ISBN 0-315-61812-4

GLACIAL GEOMORPHOLOGY AND CHRONOLOGY IN THE SELAMIUT RANGE/NACHVAK FIORD AREA, TORNGAT MOUNTAINS, LABRADOR

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GLACIAL GEOMORPHOLOGY AND CHRONOLOGY IN THE SELAMIUT RANGE/ NACHVAK FIORD AREA, TORNGAT MOUNTAINS, LABRADOR

by

© D. J. A. EVANS, B.A.

A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Science

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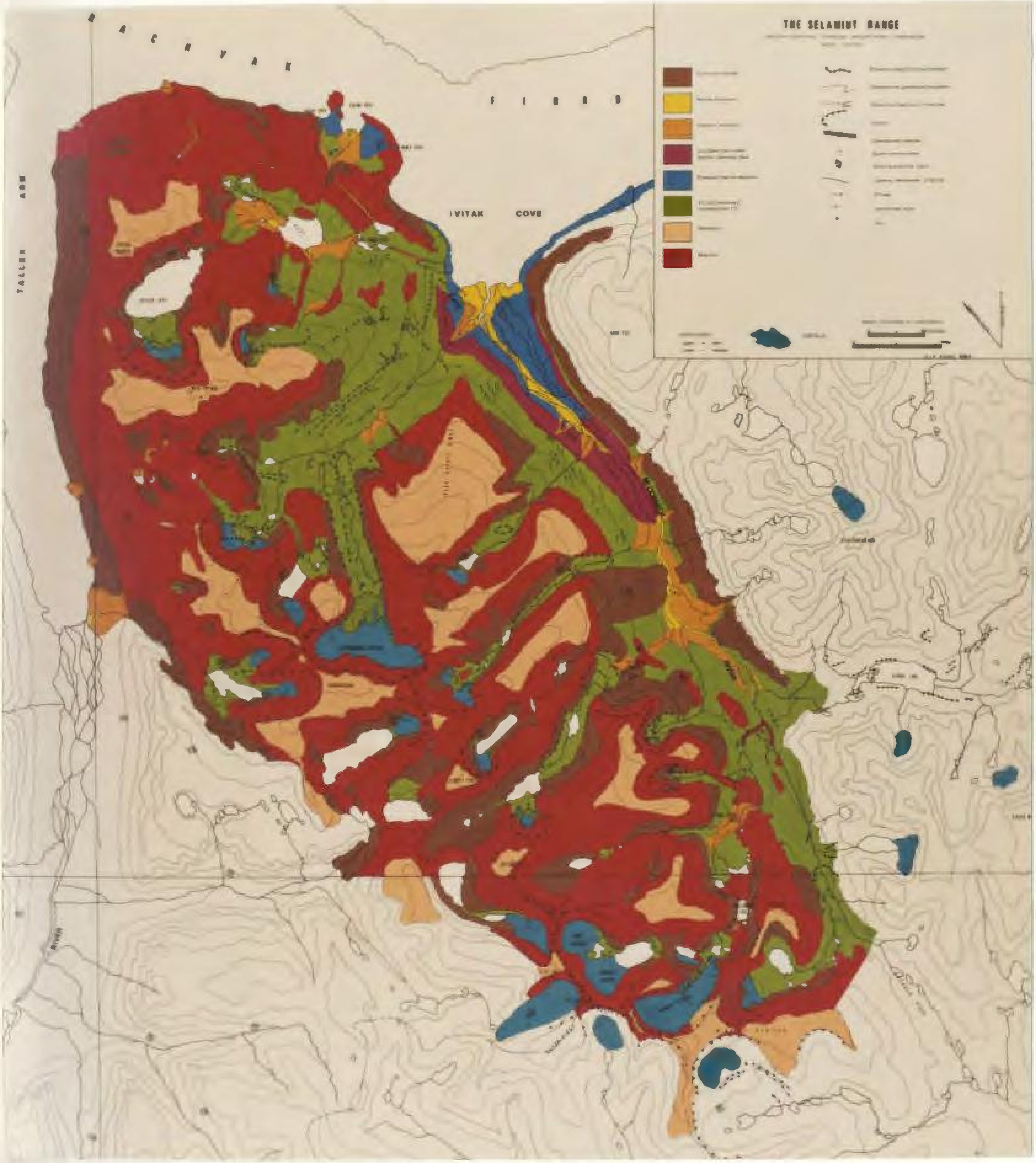
July 1984

St. John's Newfoundland

ISBN 0-315-61812-4

To absent friends,

especially Andy Lawson (S.D.U.C. 1979-1983)



Frontispiece: The surficial geology of the Selamiut Range.

ABSTRACT

The summits of the Selamiut Range are the highest in the Torngat Mountains of northern Labrador and contain some of the only permanent ice bodies of the eastern Canadian mainland. As they may have constituted a physical barrier to ice moving eastward from the Ungava ice-dispersal centre, their glacial history is elaborate in a regional context. Consequently a complex interaction of local and regional ice masses is manifest in the morphochronological record dating from the Late Quaternary through the Holocene.

Physiographically the Selamiut Range is a plateau, dominated by deep cirques and cirque outlet valleys with precipitous bounding rock walls. Colluvial processes are extremely active and consequently many surficial units have been extensively remodelled in dynamic landscape systems.

The northern half of the field area contains a wealth of glacial and periglacial landform assemblages and former local and regional ice activity has been determined from the cross-cutting relationships of certain morainic features.

Within the McCornick River Valley a sequence of shorelines documents the depths and extent of ice-dammed lakes during glaciation. A further 33 metre marine limit demarcates former sea level during the final glaciation of the area.

Three glaciations or stillstands are suggested for the field area after consideration of the landform evidence and are named the Ivitak, Nachvak and Superguksoak Glaciations.

The adoption of a 1.5 cm ka $^{-1}$ soil development rate dates the three glaciations or stillstands for the Selamiut/Nachvak area; the Ivitak Glaciation at >>40 ka; the Nachvak Glaciation at c.23 ka; and the Superguksoak I Glaciation at 10-12 ka. B.P. Two further Neoglacial events were restricted to the cirque basins and are correlated locally by a combination of pedology, lichenometry and morphologic superimposition.

A number of chronocorrelative inferences are made for northern Labrador based upon the existing empirical data. Glacial styles appear to differ quite considerably from fiord to fiord along the coastal section of the Torngat Mountains. The solution of discrepancies within the general northern Labrador chronology resides in the successful construction of an absolute dating framework for the marine limits of the region. Relative chronologies may then attain a significant applicability.

ACKNOWLEDGEMENTS

The completion of this thesis has been greatly facilitated by the unfailing logistical and financial assistance and informative commentary provided by Dr. R. J. Rogerson of the Geography and Earth Science Departments at Memorial. Without his help the presentation of this thesis would be deficient in many ways. I hope that the finished work is some reward for his supervision. I would further like to extend my best wishes to the Rogerson family.

The School of Graduate Studies at Memorial provided funding through a two year graduate assistantship and further financial assistance was provided indirectly by Energy, Mines and Resources Canada Research Agreement no. 283 and N.S.E.R.C. Operating Grant no. A 6105. Northern Sciences Training Grants also covered expenses for two field assistants, Dorothea Weyenberg and Lloyd St. Croix.

I am grateful to the Department of Geography at Memorial for the provision of facilities on campus during my two year stay at the University. Gail and Glenda always offered courteous service in the Department's general office and the Cartographic Laboratory gave advice and assistance in the preparation of the figures and maps in the text.

My typist Jeannie Hiscock of the Earth Science Department had the most difficult task of deciphering my handwriting.

The exhausting fieldwork undertaken in the Torngat Mountains during the summer of 1983 was a great success mainly due to the hard work of my principal field assistant Lloyd St. Croix. His enthusiasm and initiative were surpassed only by his patience and humour in what were often far from comfortable working conditions. Messrs. Hazen

Russell, Dave Branson and Bill Ritchie also contributed to a congenial atmosphere around base camp when the going got rough! To all I extend my best wishes.

Bruce Ryan and the E.M.R. party at Saglek Fiord provided invaluable logistical support for our field party while in northern Labrador. Petro Canada Exploration Inc. provided helicopter flight time in leaving the field. Wayne Tuttle of E.M.R. was of great assistance during preparations at Goose Bay.

Dr. A. S. Dyke of the Geological Survey of Canada offered helpful advice during initial air photo interpretation and Dr. R.N.W. DiLabio of the Terrain Sciences Division in Ottawa kindly undertook geochemical analysis on till samples collected in the field. Thanks also to Dr. P.W. Birkeland of the University of Colorado and Peter Clark of the University of Illinois for useful comments in personal communications.

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INTRODUCTION

The Torngat Mountains of northern Labrador have been the focus of much speculation and theorization in Quaternary science over the last century. Elaborate models of glacial style have been suggested at various times but none have gained disciplinary credibility due mainly to a shortage of detailed field work and a paucity of unequivocal evidence in support of particular standpoints. Nonetheless researchers are in agreement as to the importance of the mountain range in the reconstruction of former ice-sheet configurations in the eastern Canadian Arctic. This has been nurtured by a favourable coastal location and an adjacency to the Labrador-Ungava ice dispersal centre.

Until very recently detailed field research throughout the range has been scarce and the palaeoclimatic and glaciological implications of the Torngat Mountains have largely eluded Quaternary scientists. It has been discovered in isolated cases, for example Andrews (1963), Loken (1962a and b), Clark (1982 and 1984a) that close scrutiny of the surficial deposits and landform assemblages in localized situations uncovers a wealth of information pertaining to regional and local ice dynamics. Although absolute dating of events proves most frustrating throughout northern Labrador, morphochronological inferences can be made on a local scale by the application of selected relative dating techniques.

A hitherto unsurveyed area to the south of Nachvak Fiord, the Selamiut Range, was chosen for this study as it includes the highest summits in the Torngat Mountains and contains the largest of present day Labrador glaciers. These latter features constituted the more salient elements as the area thus displays some potential for hosting large local ice masses during continental glaciation. The adjacency of Nachvak Fiord also introduced the additional complications of regional ice moving from central Labrador-Ungava eastward to the sea.

CHAPTER 1 PAST RESEARCH IN NORTHERN LABRADOR

(i) Glacial Styles and the Inundation Debate

Work by Daly (1902) and Coleman (1920) initiated the construction of a morphochronological framework for the glacial history of the eastern Canadian arctic based upon observations made in the Torngat Mountains. They concluded that a wide occurrence of high altitude felsenmeer spreads and the presence of distinct upper limits to glacial landforms in the area were attributable to a restricted glacial style. They maintained that during the last glaciations glacier ice moved only along the major through-troughs in the Torngat Mountains. Nunatak areas existed where plateaus and peaks rose above the limits of regional and local ice masses. Further support for this standpoint came from Fernald (1925) who used the "nunatak hypothesis", originally applied in Scandinavia, to explain disjunct plant species on high summit areas.

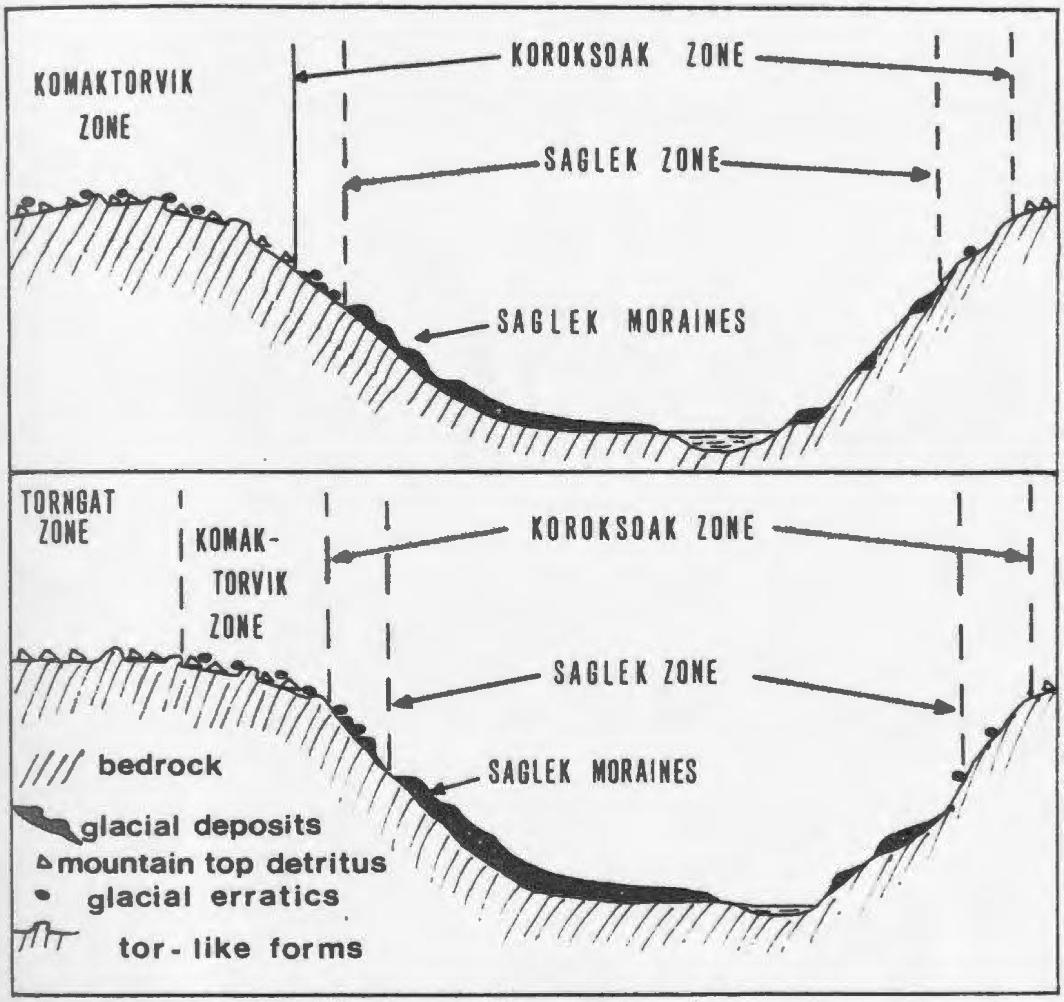
Refutation of the theory and a contradictory model came from British mountaineer and geologist N.E. Odell in 1933 and 1938. On the questionable evidence of poorly-preserved striations on certain Torngat summits Odell suggested glacial inundation during the last glaciation and post-glacial felsenmeer development. Further refutation of Daly and Coleman's work came from Tanner (1944), who uncritically accepted Odell's observations, and Flint et.al. (1942). This school of, what was later termed, "the maximum Wisconsin viewpoint" (Ives 1978) gained considerable impetus from the monumental work of the greatly-respected Flint (1943, 1947, 1957, 1959 and 1971). The dominance of the viewpoint began to wane however with the reports offered by Ives (1957, 1958a and b, 1960, 1963, 1966, 1974, 1975 and 1978) on fieldwork undertaken throughout the eastern Canadian arctic and more specifically in the Torngat Mountains themselves. After gaining the support of Loken (1962a), Ives virtually reinstated the "minimum Wisconsin viewpoint" that had been prematurely refuted three decades earlier.

To defend his standpoint Ives introduced the theory of "weathering zones" to explain field observations made in the Torngat Mountains. These weathering zones are defined by the varying degrees of weathering of surface material and associated glacial landforms; Ives (1958a and b, 1960, 1963 and 1978), Loken (1962a), Andrews (1963), Tomlinson (1963) and Johnson (1969). Since the conception of the theory it has been adopted on Baffin Island by many workers, including Loken (1966), Ives (1966, 1974), Pheasant and Andrews (1973) and Andrews (1974) and has been elaborated theoretically and practically by Birkeland (1974), Dyke (1977, 1979), Colman (1981), Colman and Pierce (1981) and Dyke et. al. (1982).

Ives's weathering zone identification (Figure 1-1) was the theoretical conclusion of considerable localized fieldwork and he summarized a plethora of research reports on Labrador in 1978. From this summary the most important diagrams in the context of this thesis are sections A, B and C in Figure 1-2. Ives identified an upper, oldest and unglaciated zone, the Torngat. This was assumed to have remained ice-free during the Wisconsin and was tentatively correlated to"zone I" of Boyer and Pheasant (1974)[1]. The lowest and most recent zone, the Saglek, was interpreted as containing Late Wisconsin glacial

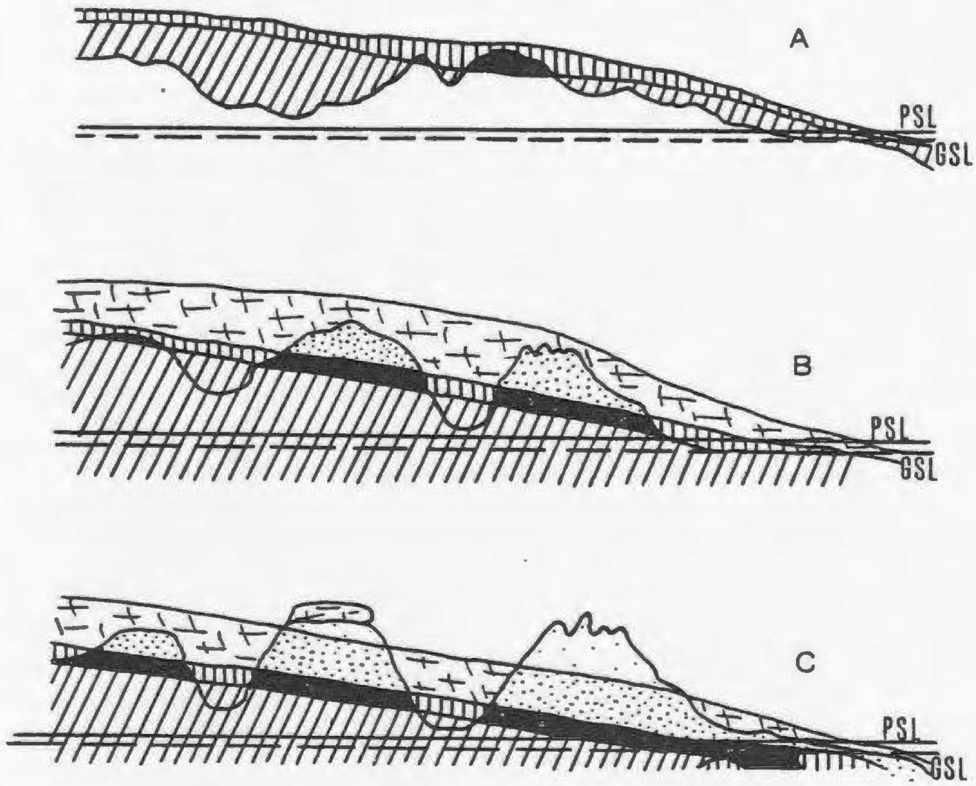
FIG.1–1 'The critical significance of the Koroksoak/Komaktorvik transition'

SOURCE; IVES (1978)



schematic cross sections of glacial troughs; upper for south Torngats; lower for central Torngats.

Fig 1-2 Weathering Zones – Theoretical Applications



PSL - present sea level GSL - glacial sea level

- ice at max. of last glaciation
- " " " " penultimate glaciation
- Koroksoak weathering zone
- Komaktorvik " "
- ice at max. of Komaktorvik glaciation
- Torngat weathering zone

A Nain - Okak section
B Nachvak "
C Inugsuin - Eclipse "

from Ives (1978)

evidence perhaps even evidence pertaining to the whole Wisconsin period. An intermediate, Koroksoak, zone was loosely associated with pre-Wisconsin glaciation. Where erratics were found on summits with similar weathering characteristics to the Torngat zone, Ives (1966, 1974, 1975 and Ives et. al. 1976) suggested a fourth zone; the Komaktorvik. This zone encompassed a collection of summits thought to have received erratics from a more extensive pre-Wisconsin glaciation. Loken (1962a) was somewhat sceptical of the so-called "erratics" and preferred a derivation from the weathering-out of inclusions.

The maximum viewpoint received a renewed impetus in the 1970's from Sugden (1974, 1976 and 1978) and Sugden and Watts (1977) which was staunchly pursued by Denton and Hughes (1981). Sugden's theoretical model of selective linear erosion for the Laurentide ice sheet credited a possibility of total ice inundation during the Wisconsin. An overdeepening of glacial valleys by active warm-based ice and the protective blanketing of intervening plateaux by cold-based, inert ice, with the possible emplacement of erratics, was regarded as feasible. Ives (1978) regarded the hypothesis as theoretically acceptable provided the post-glacial (Holocene) development of felsenmeer was not suggested.

The concept of weathering zone boundaries representing thermal regime differences within a continental ice sheet, as suggested in Sugden's model, was refuted by Grant (1977) when he considered the presence of ice marginal moraines. Since that date, however, Grant (1981) has reconsidered his stance and suggested that some low lying areas in maritime Canada, previously identified by him as unglaciated during the Late Wisconsin, were in fact covered by cold-based ice.

Footnote;

1. Boyer and Pheasant (1974) identified three weathering zones in the Maktak/Narpaing Fiord area using several weathering characteristics. The lowest zone in altitude, Zone III, was thought to contain evidence of glaciation from >5,000 B.P. to <110,000 B.P. Zone II was suggested to be stratigraphically older and contained morphostratigraphic units. Zone I lacks any such units and was characterized by mature felsenmeer, tors and weathering pits.

(ii) Localized Case Studies

After the pioneer research by Daly, Coleman, Odell, Tanner and Flint, the earliest detailed studies in northern Labrador included the definition and delimitation of the lowest or most recent weathering zones and glacial landforms. During his areal reconnaissance of the Torngat Mountains in 1957 and 1958 Ives identified the "main kame terrace-lateral moraine complex" as the boundary of the Saglek and Koroksoak weathering zones in the Nakvak Valley, Saglek Fiord. Ives later traced this feature throughout the southern Torngat Mountains (Figure 1-3).

Loken (1962a and b) working in the northern half of the range recognized three weathering zones but found no coincident lateral moraine complex that might represent the Saglek level identified further south by Ives. Loken proposed a localized late glacial and post glacial chronology based upon moraines and strandlines in the vicinity of Telliaosilk and Noodleook Fiords, Eclipse River and Two Loon Lake (Figure 1-4). Using an isobase map constructed from strandline altitudes, Loken suggested that deglaciation from the Late Wisconsin maximum was complex and involved several readvance phases.

Much further south Andrews (1960, 1963) identified possible Saglek moraine correlatives[1] and a lateral moraine-kame terrace system in the valleys leading to Okak Bay and an end moraine complex encircling Umiakoviarusek Lake (Figure 1-5). The latter was named the Tasiuyak moraine by Andrews and assigned a more recent date than the Saglek moraines. Johnson (1969) confirmed the existence of the younger morainic system in the Port Manvers Run - Southern Kiglapait Mountains

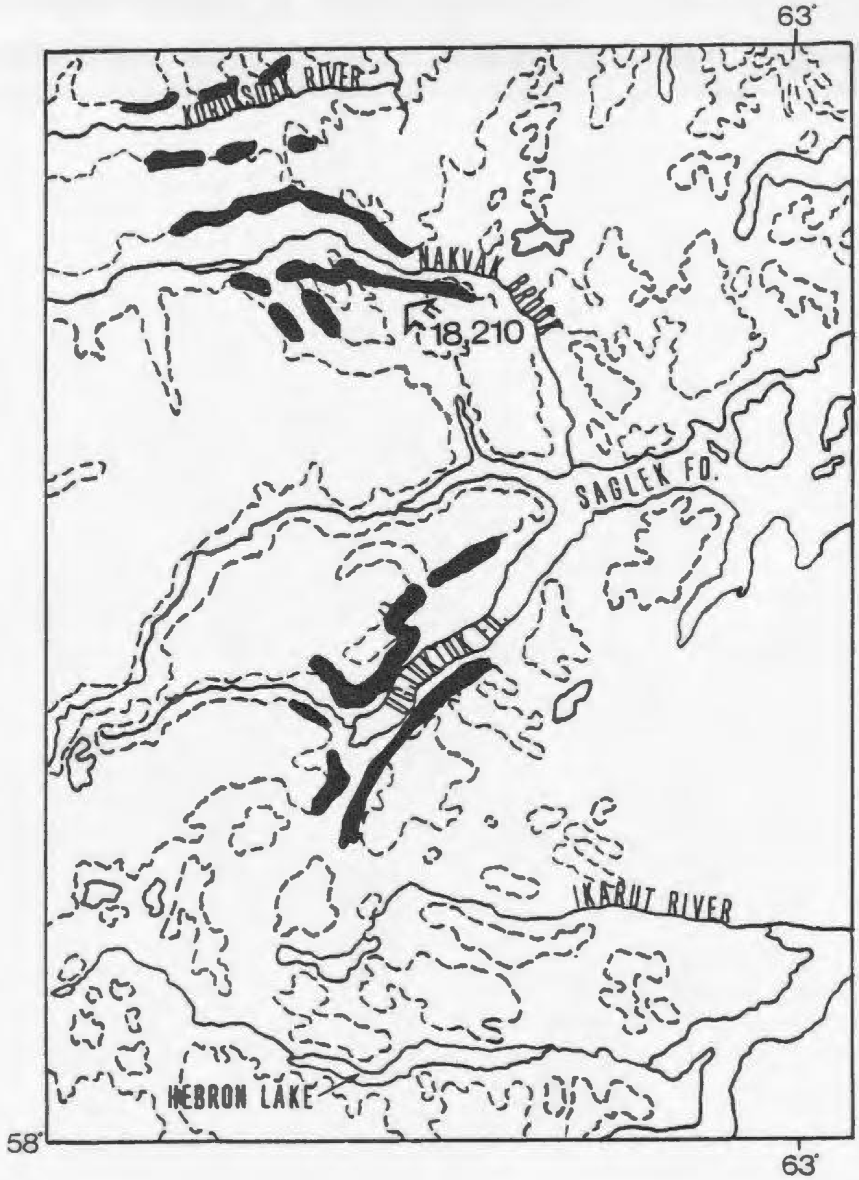
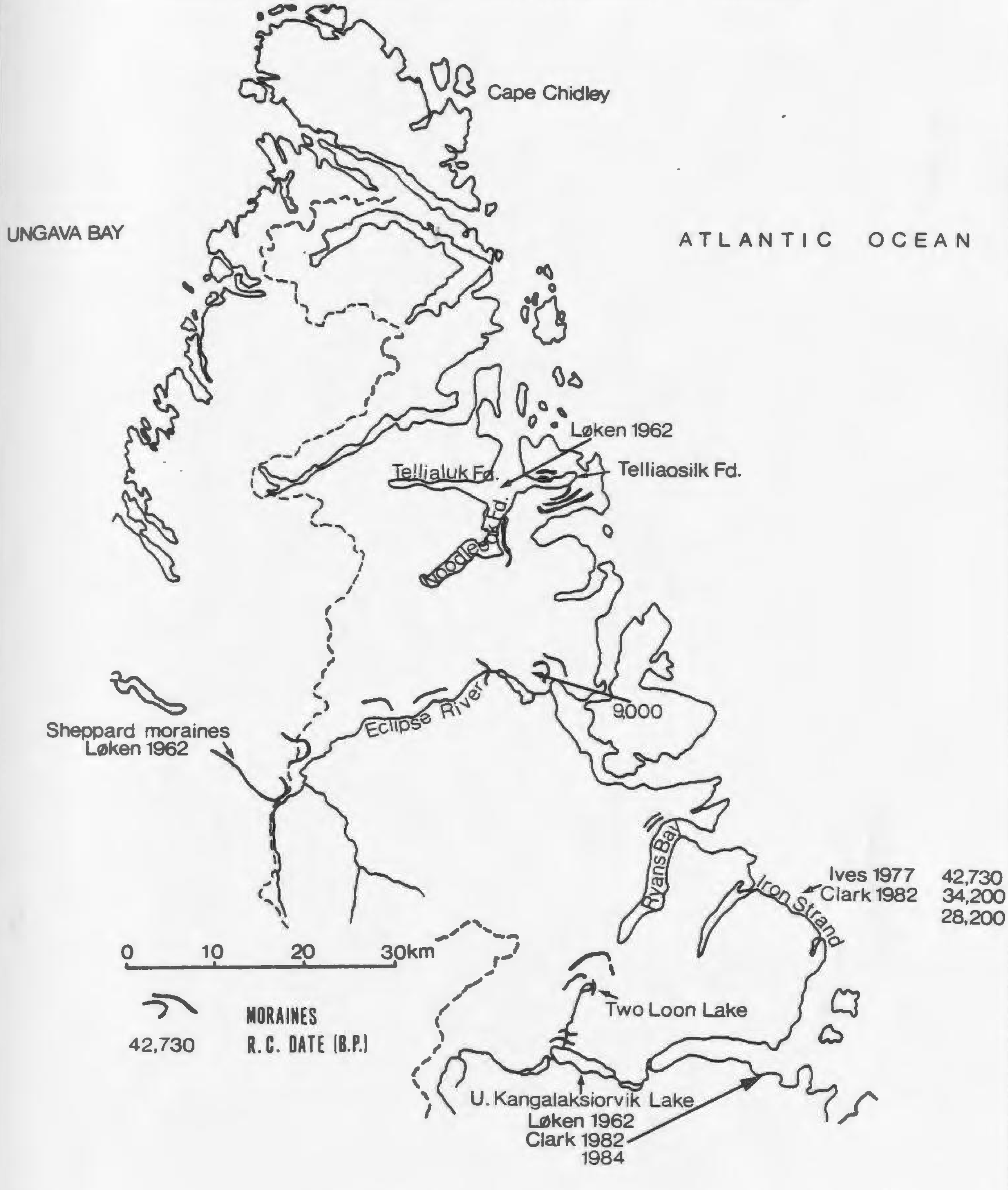


Fig. 1-3

SAGLEK FIORD AREA
Ives 1976

SAGLEK MORAINES
610M CONTOUR
R.C. DATE -
SHORT ET AL. 1981

FIG.1-4 LOCALISED RESEARCH IN NORTHERNMOST LABRADOR



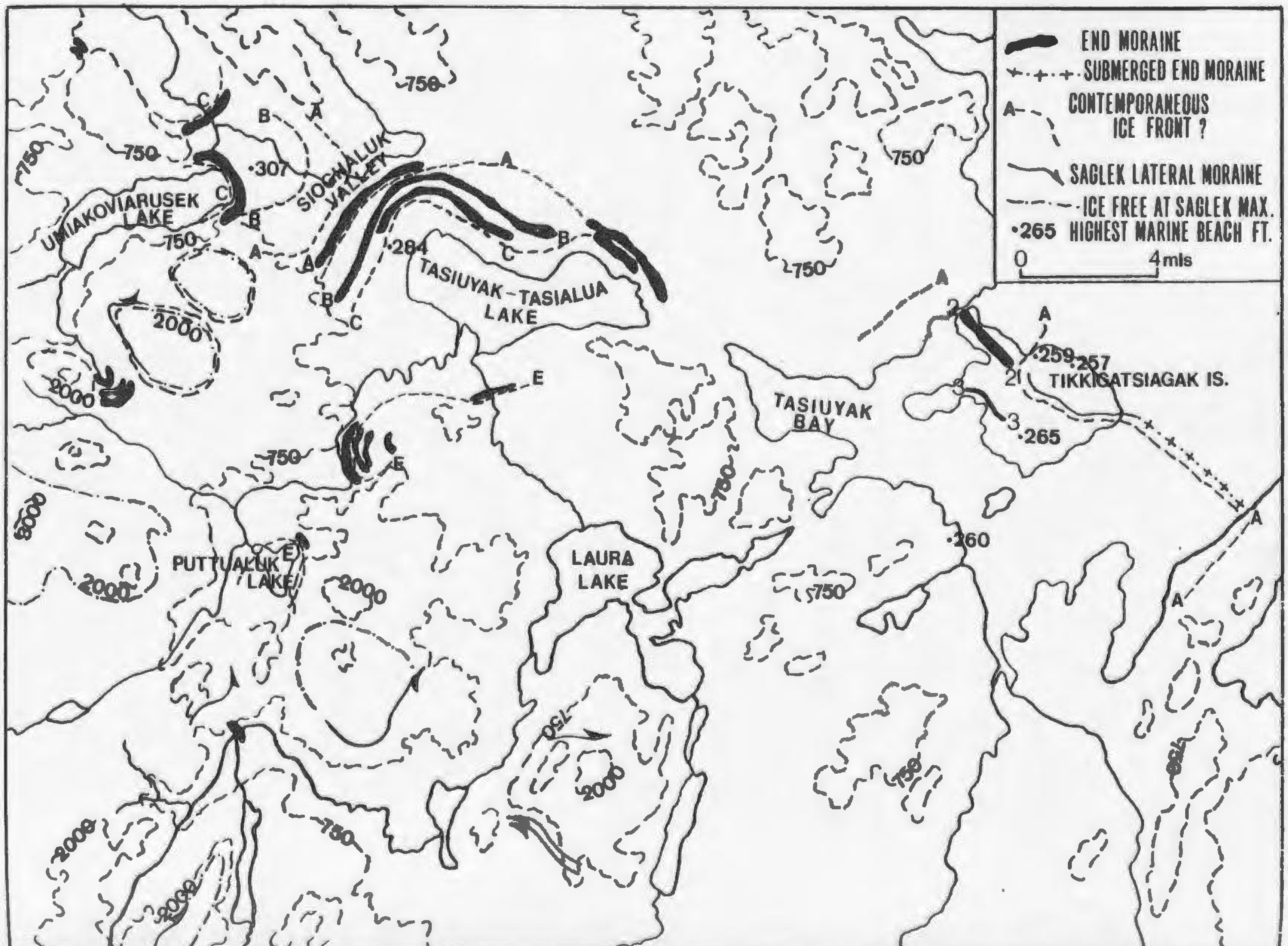


Fig. 1-5 NORTHERN NAIN-OKAK
ANDREWS
1963

area. This work further south attested to the complex deglacial chronology suggested by Loken (1962b) and Andrews (1963).

Following the recovery of ancient mollusc shell fragments at Iron Strand by Ives (1977), Clark (1982) undertook comprehensive fieldwork from the coast westwards to the Two Loon Valley, examined in less detail by Loken (1962b). From the coastal stratigraphy Clark suggested that Iron Strand had remained ice free since the middle Wisconsin and recognized the lateral moraine—outwash complex just short of Ryan's Bay as the Late Wisconsin maximum (Figure 1-4). Clark (1984b) later modified his supposed ice limits in a paper based on a marine limit outside an undated moraine at the mouth of Kangalaksiorvik Fiord (Figure 1-4). Using calculated basal shear stresses for the former ice sheet in the area Clark suggested that ice extended through Kangalaksiorvik and formed an ice shelf at the coast. Since this work lies closest to the present field area it will be described and discussed in greater detail later.

Cirque glacier dynamics in the vicinity of the Selamiut Range during deglacial and Holocene times have been investigated by McCoy (1983). Using lichenometry McCoy postulated several Holocene/neoglacial periods of moraine construction and abandonment below Cirque Mountain (see Surficial Geology Map for location) and tentatively assigned a Late Wisconsin date to the outermost moraines within the bowl of cirques overlooking the McCornick Valley. These conclusions verify earlier suggestions of active cirque glaciers throughout the postglacial; Andrews (1963), Tomlinson (1963), Johnson

(1969) and Clark (1982).

Footnote;

1. The heights of Ives's Saglek moraines were approximately 610 m. Andrews documented a height of 515-700 m for his correlatives, while Johnson records 460-700 m.

(iii) Existing Chronologies

After the recognition of three altitudinally-arranged weathering zones on Baffin Island by Ives (1966, 1974 and 1975), Pheasant and Andrews (1973) and Boyer and Pheasant (1974) there was considerable progress in the development of an absolute chronology by Andrews et. al. (1975) and Andrews and Miller (1976). Baffin Island zone III, the lowest in altitude, was regarded as a loose correlative of the Saglek zone in the Torngat Mountains on morphochronological grounds by Ives et. al. (1976). Furthermore Ives (1976) concluded that the Saglek moraines represented the highest stand of glaciers at the Wisconsin glacial maximum in the area. A date obtained from fresh water fauna in a lake dammed by the Saglek moraine south of Nakvak Brook suggests that it might be as young as 18,000 B.P., Short et. al. (1981), Figure 1-3.

In the northern Nain-Okak section of the Labrador coast Andrews (1963) suggested that the Saglek moraine correlatives dated either from the last major glaciation at around 25ka. B.P. or from a late glacial substage. Deglaciation from the Saglek level was then interrupted by several glacial phases depositing, in chronological order, his Tikkigatsiagak Island moraines, the Tasiuyak - Tasialua moraines and the Umiakoviarusek moraines[1], (Figure 1-5). Andrews correlated his Tasiuyak phase with Loken's (1962b) Noodleook phase in Table 1-1. Johnson (1969) correlated certain deglacial phases in central Nain-Okak with events outlined by Andrews[2].

Loken (1962b) had similarly suggested a complex deglacial chronology after the margin of the Wisconsin ice sheet had withdrawn from the shelf to the present coastline. Several halts and readvances interrupted the late glacial and postglacial emergence of northernmost

Labrador. By correlating morainic features with four distinct strandlines along the coast Loken reconstructed the chronology in Table 1-1.

Table 1-1; Loken's chronology for northernmost Labrador.

Phase	Main moraine features	Strandline	Approx. elevation	Remarks	Relative/ absolute age
Noodleook	Telliaosilk, Noodleook, Base camp Moraines. At north end of Ryans Bay?	S.L.1	50M	Readvance phase	Oldest
Two Loon	Lower level in Eclipse Valley, Two Loon Lake	S.L.2(?)	45M	Readvance phase	
Kanga-laksiorvik	Two Loon Valley	S.L.3	30M	Readvance phase Transgression	9,000±200[3]
	Sheppard				
		S.L.4	15M	Transgression	Youngest

Prior to the 1970's the chronologies had remained largely relative and consequently localized. Under those circumstances cross correlation was extremely tentative.

In 1977 Ives recovered mollusc shells, yielding a date of 42,730 +6680 and -9970 B.P., from sediments at Iron Strand (Figure 1-4). Ives concluded that this part of the Labrador coast had not been covered by Saglek or Wisconsin ice. Clark (1982) verified the distal position of Iron Strand at the Wisconsin maximum and from one section obtained dates of 34,200 B.P. from a glaciomarine unit and 28,200 B.P. from an overlying bedded sand unit. He concluded that the former date represents deglaciation from the Labrador coast from 30-40 ka. B.P. and that the upper sand unit confirms the ice free nature of the area since that time.

At another location on the coast Clark found evidence of an early glacial episode in a fossiliferous silty till. Shell amino acid ratios compared favourably with those associated with Kogalu glaciation (>70 ka. B.P.) of Andrews et. al. (1981) on Baffin Island[4].

Clark assigned a Late Wisconsin or ≥9 ka. B.P. date to the lateral moraine-outwash complex in the Two Loon valley based upon pedological data. This complied with the date assigned to this system by Loken (1962b). Both workers suggested that this "Two Loon Phase" pre-dated the formation of the Sheppard moraines (Figure 1-4). Clark (1984) has more recently drawn the limit of the Late Wisconsin maximum (c.10 ka. B.P.) at the mouth of Kangalaksiorvik Fiord, with an associated marine limit at 55 metres.

McCoy (1983) focused on the glacial chronology from the Late Wisconsin to the present utilizing lichenometric and pedological data in the bowl of cirques below Cirque Mountain and at Upper Komaktorvik Lake. He concluded that glacial recession in the area occurred around <150,400, 550-750, 950, ≥1,850, >1,850, ≥2,800, >2,800, ≥4,000 and >> 4,000 years B.P. and correlated the last three phases with events on the Cumberland Peninsula of Baffin Island. McCoy further suggested that the moraines dating to >>4,000 B.P. may be equated to the Late Wisconsin maximum in the area.

Footnotes;

1. Positions A-A mark contemporaneous ice fronts at the maximum limit of the Tasiuyak readvance. The sea was 79m higher and excluded from the interior. An ice dammed lake was contained at the head of the Tasiuyak-Tasialua basin. Retreat and stillstand produced positions B-B and perhaps 2-2. There was a rapid retreat from A-A to 3-3.

The Umiakoviarusek moraine was deposited during the final phase of the glacial lake. Ice then retreated allowing the sea to invade the interior, (C-C). After retreat from this position another readvance deposited moraines E-E.

2. Deglaciation in central Nain-Okak according to Johnson was in five stages:

I. The maximum advance of the most recent glaciation or Koroksoak. Kiglapait Plateau and Kiglapait Mountains were ice free at end of step I; IIA. The maximum extent of the Saglek glacial equivalent; IIB. Loosely correlated with Andrews's Tasiuyak Phase; III. Might be synchronous with Andrews's E-E phase above; IV. Intensification of ice-wasting leads to extensive kame terrace construction. Isostatic rebound well advanced; V. Stagnant ice in low lying areas prevents marine incursion. Thus highest shorelines are found on outer coast.

3. Absolute date is from shells at 29m above sea level and is not related to a specific sea level. It is correlated with moraine system at northern end of Eclipse Channel.

4. Andrews et. al. had concluded that the shells collected at Iron Strand by Ives (1977) were correlated to the Kogalu Member of the Clyde Foreland Formation of Miller et. al. (1977).

CHAPTER 2 OBJECTIVES AND TECHNIQUES

(i) Objectives

The realization of a field study of this nature relies largely upon the suitability of the techniques involved. In an attempt to compensate for restrictions imposed upon certain techniques by the nature of local environments, objectives must remain suitably flexible.

The broad objectives of this study are:

1. The production of a surficial geology map for the Selamiut Range including the mapping of all landforms.
2. A determination of the roles of regional and local ice movement in the area from the demarcation of former ice margins and the identification of possible weathering zone correlatives.
3. The reconstruction of a glacial chronology for the Selamiut Range and part of Nachvak Fiord based upon absolute and relative dating techniques.

After analysis of the results obtained and the formulation of a relative chronology for the research area, the discussion will attempt to correlate Quaternary events in the Selamiut-Nachvak region with those postulated by previous workers in northern Labrador. This will to some extent fill in the ground area between Loken and Clark's research to the north and Ives's work in the Saglek area. Some similarities between the results of this study and work by Andrews and Johnson much further south will also be suggested. The contemporaneity of landforms and the synchroniety of glacial events throughout northern Labrador will be further estimated.

(ii) Techniques

In this section field and analytical techniques are discussed, their merits and deficiencies relative to this study explained and a justification for their adoption presented.

a) Mapping;

Before any fieldwork is undertaken air photographs and topographical maps must be consulted in order to establish the focus and intensity of field scrutiny. Although the present topographical mapping of the Selamiut Range is only preliminary, air photographs for the area are adequate and so logistical preparation was relatively thorough.

Prior to fieldwork 1:50,000 scale maps were enlarged to 1:25,000 and used to demarcate landforms and surficial units from the examination of the air photographs. Information was then either verified or altered according to accuracy during and after the field season. During the final analysis of data and the drafting of the major surficial geology map the air photographs were used as a constant reference for determining the accuracy of landform/sediment classifications.

Such classifications were essentially the product of a combination of the air photograph interpretation and ground-truth traversing. The latter involved the coverage of much of the Selamiut Range on foot to enable a closer scrutiny of landforms identified on the air photographs and the recognition of less distinct morphological units that were overlooked during air photograph interpretation. Covering such a large area on foot also enables the sampling of certain surficial deposits. This is not only critical for certain analytical techniques outlined below but is also a valuable component in the classification of landforms.

b) Pedological dating of glacial landforms;

The recognition and mapping of glacial landforms enables the development of a model of ice styles. Concurrently, a chronological framework must be constructed to determine the succession of glacial events in an area. Absolute chronologies are difficult to construct throughout the eastern Canadian Arctic due to a dearth of organic rich stratigraphic units. As a result alternative, relative, chronologies must be constructed. The dating of surficial units, more specifically moraines, by the differential extent of pedogenesis has been widely adopted in chronological reconstruction.

Birkeland (1974) outlined the use of soil development in Quaternary studies. In 1978 he appl. .' soil parameters to the relative dating of localized glacial events on Baffin Island. A chronosequence of soils on moraines on the Cumberland Peninsula was constructed by Evans and Cameron (1979). These studies involved considerable laboratory analysis but it has been concluded by several workers especially Clark (1984a) and McCoy (1983), in areas adjacent to this study, and Birkeland (pers. comm.) that field observations such as depth, horizonization and colour suffice for relative dating. These data were collected from soil pits excavated on the moraine crests of the field area. Further pits were excavated on till sheets and major terraces to assist in the analysis of soil development on different surficial units and to avoid the construction of a subjective chronology based upon moraine crest soils alone; (see Location Base Map for siting of soil pits).

Pits were dug, where possible, to below the Cox horizon in order to record the absolute depth of weathered regolith. Identification and measurements of the soil horizons were made to the nearest centimetre and colours described wet using the Munsell Soil Colour Chart.

The only laboratory analysis undertaken on the samples collected in the field was to obtain a pH value for each horizon. Particle size, chemical and mineralogical analyses were avoided as they involve time consuming procedures and have achieved only limited success in past work on pedological dating.

A Colour Development Equivalent (C.D.E.) was developed by Buntley and Westin (1965) and involves a calculation using the values of hue and chroma where hue is expressed as follows; 10R=7, 2.5YR=6, 5YR=5, 7.5YR=4, 10YR=3, 2.5Y=2 and 5Y=1. These values are multiplied by the chroma value to obtain a numerical notation of oxidation.

c) Lichenometry;

The use of lichen size as a measure of age of recent moraines was initiated by Beschel (1950). Since that time lichenometric dating has been employed exhaustively in the determination of glacial fluctuations in the Late Holocene. In a more recent synthesis Locke et. al. (1979) state that lichenometry may be used to either;

"1. correlate substrates on the basis of lichen size or cover (relative dating and correlation), and

2. to date surfaces by converting lichen size to age via a lichen growth curve".

The lichen "Rhizocarpon geographicum sensu lato" ("in a broad sense" so as to avoid misidentification) was used in this study. Therc are three reasons for the popularity of the species in most research involving lichenometric dating; its ubiquity in the polar/alpine environment; it is an early colonizer of fresh rock surfaces; it grows slowly.

Sampling procedures were undertaken along the lines documented by Locke et. al. (1979). The technique involved in relative dating and correlation requires a twenty minute search of each moraine to find the largest Rhizocarpon geographicum. Comparisons are made between the diameter sizes obtained in this study and those found by McCoy (1983) in an adjacent area.

McCoy's (1983) lichenometric dating in the bowl of cirques and Cirque Lake below Cirque Mountain was the first undertaken in northern Labrador. As a result McCoy had to rely upon a lichen growth curve from Baffin Island, (Miller and Andrews 1972), for dating control. McCoy's lichen growth sites at Cirque Lake were visited and photographs were taken to enable later photogrammetric analysis[1].

McCoy reconstructed a relative glacial chronology for the bowl of cirques/Cirque Lake area by recording the dimensions of the largest lichen thalli from each moraine. This simple procedure was attempted in the Selamiut Range but was found largely unsuitable. McCoy's research area was ideal for such a study mainly due to the comparatively open nature of the bowl of cirques and the preservation of the moraines. Throughout the Selamiut Range the cirque glaciers are rather more isolated and their outlet valleys bounded by precipitous cliffs. These factors, combined with the rapidly weathered nature of the bedrock in the area, contribute to active screes and regular rock avalanches. Consequently many moraines have been modified to protalus ramparts. Therefore lichenometry may date the termination of rock fall rather than moraine abandonment.

Despite the unsuitability of the techniques for relative dating in the Selamiut Range a further lichen growth station was established at 915m below Minaret Glacier. McCoy's lichen growth station at Cirque Lake was at 457m. These two sites may well prove critical in the establishment of lichen growth curves at higher altitudes in the low Arctic.

d) Geochemistry

A number of till samples were collected in the field area and the sample sites are included on the Location Base Map at the back of this thesis (Figure A3). Samples were collected either from freshly exposed sections or from the unweathered lower horizons of certain soil pits.

All the samples were sent to the Geological Survey of Canada in Ottawa for geochemical analysis. The samples were analysed for base metal and uranium content. Atomic absorption techniques were used to gain measures of copper, lead, zinc, cobalt, nickel, chromium, manganese and iron and colourimetric and fluorimetric methods were used to obtain data on arsenic and uranium respectively. Together with providing information on the economic geology of the field area it was hoped that the data might reveal information on the former dominant ice flow directions in the Selamiut Range/Nachvak Fiord area.

Footnote;

1. Negatives of the slides taken in the field were enlarged until the lcm square scales, used in 1978 by McCoy and in this study, overlay each other exactly. The lichen perimeters were then traced from the resulting prints of the lichens and their mean diameters obtained using a "Hi-State" Precision Coordinate Digitizer.

CHAPTER 3 THE FIELD AREA

(i) Orientation

The Selamiut Range is aligned approximately north-northwest to south-southeast and situated imm..diately south of Nachvak Fiord in the south central Torngat Mountains. As is the case along the entire northern Labrador coast, the mountains are essentially a dissected plateau. An ancient, certainly pre-Wisconsin, glaciation was responsible for the cutting of deep troughs and fiords by outlet glaciers or selective linear flow of a Laurentide ice sheet.

Local and regional ice movements possibly postdating the formation of Nachvak Fiord and other major troughs have sculptured the Selamiut Range creating a deeply fretted mountain landscape that possesses the largest contemporary ice bodies on the eastern mainland of North America.

The Selamiut Range (see Figure A-3 in wallet) is isolated by three distinct physical features and a political boundary; Nachvak Fiord to the north; Tallek Arm to the west; the McCornick Valley to the east; and the Quebec - Newfoundland border to the south. The latter is drawn along the divide between Ungava Bay and Labrador Sea drainage and over the highest summit of both provinces, Mount Caubvick (1,738m)[1]. Base camp in the summer of 1983 was established at Ivitak Cove in the northeast of the field area. Most work was conducted out of base camp although several light camps were set up during the extensive traversing of the area.

Footnote;

1. Caubvick is one of the few official names in the Selamiut Range. The majority of names used in this study have been adopted purely for ease of reference.

(ii) Geology and General Surficial Units[1].

The geology of Nachvak Fiord has been mapped by Taylor (1979) and Wardle (1983). The complexities of the metamorphic rocks of the Selamiut Range are known, however, only on a preliminary basis.

With the exception of late sills (<1.8Ga) on Idyutak Mountain and at Eskimo Cove the dominant rock types in the Selamiut Range are anorthosites and gneisses of Archean age. The field area lies entirely within the Churchill Inner Zone as defined by Wardle (1983) and geological strike is dominantly south-east to north-west. The McCornick Valley is parallel to and may be the physiographic expression of the boundary between the Churchill Inner Zone and the Churchill Border Zone.

Wardle (1983) has introduced the term "Nachvak gneiss" for the granitoid gneisses of the area which are present throughout the western portion of the Churchill Border Zone. Within the Churchill Inner Zone the Nachvak gneiss contains a 5 km wide body of anorthosite which represents the dominant rock type for the eastern half of the Selamiut Range. On the northern shore of Nachvak Fiord the anorthosite begins a northerly plunge under the Nachvak gneiss.

Of some importance in this study is the susceptibility of these rock types to weathering processes. This is especially the case in a low Arctic environment of considerable altitudinal diversity. Felsenmeer spreads may develop over relatively short periods of time and vast numbers of inclusions weather out in situ, rendering the identification of higher altitude weathering zones extremely tentative.

Local till displays varying degrees of grusification the greatest extent of which is observed at higher altitudes. Younger tills in the lower valleys contain exposed boulders with extensive micropitting and minor surface disintegration. Such weathering characteristics would be attributed to very old glaciated terrain using Dyke's (1979) weathering scale.

The implications of such rapidly weathered bedrock have been mentioned in the techniques section of Chapter 2. Further implications to the surficial geology of the area are considerable especially in the cirque basins and high altitude valleys where rock falls and screes are highly active and fresh material is being continually exposed.

The major surficial units consist of residuum (felsenmeer), scree and colluvium, till and moraine, and outwash deposits. Residuum blankets the upper plateau and descends the gentler slopes of the area to relatively low altitudes. Intensive periglacial processes are manifest in many landforms, the development of some landforms reflecting the undulations of the felsenmeer blanket. Well-developed patterned ground on the level summit plateaux changes into cryoplanation deposits, altiplanation terraces and nivation hollows which, in turn, give way to extensive solifluction sheets and lobes on the lower slopes.

Screes or talus slopes are extremely active throughout the Selamiut Range, due to the (aforementioned) rapidly weathered bedrock of the area, and constitute a large proportion of the surficial deposits. In many cases these screes mask and often modify glacial landforms and, therefore, impede landform classification. Most moraines and outwash units are discernable however especially in the lower valleys and in the Idyutak Pass/Ivitak Rigg area. It is in the latter area and the adjacent Ivitak/McCornick valley confluence, that glacial activity is best documented in the geomorphological evidence. The classification and mapping of surficial units will be discussed further in Chapter 4.

Footnote;

1. A unit refers specifically to a distinct ground surface sediment/drift assemblage.

(iii) Physiographic Regions

Three broad physiographic regions have been identified for the Selamiut Range: a) the fretted mountain summits and felsenmeer plateaux; b) the upland cirques and outlet valleys; c) the lower valley. As these classifications are not inclusive of every square kilometre of the research area a cartographic reproduction of the regions, defining absolute limits, is not presented. For example at many localities the broad physiographic regions are connected by quite extensive lower mountain shoulders and slopes. The zonal classifications are defined, however, as follows;

The fretted mountain summits and felsenmeer plateaux form the central block of the field area (Plate 3-1). They survive as residuals to the local incision of cirques. From Ivitak Valley south this is the dominant landscape where steep rock walls are both produced by and through shading do facilitate the survival of small cirque glaciers. North of Ivitak Valley the mountain and felsenmeer plateaux topography is restricted to the only summits in the area, Idyutak and Mesa-Top Mountains.

The upland cirques of the area have been distinctly cut into an upland surface of erosion or peneplain, one of many observed in northern Canada by a number of researchers and documented by Bird (1967). Ambrose (1964) considered the present topography of the north-east coast of Labrador to be the product of an exhumed paleoplain of pre-Paleozoic age that had been substantially modified by glacial erosion. Coastal remnants of a former peneplain surface in the Torngat

Mountains at over 1500 metres are considered by Bird (1959 and 1967) to be associated with a warped, exhumed surface in the George River basin rather than a block-faulted fragment of a larger Labrador-Ungava peneplain that was uplifted during the Tertiary.

The products of later Pleistocene glaciation are the spectacular fiords and cirques. Collectively a major component of the physiography of the field area, the upland cirques are connected to the lower valley by a series of smaller outlet valleys (Plate 3-2). To the south of Ivitak Valley these outlet systems are bounded by steep rock walls and are characterized by dynamic scree accumulations. In the north however the cirque bowls possess a more open aspect due to the coalescing of larger ice bodies during glaciation.

The lower valley topography is by far the least represented by area in the Selamiut Range but is nonetheless critical in the reconstruction of the geomorphological history of the region. This topographic unit includes the McCornick River valley and the lower half of Ivitak Valley. These may be further subdivided as the former aligns with the structural trend of the area. Ivitak valley has been modelled by more recent glaciation and is aligned tranverse to geological structures, similar to the central upland cirque valleys.

Plate 3-1; Landscape typical of the fretted mountains and felsenmeer plateaux.

Plate 3-2; A cirque outlet valley below the summits of Selamiut Tower and Gneissberg.

CHAPTER 4 RESULTS

This chapter will deal specifically with the presentation of tabulated data, the cartographic reproduction and diagrammatic formulation and the overall analysis of research observations. The construction of a localized chronology and regional correlations will be dealt with under separate chapters.

The opening section of this chapter will deal with the definitions of units represented on the Surficial Geology Map (Figure A-4). This will then be followed by a description of the major evidence from moraines and associated landforms. Evidence for strandlines and beach levels and the deposition of water lain deposits will then be presented. The following sections are then devoted to the results of pedological analysis, lichenometry and geochemistry.

(i) The Surficial Geology Map

The Surficial Geology Map (Figure A-4) is enclosed in the wallet at the back of this thesis. In addition to surficial units, landforms are also represented. To avoid unnecessary cluttering, inferred glacial limits have been drawn on the Location Base Map (Figure A-3) which further includes sample siting.

Based largely on the style of presentation by Dyke et. al. (1982) on Baffin Island, nine surficial units are recognized for the Selamiut Range: bedrock, residuum/felsenmeer, till and moraine, supraglacial till, emerged marine deposits, glacier-dammed lake deposits, inactive alluvium, active alluvium, and colluvium or scree. The limits defined on the map are often gradational as surficial deposits in the area rarely display distinct boundaries especially when mapped at a scale of

1:25,000.

(a) Bedrock

Areas defined as bedrock are typified by scoured bedrock, in many locations overlain by glacially-transported boulders and a thin till cover lining natural hollows. In some areas bedrock outcrops as slopes too steep to facilitate the development of residuum or the deposition of till. The precipitous cirque backwalls, arêtes, gendarmes, hornes and outlet valley cliffs are included in this category.

The deep incision of the Selamiut Range by active cirque glaciers, probably throughout more recent glacial history, is the fundamental reason for the dominance of bedrock as a surficial unit. Ice scoured bedrock and ice moulded topography are more characteristic of the northern half of the Selamiut Range where roche moutonnées, whalesbacks and striated bedrock outcrops are prominent features. To the south bedrock of the deeply dissected terrain dominates.

(b) Residuum

Residuum is predominantly felsenmeer with interstitial grus on most summits and all summit plateaux. Continued activity is suggested by tombstone forms at various stages of erection. Individual felsenmeer blocks may approach $1m^3$ on steeper summit slopes. The less active felsenmeer blankets of the level plateaux display extensive sorting into polygons and circles. These features are often over 2 metres in diameter with up to 0.5m depth of fine sediment in their centres. The patterned forms become elongated with small increases in slope angle.

On only a few broad summits tors or castellated rock outcrops have developed up to a height of approximately 3 metres. At the lowest edges of several felsenmeer blankets, especially in the north of the field area, grusified till is included in the classification of this surficial unit. Active periglacial landforms such as altiplanation terraces, patterned ground, nivation hollows and stone banked solifluction lobes are abundant and the underlying topography has been subdued by weathering processes (Plate 4-1).

(c) Till and moraine

The till and moraine unit includes material generally greater than one metre thick lining both the low valley and upland cirque outlet valleys. At the margins of contemporary ice bodies considerable depths of material are present in morainic landforms. In some locations bedrock outcrops as roche moutonées or ice moulded landforms. Beneath the steeper cliffs of the area active screes have been deposited as protalus ramparts, essentially modifying many moraines. Moraines in the lower McCornick Valley have been subdued due to inundation by proglacial lake water as will be discussed below. Material is generally matrix poor in the Selamiut Range with a wide size range of cobbles and an abundance of gravel. On the south shore of Nachvak Fiord a matrix rich diamicton, containing few rounded boulders, is exposed.

(d) Supraglacial debris

Sizable surface areas of the glaciers in the field area are covered, in most cases, with supraglacial debris. This material, which is presumably both englacial and supraglacial in origin, accumulates

Plate 4-1; The summit ridge of Mesa-Top Mountain displaying one of the few summit tors of the area (foreground) and a patterned felsenmeer blanket.

as a thin mantle often less than 50 cm thick with occasional medial moraines merging with ice-cored end moraine, illustrated by Superguksoak Glacier in the centre of the Selamiut Range, (Plate 4-2).

(e) Marine and ice dammed lake deposits

An area demarcated as containing emerged marine sediment was determined along Nachvak Fiord by a clear upper marine limit, marked by a bench, above which tills appear to be unmodified by wave action. The material below this limit ranges from wave modified till to beach sediments of sands, silts and clays. The bench was measured by altimeter at 32 metres a.s.l., east of Ivitak Cove and at 33 metres in the vicinity of Eskimo Cove.

Higher shorelines exist only in the McCornick Valley where they are interpreted as representing the water levels of former glacier-dammed lakes. Sediments deposited into these lakes include complex outwash/sandur material and laminated silts and clays which are exposed at the confluence of the McCornick and Ivitak Valleys.

(f) Alluvium

Inactive alluvium is principally cobble outwash and proglacial outwash gravels in the form of terraced and channelled sandar. There are several intermittently active alluvial fans composed of a wide range of material from sand to boulder gravel. In most areas this material has been deposited over several surficial units during more recent glacial/deglacial phases and even the post glacial.

The active alluvium of the study area is largely composed of seasonally flooded cobble outwash grading into gravel and sand material downstream. These deposits are occasionally present in some upland locations.

Plate 4-2; Superguksoak Glacier, its extensive cover of supraglacial till and complex end moraine (Stereopair).

(g) Colluvium

At the bases of the many steep bedrock cliffs of the area scree slopes are extensive features and remain highly active. Material ranges from coarse gravel to large blocks. In several locations large scale rock avalanches have obliterated the former morphology where blocks over $120m^3$ have fallen from bedrock cliffs. The largest rock fall in the field area is on the central section of the east facing side of the McCornick Valley. With a surface area of approximately 1 km^2 the avalanche debris has obliterated the glacial geomorphology of the central McCornick Valley and considerable material was deposited on the opposite valley slope during the catastrophic event. Another smaller but still quite considerable rock avalanche, measuring approximately 0.25 km^2 in area, masks any glacial landforms above Selamiut Force.

The vegetational colonization of the low angled sections of several lower valley scree slopes suggests that they are relict features. Many lateral moraines have been extensively modified by the construction of protalus ramparts at the bases of highly active rock-glacierized screes. As a result many contemporary protalus ramparts are assigned a morainic status on the surficial geology map (Plate 4-3).

(ii) Major Moraines and Associated Landforms

The most impressive moraines of the entire field area occur to the north on Ivitak Rigg and in Ivitak Valley. Within this area morphological evidence appears to cover a broad span of chronological

Plate 4-3; A lateral moraine/protalus rampart at the head of Ivitak Valley. The till unit is visible below the larger scree material.

events and reflects a complex interaction between regional and local ice masses.

The major morainic unit has been named the "Ivitak Moraine" and can be traced along the south facing slope of Ivitak Valley where it is the highest of three lateral features and descends from 400 to 300 metres a.s.l. in a distance of 2 kms. The moraine continues for 1.5 kms around Ivitak Rigg and into Ivitak Cove where it further descends to 140 metres a.s.l. (Plates 4-4, 4-5 and 4-16). Immediately south of the streams draining Three Pond's Pass the Ivitak Moraine disappears and is cross-cut by an end moraine ("Base Camp Moraine") the orientation of which suggests it was deposited by Nachvak Fiord ice.

Ivitak Rigg is blanketed on its lower flanks by a grusified till containing two distinct sets of morainic landforms. One end moraine has been deposited immediately above the Ivitak Moraine in Ivitak Valley. Another hummocky moraine is positioned on the crest of Ivitak Rigg and would logically postdate the Ivitak Moraine.

To the north of Three Pond's Pass a large abandoned meltwater channel, just under 1 km in length and containing well-developed relict patterned ground, trends northwest to southeast. Stone circles within the channel are over 1 metre in diameter in most cases and borders are composed of large cobbles.

From northwest to southeast between Three Pond's Pass and the Ivitak Moraine in Ivitak Cove, meltwater channels, grade into ice scoured bedrock and glacially transported boulders and then into large lateral meltwater features. The latter trend with a former northwest to southwest ice margin and end abruptly at the Ivitak Moraine (Plate 4-4).

Two lateral moraines, altitudinally lower than the main Ivitak Moraine, document a pause in deglaciation from the more prominent feature (Plate 4-5). The lower lateral moraine can be traced below and outside the end moraine complex at the outlet of Superguksoak Valley and at the same altitude on the opposite slope within Ivitak Valley. A moraine and drift sheet was deposited at the head of Ivitak Valley by ice from North and South Bowls. Three distinct end moraines are apparent within the confines of Superguksoak Valley (Plate 4-2) and South Bowl. At the western end of Idyutak Lake the outermost of three, possibly chrono-correlative, moraines appears to have been deposited in lake water. Several central Selamiut cirque valleys contain at least two similar moraines but preservation is generally poor.

Evidence for glaciation in the McCornick Valley, other than its classical 'U'-shaped form and a very old till sheet is scarce. Meltwater features around and above 80 metres (Plates 4-6, 4-7 and 4-8) were cut into the till sheet, probably during the last deglaciation of the valley. An indistinct end moraine is located in the central section of the lower McCornick ("Lower McCornick Moraine") and has been remodelled by lake water and a more recent outwash fan (Plate 4-6). Behind this largely subdued moraine lateral meltwater channels, on the east facing valley slope, become more abundant (Plate 4-7).

Plate 4-4; The Ivitak Moraine and associated landforms. Base Camp Moraine is visible bottom right and extends diagonally to the right-centre of the photograph where the Ivitak Moraine ends abruptly. Abundant meltwater channels are clearly visible above the Ivitak Moraine. Two glacial-lake shorelines are also visible below the Ivitak Moraine.

IR = Ivitak Rigg BCM = Base Camp Moraine

IM = Ivitak Moraine

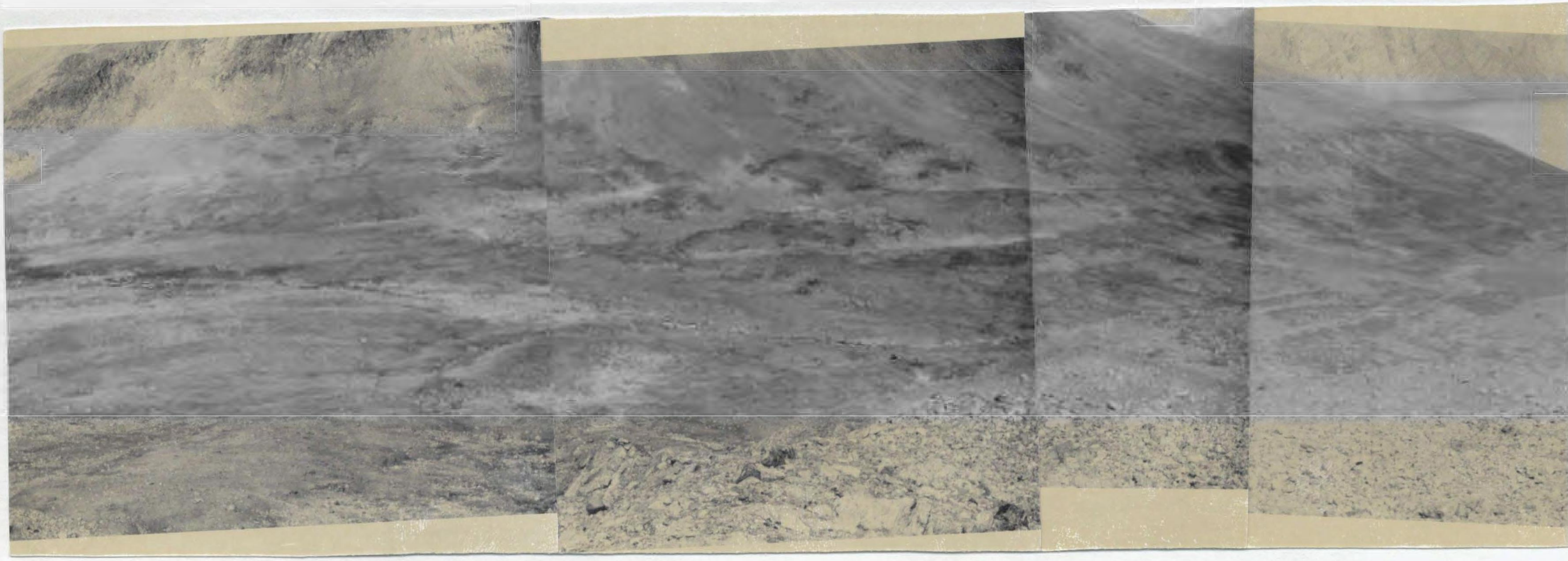


Plate 4-5; The Ivitak Valley lateral moraines. The Ivitak Moraine is the uppermost, more prominent feature. The Superguksoak end moraine complex is in the foreground.

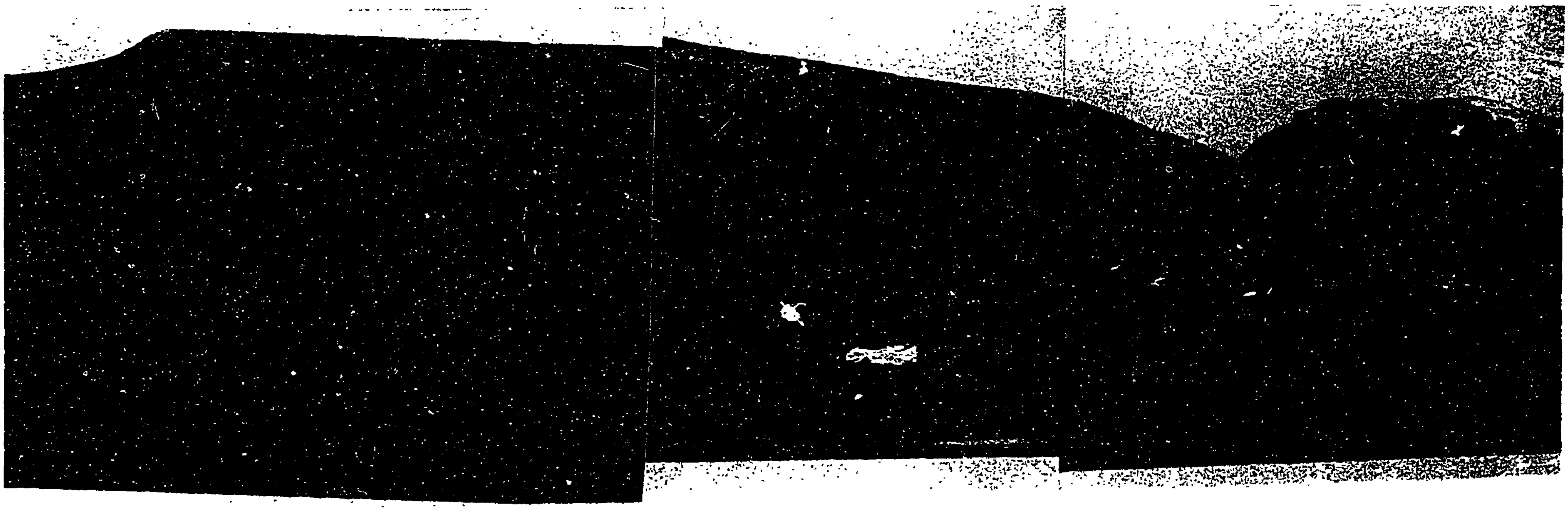


Plate 4-6; The east facing slope of the lower McCornick Valley. The Lower McCornick Moraine is visible on the far left. Lateral meltwater channels extend down valley, towards the right, at altitudes greater than 80 metres. Below this surficial deposits of till, lake clays and outwash gravel have been severely gullied by postglacial slope processes.

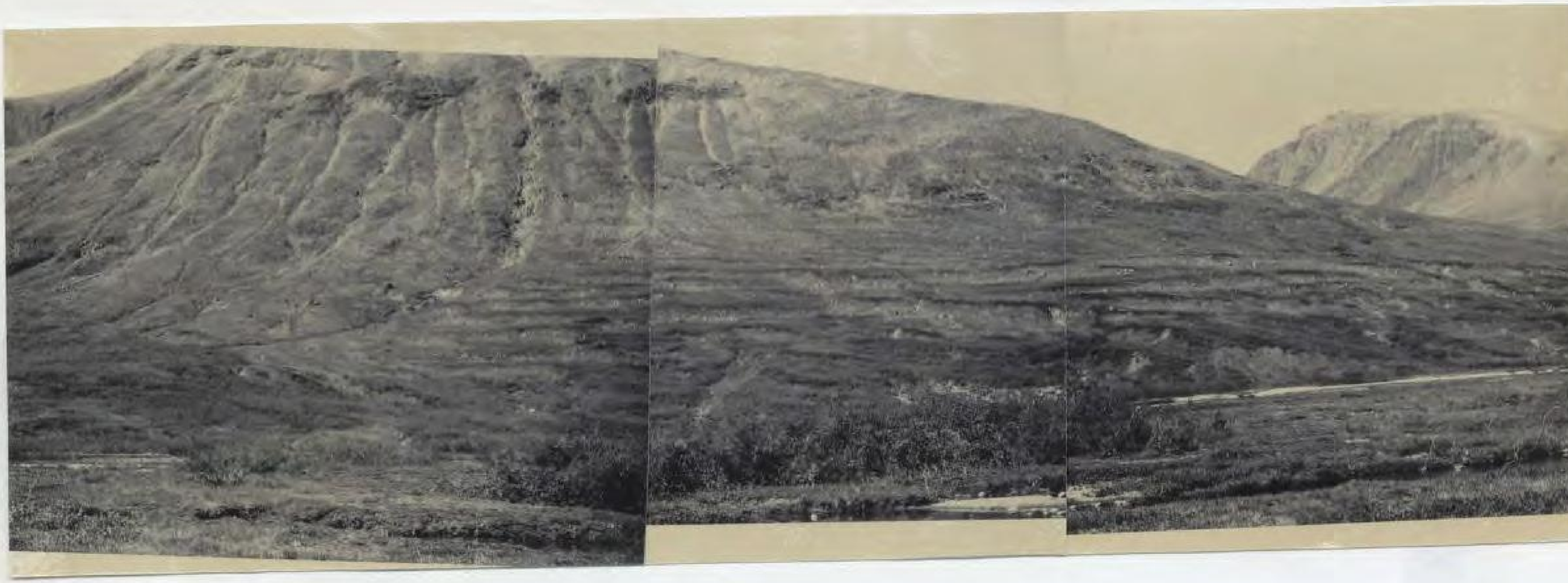


Plate 4-6; The east facing slope of the lower McCornick Valley. The Lower McCornick Moraine is visible on the far left. Lateral meltwater channels extend down valley, towards the right, at altitudes greater than 80 metres. Below this surficial deposits of till, lake clays and outwash gravel have been severely gullied by postglacial slope processes.

Plate 4-7; The middle McCornick Valley east-facing slope illustrating the lower river terrace (e.f.t.), the 80 metre lake shoreline and the lateral meltwater channels above.
LS = Lake shoreline

Plate 4-8; The most prominent sections of the 80 metre lake shoreline and e.f.t. in the middle McCornick Valley.

A further extremely faint, end moraine ridge ("Middle McCornick Moraine") has been identified below a large rock avalanche at the southern end of the McCornick Valley (Plate 4-9). This landform has been eroded and subdued by an extensive outwash complex and the more recent rock avalanche.

The completion of the McCornick Valley morainic sequence is provided below Stone Circle Falls, (Plate 4-10). This area of the upper McCornick Valley contains an extensive fresh end moraine, hummocky moraine/outwash complex ("Upper McCornick Moraine"). The postglacial dissection of this areas surficial deposits has revealed a complex stratified drift unit (Plate 4-11).

Cirque glacier activity is well documented by moraine evidence and a chronological sequence of landforms can be traced along the lengths of the larger upland cirque outlet valleys. In many cases, however, active screes hamper the identification of specific landform types where recent morphologic evidence has been obliterated. End moraines at the lower ends of the cirque outlet valleys, expecially on the east facing slope of the McCornick Valley, may be correlated with older glacial events in the study area.

Plate 4-9; View from the summit of the Middle McCornick Moraine across the upper McCornick sandur. The feature has been substantially subdued by fluvial erosion.

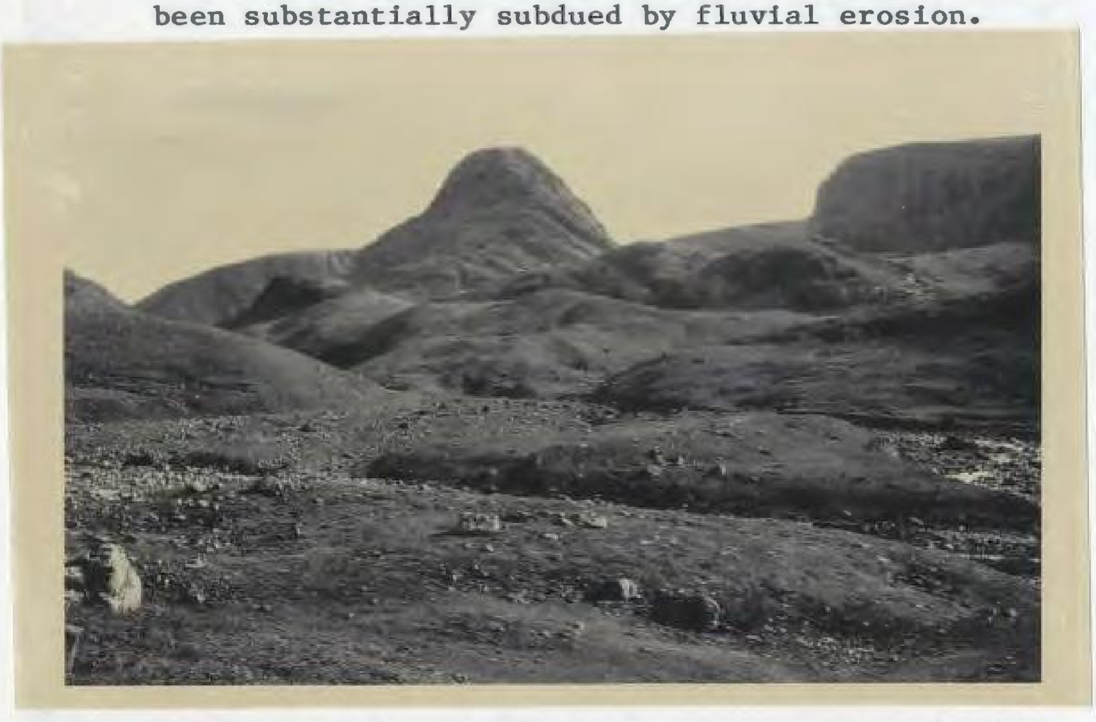


Plate 4-10; The Upper McCornick Moraine and associated landforms. The hummocky/end moraine is visible in the centre middleground. Dissected till/outwash material constitutes the foreground.

Plate 4-11; A complex stratified till unit exposed by post glacial
erosion in the Upper McCornick Moraine.

(iii) Strandline Evidence and Water Lain Deposits

This section will deal with the areas to which substantial waterlain deposits, shorelines and the largest of the outwash complexes are restricted, specifically the McCornick Valley, Ivitak Cove and Eskimo Cove.

In the upper McCornick Valley, below the Cirque Lake valley outlet, an extensive sandur grades northwards for 2.5 kilometres from the Upper McCornick Moraine, (Plates 4-12 and 4-12B). Recent fluvial activity has eroded cliffs that expose a gradational sequence of matrix poor till and outwash rubble.

On the valley floor, immediately east of Selamiut Force, the sandur surface contains a number of abandoned stream channels probably cut during the most recent deglaciation of the area, (Plate 4-13).

Rubble outwash continues to the north and has been overlain by rock avalanche material. Below this at an altitude of 80 metres contorted and cross-bedded meltwater sediments, possibly deposited pro-glacially, have been exposed by fluvial erosion. These are, in turn, overlain disconformably by coarse outwash, (Plate 4-14). The continuation of a bench along the east facing slope of the McCornick Valley at 80 metres (Plates 4-7 and 4-8) suggests the former presence of a proglacial lake, into which outwash sediments were deposited. Subsequent faulting of the sediments may have accompanied melt-out of buried ice. The 80 metre bench continues for 2.5 kms north before disappearing on the eastern flanks of High Spirit Ridge.

Three terraces in the McCornick Valley, two on the west facing slope (Plate 4-15) and one on the east facing slope (Figure 4-1), have

Plate 4-12B

Plate 4-12; The upper McCornick Valley sandur extending from Cirque Lake outlet on the far right to the Middle McCornick Moraine on the far left of Plate 4-12B.

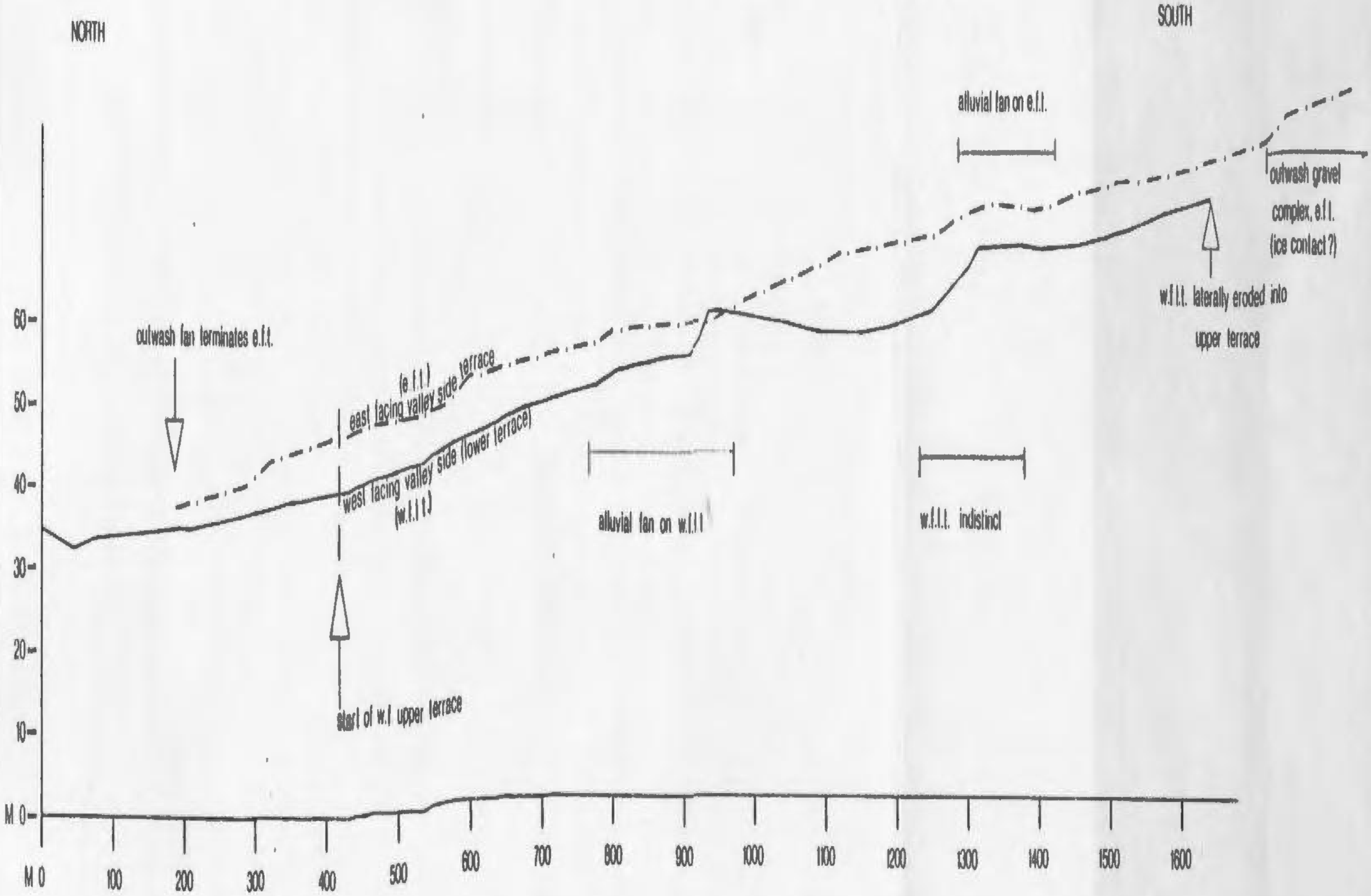
Plate 4-12B; Northward extension of Plate 4-12. The subdued Middle McCornick Moraine is marked M.

Plate 4-13; Abandoned channel on the upper McCornick sandur surface.

Plate 4-14; Contorted and cross-bedded meltwater sediments overlain by coarse rubble outwash at approximately 80 metres a.s.l. in the Middle McCornick Valley. Samples for grain size analysis marked 1-5 (Appendix I).

Plate 4-15; Two river eroded terraces on the west-facing valley side of the McCornick river.

Fig.4-1 THE McCORNICK RIVER VALLEY TERRACES



been cut by lateral movement of the McCornick River. These terraces grade down to between 33 and 35 metres, the marine limit in the area (as will be discussed later in this section).

Two major benches were identified in the lower McCornick/Ivitak Cove area at 67 and 53 metres (Plate 4-16). The upper bench is most prominent between the Ivitak Valley river, where it planes the Ivitak Valley end moraine, and the Base Camp Moraine. The lower 53 metre bench also terminates at the Base Camp Mora ne and it is noticeable that both trimlines plane the southern distal slope of the moraine (Plates 4-16 and 4-17). The 53 metre bench continues for approximately 1 km southward along the McCornick Valley where it lies immediately above a unit of laminated silts and clays. The laminae have been exposed in a cliff section by the McCornick River in Ivitak Cove and appear in several locations in the McCornick Valley at around 50 metres (Plate 4-18).

At the outlet of Ivitak Valley in Ivitak cove the silt and clay sediments are overlain by quite considerable depths of coarse outwash material (Plate 4-19). This grades into gravel outwash around the intertidal zone where the material displays a surface relief typical of thermokarst topography (French 1976, Ch. 6).

Short sections of the 53 metre bench can be traced behind the Lower McCornick Moraine, further south, and on the opposite side of the McCornick Valley below the western face of Kirk Fell. It is important to note that the 53 metre bench was not found and is therefore not present in the Eskimo Cove area nor to the east of Ivitak Cove on the

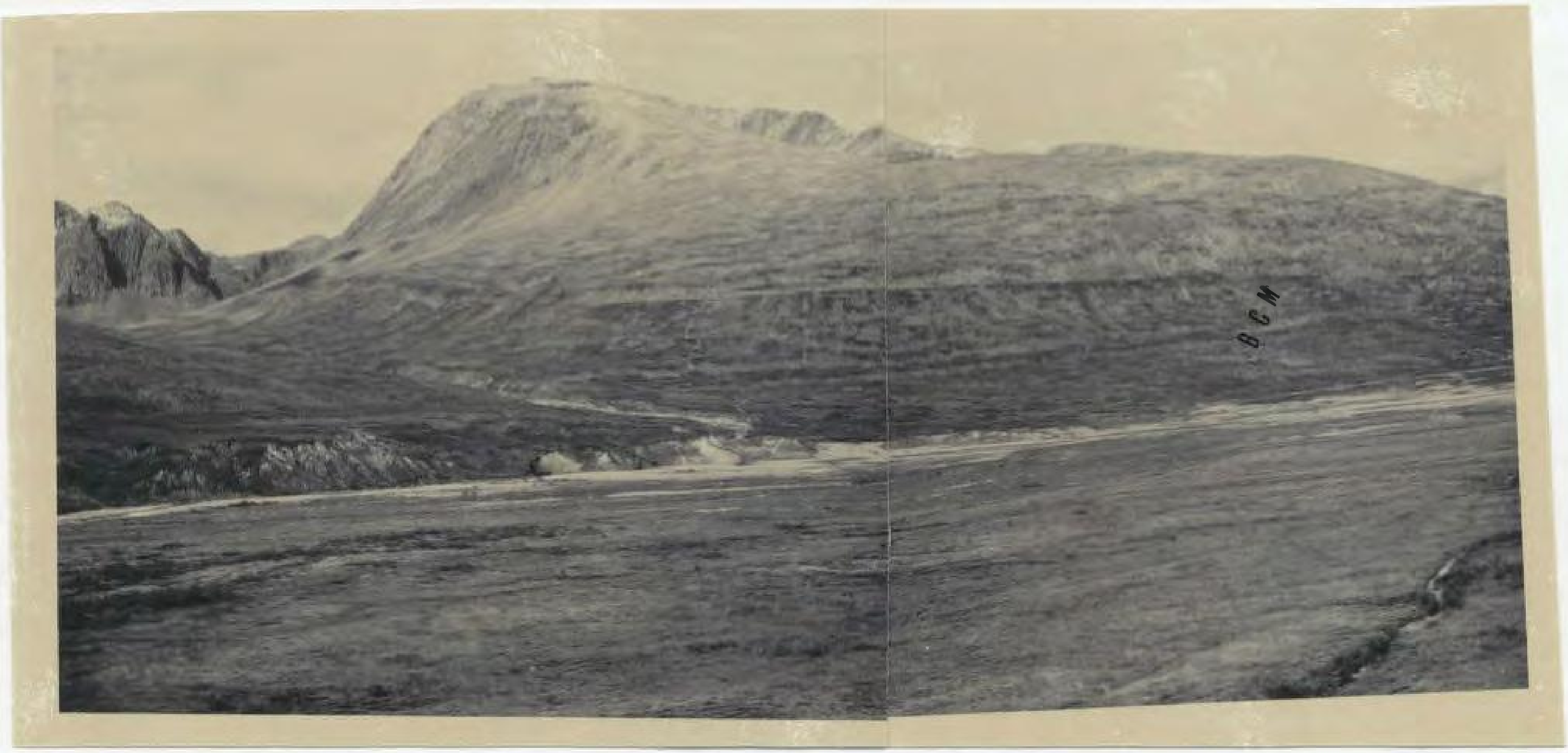


Plate 4-16; The most prominent sections of the 67 and 53 metre shoreline in Ivitak Cove. The Ivitak Moraine is also prominent and the trend of Base Camp Moraine is marked BCM.

Plate 4-17; The 67 and 53 metre shorelines from the planed section of the Ivitak Valley end moraine. The planing of the Base Camp Moraine is evident in the right middleground.

Plate 4-18; A cliff exposure of the clay and silt laminae in the lower McCornick Valley.

Plate 4-19; Coarse outwash material overlying silt and clay sediments at the Ivitak Valley outlet. Silts and clays are exposed in the section to the right of the spade.

south side of Nachvak Fiord. The highest bench east of Ivitak Cove is 33 metres above sea level and is cut in a clay rich diamicton (Plate 4-20).

Beach sediments consisting of sand, silt and clay are exposed in a cliff-face on a tombolo separating Eskimo and Grave Cove's (Plate 4-21). Similar material constitutes the major surficial unit within Eskimo Cove and is cut by a 33 metre bench in Mum's Cove. A number of large boulders rest on the up-fiord slope of the tombolo surface but none are included in the exposed stratigraphy.

Within the McCornick Valley and Ivitak Cove evidence for a 33 metre bench is scarce. A small bench has been cut on the lower Base Camp Moraine in Ivitak Cove and the alluvial terraces of the McCornick Valley grade down to between 33 and 35 metres (Figure 4-1). All other evidence appears to have been obliterated by more recent erosional processes.

However, further sections of the 33 metre strandline have been observed from air photograph interpretation. A small terrace exists on the northern shore of Nachvak Fiord, directly north of Tallek Arm, whilst a more prominent feature appears to exist in Tinutyarvik Cove, 10 kms east of the field area.

Several short sections of storm beach material exist in Ivitak Cove and its environs, (Plate 4-22). These deposits have been cut at various levels at and below 10 metres.

Plate 4-20; The marine bench at 33 metres below the north east flanks of Kirk Fell.

Plate 4-21; Sand, silt and clay sediments exposed at Eskimo Cove.
Strata dip towards camera.
Samples: 1 - 85% silt/clay
2 - 5% silt/clay

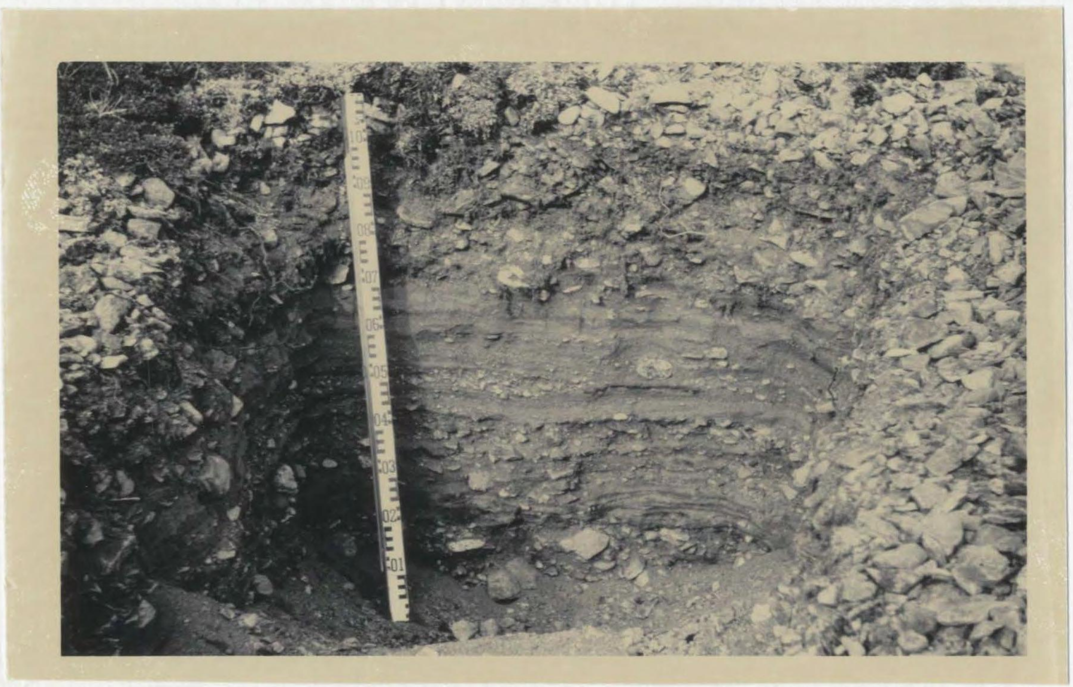


Plate 4-22; Section in raised storm beach material (4 m a.s.l.) in Ivitak Cove.

(iv) Pedological Data

Pedological data were employed in the development of a relative chronology of landform construction and are presented in Tables 4-1 and A2 in appendix II. Soil pit locations are depicted on the Location Base Map.

The deepest soils in the field area, illustrated by Plate 4-23, largely fit the classification of the Arctic Brown soil in its normal phase, (Rieger, 1974). By the U.S. soil taxonomy these soils appear to satisfy the prerequisites of the Pergelic Cryochrept which is ideally a well-drained soil with little or no dark upper horizon. All soils were relatively acid with pH values ranging from 4.0 to 6.9. Without further laboratory analysis sub-classification is not possible.

Well-developed soils do appear to have undergone intensive silt and clay translocation and horizonization is complex in many cases with iron and humic concentrations in lower horizons. In many shallower soils A and some B horizons display humus concentration. This would satisfy the criteria for classification as a Pergelic Cryumbrept but again further analysis is necessary for a confident subdivision.

The data presented in Table 4-1 is a summary of observations made on each soil pit location and material. Included at this juncture are location number, altitude, depth to the base of the Cox horizon and the colour development equivalent or C.D.E. Figure 4-2 depicts the major moraines of the field area and associated soil depths. This map is a further summary of field data and the Location Base Map (Figure A-3) must be consulted for a representation of all soil pits. More elaborate description of pit location is available in Table A2 in appendix II.

Plate 4-23; Soil pit no. 37. Overall depth is 77 cm including the Cox horizon. The soil dates from the Ivitak phase or glaciation.

Colour development equivalent values were obtained for all horizons but only values for B horizons are included in Table 4-1 as it is the B horizon that is regarded as the most critical in the determination of oxidation over time (Birkeland 1974).

Table 4-1 Summary of soil data for the field area.

Soil pit no.	Altitude (M)	Depth to base of Cox horizon (CM)	C.D.E.
1	20	29	8
2*	33	11	3
3*	40	26	8
4	110	76	9
5*	320	30	16
6	310	22	16
7	320	10	16
8*	15	24	9
9	230	14	16
10	130	31	24
11	15	29	12
12	560	14	16
13	340	16	9
14	350	52	16
15	350	14	12
16	462	29	8
17*	340	34	30
18	140	64	18
19	145	41	20
20	150	39	16
21	155	71+	30
22	160	46	18
23	165	65+	24
24	170	45	24
24A	175	70+	12
25	175	37	8
26	12	29	36
27	56	53	24
28	50	35+	12
29	42	32+	24
30	21	21	36
31	33	14	6
32	67	24	16
33	67	17	16
34	53	24	9
35	53	22	10
36	95	23	16
37	290	77+	20
38	325	52+	20
39*	322	24	12
40	175	37	18

41	370	58+	15
42*	430	11	24
43*	420	16	16
44	465	7	3
45	465	0	-
46	455	5	24
47	455	35	6
48	310	35	16
49	450	11	15
50	450	9	6
51	450	27	12
52	458	13	12
53	458	18	12
54	460	17	20
55	460	16	16
56	460	16	12
57	55	16	15
58	80	67+	15
59	50	23	36
60	150	18	6
61	110	48	20
62	60	17	8
63	100	6	12
64	120	17	15
65	140	23	24
66	150	11	24
67	300	23	8
68	220	21	12
69*	180	9	16
70	210	3[illegible]	9
71	310	25	9
72	310	25	24
73	320	12	8
74	322	12	16
75	380	14	9
76	400	22	12
77	590	22	24
78	600	9	16
79	33	28	-

* Soil pits containing more than one soil stratigraphy. Only the uppermost soil depth is included in this table. See Table A2 in appendix II for full details.

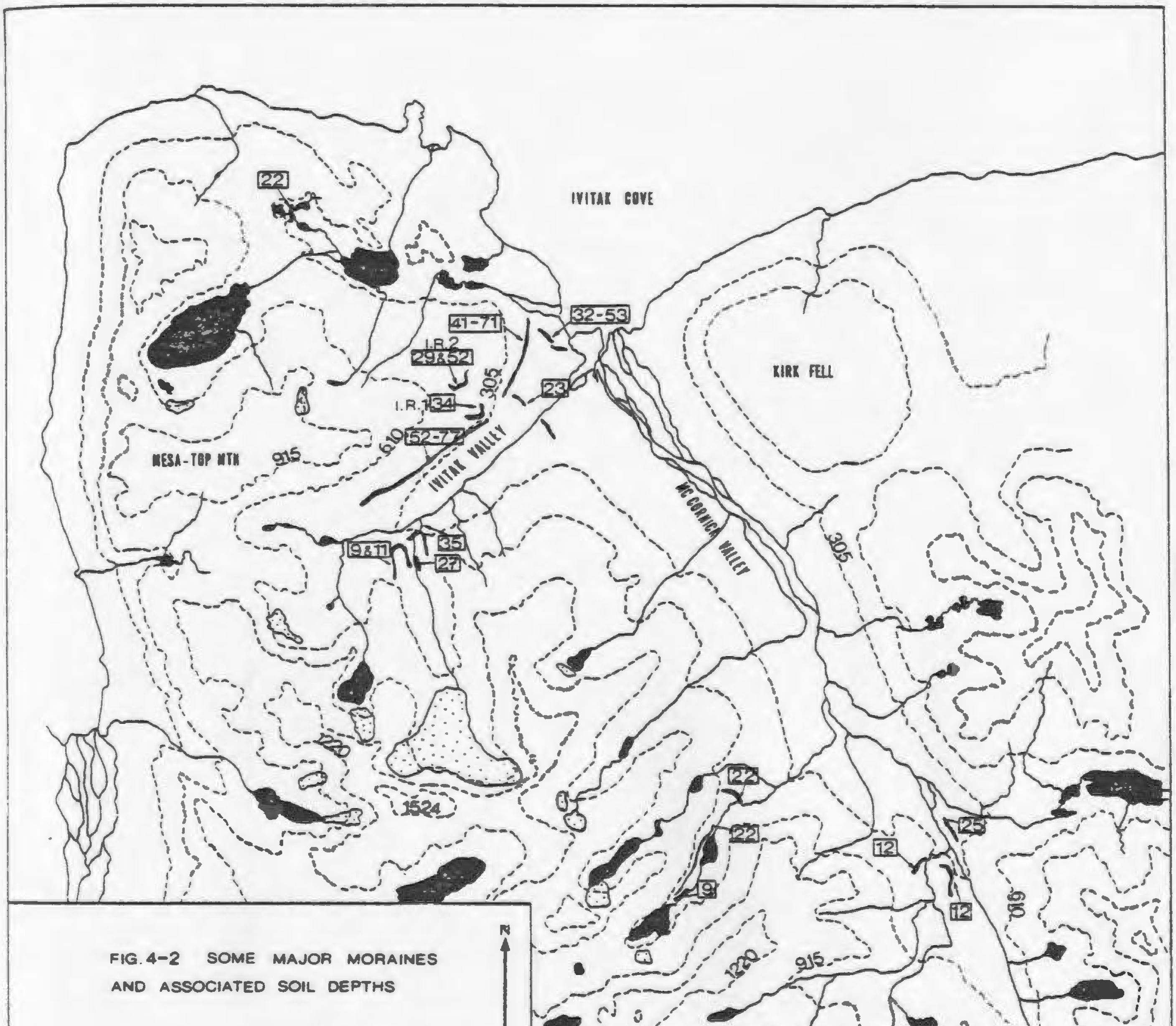


FIG. 4-2 SOME MAJOR MORAINES AND ASSOCIATED SOIL DEPTHS

(v) Lichenometry

The local environmental limitations to lichenometry were outlined in Chapter 2. Cirque outlet valleys at the centre of the Selamiut Range are characterized by steep bounding rock walls and highly active screes. Such circumstances increase the likelihood of "erratic" lichen emplacement (Locke et.al. 1979) and only contribute to an already substantial list of restrictions to the techniques applicability.

Lichenometric observations were recorded in three cirque basins in the northern half of the field area; Superguksoak Valley; the western end of Idyutak Lake; and South Bowl. A chronological framework was constructed for Holocene cirque glacier activity using the lichen data, several soil depth measurements and inferred geomorphological events and is discussed in the following chapter.

Data processed on the lichen growth sites established by McCoy in 1978 are available in Appendix III. Growth rates range from 0.22 to 0.30 mm yr^{-1} and are substantially greater than the rate calculated by Miller and Andrews (1972) for Baffin Island (0.03 mm yr^{-1}). However a growth period of 300 years was used by Miller and Andrews compared to only 5 years in this study. Therefore the high growth rate obtained here may be a product of the lichen "great period" (Locke et. al. 1979).

(vi) Geochemistry of Tills

The 33 till sample sites are included on the Location Base Map (Figure A-3) and data are tabulated in Table A4 of Appendix IV.

The geochemical laboratory data is presented in histogram form in Figure 4-3. An insufficient amount of sample was available for arsenic detection in 17 samples but the element was insignificant in samples analyzed. Only 21 samples were analyzed for uranium for the same reason. The lower detection limit for arsenic is 2 ppm. Of the 16 samples analyzed for the element 12 revealed values of <2 ppm. As a result a histogram for As. is not presented in Figure 4-3.

No spatial pattern can be detected from the mapping of the geochemical data, except perhaps that the percentage concentrations of base metals are generally greater in very recent tills near the contemporary glaciers of the field area.

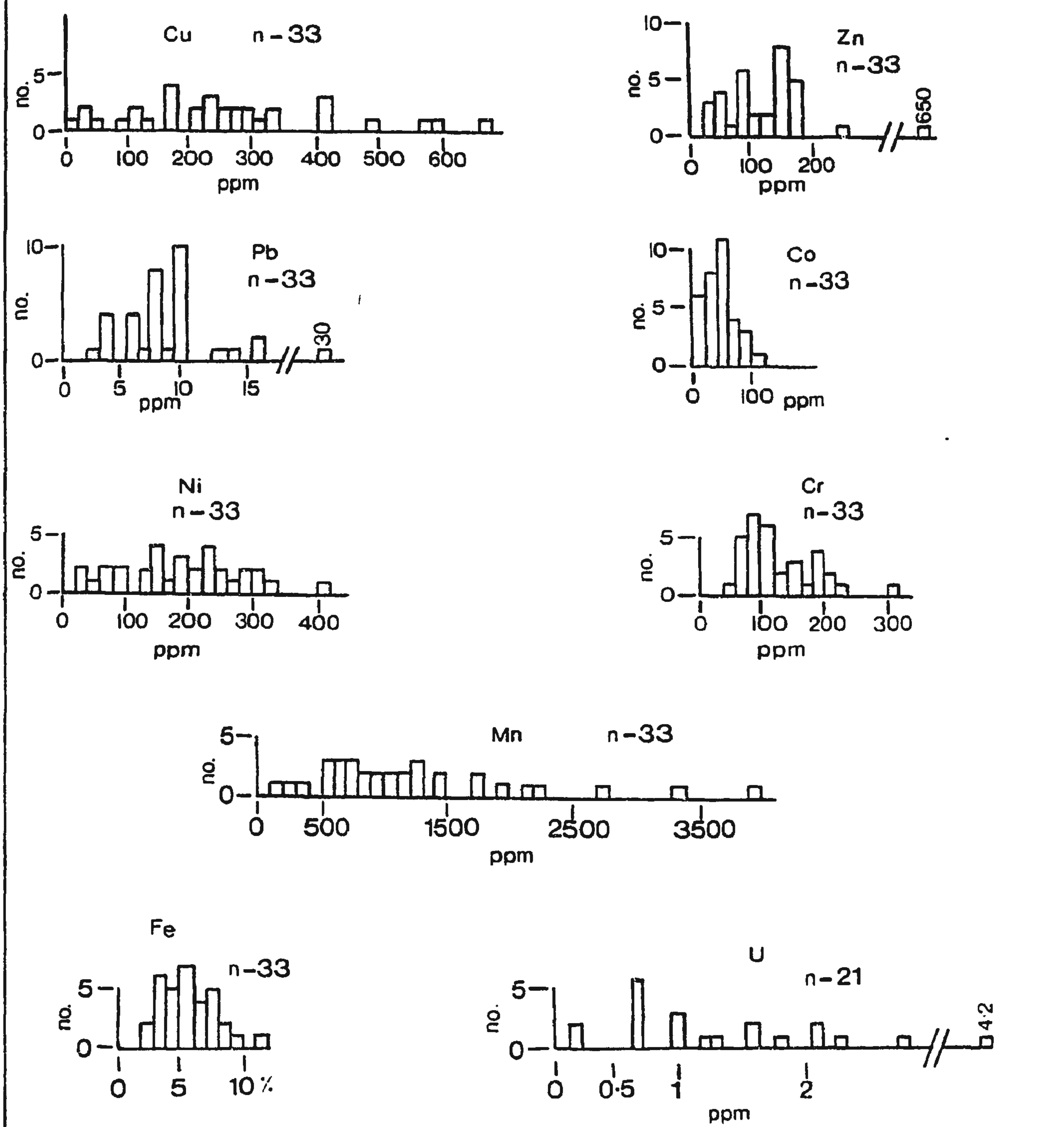


Fig. 4-3 Till geochemistry from Nachvak/Selamiut area

CHAPTER 5 ANALYSIS AND ATTENDANT DISCUSSION

This chapter will first attempt to interpret geomorphic events within the field area by morphochronological inference and the use of the soil data summarized in the previous chapter and tabulated in a more comprehensive format in Appendix II. Explanation of soil development and certain anomalous data is offered where pertinent.

A rationale upon the use of pedologic and lichenometric data is then provided together with some technical considerations pertaining to the construction of a relative chronology for the Selamiut Range/Nachvak Fiord area which is in turn presented at the end of this chapter.

Some comments are also provided on the geochemical data of tills from the field area.

(i) Interpretation of Geomorphic Events.

A number of chronological inferences may now be postulated using morphostratigraphy and relative dating techniques.

The most comprehensive glacial chronological record applies to the Ivitak Valley/Ivitak Rigg area. The Base Camp Moraine appears to postdate the Ivitak Moraine due to its cross-cutting relationship and pedological data, (see Location Base Map, Figure A-3, for siting and section (iv) of Chapter 4 for data). For example soil depths on the Base Camp Moraine range from 32-53 cm whilst depths range from 41-77 cm on the Ivitak moraine.

End moraine I.R.1 on Ivitak Rigg appears contemporaneous with the main Ivitak Moraine and is possibly interlobate. I.R.2 on the Rigg was probably deposited during a stillstand in deglaciation from I.R.1.

The large lateral meltwater channels above the Ivitak Moraine in Ivitak Cove (Plate 4-4) predate the deposition of the latter morainic feature and were cut during deglaciation from a phase where ice covered Ivitak Rigg and may have been interlobate with Ivitak Valley ice.

Idyutak Pass, to the north of Ivitak Rigg, has not been glaciated for a considerable period of time. This is suggested by the depth of soil development and extensive patterned ground (now fossil) on the till sheet in the area. Soil pit no. 5 was excavated on a till bench/moraine in Idyutak Pass and revealed an overall depth of 90+cm. The upper 30 cm of this pit represents an upper soil stratigraphy postdating a period of intense periglacial activity. Cirque glaciers in the vicinity have remained active however depositing a major moraine in Cwm Dyli which may be Holocene in age.

Pedological data, specifically depths of 14 and 16 cm for soil pits 9 and 13 respectively, suggest that ice from Cwm Dyli, a smaller cirque immediately north, and Idyutak Lake coalesced and moved into Three Pond's Pass during a quite recent glaciation. During this phase the ice cover in Idyutak Pass was far from complete. The large abandoned meltwater channel containing well-developed relict patterned ground and located to the north of Three Pond's Pass was therefore cut during deglaciation from an earlier inundating episode.

A morphochronological record of the more recent glacial events is well preserved in Ivitak Valley. Pedological data suggest that the higher of the two lateral moraines that lie altitudinally lower than the main Ivitak Moraine varies little in age from the more prominent landform. Soil depths at this point on the Ivitak Moraine vary from

52-77+ cm and soil pit no. 41, on the second highest of the lateral features, revealed an overall depth of 58+cm.

The lower lateral moraine is correlated, using pedological criteria, with the end moraine at the outlet of Ivitak Valley. Pit no. 48, on the crest of the lateral moraine, measured an overall soil depth of 35 cm and pit no. 36, on the end moraine, measured 23 cm. Pit no. 47, on the hummocky till sheet outside the Superguksoak end moraine complex, measured a correlative depth of 35 cm and an overall depth of 37 cm was found in pit no. 40 on the till sheet of the floor of Ivitak Valley.

Further contemporaneity is suggested between the end moraine of the Ivitak Valley outlet and the Base Camp Moraine (overall soil depths of 53, 35+ and 32+cm in pit nos. 27, 28 and 29 respectively) and is substantiated by the terracing of both features by the same lake shoreline at 67 metres (see section iii of Chapter 4). Anomalous depths of 21 and 14 cm for pits 30 and 31 on the Base Camp Moraine may be explained by their siting below the marine limit (33 metres).

Glacial conditions in Ivitak Valley appear to be almost entirely dominated by an extended Superguksoak Glacier. The moraine and drift units of North and South Bowls at the head of the valley suggest only restricted cirque glaciation during the most recent glacial events. This is verified by pedological and lichenometric data (Figure 5-1). The greater antiquity of the till sheet distal to the South Bowl end moraine and between it and the outer Superguksoak Valley end moraine, is attested by well-developed and relict patterned ground (Plate 5-1). These impressive features do not occur on the ice proximal side of either end moraine system.

Fig. 5-1 LICHENOMETRY OBSERVATIONS

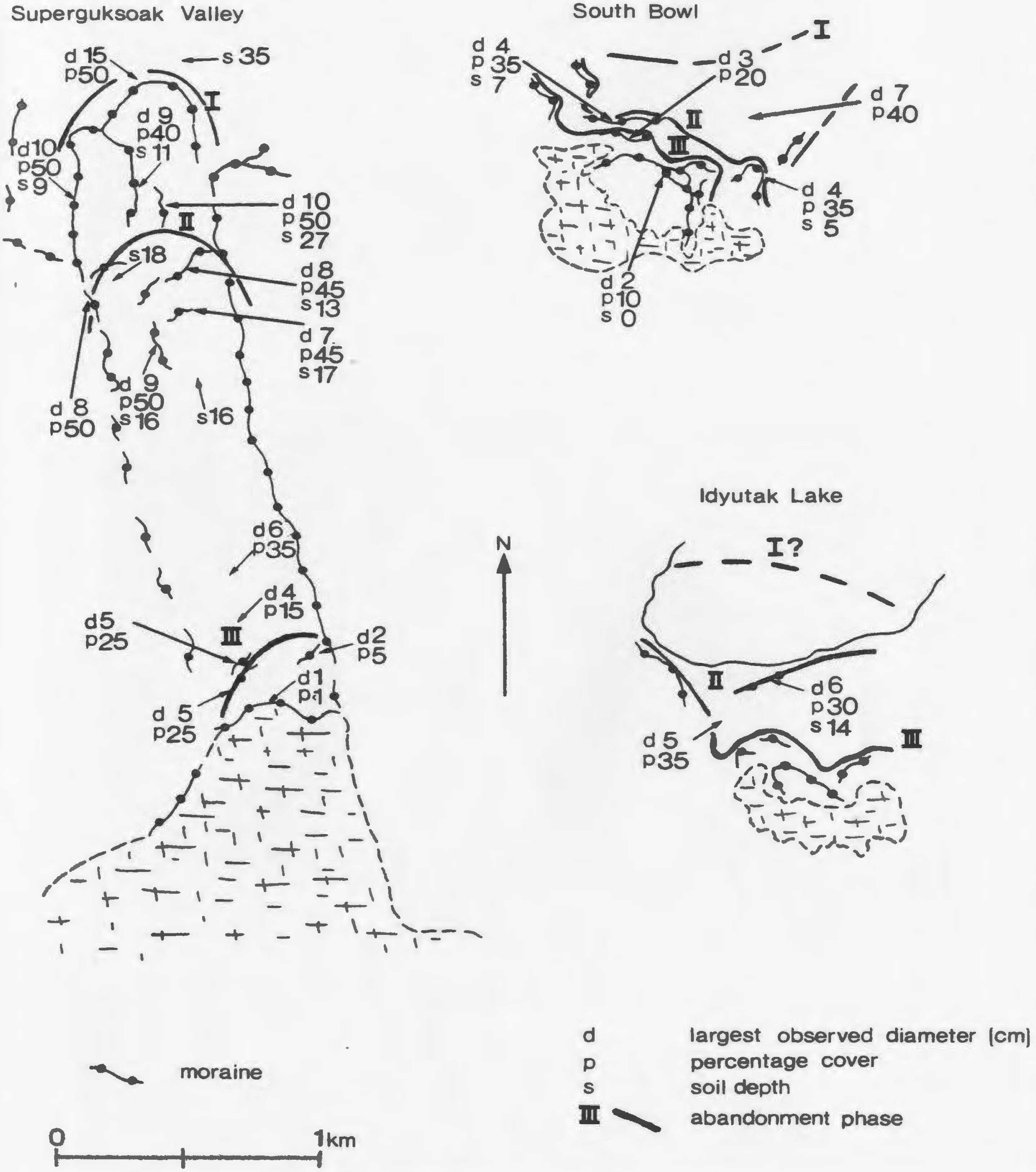


Plate 5-1; Well developed patterned ground in bouldery till in the upper Ivitak Valley.

Of the three end moraines within the Superguksoak Valley (Plate 4-2 and Figure 5-1) the outermost moraine loop is of a sufficient size to suggest a lengthy stillstand or readvance phase postdating the abandonment of the Base Camp Moraine and its correlatives. Immediately inside the outer loop moraine is a smaller and less prominent end moraine which appears to be similar in age, therefore representing a further stillstand during deglaciation.

Ice dynamics within the Superguksoak catchment appear to be quite complex. A subsidiary moraine loop on both the inner and outer moraines, together with remarkably well-preserved medial moraines, suggest that ice in the higher cirque to the west of Superguksoak Glacier is highly responsive to glacial conditions. This assumption is substantiated by the morainic complex on the broad bedrock ridge between the two cirque valleys. During glaciation ice from the upper cirque would appear to move out over the broad intervening ridge and coalesce with Superguksoak ice rather than escape down its own narrow outlet valley. This would provide the necessary impetus for the production of two major ice lobes within one outlet valley, which may or may not advance and retreat in phase with each other.

Two phases of deglaciation may be postulated for the lower McCornick Valley after consideration of the landform evidence outlined in section (ii) of Chapter 4. Meltwater features at the northern end of the McCornick Valley predate a stillstand at or readvance to the Lower McCornick Moraine. A more recent deglacial phase is then documented by the occurrence of more abundant marginal meltwater channels immediately south of the moraine and on the east facing slope of the McCornick Valley.

The last deglaciation of the lower half of the McCornick Valley was responsible for deposition in an 80 metre proglacial lake. A later readvance of ice from the upper McCornick Valley deposited the now subdued Middle McCornick Moraine and, together with outwash from cirque glaciation in the hanging valleys above, accounts for the disconformity between the faulted meltwater sediments and the overlying coarse outwash at 80 metres. Abandonment of this moraine released meltwater that deeply incised the outwash material, deposited during glaciation, and assisted lateral erosion by the McCornick River. Further deposition of coarse outwash material on the upper McCornick sandur was facilitated by later, less extensive glaciation.

Soil data suggest that the river terraces of the northern half of the McCornick Valley (Plates 4-7, 4-8 and 4-15) were cut immediately after the abandonment of the Middle McCornick Moraine. Comparable soil depths of 17 cm were found in pits 62, on the upper terrace of the west facing slope of the valley, and 64 on the Middle McCornick Moraine crest.

The survival of contemporary ice fields in the southern Selamiut Range, Minaret, Toth and Caubvick Glaciers, suggest that the upper McCornick Valley would be host to a substantial coalescing ice mass extending from the upland cirques during the onset of glacial conditions. The Upper McCornick Moraine is the product of such a localized advance.

Surface channelling of the upper McCornick Valley sandur could have taken place when ice was wasting back from the Upper McCornick Moraine complex. It is possible that the sandur/outwash deposits of the upper McCornick Valley represent deposition during more than one glacial/deglacial cycle. An absence of morainic evidence, substantial enough to suggest multiple glaciation of the whole McCornick Valley, lends support to this assumption. Indeed the subdued nature of the Middle McCornick Moraine (outlined in the previous Chapter) suggests that considerable meltwater was produced in the upper McCornick postdating the abandonment of the feature.

Pedological data from the trimlines along the McCornick Valley suggest that the ages of the 67 and 53 metre trimlines are not significantly different. On the 67 metre bench soil pit nos. 32 and 33 reveal overall solum depths of 24 and 17 cm respectively. Pit nos. 34 and 35, excavated on the 53 metre bench, reveal solum depths of 24 and 22 cm respectively. Furthermore soil pit 57, on a subdued recessional moraine at 55 metres, and pit 59, on the crest of the Lower McCornick Moraine at 50 metres, contained respective solum depths of 16 and 23 cm. As their heights suggest, the two latter sites were below the surfaces of at least two of the former water levels in the McCornick Valley.

An overall solum depth of 17 cm from pit no. 62, as mentioned above, together with a cross-cutting relationship of the river terraces grading down to approximately 33 metres (the marine limit) suggest that their formation postdates the cutting of the 67 and 53 metre benches.

It is likely that the McCornick Valley hosted proglacial lake water during glaciation. From the evidence just discussed the presence of a further lake body is postulated. The planing of the Base Camp Moraine by both the 67and 53 metre trimlines suggests that the glacial and lacustrine features are contemporaneous. The absence of trimlines of a similar altitude in Nachvak Fiord suggests the damming of the McCornick Valley by fiord ice. This would explain the presence of laminated silts and clays in the lower McCornick Valley.

The prominence of two lake shorelines, together with deep, relict gullies that cut through the soft sediments down to river level (Plate 5-2), imply rapid or even catastrophic drainage from 67 metres and an immediate refilling of the lake to 53 metres. It is hypothesized that a shorter period of time was required to cut the 53 metre bench in silts and clays, originally deposited in the longer lived 67 metre lake, than to cut the 67 metre bench in till, deposited during an earlier glaciation. This explains both the equal prominence and the similar age of the two features. Coarse outwash material overlying the silt and clay laminae in Ivitak Cove was deposited during deglaciation from the Ivitak Valley end moraine and the final emptying of the glacier-dammed lake.

Solum depths on the 33 metre benches and on surficial units below 33 metres are comparable to soils of moraine crests and trimlines that document events known to predate the former morphostratigraphically. Differences in till matrix may be responsible for certain anomalies that arise in the depth/age relationships of the soil data. For example, soil pit nos. 1 (solum depth 29 cm), 2 (11 cm), 8 (24 cm), 11

Plate 5-2; View from 53 metre shoreline of relict gullies cutting down to river level through the silt and clay laminae.

(29 cm), 26 (29 cm) and 30 (21 cm), together with an observed solum depth of 28 cm on the 33 metre shoreline below Kirk Fell in Nachvak Fiord, average 24 cm in depth. These pits are all at or below the marine limit in the area. The depth of 24 cm is generally similar or slightly greater than depths obtained on features of later land-forming episodes including pit nos. 34 (depth 24 cm) and 35 (22 cm), on the 53 metre lake shoreline, and nos. 64 (17 cm), 65 (23 cm) and 67 (23 cm) on the Middle McCornick Moraine/till sheet.

Soil depths from pit nos. 28 and 29 (35+ and 32+cm respectively) on the lower half of the Base Camp Moraine are also two of the deepest of several correlative surficial units. Pit no. 4 with a depth of 76 cm and on a recessional moraine of a more recent age than its depth suggests is a further example.

Pedological data, as a result of certain anomalies, were not employed in the construction of the section of chronology involving the landform evidence at and below 33 metres. Instead morphostratigraphic relationships were used exclusively.

The cutting of the 33 metre marine bench must post-date the evacuation of ice from this part of Nachvak Fiord and, therefore, the emptying of the final, 53 metre, McCornick ice-dammed lake. The similarity between soil depths from the lake shorelines and the marine bench is inconsistent with this sequence and is discussed in more detail in the following section.

(ii) Review and Interpolation of Pedologic and Lichenometric Data.

As outlined in Chapter 2, the most useful parameter for relative dating purposes has been recognized in several case studies as overall soil depths or, more specifically, the extent of oxidation. These were found to be the most appropriate data in this study when considering events separated by substantial time intervals. Thus the distribution of soil depths may take on real importance in understanding glacial chronologies.

The differentiation of closely spaced chronological events remains uncertain. For example, moraines documenting the most recent cirque glaciations in the field area provide a range of soil depths from 0-20 cm (see Figure 5-1). Clearly several subdivisions within such a small range of values render chronological classification tentative. In some cases lichenometry may aid classification (McCoy 1983) and the success of this technique will be discussed below.

Clark (1984a) has adopted the colour-development equivalents (C.D.E.) of Buntley and Westin (1965) to calculate the intensity of oxidation of soil horizons. In Clark's case the value for the C.D.E. in the cambic B horizon increased with preconceived age and, to some extent, depth therefore facilitating the chronological differentiation of surficial units.

It must be outlined at this juncture that individual field identification problems hamper the establishment of pedology as a dating control. Although Clark (1984a) acknowledges the applicability of the depth of solum and the intensity of oxidation as useful dating tools he excludes the Cox horizon in both cases. The Cox horizon was introduced as a sub-classification of a soil's parent material and essentially identifies the extent of oxidation of the regolith. It is therefore considered part of the solum in this study.

C.D.E. values are included in Table 4-1 but they neither vary directly with soil depth nor with the relative ages determined by morphological superimposition in the Selamiut field area. The average C.D.E. for the B horizons of the deeper soils of the Selamiut Range/Nachvak Fiord area is 19 with an overall range of 8-30. For the shallower and more recently formed soils the average C.D.E. is the same but the overall range of values is from 6-36. Clark's (1984a) Figures were rather more conclusive. For example;

Iron Strand Drift	Coleman Drift	Two Loon Drift	Four Peaks Drift
C.D.E. 15-30	8-16	4-6	No cambic B.

oldest   youngest

A G E

In the case of the Selamiut Range/Nachvak Fiord figures the C.D.E. is thought to be an uncertain chronological indicator.

Using overall solum depths as a chronological indicator is also not infallible. Once the differential soil horizonization rates that accompany pedogenic environments are taken into account the dating method becomes restricted when comparing data from landforms composed of dissimilar material, as was suggested in the previous section.

Soils developing on the Nachvak Fiord regional till may have undergone accelerated pedogenesis. This matrix rich till probably facilitates a greater development of solum depth whereas Selamiut drift units are composed of coarser, less comminuted material and extensive pedogenic profiles require a greater time span. Paradoxically, although clay/silt rich materials normally exhibit distinct shallow horizons, soil depths will accumulate very slowly on material similar to the laminated clays of the lower McCornick due to a general decrease in leaching and deep soil forming processes.

Such inherent problems in the use of soil development in constructing Quaternary dating frameworks are suitably summarized by Birkeland's (1974, p. 144) statement.

> "...any quantitative classification scheme of soil profile development should take into account the original texture of the parent material, just as stratigraphic correlations based on soil development should, because finer-textured soils commonly develop profile characteristics more rapidly."

Soil pit nos. 1 and 2 display deep, well developed horizonization in a surficial sand unit that may be Holocene in age. The sand unit was sectioned in Eskimo Cove (Plate 4-21). The deposition of such fine sediments in a beach environment is attributed to the protective lagoon that the Cove represents and the resultant reduction in storm beach material. It may be noted that Birkeland (1978) suggested that soil development in marine sediments on Baffin Island was ten times more rapid than on inland tills. This would explain the deep soil development in Eskimo Cove.

In several profiles the interruption of soil development is documented by sub-solum horizonization. In pit nos. 5, 17 and 39 this is attributed to frost heave, possibly when the sites were ice-marginal during glaciation or during local climatic deterioration that post-dated initial pedogenesis. Soils in pit nos. 42, 43 and

69 appear to have been overridden in the first two cases by a thin till cover and in the latter case by highly active colluvium. Pit 69 is sited below an intermittently-active scree slope and therefore its value to the chronological framework is restricted.

Table 5-1 includes data from the measurement of the lichen "Rhizocarpon Geographicum sensu lato" on the moraines investigated in the field and presents relative chronologies for events within the three major cirque basins that were surveyed. Soil characteristics were extracted from Table A2 in Appendix II and are cartographically represented with the associated lichen data in Figure 5-1.

Although there are three distinct end moraine units in Superguksoak Valley and South Bowl the lichen data lack any distinct clustering. Therefore the dating of deposits, using the growth curve of Miller and Andrews (1972), fails to highlight any obvious moraine abandonment phases that might display synchroneity with events postulated by McCoy (1983).

The data generally suggests that cirque glacier fluctuations were slightly out-of-phase between the three basins studied but moraine abandonment occurred in three distinct phases numbered I to III. As each cirque basin had a unique glacial history, prefixes denote the locations of the event documented by each lichen measurement (see Table 5-1). Documentation of a more complex glacial retreat, similar to that observed by McCoy, is not preserved in the landform evidence but may be reflected in the spectrum of lichen diameters present in Table 5-1. This is assuming that the size gradation is not a function of sampling error.

Table 5-1; Lichenometry observations and associated moraine characteristics.

Location[a]	Maximum Rhizocarpon thallus diameter (cm)	Lichen Cover %	Approximate age (yr. B.P.)[b]	Local abandonment phase[c]	Soil characteristics
S.V.	1	<1	<100	S.V. Modern	Boulders on moraine surface. Ice cored moraine.
S.V.	2	5	<250	S.V. III	Ditto.
S.B.	2	10	<250	S.B. Modern	No soil development.
S.B.	3	20	<650	S.B. III	---
S.V.	4[d]	15	1000	S.V. II	Ice scoured bedrock.
S.B.	4	35	1000	S.B. II	B/C 0-7cm Cn 7-22cm+
S.B.	4	35	1000	S.B. II	B/C 0-5cm Cn 5-30cm+
S.V.	5	25	<1500	S.V. III	---
S.V.	5	25	<1500	S.V. III	---
I.L.	5	35	<1500	I.L. II	---
I.L.	6	30	<2000	I.L. II	B 0-10cm Cox 10-14cm Cn 14-29cm+
S.V.	6	35	<2000	S.V. II	Ice scoured bedrock.
S.B.	7	40	≥2000	S.B. I	--
S.V.	7	45	≥2000	S.V. II	B 0-5cm Cox 5-17cm
S.V.	8	45	≥2500	S.V. II	B 0-4cm Cox 4-13cm
S.V.	8	50	≥2500	S.V. II	---
S.V.	9	40	<3000	S.V. I	Ah 0-3cm B/C 3-7cm Cox 7-11cm Cn 11-26cm+
S.V.	9	50	<3000	S.V. II	B 0-6cm Cox 6-16cm
S.V.	10[e]	50	>3000	S.V. I	B/C 0-4cm Cox 4-9cm Cn 9-34cm+

Table 5-1 (cont)					
S.V.	10[e]	50	>3000	S.V. I	A 0-4cm B 4-9cm Clox 9-17cm C2ox 17-27cm Cn 27-42cm+
S.V.	15[e]	50	>>4000	S.V. I	---

a. S.V. - Superguksoak Valley
   S.B. - South Bowl
   I.L. - Idyutak Lake (western end)

b. Ages determined from Rhizocarpon Geographicum growth curve for the Cumberland Peninsula, Miller and Andrews (1972).

c. Morphochronologically inferred from superimposition.

d. Sited close to natural snow patch hollow.

e. Indistinct margin. Lichen diameter indicative of minimum age only.

(iii) Till Geochemistry

From the geochemical data on 33 till samples a number of general conclusions can be made. Table 5-2 is a compilation of till samples with anomalous base metal contents. These samples are isolated by the application of "background levels", Dyke (1983). Sample sites with values falling in the high tails of the histograms in Figure 4-3 reveal base metal contents above normal background levels. High tails, or the boundary between background levels and higher levels of element concentration, begin at about 100 ppm. for copper, lead, cobalt, nickel and chromium; 150 ppm. for zinc; 1000 ppm. for manganese; 10 percent for iron and between 0 and 1.6 ppm. for uranium (Dyke 1983).

By these criteria only three till samples are excluded from Table 5-2; samples J, M and a. The remaining 30 samples all reveal high base metal concentrations. As no regional averages for anomalous base metal contents are available it is impossible to say whether or not the surficial units of the Selamiut/Nachvak area are abnormally rich for northern Labrador.

As the area of data collection was restricted, any attempt at interpretation of ice flow directions would be ambitious. Furthermore, most of the sample sites were located on the Selamiut local till sheets. It is evident, however, that the highest base metal concentrations were from sites within the upland cirque basins. This may be a reflection of till comminution (Table 5-2) and an associated leaching of base metal concentrations.

According to the threshold of background levels suggested by Dyke (1983) the Selamiut Range tills contain high concentrations of copper, nickel, chromium and manganese and, to a lesser extent, zinc. As the

Table 5-2; Till samples with high base metal contents

Sample no.*	Element units, P.P.M.									Till comminution
	Cu	Pb	Zn	Co	Ni	Cr	Mn	Fe(%)	U	
A(07)	115									Local cirque (L.C.)
B(08)	405		170		320	180	1050		1.6	Cirque outlet valley (C.O.V.)
C(11)	205				164					Regional (R.)
D(12)	240		158		186	148				R.
E(14)	230		156		190	104	1175			C.O.V.
F(15)	177		176		124		2100			C.O.V./R.
G(16)	135						1225		2.1	C.O.V./R.
H(18)									1.6	C.O.V.
I(22)	260		154		194	117	1150			C.O.V.
K(24)									1.8	C.O.V.
L(25)	103				271	178	2726	11.2		C.O.V.
N(27)	170				220	111	1452			L.C.
O(28)	200				130					L.C.
P(29)	590		172		318	138	1950		2.8	L.C.
Q(30)	240				234	140	1450		2.1	L.C.
R(31)	560		242	110	224	108	3300			L.C.
S(32)	298		154		200	193				L.C.
T(33)	335		150		148	122	1750			L.C.
U(34)	400		174		256	234	2250			L.C.
V(35)	223				144					L.C.
W(36)	295				153					L.C.
X(38)	487		156		294	191				L.C.
Y(39)	400		160		308	200	1000			L.C.
Z(40)	310		158		252	210	1710			C.O.V.
b(43)	220				284	192				R.
c(45)	260				218		1250		4.2	C.O.V.
d(52)	660		650		411	107	3982			C.O.V./L.C.
e(53)	335				466	300				C.O.V.
f(54)	172				226	158				C.O.V.
g(56)	160				150	105	1250		2.3	C.O.V./L.C.

*Letter prefixes are used here to avoid confusion on the Location Base Map.

samples are from locally derived tills the base metal concentrations are a reflection of the local bedrock geology. Dyke (1983) notes that high base metal contents, especially chromium, in locally derived material are associated with ultrabasic rocks and dykes. The Selamiut Range tills are no exception to this, albeit generalized, axiom (see section ii of Chapter 3).

(iv) A localized Relative Chronology

From the evidence presented and discussed in previous chapters a localized chronology can be constructed for the Selamiut Range/Nachvak Fiord area. The chronology is based entirely on relative dating techniques because there was no recovery of datable organics pertaining to the pre-Holocene environment. The aim of this section is to provide a hypothetical record of past glacial and associated events and to allocate some localized nomenclature.

Figures 5-2 to 5-5 demarcate the inferred limits of three major glacial events; the Ivitak; Nachvak; and Superguksoak "glaciations". Soil pit locations depicted on Figures 5-3 to 5-5 are indicative of soil development since the preceding glaciation. The soil data are presented graphically in Figure 5-6 which illustrates the modal distributions of soils classified under the three major soil forming periods.

The glacial limits from figures 5-2 to 5-5 are further depicted on the Location Base Map and their relationship to moraines may be cross examined by reference to the Surficial Geology Map.

a) The Ivitak glaciation (Figure 5-2).

The earliest, Ivitak, glaciation can be tentatively subdivided by landform interpretation. An early Ivitak phase was responsible for the deposition of a high altitude till sheet on the eastern flanks of Mesa-Top Mountain, which remained isolated as a nunatak. Similar extensive felsenmeer-covered summits throughout the Selamiut Range attest to the presence of unglaciated enclaves during the early Ivitak glaciation.

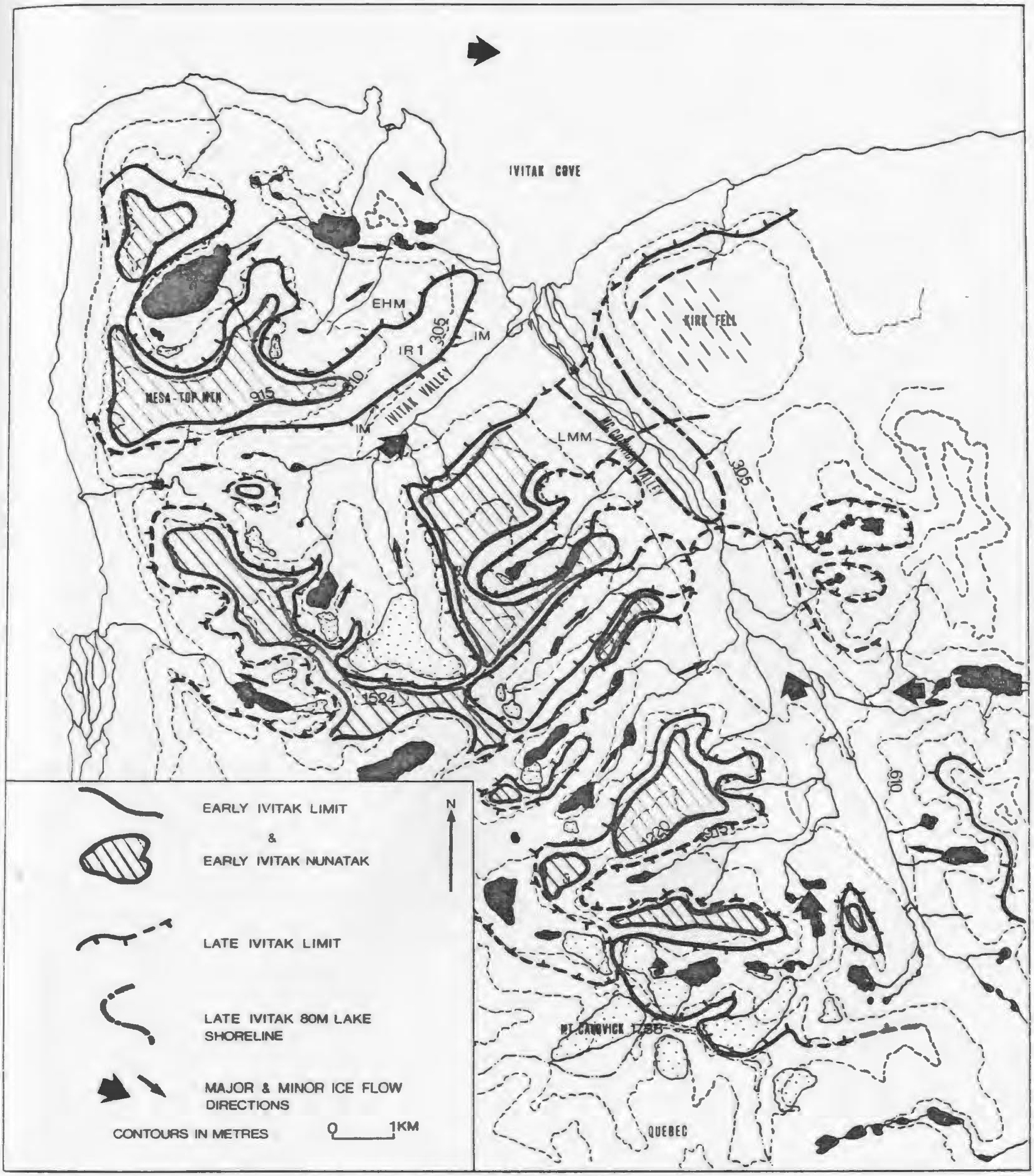


FIG. 5–2 IVITAK GLACIATION

The termination of the early Ivitak phase was marked by the abandonment of the end/interlobate moraine above Ivitak Valley (I.R. 1 on Figure 5-2). Deposition of the Ivitak Moraine (I.M. on Figure 5-2) took place during a late Ivitak phase. At that time ice on Ivitak Rigg was depositing the end hummocky moraine, I.R. 2, at approximately 460 metres (E.H.M. on Figure 5-2). A stadial differentiation for the early and late Ivitak events would be tentative but the prominence of the Ivitak Moraine suggests that the late Ivitak was of significant duration.

This assumption is supported by evidence of an 80 metre ice-dammed lake in the McCornick Valley. Prior to the late Ivitak, McCornick ice retreated generating sufficient meltwater to produce deep lateral meltwater channels on the valley's steep east-facing slope. The susceptibility of McCornick ice to rapid fluctuation is apparent when assessing its potential feeding grounds. Rather than being a dominant ice flow through-trough containing Laurentide outlet glaciers like Nachvak Fiord, the McCornick Valley probably received ice only from extended cirque glaciers.

At its furthest extent during the early Ivitak phase the McCornick Valley ice lobe probably stood at the Lower McCornick Moraine (L.M.M. on Figure 5-2). At the maximum of the late Ivitak glaciation the coalescing ice mass in the McCornick Valley stood somewhere above 80 metres in the valley bottom. Ice-contact sediments were deposited at the shores of the 80 metre ice-dammed lake that was cutting a prominent shoreline along the central and lower McCornick.

b) The Nachvak glaciation (Figure 5-3)

The following, Nachvak, glaciation was marked by extended cirque glaciers within the Selamiut Range proper and regional ice activity in Nachvak Fiord. Ice in the Fiord did occupy Ivitak Cove and deposited the Base Camp Moraine on the west shore (B.C. M. on Figure 5-3). Movement of ice over the bedrock bluff separating Ivitak and Eskimo Coves is suggested by striated roches moutonnees at approximately 150 metres but may have been short lived. This latter suggestion may explain the great depth of soil pit no. 4, on a recessional moraine at 110 metres, at the back of Eskimo Cove (R. M. on Figure 5-3). The overall depth of 76 cm is indicative of post Ivitak soil development rather than post Nachvak (see Figure 5-6).

Ice in Ivitak Valley stood at the end moraine at the valley mouth (I.E.M. on Figure 5-3) and at the lowest of the three Ivitak lateral moraines (Plate 4-5). This ice lobe was fed almost entirely by an extended Superguksoak Glacier. The extent of ice in North and South Bowls is uncertain but may not have been confluent with Superguksoak ice. This is suggested by the fossil patterned ground of the upper Ivitak Valley (Plate 5-1) which does not extend onto Nachvak glacial till surfaces.

The furthest extent of cirque glacier ice at this time was in the upper McCornick Valley. An ice lobe at the Middle McCornick Moraine (M.M.M. on Figure 5-3) was fed by coalescing valley glaciers fed by cirques in the Cirque Lake/Cirque Mountain basin and the Minaret/Caubvick cirque complex.

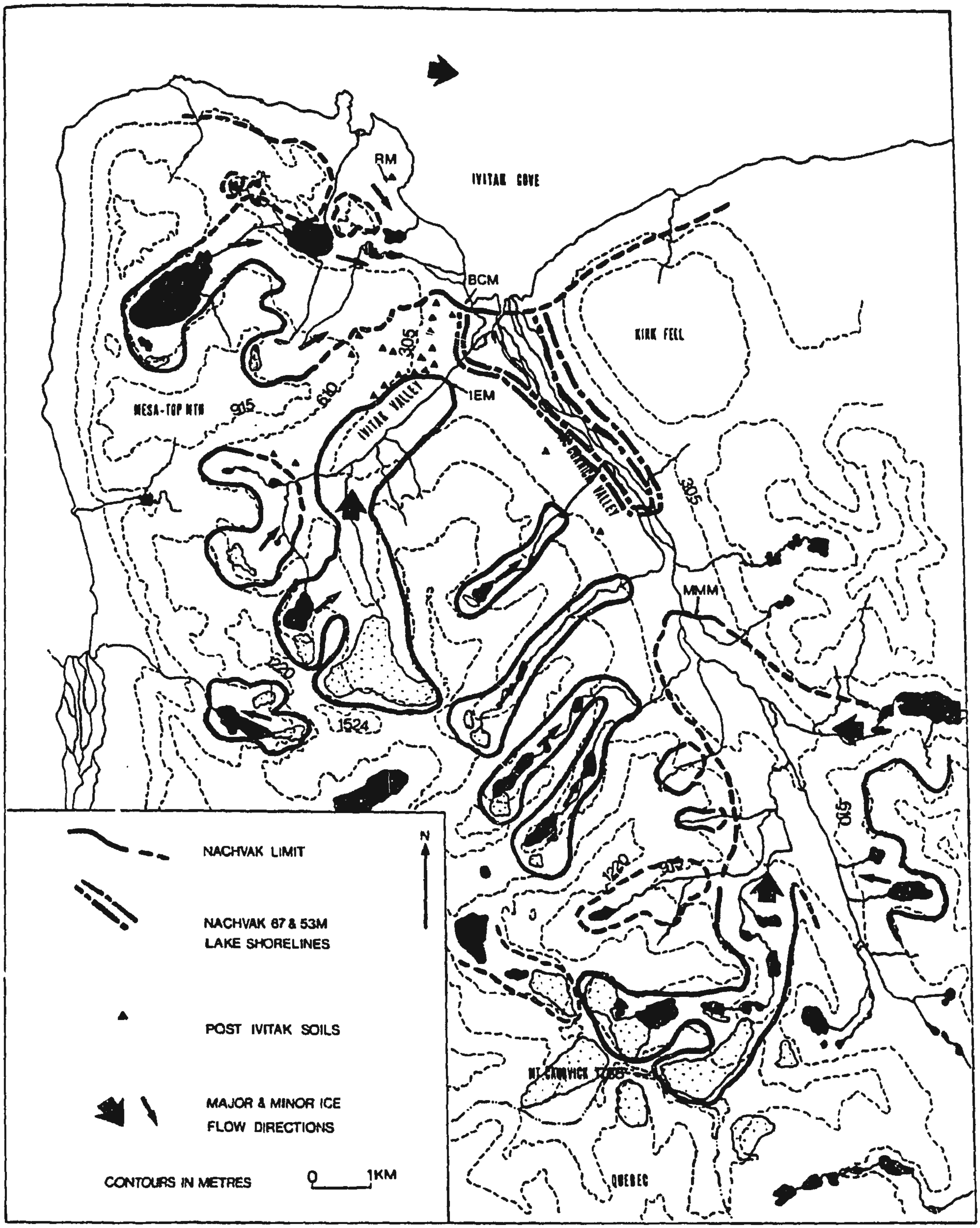


FIG. 5-3 NACHVAK GLACIATION

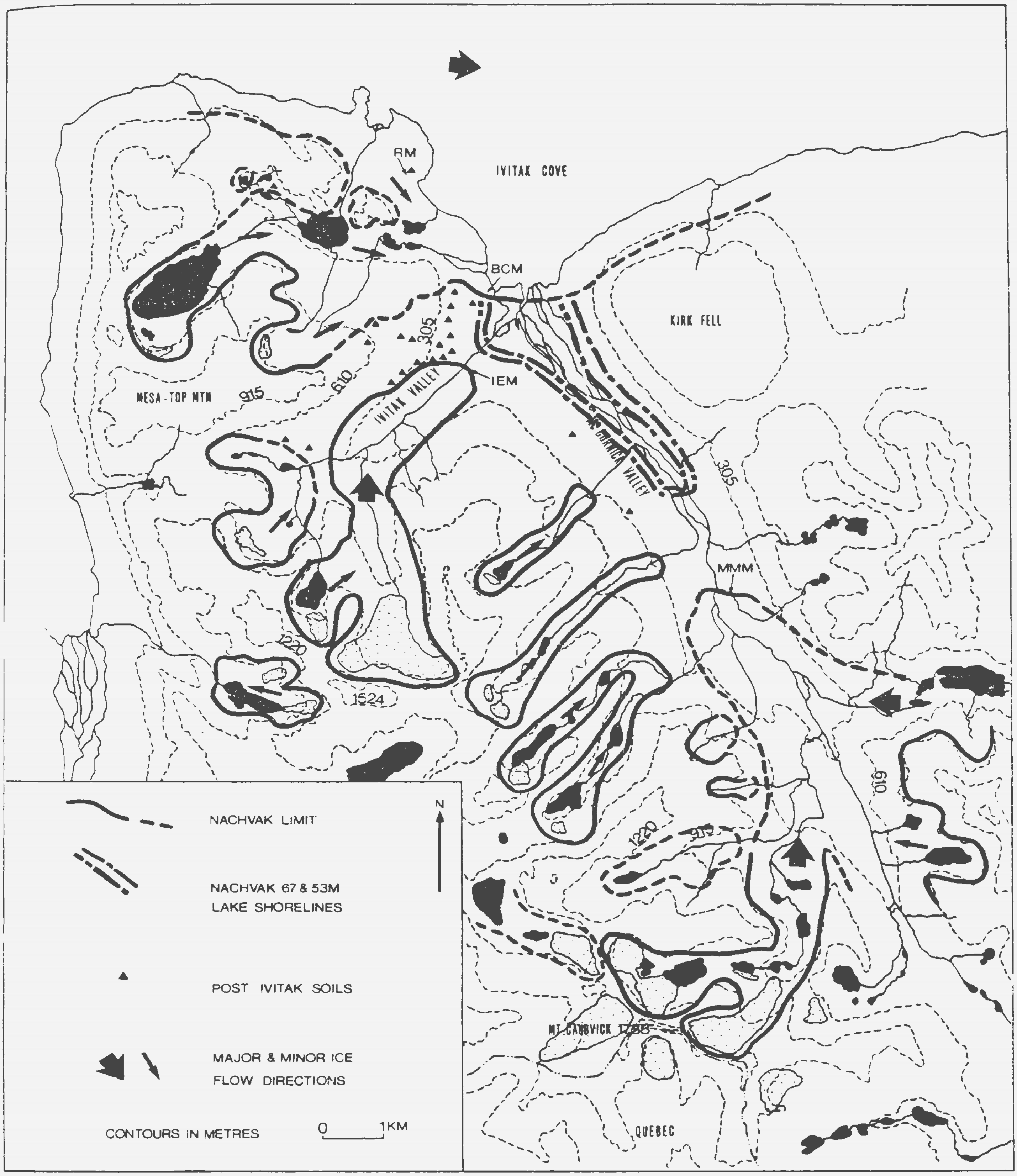


FIG. 5-3 NACHVAK GLACIATION

Throughout the Nachvak phase the lower McCornick Valley was again the host of an ice-dammed lake. Two levels are recorded at 67 and 53 metres. The chronological significance of these two trimlines is not fully understood but their age similarity has been previously discussed.

c) The Superguksoak I glaciation (Figure 5-4).

The final major glaciation in the region is documented only in the Selamiut Range by the end moraines in the cirque outlet valleys. Smaller cirque glaciers almost reached the extent achieved at the maximum of the Nachvak glaciation but the separate morainic systems are well defined on the ground.

The classification of this glacial episode is in respect to the dominant end moraine system at the outlet of Superguksoak Valley (Plate 4-2). However the most extensive ice lobe again occupied the upper McCornick Valley. Ice from the Minaret/Caubvick cirque complex deposited the end/hummocky moraine referred to as the Upper McCornick Moraine (U.M.M. on Figure 5-4). Concurrently ice in the Cirque Lake basin reached the lip of the containing hanging valley.

If ice occupied Nachvak Fiord during Superguksoak I it did not extend as far east as the Tallek Arm/Ivitak Cove area. From this point eastwards a marine limit of 33 metres records the sea level at the glacial maximum. Lateral channel migration of the McCornick River, swollen by meltwater, eroded at least two terraces in the McCornick Valley. The terraces also grade down to approximately 33 metres.

d) The Superguksoak II and III episodes (Figures 5-1 and 5-5).

From observations made on two sets of moraine units, correlative

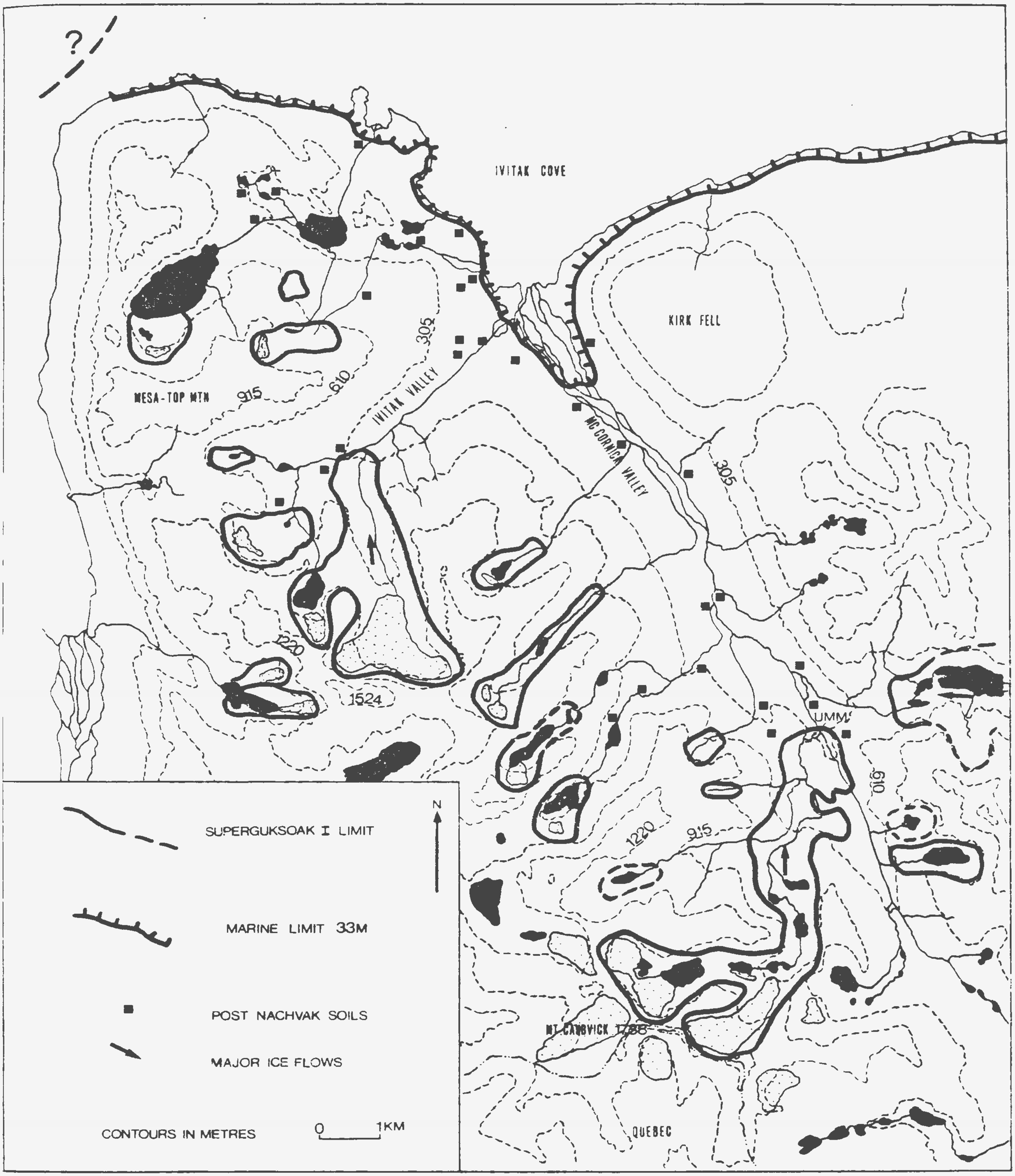


FIG 5-4 SUPERGUKSOAK I GLACIATION

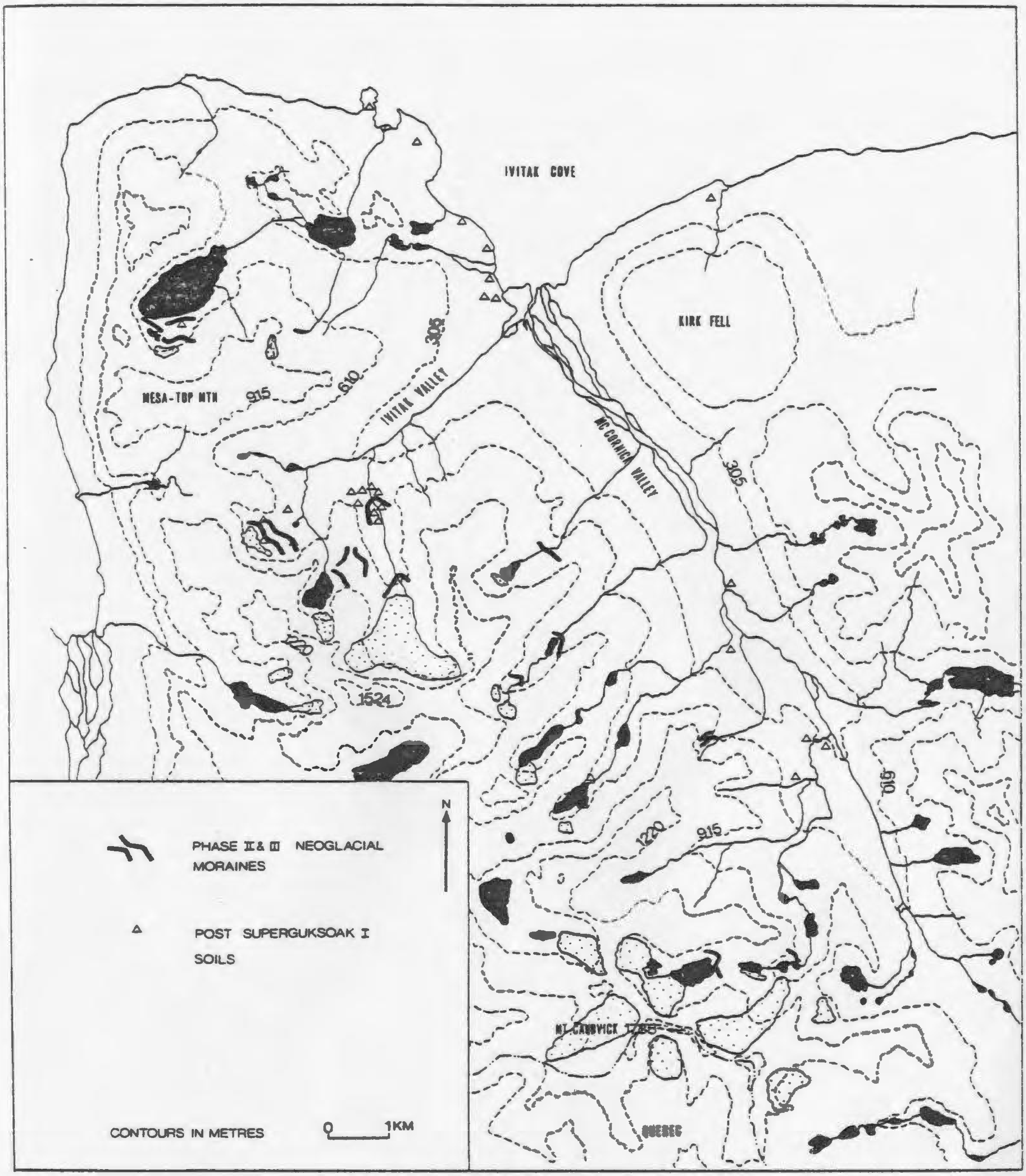


FIG. 5-5 NEOGLACIATION

throughout the Selamiut (see previous section), two cirque glaciations are postulated postdating the Superguksoak I episode. These events are classified Superguksoak II and III after their most distinctive preservation within the Superguksoak Glacier valley.

e) Summary table for relative chronology of the field area (Table 5-3).

Event	Moraines	Lake shoreline	Marine Limit	Relative age
Early Ivitak	I.R.1 L.M.M.			oldest
Late Ivitak	I.R.2 (E.H.M.) I.M.	80 metres		
Nachvak	B.C.M. I.E.M. M.M.M.	67 and 53 metres		
Superguksoak I	Superguksoak Valley end moraine U.M.M.		33 metres	
Superguksoak II	Cirque glaciation			
Superguksoak III	Cirque glaciation			youngest

For abbreviations see previous sections.

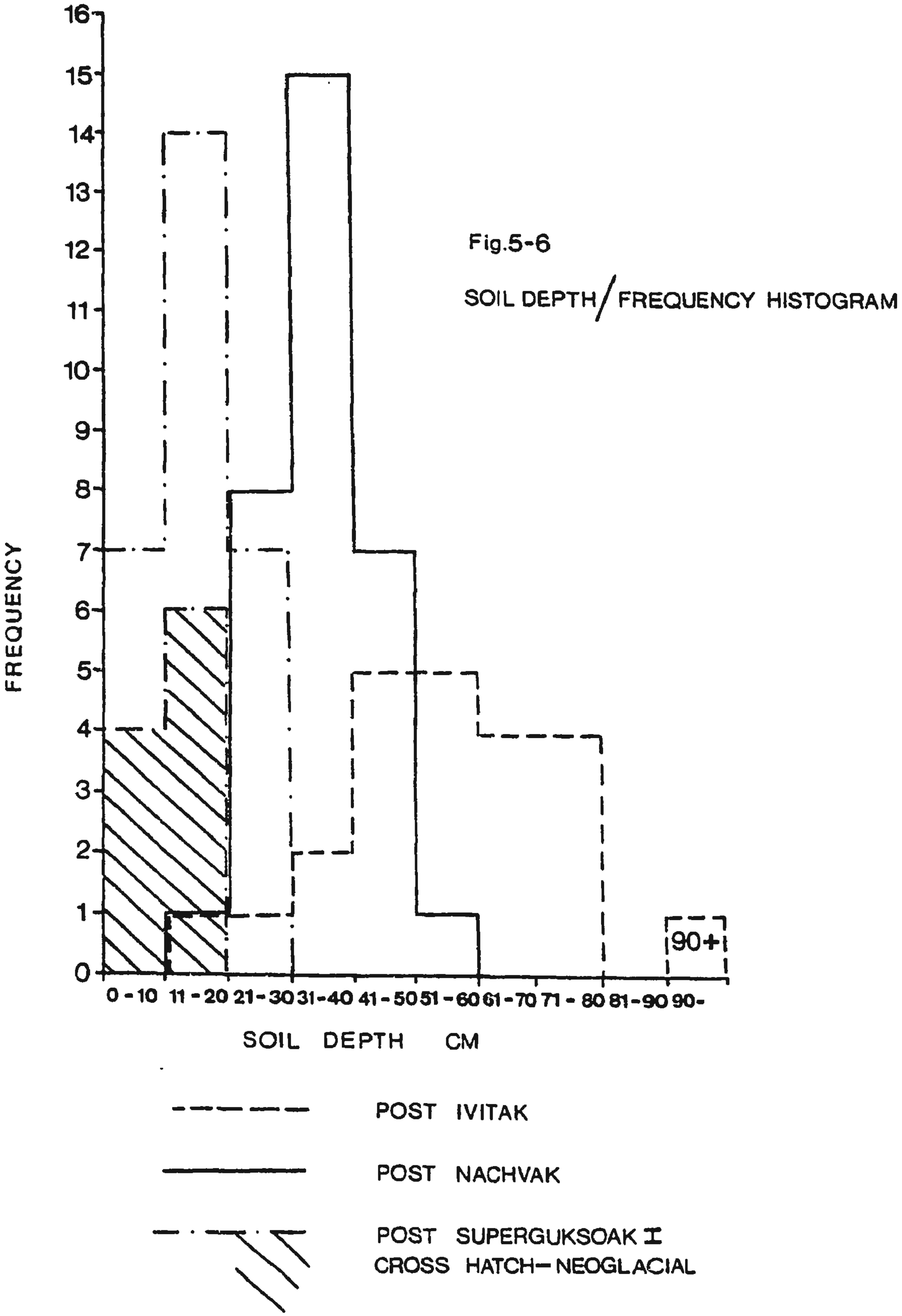


Fig.5-6

SOIL DEPTH/FREQUENCY HISTOGRAM

CHAPTER 6 AN ABSOLUTE CHRONOLOGY AND SOME TENTATIVE REGIONAL CORRELATIONS

The overall aim of this chapter is to attempt to define glacial activity within a regional framework and to explain any discrepencies that might emerge from the correlations involved. An absolute chronology is suggested for localized events in the vicinity of the Selamiut Range/Nachvak Fiord area based on the rate of soil development through time. Applicability to the contemporary Quaternary framework is assessed and possible alternative landforming sequences examined.

A number of glaciological, glacial geomorphic and relative sea level considerations are involved in temporal and spatial ice sheet reconstructions. Some conclusions are reached based upon the data available, but a closing section on future research outlines the necessity of substantiating the evidence so far collected in northern Labrador in order to enhance the present state of knowledge on Quaternary glaciations of the area.

i) An Absolute Chronology for the Selamiut Range/Nachvak Fiord Area.

As no datable material was recovered in the field area average soil depths from landforms grouped under the three major glacial phases, were used as tentative age indicators. This involves the determination of soil development over time which on Baffin Island has been calculated at approximately 1 cm ka^{-1} (Evans and Cameron 1979). Clark (1984a) questions the long term linear function of solum development calculated by Evans and Cameron and prefers Birkeland's (1978) decreasing rates of development with time. Using two absolute dates Clark has constructed a growth rate curve that involves 1.25 cm

ka^{-1} of soil development for the first 9 ka years and 0.9 cm ka^{-1} as a minimum rate thereafter.

The definition of the soil solum was discussed in section (ii) of Chapter 5. In his field area Clark (1984a) excluded the Cox horizon in his measurement of the depth of solum whereas it was included in the overall depth in this particular study. As a result overall depths are considerably greater than those found on contemporaneous landforms by Clark further north. Furthermore soil development rates would be calculated as greater in Clark's field area with the inclusion of the Cox[1].

Assuming that soil site locations were similar in both studies[2] a number of environmental variables may be assessed in order to determine the difference in rate of solum development between the Selamiut Range and Baffin Island. Soil pit locations on Baffin Island had a Polar Desert-type vegetation cover and even the older moraines that were examined were covered in a lag gravel pavement with little or no vegetation, (Evans and Cameron 1979). This is in strong contrast to the Selamiut Range where the dwarf shrub vegetation is typically dense on the older moraines, and the low Arctic environment probably facilitates faster soil development.

Unfortunately no chronosequences of soils have been constructed for northern Labrador other than Clark's (1984a), as there is no absolute dating control. Such a control would involve the dating of the landform features subject to pedological analysis by their association with stratigraphies and other datable assemblages. Clark (1984a) attempted to do this but his development curve contains only one absolute date from Iron Strand and as he did not include the Cox horizon as part of the soil solum his conclusions cannot be effectively compared with the results of this study.

After the consideration of possible environmental variables it is assumed that soil development would be approximately 1.5 cm ka^{-1} in the Selamiut Range. This is 0.25 cm ka^{-1} greater than Clark's maximum rate but includes the development of the Cox horizon. Furthermore Birkeland's (1978) time decay function of soil development is not adopted due to the lack of absolute dating control.

The average depths of the three soil forming periods represented in Figure 5-6 thus produce ages of >>40 ka. B.P. for the late Ivitak glaciation, c.23 ka. B.P. for the Nachvak glaciation and c.12 ka. B.P. for the Superguksoak I glaciation[3]. As some of the post Superguksoak I soils are located on marine sand and gravel units where soil development is accelerated (Birkeland 1978) and on the Nachvak regional till, the date of 12 ka B.P. is regarded as a maximum. The Superguksoak I glaciation may date to c.10 ka. B.P. if the marine limit in the area is compared to work further north (Loken 1962b), as will be discussed in the following section.

The Neoglacial history is somewhat more complex and is contained in Table 5-1 of Chapter 5. It is relevant to comment here that McCoy's (1983) end moraines within the Cirque Lake basin, dated at >>4 ka. B.P. and equated to the Late Wisconsin maximum, appear correlative to the Superguksoak I moraines.

Footnotes;

1. As Clark did not find the base of the Cox the calculation of a soil development rate compatible to the data used in this study (i.e. depth of solum including Cox) is impossible. Using Clark's rates of 1.25 and 0.9 cm ka^{-1} on soil depths excluding the Cox in the Selamiut/Nachvak area, dates for the Ivitak, Nachvak and Superguksoak I phases become >>32 ka, c.11 ka and c.10 ka respectively. This would seriously challenge the present fragmentary glacial history for northern Labrador especially when two major glacial events lie within 1,000 years of each other.

2. Elevation of soil pits ranged from 160-630 metres on Baffin Island and from 12-600 metres in the Selamiut Range. Therefore differences in altitudinal restrictions on soil development are disregarded.

3. Average depths are for all soil pits. As Evans and Cameron and Clark used only moraine crests the average figures for crest pits alone from the Selamiut Range are recognized here and produce dates of >>34 ka, 16 ka and 9 ka B.P. for the Ivitak, Nachvak and Superguksoak I glaciations respectively. The most significant effect is on the dating of Nachvak Glaciation but this does not affect chronocorrelative inferences made in section (ii) of this chapter.

(ii) Regional Correlations

The localized chronologies of past research have been tabulated in Table 6-1 and any cross-correlations, whether suggested by the original authors or inferred by this study, are indicated. Although the areal coverage of all the studies cited is extensive, approximately 325 kms. from Nain-Okak in the south to Port Burwell in the north, inferred synchronism is quite specific in some cases.

In comparison to the chronologies of Loken (1962b) and Andrews (1963) the framework of events for the Selamiut/Nachvak area is relatively simple. This is considered largely a function of the general physiography of the area and will be discussed in more detail below. However, the Ivitak phase, dated at >>40 ka.B.P., may be tentatively correlated, at least in part, to the $\geq$70 ka. B.P. (Kogalu) glaciation at Iron Strand (Clark 1982, 1984a). As deglaciation at Iron Strand occurred between 30 and 40 ka B.P. the late Ivitak phase may date to around 40 ka B.P. but ice marginal activity cannot be regarded as entirely synchronous along the Labrador coast. The Nachvak phase (c.23 ka) is correlated to the Saglek Glaciation dated at approximately 18 ka B.P. by Ives (Short et. al. 1981) and <25 ka B.P. by Andrews (1963).

Nevertheless, Clark and Josenhans (1983) have attempted to correlate the Early Wisconsin ($\geq$70 ka B.P.) glaciation on Iron Strand with a moraine system 25-30 kms seaward of the coast, stretching from Noodleook Fiord to Saglek Bay. Although only an Early Wisconsin glaciation is postulated two glacial advances are suggested for the formation of the moraine. A till dating from 24 ka B.P. has been

Table 6-1; Glacial and sea level chronology for northern Labrador compiled from various localized case studies (see chapter 1).

Torngat Mountains Ives (various)	Northernmost Labrador Loken (1962b)	Nain-Okak Andrews (1963)	Nain-Okak and Kiglapait Mts. Johnson (1969)	Iron Strand and Kangalaksiorvik region Clark (1982, 1983, 1984a)	Cirque Mountain and environs McCoy (1983)	Selamiut Range/ Nachvak Fiord This study.
	Various sea levels below 10M			Four Peaks drift c.2.5ka.B.P.	Various moraine abandonment phases <150->2.8ka.B.P.	Superguksoak III <1.5ka.B.P. Superguksoak II <3ka.B.P.
					Late Wisconsin Maximum ? >>4ka.B.P. Cirque Mountain	
	Transgression S.L.4 15M.	Readvance to Puttualuk Lake	Phase III (Puttualuk Lake correlative)	Two Loon and Coleman drifts c.9ka.B.P.		
	Kangalaksiorvik Phase S.L.3 34-28M 9ka.B.P.	Retreat Stillstand at Umiakoviarusek moraines S.L.94M		c.10ka.B.P. ice at mouth of Kangalaksiorvik Fiord S.L.55M		Superguksoak I Glaciation, S.L.33M c.10-12 ka.B.P.
	Two Loon Phase S.L.2 45-31M	Stillstnd at Tasiuyak 'B moraines S.L. c.79M		?		
	Noodleook Phase S.L.1 56-41M	Tasiuyak Readvance S.L. c.79M	Phase IIB (Tasiuyak)			
Saglek Glaciation c.18ka.B.P.		Saglek Glaciation <25ka.B.P.?	Phase IIA (Saglek)	Iron Strand drift >26.2ka.B.P.		Nachvak Glaciation c.20-24ka.B.P.
Koroksoak Glaciation			Phase I (Koroksoak)	c.30-40ka.B.P. Deglaciation		Late Ivitak Glaciation c.>40ka.B.P.
Torngat Glaciation				≥70ka.B.P. (Kogalu) glaciation		Early Ivitak Glaciation c.>>40ka.B.P.

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recorded from the Hopedale Saddle Region by Josenhans (1984) and suggests that shelf glaciation was not restricted to the Early Wisconsin, at least in southern Labrador.

The Superguksoak I moraines are regarded as equivalent to the "Late Wisconsin maximum" moraines of McCoy (1983) in the Cirque Lake basin. This is determined on the basis of pedology, lichenometry and morphological prominence. The Kangalaksiorvik Phase of Loken (1962b), dated at 9 ka B.P., is also a correlative and it must be noted here that the marine limit at 9 ka B.P. in both localities appears to be comparable.

Certain discrepencies arise when comparing the Selamiut/Nachvak late glacial chronology and supposed synchronous events in the Iron Strand/Kangalaksiorvik region, 40 kms north (Clark 1982,1984a and b). Clark has reconstructed local ice sheet configurations and has determined that ice filled Kangalaksiorvik Fiord and calved into the sea at 10 ka B.P. A 55 metre marine limit in Kangalaksiorvik Fiord has been equated to the same glacial event. In Nachvak Fiord the marine limit at c.10 ka B.P. was 33 metres and ice lay west of Ivitak Cove, almost 35 kms further inland than at Kangalaksiorvik. Therefore a maximum difference of 22 metres exists between the marine limits at c.9-10 ka B.P.. in Kangalaksiorvik Fiord on the one hand and Eclipse Harbour (Loken 1962b) and Nachvak Fiord on the other. A 56 metre marine limit is recorded by Loken but for his earlier, Noodleook Phase.

From Table 6-1 it can be seen that a lacuna exists in Clark's chronology spanning the time period 28.2 to 10 ka B.P. This may be a corollary of landform preservation or, more specifically, physiographic uniqueness. Whereas most other localized case studies in northern

Labrador document a "classic" Late Wisconsin glaciation between 18 and 25 ka B.P. Clark's Late Wisconsin maximum is dated at c.10 ka B.P. and appears more extensive than the similarly dated Superguksoak I phase. Although McCoy (1983) also dates the Late Wisconsin maximum to >>4 ka B.P. he advocates restricted cirque glaciation.

It would appear that if all the late glacial geomorphological events cited are synchronous ice extended abnormally far in Kangalaksiorvik Fiord. As a corollary isostatic loading of the crust, being greater in Kangalaksiorvik Fiord, may have produced a significantly higher marine limit at 9 ka B.P.[1]. This possibility might explain the difference between the marine limits on this part of the coast and in Eclipse Harbour as Clark (1984b) has attributed a north-easterly decrease in the marine limit, down to 15 metres at Port Burwell, to a northerly decrease in Laurentide ice thickness. A southerly decrease is also a possibility due to certain physiographic considerations that are discussed below.

Alternatively it is conceivable that a restrained rebound effect (Tanner 1965, Andrews 1970) was responsible for the lower sea level in Nachvak Fiord. This is assuming that ice did not leave the fiord until long after the later Late Wisconsin maximum of 9 ka B.P. This further suggests that ice lay in the fiord until c.8 ka B.P. assuming an average emergence rate, common to much of Arctic Canada (Andrews, 1970) for the period immediately after glaciation, of 3 metres per century since 9 ka B.P. This would implicate an exceedingly high rate of soil development since 8 ka B.P.; between 2 and 3 cm ka^{-1} in most of the post Superguksoak soils.

Figure 6-1 offers a possible solution to these discrepencies. This map of northern Labrador illustrates the physiographic distinctions of various locations involved in the chronology of Table 6-1. Immediately apparent is the barrier that the Torngat Mountains present to ice moving eastward from the Ungava ice dispersal centre. Ice needs to reach considerable thicknesses before it can breach the Torngat watershed and move along major through-troughs such as Nachvak Fiord.

However, summit heights decrease quite rapidly to the north and ice would tend to exploit the wider through-troughs throughout glaciation and would consequently extend further down Kangalaksiorvik Fiord. In essence Laurentide ice would diverge and channel around the central Torngat summit block and the eastward ice limit would depend on trough depth and width along the coast between Hebron and Kangalaksiorvik Fiord's. Cirque glaciation would be quite extensive, however, assuming glacial conditions were climatically controlled.

Following these considerations it is quite possible that the 9 ka B.P. margin was so irregular because ice did not gain a sufficient depth at the Labrador/Ungava watershed to attain a synchronous maximum ice limit, similar to one manifest in the offshore end moraines equated to the Early Wisconsin by Clark and Josenhans (1983).

This general hypothesis would explain not only the differential extent of Late Wisconsin ice along the northern Labrador coast but could further explain the higher marine limit in Kangalaksiorvik Fiord by suggesting differential crustal loading. If this is considered the most feasible explanation, a gradient on the elevation of

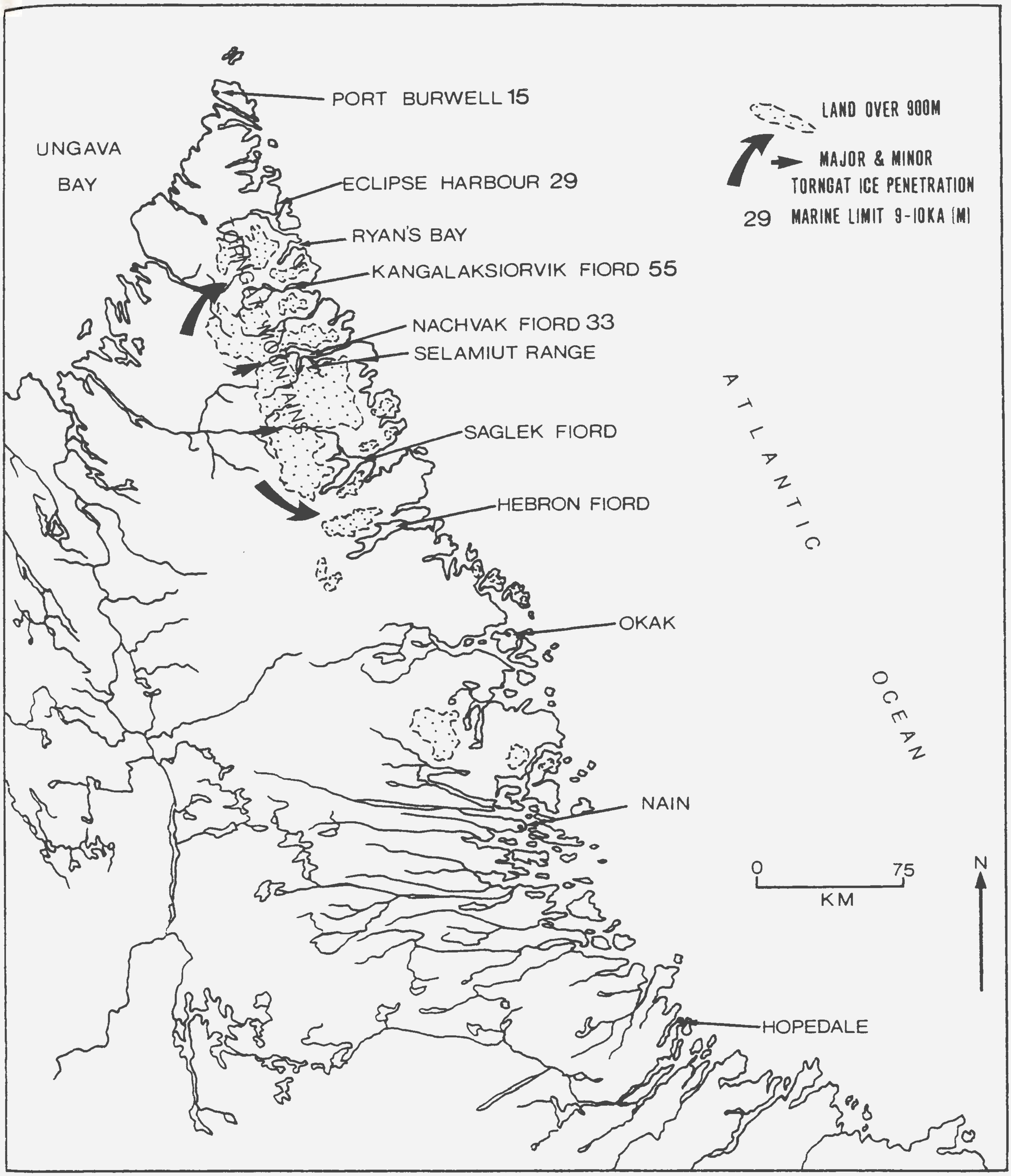

FIG. 6-1 NORTHERN LABRADOR

contemporaneous marine limits from Nachvak Fiord to Kangalaksiorvik Fiord would be less than 0.6 metres/km. This is an acceptable figure compared to the results of many studies on isostatic readjustment in the eastern Canadian Arctic.

Footnote;

1. Clark suggests c.10 ka B.P. but as the only absolute data so far recorded is 9 ka B.P. (Loken 1962b) it is adopted here.

CHAPTER 7

SUMMARY AND CONCLUSION

A RATIONALE FOR FUTURE RESEARCH

The Torngat Mountains represent a formidable physiographic barrier to the eastward flow of any Laurentide ice sheet. During Wisconsin glaciation ice moved along major through troughs isolating much of the upland plateaux as nunataks. During the Late Wisconsin, glaciation was restricted to local cirques and regional ice attained differential extent along the Labrador coast.

This complex interaction of local and regional ice masses is manifest in the geomorphological evidence in the Selamiut Range. Other than bedrock the major surficial units are predominantly residuum or felsenmeer, till and moraine, colluvium and outwash deposits. A major lateral feature (the Ivitak Moraine), together with moraines that possess cross-cutting relationships, document the interaction of local and regional (fiord) ice in the Ivitak Cove/Nachvak Fiord area. Ice-dammed lake sediments and shorelines at 80, 67 and 53 metres are evident in the McCornick Valley. A marine bench at 33 metres in Nachvak Fiord documents the marine limit and is associated with the last major glaciation in the field area.

A combination of morphochronological inference and relative dating techniques, specifically pedological analysis and lichenometry, isolates three major glacial phases; the Ivitak, Nachvak and Superguksoak I glaciations. The Ivitak phase is subdivided into early and late events and two further episodes, the Superguksoak II and III, are suggested for local cirque glacier activity during the Holocene.

During the Ivitak glaciation local and regional ice was active in the Nachvak/Selamiut area but the lower half of the McCornick Valley remained unglaciated, at least during the late Ivitak phase. At that time an 80 metre proglacial lake occupied the Valley. The higher summit plateaux remained unglaciated throughout the Ivitak glaciation.

Local cirque glaciation was restricted to cirque outlet valleys during the Nachvak phase but regional ice occupied Nachvak Fiord. The major sources of local ice were Superguksoak glacier, in the north of the field area, and Minaret and Caubvick glaciers and the Cirque Mountain bowl of cirques in the south. The lower McCornick Valley again hosted a proglacial lake dammed by the Nachvak Fiord regional ice mass. Two levels are recorded at 67 and 53 metres.

The Superguksoak I glaciation was marked by extended local cirque glaciers. Regional ice lay west of Tallek Arm in Nachvak Fiord and a marine limit of 33 metres was cut.

After a careful consideration of the various techniques employed in the analysis of pedological data, specifically Evans and Cameron (1979), Birkeland (1978) and Clark (1984a), overall depth to the base of the Cox horizon was taken as the most important variable in determining soil development over time.

An assumed soil development rate of 1.5 cm ka^{-1} revealed dates of >>40 ka B.P. for the Ivitak glaciation, c.23 ka B.P. for the Nachvak glaciation and 10-12 ka B.P. for the Superguksoak I glaciation, using data from soil pits excavated on moraines and till sheets and other landforms in the field area.

Regional correlations reveal certain discrepencies between the

Selamiut/Nachvak chronology and events further north around Kangalaksiorvik Fiord (Clark 1984a and b). At the latter site the marine limit at 10 ka B.P. was 55 metres, 22 metres higher than the marine limit in Nachvak Fiord/Ivitak Cove. A date of 9 ka B.P. was obtained for a 29 metre shoreline to the north of Kangalaksiorvik Fiord by Loken (1962b).

Two theories are formulated to explain the discrepencies. The first theory involves the differential loading of the crust by ice lobes of different extent and thickness. This would explain a greater depression of Kangalaksiorvik Fiord during glaciation. The second theory involves a restrained rebound effect in Nachvak Fiord suggesting that ice remained in the Fiord until c.8 ka B.P. The first theory assumes a deeper and more extensive glaciation of Kangalaksiorvik Fiord than Nachvak Fiord c.9 ka B.P. In the second theory ice occupied both fiords at c.9 ka B.P. but remained longer in Nachvak.

The outlined reconstruction of a glacial and sea level history for northern Labrador based upon existing empirical data is still hypothetical. Conclusions will remain inferential until considerably more fieldwork is undertaken and a greater recovery rate of datable assemblages facilitates the construction of a more comprehensive absolute dating framework.

Of critical importance to the applicability of the Selamiut/Nachvak chronology is the interpretation of a) the sea level history of northern Labrador and b) soil development rates for the eastern Canadian Arctic regions. Even a partial solution of a). would provide a more rigorous chronological framework for the application of b).

The inferential nature of the glacial history of northern Labrador, as it stands, is suitably illustrated by the fragmentary evidence for the 18-23 ka B.P. "classic" Late Wisconsin maximum throughout the region. If a more complex chronology is accepted for northern Labrador a number of possible combinations exist that may explain the difference in the marine limit between Kangalaksiorvik Fiord and Nachvak Fiord and Eclipse Harbour at c.9 ka B.P.:

1. Ice in Kangalaksiorvik Fiord reached a similar or greater extent at 9 ka B.P. than at 18 ka B.P. Therefore the sea levels at both episodes were the same or the earlier marine limit may have been obliterated. The differential loading theory would still apply.
2. Any sea level higher than 55 metres at Kangalaksiorvik might be absent assuming the 55 metre limit is the 9 ka. B.P. sea level in the differential loading theory.
3. Any sea level lower than 55 metres at Kangalaksiorvik might be absent assuming the 55 metre limit is the 18-23 ka B.P. sea level and a 9 ka B.P. marine terrace has not been locally preserved.
4. The Kangalaksiorvik Fiord 55 metre limit is of an undetermined age and a 30 metre limit in the area, if found, may date to 9 ka B.P. Ice may have remained in Nachvak Fiord until later and therefore the 33 metre limit may date from c.8 ka B.P. This combination disregards the pedological relative chronology of this study.

5. The Kangalaksiorvik Fiord 55 metre limit dates from 9 ka B.P. but as ice lay in Nachvak Fiord very late the marine limit at 33 metres dates from <9 ka B.P. This combination disregards several morphochronological inferences and the pedological relative chronology of this study.

It is imperative that the relationships between terrestrial and marine landform assemblages be rigorously tested in future research. Furthermore it is quite obvious that the elaborate combinations of possibilities outlined above would be clarified once the different marine limits are dated. As nothing higher than 29 metres has been dated (Loken 1962b) we may assume that the differential loading theory is reasonable until other marine limits are dated with any certainty. It is highly probable that the state of preservation of further glacial sea levels is more favourable at other localities along the northern Labrador coast.

Furthermore if the time-decay function of soil development (Birkeland 1978) is realistic, verification will materialize with the addition of more absolute dates to the, largely superficial, regional chronology. Agreements must be made upon the most suitable pedological parameters for the dating of surficial deposits.

The relative chronology presented in this study documents a number of local and regional glacial trends for the Selamiut/Nachvak area. The tentative dates assigned to events in the chronology may serve as a suitable working hypothesis for further work in adjacent areas and throughout northern Labrador generally. However the accuracy of regional chronologies relies entirely upon a sufficient areal coverage of localized enquiry.

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Appendix I

Grain size analysis of middle McCornick Valley meltwater sediments.

Table Al

1*(%)	2(%)	3(%)	4(%)	5(%)	
1	46	73	2	22	Gravel
0.5	15	3	2	3	Very coarse sand
0.9	18	7	13	5	Coarse sand
9	12	8	17	5	Medium sand
58	6	7	46	9	Fine sand
26	2	2	17	43	Very fine sand
4	1	-	2	10	Coarse silt
0.6	-	-	1	3	Fine silts and clays

*Numbers refer to locations on Plate 4-14.

Appendix II

Table A2; Data and pertinent information for soils of the Selamiut Range/Nachvak Fiord area. For explanation of relative age assignment see Chapter 5.

Table A2: Data and pertinent information for soils of the Selamiut Range/Nachvak Fiord area.

Location no. and relative age*	Altitude (M)	Horizon**	Depth (CM).	Colour (Field)	pH	C.D.E.	Location details.
1. Superguksoak	20	B	0-7	7.5YR 3/2	5.2	8	Tombolo surface in Eskimo Cove - beach sands and gravels.
		Cox	7-29	2.5YR 5/4	5.4	8	
		Cn	29-89+	10 YR 5/4	5.4	12	
2. Superguksoak	33	O/Ah	0-5	10 YR 2/2	5.1	6	II Bhb is a lens of material implying disturbance by congeliturbation on planed marine sediments in Mum's Cove.
		AE	5-8	2.5Y 6/8	5.8	16	
		Bg	8-11	10 YR 5/1	5.3	3	
		II Cox	11-17	2.5Y 6/6	5.7	12	
		II Cn	17-22	10 YR 5/4	6.0	12	
		II Bhb	22-25	7.5YR 3/2	5.6	8	
		II Cn	25-45+	10 YR 5/4	6.0	12	
3. Nachvak	40	Ah	0-8	5 YR 3/2	4.9	10	Moraine at back of Eskimo Cove.
		Bh	8-20	7.5YR 3/2	5.4	8	
		B/Cox	20-26	7.5YR 4/4	5.4	16	
		II Cox	26-30	2.5Y 5/4	6.9	8	
		II Cn	30-50+	10 YR 5/4	6.1	12	
4. Ivitak	110	O/A	0-39	7.5YR 2/0	5.1	0	Recessional moraine above Eskimo Cove. B horizon ends abruptly at iron stained cobbles.
		B2	39-51	10 YR 3/3	5.6	9	
		B3	51-76	10 YR 3/2	5.3	6	
		II C					
5. Ivitak/ Nachvak	320	A	0.10	7.5YR 2/0	4.2	0	Till bench in Idyutak Pass. Overall depth from Ivitak glaciation. Disturbance by periglacial processes during Nachvak glaciation was followed by development of 30cm of soil solum?
		B	10-22	7.5YR 3/4	4.7	16	
		Cox	22-30	2.5Y 5/4	4.7	8	
		II B2b	30-55	5 YR 3/3	5.0	15	
		II B3b	55-75	7.5YR 4/2	5.0	8	
		II Coxb	75-90+	2.5Y 5/2	5.3	4	

Table A2 (cont)

6. Nachvak	310	B/Cox	0-22	7.5YR 4/4	5.6	16	Hummocky moraine below back wall of Idyutak Pass.
		Cn	22-52+	2.5Y 5/4	6.3	8	
7. Nachvak	320	B/Cox	0-10	7.5YR 4/4	5.4	16	Outwash from gorge below Idyutak Lake.
		Cn	10-50+	2.5Y 4/4	5.8	8	
8. Superguksoak	15	Ah	0-3	10 YR 3/2	5.2	6	Till bluff in Ivitak Cove. Heavily solifluected slope. Date of buried horizons probably Nachvak?
		B	3-24	10 YR 4/3	5.0	9	
		II Bb	24-41	10 YR 5/3	5.4	9	
		II Coxb	41-71+	2.5Y 5/2	5.2	4	
9. Nachvak	230	Ah	0-3	7.5YR 2/0	4.7	0	On till sheet in Three Pond's Pass.
		B	3-7	7.5YR 3/4	5.0	16	
		B/Cox	7-14	10 YR 4/4	5.6	12	
		Cn	14-34+	10 YR 5/2	5.8	6	
10. Nachvak	130	01	0-4	10 R 2.5/1	4.7	7	Till bluff in Ivitak Cove. B horizon ends abruptly at iron stained cobbles.
		Ah	4-7	5 YR 4/1	4.4	5	
		A/E	7-11	2.5Y 4/4	4.4	8	
		Birh	11-31	2.5YR 2.5/4	4.9	24	
		II Cn					
11. Superguksoak	15	01	0-4	10 R 2.5/2	4.9	14	Till bluff in Ivitak Cove.
		02/A	4-11	5YR 2.5/1	5.2	5	
		B	11-29	10YR 3/4	4.9	12	
		C	29-42+	2.5Y 4/4	5.0	8	
12. Superguksoak/ Neoglacial	560	B	0-10	7.5YR 3/4	5.8	16	End moraine at western end of of Idyutak Lake.
		Cox	10-14	2.5Y 4/4	6.2	8	
		Cn	14-29+	2.5Y 3/2	5.8	4	
13. Nachvak	340	B	0-4	7.5YR 3/2	4.8	8	In hummocky moraine and meltwater features above Three Pond's Pass.
		B/C	4-16	10 YR 3/3	4.9	9	
		Cn	16-36+	7.5YR 3/4	5.2	16	

Table A2 (cont)

14. Ivitak	350	B	0-7	7.5YR 3/4	5.3	16	Hummocky moraine on Ivitak Rigg.
		Cox	7-52	2.5Y 5/4	5.3	8	
		Cn	52-72+	10YR 4/3	5.0	9	
15. Ivitak	350	B	0-9	7.5YR 3/2	5.1	8	Hummocky/end moraine crest on Ivitak Rigg.
		B/C	9-14	10YR 4/4	5.5	12	
		Cn	14-29+	10YR 4/2	5.7	6	
16. Ivitak	462	O/A	0-6	2.5YR 2.5/2	5.6	12	Ditto.
		B	6-13	7.5YR 3/2	5.6	8	
		C1ox	13-17	10YR 5/4	5.6	12	
		C2ox	17-29	2.5Y 6/4	5.7	8	
		Cn	29-54+	10YR 5/2	6.3	6	
17. Ivitak	340	O/A	0-5	5 YR 2.5/2	4.4	10	Outside hummocky end moraine on Ivitak Rigg.
		B	5-26	5YR 4/6	5.2	30	
		Cox	26-34	10YR 5/6	5.5	18	
		II Coxb	34-47	2.5Y 5/4	5.5	8	
		II Cnb	47-72+	10YR 5/4	5.4	12	
18. Ivitak	140	Ah	0-6	10YR 2/1	4.6	3	Ivitak moraine, marginal channel.
		B	6-34	10YR 3/6	4.5	18	
		Cox	34-64	2.5Y 5/4	5.1	8	
19. Ivitak	145	Ah	0-7	10YR 2/2	4.4	6	Ivitak moraine crest. B horizon ends abruptly at iron stained cobbles.
		Bh	7-33	7.5YR 3/4	4.6	16	
		Bir	33-41	5 YR 3/4	5.0	20	
		II Cn					
20. Ivitak	150	Ah	0-5	10YR 2/1	5.0	3	Ivitak moraine crest
		B	5-28	7.5YR 4/4	4.9	16	
		Cox	28-39	2.5Y 4/4	5.4	8	
		Cn	39-49+	10YR 5/2	5.1	6	
21. Ivitak	155	Ah	0-3	10YR 2/1	4.5	3	Ditto.
		B	3-21	7.5YR 3/4	4.6	16	
		Bir	21-34	5 YR 4/6	4.9	30	
		C1ox	34-46	2.5Y 4/4	5.2	8	
		C2ox	46-71+	10YR 4/6	5.4	18	

Table A2 (cont)

22. Ivitak	160	Ah	0-7	10YR 2/1	5.0	3	Ditto.
		B2	7-33	10YR 3/6	5.2	18	
		B3	33-46	2.5Y 4/4	5.0	8	
		Cn	46-57+	2.5Y 5/2	5.6	4	
23. Ivitak	165	Ah	0-5	10YR 2/2	4.6	6	Ivitak moraine, marginal channel.
		B2	5-28	10YR 3/4	5.1	12	
		B3	28-42	2.5YR 4/4	5.2	24	
		Cox	42-65+	2.5Y 6/6	5.1	12	
24. Ivitak	170	Ah	0-3	10YR 2/2	4.8	6	Ivitak moraine crest. B/Cox horizon ends abruptly at tightly packed cobbles.
		E	3-9	10YR 3/6	4.8	18	
		B2	9-30	2.5YR 2.5/4	5.0	24	
		B/Cox	30-45	10YR 5/4	5.4	12	
		II Cn					
24A. Ivitak	175	Ah	0-6	10YR 2/2	4.6	6	Ivitak moraine crest.
		B2	6-33	7.5YR 3/2	4.7	8	
		B3	33-40	10YR 3/4	5.3	12	
		Cox	40-70+	2.5Y 5/6	5.4	12	
25. Ivitak	175	Ah	0-12	5YR 2.5/2	4.9	10	Ridge of meltwater channel above Ivitak moraine.
		B	12-29	7.5YR 3/2	5.1	8	
		Cox	29-37	2.5Y 5/4	5.4	8	
		Cn	37-47+	10YR 5/4	5.6	12	
26. Supergukaoak	12	Ah	0-6	5YR 3/2	4.8	10	Till bench to the north of the lower Base Camp Moraine. II Cn is packed angular gravel.
		Bh	6-29	2.5YR 3/6	5.1	36	
		C/Cn	29-40	2.5Y 4/4	5.3	8	
		II Cn					
27. Ivitak	56	O1	0-5	5YR .5/1	4.3	5	Marshy, levelled surface above lower Base Camp Moraine.
		A	5-12	5YR 2.5/2	4.0	10	
		A/E	12-17	2.5Y 4/4	4.5	8	
		Birh	17-37	7.5YR 3/2	4.5	8	
		Bir	37-43	2.5YR 2.5/4	5.0	24	
		B/Cox	43-53	10YR 3/4	5.1	12	

Table A2 (cont)

28. Nachvak	50	Ah	0-3	7.5YR 3/4	4.6	16	Lower Base Camp
		B/C	3-10	10 YR 3/4	4.8	12	Moraine, crest.
		Cox	10-35+	2.5Y 6/2	5.3	4	
29. Nachvak	42	Ah	0-3	7.5YR 5/0	4.9	0	Ditto.
		E	3-8	10 YR 4/6	4.8	18	
		B/C	8-15	7.5YR 4/6	5.1	24	
		Cox	15-32+	2.5Y 5/6	5.4	12	
30. Superguksoak	21	Ah	0-4	7.5YR 5/0	4.8	0	Marine inundated
		E	4-13	10YR 3/6	4.7	18	eastern end of lower
		B/Cox	13-21	2.5YR 3/6	5.1	36	Base Camp Moraine.
		Cn	21-35	5YR 4/6	5.3	30	II Cn is compact till
		II Cn					clasts.
31. Superguksoak	33	Ah	0-2	2.5YR 3/2	4.9	12	Marine eroded bench
		B	2-6	10YR 4/2	4.9	6	on lower Base Camp
		B/C	6-14	2.5Y 5/2	5.4	4	Moraine.
		Cn	14-44+	5YR 5/1	6.2	5	Cn is lake clays.
32. Nachvak	67	Ah	0-11	10YR 2/2	4.4	6	Upper lake shoreline
		B	11-24	7.5YR 3/4	5.0	16	II Cn is compact
		C	24-36	5YR 3/4	5.1	20	gravel.
		II Cn					
33. Nachvak	67	O/A	0-4	10YR 2/2	4.5	6	Ivitak Valley end
		B	4-11	7.5YR 3/4	5.0	16	moraine, planed
		Cox	11-17	2.5Y 5/6	5.3	12	surface.
		Cn	17-57+	2.5Y 4/2	5.3	4	
34. Nachvak	53	Ah	0-8	10YR 2/1	4.9	3	Lower lake shoreline
		B	8-20	10YR 3/3	5.5	9	below western face of
		Cox	20-24	10YR 5/4	5.8	12	Kirk Fell.
		Cn	24-44+	10YR 4/2	5.9	6	Cn is lake clays.
35. Nachvak	53	A/E	0-6	5YR 3/3	4.8	15	Lower lake shoreline
		Bh	6-18	5YR 2.5/2	4.7	10	cut in laminated
		Cox	18-22	2.5Y 4/4	5.0	8	clays.

Table A2 (cont)

36. Nachvak	95	Ah	0-5	10YR 3/2	4.7	6	Ivitak Valley end moraine
		B2	5-18	7.5YR 3/4	5.3	16	
		B/Cox	18-23	2.5Y 4/4	5.3	8	
		Cn	23-58+	2.5Y 6/2	5.0	4	
37. Ivitak	290	O	0-4	5YR 2.5/2	4.2	10	Crest of lateral drainage channel on Ivitak moraine in Ivitak Valley. (Plate 27).
		A	4-7	10YR 6/2	4.5	6	
		A/E	7-17	7.5YR 4/6	4.6	24	
		Bir	17-32	5YR 3/4	4.8	20	
		C11ox	32-52	5YR 4/6	5.3	30	
		C12ox	52-77+	2.5YR 3/6	5.1	36	
38. Ivitak	325	Ag	0-4	7.5YR 4/0	4.6	0	Interlobate moraine crest on Ivitak Rigg.
		Bir	4-16	2.5YR 2.5/2	4.9	12	
		B/C	16-32	5YR 3/4	5.3	20	
		Cox	32-52+	10YR 5/4	5.2	12	
39. Ivitak	322	Ah	0-4	10YR 2/1	5.0	3	Ivitak moraine crest in Ivitak Valley. Upper horizons have developed since Nachvak glaciation?
		Bh	4-24	10YR 4/4	5.1	12	
		II Ahb	24-27	5YR 2.5/1	5.2	5	
		II Bb	27-45	5YR 4/6	5.2	30	
		II Cox	45-65+	2.5Y 5/4	5.3	8	
40. Nachvak	175	Ah	0-4	5YR 2.5/1	4.4	5	Ivitak Valley bottom.
		B21	4-12	10YR 3/6	4.5	18	
		B22	12-27	7.5YR 4/4	4.9	16	
		Cox	27-37	2.5Y 5/4	5.2	8	
		Cn	37-57+	10YR 4/3	5.4	9	
41. Ivitak	370	A	0-6	7.5YR 3/2	5.0	8	Ivitak Valley lateral moraine crest below main Ivitak Moraine.
		B2	6-28	5YR 3/3	5.5	15	
		B3	28-38	10YR 4/3	5.5	9	
		Cox	38-58+	2.5Y 4/2	5.9	4	
42. Ivitak	430	B	0-4	7.5YR 4/6	5.3	24	End moraine in North Bowl. Upper stratigraphy dates from Superguksoak, middle stratigraphy from Nachvak and overall depth from Ivitak?
		Cox	4-11	2.5Y 5/4	5.1	8	
		II Bb	11-21	5YR 3/4	5.0	20	
		II Coxb	21-31	2.5Y 5/4	5.4	8	
		III Bh	31-56	10YR 4/4	5.8	12	

Table A2 (cont)

43.	Superguksoak	420	Ah	0-3	7.5YR 3/2	5.1	8	Till sheet at outlet of South Bowl. II Cox probably dates from Nachvak?
			B	3-8	7.5YR 3/4	5.1	16	
			Cox	8-16	2.5Y 5/4	5.8	8	
			Cn	16-28	10YR 5/4	6.2	12	
			II Cox	28-38+	2.5Y 5/6	6.2	12	
44.	Neoglacial	465	B/C	0-7	10YR 3/1	4.8	3	End moraine crest in South Bowl.
			Cn	7-22+	10YR 4/4	5.8	12	
45.	Neoglacial	465	Cn	0-25+	10YR 3/6	6.0	18	Ditto, (recent feature).
46.	Neoglacial	455	B/C	0-5	2.5YR 2.5/4	5.7	24	Ditto, (date as pit 44).
			Cn	5-30+	10YR 4/6	5.6	18	
47.	Nachvak	305	B	0-15	10YR 3/2	5.2	6	Till sheet below Superguksoak end moraine complex.
			Cox	15-35	2.5Y 5/4	5.7	8	
48.	Nachvak	310	A	0-5	5YR 3/3	5.0	15	Lateral moraine crest below Superguksoak Valley.
			B	5-17	7.5YR 3/4	5.1	16	
			Cox	17-35	10YR 4/6	5.8	18	
49.	Superguksoak	450	Ah	0-3	7.5YR 3/2	4.5	8	Medial moraine crest at Superguksoak outlet.
			B/C	3-7	5YR 3/3	4.7	15	
			Cox	7-11	10YR 4/6	5.0	18	
			Cn	11-26+	10YR 3/3	5.4	9	
50.	Superguksoak	450	B/C	0-4	10YR 3/2	4.8	6	Lateral moraine crest at Superguksoak outlet.
			Cox	4-9	2.5Y 4/4	5.7	8	
			Cn	9-34+	10YR 4/4	5.2	12	
51.	Superguksoak	450	A	0-4	10YR 2/2	4.6	6	Medial moraine crest at Superguksoak outlet.
			B	4-9	10YR 3/4	4.9	12	
			C1ox	9-17	2.5Y 5/4	5.2	8	
			C2ox	17-27	2.5Y 6/4	5.7	8	
			Cn	27-42+	10YR 5/3	5.3	9	

Table A2 (cont)

52.	Superguksoak/ Neoglacial	458	B Cox	0-4 4-13	10YR 3/4 2.5Y 5/2	5.0 5.6	12 4	End moraine crest at Superguksoak outlet.
53.	Superguksoak/ Neoglacial	458	B Cox	0-6 6-18	10YR 3/4 2.5Y 5/4	4.5 4.9	12 8	Ditto.
54.	Superguksoak/ Neoglacial	460	B Cox	0-5 5-17	5YR 3/4 5Y 6/3	4.8 4.9	20 3	Ditto.
55.	Superguksoak/ Neoglacial	460	B Cox	0-6 6-16	7.5YR 3/4 2.5 Y 6/2	4.9 5.3	16 4	Ditto.
56.	Superguksoak/ Neoglacial	460	Ah B C	0-3 3-16 16-36+	10YR 3/3 10YR 4/4 2.5Y 6/4	4.5 4.9 5.4	9 12 8	Till sheet at Superguksoak outlet.
57.	Nachvak	55	O/Ah B Cox Cn	0-4 4-8 8-16 16-46+	5YR 2.5/2 5YR 3/3 10YR 5/8 10YR 5/3	4.6 4.6 5.0 5.6	10 15 24 9	Very faint recessional moraine hummock - lower McCornick Valley.
58.	Ivitak	80	Ah B2 B3 B/Cox	0-10 10-22 22-42 42-67+	10YR 2/1 5YR 3/3 2.5Y4/4 10YR 4/3	4.8 4.9 5.2 5.3	3 15 8 9	Lower McCornick till sheet.
59.	Nachvak	50	B Cox Cn	0-15 15-23 23-43+	2.5YR 3/6 2.5Y 5/6 2.5Y 4/2	4.8 5.8 5.6	36 12 4	Lower McCornick Moraine crest.
60.	Nachvak	150	A/Bh Cn	0-18	10YR 3/2	5.0	6	On coarse till-small cirque outlet on east facing slope of lower McCornick Valley. Cn is packed till clasts.

Table A2 (cont)

61. Ivitak	110	Ah	0-8	10YR 2/1	4.7	3	Lateral meltwater channel, east facing slope of middle McCornick Valley.
		Bir	8-38	5YR 3/4	4.8	20	
		Cox	38-48	2.5Y 5/4	5.3	8	
		Cn	48-63+	2.5Y 4/2	5.3	4	
62. Nachvak	60	A	0-5	10YR 2/1	4.7	3	Upper alluvial terrace, west facing slope of McCornick Valley.
		B	5-11	7.5YR 3/2	4.8	8	
		Cox	11-17	10YR 5/8	5.0	24	
		Cn	17-37+	7.5YR 3/4	5.2	16	
63. Neoglacial	100	Ah	0-2	7.5YR 2/0	4.9	0	In avalanche debris on floor of McCornick Valley. C is undisturbed cobble gravel.
		B	2-6	10YR 3/4	5.2	12	
		IIc	6-36+				
64. Nachvak	120	Bir	0-5	5YR 3/3	4.8	15	Middle McCornick Moraine crest.
		Cox	5-17	2.5Y 5/4	5.2	8	
		Cn	17-42+	10YR 5/2	5.6	6	
65. Nachvak	140	A	0-3	10YR 4/1	3.9	3	Till terrace up valley from Middle McCornick Moraine.
		B	3-6	7.5YR 6/6	4.5	24	
		Birh	6-15	5YR 2.5/2	5.4	10	
		B/C	15-23	2.5YR 2.5/4	5.5	24	
		Cn	23-38+	7.5YR 3/4	5.5	16	
66. Superguksoak	150	B	0-5	7.5YR 4/6	4.5	24	On inactive alluvium below Selamiut Force.
		B/C	5-11	5YR 3/3	4.8	15	
		Cn	11-33+	7.5YR 3/2	5.1	8	
67. Nachvak	300	B	0-12	10YR 3/2	4.9	6	On outwash gravel at Selamiut Force.
		B/C	12-23	7.5YR 3/2	5.1	8	
		C	23-38+	10YR 4/3	5.3	9	
68. Nachvak	220	B	0-10	10YR 3/4	4.9	12	On upper McCornick Valley till.
		Cox	10-21	5Y 5/3	5.2	3	
		Cn	21-33+	5Y 5/2	5.8	1	

Table A2 (cont)

69. Nachvak	180	B21	0-3	7.5YR 3/2	4.9	8	Till terrace on west facing slope of upper McCornick Valley. Below intermittently active screes. Overall depth probably anomalous.
		B22	3-9	7.5YR 3/4	5.1	16	
		II Ab	9-11	7.5YR 2/0	5.3	0	
		II B/Cb	11-24	7.5YR 4/6	5.2	24	
		II Coxb	24-49+	2.5Y 4/4	5.4	8	
70. Nachvak	210	B	0-9	10YR 3/3	5.3	9	On matrix-poor till below Cirque Lake outlet.
		B/Cox	9-30	10YR 4/3	5.1	9	
		Cn	30-40+	7.5YR 4/2	5.5	8	
71. Nachvak	310	B	0-8	10YR 4/3	5.2	9	Interlobate moraine bluff crest below Cirque Lake outlet.
		C2ox	8-18	5Y 5/3	5.4	3	
		C3ox	18-25	5Y 4/2	5.5	2	
		Cn	25-45+	10YR 4/1	5.5	3	
72. Nachvak	310	Ah	0-7	7.5YR 2/0	4.8	0	In meltwater channel below Cwm Ddu cirque outlet.
		B2	7-17	5YR 2.5/2	4.8	10	
		Birh	17-25	2.5YR 2.5/4	5.1	24	
		C	25-40+	10YR 3/3	5.5	9	
73. Superguksoak	320	B	0-5	10YR 3/2	5.3	6	Upper McCornick Moraine complex.
		B/C	5-12	7.5YR 4/2	5.6	8	
		Cn	12-32+	10YR 5/1	5.3	3	
74. Superguksoak	322	Ah	0-4	10YR 2/1	4.7	3	Ditto.
		B	4-9	7.5YR 3/4	4.8	16	
		Cox	9-12	10YR 5/6	5.8	18	
		Cn	12-27+	10YR 5/2	5.3	6	
75. Superguksoak	380	B	0-6	10YR 4/3	5.3	9	Ditto.
		Cox	6-14	10YR 5/4	5.3	12	
		Cn	14-29+	10YR 4/2	5.7	6	
76. Nachvak	400	Bir	0-10	5YR 3/2	4.7	10	End/hummocky moraine crest above Selamiut Force.
		B/C	10-22	10YR 3/4	5.0	12	
		Cn	22-37+	10YR 4/3	5.2	9	

Table A2 (cont)

77. Nachvak	590	A/B	0-8	7.5YR 3/4	4.8	16	Lateral moraine in
		B2	8-15	7.5YR 4/6	5.1	24	cirque outlet valley
		Cox	15-22	2.5Y 5/6	5.8	12	above Selamiut Force.
		Cn	22-42+	10YR 4/4	5.2	12	
78. Superguksoak	600	B	0-5	7.5YR 3/4	5.1	16	Ditto.
		Cox	5-9	2.5Y 4/4	5.3	8	
		Cn	9-24+	10YR 4/2	5.5	6	
observed depth	33	A	0-3				Marine bench on north
Superguksoak		B	3-15				east flank of Kirk
		Cox	15-28				Fell in Nachvak
		Cn	28-100+				Fiord.

*Classifications are based upon the chronology proposed in Chapter 5, section IV.
**Horizon classification follows the system introduced by Birkeland (1975).

Appendix III

Lichen Growth Data

Refer to Figures A1 and A2 for comparisons of size between 1978 and 1983 and for determination of growth rate on lichen growth sites established by McCoy in 1978 in the Cirque Lake basin (457 metres).

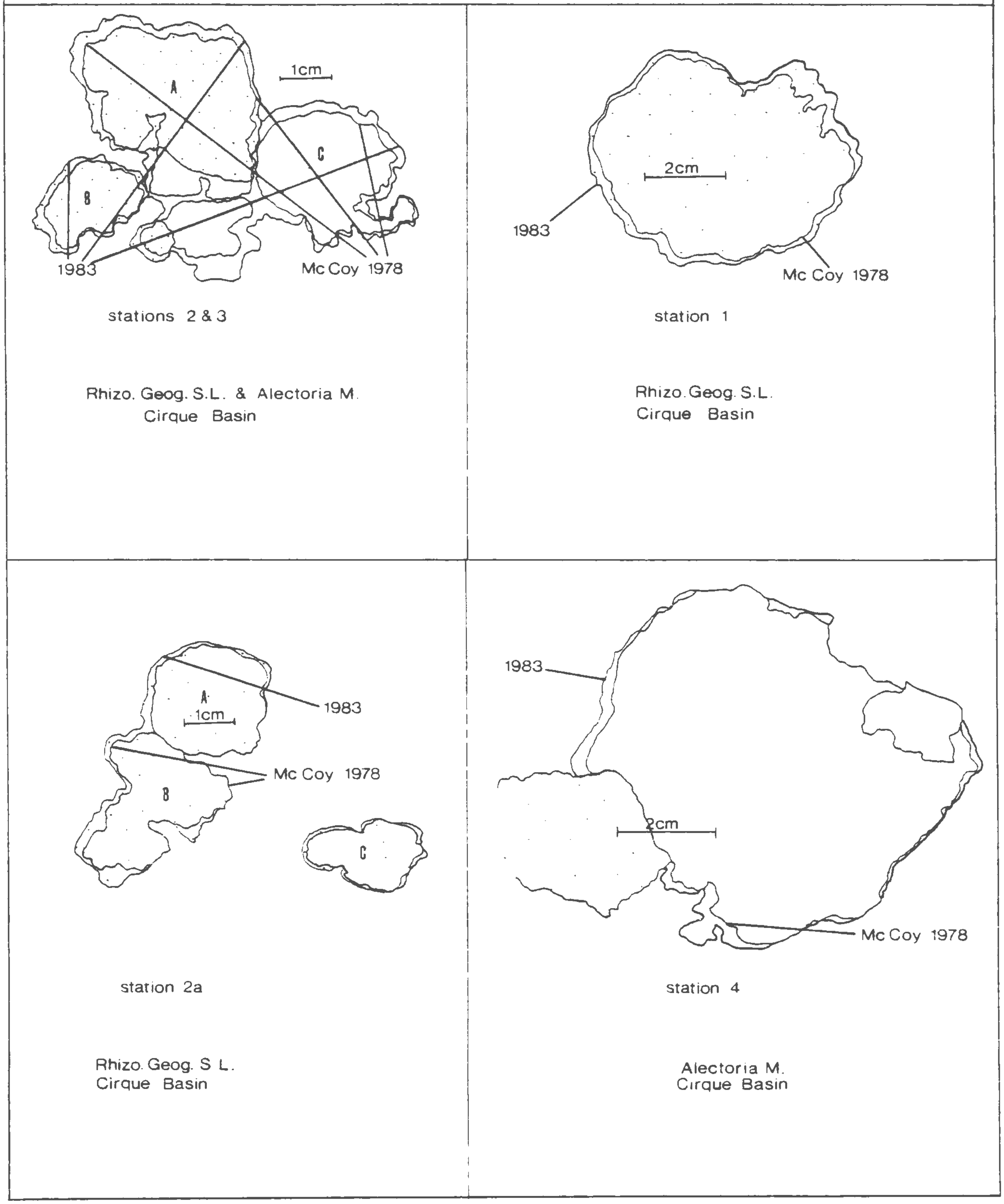
Table A3: Lichen growth data.

Lichen site Station	Suffix	Area (cm^2) 1978	1983	% growth	Average 0 1978	1983	Inc. in 0 (cm)	Growth 0 (mm yr^{-1})
2 & 3	a	9.20	10.04	9.13	3.42	3.58	0.16	0.32
2 & 3	b	2.37	3.08	29.96	1.74	1.98	0.24	0.48
2 & 3	c	5.66	7.27	28.44	2.68	3.04	0.36	0.72
2 & 3	N.A.*	19.16	24.98	5.82	4.94	5.64	0.70	1.40
1	-	19.13	22.32	16.67	4.93	5.33	0.40	0.80
2a	a	4.59	5.03	9.58	2.42	2.53	0.11	0.22
2a	b	4.64	5.65	21.76	2.43	2.68	0.25	0.50
2a	c	2.29	2.73	19.21	1.71	1.86	0.15	0.30
4	-	35.17	37.57	6.82	6.69	6.92	0.23	0.46

*Figures are for total area of four lichens (Fig. A1)

Four further lichen sites were established at the Interlaken camp site below Minaret Glacier at an altitude of 915 metres. Sites 1, 2 and 3 were located 50 metres southeast and site 4, 40 metres south of the camp site cache. All the sites were marked by yellow paint and orange flagging.

Fig. A1
The Growth of Rhizocarpon Geographicum S.L. & Alectoria Minuscula 1978 - 1983



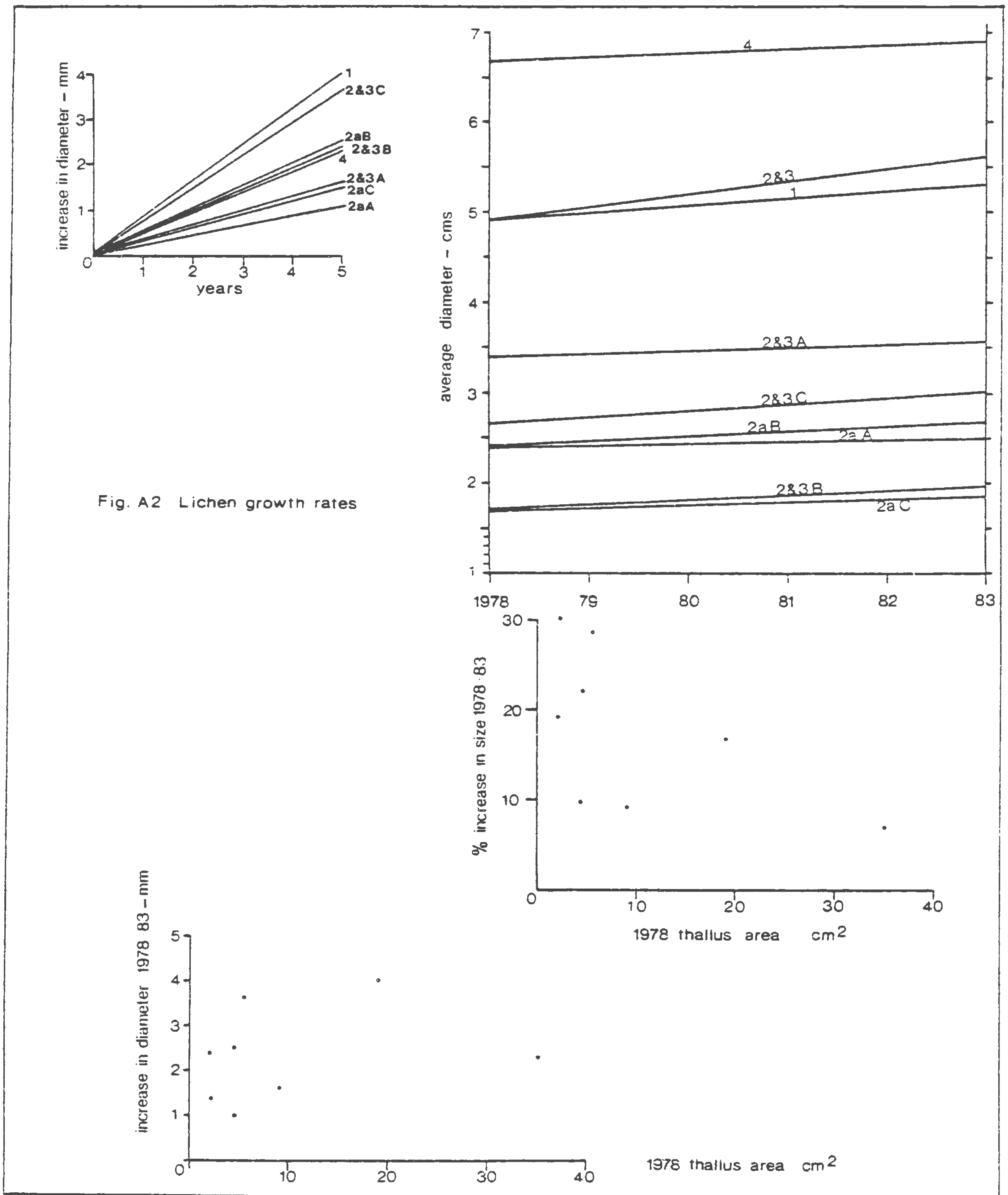


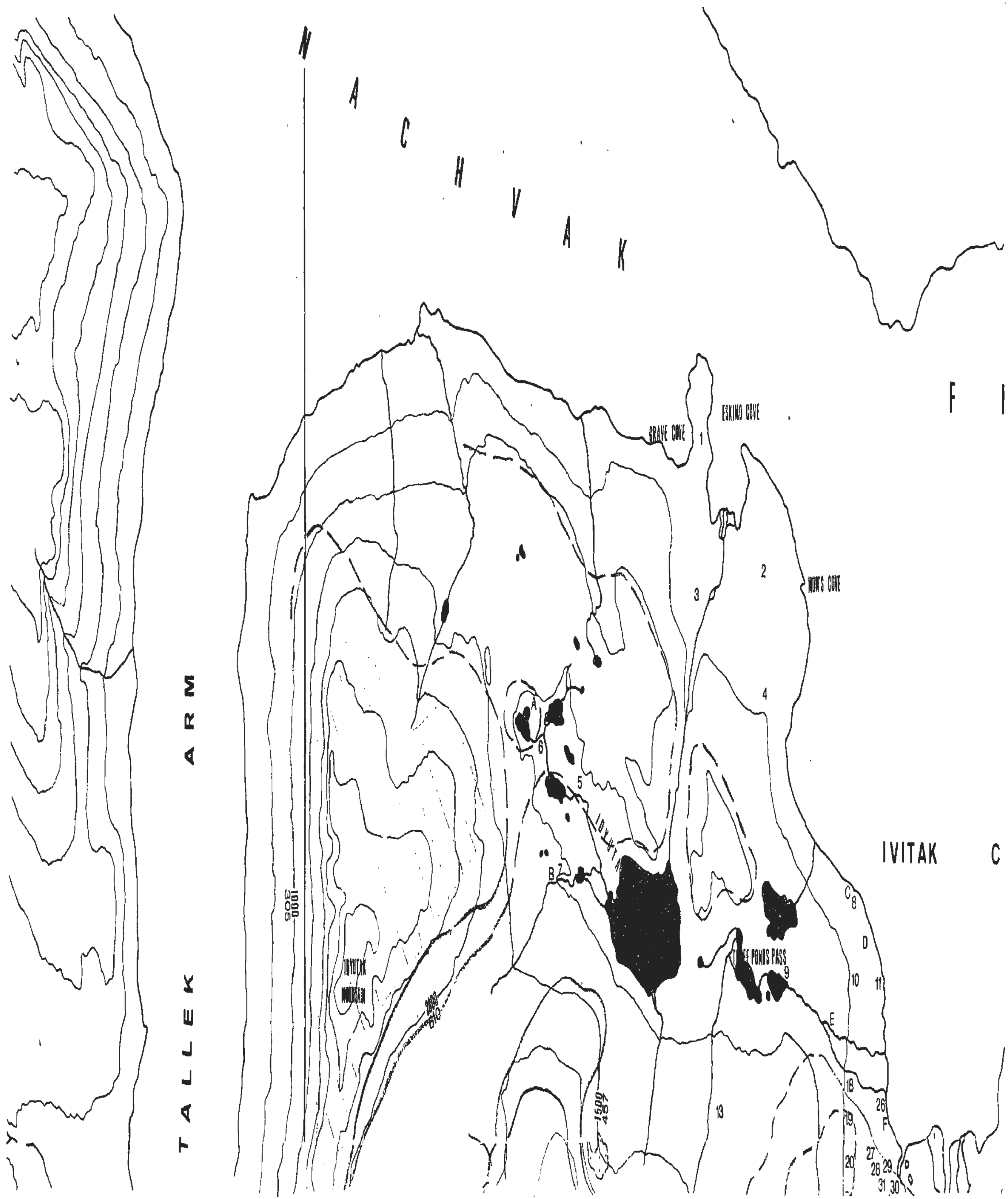
Fig. A2 Lichen growth rates

Appendix IV

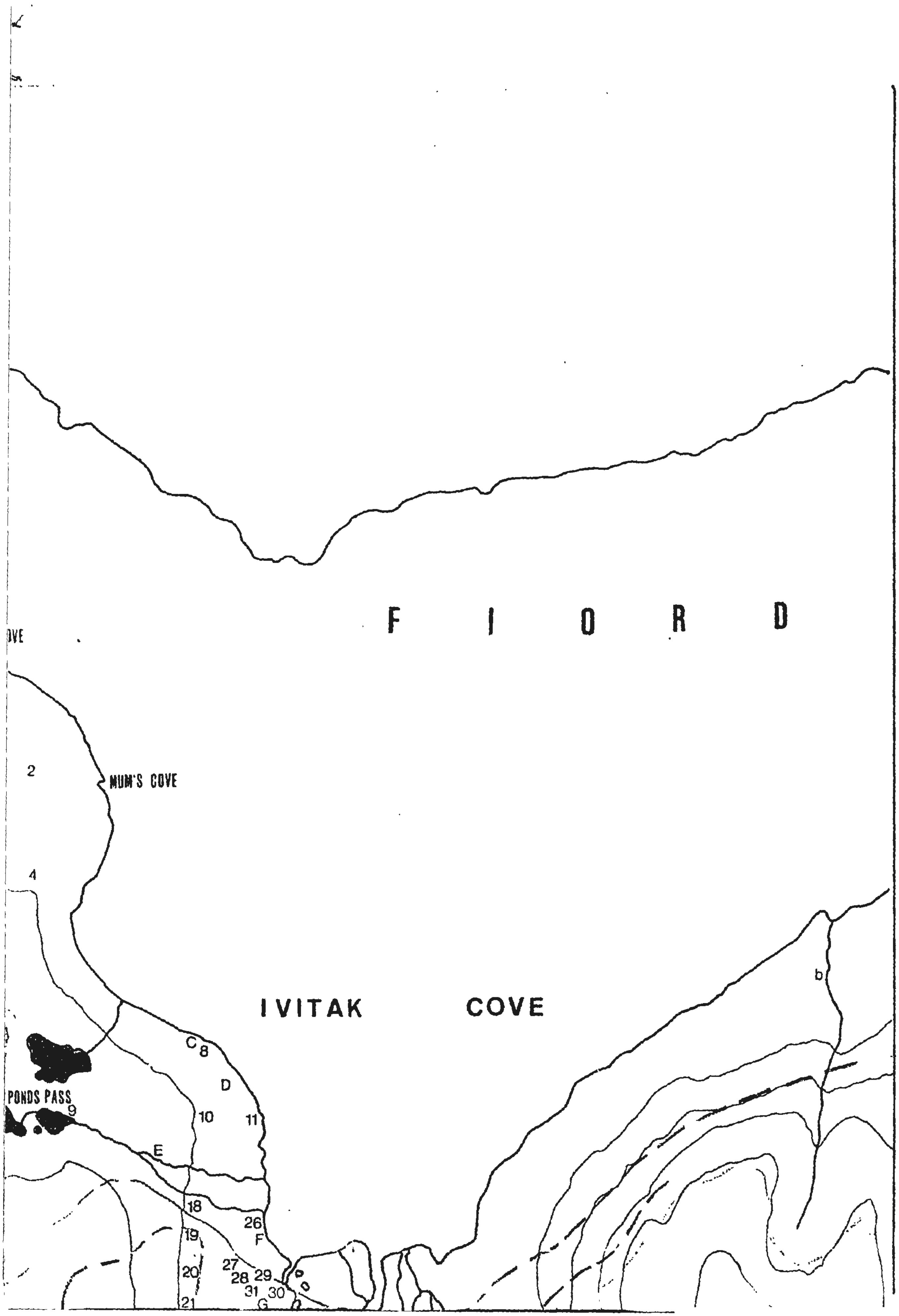
Till geochemistry data - Table A4

Sample no.	Element units:									
	Cu	Pb	Zn	Co	Ni	Cr	Mn	Fe	As	U
A (07)	115	10	74	18	76	74	397	3.2	IS	IS
B (08)	405	8	170	50	320	180	1050	7.3	IS	1.6
C (11)	205	8	84	42	164	98	750	4.5	IS	0.7
D (12)	240	6	158	34	186	148	510	5.8	<2	0.7
E (14)	230	10	156	66	190	104	1175	4.8	IS	IS
F (15)	177	16	176	58	124	97	2100	5.0	IS	1.0
G (16)	135	10	94	46	82	69	1225	4.2	8	2.1
H (18)	80	3	44	30	89	91	568	2.3	IS	1.6
I (22)	260	10	154	50	194	117	1150	6.4	<2	IS
J (23)	39	9	28	30	65	60	841	3.0	IS	IS
K (24)	37	8	24	5	29	68	107	3.5	<2	1.8
L (25)	103	16	90	96	271	178	2726	11.2	IS	IS
M (26)	42	8	32	19	56	71	254	3.4	IS	IS
N (27)	170	10	56	71	220	111	1452	4.8	IS	IS
O (28)	200	4	50	38	130	54	640	3.2	IS	IS
P (29)	590	14	172	86	318	138	1950	7.6	3	2.8
Q (30)	240	10	124	66	234	140	1450	6.6	<2	2.1
R (31)	560	30	242	110	224	108	3300	8.9	IS	IS
S (32)	298	10	154	40	200	193	775	6.6	<2	0.7
T (33)	335	8	150	56	148	122	1750	6.5	IS	1.0
U (34)	400	10	174	72	256	234	2250	9.0	IS	IS
V (35)	223	4	94	36	144	87	600	3.9	<2	0.7
W (36)	295	7	87	32	153	94	514	5.3	IS	IS
X (38)	487	10	156	48	294	191	900	7.4	2	1.2
Y (39)	400	8	160	46	308	200	1000	7.7	<2	0.7
Z (40)	310	6	158	48	252	210	1710	8.5	<2	1.0
a (41)	12	4	54	12	38	93	900	2.0	IS	1.3
b (43)	220	4	116	24	284	192	800	5.4	<2	0.2
c (45)	260	8	144	58	218	98	1250	5.8	3	4.2
d (52)	660	13	650	88	411	107	3982	7.4	IS	IS
e (53)	335	6	134	16	466	300	675	5.6	<2	0.7
f (54)	172	6	96	18	226	158	725	4.9	<2	0.2
g (56)	160	10	100	20	150	105	1250	5.2	<2	2.3

All figures are in p.p.m. with the exception of Fe which is %.
See Location Base Map for siting.
I.S. = Insufficient sample.



NACHVAK
FI
TALLEK ARM
IVITAK C
GRAVE COVE
ESKIMO COVE
PONDS PASS
1000
305
2000
610
1500
457



FIORD
OVE
2
MUM'S COVE
4
IVITAK
COVE
b
C
8
D
PONDS PASS
9
10
11
E
18
26
F
19
20
27
28
29
31
30
21
G

FIG. A3

LOCATION BASE MAP

scale; 1:25,000

TILL SAMPLES - A-Z, a-g

SOIL PIT LOCATIONS - 1-78

E. IVITAK LIMIT WITH NUNATAKS

L. IVITAK LIMIT

NACHVAK LIMIT

SUPERGUKSOAK I LIMIT

NEOGLACIAL MORAINES

MAP

0

A-Z, a-g

1-78

IVITAK LIMIT WITH NUNATAKS

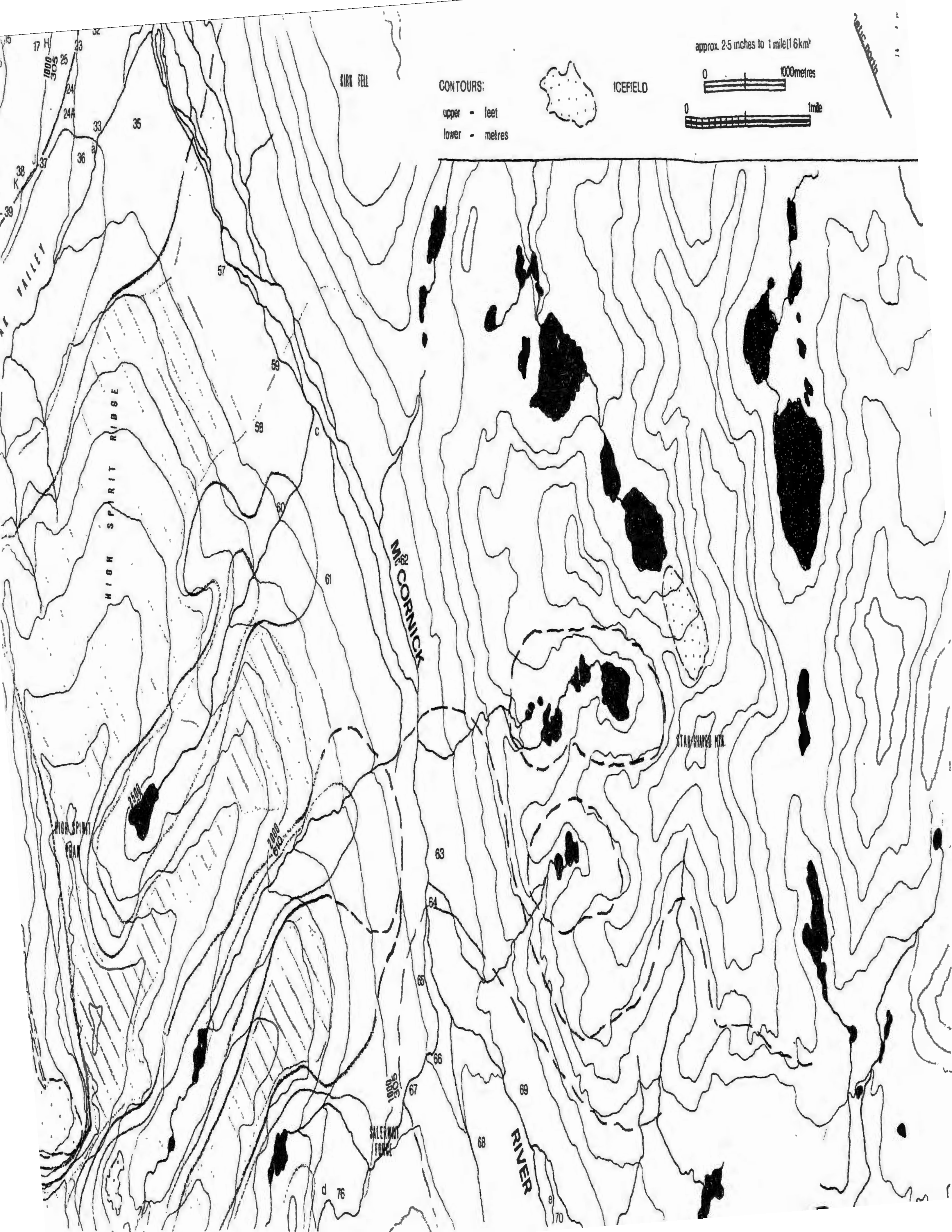
IVITAK LIMIT

NACHVAK LIMIT

SUPERGUKSOAK I LIMIT

NEOGLACIAL MORAINES

MESA-TOP MTN
IVITAK VALLEY
HIGH SPIRIT RIDGE
NORTH BOWL
SOUTH BOWL
HIGH SPIRIT PEAK
SUPERGUKSOAK GLACIER
TORNGARSSOAK
1000
305
2500
762
3000
915


approx. 2·5 inches to 1 mile (1·6 km)
CONTOURS:
upper - feet
lower - metres
ICEFIELD
0
1000metres
0
1mile
KIRK FELL
HIGH SPIRIT RIDGE
HIGH SPIRIT PEAK
2500
Mt. McCORNICK
STAR SHAPED MTN
RIVER
17
H
23
25
1000
305
24
24A
33
35
36
37
38
39
J
K
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c
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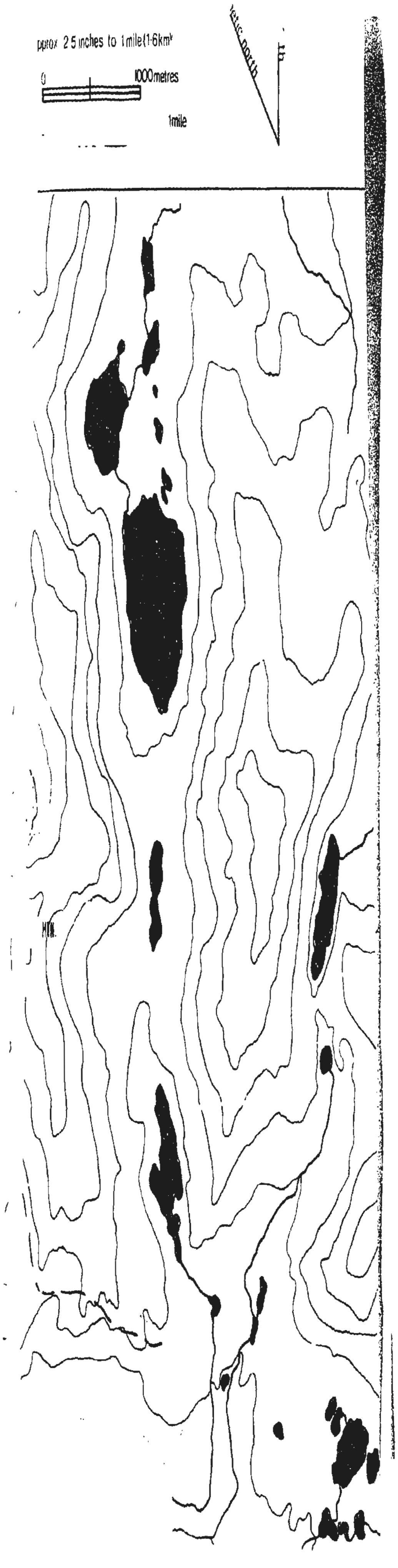
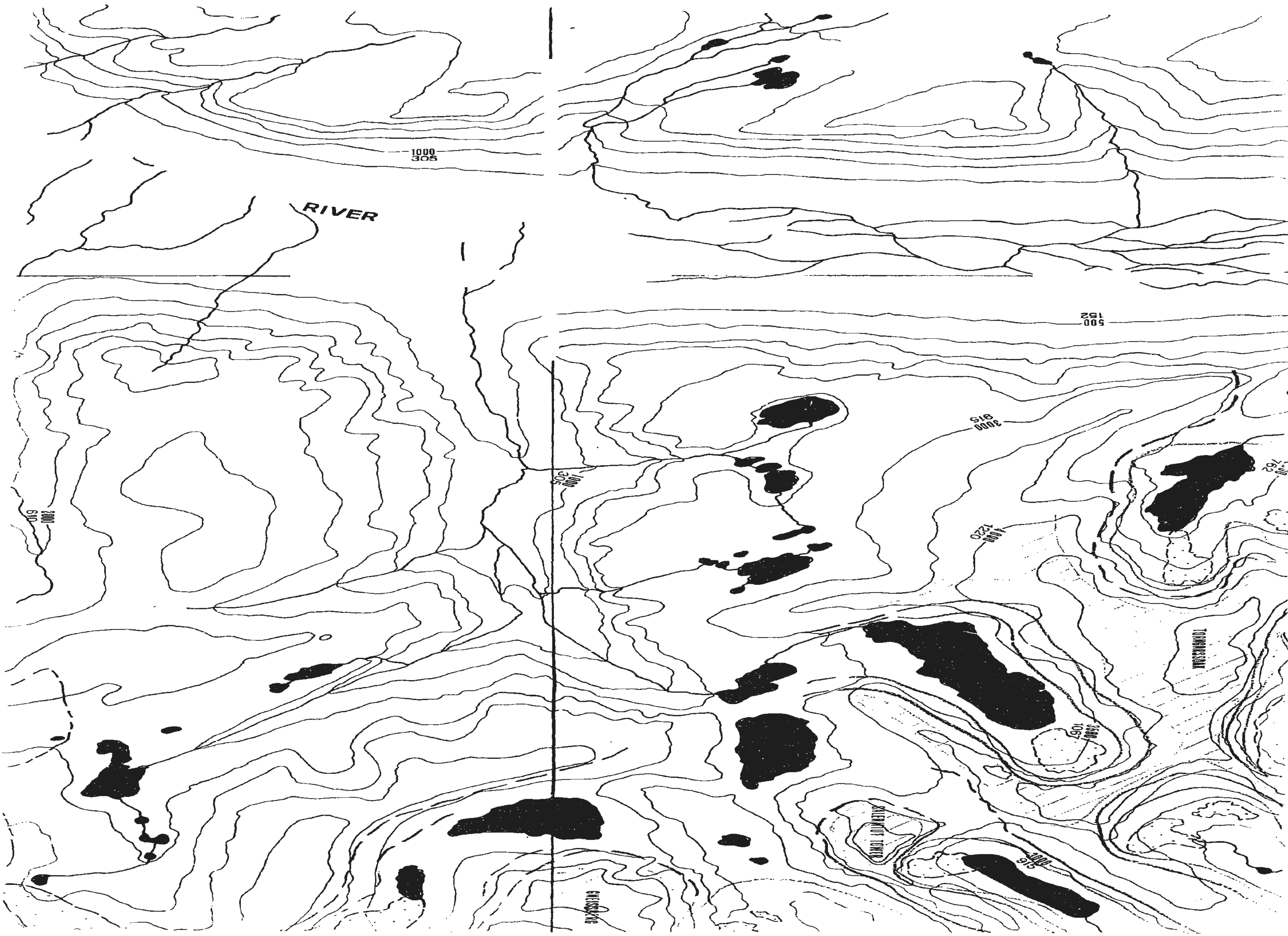
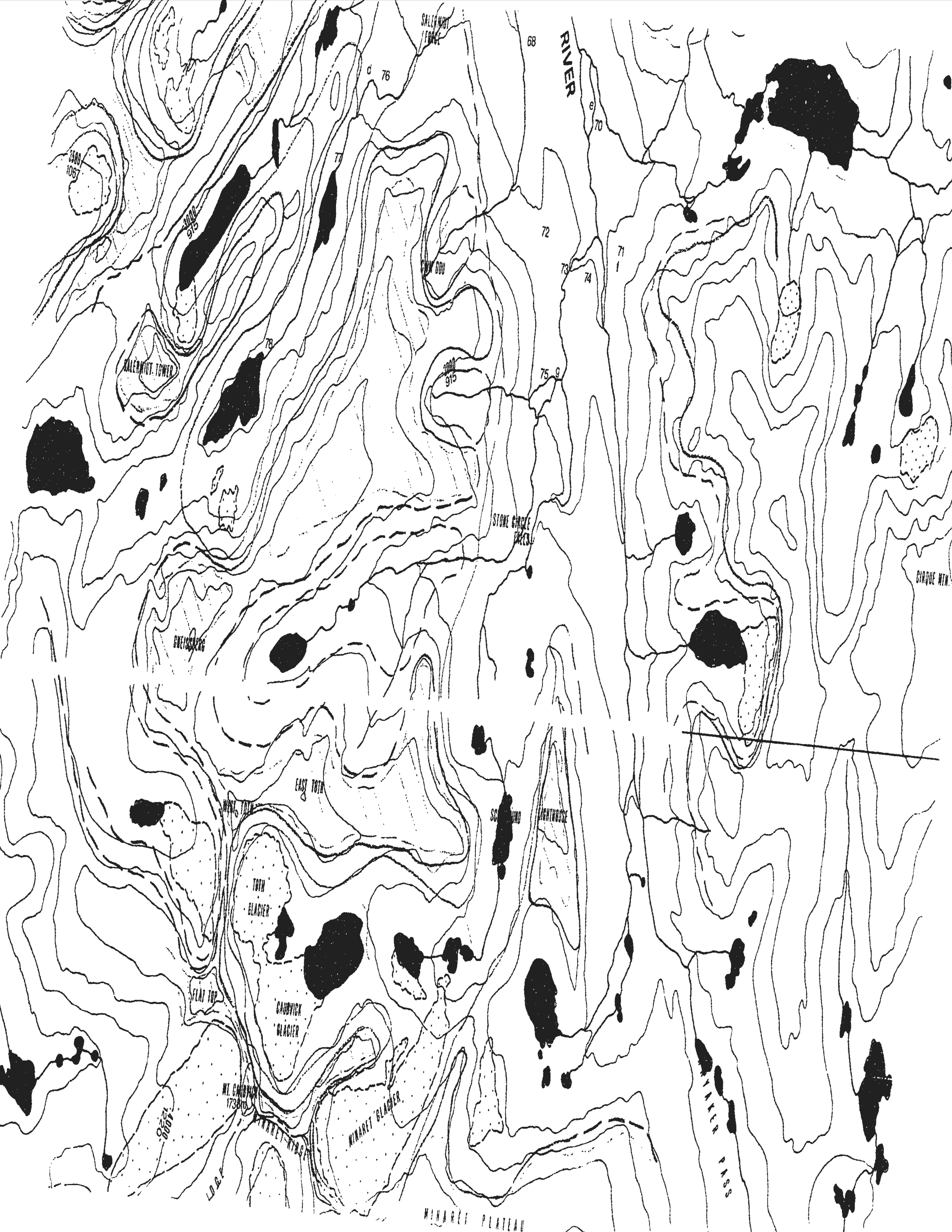
68
d
76
e
70

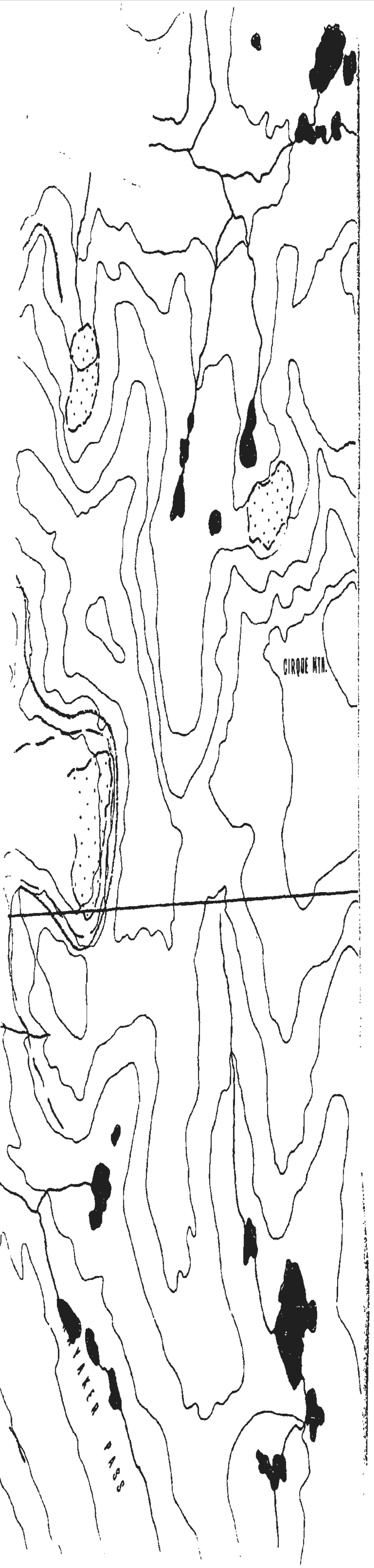

pprox 2 5 inches to 1 mile (1·6km)
0
1000 metres
1mile
north
HW.

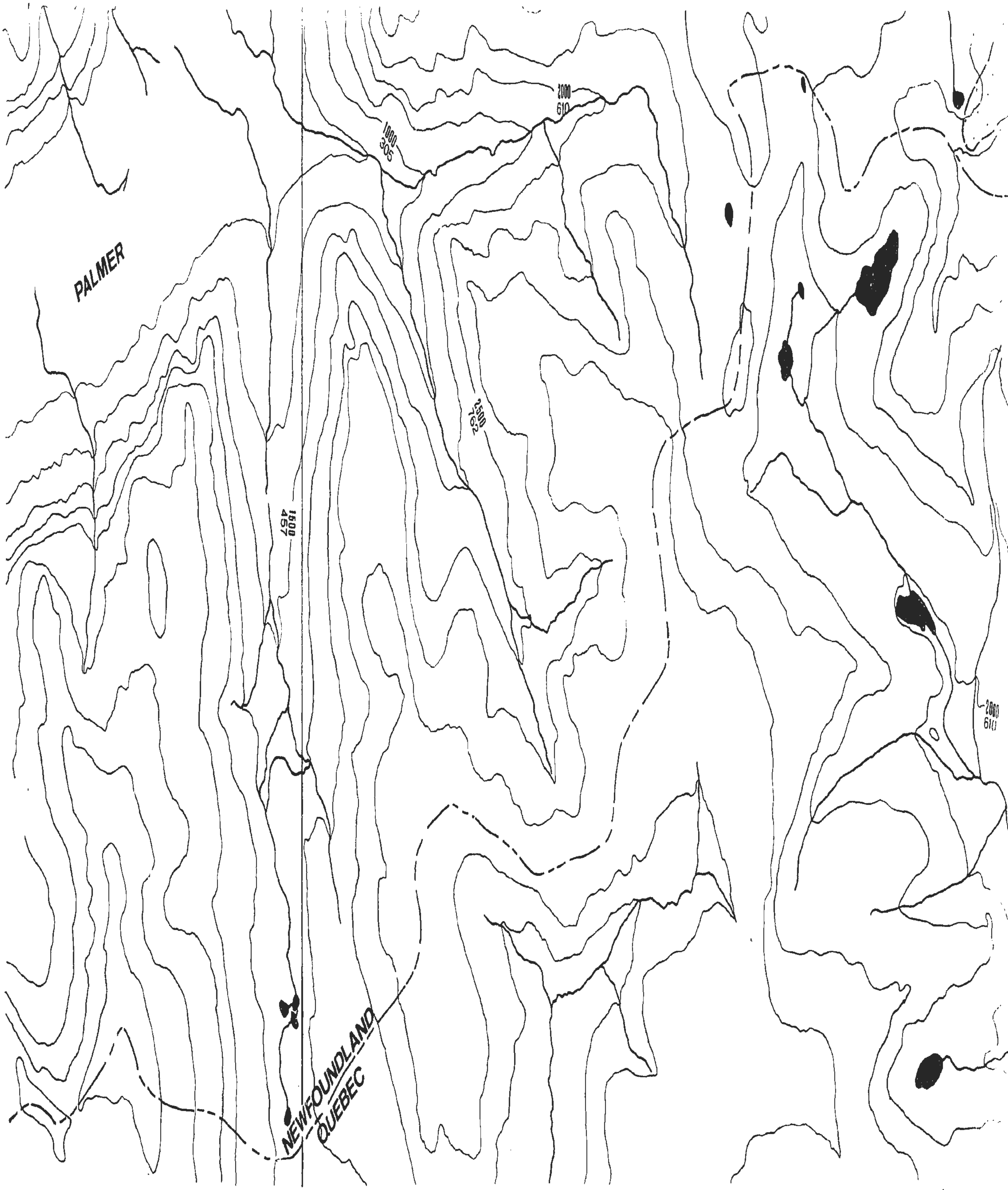


1000
305
RIVER
500
152
3000
915
1000
305
2000
610
4000
1220
TORNGARSSOAK
GNEISSBERG
3000
915

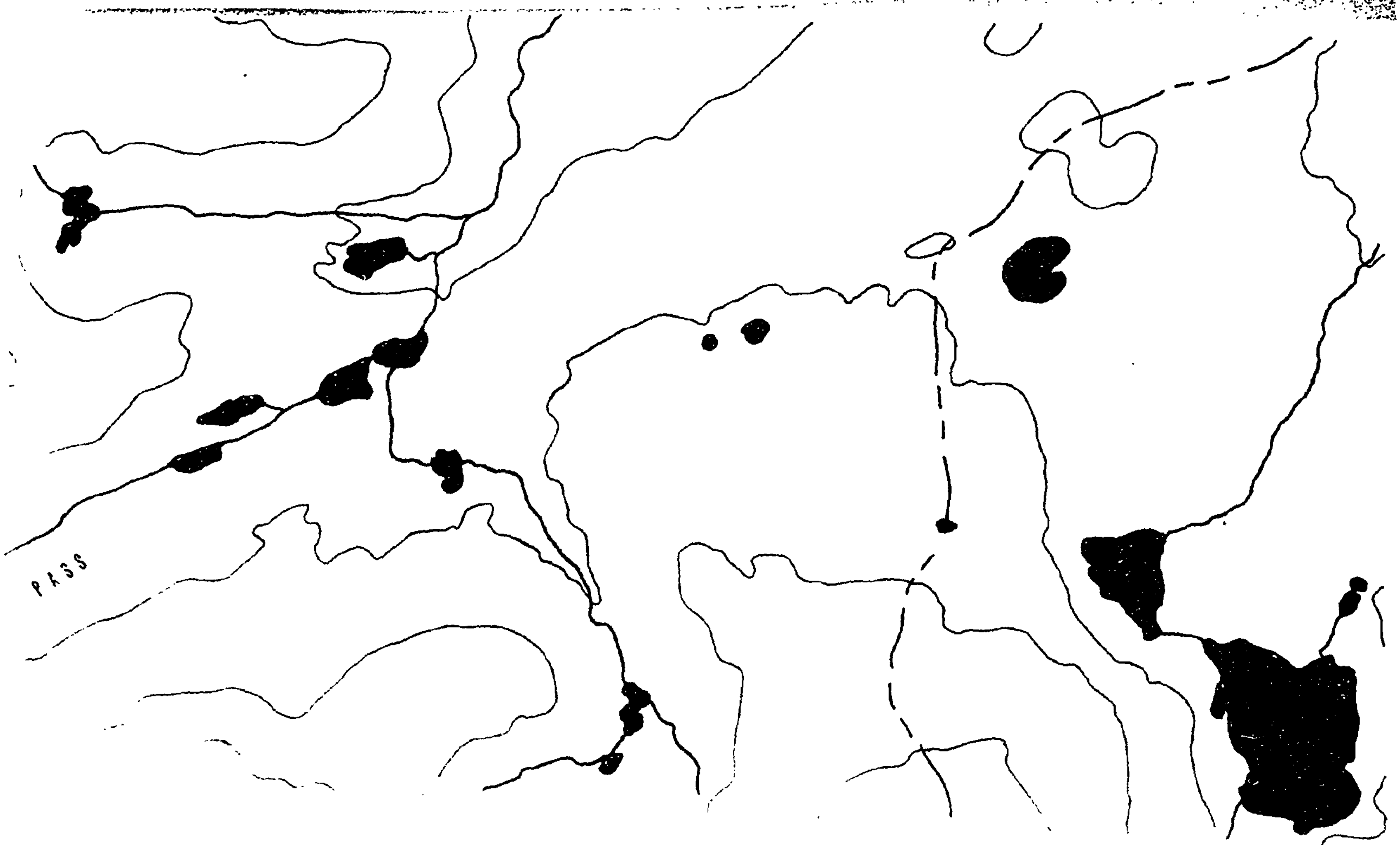


RIVER
68
76
70
72
73
74
71
77
78
75
3500
1067
3000
915
SALERMIUT TOWER
CWM DDU
CIRQUE MTN
GNEISSBERG
EAST TOTH
TOTH GLACIER
FLAT TOP
CAUBVICK GLACIER
MINARET GLACIER
4000
1220
MINARET PLATEAU

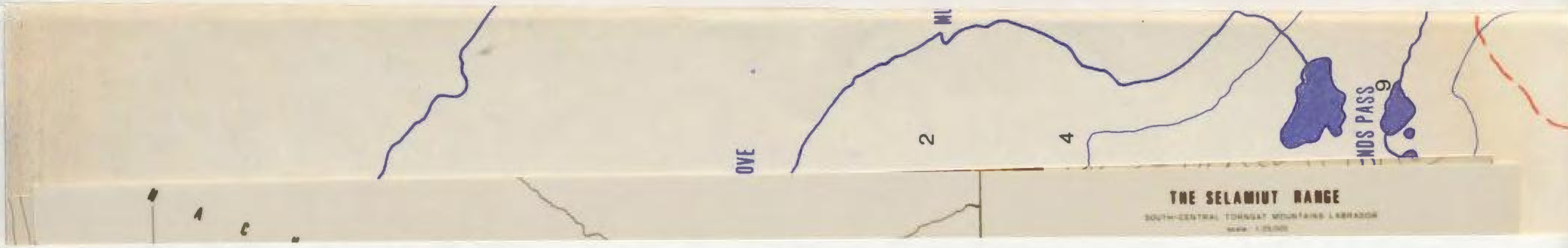

CIRQUE MTN.


PALMER
1000
305
2000
610
1500
457
2500
762
2000
610
NEWFOUNDLAND
QUEBEC

4000
1220
MINARET PLATEAU
PASS
3500
1067
2000
610


PASS


THE SELAMIUT RANGE
NACHVAK
FIORD
IVITAK COVE
TALLEK ARM


THE SELAMIUT RANGE
SOUTH-CENTRAL TORNGAT MOUNTAINS LABRADOR