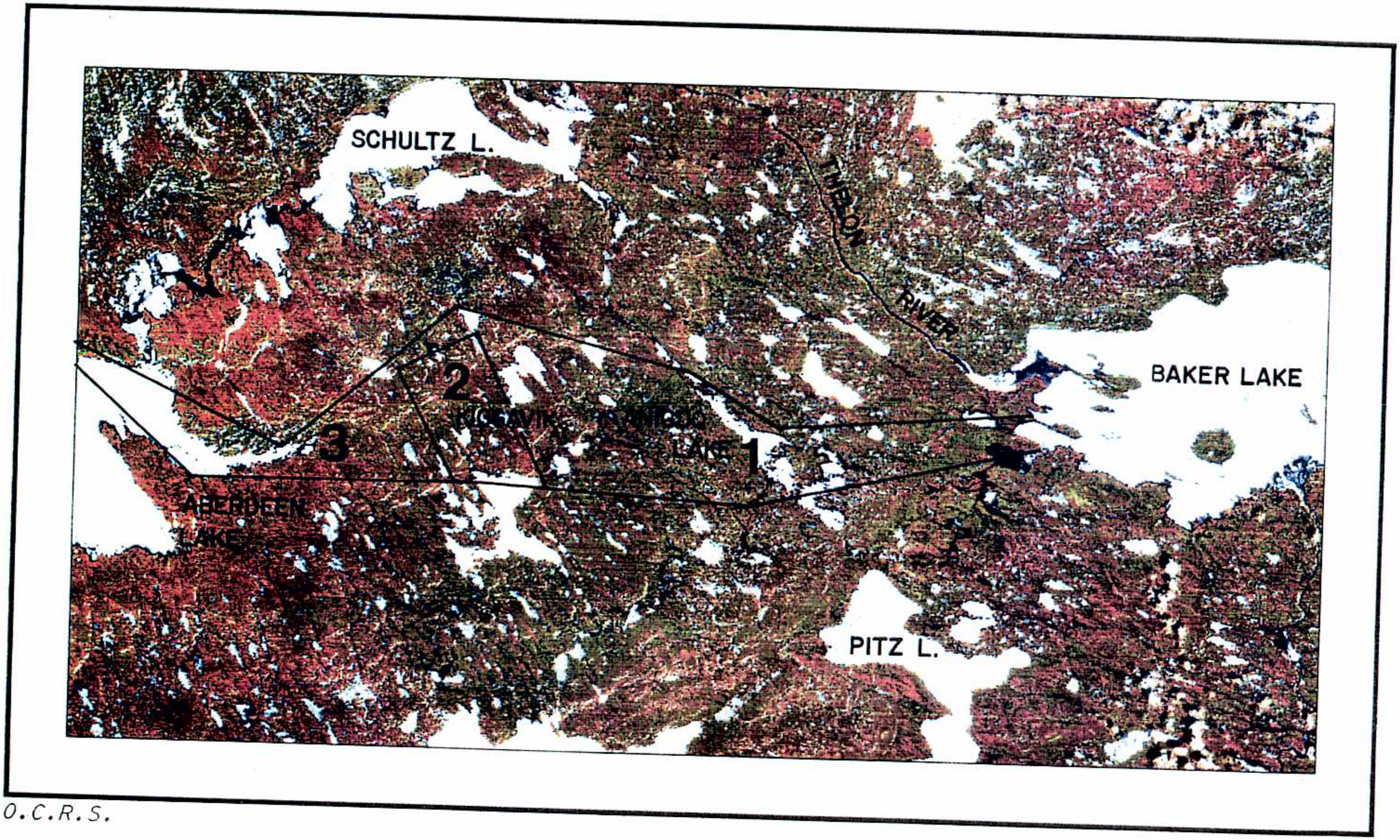
2.0 STUDY AREA

The project study area extends from Baker Lake in the east to a proposed limestone quarry in the west, with the proposed Kiggavik mine site in the approximate geographic centre (Figure 2.1). The area encompassing the Kiggavik project area lies within the Kazan Physiographic Region and two Physiographic Subdivisions: the Thelon Plain and the Kazan Upland (Wiken et al., 1987) (Figure 2.2). This study area encompasses terrain required for winter road corridors from Baker Lake to the Kiggavik site and from the Kiggavik site to the limestone quarry. Figure 2.1 is a Landsat Thematic Mapper (TM) satellite image enhanced to better discriminate terrain conditions associated with the general region. Four geographic units are delineated on the Landsat image to facilitate a brief description of the study area. These include:

1. the winter road corridor between Baker Lake and the Kiggavik mine site;
2. the Kiggavik site development and surrounding area;
3. the winter road corridor between the Kiggavik site and the limestone quarry site north of Aberdeen Lake; and
4. the dock facility near Baker Lake.

The Kiggavik study area includes not only the area subject to infrastructure development, but also a 1,113 km^2 area centered on the present Kiggavik exploration camp.

Each of the four study areas represents significantly different landscape conditions. The winter road corridor between Baker Lake and the Kiggavik site encompasses two distinct physiographic terrain units. The terrain between Baker Lake and Aniguq Lake (variously referred to as Long Lake or Audra Lake) is characterized by low, flat poorly-drained terrain dominated by wet sedge and low shrub meadows on organic or sandy till soils, and by sandy/gravelly marine beach and foreshore deposits with discontinuous Lichen Steppe vegetation cover. Near Baker Lake, the terrain is dominated by conspicuous bedrock hills. Raised marine beach deposits occur along the flanks of the hills, while crests are typically bare (wave washed) or covered by a thin veneer of marine sands and gravels. Between Aniguq Lake and the Kiggavik site, the terrain is characterized by a moderately well-drained upland sandy till, with Lichen-Heath vegetation cover.



O.C.R.S.

Figure 2.1

COLOUR COMPOSITE OF LANDSAT THEMATIC MAPPER DATA RECORDED ON JUNE 22, 1988
INFRARED (BAND 4) PRINTED AS RED
RED (BAND 3) PRINTED AS GREEN
GREEN (BAND 2) PRINTED AS BLUE

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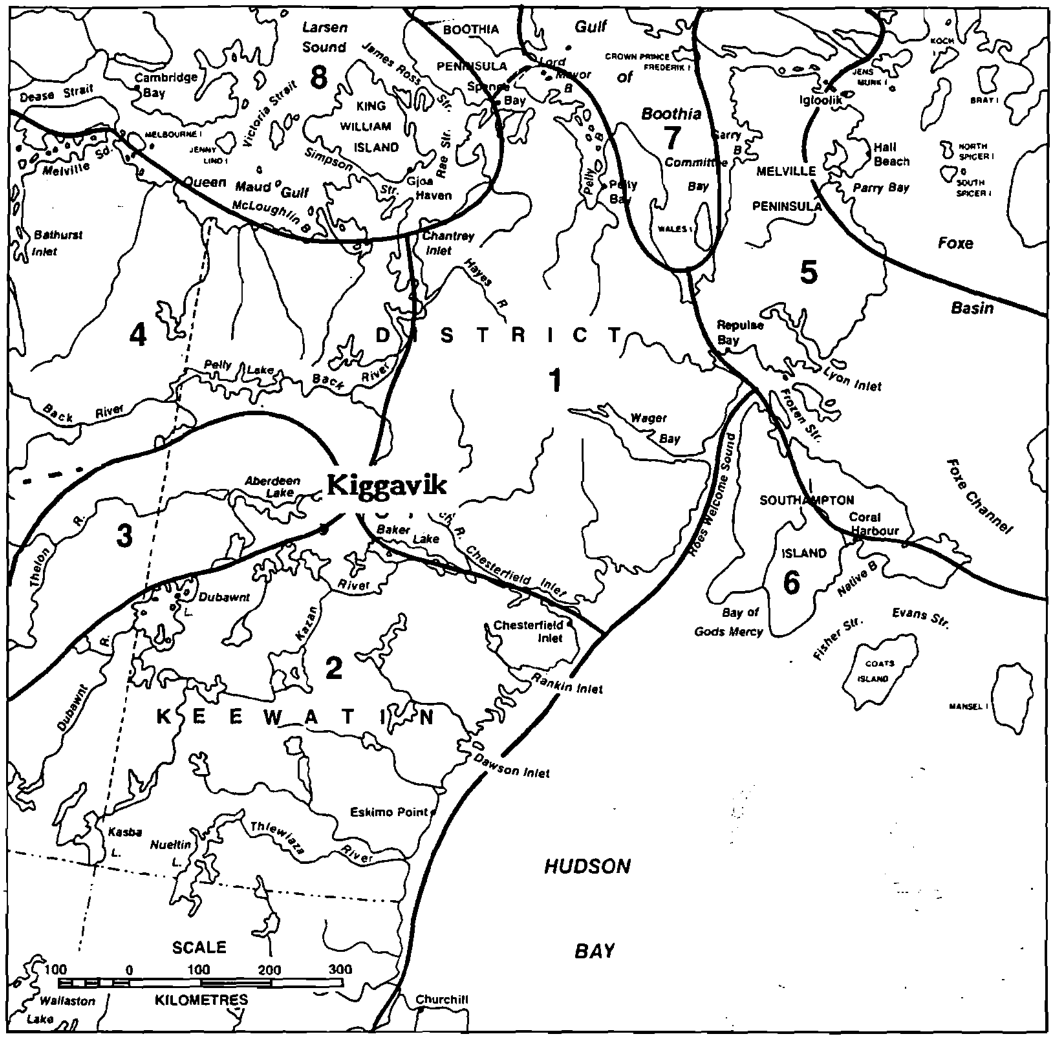
20000 0 20000 METRES 60000 80000 100000



PHYSIOGRAPHY

SUBDIVISIONS	REGION	CATEGORY
1. Wager Plateau 2. Kazan Upland 3. Thelon Plain 4. Back Lowland	Kazan Region	Canadian Shield
5. Melville Plateau	Davis Region	
6. Southampton Plain	Hudson Region	
7. Boothia Plain 8. Victoria Lowland	Arctic Lowlands	Borderland

Figure 2.2: The Physiographic Regions of the District of Keewatin (Source: Wiken et al. 1987)

The Kiggavik site development area and the winter road corridor between the Kiggavik site and the east end of Aberdeen lake is characterized, below an east-west trending escarpment, by an undulating coarse loamy till plain frequently moulded into northwest-southeast trending drumlins. On this coarse loamy textured till material, where silt content ranges from 17% to 37%, a Moss-Heath vegetation dominates. Above the escarpment, a sandy textured compact till, with a Lichen-Heath vegetation dominates. At the east end of Aberdeen Lake a series of raised glaciolacustrine beach ridges have been cut into a sandy/gravelly glaciofluvial outwash delta. Post-glacial fluvial activity has contributed to the dissection of the deposit. Lichen-Steppe vegetation cover is associated with these well drained deposits.

The winter road corridor between Aberdeen Lake and the limestone quarry site is characterized by rolling sandy/gravelly hills interspersed with a myriad of lakes. Lichen Steppe vegetation occurs on better drained crests and upper hillslopes, with sedge and shrub meadows on poorly drained landscape positions.

The proposed dock facility is located along the north shore of Baker Lake approximately 10 km east of the Hamlet of Baker Lake. The site is characterized by a series of sandy/gravelly raised beach deposits which flank a bedrock knob.

3.0 METHODS AND PROCEDURES

There are a number of approaches which can be used to acquire environmental baseline information, each with its own particular usefulness. For this study, the Ecological Land Survey (ELS) approach has been used. Guidelines for this approach have been published by the Federal Environmental Assessment Review Office (FEARO) (Environment Canada 1980). ELS is an effective method for developing an integrated resource database, which facilitates subsequent project planning and data analysis required for environmental screening, evaluation or assessment. ELS uses a hierarchical approach to land survey and classification where information is assembled at various levels of generalization. Table 3.1 describes the levels of ecological generalization associated with ELS. In this study the level of detail is similar to that described for ecosections and ecosites.

Ecoregions and ecodistricts for the area have been previously described (Wiken et al., 1987) and are incorporated into this report.

3.1 Remote Sensing Data

Ecological Land Survey, because of its focus on landscape and landscape patterns, makes extensive use of remote sensing data, including satellite imagery and aerial photography. In this study Landsat Thematic Mapper (TM) satellite data as well as various scales of aerial photography have been employed at each of the levels of ELS generalization described.

3.1.1 Landsat TM Data

A June 22, 1988 Landsat TM scene for the general region centering on the Kiggavik site was obtained from the N.W.T. Department of Renewable Resources in Yellowknife and used to evaluate terrain conditions at different locations and scales. Image enhancement procedures were used to highlight both regional and local resource patterns and distribution. All procedures were carried out using a micro-based image analysis system (EASI-PACE) developed by PCI Inc. Results are used both as stand-alone products and with other spatial data in a micro-based GIS (SPANS).

TABLE 3.1: LEVELS OF ECOLOGICAL GENERALIZATION PROPOSED BY THE CANADA COMMITTEE ON ECOLOGICAL LAND CLASSIFICATION
(Source: Environment Canada, 1980)

Definitions:

Ecozone: an area of the earth's surface representative of large and very generalized ecological units characterized by interactive and adjusting abiotic and biotic factors.
Ecoprovince: a part of an ecozone characterized by major assemblages of structural or surface forms, faunal realms, and vegetation, hydrological, soil and climatic zones.
Ecoregion: a part of an ecoprovince characterized by distinctive ecological responses to climate as expressed by the development of vegetation, soil, water, fauna, etc.
Ecodistrict: a part of an ecoregion characterized by distinctive assemblages of relief, geology, landforms, soils, vegetation, water and fauna.
Ecosection: a part of an ecodistrict throughout which there is a recurring assemblage of terrain, soils, vegetation, water bodies and fauna.
Ecosite: a part of an ecosection in which there is a relative uniformity of parent material, soil, hydrology and vegetation.
Ecoelement: a part of an ecosite displaying uniform soil, topography, vegetation and hydrology.

Level of Generalization	Examples of Common Benchmarks for Recognition					
Common Map Scale*	Geomorphology	Soils	Vegetation	Climate	Water	Fauna
Ecoregion 1:3,000,000 to 1:1,000,000	Large-order landforms or assemblages of regional landforms	Great groups or associations thereof	Plant regions or assemblages thereof	Meso or small order macro	Large water basin	Assemblages of faunal communities
Ecodistrict 1:500,000 to 1:125,000	Regional landforms or assemblages thereof	Subgroups or associations thereof	Plant districts or assemblages thereof	Meso or large order micro	Drainage pattern: water quality	Faunal community or some specialized habitat
Ecosection 1:250,000 to 1:50,000	Assemblages of local landforms or a local landform	Families or associations thereof	Plant associations or assemblages thereof	Large order micro to small order micro	River reaches, lakes and shoreland	Specialized habitat within a community or a lower order community
Ecosite** 1:50,000 to 1:10,000	A local landform or portion thereof	Soil series or associations thereof	Plant association or community	Small order micro	Subdivision of above	Portions of a community or total habitats of some small species
Ecoelement 1:10,000 to 1:2,500	A local landform or portion thereof	Phases of soil series or a soil series	Parts of a plant association or subassociation	Small order micro	Sections of small streams	

* Map scales should not be taken too restrictively, as they will vary with the setting and objectives of the survey.

** More so than others; this level is frequently subdivided into phases to indicate a passing or temporary state (e.g., seral).

3.1.2 Aerial Photography

In 1986, as part of an initial baseline studies program, 1:63,360 scale aerial photography was used to delineate and describe complex landscape polygons (ecosections) for a 1,113 km^2 area centred on the proposed Kiggavik development. Subsequently, Urangesellschaft Canada Limited commissioned new aerial photography for much of the study area at various scales. Photographic scales acquired include: 1) 1:40,000 for the entire area between Baker Lake and the east end of Aberdeen lake, and 2) 1:25,000 and 1:6,000 for the Kiggavik site area. This photography has been used for all studies since 1986.

In addition to Landsat evaluation, the winter road corridor between Baker Lake and the Kiggavik site was mapped using 1:40,000 scale (1986) photography. The Kiggavik site development area was mapped using 1:25,000 scale (1986) photography. This mapping scale provides greater spatial resolution of the landscape (hence more homogeneous mapping polygons) required for more detailed site planning and development. The scale is considerably larger than the mapping scale used during the pre-feasibility environmental study when 1:63,360 scale photography was used. The winter road corridor between the Kiggavik site and Aberdeen Lake utilized existing ecological mapping (1:50,000) (Beak 1986) which was done using 1:63,360 scale photography obtained through the National Air Photo Library (NAPL) in Ottawa. The area between Aberdeen Lake and the limestone quarry site was also mapped at a scale of 1:63,360 using photography obtained through NAPL of the same scale.

3.2 Field Reconnaissance

Field reconnaissance programs in support of the ELS mapping program were carried out in each of three years: July 1986, July 1988 and August 1989.

1986 Reconnaissance

During a five-day period in early July, detailed ground sampling was undertaken in the vicinity of the Lone Gull exploration camp and the Skinny Lake area. Field traverses, planned from a review of small-scale 1;63,360 aerial photography, were designed to cross representative terrain conditions in the vicinity of the Kiggavik site, and to identify areas potentially sensitive to disturbance.

A number of representative soil pits and vegetation sample plots were established on the major landforms in the Kiggavik area, and complete soil profile and vegetation species descriptions were completed. Soil samples for each horizon described were taken for subsequent physical and chemical analyses. A 10 m x 10 m vegetation plot was established at each sampling location and a list of all species occurring on the plot was recorded and estimates of percentage cover were made. All collections were identified using Hulten (1968), Fernald (1950), and Porsild (1964) for vascular plants, and Crum and Anderson (1981), Hale (1969), Conrad and Redfearn (1979) and Brodo (1981) for mosses and lichens.

Helicopter reconnaissance flights over portions of the area were made in order to annotate the 1:63,360 black and white aerial photographs. Notes on the vegetation, surficial deposits and landforms were recorded, and general relationships observed between landforms and vegetation to facilitate air photo interpretation during the initial mapping phase of the project.

1988 Reconnaissance

A three-day field program was carried out during late July 1988 for the purpose of conducting a helicopter reconnaissance survey of each of the recently proposed winter road routes and dock facility area. Detailed ground studies of vegetation, soil and landform were not planned since this work, particularly in the Kiggavik site development area, had been previously conducted as part of the pre-feasibility study in 1986. Vegetation studies, similar to those carried out during the pre-feasibility study at the Kiggavik site, had been conducted during the Polar Gas Project (Thompson et al., 1978), and it was felt this work was relevant for areas in the Baker Lake vicinity and could be used directly at this stage in the environmental assessment of the Kiggavik project.

Prior to the field reconnaissance, preliminary air photo interpretation of the proposed winter road corridors was undertaken and areas of potential concern marked for field examination.

During August 1988, realignment of the winter road routes, particularly the routing between Aniguq Lake and Baker Lake, resulted in portions of the road system being outside the assessed corridor. For these areas, and for the winter road corridor to the limestone quarry, photo interpretation has been carried out.

During the field reconnaissance, five locations in the Kiggavik site development area were selected for use as long-term monitoring stations of airborne particulate matter. Summer forage material (sedges and grasses) typically used by caribou (Thompson et al., 1978) was collected for subsequent laboratory analysis.

1989 Reconnaissance

A brief two-day field program was carried out in late August 1989 for the purpose of examining (on the ground) the proposed infrastructure associated with the development of the mine. Road access routes at the Kiggavik site were all traversed, and all facility development sites examined. The proposed airstrip and waste rock dump sites were also examined.

3.3 Photo Interpretation and Mapping

Winter road corridors and the Kiggavik site development plans proposed by I.D. Group Inc. (1988) were used as a geographic framework to focus the ELS and environmental assessment. Using aerial photography described in Section 3.2, detailed photo interpretation of landscape patterns reflecting different ecological communities and processes was conducted for each of the four major study areas. Patterns were delineated on air photos as polygons. Each polygon is as homogeneous, with respect to pattern and process, as scale permits. At scales of 1:40,000 and 1:63,360, most polygons reflect recurring patterns of diverse ecological communities. Polygons delineated using the 1:25,000 scale photography are typically more internally homogeneous than those delineated at smaller scales. Regardless of scale however, dominant ecological processes within polygons are more similar than those in adjacent polygons.

Following polygon delineation, annotations for each of the polygons were prepared using photo interpretation techniques. During the field reconnaissance, terrain features (i.e., vegetation types, landforms, surficial deposits, hydrologic character, etc.) were noted on 1:63,360 scale photos. These observations were used during this phase of the mapping.

Baseline resource description maps, using the ELS approach, were prepared for each of the following areas:

1. the winter road corridor between Baker Lake and the Kiggavik site;
2. the winter road corridor between the Kiggavik site and the limestone quarry; and
3. the Kiggavik site development area.

To obtain appropriate scale and detail, thirty-five millimetre (35 mm) photos were obtained for the dock site and used for resource description purposes. The ELS base maps were subsequently used for thematic resource mapping and environmental assessment.

The vegetation classification is based on physiognomic appearance. The vegetation types have been described previously (BEAK, 1988) and were used in the pre-feasibility study of the Kiggavik site development area. Descriptions of the vegetation types have been updated for this study, and include integration of the Polar Gas Project work by Thompson et al. (1978).

3.4 Geographic Information System Analysis

Subsequent to the original mapping efforts, it was decided to incorporate all ELS data into a Geographic Information System (GIS). All maps were digitized and data analysis and modelling carried out using SPANS, a micro-based GIS. Polygon attribute data were stored in a dBase III relational data base management system and used during SPANS analysis. All facilities, including each of the winter road corridors, were digitized and stored for use as part of the impact assessment. Summary area statistics for major vegetation and surficial deposits complexes were generated, as were habitat loss statistics resulting from infrastructure development.

4.0 TERRESTRIAL BASELINE RESOURCE DESCRIPTION

4.1 Background Resource Component Description

4.1.1 Surficial Deposits

Surficial materials in the Kiggavik project area can be grouped into five major deposits:

- glacial till, including a sandy compact till and a coarse loamy-textured till,
- glaciofluvial deposits,
- glaciolacustrine deposits,
- glaciomarine deposits, and
- peat/organic deposits.

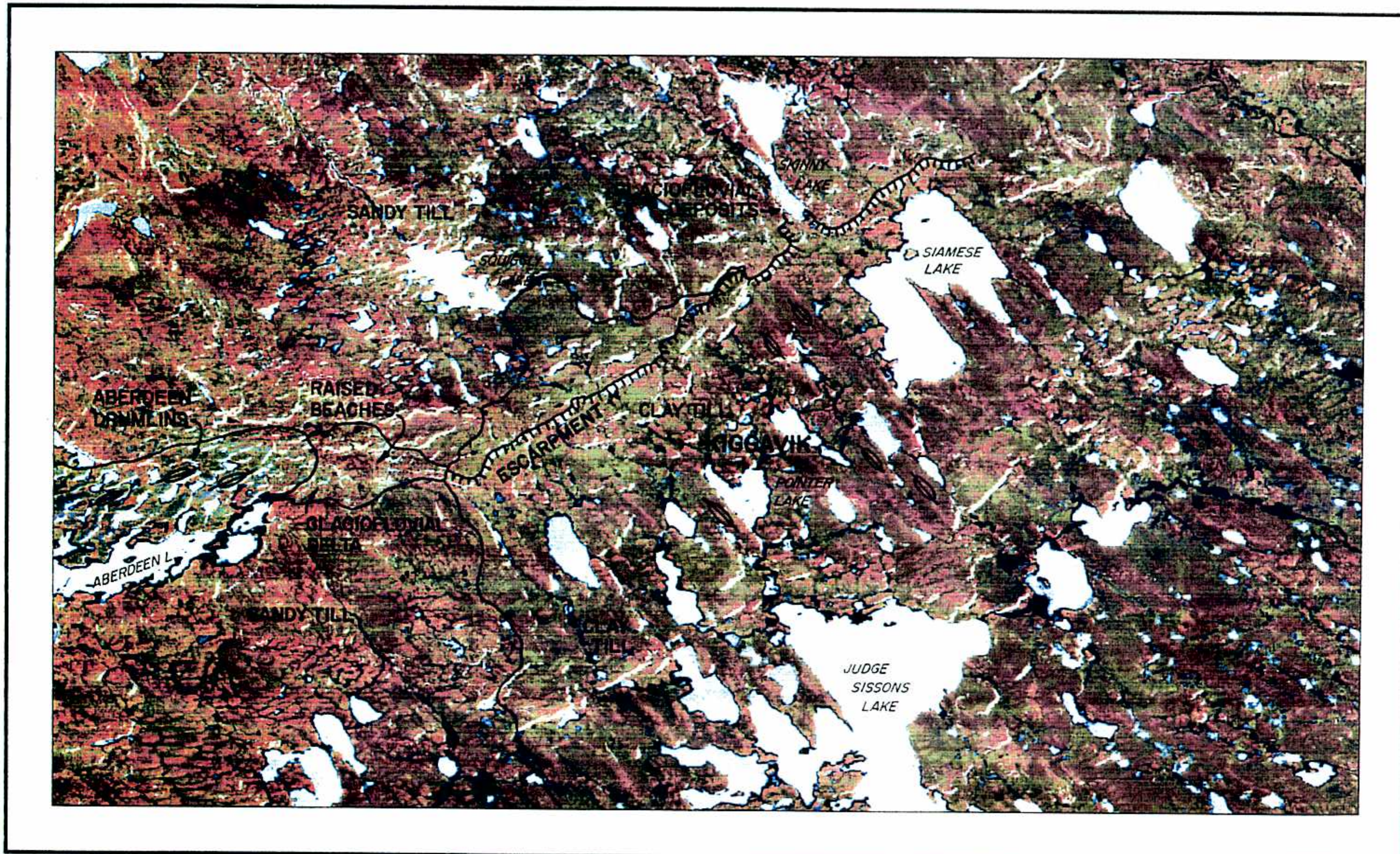
Figures 4.1 and 4.2, enhanced Landsat TM images of the general study area, have been used to locate major landscape features.

Glacial Till Deposits

Glacial till deposits are the most widespread of surficial materials in the project area and are represented by two major till types:

1. a buff-coloured, sandy-textured till (Figures 4.1 and 4.2) which dominates the area north of the east-west trending escarpment in the Kiggavik area; the area between the Kiggavik site and Baker Lake (where the till has been extensively modified by post-glacial marine activity), and the area north of Aberdeen Lake to the limestone quarry; and
2. a reddish-coloured, coarse loamy-textured till with a relatively high silt component (17 to 37%), which dominates the area below the escarpment (Figure 4.1).

Each of the tills represents two different phases of glaciation (Thomas 1985). The sandy till results from an early east-west trending ice movement through the area and is typically a hard, compact till containing up to 30% material greater than 2 mm in size



O.C.R.S.

Figure 4.1

COLOUR COMPOSITE OF LANDSAT THEMATIC MAPPER DATA RECORDED ON JUNE 22, 1988
INFRARED (BAND 4) PRINTED AS RED
RED (BAND 3) PRINTED AS GREEN
GREEN (BAND 2) PRINTED AS BLUE

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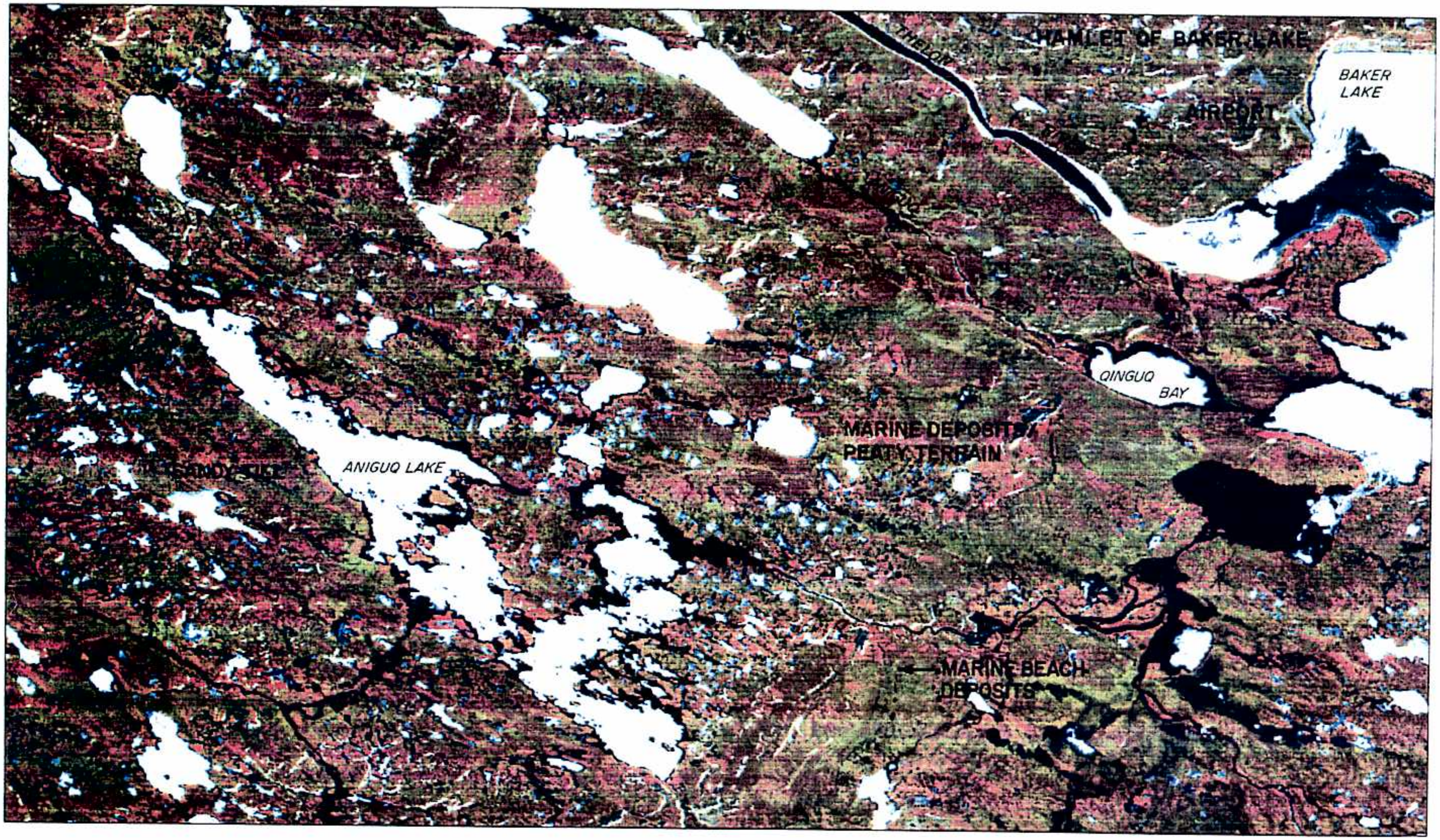

O.C.R.S.

Figure 4.2

COLOUR COMPOSITE OF LANDSAT THEMATIC MAPPER DATA RECORDED ON JUNE 22, 1988
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RED (BAND 3) PRINTED AS GREEN
GREEN (BAND 2) PRINTED AS BLUE

SCALE 1:150000

5 0 KILOMETRES 10 15

5000 0 METRES 10000 15000

and 5% silt and clay. Thickness of the deposits vary from deep blankets tens of meters thick, to veneers less than one meter thick with bedrock knobs protruding. This latter condition is particularly evident in the area between the Kiggavik site and Baker Lake. In the Aberdeen Lake area, the till is moulded into east-west trending drumlins (Figure 4.1) which were subsequently modified through glaciolacustrine activity. The till in the area between Baker Lake and the Kiggavik site has been extensively modified by a post-glacial marine transgression (up to 180 m above sea level). Sandy foreshore and beach deposits are commonly associated with the till in this area (Figure 4.2).

Patterned ground, such as striping and stone circles, are common periglacial features associated with the till. Surface relief of the till is typically gently undulating, with numerous scattered lakes, ponds and streams occupying shallow, basin-like depressions.

The coarse loamy-textured till, occurring primarily in the Kiggavik area south of the escarpment, has been described by Thomas (1985) and Griep (1985) as a clay till deposited by a late northwestward flow of ice through the area. Although clay content of the till is relatively low (1% to 13%), silt content ranges from 17% to 35% (Tables 4.1, 4.2 and 4.3). When classified according to the Canadian System of Soil Classification (CSSC) (1978), textures range from silty sand to sandy loam (Tables 4.1, 4.2 and 4.3). In the Kiggavik study area, the till has been moulded into drumlins (Figure 4.2). Permafrost features associated with the till include sorted circles, earth/moss hummocks, and striping.

Glaciofluvial Deposits

Sandy glaciofluvial deposits occur most extensively on the east end of Aberdeen Lake and the south and west shores of Skinny Lake (Figure 4.1). Small, scattered deposits are found in the vicinity of the Lone Gull exploration camp and southeast of the Kiggavik site. Thickness of the deposits have not been accurately determined, however surface coring in most deposits reached at least 3 m. Active layer depths typically reach 1.0 m ± 0.2 m. Ice wedge polygon surface patterns are typical of these landforms.

Glaciolacustrine Deposits

Glaciolacustrine deposits occur primarily as the result of modification of previously developed landforms along the shores of Aberdeen and Squiggly Lakes. Terraces

TABLE 4.1: SUMMARY OF THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF THREE ORTHIC STATIC CRYOSOLS IN THE KIGGAVIK AREA

	Site LG001 Horizon		Site LG002 Horizon			Site LG003 Horizon		
	Bm	Cg	Bm	C	Cz	Bm	Cg	Cgz
Chemical Characteristics								
Horizon Thickness (cm)	0-8	8-27	0-7	7-30	30-53	0-7	7-42	42-81
pH ($CaCl_2$)	5.4	5.4	5.3	5.9	6.1	5.3	4.7	6.4
Ca (Meq/100 g)	2.75	1.65	2.40	2.20	2.90	4.90	1.60	2.55
Mg (Meq/100 g)	0.65	0.39	0.56	0.42	0.49	1.64	0.53	0.69
K (Meq/100 g)	0.08	0.06	0.09	0.08	0.14	0.16	0.08	0.13
Na (ppm)	10	10	10	20	L 10	L 10	40	10
Fe[1] (%)	0.035	0.024	0.033	0.022	0.018	0.118	0.063	0.015
Al[1] (%)	0.015	0.011	0.018	0.012	0.013	0.035	0.025	0.011
% Base Saturation[2]	67.2	63.6	60.4	67.5	71.6	63.2	44.1	73.7
CEC[3]	5	2	3	3	4	11	5	4
Mechanical Analysis								
% Sand	68.2	63.8	70.4	63.8	62.0	69.3	64.3	54.7
% Silt	25.6	32.1	23.9	29.2	29.0	17.0	28.3	35.9
% Clay	6.2	4.1	5.8	7.0	9.0	13.7	7.4	9.4
Soil Texture[4]	Silty sand	Silty sand	Silty sand	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam

L = less than.

1 Pyrophosphate extractable Fe and Al.
2 Proportion of CEC occupied by bases is termed % base saturation.
3 CEC calculated value: Ca + Mg + K/Ca + Mg + K + Al.
4 Sand, silt and clay fractions based on Canadian System Soil Classification standards where: sand = 2.0 - 0.05 mm; silt: 0.05 - 0.002 mm; clay: L 0.002 mm.

TABLE 4.2: SUMMARY OF THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF A GLEYSOLIC STATIC CRYOSOL IN THE KIGGAVIK AREA

	Site LG004 Horizon	
	Cg	Cg2
Chemical Characteristics		
Horizon Thickness (cm)	0-35	35-90
pH ($CaCl_2$)	4.0	5.4
Ca (Meq/100 g)	0.37	1.45
Mg (Meq/100 g)	0.16	0.49
K (Meq/100 g)	0.05	0.09
Na (ppm)	L 10	20
Fe[1] (%)	0.025	0.024
Al[1] (%)	0.008	0.012
% Base Saturation[2]	39.2	61.0
CEC[3]	L 1	2
Mechanical Analysis		
% Sand	75.1	72.8
% Silt	24.1	21.5
% Clay	0.8	5.7
Soil Texture[4]	Loamy sand	Loamy sand

L = less than.

1 Pyrophosphate extractable Fe and Al.

2 Proportion of CEC occupied by bases is termed % base saturation.

3 CEC calculated value: Ca + Mg + K/Ca + Mg + K + Al.

4 Sand, silt and clay fractions based on Canadian System Soil Classification standards where: sand = 2.0 - 0.05 mm; silt: 0.05 - 0.002 mm; clay: L 0.002 mm.

TABLE 4.3: SUMMARY OF THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF A BRUNISOLIC STATIC CRYOSOL IN THE KIGGAVIK AREA

	Site LG005 Horizon	
	Bm	Cgz
Chemical Characteristics		
Horizon Thickness (cm)	0-12	12-29
pH ($CaCl_2$)	5.4	4.5
Ca (Meq/100 g)	1.9	0.7
Mg (Meq/100 g)	0.53	0.29
K (Meq/100 g)	0.05	0.04
Na (ppm)	30	40
Fe[1] (%)	0.033	0.038
Al[1] (%)	0.015	0.009
% Base Saturation[2]	59.3	50.7
CEC[3]	3	1
Mechanical Analysis		
% Sand	64.8	66.9
% Silt	30.7	31.5
% Clay	4.6	1.6
Soil Texture[4]	Silty sand	Silty sand

[1] Pyrophosphate extractable Fe and Al.

[2] Proportion of CEC occupied by bases is termed % base saturation.

[3] CEC calculated value: Ca + Mg + K/Ca + Mg + K + Al.

[4] Sand, silt and clay fractions based on Canadian System Soil Classification standards where: sand = 2.0 - 0.05 mm; silt: 0.05 - 0.002 mm; clay: L 0.002 mm.

developed in the sandy glaciofluvial deposits at the east end of Aberdeen Lake and the wave-washed surfaces of the drumlins along the north shore of the lake are evidence of this activity.

Glaciomarine Deposits

Glaciomarine deposits in the form of sandy beach and foreshore deposits, and sandy-gravelly raised shorelines around bedrock hills are characteristic of the terrain between Aniguq Lake and Baker Lake (Figure 4.2). Deposits are typically thin and feature ice-wedge polygon patterns.

Organic Deposits

Organic deposits occur frequently throughout the project area, but are particularly significant in the Kiggavik site development area where they are associated with seepage zones along the escarpment. Poorly-drained depressions and drainageways between lakes and ponds are other typical locations for organic material to occur. The area between Aniguq Lake and Baker Lake, particularly west of the Qinguq River, exhibits extensive development of poorly-drained peaty terrain (Figure 4.2).

4.1.2 Soils

4.1.2.1 Physical and Chemical Characteristics

Soils of the project area are predominantly Turbic Cryosols and are characterized by a shallow active layer (100 cm to 120 cm), various amounts of ice in the perennially-frozen horizons and a cold climate (Figure 4.3) (Table 4.4). Cryogenetic processes, especially cryoturbated soils, are often recognized or associated with patterned ground features such as sorted and non-sorted nets, circles, polygons, stripes and hummocks. Site development associated with the Kiggavik project occurs mainly within the coarse loamy-textured till deposits. As a result, soil sampling has been confined to these materials.

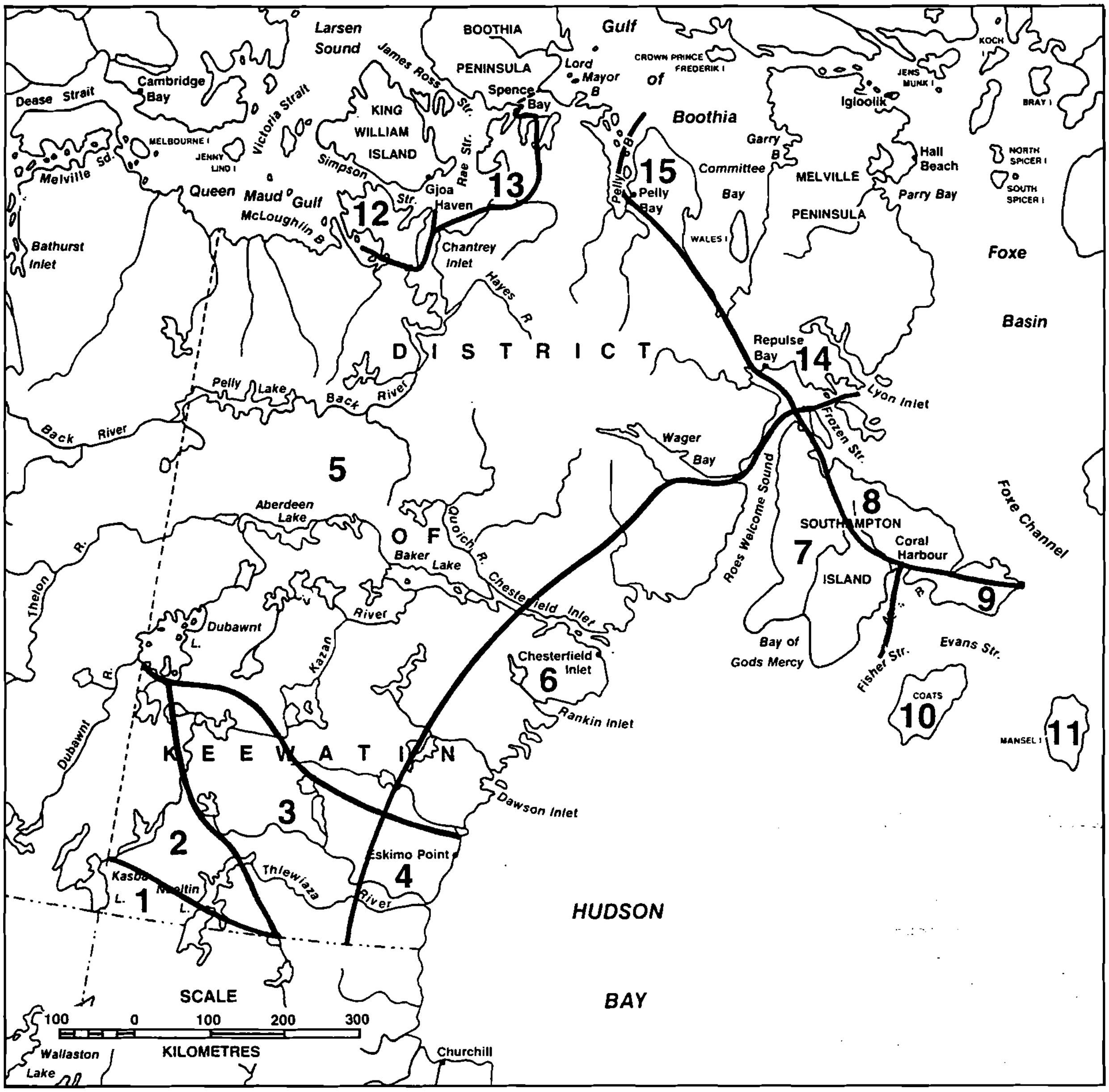


Figure 4.3: Soils of the District of Keewatin
(Source: Wiken et al. 1987)

TABLE 4.4: LEGEND FOR FIGURE 4.3
Dominant Soil Subgroups (all with significant stony and lithic phases)

	Dominant Subgroups (more than 40% areal)	Subdominant Subgroups (less than 20% areal)	Significant Subgroup Inclusions	Soil Order
1.	Orthic Humo-Ferric Podzol	Orthic Humic Gleysol Fibric Organic Cryosol	Rockland Orthic Dystric Brunisol	PODZOL
2.	Orthic Dystric Brunisol	Rockland	Orthic Gray Luvisol Orthic Eutric Brunisol	BRUNISOL
3.	Orthic Dystric Brunisol	Rockland		
4.	Brunisolic Turbic Cryosol	Regosolic Turbic Cryosol	Fibric Organic Cryosol	CRYOSOL
5.	Regosolic Turbic Cryosol	Gleysolic Turbic Cryosol	Rockland	
6.	Rockland	Regosolic or Gleysolic Turbic Cryosol	Orthic Turbic Cryosol	
7.	Regosolic Turbic Cryosol	Orthic Turbic Cryosol	Gleysolic Turbic Cryosol Rockland	
8.	Regosolic Turbic Cryosol	Rockland Gleysolic Turbic Cryosol	Gleysolic Turbic Cryosol	
9.	Regosolic or Brunisolic Turbic Cryosol	Gleysolic Static Cryosol		
10.	Regosolic or Brunisolic Turbic Cryosol	Orthic Turbic Cryosol Rockland	Mesic Organic Cryosol	
11.	Regosolic Turbic Cryosol	Brunisolic or Orthic Turbic Cryosol	Mesic Organic Cryosol	
12.	Orthic Turbic Cryosol	Gleysolic Turbic Cryosol	Regosolic Turbic Cryosol	
13.	Gleysolic or Orthic Turbic Cryosol	Regosolic or Brunisolic Turbic Cryosol	Regosolic Static Cryosol	
14.	Regosolic Turbic Cryosol	Brunisolic Turbic Cryosol	Gleysolic Turbic Cryosol	
15.	Regosolic Turbic Cryosol	Brunisolic Turbic Cryosol	Rockland	

Coarse Loamy Soils

In the immediate vicinity of the Lone Gull exploration camp, soils are developed in the reddish, coarse loamy-textured till. Three major subgroups of the Cryosolic Order of the CSSC (1978) were described for the area: Orthic Static Cryosol, Gleysolic Static Cryosol and Brunisolic Static Cryosol. Chemical and physical characteristics of these soils are provided in Tables 4.1, 4.2 and 4.3. In general, the soils are typically low in bases (Ca, Mg, K) with a low cation exchange capacity (CEC). The low CEC indicates a low potential buffering capacity, which is further limited because of the shallow active layer, and short period of thaw associated with these soils. These results are consistent with those observed by Tarnocai (pers. comm., Wickware) for the Boothia Peninsula northeast of the study area.

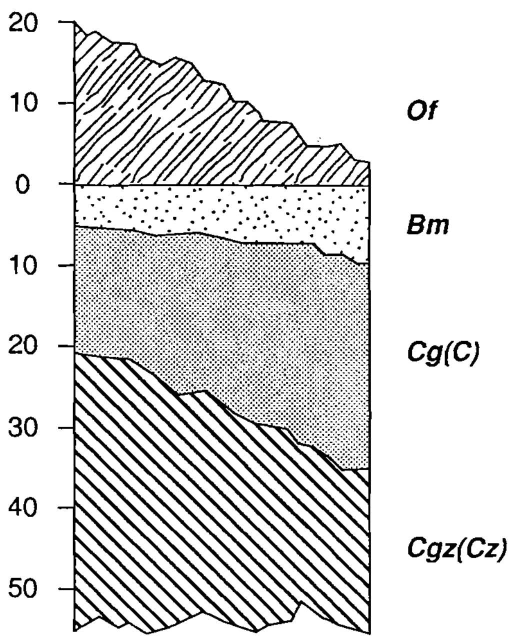
Orthic Static Cryosol

Three sites in the Kiggavik project area were classified according to CSSC as Orthic Static Cryosols. A typical profile associated with this subgroup is presented in Figure 4.4. Although these soils are typically associated with patterned ground features such as earth hummocks, frost circles, mudboils and stripes, there was little evidence of cryoturbation in the mineral horizons. Some turbic activity was observed in the surface organic and upper mineral soil layer, but not of sufficient magnitude to classify the soils as Turbic Cryosols. Most of these finer-textured soils have distinct vesicular pore structure. The development of these pores is associated with microscale ice lens formation in the soil.

Soil temperatures were not measured, however Tarnocai (1977) in the Hayes River area north of the Kiggavik site development area showed that near-surface soil temperatures (0 cm to 50 cm) on north-facing slopes ranged from 2^{o}C to 5^{o}C. On south-facing slopes, temperatures ranged from 3^{o}C to 8^{o}C. Most importantly, however, is the low thermal buffering capacity characteristic of Cryosolic soils. These soils respond quickly to changes in air temperature. This is mainly due to the shallow active layer which provides only a small amount of stored energy. The underlying permafrost acts as a heat sink and continuously removes energy from the thawed layer of the soil. The slightest decrease in air temperature (due to storms or reduced photoperiod) quickly lowers the soil temperature at all depths. This cooling causes the permafrost table to rise long before the surface freezes (Tarnocai, 1977).

figure 4.4

Diagramatic profile and description of a typical orthic static cryosol in the Kiggavik Study Area



Of	20 to 0 cm, moderately decomposed moss peat; hummocky: clear, smooth boundary.
Bm	0 to 3 cm, reddish brown (2.5YR4/2), acid, coarse loamy, vesicular pore structure, sticky, plastic, diffuse boundary.
Cg	8 to 30 cm, weak red (2.5 YR4/2) acid, coarse loamy, sticky, plastic, diffuse boundary, mottles (10YR5/6).
Cgz	30 to 53 cm, weak red (2.5 YR4/2), neutral, coarse loamy, sticky, plastic, frozen, mottles (10YR5/6)

Description

Occurs on upper-middle slope positions with mid-slope sites more likely to show evidence of mottling in the profile.

Surface material is typically hummocky with hummocks 10 to 30 cm in height.

Frost heaved angular rocks frequently occur immediately below the moss layer and in the upper 10 to 15 cm of the mineral soil. Rocks may often be thrust through the organic surface by cryoturbation processes.

Active layer typically 90 to 100 cm in depth.

Vesicular soil structure in upper soil profile due to micoscale ice lens formation.

Brunisolic Static Cryosols

Brunisolic Static Cryosols are associated with crest and upper slope landscape positions on coarse loamy textured parent materials. A typical profile of these soils is shown in Figure 4.5. Moss hummocks range from 10 cm to 30 cm in height and mud circles are characteristic. The Bm horizons are greater than 10 cm in thickness and the soils are generally acid in nature. The pH ranges from 5.4 in the upper part of the solum to 4.5 in the lower. Vesicular pore structure also occur in these soils and temperatures are similar to those described for Orthic Static Cryosols.

Gleysolic Static Cryosols

Gleysolic Static Cryosols are associated with lower slope and depressional landscape positions on coarse loamy-textured parent materials. Sites are characterized by strong surface microtopography consisting of large moss hummocks up to 1 m^2, and smaller grass/sedge tussocks up to 20 cm x 20 cm in size. Soils are gleyed and/or mottled to the surface, and the active layer typically deeper earlier in the thaw season than on better drained sites. In the Kiggavik study area, these sites generally receive a constant supply of water from upslope snowbeds resulting in saturation throughout the short summer period. A typical profile of this soil is presented in Figure 4.6.

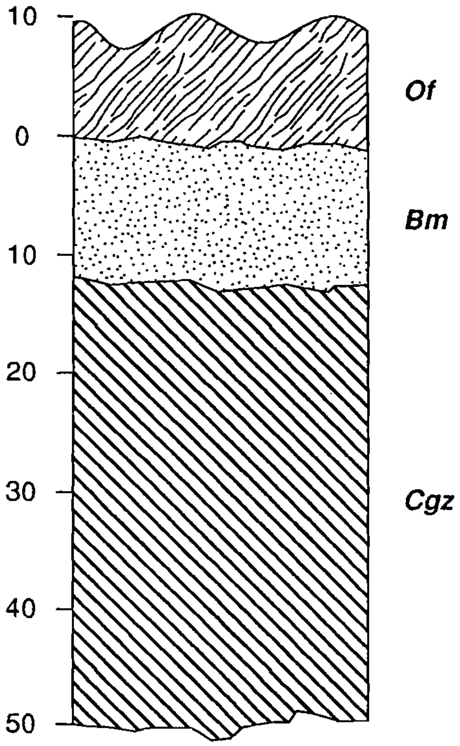
Coarse Textured, Sandy Soils

Although the Kiggavik study area is dominated by coarse loamy-textured soils, sandy textured till and glaciofluvial deposits occur frequently. As noted earlier, these deposits are typically found in the Aberdeen Lake area, north of the Kiggavik site and in the eastern parts of the study area.

Soils on the sandy glaciofluvial materials are typically classified as Regosolic Static Cryosols. Such soils show little profile development. Thin Ah horizons may occur where a more continuous lichen/moss cover has developed. These soils are generally well- to rapidly-drained, with the active layer typically extending to 1 m ± 0.20 m. Surface layers are frequently exposed to strong winds and experience constant deflation. As a result, surface cover is typically sparse to non-existent. Sandy till deposits are typically better stabilized and have a more continuous lichen/moss cover. Brunisolic or Orthic Static Cryosols develop in these soils depending on the thickness of the Bm horizon.

figure 4.5

Diagramatic profile and description of a brunisolic static cryosol in the Kiggavik Study Area



Of	10 to 0 cm, moderately decomposed moss peat; hummocky: clear, smooth boundary.
Bm	0 to 12 cm, reddish brown (2.5YR4/2), acid, coarse loamy, vesicular pore structure, sticky, plastic, diffuse boundary.
Cgz	12 to 29 cm, pinkish grey (5YR6/2), acid, coarse loamy, sticky, plastic, frozen, mottles (10YR5/8)

Description

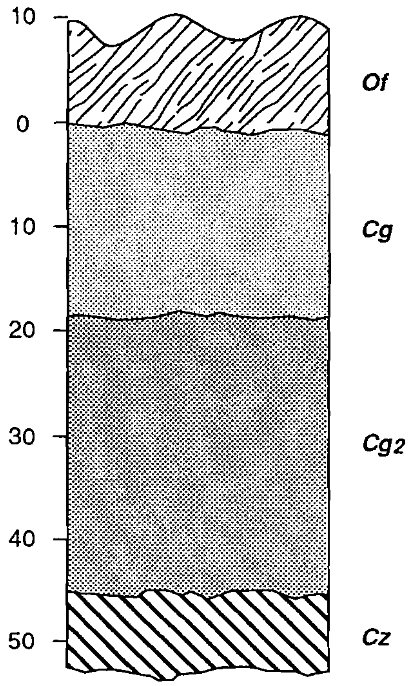
Occurs on well drained slopes with upper slope landscape positions more likely to show evidence of mottling.

Surface material is typically hummocky with hummocks 10 to 30 cm in height. Mudboils frequently occur on these soil conditions.

Surface soils characteristically have a lag of fragmental angular rocks.

figure 4.6

Diagramatic profile and description of a typical gleysolic static cryosol in the Kiggavik Study Area



Of	10 to 0 cm, moderately decomposed moss and sphagnum moss; hummocky diffuse boundary.
Cg	0 to 35 cm, reddish grey (10R5/1), mottled (10YR5/8), acid, coarse loamy, sticky, plastic, diffuse boundary.
Cg_2	35 to 90 cm, weak red (10R5/3), mottled (10YR5/8), acid, coarse loamy, sticky, plastic, diffuse boundary.
Cz	90+ cm, frozen

Description

Located in a seepage track, downslope characterized by strong microtopography with large hummocks (up to 100 cm x 100 cm) and grass / sedge tussocks (20 cm x 20 cm)

Soils are typically thawed to a greater depth than better drained sites and are extremely spongy.

Typically, these soils are located in downslope positions which are fed throughout much of the summer period by meltwater from upslope snowbanks.

Organic Soils

Organic soils, as defined by CSSC, were not observed in the Kiggavik study area. Most soils classified as Gleysolic Cryosols, however, have significant accumulations of organic material (typically Sphagnum peat or sedge peat), with depths of 20 cm to 30 cm and characteristics associated with organic sites. These sites generally have a surface to near-surface watertable and are dominated by a monocot vegetation cover. Sites are typically found in small depressions where small ponds also occur, or at the base of the escarpment where a continuous supply of seepage water is available throughout the thaw season from late-laying snowbeds.

4.1.3 Vegetation

The Kiggavik study area lies within the Low Arctic Ecoprovince (Ecoregions Working Group, 1989) (Figure 4.7) and is characterized by a continuous vegetation cover broken only by bedrock outcropping or active aggraded surfaces. This continuous vegetative cover is composed of a variety of foliose, squamulos and fruticose lichens, together with various moss species in the surface ground layers; by ericaceous shrub and heath species, and by a variety of herbs, grasses and sedges.

Previous botanical studies in the area have used a physiognomic approach for vegetation classification and description (Urangesellschaft, 1979, 1981; Thompson et al., 1978). In order to make appropriate use of this information a similar approach was adopted for this study.

Vegetation conditions vary over the study area, but are generally related to various material types and reflect differences in moisture conditions. Moisture, in turn, is influenced by differences in topography, texture and depth of the active layer. Soil moisture, which is a dominant factor in determining the nature of the plant community, can be relatively uniform over large areas such as well-drained hilltops and ridges, or imperfectly drained slopes. Moisture conditions also change over short spatial distances, reflecting changes in material sorting (i.e., striping on drumlins), or on hummocky terrain where moisture varies vertically as well as horizontally. Such local variations are reflected in changes in vegetation and give the terrain a particular appearance such as striped or patchy. Cryoturbation processes such as frost boils also influence the type and distribution of plant communities and give the terrain a spotted appearance.

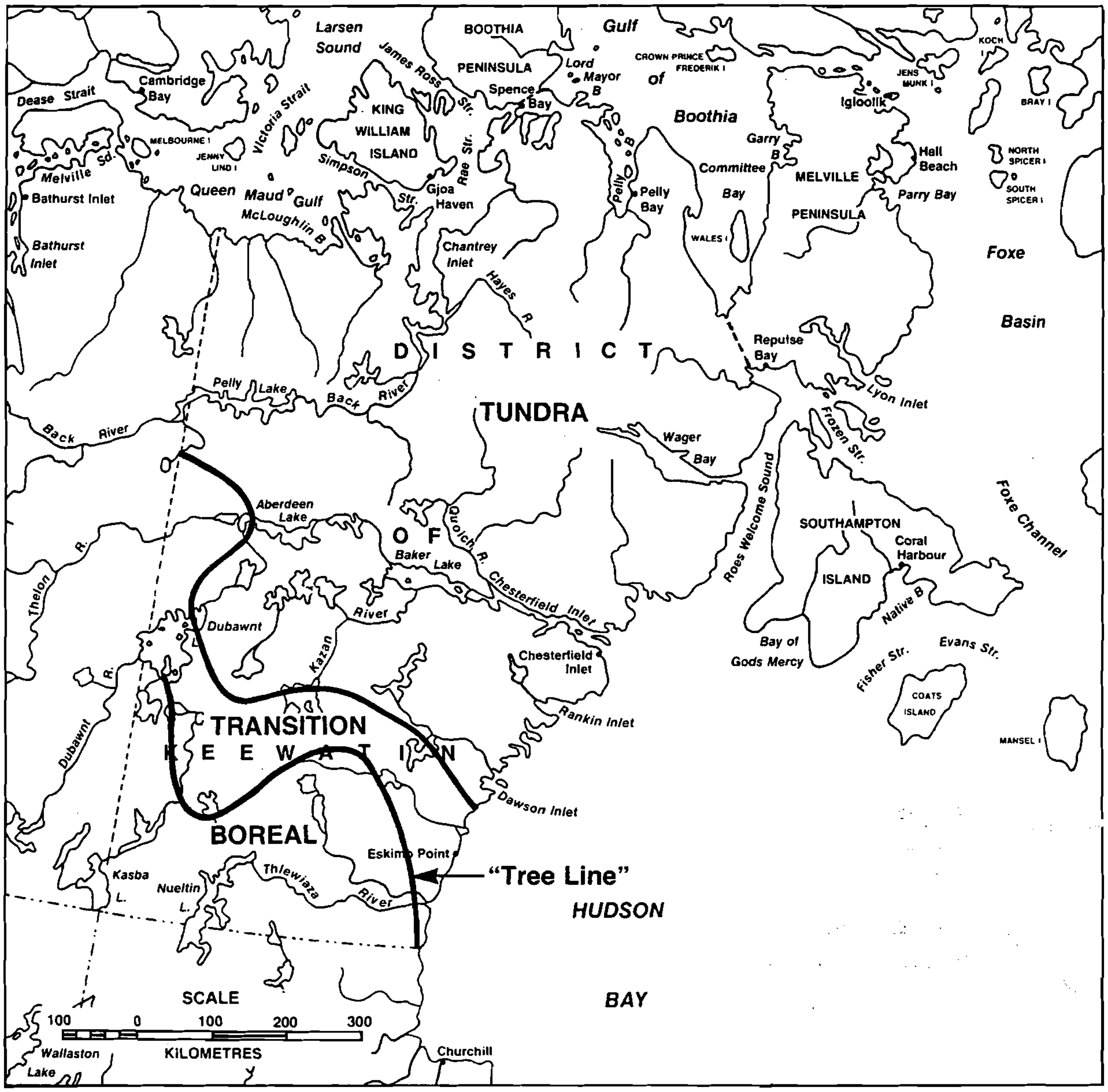


Figure 4.7: Northern limit of tree species
(Wiken et al. 1987)

The following sections provide a general discussion on the nature of the major physiognomic vegetation types observed in the study area. Wherever possible, comments pertinent to the relationships between the plant communities and the surficial materials are provided. Much of the information is based on observational data recorded during helicopter flights over the areas, or during short ground stops during those flights. A list of all plant species for the area is presented in Table 4.5.

Major Physiognomic Vegetation Types

Rock Barrens

Rock barrens generally occur on xeric, windswept upper slopes, ridge tops and large level boulder fields. Vegetation cover is typically less than 50%, of which 70% or more is crustose lichen. The visual appearance is one of rock and bare ground. Lack of adequate moisture, enhanced dessication due to constant wind exposure and a lack of accumulated soil contribute to these areas being almost devoid of vascular vegetation. Snow and soil accumulate in small protected sites resulting in the growth of ericaceous shrubs (Empetrum nigrum, Ledum decumbens), as well as grasses (Hierochloe alpina) and forbs (Diapensia lapponica).

Lichen Steppe

Lichen Steppe vegetation occurs on rapidly drained, sandy, coarse textured glaciofluvial and glaciolacustrine parent materials. Periglacial polygonal patterns are frequently observed on these deposits. The Lichen Steppe community is dominated by fruticose lichens including the black (Cornicularia divergens) and green (Alectoria ochroleuca) lichens and Stereocaulon spp., Cladina alpestris, Cladina mitis, Cladina rangiferina, Cetraria cucullata and Cetraria nivalis. The grass Hierochloe alpina, and the sedge Luzula nivalis are usually conspicuous. Scattered forbs include Diapensia lapponica, Saxifraga tricuspidata, Potentilla spp., Oxytropis spp. and Astragalus spp.

Strong winds and the relatively flat, exposed position of the landform results in continuous process surface deflation. Lichen is typically patchy as a result of the deflation process.

TABLE 4.5: SUMMARY OF PHYSIOGNOMIC SPECIES GROUPS AND COMPONENT PLANT SPECIES COMPILED FROM EXISTING STUDIES OF THE AREA AND DURING CURRENT STUDY

Shrubs and Heaths

Salix herbacea
Salix richardsonii
Salix reticulata
Salix alexensis
Salix cordifolia
Salix arctica
Salix spp.

Betula glandulosa

Andromeda polifolia
Arctostaphlos alpina
Arctostaphlos rubra
Vaccinium uliginosum

Dryas integrifolia
Empetrum nigrum
Ledum decumbens
Loiseleurla procumbens
Cassiope tetragona
Phyllodoce coerulea
Rhododendron lapponica
Vaccinium vitis-idaea

Forbs

Oxyria digyna
Polygonum viviparum
Stellaria longipes
Cerastium arcticum
Cerastium spp.
Caryophyllacease spp.
Sagina intermedia
Arenaria spp.
Silene acaulis
Ranunculus sulphureus
Ranunculus sabinei
Melandrium apetalum
Papaver radicatum
Cochlearia officinalis
Eutrema edwardsii
Cardamine bellidifolia
Draba alpina
Draba bellii
Draba lactea
Draba otlongata
Draba sp.
Arabis arenicola
Braya purpurascens
Parrya arctica
Parrya nudicaulis
Parrya spp.

Cruciferae spp.
Saxifraga caespitosa
Saxifraga cernua
Saxifraga flagellaris
Saxifraga foliolosa
Saxifraga hieracifolia
Saxifraga hirculus
Saxifraga nivalis
Saxifraga oppositifolia
Saxifraga tenuis
Saxifraga tricuspidata
Potentilla hyparctisa
Potengtilla vahliana
Potentilla spp.
Astragalus alpinus
Asragalus eucosmus
Oxytropis maydelliana
Oxytropis arctica
Hedysarum mackenzii
Spilobium latifoliar
Pyrola grandiflora
Armeria maritima
Castillepa pallida
Pedicularis arctica
Pedicularis lapponiza
Pedicularis lanata
Pedicularis sucetica
Aster spp.
Artemisid spp.

Graminoids

Eriophorum angustifo
Eriophorum triste
Eriophorum scheuchzari
Eriophorum vaginatus
Eriophorum spp.
Juncus biglumis
Juncacease spp.
Luzula wahlenbergii
Luzula confusa
Luzula nivalis
Equisetum varieqatum

Alopecurus alpinus
Phippsia algida
Acrtagrostis latifolia
Hierochloe alpina
Trisetum spicatum
Poa alpigena
Poa arctica
Poa abbreviata
Poa spp.
Pleuropogon sabinei
Colpodium vahlianum
Dupontia fisheri
Puccinella bruggemanni
Festuca brachyphylia
Festuca baffinensis
Agropyron latiglume
Carex scorpoldes
Carex bigelowi
Carex glacialis
Carex misandra
Carex aquatilis
Carex rostrata
Carex rariflora
Carex stans

Alectoria ochroleuca
Cetraria andrejevii
Cetraria delisei
Cetraria islandica
Cetraria nivalis
Cetraria tilesii
Cladina alpestris
Cladina rangiferina
Cladonia bellidificra
Cladonia chlorophaea
Cladonia amaurccraea
Cladonia coccifera
Cladonia verticillata
Dactylina arctica
Cornicularia divergens
Pertusaria coriacea
Pertusaria dactylina
Siphula spp.
Solorina crocea
Sphaerophorus globcsus
Stereocaulon albicans
Thamnolia vermiculatis
Rock crustose lichens

Sphagnum spp.
Lycopodium selago
Rhocomitrium lanugincsum
Aulacomnium turgidum
Dicranum elongatum

Lichen-Heath

Lichen-Heath is a major vegetation type throughout the Keewatin. Lichen-Heath primarily occur on better-drained upland sites (typically sandy till parent material) but where the soil contains sufficient proportion of fine material to support ericaceous shrub growth. In the Kiggavik study area, the type is frequently associated with bedrock outcrop and felsenmeer along the escarpment.

Cover in this type is typically extensive with little bare or exposed ground. Fruticose lichens dominate in the lower stratum and are characterized by species such as Alectoria ochroleuca, Cornicularia divergens and Cetraria nivalis. Other lichen species present include Stereocaulon spp. Cetraria spp., Cladonia spp., Cladina spp., Thamnolia vermicularis and Dactylina arctica. Moss species such as Rhacomitrium lanuginosum and Aulacomnium turgidum occur frequently. Ledum decumbens, Cassiope tetragona, Empetrum nigrum, Vaccinium uliginosum and Vaccinium vitis-idaea dominate in the shrub layer. The shrub and moss species typically occur on small frost-related moss hummocks characteristic of the community.

Moss-Heath

The Moss-Heath vegetation type is commonly associated with well to imperfectly drained coarse loamy textured till deposits which occur most extensively in the Kiggavik study area. Large moss hummocks (greater than 20 cm) and frost boils are characteristic of this type.

Moss hummocks are characterized by Dicranum elongatum and Aulacomnium turgidum together with a lichen component dominated by Cetraria nivalis and Alectoria ochroleuca. Grasses and sedges including Eriophorum vaginatum, Carex scorpoides and Luzula confusa occur frequently. Heath species are dominated by Dryas integrifolia, Vaccinium vitis-idaea, Cassiope tetragona, Betula glandulosa, Andromeda polifolia and Arctostaphlos alpina.

On drumlin landforms in the Kiggavik study area, heath species become concentrated in parallel rills which typically develop on the finer-textured materials. This concentration of shrubs helps accentuate the appearance of striping commonly observed from the air and on aerial photographs.

Dwarf Shrub

The Dwarf Shrub type occurs on a variety of landscape materials and positions in the study area. The type frequently occurs along anastamosing drainage where thickets of Betula glandulosa and Salix spp., up to 50 cm to 70 cm in height, may occur. Shrub communities of similar composition also occur in sheltered locations such as the lee of bedrock outcrops, or on lower and toe slope positions where moisture conditions are favorable. The type also occurs on undulating-to-level terrain of sandy textured till. Characteristic species of this types include: Ledum decumbens, Cassiope tetragona, Arctostaphlos alpina, Arctostaphlos rubra, Vaccinium vitis-idaea, Vaccinium uliginosum, Salix alaxensis and Betula glandulosa.

Sedge Meadow

Sedge Meadows occur in wet lowland areas typically in association with an organic soil substrate. The visual appearance is one of uniform cover dominated by Carex spp. Standing water frequently occurs. Shrubs are generally restricted to the driest areas, typically at the edges or on Sphagnum mounds. Mosses and algae occupy the areas between the sedges. Forbs are not generally abundant but include: Polygonum viviparum, Saxifraga hirculus, Rubus chamaemorous, Petasites frigidus and Pedicularis spp.

Tussock Meadow

The Tussock Meadow type occurs on a slightly higher landscape position than the Sedge Meadow, but in still relatively wet or moist conditions (e.g., drainage/seepage zones). Physiognomically the type is characterized by small graminoid tussocks (10 cm to 20 cm) dominated by cottongrass (Eriophorum vaginatum) and Carex spp. Heath and shrub species also occur sporadically and include such species as: Ledum decumbens, Empetrum nigrum and Betula glandulosa.

4.2 Ecological Land Survey

Description of the terrestrial resource components for the study area have been prepared within the context of the ELS framework.

Ecoregions and ecodistricts for the area have been previously described (Wiken et al., 1987) and those maps and descriptions have been used for this report. The maps include comprehensive information on the landforms, topography, hydrology and vegetation for each of the delineated polygons at various scales. A brief description and discussion for each of the ELS landscape units follows.

4.2.1 Ecoregions

The Kiggavik project area falls within three major Ecoregions (Figure 4.8):

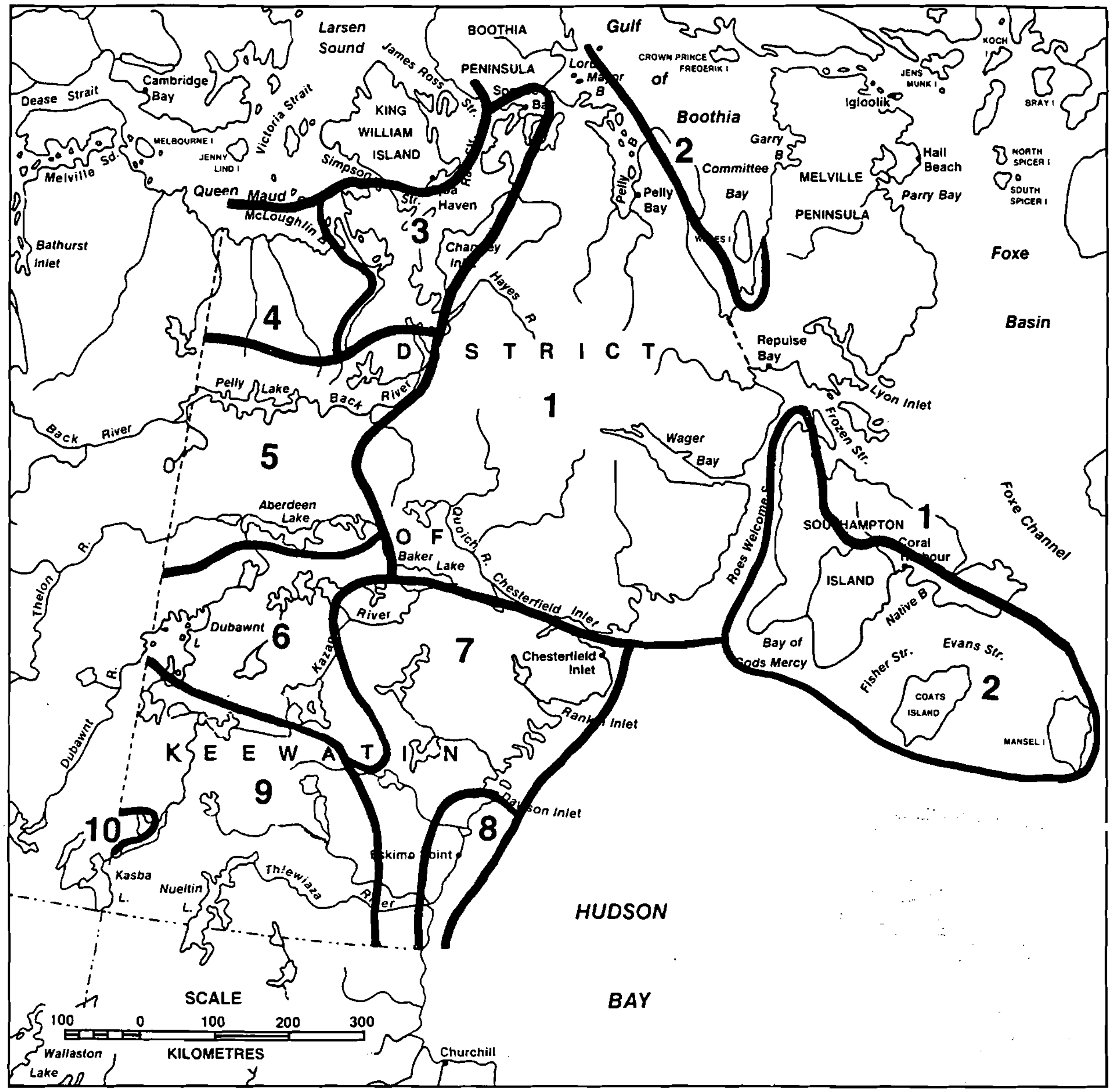
1. Garry Lake Plains,
2. Dubawnt Plains, and
3. Rankin Plains.

The winter road corridor from the Kiggavik site to the limestone quarry is located in the Garry Lakes Ecoregion; the Kiggavik mine site and the winter road corridor between the Kiggavik site and Aniguq Lake are located in the Dubawnt Plains ecoregion, while the dock facilities and the winter road corridor between Aniguq Lake and Baker Lake occurs in the Rankin Plains Ecoregion. Wiken et al. (1987) describe the three ecoregions as follows.

Garry Lake Plains Ecoregion

The Garry Lake Plains Ecoregion is dominated by level-to-hilly plains consisting primarily of deep to shallow morainal deposits. Many areas within the ecoregion are mantled by fine deposits of marine or glaciolacustrine origin. It is characterized by:

- o broadly sloping lowlands and plateau consisting of massive rock, glacial moraine and marine sediments;
- o young and slightly weathered soils which are typically frost-churned;
- o patterned ground, continuous permafrost and a shallow depth of thaw (less than 100 cm);
- o a largely continuous vegetation cover comprised of medium to low shrubs mixed with lichens and heath;



1 Boothia-Foxe Shield
2 Boothia-Foxe Lowland
3 Back River Plains
4 Queen Maud Lowland
5 Garry Lake Plains
6 Dubawnt Plains
7 Rankin Plains
8 Hudson Plains
9 Ennadai Plains
10 Wholdaia Plains

Figure 4.8: Ecoregions of the District of Keewatin
(Source: Wiken et al. 1987)

- abundant small lakes and ponds often isolated or linked by a poorly-organized drainage system; the larger rivers flow northerly or easterly;
- short, cool summers with nearly continuous sunshine, and long cold winters with little daylight; and
- wildlife represented by barren-ground caribou, muskox, arctic fox, waterfowl, barren-ground grizzly bear and wolf.

Dubawnt Plains Ecoregion

The Dubawnt Plains Ecoregion is dominated by a low-lying, rolling plain comprised primarily of deep to shallow morainal deposits in elongated to fluted northwesterly trending ridges. The Ecoregion is characterized by:

- infrequent rocky outcrops, wetlands and eskers found in limited areas;
- young and slightly weathered soils which are frost-churned;
- patterned ground, continuous permafrost and a shallow depth of thaw (less than 100 cm);
- a largely continuous vegetation cover comprised of medium to low shrubs mixed with lichens and heath;
- abundant small lakes and ponds often isolated or linked by a poorly-organized drainage system; the larger rivers flow northerly or easterly;
- short, cool summers with nearly continuous sunshine, and long, cold winters with little daylight; and
- wildlife represented by barren-ground caribou, barren-ground grizzly bear, muskox, waterfowl and raptors.

Rankin Plains Ecoregion

The Rankin Plains Ecoregion is dominated by a gently rolling morainal plain, partly modified by marine submergence. The coastal portion consists of deep silt and sand deposits while the inland portion is characterized by extensive areas of marine and alluvial deposits which have been reworked by marine action. There are numerous raised beaches and eskers. It is characterized by:

- broadly sloping lowlands and plateaux consisting of massive rock, glacial moraine and marine sediments;

- low relief with gentle slopes towards the Hudson Bay coastal plain; elevations under 50 m;
- young and slightly weathered soils which are frost-churned;
- patterned ground, continuous permafrost and a shallow depth of thaw (less than 100 cm);
- a largely continuous vegetation cover comprised of medium to low shrubs mixed with lichens and heath;
- abundant small lakes and ponds often isolated or linked by a poorly-organized drainage system with the larger rivers flowing northerly or easterly;
- short, cool summers with nearly continuous sunshine and long, cold winters with little daylight; and
- wildlife represented by barren-ground caribou, waterfowl, Arctic fox, and raptors.

4.2.2 Ecodistricts

Ecodistricts are subdivisions of ecoregions. Within each of the three ecoregions described for the project area, parts of four ecodistricts are included (Figure 4.9):

- Garry Lake Plains Ecoregion - Deep Rose Lake (AL05)
  - Marjorie Hills (AL06)
- Dubawnt Plains Ecoregion - Mallery Lake (DL06)
- Rankin Plains Ecoregion - Kaminuriak Lake (CT01)

Deep Rose Lake Ecodistrict (AL05)

1. Terrain

The Deep Rose Lake Ecodistrict is a gently rolling to hummocky plain that is composed of bouldery moraine and coarse textured glaciofluvial materials such as eskers. Wetlands are scarce. The depth of thaw is 0.5 m to 1.0 m.

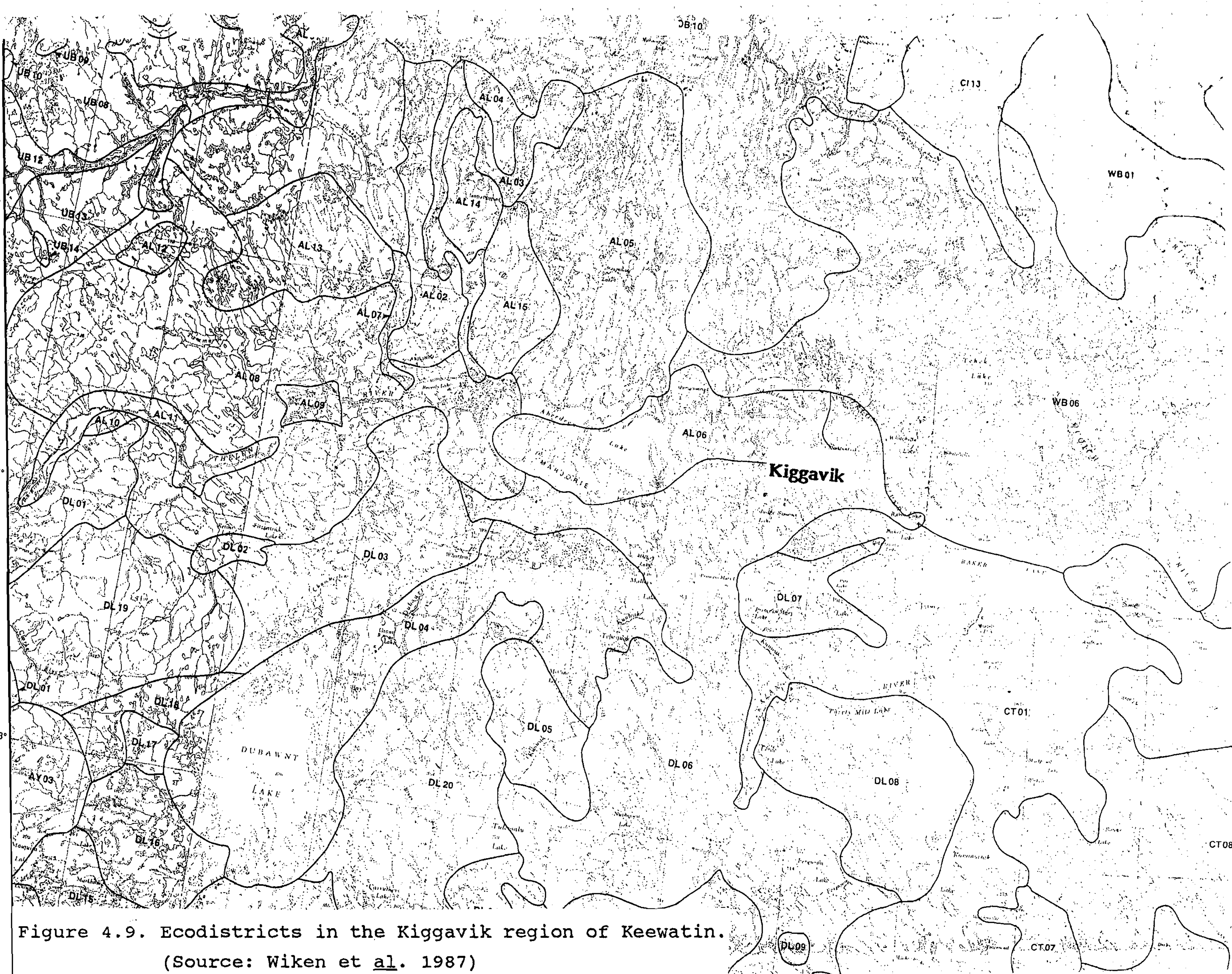


Figure 4.9. Ecodistricts in the Kiggavik region of Keewatin. (Source: Wiken et al. 1987)

2. Vegetation

Black lichens with some heath dominate hillcrests. This assemblage grades downslope into a mixed lichen and low shrub complex and further into sedge communities in the wet depressions or drainageways.

3. Water

Streams have very irregular channels, owing to the hummocky terrain. The flow trends northerly or southerly. Lakes occupy up to 40% of the ecodistrict. While some are large and deep, most are less than 2 km^2 in area and shallow.

4. Wildlife

Wildlife is represented by barren-ground caribou, Arctic fox, muskox, barren-ground grizzly bear and wolf.

Marjorie Hills Ecodistrict (AL06)

1. Terrain

The Marjorie Hills Ecodistrict is characterized by a hilly to mountainous terrain where the local relief is high (20 m to 50 m). Surficial materials are largely colluvium and morainal. Rock outcrop characterize upper and crest landscape positions.

2. Vegetation

A mixed complex of lichens and low to medium shrubs covers the lower and mid slopes. This grades into a sparse and discontinuous lichen cover with altitude or increasingly rocky areas.

3. Water

Streams and lakes are not common. Streams occupy shallow gorges. Seepage rills are common to vegetated slopes.

4. Wildlife

Barren-ground caribou, barren-ground grizzly bear and raptors are the most significant species.

Mallery Lake Ecodistrict (DL06)

1. Terrain

The Mallery Lake Ecodistrict is a low-lying to nearly-level plain which is comprised primarily of deep to shallow morainal deposits. Some scattered rock outcrops and wetlands are present. Discontinuous eskers are often connected by outwash channels containing little or no glaciofluvial deposits. The depth of thaw is about 1 m.

2. Vegetation

Lichen complexes along with medium to low shrubs predominate while wetlands have a sedge-moss cover. The vegetative cover is fairly lush and continuous.

3. Water

In the northern part of the ecodistrict the streams flow towards Baker Lake while in the southern part they flow towards the Kazan River and Forde Lake.

4. Wildlife

Wildlife is represented by barren-ground grizzly bear, muskox, waterfowl and raptors.

Kaminuriak Lake Ecodistrict (CT01)

1. Terrain

The Kaminuriak Lake Ecodistrict is an interior plain that consists of fluted and drumlinized ridges oriented in a southeast direction, bedrock knolls or shattered rock, subduded eskers and wetland areas. Marine sediments and alluvial deposits occur in lower areas and raised beaches around a number of hills. Solifluction stripes are common on slopes. Relief is low (10 m to 30 m) over a long, gentle slope inclined toward the coast. Soils display a shallow depth of thaw and are frost-churned.

2. Vegetation

The major vegetation cover is composed of lichens along with low shrubs and low heath associations. A sedge-moss community is associated with the wet hollows on drainageways while a dark lichen-heath community dominates on the harsher and drier sites. The vegetative cover is continuous and dense, except on eskers and boulder fields.

3. Water

Rivers and streams are aligned on a southeasterly axis. Channels are irregular, broad and linear. Stream density is low. Streams meandering through wetlands are common. Lakes and ponds are few and occupy about 10% of the surface cover. Lakes are elongated and average 5 km^2 to 10 km^2 in area with irregular shorelines.

4. Wildlife

Barren-ground caribou, waterfowl and raptors are the most significant species.

4.2.3 Ecosections and Ecosites

Ecosections (subdivisions of ecodistricts) and Ecosites (subdivisions of ecosections) were initially delineated and described for a 1,113 km^2 area centered on the Kiggavik development site during the 1986 studies using 1:63,360 scale black and white aerial photography (Figures 4.10 and 4.11). A total of six ecosections for the development area are recognized. Each of the ecosections were generalized from 177 ecosites and represent distinctive land areas with recurring patterns of similar landforms, soils, vegetation and hydrology.

Based on the mapping carried out in 1986, three vegetation complexes (Figure 4.12; Table 4.6) dominate the area: Moss-Heath/Lichen-Heath (17,181 ha), Lichen-Heath/Low Shrub (15,708 ha) and Lichen Steppe/Lichen-Heath (13,019 ha). Lichen Heath and Lichen Steppe

Ecosections of the Kiggavik Study Area

Figure 4.10

Ecosites of the Kiggavik Study Area

Figure 4.11

Figure 4.12

Dominant Vegetation: Kiggavik Study Area

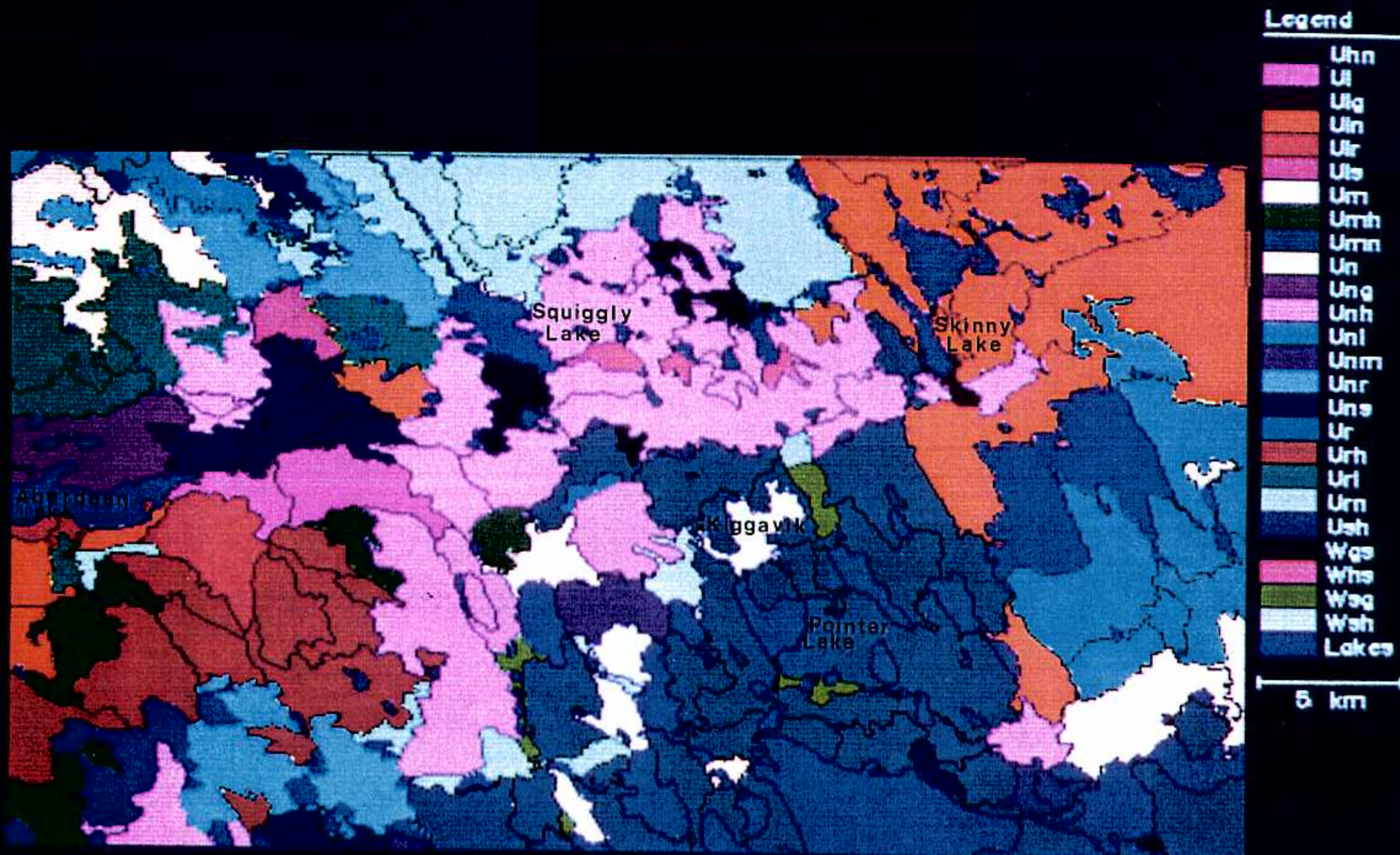


TABLE 4.6: AREA OF MAJOR VEGETATION COMPLEXES IN THE KIGGAVIK STUDY AREA

Vegetation Complex (Map Symbol)	km^2	ha
Low shrub-boulder/lichen heath (Uhn)	5.38	538
Lichen steppe (Ul)	14.97	1,497
Lichen steppe/sedge meadow (Ulg)	1.43	143
Lichen steppe/lichen heath (Uln)	130.19	13,019
Lichen steppe/rock barrens (Ulr)	12.93	1,293
Lichen steppe/low shrub (Uls)	4.79	479
Moss heath (Um)	13.41	1,341
Moss heath/low shrub-boulder (Umh)	24.29	2,429
Moss heath/lichen heath (Umn)	171.81	17,181
Lichen heath (Un)	46.84	4,684
Lichen heath/sedge meadow (Ung)	13.86	1,386
Lichen heath/low shrub-boulder (Unh)	157.08	15,708
Lichen heath/lichen steppe (Unl)	70.11	7,011
Lichen heath/moss heath (Unm)	7.81	781
Lichen heath/rock barrens (Unr)	45.44	4,544
Lichen heath/low shrub (Uns)	28.58	2,858
Rock barrens (Ur)	1.02	102
Rock barrens/low shrub-boulder (Urh)	61.31	6,131
Rock barrens/lichen steppe (Url)	37.42	3,742
Rock barrens/lichen heath (Urn)	73.53	7,353
Low shrub/low shrub-boulder (Ush)	3.51	351
Sedge meadow/low shrub (Wgs)	5.95	595
Low shrub-boulder/low shrub/sedge meadow (Whsg)	3.88	388
Low shrub/sedge meadow (Wsg)	6.64	664
Low shrub/low shrub-boulder/sedge meadow (Wshg)	4.87	487
Lakes	166.28	16,628
TOTAL AREA	1,113.33	111,333

complexes dominate to the north and west in the study area while the Moss-Heath and Low Shrub communities dominate in the south and east (Figure 4.12). These vegetation trends are generally related to the surficial deposits of the area (Figure 4.13; Table 4.7), where the Moss-Heath and Low Shrub communities are associated with the finer textured, imperfectly drained till in the south and east, and the Lichen-dominated communities associated with the sandy textured, well-drained soils to the north and west. General descriptions for each of the ecosections follows:

Aberdeen Lake North Ecosection (ALN)

The ALN Ecosection is approximately 230 km^2 and includes 42 ecosites. The Ecosection is dominated by two major surficial deposits: (1) a sandy east-west trending till, and (2) a large glaciofluvial deposit (delta) which was formed near the east end of Aberdeen Lake following deglaciation of the Lake Aberdeen basin (Figure 4.1) (Figure 4.13).

The sandy till, which is best expressed by a large drumlin field (Figure 4.1) along the north shore of Aberdeen Lake, has been modified by post-glacial lacustrine activity and typically exhibits a boulder-strewn surface. The glaciofluvial material at the east end of Aberdeen Lake has been subjected to post-glacial fluvial activity and is dissected and channeled over much of its area. The ecosection boundary between this ecosection and the Squiggly Lake Ecosection defines the approximate eastern limit of east-west oriented sandy till in the study area (Thomas, 1985). Relief in the area is generally moderate, although some areas, particularly in the west and northwest, may be locally more rugged.

Both the sandy till and glaciofluvial deposits are relatively well-drained and support distinctive tundra vegetation communities (Figure 4.6). Lichen-Heath dominated communities occur most frequently on the sandy till, whereas a Lichen-Steppe community dominates on the well-drained, coarse-textured sandy glaciofluvial deposits. The vegetation cover on these latter deposits is frequently sparse, discontinuous and unstable due to surface deflation activity.

Aberdeen Lake South Ecosection (ALS)

The ALS Ecosection is approximately 145 km^2 and includes 27 ecosites. The ecosection has a generally less rugged topographic expression although along the south shore of

Figure 4.13 Surficial Deposits: Kiggavik Study Area

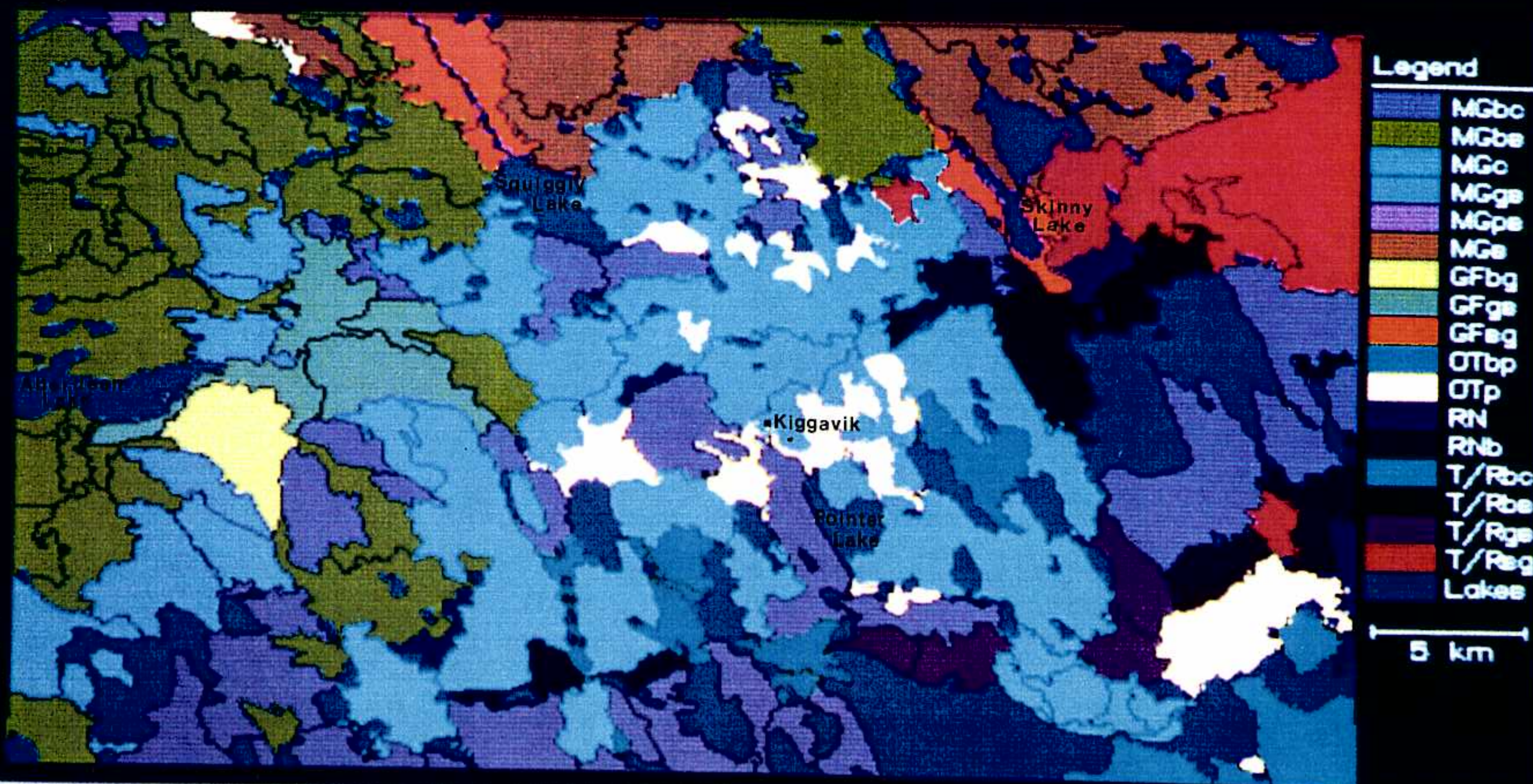


TABLE 4.7: AREA OF SURFICIAL DEPOSITS COMPLEXES IN THE KIGGAVIK STUDY AREA

Surficial Deposits (Map Legend Symbol) Complex	km^2	ha
Silty ground moraine (boulders) (MGbc)	154.06	15,406
Sandy ground moraine (boulders) (MGbs)	180.91	18,091
Silty ground moraine (MGc)	215.47	21,541
Sandy, gravel ground moraine (MGgs)	47.60	4,760
Sandy ground moraine (organic) MGps)	1.48	148
Sandy ground moraine (MGs)	69.63	6,963
Sandy, gravel glaciofluvial (boulders) (GFbg)	166.28	16,628
Gravelly, sandy glaciofluvial (GFgs)	10.88	1,088
Sandy, gravelly glaciofluvial (GFsg)	28.82	2,882
Organic (boulders) (OTbp)	19.74	1,974
Organic (OTp)	21.57	2,157
Bedrock knob (RN)	48.89	4,889
Bedrock knob (boulders) (RNb)	10.07	1,007
Silty, shallow till/bedrock (T/Rbc)	25.67	2,567
Sandy, shallow till/bedrock (T/Rbs)	18.63	1,863
Gravelly, sandy shallow till/bedrock (T/Rgs)	19.32	1,932
Sandy, gravelly shallow till/bedrock (T/Rsg)	17.66	1,766
Lakes	56.64	5,664
TOTAL AREA	1,113.33	111,333

Aberdeen Lake, the area is dissected and gullied by the downward erosional activities of numerous creeks and streams which flow from the surrounding uplands.

The area is generally a rolling to undulating, bouldery sandy till with numerous bedrock outcrops and a surface dominated by rocks and boulders (rock barrens) (Figure 4.13). Minor glaciofluvial deposits associated with those described for the ALN ecosection also occur and in scattered pockets in various other ecosites.

The ecosection is dominated by Lichen-Heath and heath vegetation types in association with the rock barrens and thin veneers covering the bedrock scarps, late-lying snowbeds provide local moisture supply zones which give rise to local wetlands dominated by graminoid and shrub communities.

Kiggavik Ecosection (KIG)

The Kiggavik Ecosection is the largest ecosection in the study area at 385 km^2 and is comprised of 52 ecosites. The area is dominated by a sandy-silty (coarse loamy-textured) till which has frequently been described as a clay till because of the sticky nature of the silt when saturated (Figure 4.13). The till, which was deposited by a later northwest trending ice front over the study area has been locally moulded into drumlins 30 m to 50 m in height and often several kilometers in length (Figure 4.1). A combination of the finer-textured material and sloping topography results in such permafrost related features as striping and small stone rings. The stripes are indicative of minor erosional activity whose appearance is enhanced by shrub vegetation which colonizes the rills.

The northern boundary of the ecosection generally follows the base of the escarpment which dominates the area (Figure 4.1). Along the base of the scarp, numerous late-lying snowbeds, in combination with seepage from the scarp itself, provide a summer-long supply of moisture. Numerous anastamosing creeks and small drainages occur in this zone. Scattered deposits of glaciofluvial material occur primarily in the northern part of the ecosection.

The coarse loamy-textured till is generally moderately well to imperfectly drained and supports a distinctive Moss-Heath vegetation (Figure 4.12). The moss forms substantial hummocks up to 20 cm to 30 cm in height, giving the terrain a rough micro-topographic appearance. The fine-textured nature of the material, in combination with the higher moisture status, also makes the soil susceptible to frost heaving. Wetlands and peat soils are dominated by graminoid tussocks and shrubs. The shrub vegetation frequently overlays a boulder pavement which results from the fine matrix material of the underlaying till being eroded from fluvial activity.

Squiggly Lake Ecosection (SQL)

The SQL Ecosection is approximately 145 km^2 in area and includes 23 ecosites. The most striking feature is the east-west scarp which constitutes much of the southern border of this ecosection. A number of ecosites (Figure 4.13) are dominated by exposed bedrock which is frequently fractured by freeze-thaw processes and covered by rock felsenmeer. Numerous draws along the escarpment are saturated with moisture and occasionally exhibit solifluction activity. The remaining area of this ecosection is characterized by a rolling to undulating, coarse loamy till plain with numerous lakes and ponds.

The ecosection is characterized by Moss-Heath and Lichen-Heath vegetation, the former associated with southern portions of the ecosection and the latter with northern parts where the till appears to be somewhat better drained and with a higher surface cover of boulders (Figures 4.12 and 4.13).

Skinny Lake Ecosection (SKL)

The SKL Ecosection cover approximately 150 km^2 with 15 ecosites. The area is dominated in the north by an apparent marine or glaciofluvially modified sandy till, and by extensive glaciofluvial deposits along the southern margin of Skinny Lake (Figure 4.13). The glaciofluvial deposits have been dissected and channeled through post-glacial fluvial activity, and are characterized by a network of ice-wedge polygons. The western boundary of this ecosection marks the approximate marine limit (180 m) defined by Thomas (1985).

The ecosection is dominated by the Lichen-Heath vegetation type on the till deposits and the Lichen-Steppe vegetation on the sandy, well-drained, coarse-textured glaciofluvial deposits (Figure 4.12). Wetlands, which occur as small pockets along lakeshores, are typically graminoid and graminoid-heath vegetation.

Sissons Lake Ecosection (SIL)

The SIL Ecosection covers approximately 100 km^2 and is comprised of 18 ecosites. The area is characterized by low local relief of marine modified till with a sandy, gravelly surface veneer and by the coarse loamy textured till. Numerous bedrock outcrops are scattered throughout the ecosection (Figure 4.13).

The Moss-Heath vegetation type occurs in association with the coarse loamy textured till and the Lichen-Heath type associated with the sandy till materials (Figure 4.12). Small wetlands along lake shorelines are characterized by tussocky graminoid vegetation and taller willow shrubs.

4.2.4 Ecosite Description: Development Areas

Ecosites at a larger scale have been delineated and described for each of the four major geographic subdivisions in the project area where some form of infrastructure development is to occur. Ecosites were originally delineated for the 1,113 km^2 area centred on the Kiggavik site using 1:63,360 aerial photography (Figure 4.11). The acquisition of larger scale photography for portions of this area made it possible to map in slightly more detail, those areas covered by this new photography. The photographic scale (1:24,000) is such that although it is possible to be more spatially discrete, the level of interpretation or generalization remains similar to that described earlier. Polygon complexity is reduced however due to the spatially improved interpretation. Area summaries for the major vegetation and surficial geology mapping complexes are provided in Tables 4.8 and 4.9. These tabular summaries relate to Figures 4.14 to Figures 4.22.

4.2.4.1 Winter Road Corridor: Baker Lake to the Kiggavik Site

The winter road corridor between the Kiggavik site and Baker Lake is characterized by two distinct physiographic conditions. Between the Kiggavik mine site and Aniguq Lake the terrain is dominated by a flat to very gently undulating, moderately well drained, sandy, glacial till parent material (Figure 4.14) and Lichen-Heath vegetation (Figure 4.15). Organic terrain is typically associated with lower landscape positions and in association with diffuse drainage and lake margins. Tussock-Sedge and Shrub vegetation

TABLE 4.8: AREA SUMMARY FOR THE MAJOR VEGETATION COMPLEXES MAPPED FOR THE KIGGAVIK STUDY AREA

	Geographic Area in hectares				
Vegetation Complex	Qinguq Bay to Aniguq Lake	Aniguq Lake to Kiggavik	Kiggavik to Aberdeen Lake	Aberdeen Lake to Limestone Quarry	Kiggavik Site Development
Lichen steppe	736.3	120.8	1,502.8	22,420.8	187.6
Lichen steppe/lichen heath	4,393.9	579.4	332.9	7,737.4	464.2
Lichen steppe/low shrub	1,300.1	2,023.2			
Lichen steppe/moss heath		311.8			
Lichen steppe/rock barrens			725.9		
Lichen steppe/sparsely vegetated				5,358.3	
Lichen heath	1,271.3	901.7	2,915.9		1,078.2
Lichen heath/lichen steppe	2,754.3		703.4		
Lichen heath/tussock meadow	465.5				
Lichen heath/moss heath		586.2	228.5		1,578.5
Lichen heath/low shrub	1,234.1	2,782.9	1,420.9		
Lichen heath/low shrub (boulders)			238.7		
Lichen heath/rock barrens			808.1		110.9
Moss heath		211.7	284.3		1,882.1
Moss heath/lichen heath		1,129.1	384.8		1,523.5
Moss heath/low shrub		5,193.3			866.9
Moss heath/lichen steppe			340.8		
Low shrub/lichen heath	963.1				
Low shrub/moss heath		138.9			
Tussock meadow/lichen heath	120.3	1,383.5			
Tussock meadow	431.2	587.8			
Tussock meadow/low shrub	284.3				
Sparsely vegetated			101.6		
Sparsely vegetated/lichen steppe			29.9		420.7
Sedge meadow			319.7		
Sedge meadow/low shrub				5,994.9	
Sedge meadow/tussock moss meadow				5,502.9	
Low shrub/sedge meadow	203.4	166.9			
Low shrub/tussock moss meadow	2,877.3				
Tussock moss meadow/sedge meadow	3,479.9				
Tussock moss meadow/low shrub	1,037.7		347.3		
Tussock moss meadow/moss heath	267.1	840.6			
Low shrub boulders/sedge meadow	3,098.7				512.5
Tussock moss meadow	342.9	229.1			
Rock barrens		66.5			
Rock barrens/lichen heath		1,665.8			
Rock barrens/moss heath		104.1			386.1
Lakes	7,583.8	4,767.7	226.9	9,023.2	1,074.7
TOTALS	32,845.1	23,790.9	10,912.6	56,037.6	10,085.9

TABLE 4.9: AREA SUMMARY (ha) FOR THE MAJOR SURFICIAL DEPOSITS COMPLEXES MAPPED FOR THE KIGGAVIK STUDY AREA

Surficial Geology Complexes	Geographic Area				
	Qinguq Bay to Aniguq Lake	Aniguq Lake to Kiggavik	Kiggavik to Aberdeen Lake	Aberdeen Lake to Limestone Quarry	Kiggavik Site Development
Sandy, gravelly ground moraine	2,984.1	9,981.8	789.6	1,319.4	
Silty ground moraine		2,047.9	3,894.2		6,430.6
Silty, veneer ground moraine		2,560.3			
Silty, bouldery ground moraine			1,481.2		326.7
Sandy, bouldery ground moraine			1,853.8		
Sandy, gravelly glaciofluvial	924.1	35.3	2,218.1	45,695.1	665.3
Bedrock knob	790.1	478.1			269.3
Bedrock knob (boulders)		168.9			420.7
Bedrock knob (till veneer)	880.8		101.6		
Shallow sandy, gravelly till/bedrock knob		2,379.9			
Shallow sandy, gravelly till/bedrock knob	148.9				
Sandy, bouldery marine deposits	294.8				
Sandy, gravelly marine deposits	8,298.6	1,254.5			
Sandy, gravelly lacustrine	82.1				
Organic Terrain	10,857.9	170.5	347.3		898.6
Lakes	7,583.8	4,767.7	226.9	9,023.2	1,074.7
TOTALS	32,845.1	23,790.9	10,912.6	56,037.6	10,085.9

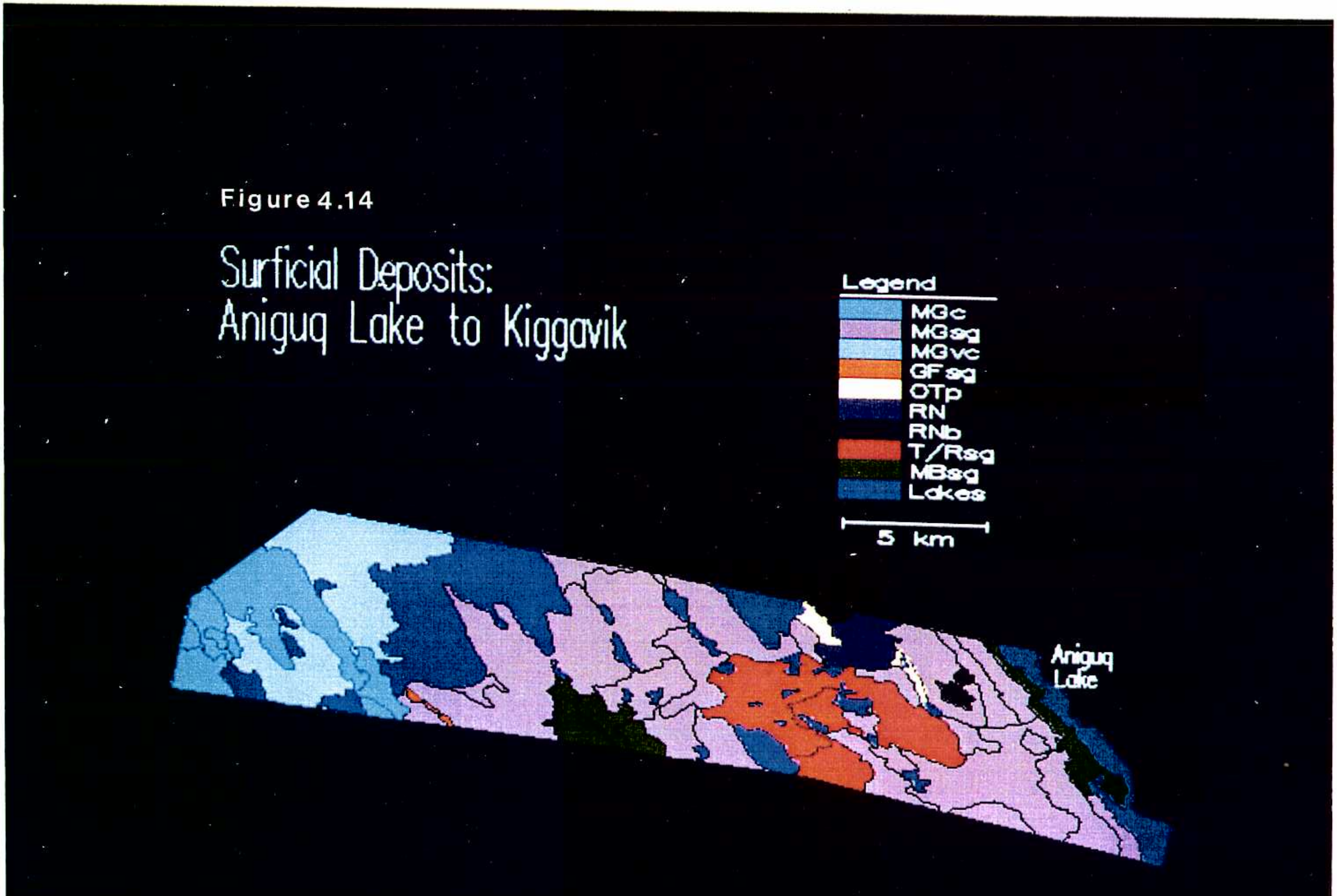
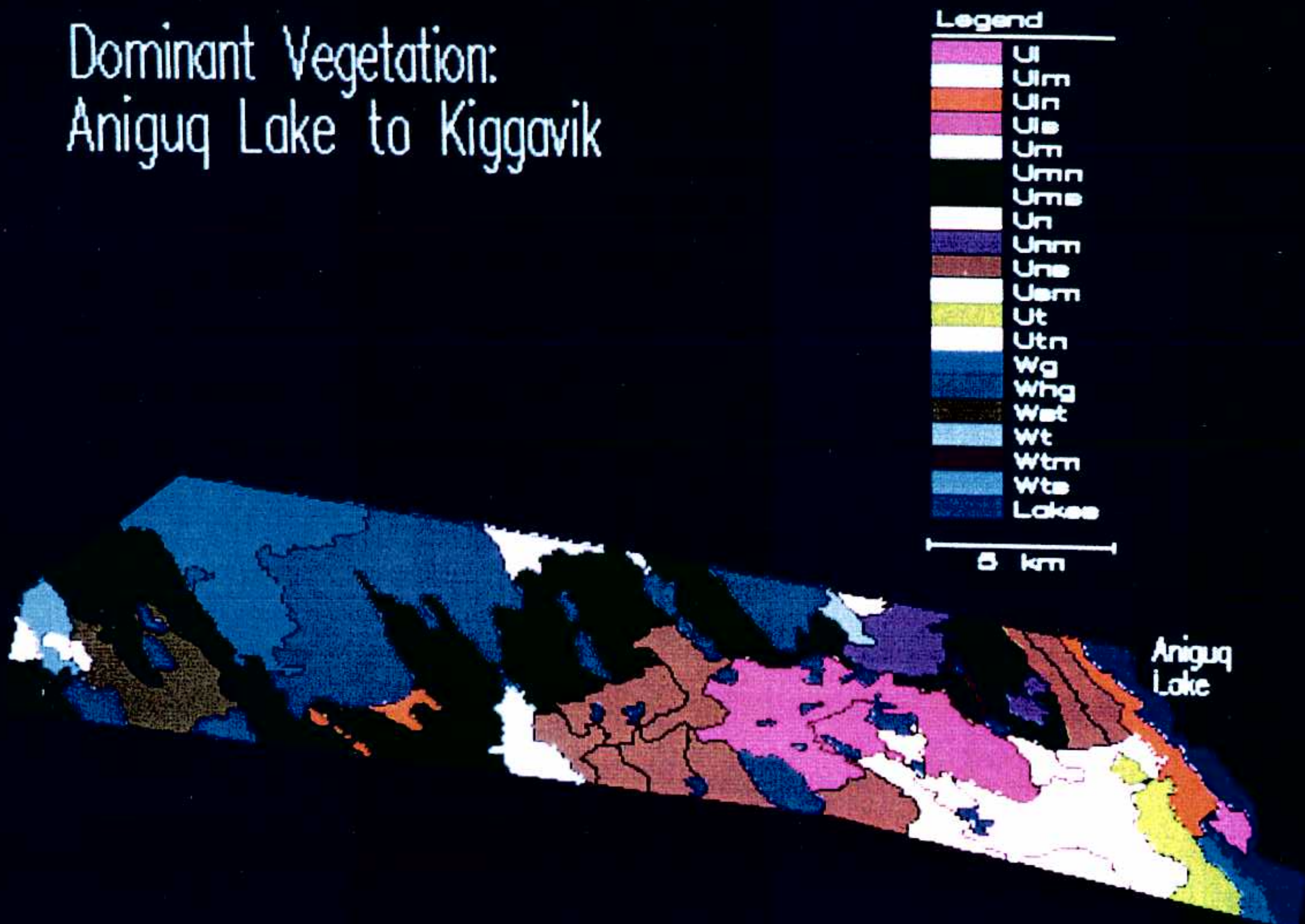


Figure 4.14
Surficial Deposits:
Aniguq Lake to Kiggavik
Legend
MGc
MGsg
MGvc
GFsg
OTp
RN
RNb
T/Rsg
MBsg
Lakes
5 km
Aniguq Lake

Figure 4.15

Dominant Vegetation: Aniguq Lake to Kiggavik



characterize these landscapes (Figure 4.15). Occasional well drained, sandy marine deposits occur, frequently in association with bedrock exposures and lake shorelines (Figure 4.14). Lichen-Steppe vegetation occurs almost exclusively with this landform. An imperfectly drained, coarse loamy-textured till in the immediate Kiggavik site development area has been moulded into distinct drumlin landforms (Figure 4.14). A hummocky Moss-Heath vegetation characterizes this imperfectly drained landform. Low shrub associations develop in parallel stripes which characterize slope facies of the till.

Between Aniguq Lake and Baker Lake (Qinguq Bay), the terrain is characterized by a flat, poorly-drained, sandy glacial till typically covered by organic deposits and by extensive and well developed sandy, marine materials (Figure 4.16). These latter materials are most characteristic of southern sections of the mapping area, whereas organic deposits occur most extensively in central and northern parts of the study area. In the vicinity of Qinguq River and Baker Lake, gravelly marine deposits frequently occur on the flanks of bedrock hills. Abandoned shorelines, a result of declining post-glacial marine levels, characterize these landforms.

Extensive tracts of Sedge and Tussock-Sedge Meadow commonly occur in this section of the winter road corridor and characterize the wetter facies associated with organic deposits (Figure 4.17). Shrub associations occupy slightly drier facies. Tussock-Sedge Meadows are also associated with poorly-drained till. Tussock-Sedge Meadows typically occupy landscape moisture facies intermediate to the wet Sedge Meadows and drier Shrub associations. Lichen Steppe vegetation is associated with sandy marine foreshore and beach deposits (Figure 4.17). These deposits are typically characterized by polygonal patterned ground.

4.2.4.2 Winter Road Corridor: Kiggavik Site to Limestone Quarry Site

The winter road corridor between the Kiggavik site and the limestone quarry site is also characterized by two distinct landscape assemblages. Between the Kiggavik site and the east arm of Aberdeen Lake, the terrain is dominated by a well-drained, gently undulating, coarse loamy-textured till (Figure 4.18). At the east end of Aberdeen Lake a large, fluvially dissected, glaciofluvial delta with raised beach ridges dominates the landscape (Figure 4.18). Associated with the till is a Moss-Heath and Lichen-Heath vegetation. The Moss-Heath type occurs under imperfectly drained conditions, whereas

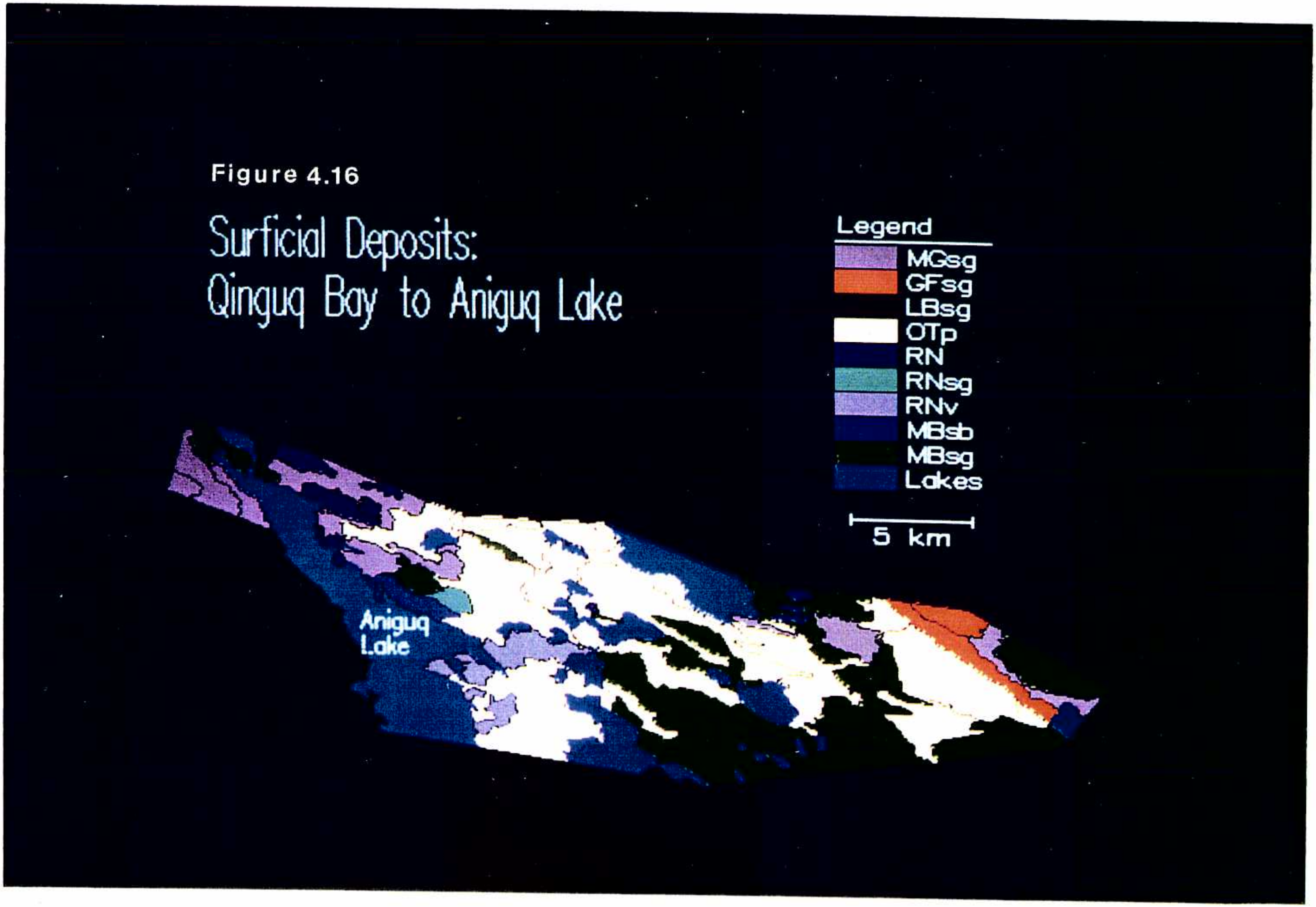


Figure 4.16

Surficial Deposits: Qinguq Bay to Aniguq Lake

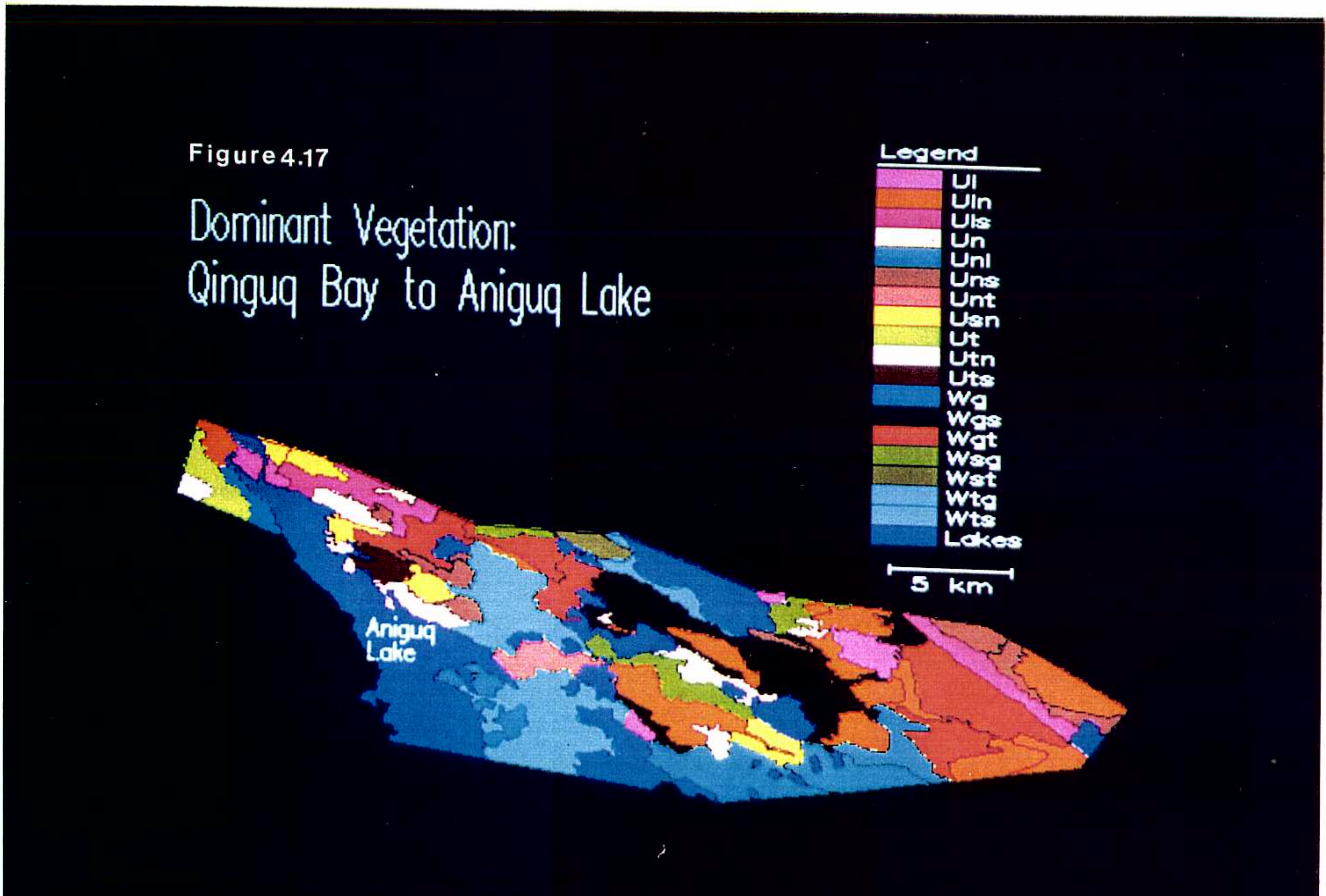


Figure 4.17
Dominant Vegetation:
Qinguq Bay to Aniguq Lake
Legend
Ul
Uln
Uls
Un
Unl
Uns
Unt
Usn
Ut
Utn
Uts
Wg
Wgs
Wgt
Wsg
Wst
Wtg
Wts
Lakes
5 km
Aniguq
Lake

Figure 4.18

Surficial Deposits: Kiggavik to Aberdeen Lake

Lichen-Heath is associated with better-drained facies (Figure 4.19). Lichen Steppe is characteristic of the sandy glaciofluvial deposits near Aberdeen Lake. A minor component of an east-west trending sandy till occurs immediately north and south of Aberdeen Lake. Lichen-Heath and Lichen Steppe vegetation is associated with this well-drained till.

The section of road between Aberdeen Lake and the limestone quarry is relatively uniform and characterized by well-drained sandy/gravelly rolling hills, interspersed with numerous lakes and ponds (Figure 4.20). Near Aberdeen Lake, where the terrain is somewhat more strongly rolling, well defined glaciolacustrine terraces occur along the flanks of the hills.

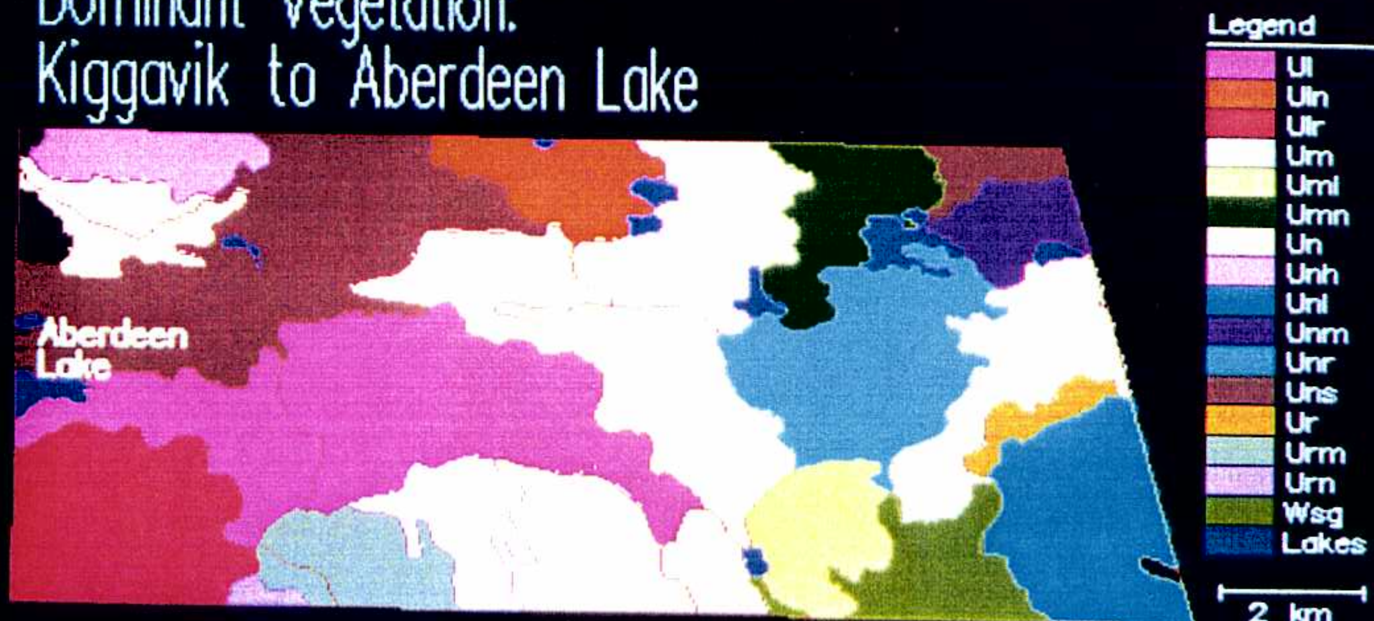
Urangesellschaft personnel who have been into the area (Pers. Comm. W. Hilger) have suggested the material may be of glaciofluvial origin. During photo interpretation of the landforms a different depositional history of the materials was considered. Thomas (1985) and Griep (1985) have described a similar landform assemblage on the northeast shore of Aberdeen Lake and suggested the material to be an east-west trending till deposit. It is possible that the landforms in the corridor are, in fact, part of this till deposit. Subsequent to deposition of the till the area was inundated by either marine or glaciolacustrine waters. During this period of inundation crests of hills were wave eroded and sands and gravels of the present day surface were deposited as caps over the till. Elevations in the Aberdeen Lake/limestone quarry area range from 80 m near Aberdeen Lake to 155 m at the limestone site. Marine or glaciolacustrine inundation in the area was up to 180 m. Extensive terracing of the deposits, particularly in the area immediately north of Aberdeen Lake are evidence of much higher water levels during the early post-glacial period.

Organic deposits occur in lower landscape positions and along diffuse drainage. A number of rivers and streams characterize the area including a major east-west flowing river which has eroded the flanks of hills creating steep, exposed gravel banks along much of its length.

Vegetation is relatively uniform throughout the section with Lichen Steppe being characteristic (Figure 4.21). Exposed sand and gravel is common on these landforms with Lichen Steppe vegetation often covering 50% or less of crest landform positions. Sedge

Figure 4.19

Dominant Vegetation:
Kiggavik to Aberdeen Lake



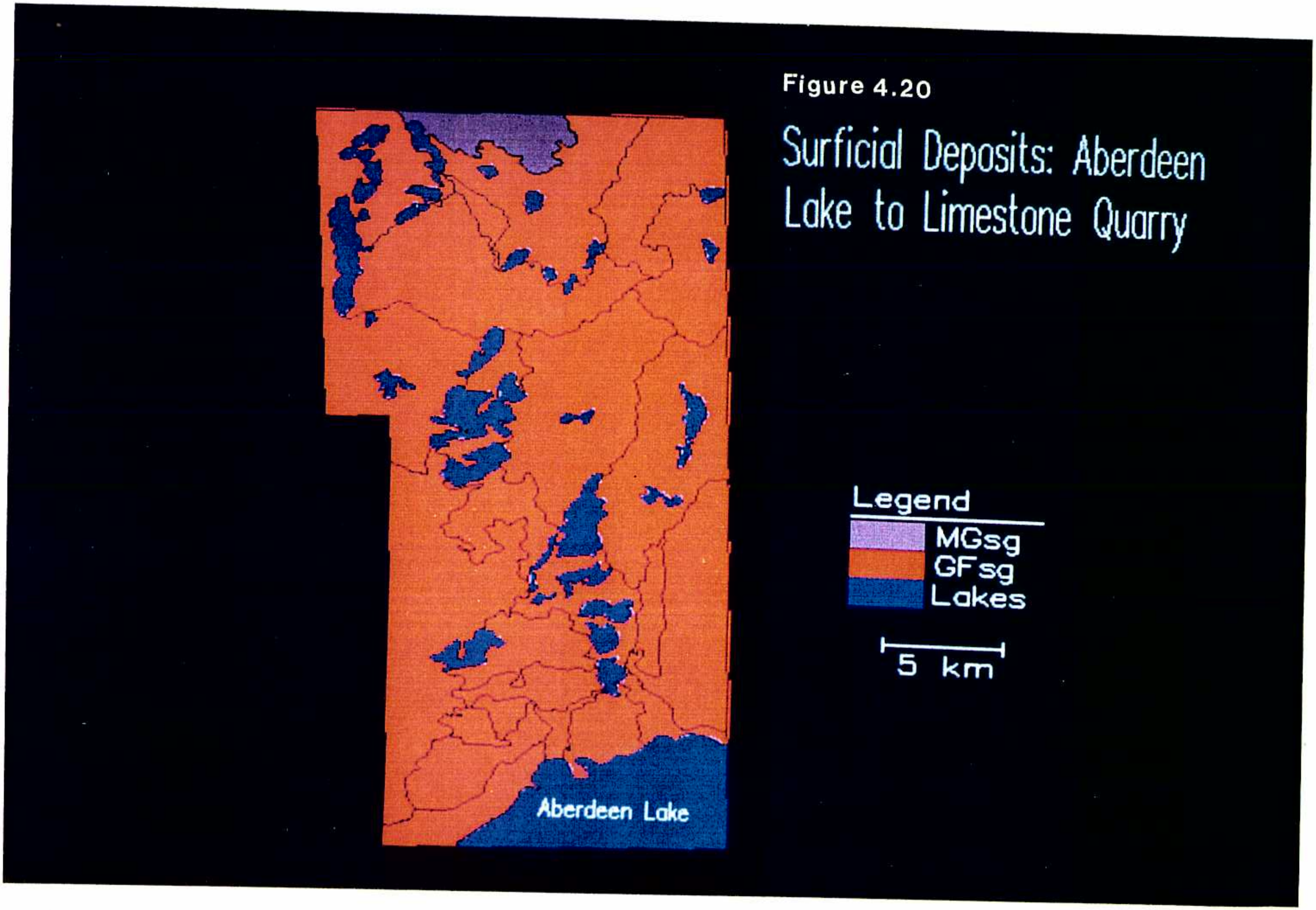
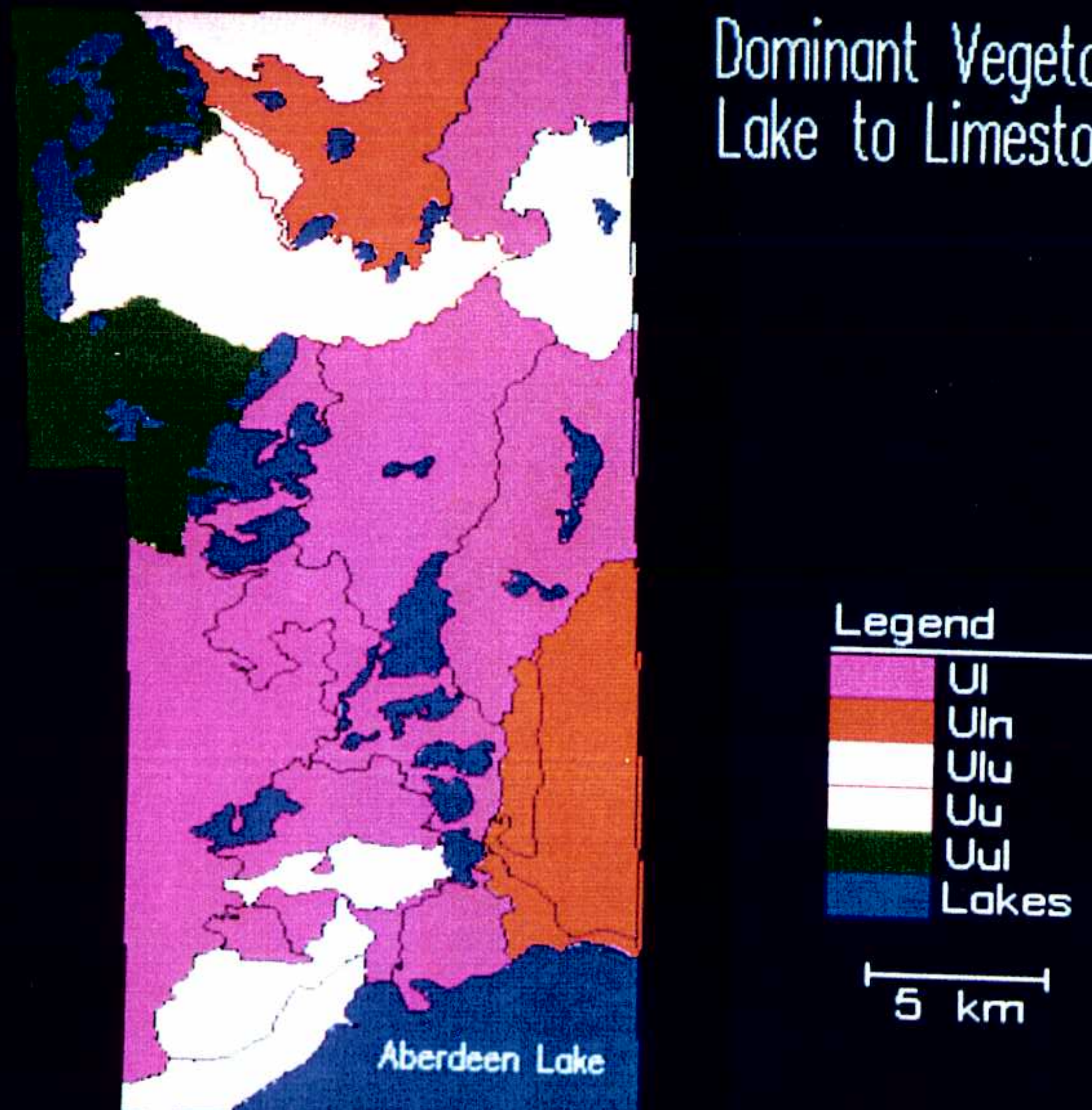


Figure 4.20

Surficial Deposits: Aberdeen Lake to Limestone Quarry

Figure 4.21

Dominant Vegetation: Aberdeen Lake to Limestone Quarry



and Tussock-Sedge Meadows occur in lower slope and poorly-drained sites. Shrub associations are not common and occur infrequently. At the limestone site itself, exposed bedrock accounts for much of the surface condition.

4.2.4.3 Kiggavik Site Development Area

The Kiggavik project development site includes portions of two distinct ecosections (Kiggavik and Skinny Lake Ecosections) described previously in the pre-feasibility study (Beak 1988) (Figure 4.10). The Kiggavik Ecosection, which comprises approximately 80% of the project area, is characterized by a moderately well to imperfectly drained, coarse loamy-textured till with significant silt content (up to 36%) (BEAK, 1988). The material was deposited by a northwest-trending ice front and has been locally moulded into drumlins 30 m to 50 m in height, and often several kilometers in length. The Skinny Lake Ecosection is characterized by a well-drained, sandy glaciofluvial outwash material which flanks the shoreline of Skinny Lake. Dominating the project area is an east-west trending fault scarp which effectively bisects the area.

The project area comprises four distinct physiographic units:

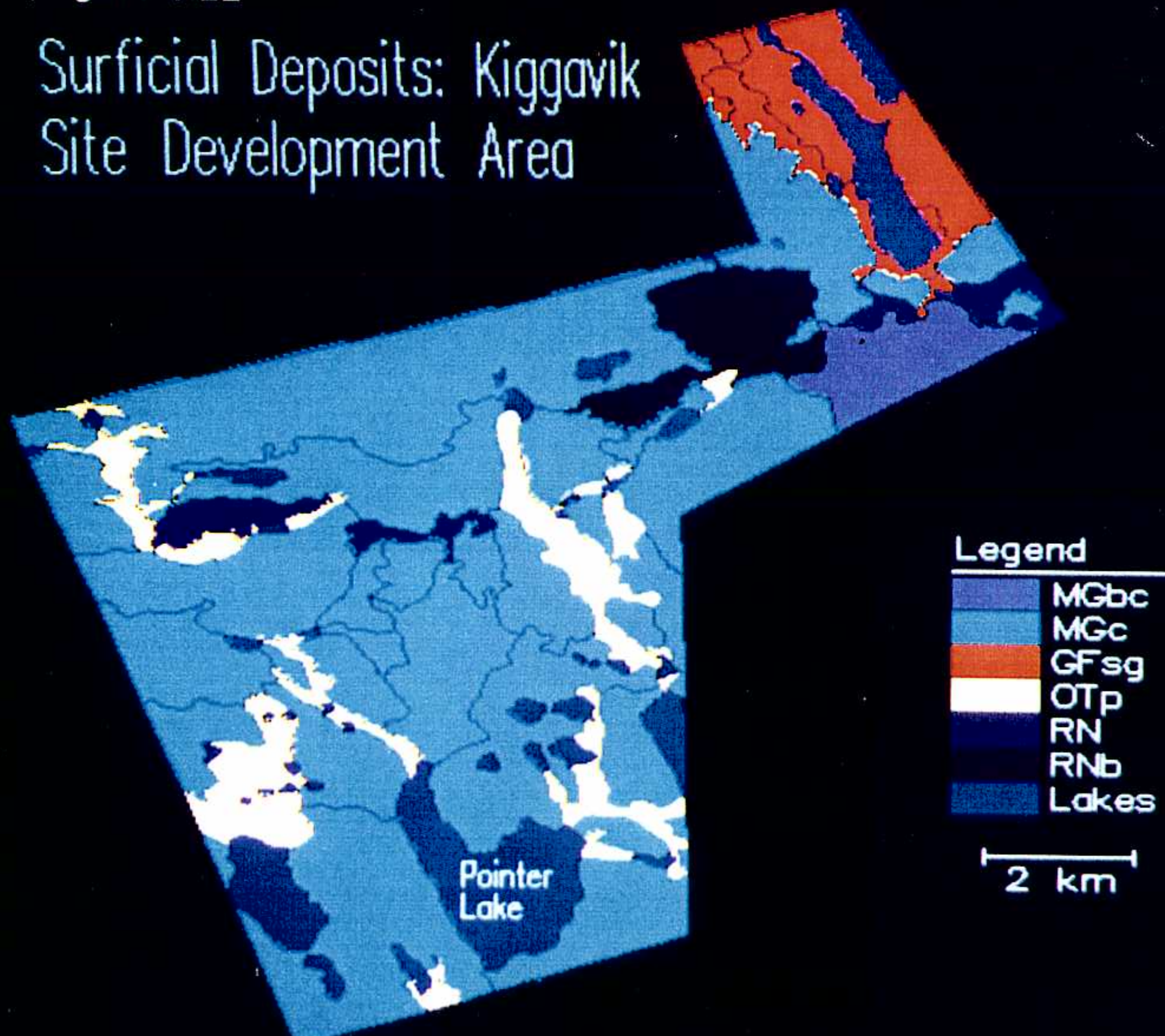
- o area below the escarpment including Pointer Lake (Escarpment South);
- o escarpment zone;
- o area above escarpment (Escarpment North); and
- o Skinny Lake.

Escarpment South

The area below the escarpment is strongly influenced by the escarpment itself. The characteristic coarse loamy-textured till has been modified by drainage (seepage) from the escarpment over much of the area between Pointer Lake and the base of the escarpment (Figure 4.22). Along the base of the escarpment, late-lying snowbeds, together with seepage water from the scarp itself, combine to supply moisture throughout much of the summer season, and feed the diffuse drainage channels characteristic of this area. Sedge and Tussock-Sedge Meadows typically occur in these drainage zones (Figure 4.22). Shrub associations occur on boulder pavements which develop as a result of washing of the finer matrix material from the till by more vigorous

Figure 4.22

Surficial Deposits: Kiggavik Site Development Area



fluvial activity during the spring melt. Immediately west of Pointer lake, and in the area of the current exploration camp, the relief is greater and the till is not affected by escarpment drainage. On these sites, which are moderately well-drained, Moss-Heath and Lichen-Heath vegetation is typical, with Shrub associations occurring in protected slope sites, and on parallel stripes associated with drumlins (Figure 4.23). Small scattered sandy, well-drained glaciofluvial or glaciolacustrine deposits with Lichen Steppe vegetation, occur in the area between Pointer Lake and the most easterly proposed pit site.

Escarpment Zone

The escarpment zone itself is characterized by exposed bedrock pavements with extensive areas of frost shattered, angular rock debris (felsenmeer) (Figure 4.22). Cryptogramic communities are associated with these Rock Barrens, while Lichen-Heath occurs where soil matrix material remains (Figure 4.23).

Numerous draws along the escarpment provide opportunity for moisture to seep down the escarpment and escape to the Pointer Lake-Judge Sissons Lake drainage system. Organic materials typically accumulate in these draws and are characterized by sedge and Tussock-Sedge Meadows (Figure 4.23). A large lobe of soliflucting organic material was observed on a slope near Cirque Lake indicating potential instability of organic deposits occupying slopes along the escarpment.

Escarpment North

The zone above the escarpment is characterized by the gently undulating coarse loamy textured till covered by Lichen-Heath vegetation (Figure 4.23). On poorly-drained depressional sites, Sedge and Tussock-Sedge vegetation occurs. Occasional small outcropings of bedrock occur but are not spatially dominant.

Skinny Lake

The Skinny Lake physiographic unit is characterized by extensive deposits of well drained, sandy glaciofluvial deposits (Figure 4.22). These deposits occur as valley train material in a narrow re-entrant along the escarpment. The deposits flank the valley

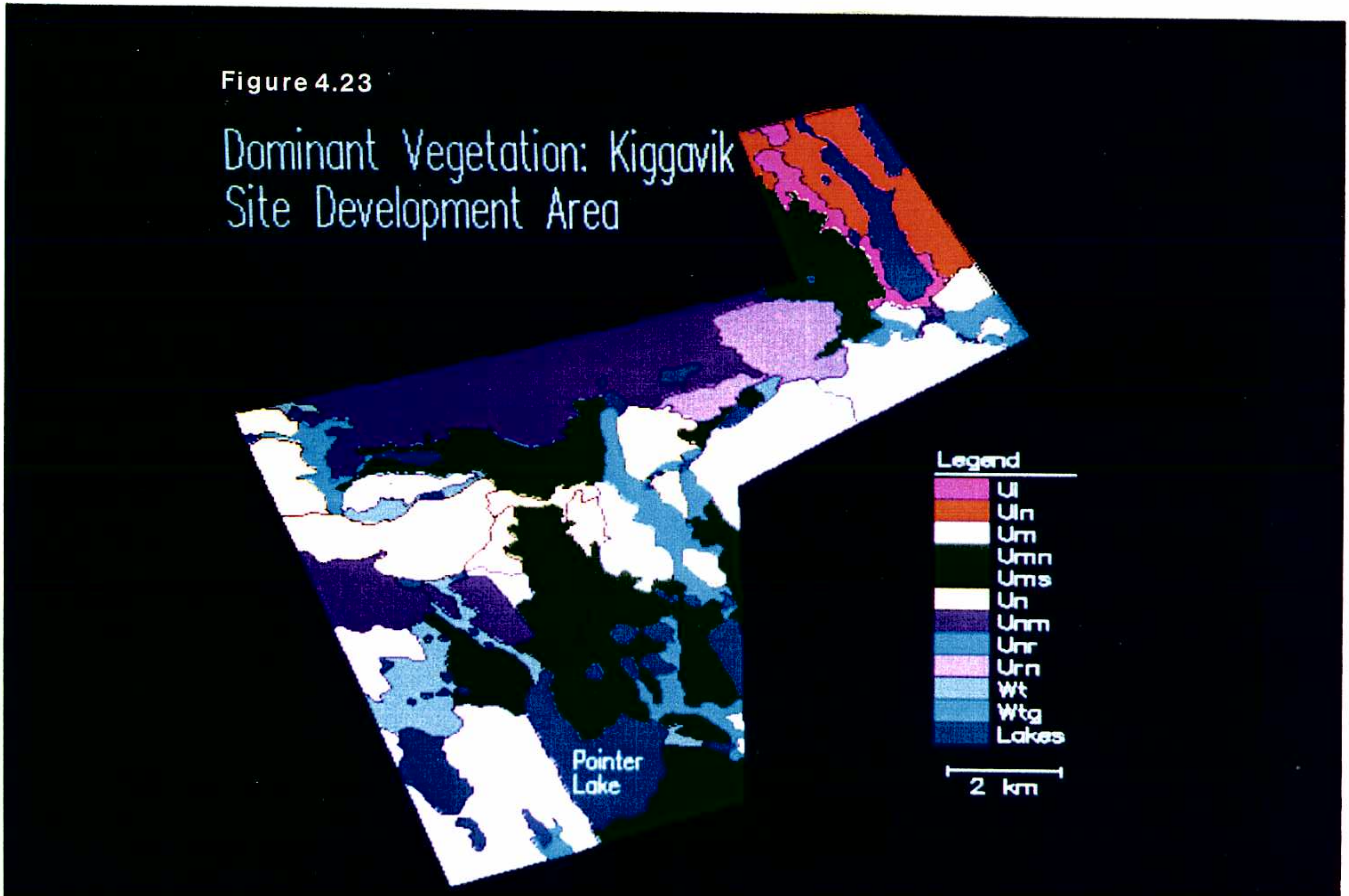


Figure 4.23

Dominant Vegetation: Kiggavik Site Development Area slopes and have been extensively dissected by fluvial action from the valley slopes. High-centred, ice wedge polygons characterize the surface of these deposits. Lichen Steppe vegetation occurs on the flat exposed surfaces, while Shrub associations occur in sheltered channels and stream banks (Figure 4.23).

4.2.4.4 Baker Lake Dock Facility

The dock facility is located approximately 10 km east from the Hamlet of Baker Lake along the north shore of Baker lake. The area is characterized by a relatively narrow and abruptly rising shoreline which has been extensively terraced by gradually declining lake levels since deglaciation (Figure 4.23). The immediate shore zone is a sparsely vegetated, gently sloping, sandy beach. Scattered patches of Lyme Grass (Elymus mollis) and Prickly Saxifrag (Saxifraga tricuspidata) are typical of this zone (Figures 4.24 and 4.25). The upper beach zone is characterized by a Lichen-Heath which has helped stabilize the sand and gravel, and by clumps of willows (Salix spp.) up to a metre in height (Figure 4.26). A series of gravel beach ridges characterizes the slope which rises from the upper beach zone to a bedrock pavement at the crest of the hill overlooking the beach zone (Figure 4.27). The gravel beaches are typically sparsely vegetated, with a Lichen-Heath vegetation on the inter-ridge benches (Figures 4.28 and 4.29).

The northeast area of the site is dominated by a wet Tussock-Sedge Meadow (Figure 4.30). This wetland supplies moisture for a stream which emanates from the wetland and has cut a major channel through the gravels to Baker Lake (Figures 4.31 and 4.32). Channel banks are exposed although apparently stable. Willow and birch (Betula glandulosa) shrubs, and patches of Lichen-Heath vegetation occupy moderate slopes, and portions of the stream channel itself.

The area between the proposed dock facility and Baker Lake is characterized by gradually sloping gravelly/sandy beach deposits which grade more steeply up a bedrock slope covered by a veneer of terraced marine sand and gravel (Figure 4.33). Lichen-Heath vegetation characterize the upper slope and crest landscape positions, while the shore zone is similar to that found at the dock site. Numerous creeks and seepage zones occur along the base of the bedrock slope and run across the beach slope towards Baker Lake (Figure 4.34). These seepage zones and small creeks are nourished by late-laying snow beds near the base of the bedrock slope, and runoff from upper slopes.

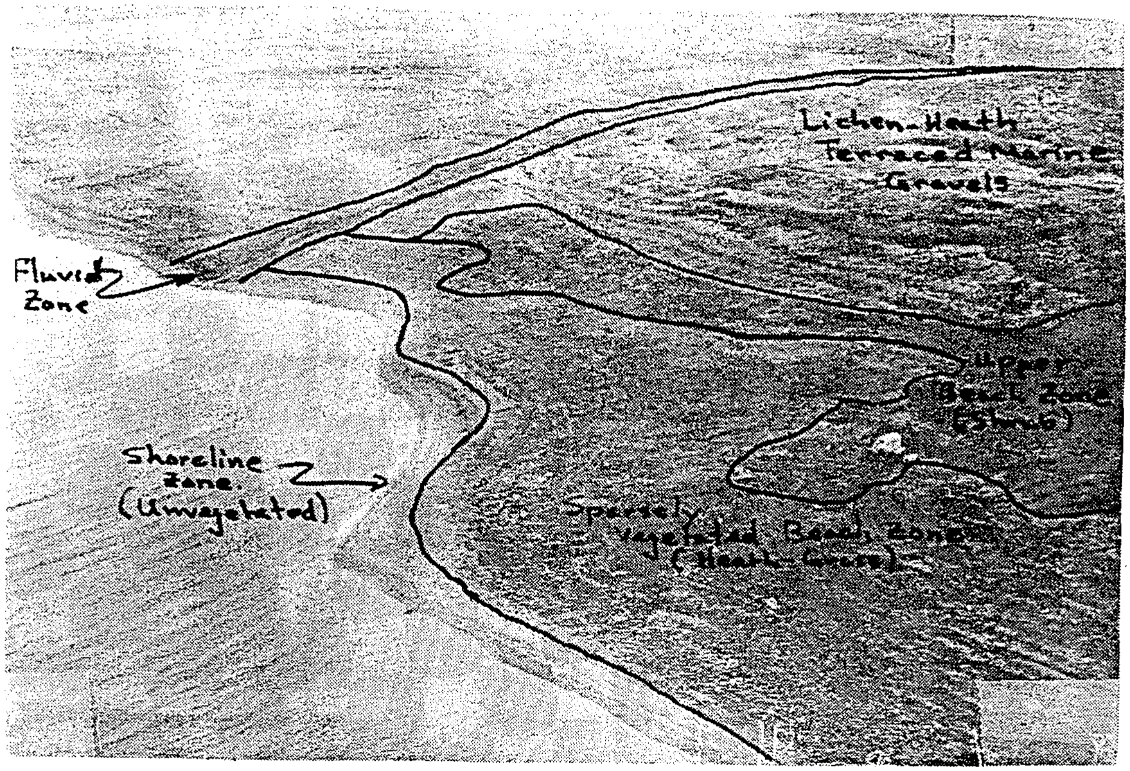


Figure 4.24: Aerial view of proposed dock site on Baker Lake. Area is characterized by a relatively narrow beach zone, and steeply rising bedrock knob with veneer beach gravel on slopes.

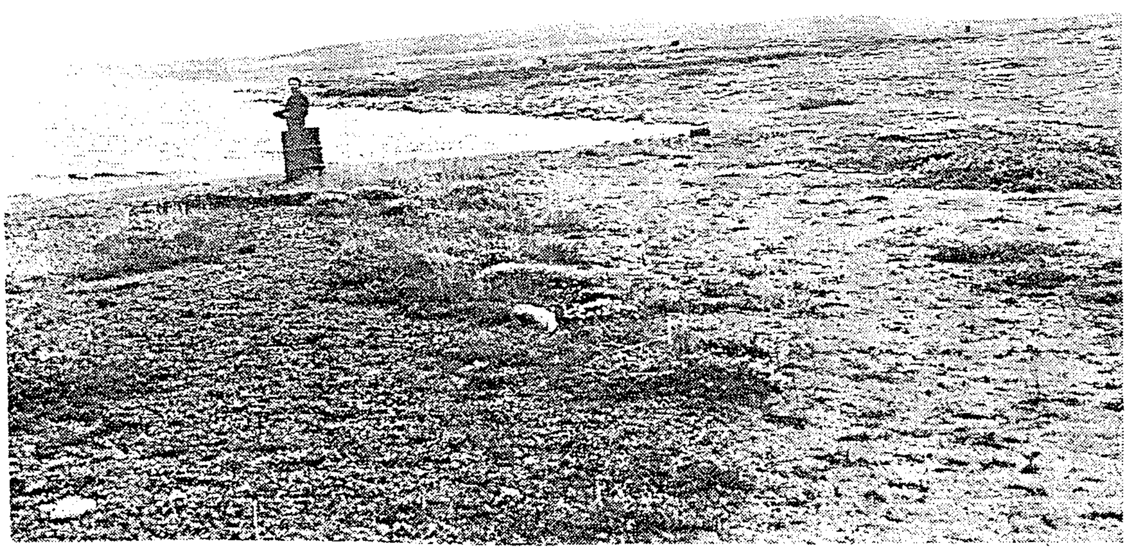


Figure 4.25: Sparsely vegetated shoreline zone with patches of lyme grass and prickly saxifrag.

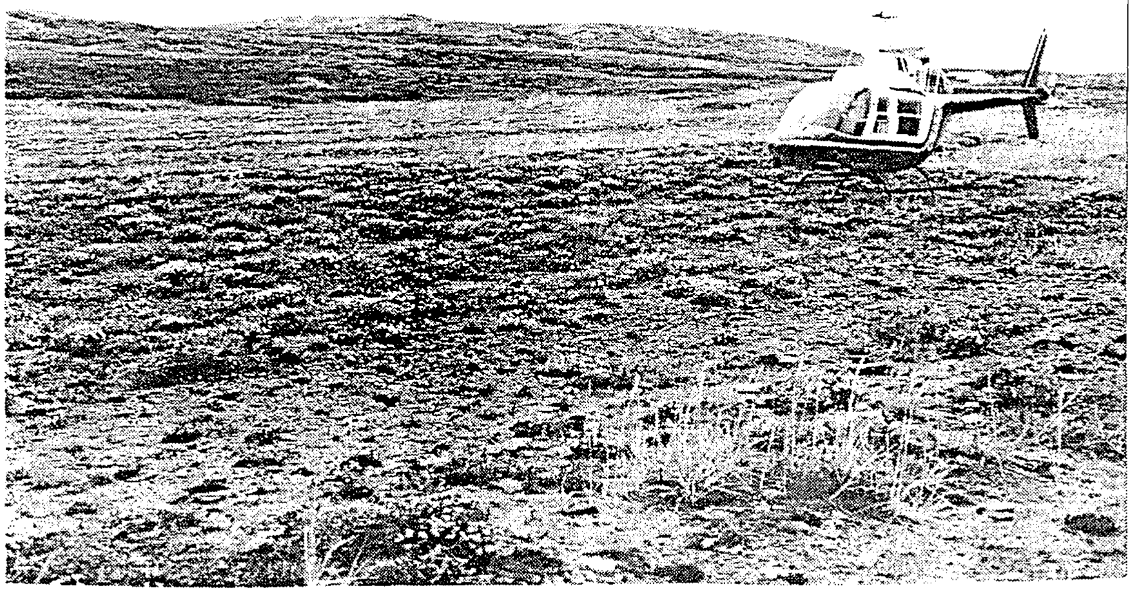


Figure 4.26: Lower beach with increasing cover of lyme grass and prickly saxifrag. Higher cover provides greater surface stability of the sandy substrate.

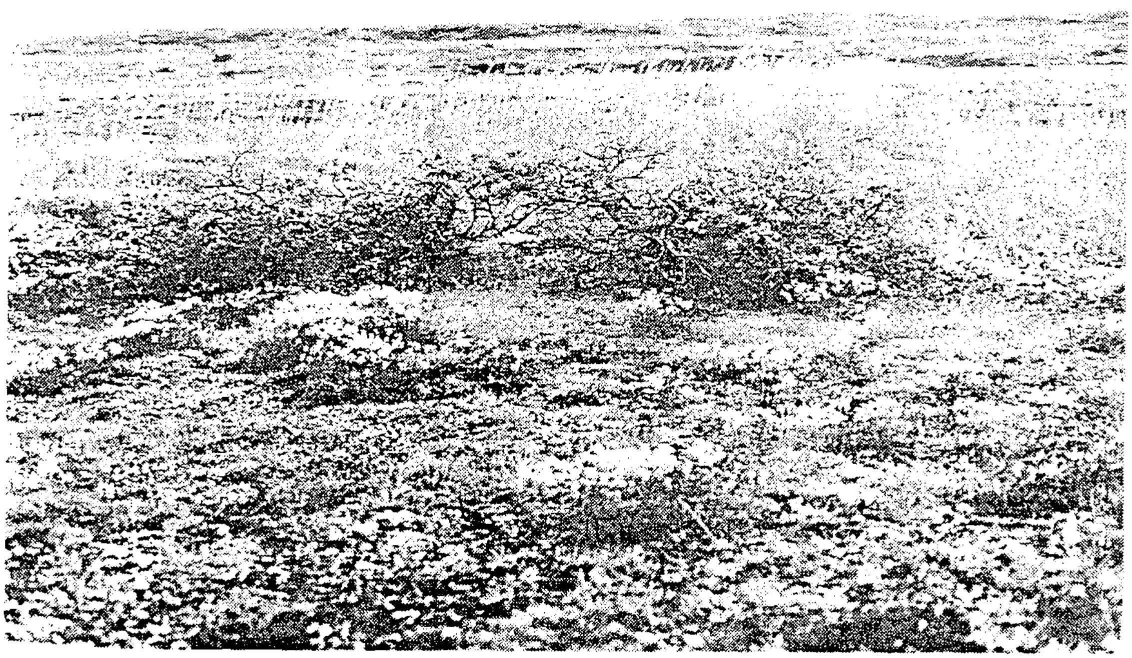


Figure 4.27: Upper beach with increased vegetative and woody shrub (Salix spp.) cover.

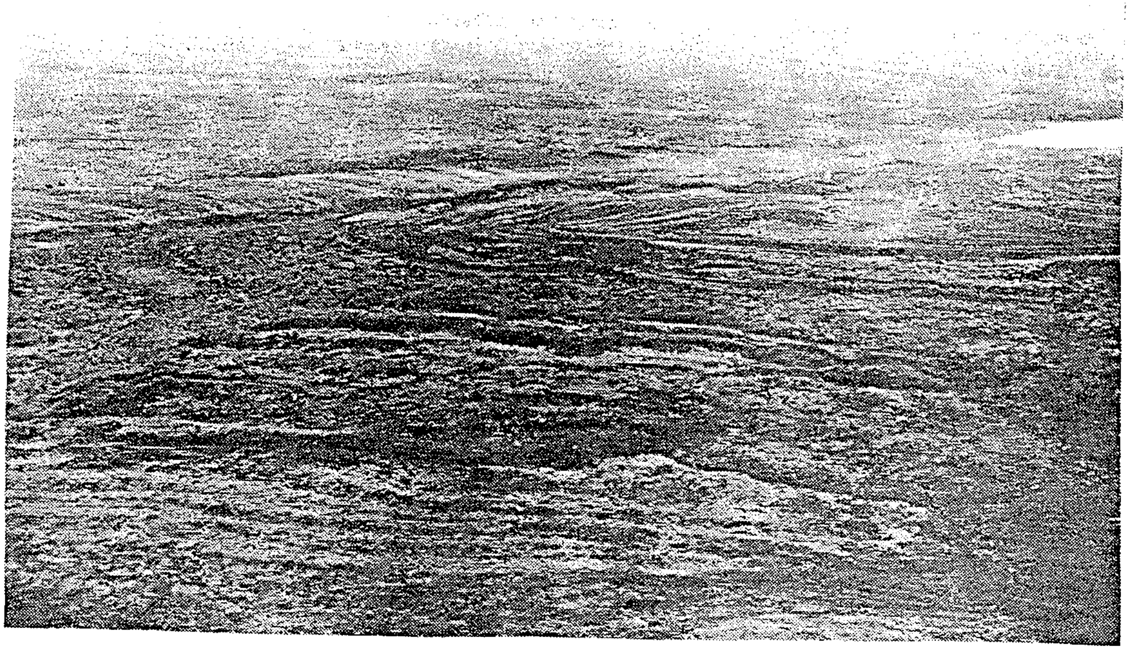


Figure 4.28: Zone of beach terrace development in marine gravels. Materials flank underlaying bedrock ridge, and formed during declining water levels in post-glacial period.

Figure 4.29: Upper terraces with bedrock ridge in background. Beach ridges are typically sparsely vegetated.

Figure 4.30: Lower beach ridges and inter-beach benches are stabilized by a Lichen-Heath vegetation.

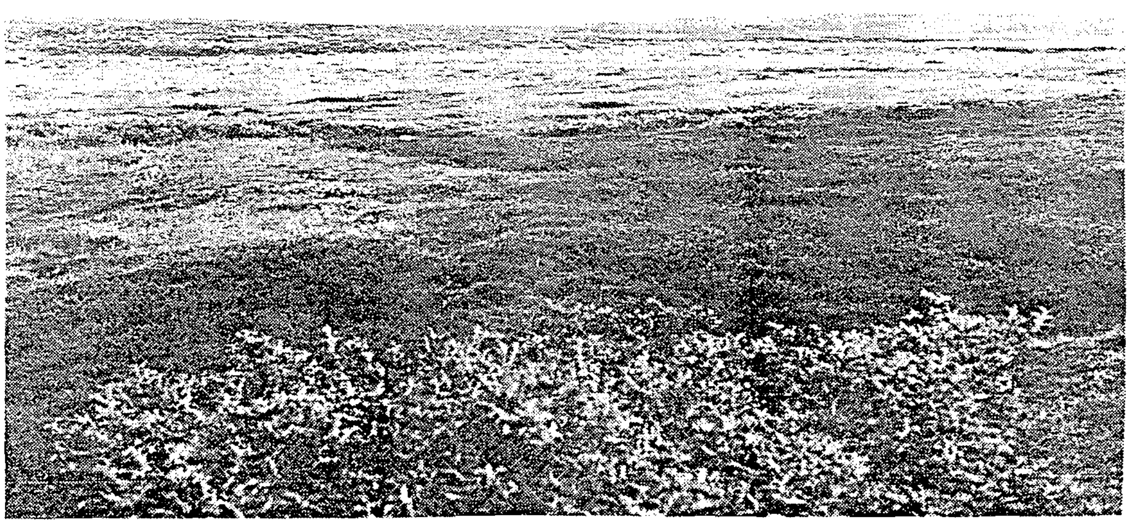


Figure 4.31: A large Tussock-Sedge Meadow occurs in a draw in the upper parts of the dock site. The meadow serves to nourish a major stream which flows from the wetland to Baker Lake.

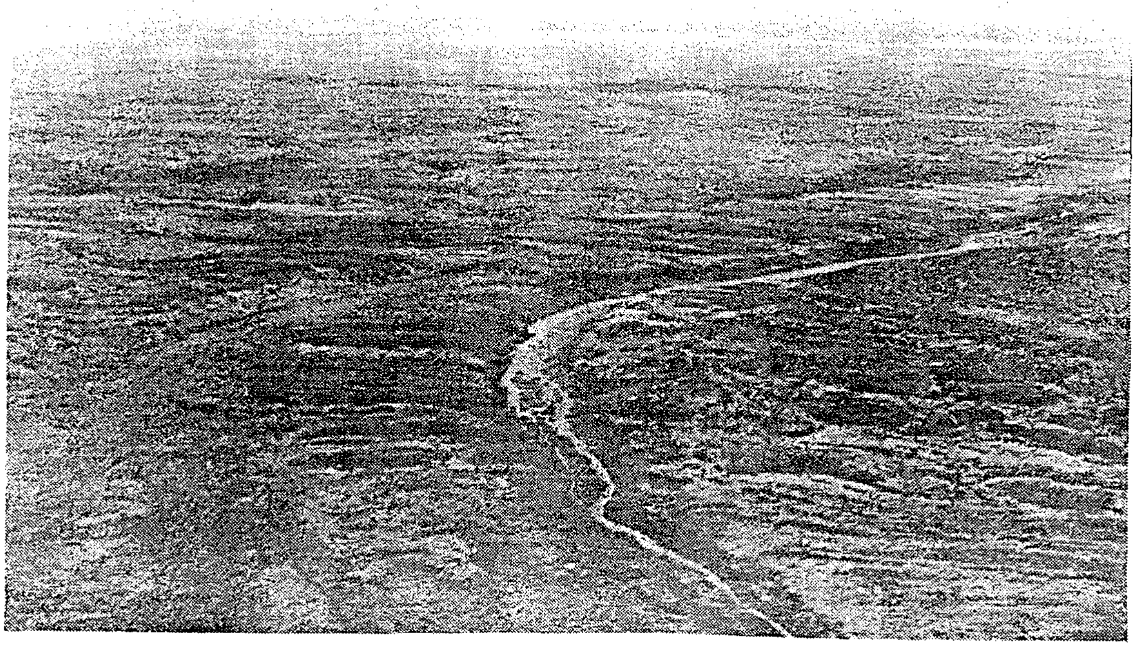


Figure 4.32: Major stream flowing from wetland to upper section of dock site area.

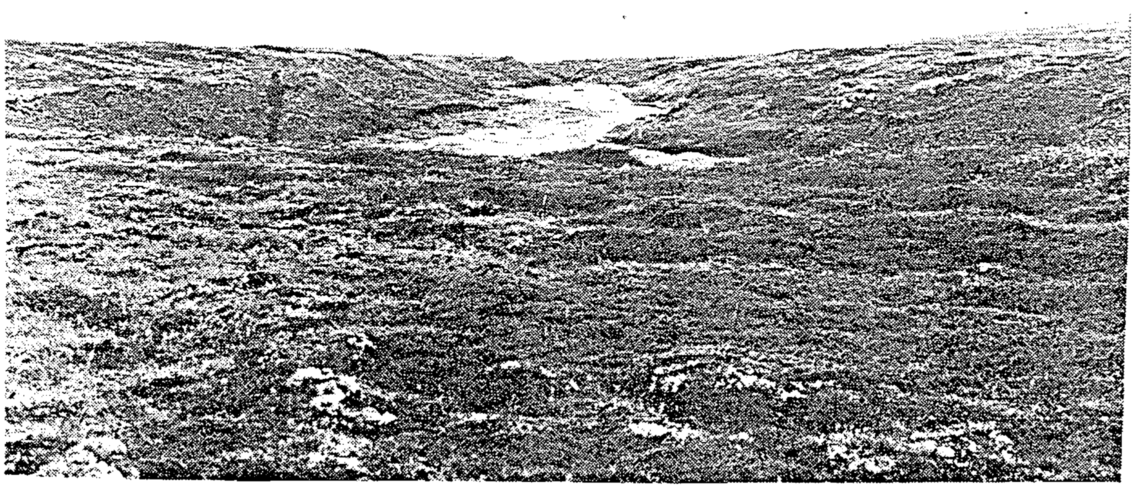


Figure 4.33: Middle reach of incised creek at dock site. Note relative stability of banks and extensive shrub and Lichen-Heath cover.

Figure 4.34: Beach zone looking east to Baker Lake from dock facility. Terrain is gently sloping from toe of bedrock ridge to lake. Note snowbeds along base of ridge.

4.3 Radionuclides in Vegetation and Soils

There is a general concern about the consequences of radionuclide releases from uranium mining operations. Awareness of the consequences which these releases might have on the environment, including its habitats, makes it necessary to have a thorough study of natural radiation levels in the area concerned prior to the beginning of mining operations (Svoboda et al., 1985). The purpose of this section of the report is to provide a general summary of natural radionuclide levels in vegetation and soils in the Kiggavik study area. The following information is taken largely from the reports by Kershaw et al. (1983) and Svoboda et al. (1985).

Svoboda et al. (1985) collected vegetation and substrate samples along two perpendicular transects (N-S and E-W) intersecting at the Main Showing at the Kiggavik site (Figure 4.35). To determine natural levels of U radionuclides, they also collected plant and substrate samples from a number of nearby localities with no reported U occurrences (Figure 4.36).

Kiggavik Site Data

The surficial environmental profiles of the two transects are shown in Figure 4.37.

The composite vegetation and composite substrate samples collected along the transects revealed distinct anomalies of the natural radionuclides at the Main Showing (0 m) and Centre Zone (750 m E) (Figures 4.38 to 4.43). U-238, Ra-226 and Bi-214 activities were three to four orders of magnitude greater at the Main Showing compared to the transect average. In the Centre Zone, which was lightly buried under glacial drift, the activities were about 100 times that of the average. Activities fell, however, to very low levels about 200 m from the Main Showing. The levels of activity were higher in the southern portion of the N-S transect because the drainage is south from the Main Showing, towards the wet, hummocky terrain (Figure 4.37). Patterns of activity of Cs-137 did not resemble the U radionuclides pattern, and showed considerable fluctuation.

Plants growing in the vicinity of the Main Showing contained high levels of U-238 and Ra-226 (Table 4.10). Radium-226 activities in plants generally decreased with increasing distance from the Main Showing. The highest Ra-226 levels were found in grasses, sedges and willows.

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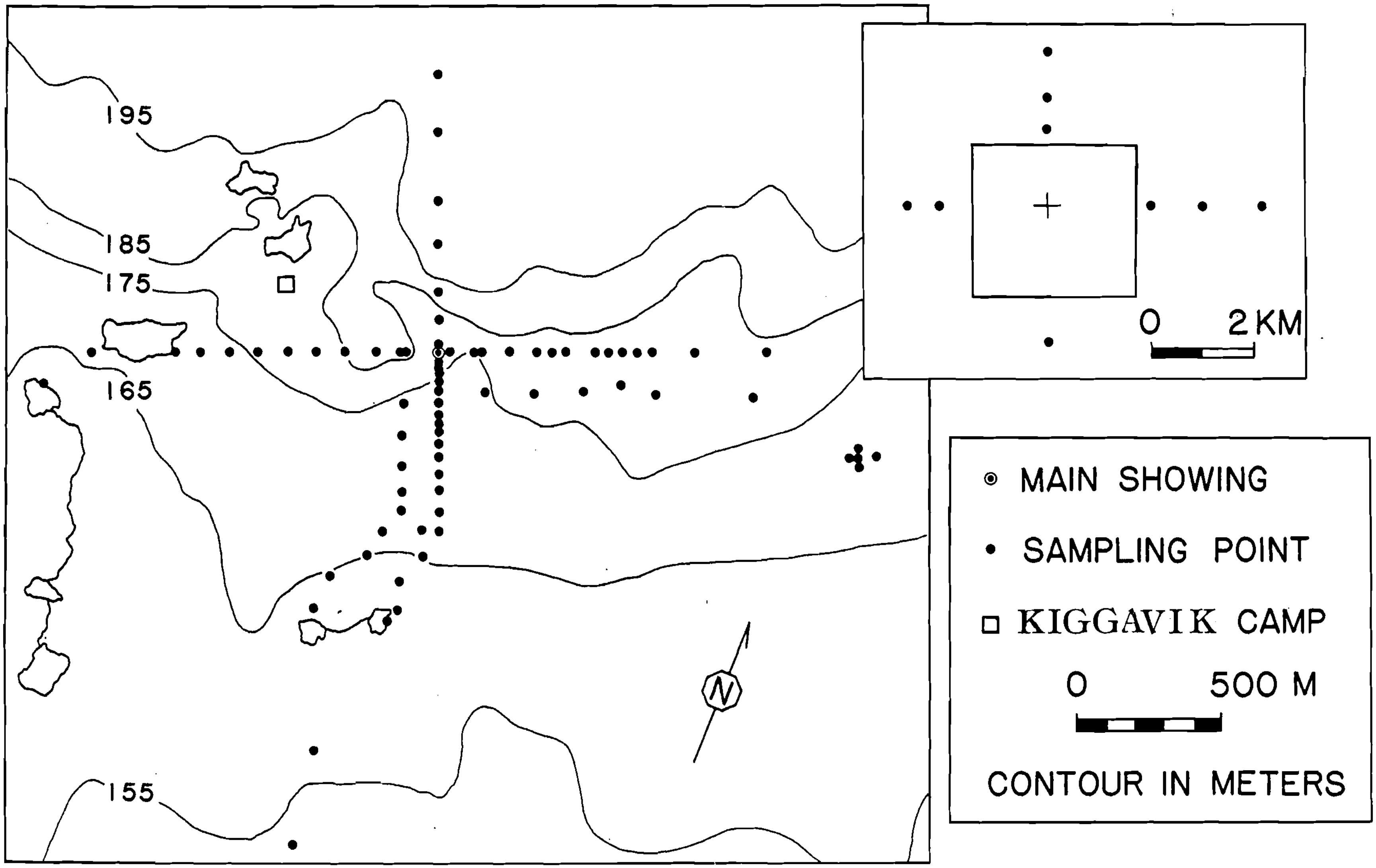


Fig. 4.35 Detailed sampling map of Kiggavik camp. The N-S and E-W transects intercept at the Main Showing. Sampling emphasis was placed on the area down-drainage from the mineralization. Inset indicates extended sampling points along the two main transects.

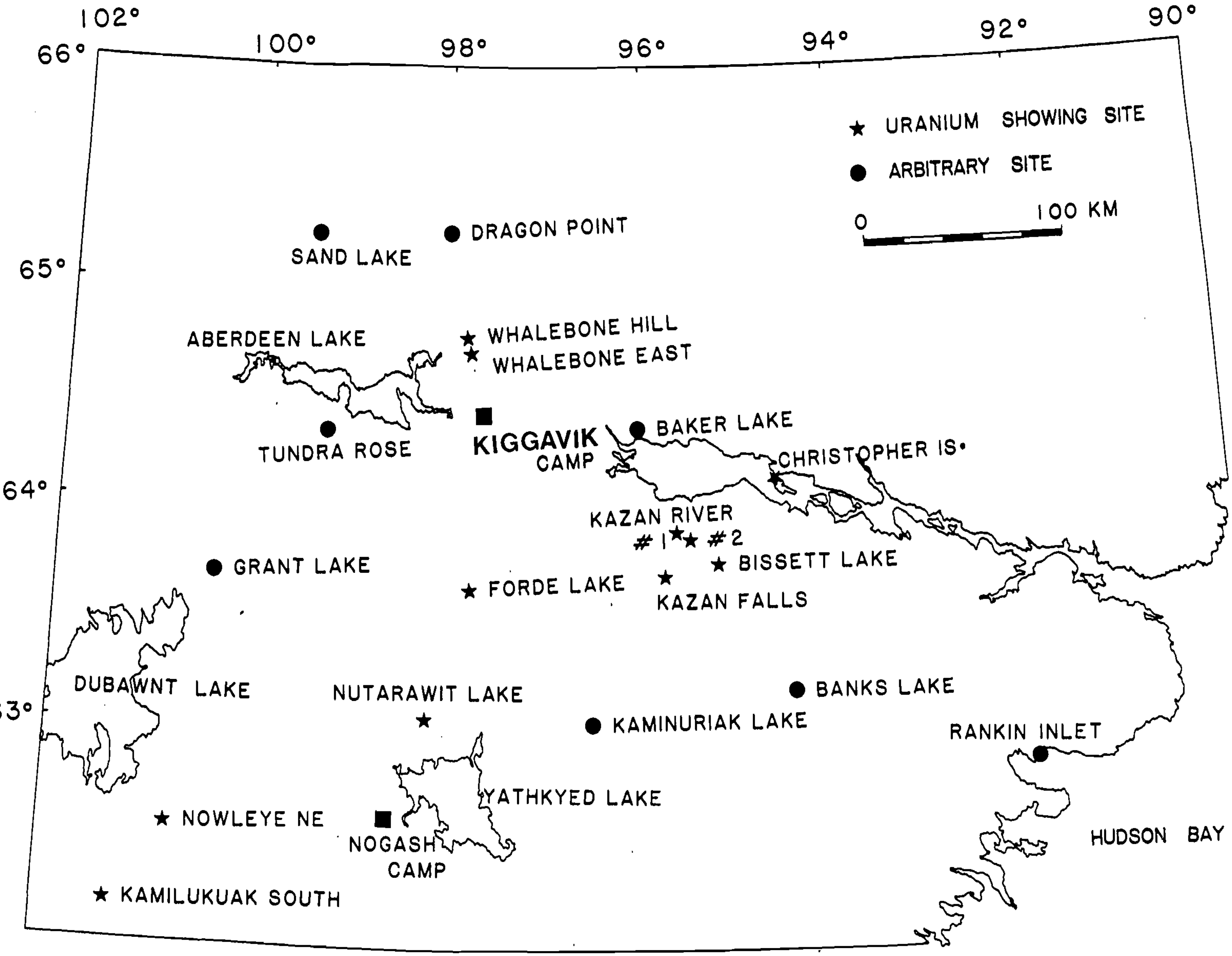


Fig. 4.36 Study area showing the intensive and extensive sampling sites and the Kiggavik and Nogash Camp sites.

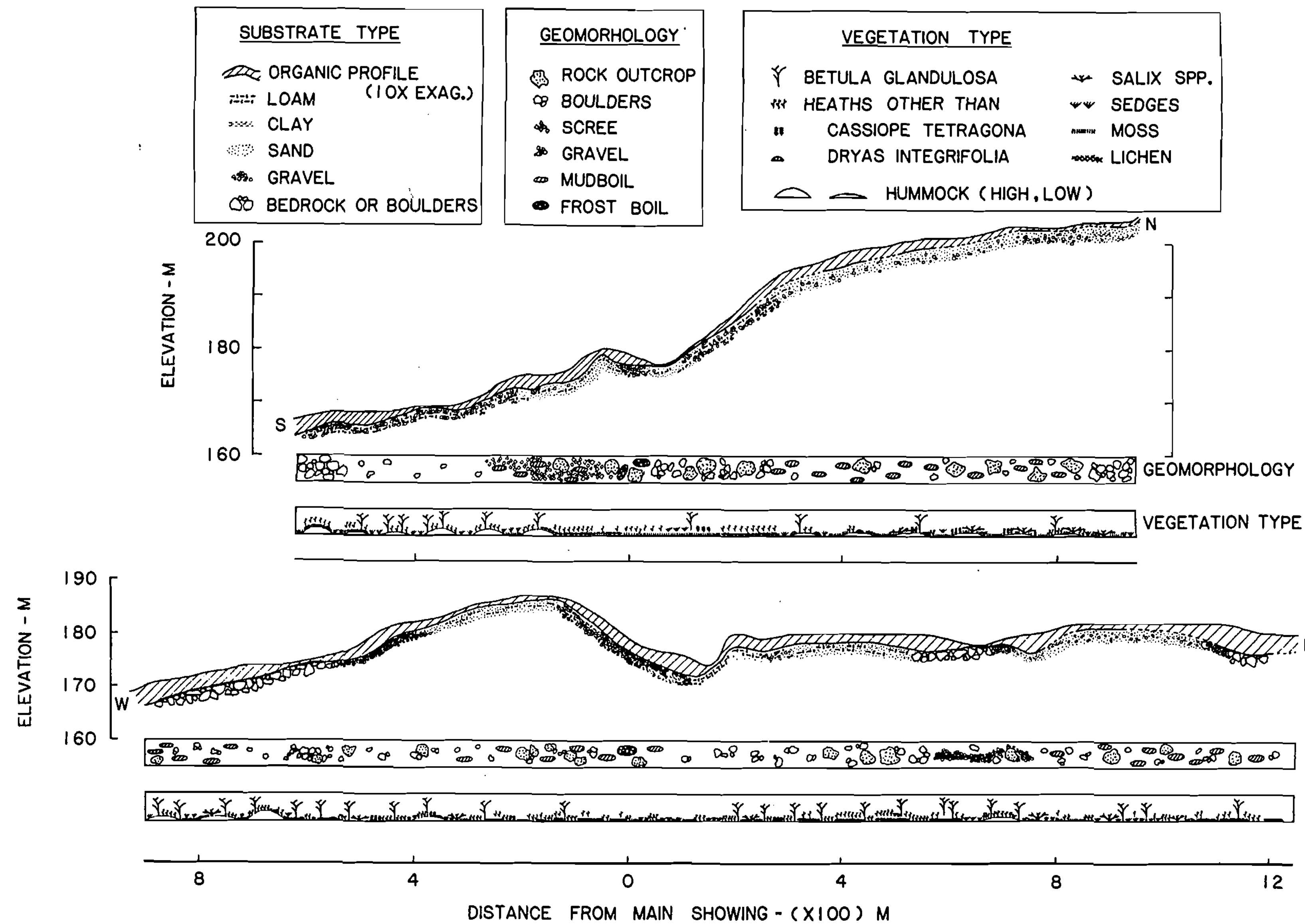


Fig.4.37 The surficial environmental profiles of the two transects of Kiggavik Camp. Thickness of substrate underlying the organic layer is not indicated.

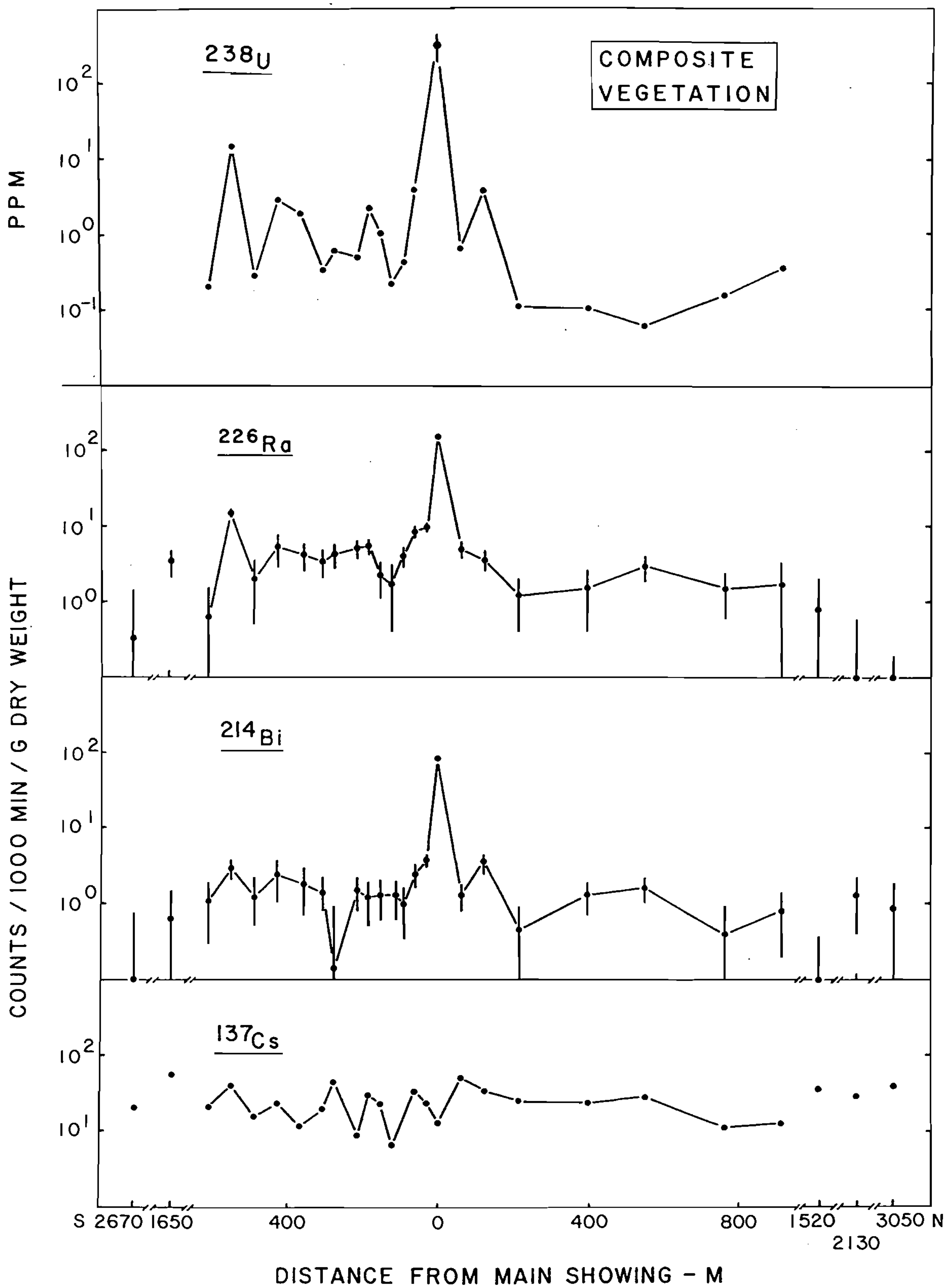


Fig.4.38 The radionuclide activity profiles of the composite vegetation along the N-S transect of the Kiggavik site.

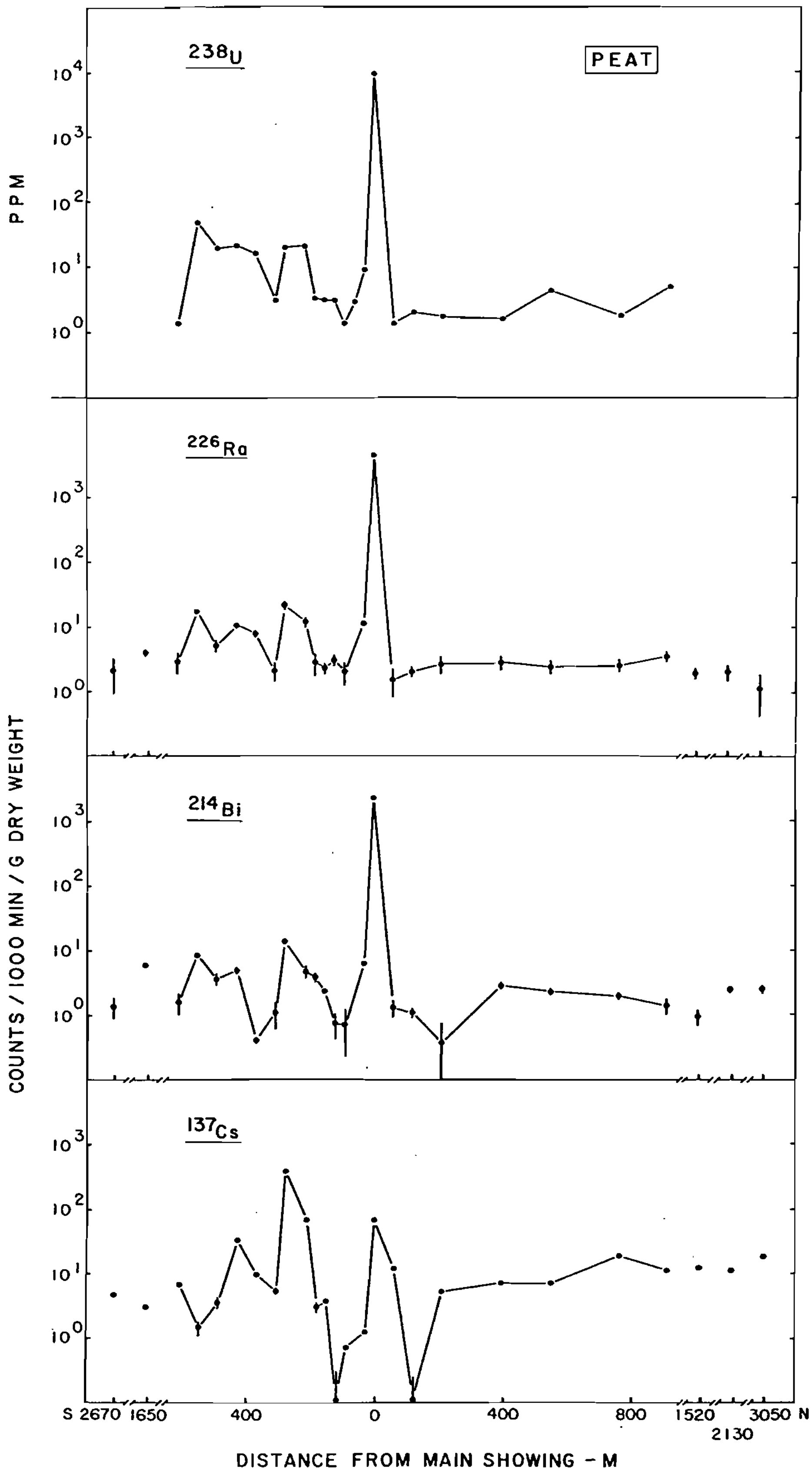


Fig. 4.39 The radionuclide activity profiles of the peat along the N-S transect of the Kiggavik site.

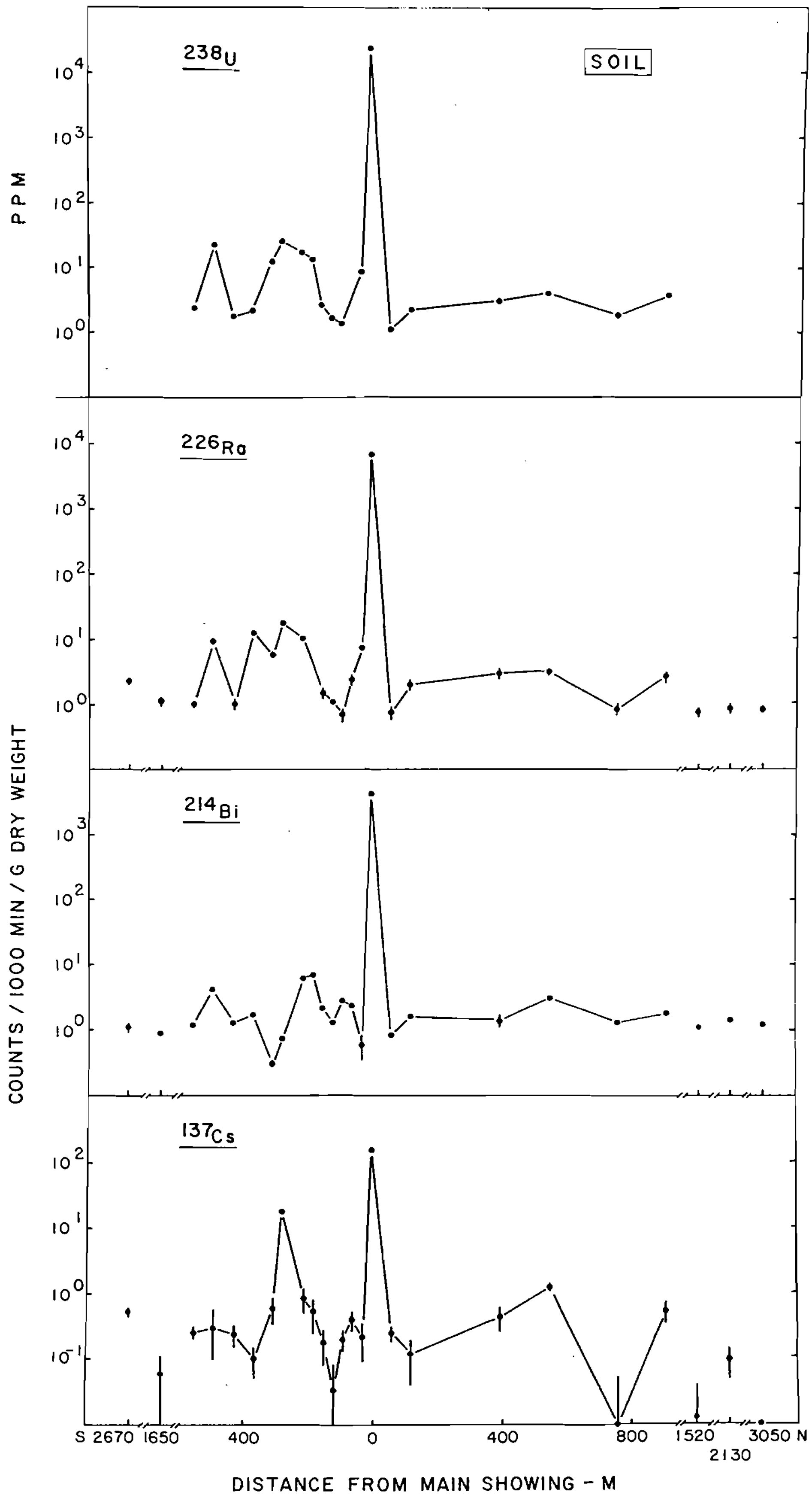


Fig. 4.40 The radionuclide activity profiles of the soil along the N-S transect of the Kiggavik site.

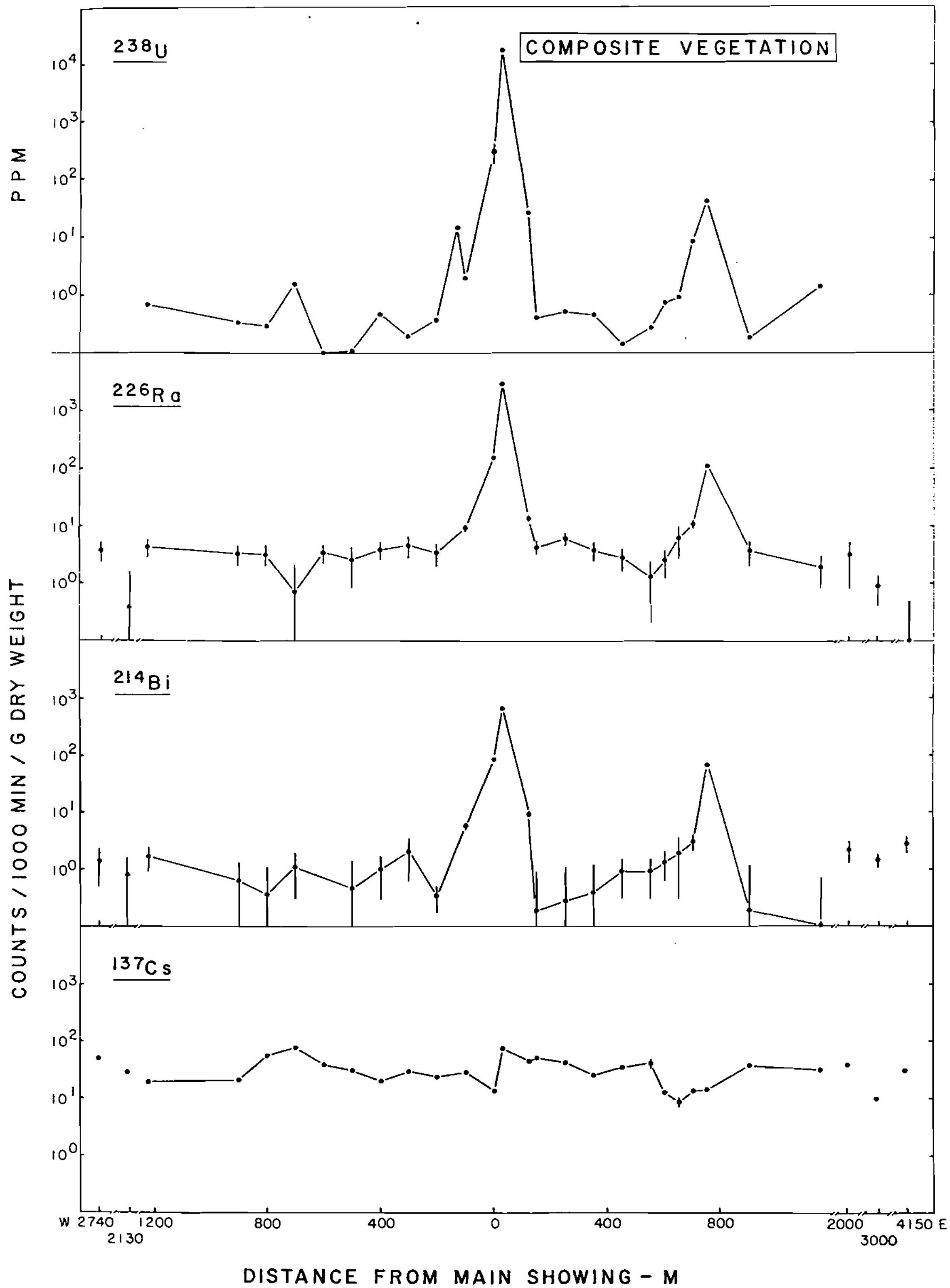


Fig. 4.41 The radionuclide activity profiles of the composite vegetation along the E-W transect of the Kiggavik site.

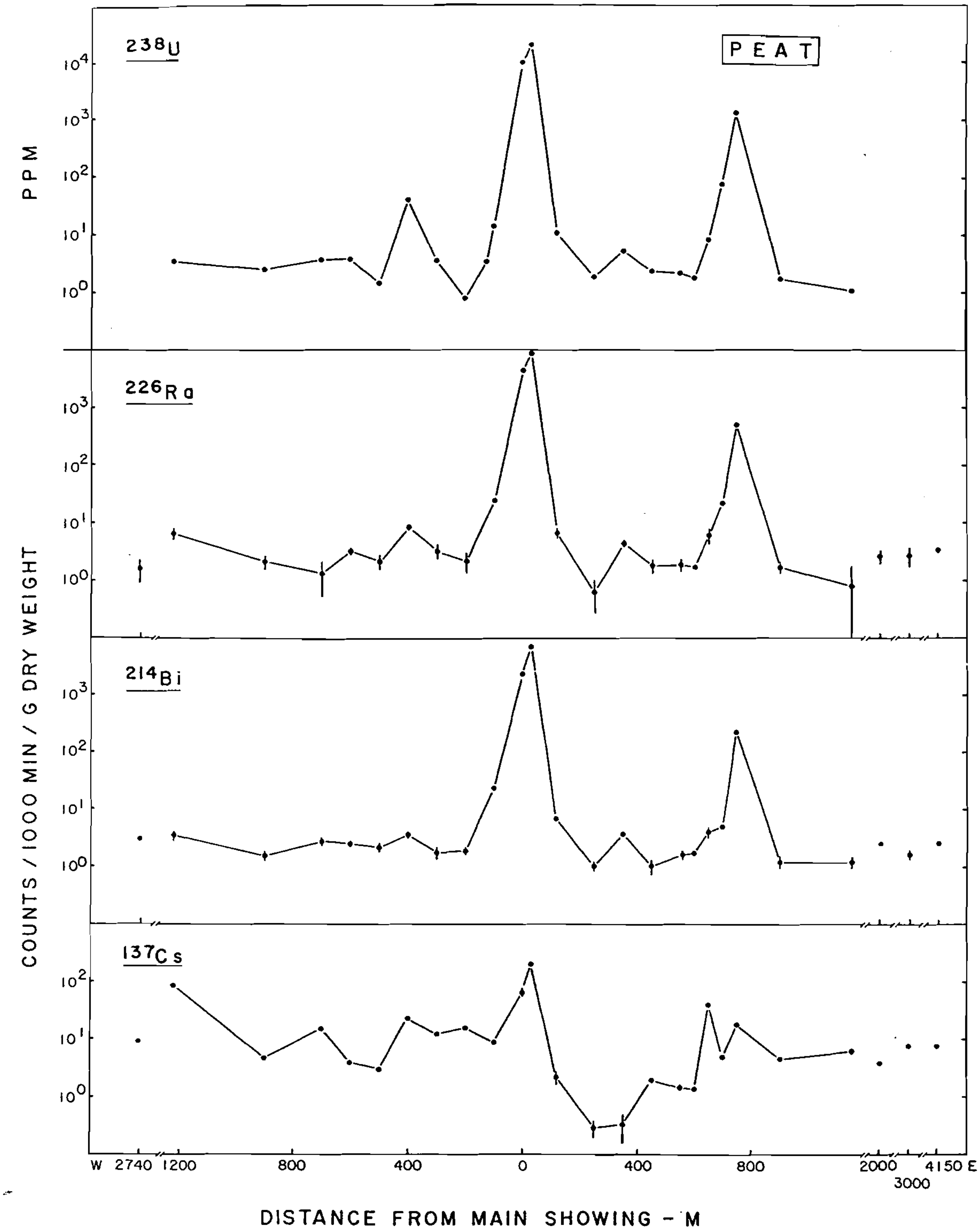


Fig. 4.42 The radionuclide activity profiles of peat along the E-W transect of the Kiggavik site.

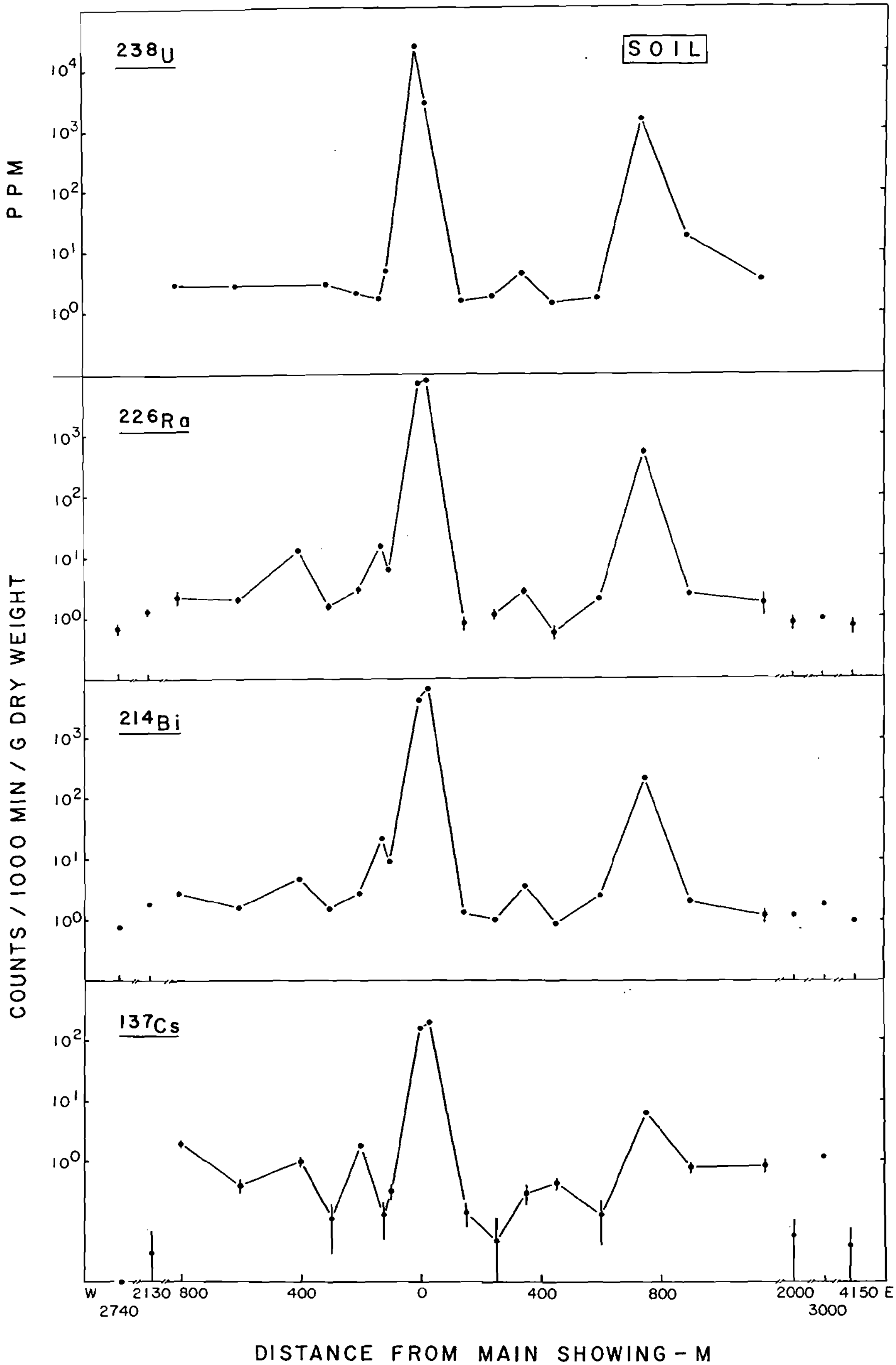


Fig. 4.43 The radionuclide activity profiles of the soil along the E-W transect of the Kiggavik site.

TABLE 4.10: RADIONUCLIDE ACTIVITIES IN PLANTS COLLECTED FROM THE THREE SAMPLING POINTS AT THE KIGGAVIK MAIN SHOWING AREA (mean ± S.D.)

	Main Showing			30 m East			125 m West		
	U-238 (ppm)	Ra-226 (pCi/g)	Cs-137 (pCi/g)	U-238 (ppm)	Ra-226 (pCi/g)	Cs-137 (pCi/g)	U-238 (ppm)	Ra-226 (pCi/g)	Cs-137 (pCi/g)
Lichens	-	60.0±7.2	17.2±1.8		- NP -			- NP -	
Mosses	408	308.3±35.3	8.7±0.9	16,000	88.9±10.4	11.3±1.3	31.1	34.3±5.0	4.5±0.5
Grasses	550	180.6±20.8	1.2±0.3	-	3,584±408	3.6±0.8	-	140±16	0.3±0.1
Sedges	1,190	351.5±40.6	4.2±0.9	298	933±107	1.8±0.5	-	2.3±2.3	2.0±0.4
Salix spp.	71.6	150.3±17.2	1.2±0.3	-	539±61	1.1±0.2	-	120±14	0.4±0.2
Betula glandulosa	-	118.3±13.5	1.3±0.3	-	82.6±9.5	2.9±0.3	26.0	78.5±9.0	0.2±0.1
Oxytropis maydelliana	87.6	107.4±12.6	2.9±0.4		- NP -		-	22.1±3.2	1.0±0.2
Arctostaphylos alpina	-	132.7±15.3	2.8±0.4	-	76.7±9.0	1.8±0.3	33.7	135±15	0.3±0.1
Vaccinium uliginosum	84.0	41.1±5.0	1.9±0.3	-	542±62	3.6±0.0	-	37.9±4.5	0.5±0.1
V. Vitis-idaea	97.0	168.6±19.4	2.0±0.4		- NP -			- NP -	
Cassiope tetragona		- NP -			- NP -		-	6.4±1.5	2.5±0.3
Ledum decumbens	235	198.6±22.6	2.2±0.3		- NP -		-	40.2±5.0	1.1±0.2
Empetrum nigrum	-	66.8±7.7	3.0±0.4	-	40.6±5.0	3.1±0.4	21.6	51.5±6.3	0.9±0.2
Dryas integrifolia		- NP -			- NP -		-	107.7±12.7	1.6±0.2

" - " not determined.

NP - not present.

The U-238/Ra-226 ratios for composite vegetation and substrates along the two transects are shown in Figure 4.44. The maximum occurs at the Main Showing, with a secondary maximum occurring at the Centre Zone (700 m and 900 m east of the Main Showing). The composite vegetation along the transects, except in the vicinity of the maxima, generally had values close to zero, suggesting that U-238 was almost avoided by plants, despite its greater concentration in the substrate. It appears that secular equilibrium (i.e., activity of U-238/activity of Ra-226 = 1) only existed in the areas of uranium showing and points of hummocky terrain. The presence of U-238 within the low-lying area south of the Main Showing indicated a significant migration of uranium in the area. Marmont et al. (1978) traced this anomaly 600 m down the slope, while Svoboda et al. (1985) detected elevated concentrations at about 500 m south of the Main Showing.

The main mechanism of mineral dispersion with the Kiggavik study area is likely snowmelt runoff. This is based on the work by Woo and Drake (1983) and by BEAK (Supporting Document No. 4). These works have documented a very large pulse of meltwater in a short period, and a pattern of extensive surface flow not confined to stream channels. These meltwaters likely entrain and transport soluble and particulate radionuclides down the topographic gradient. This is reflected in the chemical data.

Based on their lichen study at the Kiggavik site, Kershaw et al. (1983) concluded that significant distributional patterns of U, Fe, Ti and Cs-137 were closely associated with the Main Showing (Figures 4.45 to 4.55). Summary levels for S, Ni and Cu are shown in Figures 4.56 to 4.59.

The observed levels of Fe (25 to 200 ug/g), Ti (3 to 35 ug/g), S (80 to 300 ug/g), Pb (1 to 14 ug/g) and Ni (1 to 6 ug/g) in Cetraria nivalis and C. cucullata are generally comparable to those reported for the same lichen species from the Mackenzie Valley, N.W.T. (Nieboer et al., 1978), although the high levels evident close to the Main Showing do suggest some contribution from a mineral-enriched substratum (Kershaw et al., 1983). The Cu concentrations (4 to 7 ug/g) are characteristic for Arctic sites without mineralization of the substratum (Kershaw et al., 1983). The low levels of U found (less than 1 ug/g) in the three lichen species are comparable with other reported natural background concentrations of this metal (Beckett et al., 1982).

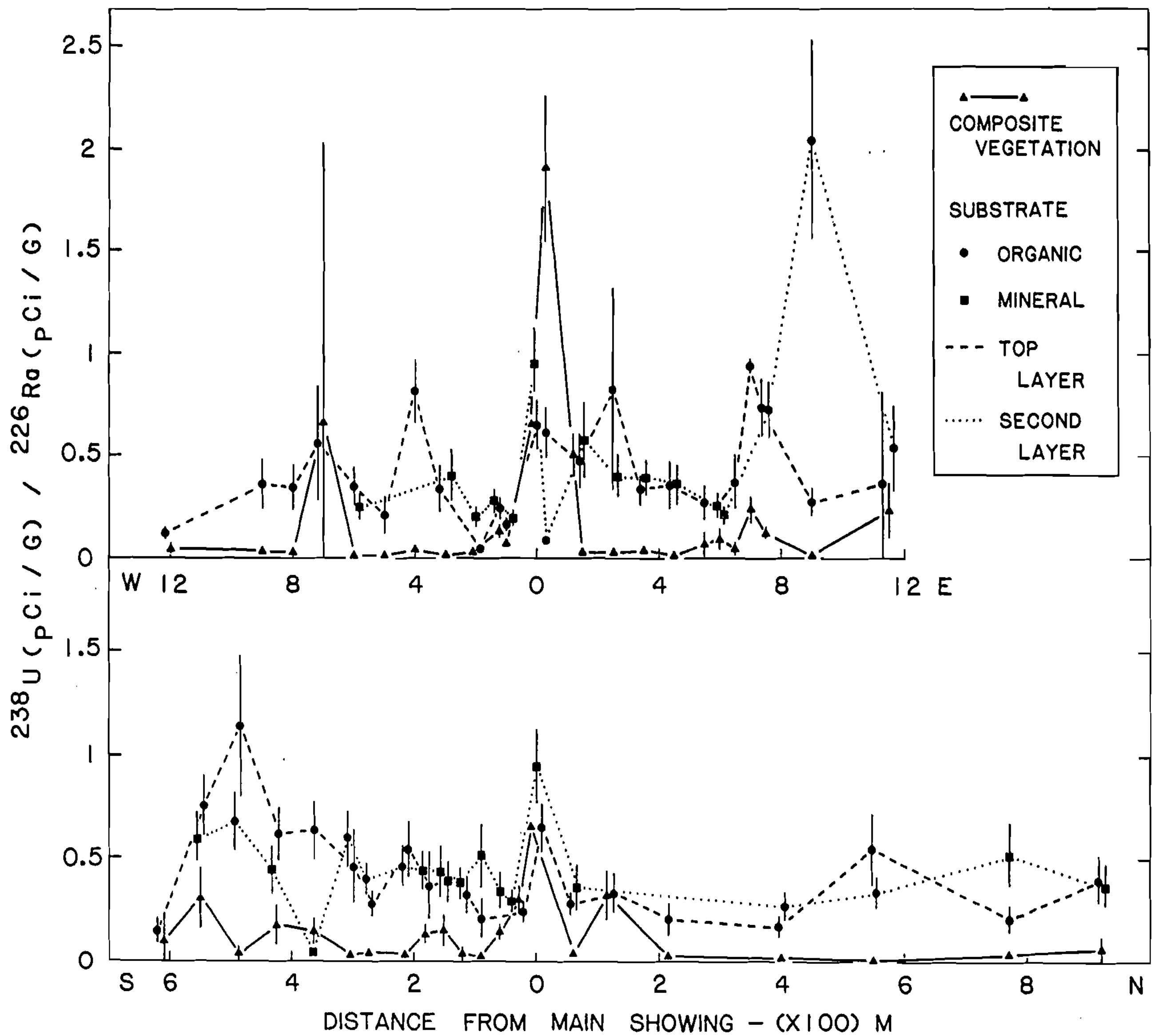
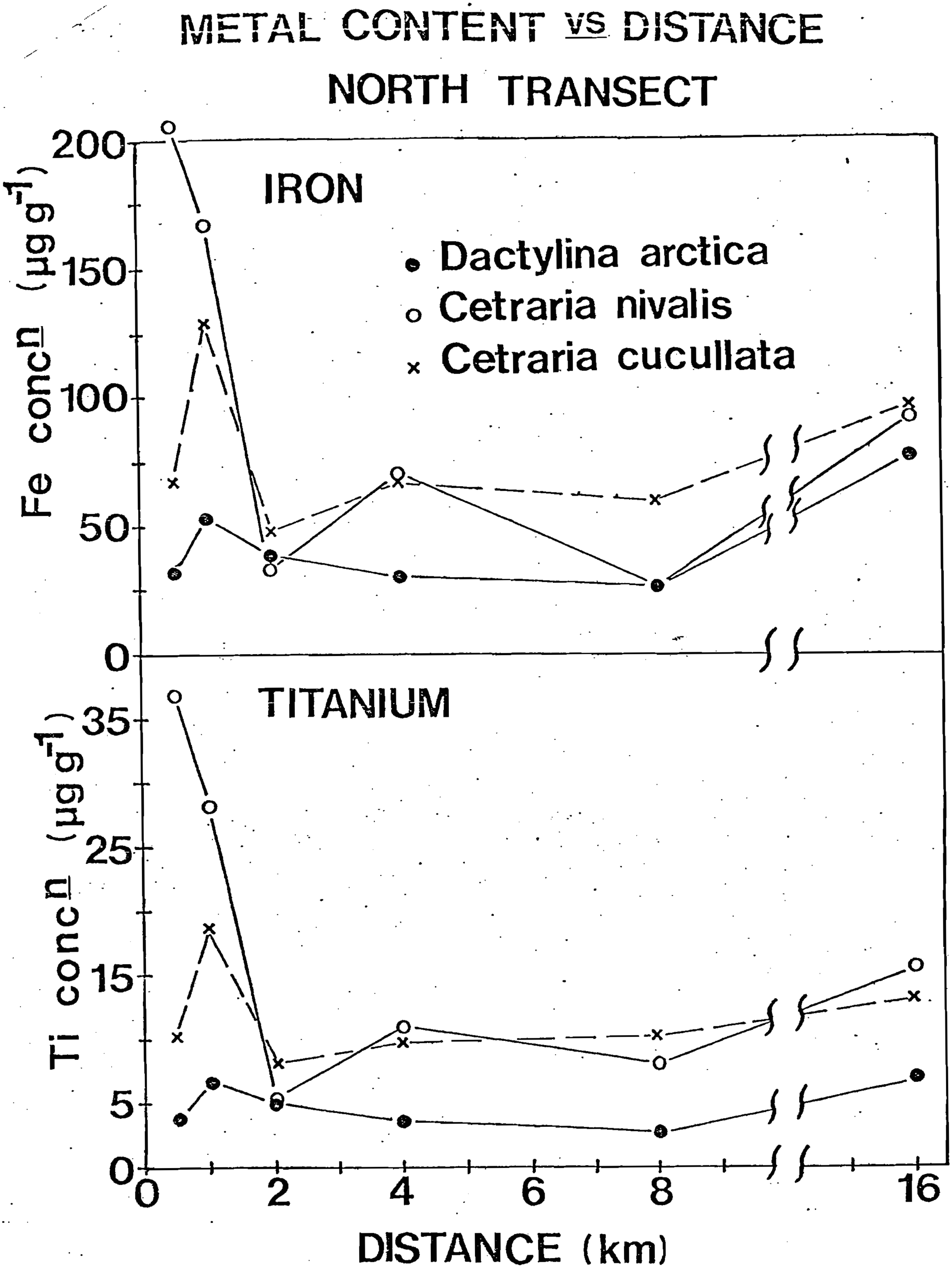
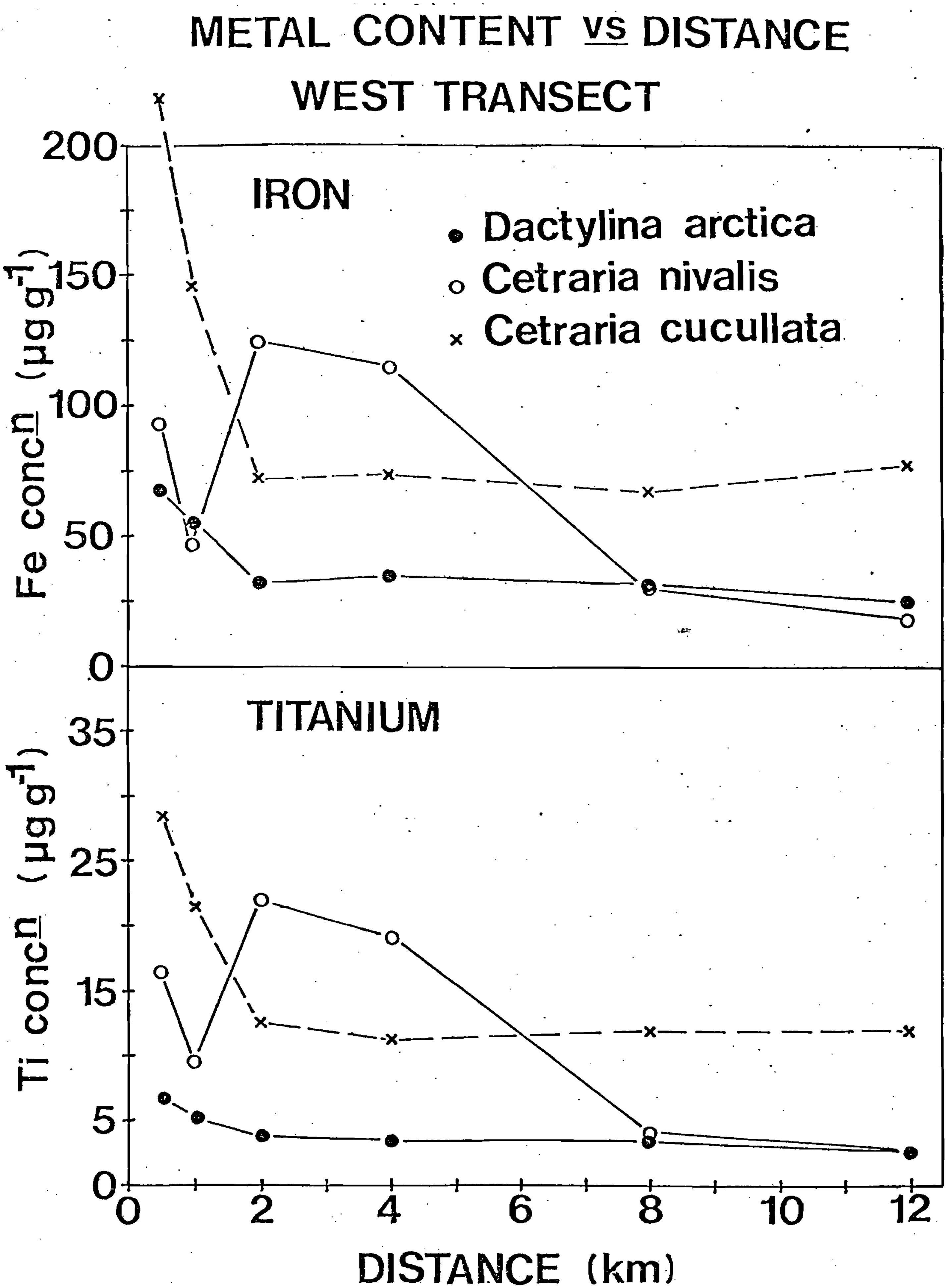


Fig. 4.44 Profiles of U/Ra values (both converted to pCi/g) in the composite vegetation and the substrates along the two main transects of Kiggavik Camp. Secular equilibrium condition exists when the U/Ra ratio is 1.



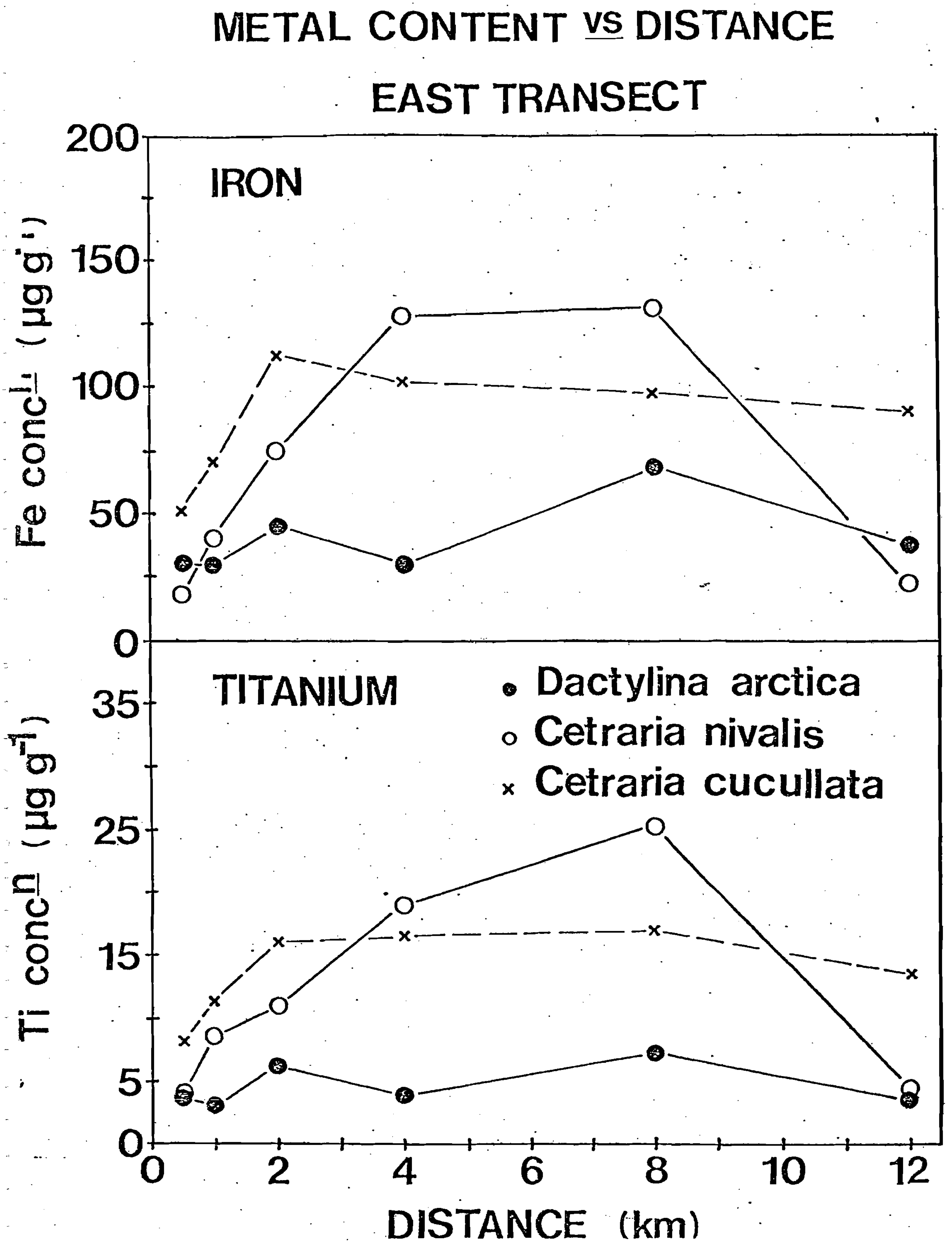
METAL CONTENT vs DISTANCE
NORTH TRANSECT
IRON
TITANIUM
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
Fe concn (µg g-1)
Ti concn (µg g-1)
200
150
100
50
0
35
25
15
5
0
0
2
4
6
8
16
DISTANCE (km)

FIGURE 4.45



METAL CONTENT vs DISTANCE
WEST TRANSECT
IRON
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
Fe concn (μg g-1)
200
150
100
50
0
TITANIUM
Ti concn (μg g-1)
35
25
15
5
0
0
2
4
6
8
10
12
DISTANCE (km)

FIGURE 4.46



METAL CONTENT VS DISTANCE
EAST TRANSECT
IRON
Fe concn (μg g-1)
200
150
100
50
0
TITANIUM
Ti concn (μg g-1)
35
25
15
5
0
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
0
2
4
6
8
10
12
DISTANCE (km)

FIGURE 4.47

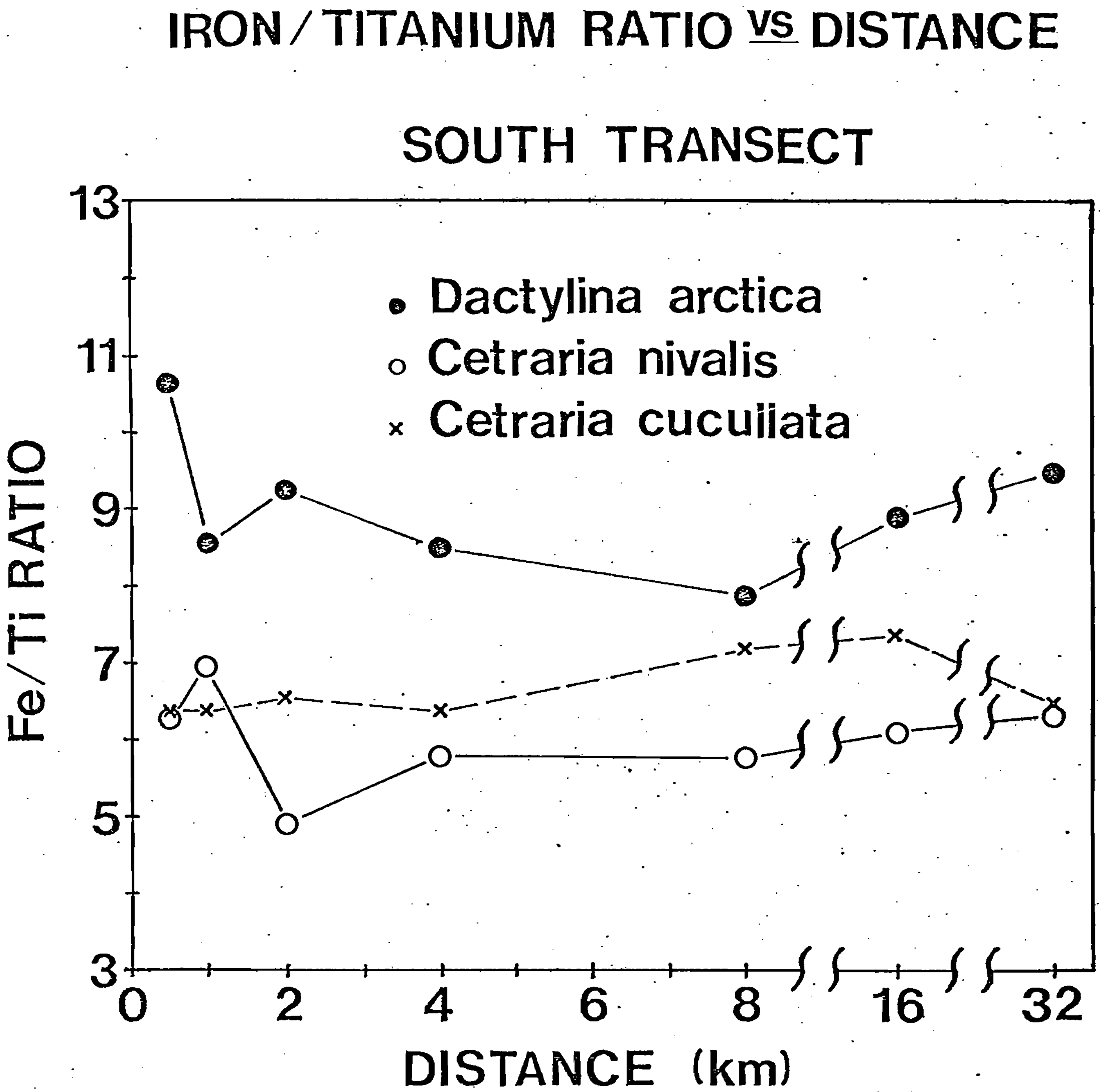

IRON / TITANIUM RATIO vs DISTANCE
SOUTH TRANSECT
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
Fe/Ti RATIO
13
11
9
7
5
3
0
2
4
6
8
16
32
DISTANCE (km)

FIGURE 4.48

IRON / TITANIUM RATIO vs DISTANCE

WEST TRANSECT

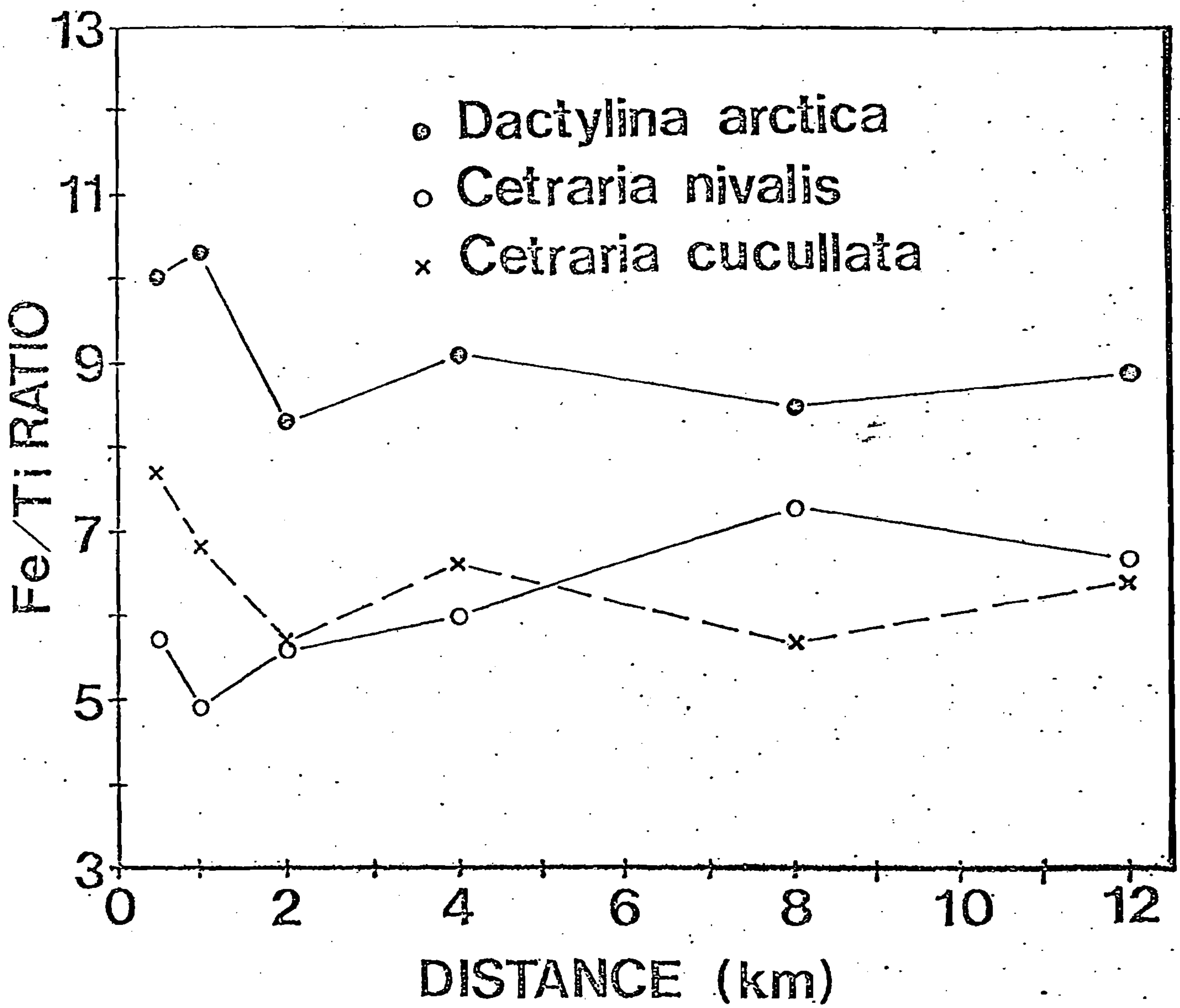
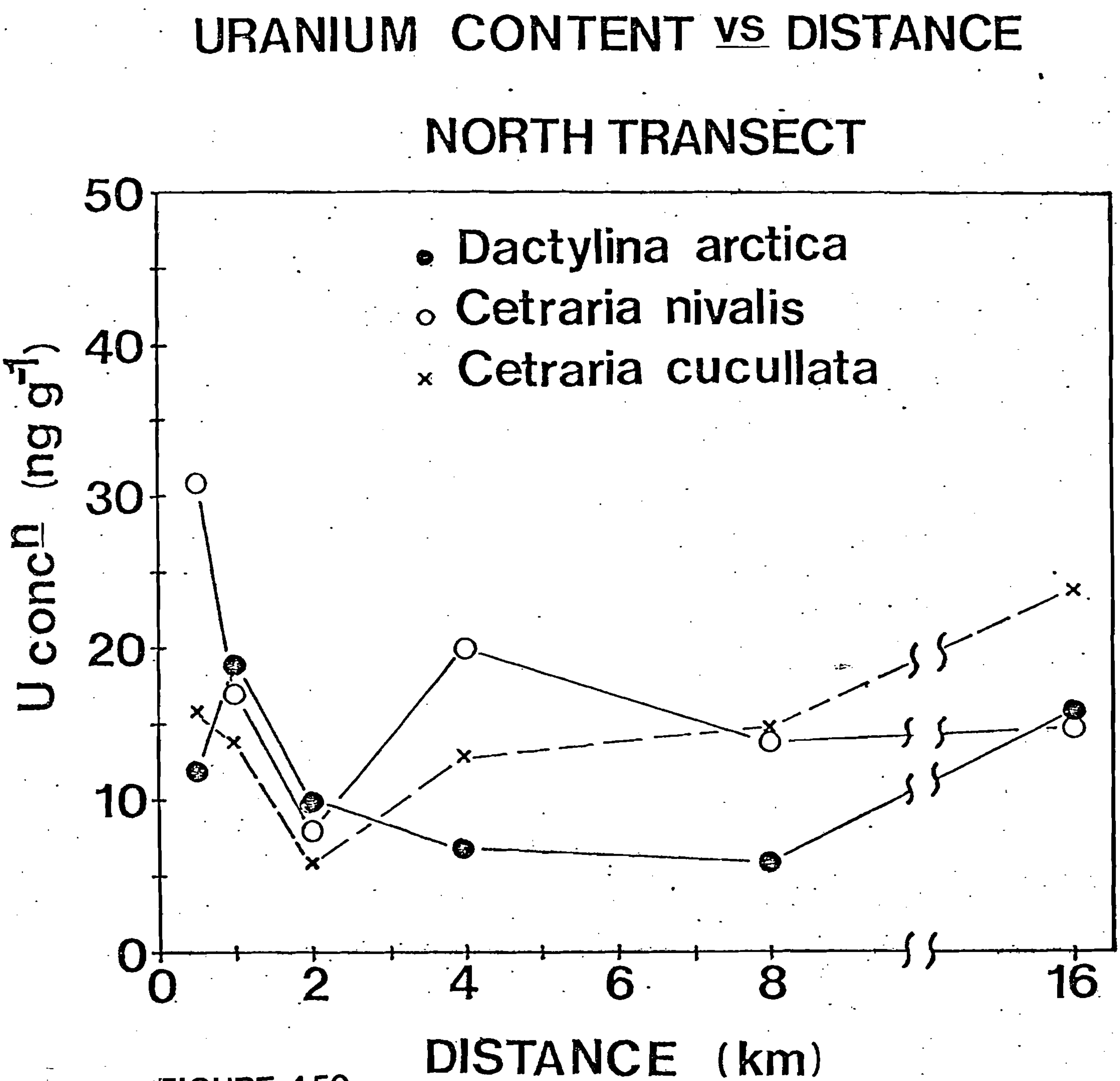


FIGURE 4.49



URANIUM CONTENT VS DISTANCE
NORTH TRANSECT
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
U concn (ng g-1)
0
10
20
30
40
50
0
2
4
6
8
16
DISTANCE (km)

FIGURE 4.50

URANIUM CONTENT vs DISTANCE.

EAST TRANSECT

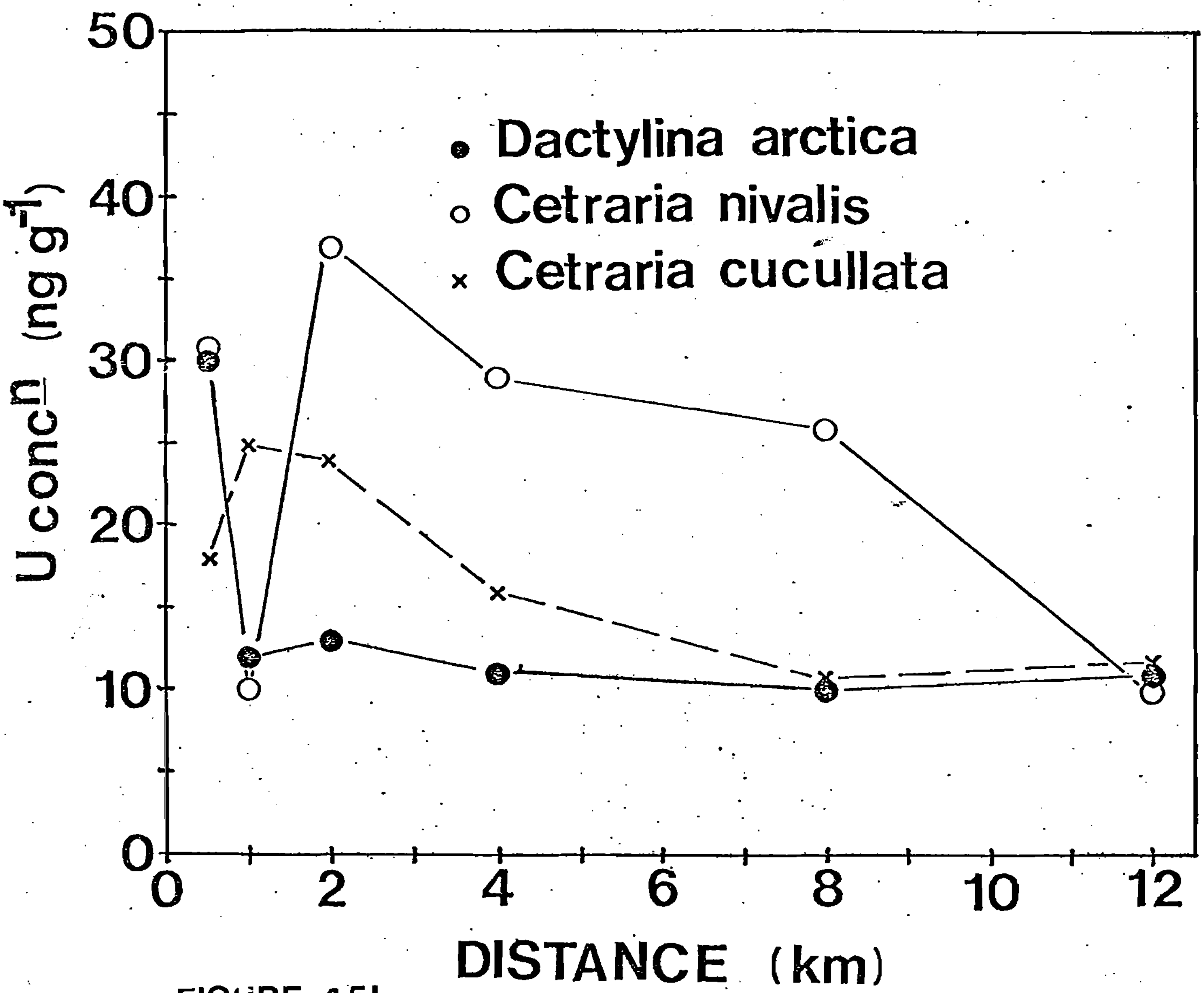


FIGURE 4.51

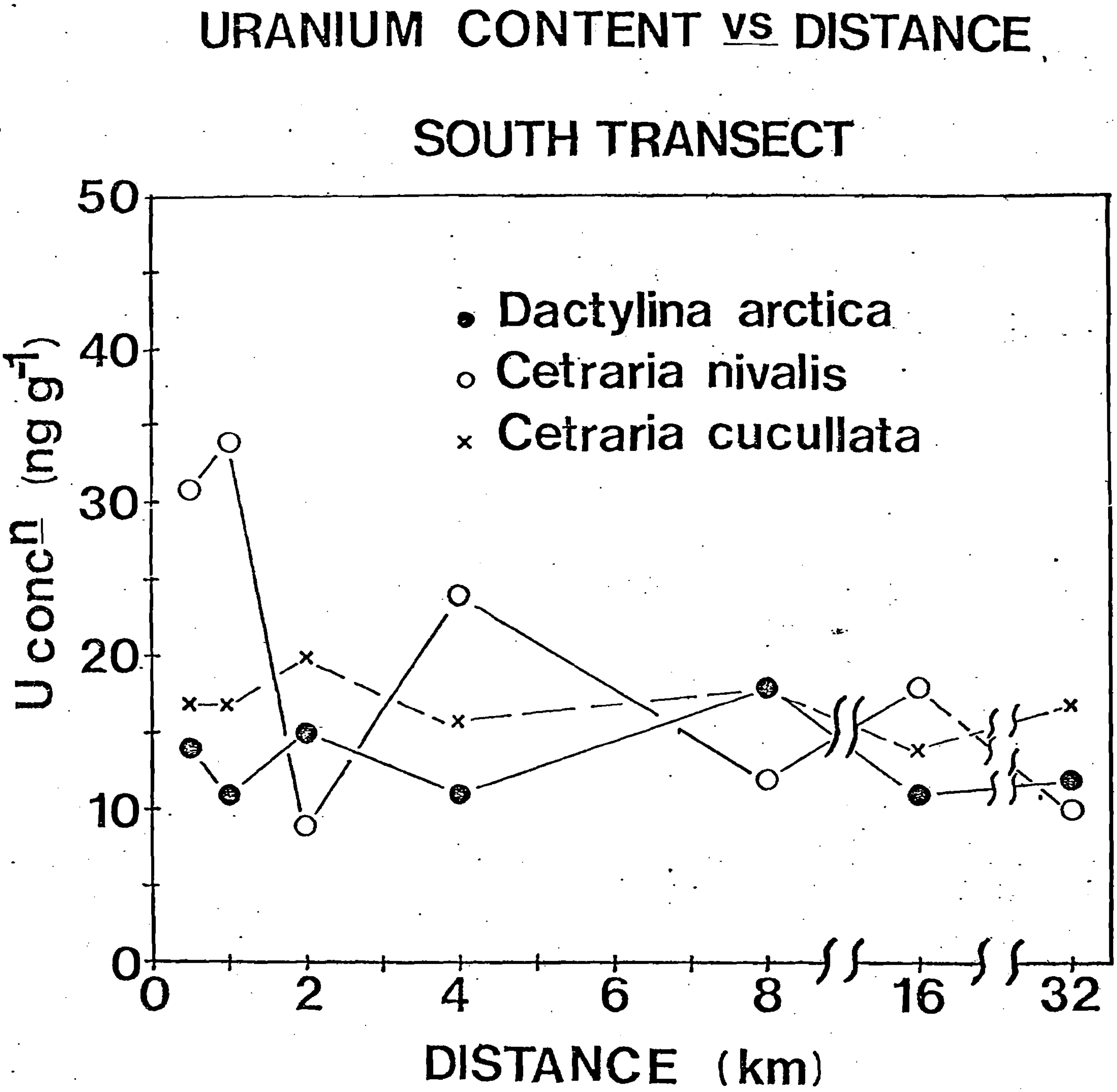

URANIUM CONTENT vs DISTANCE
SOUTH TRANSECT
U concn (ng g-1)
50
40
30
20
10
0
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
0
2
4
6
8
16
32
DISTANCE (km)

FIGURE 4.52

URANIUM CONTENT vs DISTANCE

WEST TRANSECT

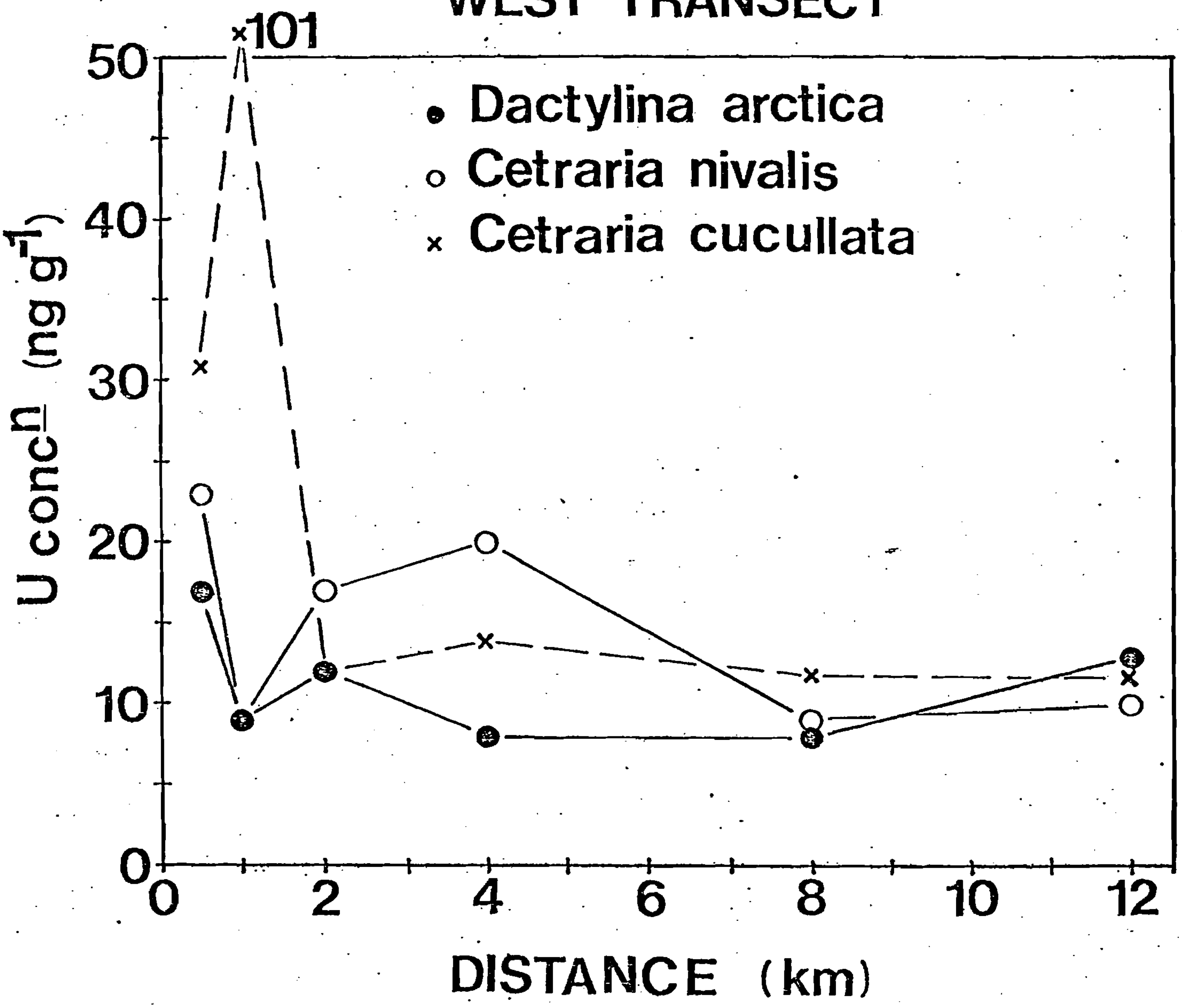
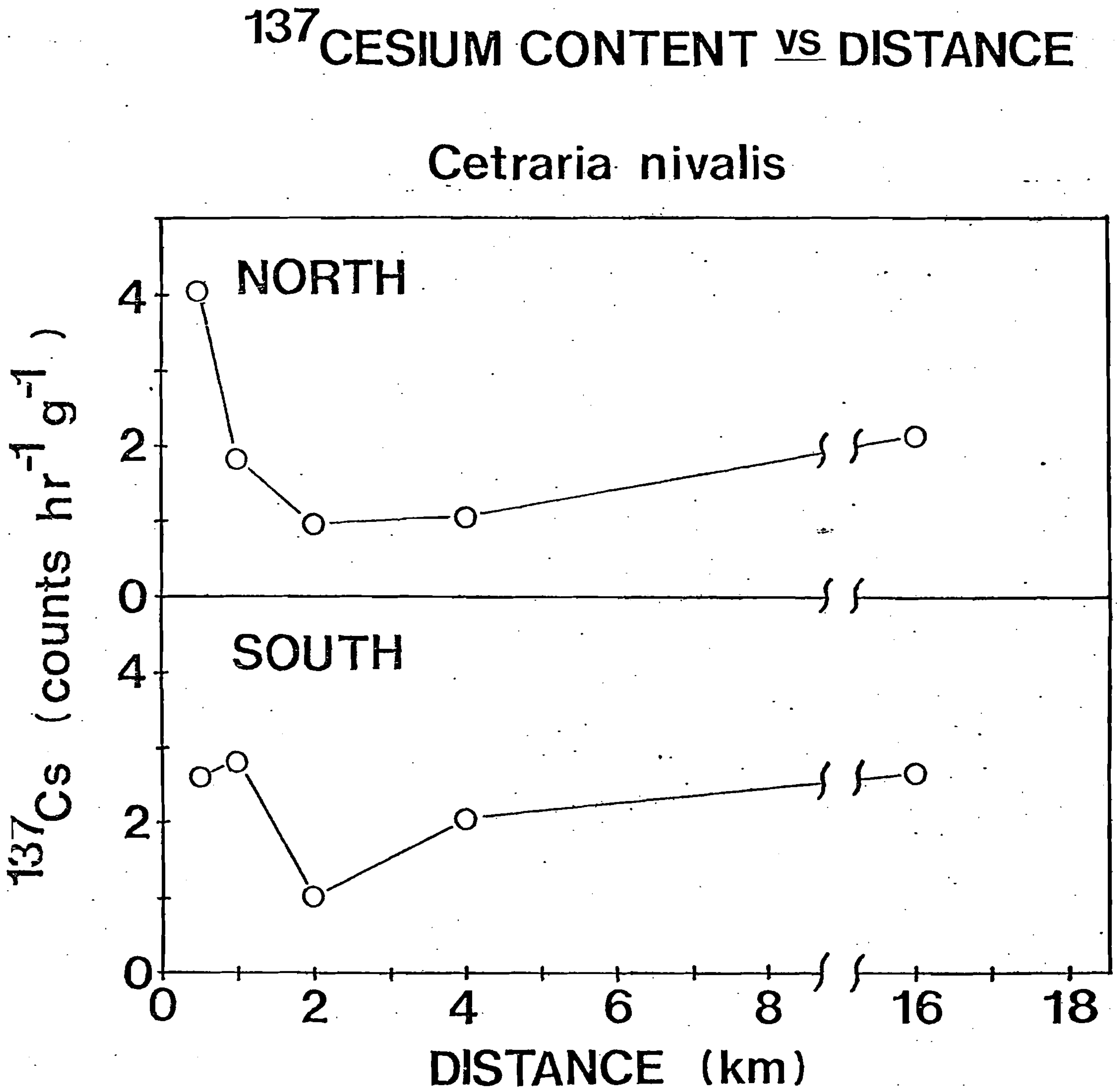
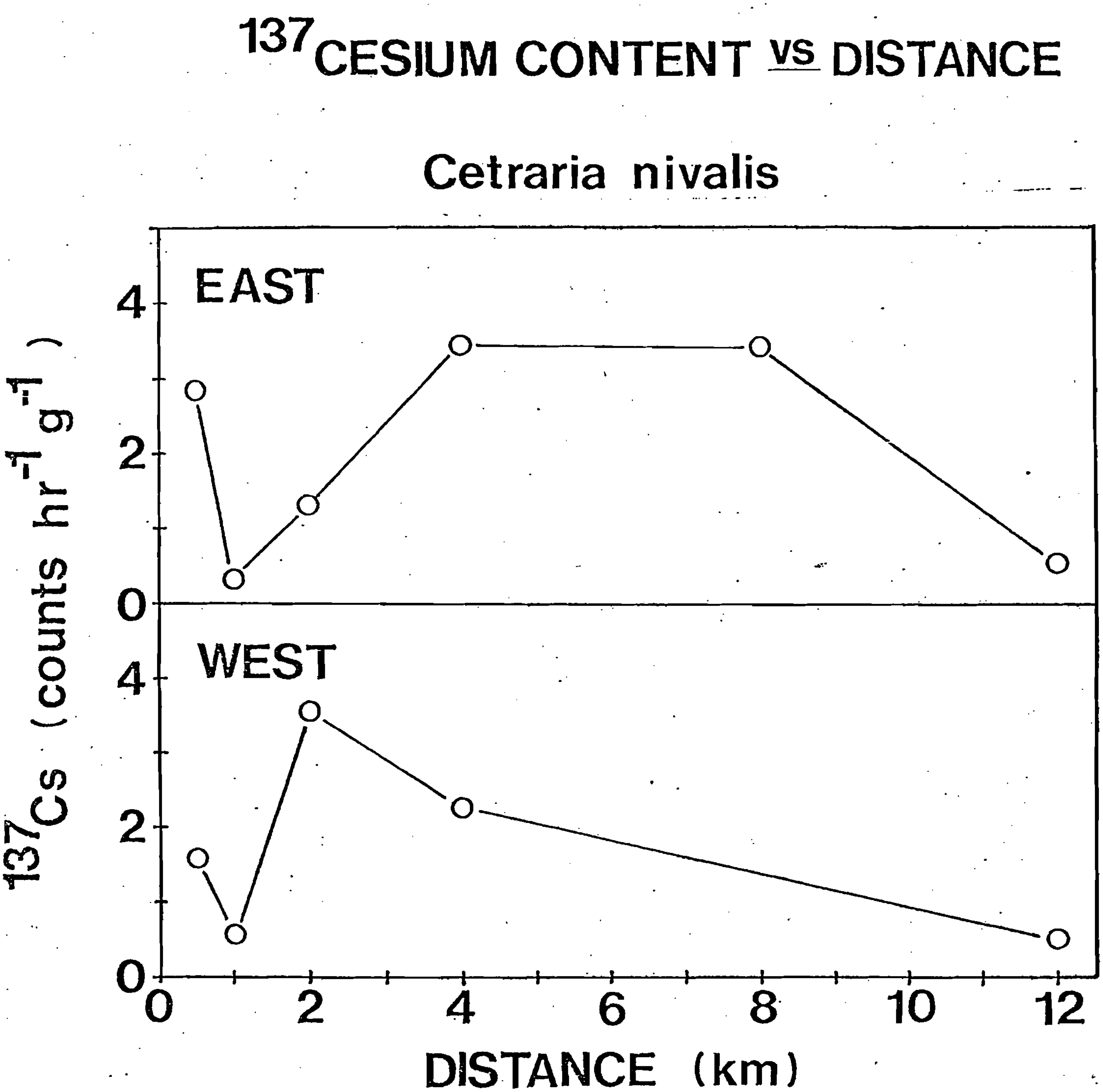


FIGURE 4.53



^{137}CESIUM CONTENT VS DISTANCE
Cetraria nivalis
NORTH
SOUTH
^{137}Cs (counts hr^{-1} g^{-1})
0
2
4
0
2
4
0
2
4
6
8
16
18
DISTANCE (km)

FIGURE 4.54



137CESIUM CONTENT vs DISTANCE
Cetraria nivalis
EAST
WEST
137Cs (counts hr-1 g-1)
0
2
4
0
2
4
0
2
4
6
8
10
12
DISTANCE (km)

FIGURE 4.55

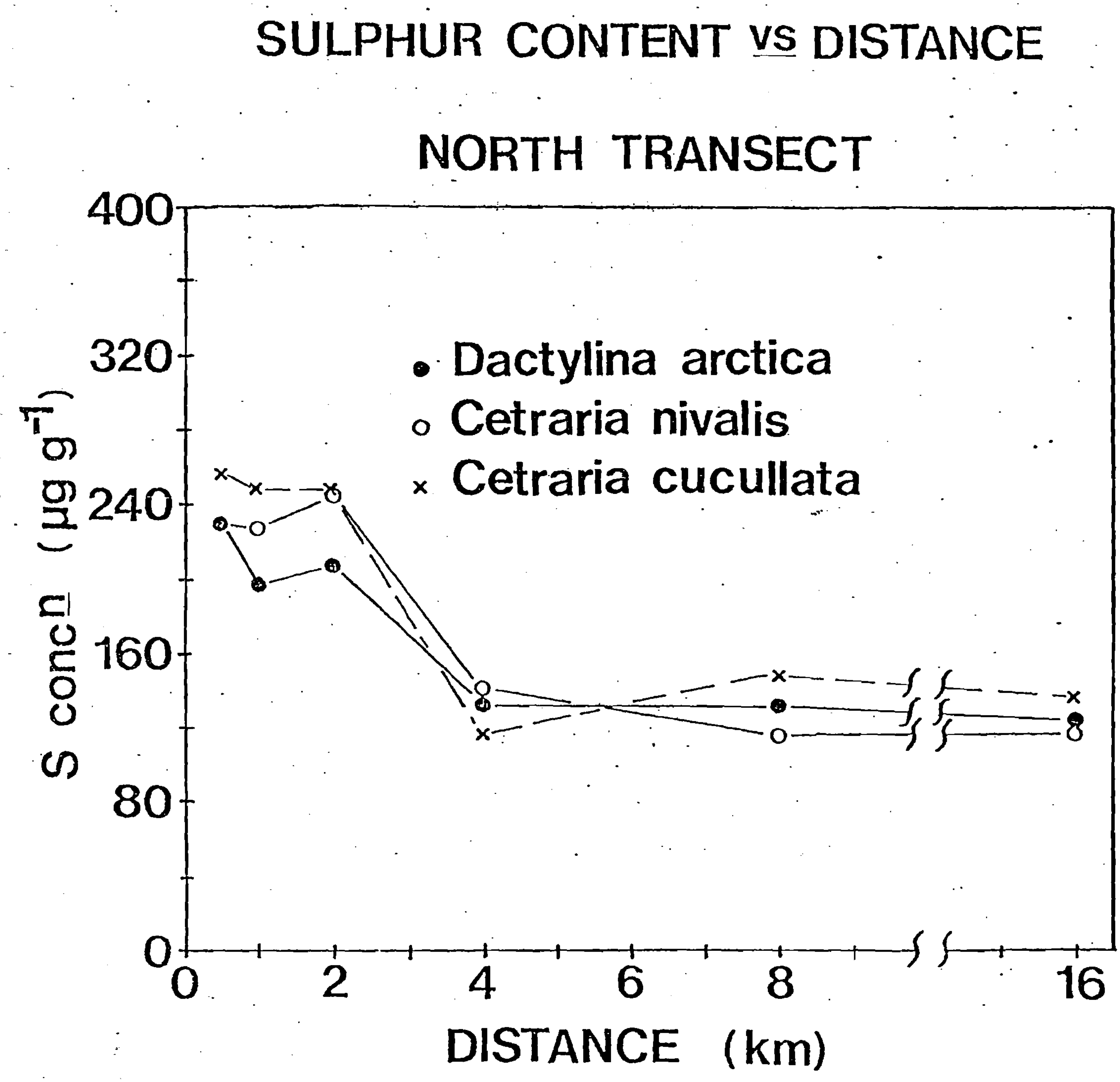
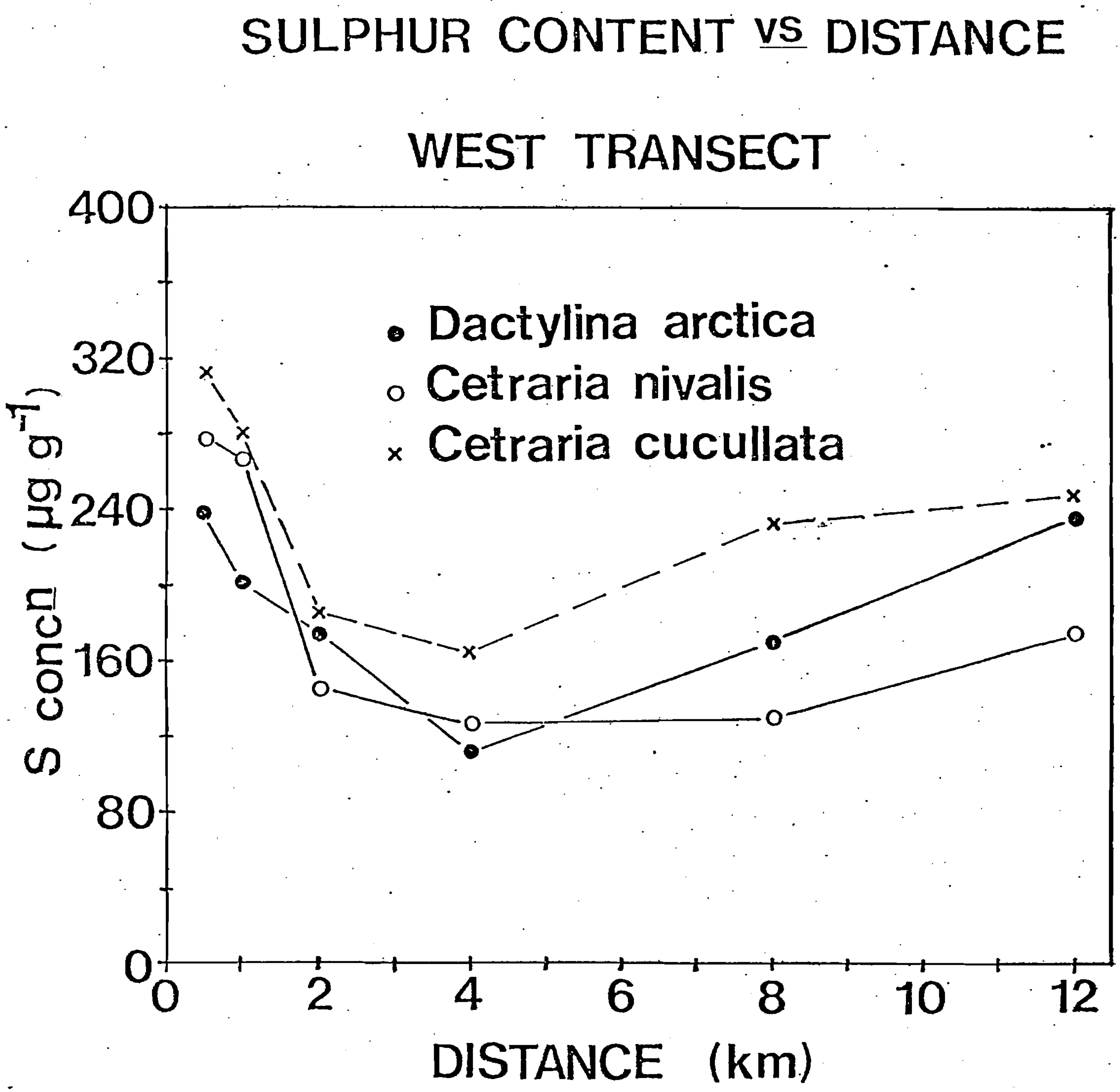

SULPHUR CONTENT vs DISTANCE
NORTH TRANSECT
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
S concn (μg g-1)
400
320
240
160
80
0
0
2
4
6
8
16
DISTANCE (km)

FIGURE 4.56



SULPHUR CONTENT vs DISTANCE
WEST TRANSECT
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
S concn (μg g-1)
400
320
240
160
80
0
0
2
4
6
8
10
12
DISTANCE (km)

FIGURE 4.57

NICKEL CONTENT vs DISTANCE

EAST TRANSECT

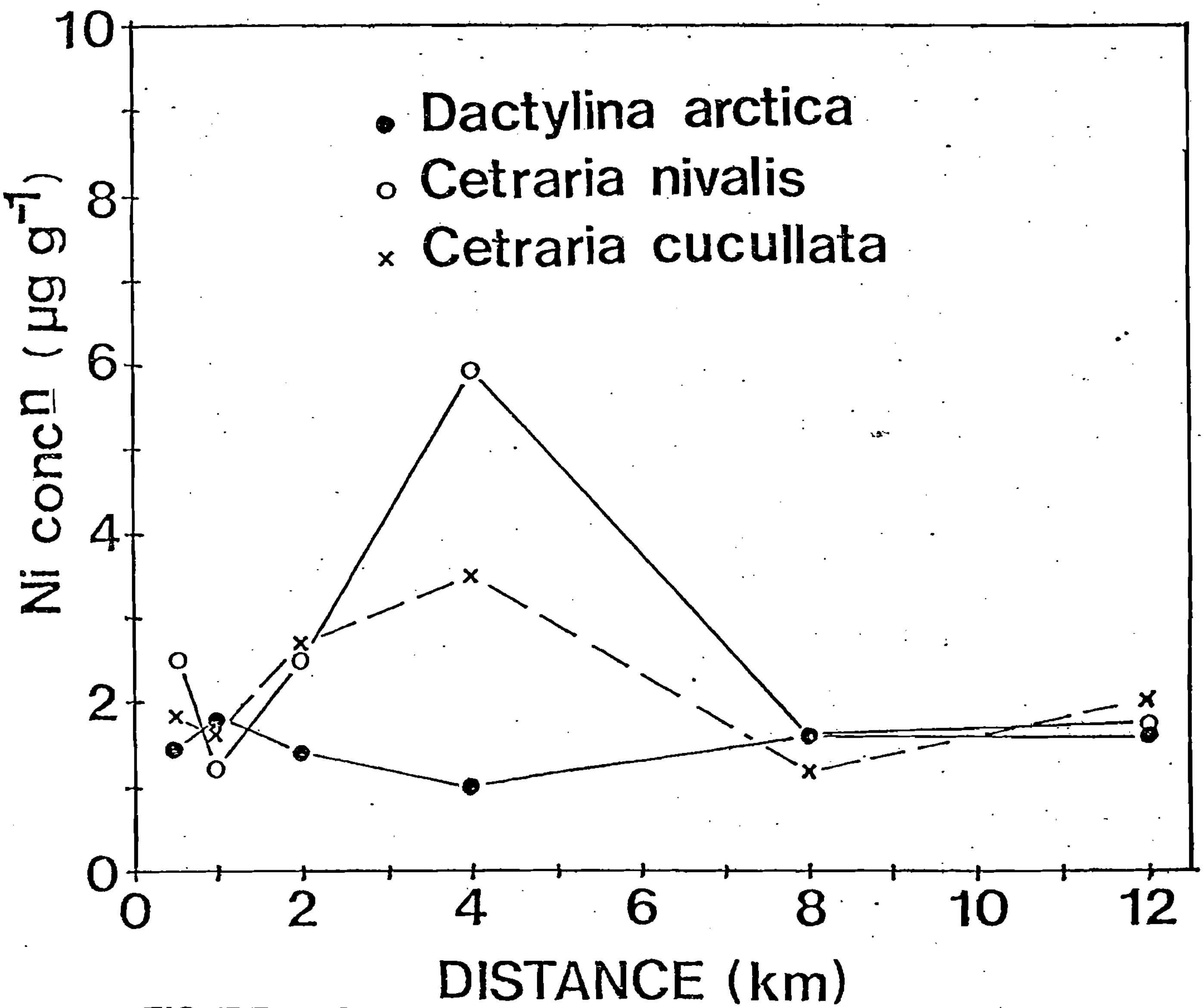
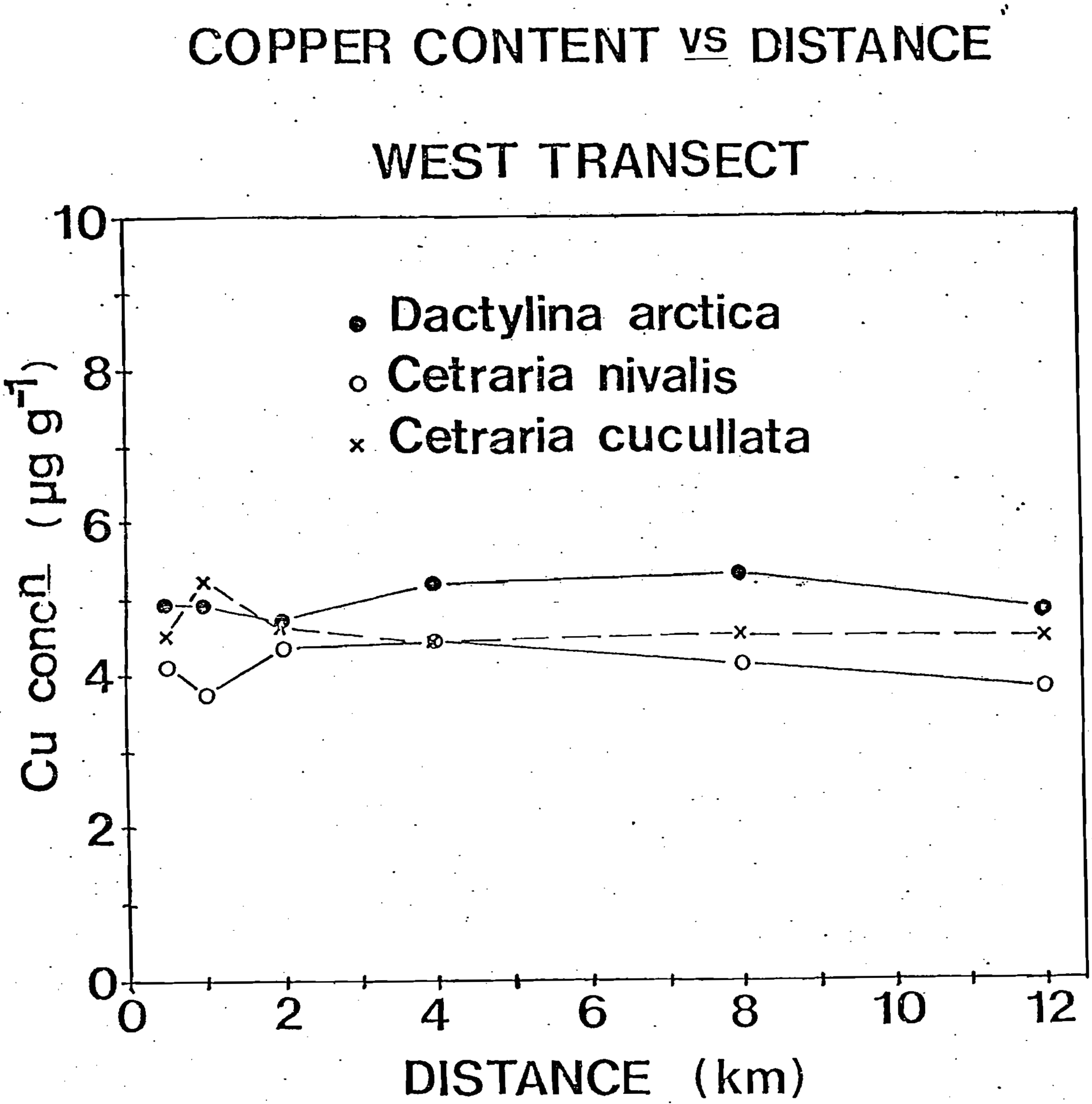


FIGURE 4.58



COPPER CONTENT VS DISTANCE
WEST TRANSECT
Dactylina arctica
Cetraria nivalis
Cetraria cucullata
Cu concn (µg g-1)
10
8
6
4
2
0
0
2
4
6
8
10
12
DISTANCE (km)

FIGURE 4.55

Data Summary

- o The plants and substrates at the Main Showing and Centre Zone contained elevated levels of the uranium-family radionuclides, but their activities are localized to an area not greater than 100 m in radius about the showing.
- o The composite vegetation and substrate revealed a detectable dispersion pattern of U-238 and Ra-226. The average levels of these nuclides were highest in the south and lowest in the north, reflecting downgradient hydrologic transport mechanisms.
- o The Cs-137 in the composite vegetation showed a remarkable consistency throughout the Kiggavik area. Cs-137 in the substrate fell rapidly with increasing depth; its distribution showed some evidence of association with the local watershed.

Regional Data

Regional site locations, where plant and substrate samples were collected for chemical analysis, are shown in Figure 4.36. Ra-226 and Cs-137 levels over the northern, central and southern regions of the area are shown in Figures 4.60 to 4.62, respectively. The legend for these figures is given in Figure 4.63.

Northern Sites

Sand Lake (SND) was situated on an esker. Detectable amounts of Ra-226 were present in the S2 of mesic habitat and in the composite vegetation and S1 of the wet habitat. Cs-137 activity was between 7.3 and 11.8 pCi/g in the composite vegetation and in traces in the top substrate layer.

Dragon Point (DP) was on a weathered esker and the orgnaic layer was better developed here. No Ra-226 was detected in composite vegetation and low amounts (0.7 to 2.1 pCi/g) were present in the substrate of all three sites. In the dry and mesic habitats, Cs-137 decreased down the profile, but in the wet habitat.

Whalebone Hill (WBH) was a plateau of barren rocks and dry mesic pockets of vegetation. This site is within an area containing localized concentrations of uranium

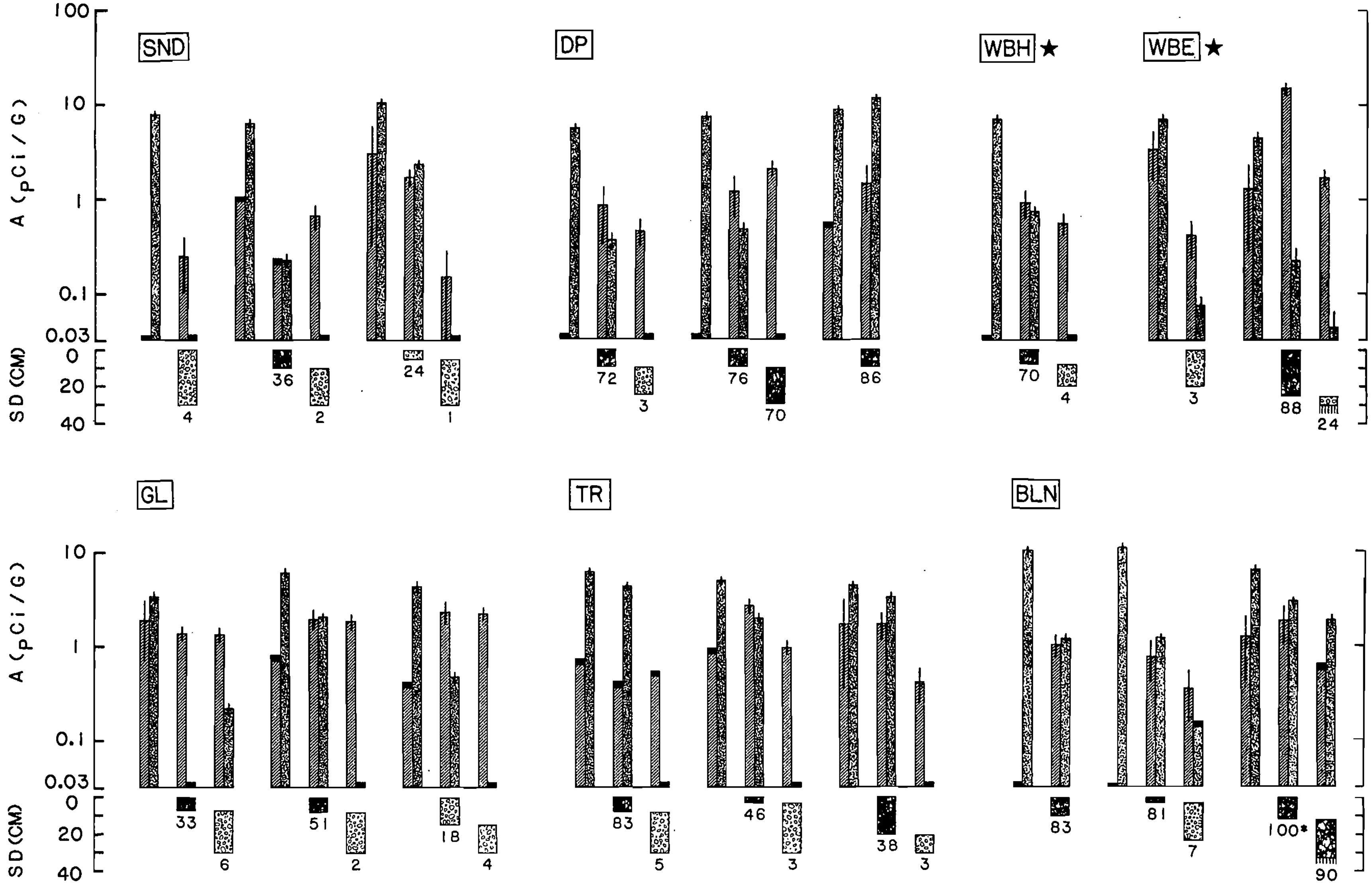


Fig. 4.60 ^{226}Ra and ^{137}Cs activities over the <u>northern</u> region of the study area.

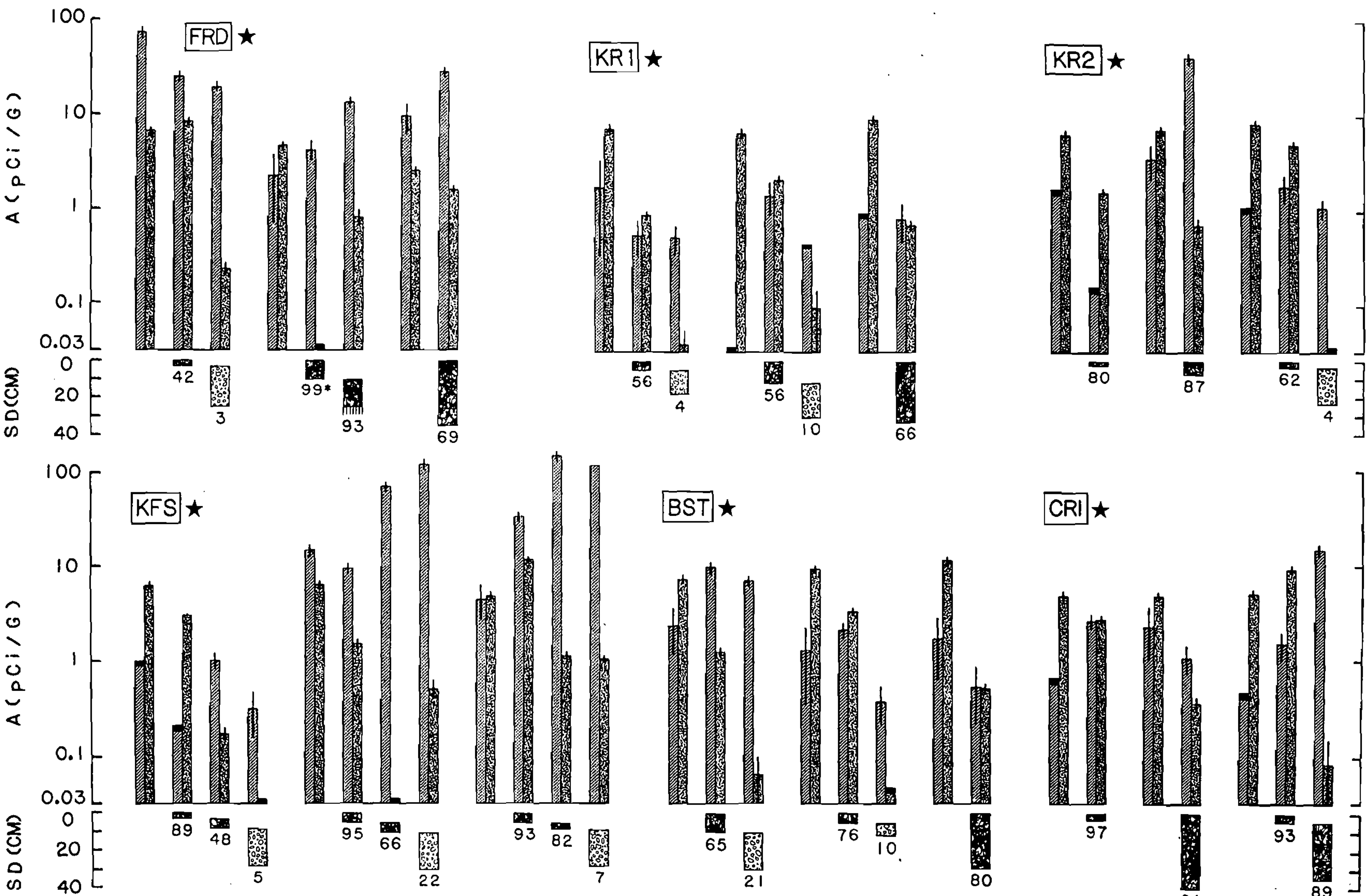


Fig. 4.61 ^{226}Ra and ^{137}Cs activities over the Central region of the studv area.

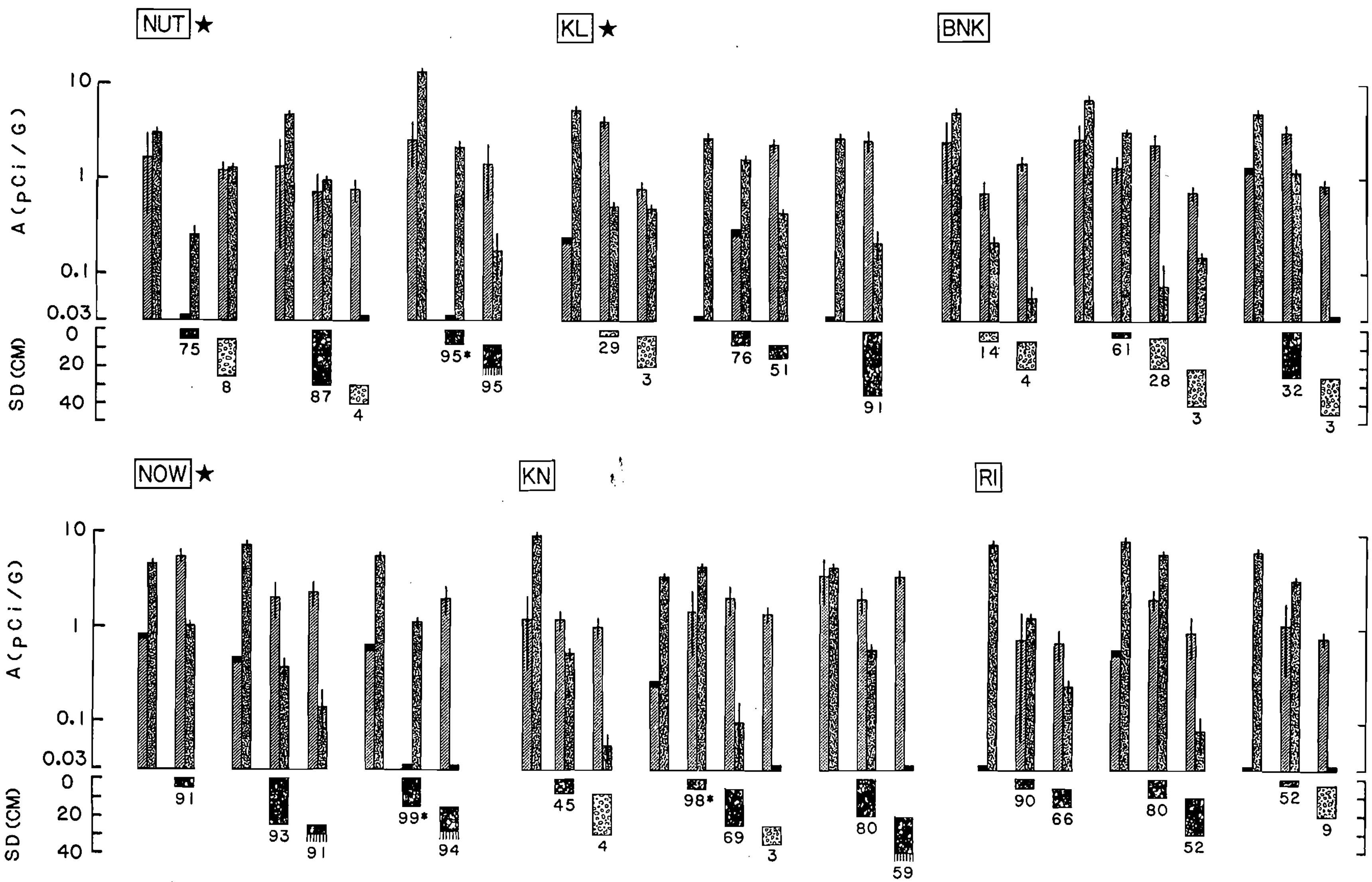


Fig. 4.62 ^{226}Ra and ^{137}Cs activities over the Southern region of the study area.

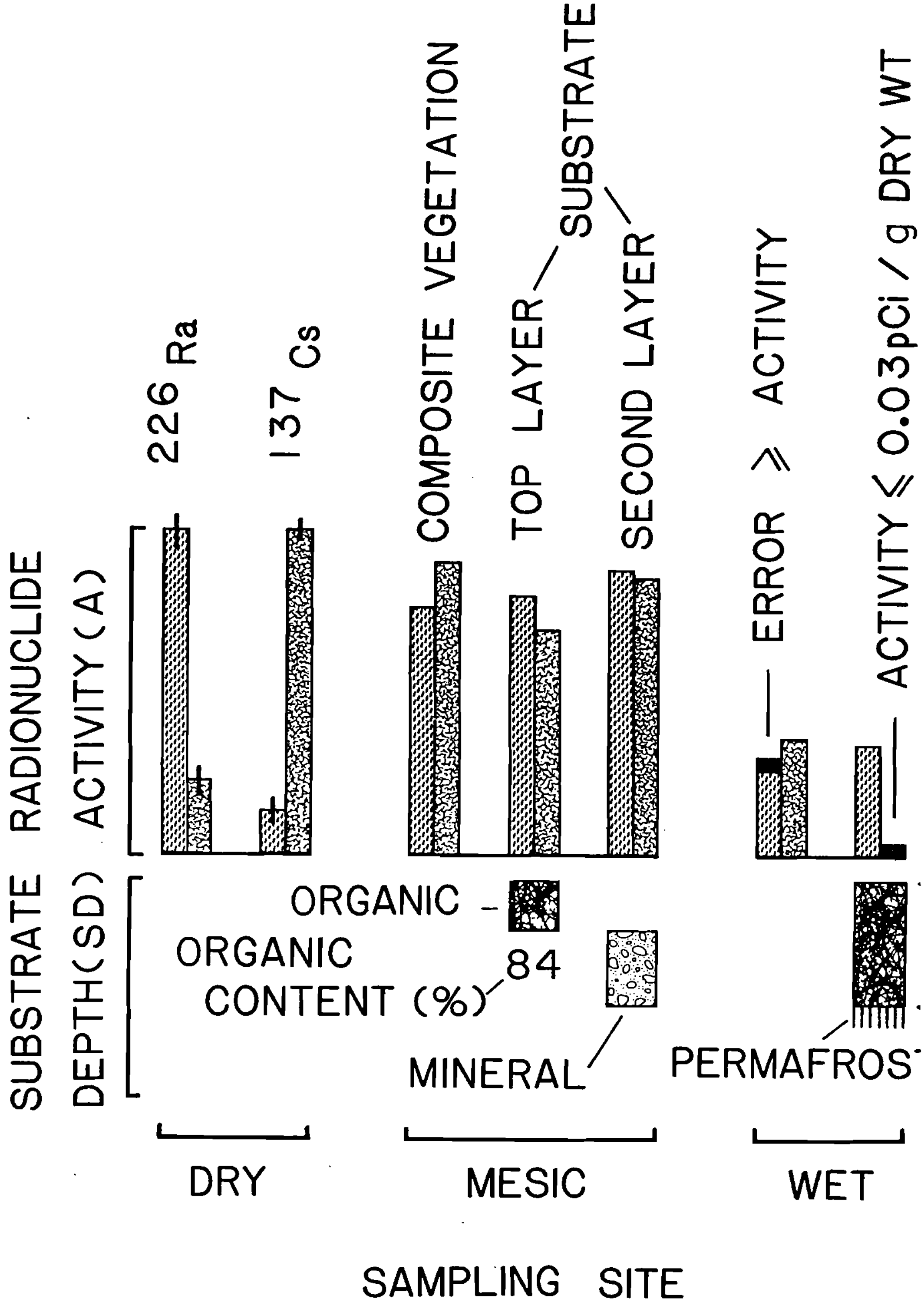


Fig. **4.63** Legend for figures 4.41 - 4.43 which show the ^{226}Ra and ^{137}Cs activities in composite vegetation and substrate samples taken at the extensive sites.

within veins. However, only background levels of radioactivity were detected at a dry site. The plant and substrate averaged 0.9 pCi/g of Ra-226 in S1 and S2 with no activity in the composite vegetation. Cs-137 was similar to Dragon Point dry habitat.

Whalebone East (WBE) was located on another plateau 6 km east-northeast from Whalebone Hill. The scintillometer search failed to locate assumed uranium veins, but there were detectable amounts of Ra-226 in the composite vegetation on the dry plateau. The mesic habitat had elevated levels of Ra-226 in composite vegetation and S2 (1.9 pCi/g). S1 (25 cm thick) was the highest with 20 pCi/g. The Cs-137 in the vegetation and substrates was negligible.

Grant Lake (GL) was flanked on its eastern shore by an esker. The scintillometer readings at the ridge-top and at the mesic east-facing slope were elevated at 5,220 and 5,570 cpm, respectively. There was a trend towards higher substrate Ra-226 from the dry to the wet habitat. Cs-137 activity in the substrate of the dry habitat increased from S1 and S2, just the opposite to the trend observed in other sites.

Tundra Rose (TR) in the Marjorie Hills has areas of uranium-phosphate-cemented sandstone. However, a very low amount of Ra-226 was present. Cs-137 in the top substrate layer was 18% higher than the average of all the sites.

Baker Lake North (BLN) was a locality about 10 km northwest of the Hamlet of Baker Lake. Natural radionuclides were similar to Tundra Rose; the Cs-137 activity was higher however.

Central Sites

Forde Lake (FRD) site was 26 km northwest of the western shore of Forde Lake. A discrete uranium rock outcrop with greater than 400,000 cpm scintillometer readings was located. In fact, the entire area had anomalous radioactivity of 10,400 and 6,820 cpm in the mesic and wet habitats. Similarly, anomalous levels of Ra-226 were detected in all samples. In dry habitat vegetation, Ra-226 was 30 times the activity found in the mesic habitat. Cs-137 in the mesic substrate samples was similar to that of Grant Lake dry habitat.

Kazan River I (KR1) was located in an area of uranium mineralization that has been prospected. The site sampled was, however, not mineralized. All samples contained less than 2.5 pCi/g of Ra-226. Cs-137 in the composite vegetation of the three habitats was fairly consistent (7.4 to 10.3 pCi/g).

Kazan River II (KR2) was 3 km south of Kazan River I, with similar ecological characteristics. The scintillometer reading at the uranium showing was 380,000 cpm, diminishing to ca. 5,000 cpm in the adjacent areas. Elevated levels of Ra-226 were detected in the composite vegetation and S1 of the mesic "showing" habitat. Small amounts of Ra-226 were present in the dry habitat samples and in composite vegetation of the wet habitat. Ra-226 content in the substrate of the wet habitat was not different from non-mineralized wet sites. The pattern of distribution for Cs-137 was quite similar to that observed at Kazan River I.

Kazan Falls South (KFS) contained a high-grade uranium mineralization; the showing was disturbed. To avoid contamination, a mesic sampling point was chosen 5 m from the excavated pit. Scintillometer readings indicated 23,700 cpm in the mesic and 27,900 cpm in the wet habitat. Anomalous Ra-226 activities were detected in the mesic and wet habitats, while background conditions prevailed at the dry habitat. In S2-wet, the Ra-226 activity of 195.7 pCi/g was the highest among all the samples collected from the sites. Substrate Cs-137 was greater in the wet habitat than in the other two.

Bissett Lake (BST) had a detectable, undisturbed uranium anomaly, with scintillometer readings between 4,500 and 16,000 cpm, due to scattered radioactive rocks. Elevated levels of Ra-226 were found in the samples of the dry site. The activity pattern of Cs-137 in the samples closely resembled that of Kazan River I.

Christopher Island (CRI) showed a widespread but a low geochemical anomaly having hairline uranium veins. However, only composite vegetation of mesic and S2-wet habitats showed elevated levels of Ra-226. Cs-137 activities were similar to other sites.

Southern Sites

Nuturawit Lake (NUT) revealed a weak scintillometer anomaly at the mesic habitat. This was not reflected in the Ra-226 activity. Cs-137 in S2-dry was higher than most other samples at comparable depths.

Kamilukuak South (KL) was the most southwesterly locality within the forest-tundra ecotone heavily overgrown with willows and dwarf birch. This locality exhibited moderate radiometric reading. Elevated Ra-226 was detected only in S1-dry. The patterns of Cs-137 distribution were similar to other sites.

Banks Lake (BNK) was another esker with no uranium mineralization. However, detectable amounts of Ra-226 were found in the composite vegetation and substrates of dry and mesic habitats, indicating the presence of a uranium-bearing fraction in the esker material. It was unusual to find a small amount of Cs-137 in S3-mesic at 20 cm to 40 cm.

Nowleye Lake (NOW), northeast of Kamilukuak, is still within the ecotone, but it exhibits a reduced shrub growth. The minor radiometric anomaly was restricted to an outcrop of about 1 km across. The only anomalous activity of Ra-226 was found in S1-dry with 7.5±1.1 pCi/g. Cs-137 activity was within the range of other sites.

Kaminuriak Lake (KN) was a non-mineralized site with a background level of radioactivity and low Ra-226, except in S2-wet which was slightly above average. Cs-137 in the composite vegetation of the dry habitat was higher than the average.

Rankin Inlet (RI) was the most easterly site. Samples were collected about 1.5 km west of the Town of Rankin Inlet on the east side of the airstrip. Ra-226 was lower than the average for the non-mineralized sites. Cs-137 activities were comparable to other sites.

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