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GEOLOGICAL SURVEY OF CANADA / COMMISSION GÉOLOGIQUE DU CANADA

NATMAP / CARTNAT
Canada's National Geoscience Mapping Program
Le Programme national de cartographie géoscientifique du Canada

DESCRIPTIVE NOTES

LANDSCAPE

The Lac de Gras map area lies in the central District of Mackenzie, on the watershed of major drainage systems flowing south (to Great Slave Lake), northwest (Coppermine River), and north (via Contwoyto Lake). Elevations range between 385-500 m. Local relief is low, commonly less than 10 m in areas of rock and till blanket. Relief greater than 15 m is common in areas of hummocky till, and some eskers are more than 45 m high; rugged rocky areas around Yamba Lake have about 50m local relief. There are numerous lakes occupying glacially scoured bedrock basins, as well as small ponds in depressions on the till surface. Most drainage ways are shallow: streams have not cut into bedrock or the till plain. The area is beyond treeline with most vegetation consisting of low shrubs, alders, and tundra heath vegetation; however, some small stands of black spruce were observed to the south of Courageous Lake.

The Quaternary geology component of the Slave Province National Mapping Program was designed to provide a regional framework for geological interpretation, environmental management, and drift prospecting (Dredge et al., 1994). The project involved helicopter-assisted ground work including terrain mapping, till sampling, and measuring of ice flow indicators. Field traverses and air photo interpretation provided information on the nature and distribution of surface materials shown on the map. About 200 samples were collected for textural analysis and trace element geochemistry (Ward et al., 1994a), 80 additional 10 kg samples were collected for heavy mineral and kimberlite indicator analyses (Ward et al., 1995), and pebble samples were collected to assess ice flow styles and glacial transport distances. Maps were constructed using 1:60 000 scale airphotos, and recompiled onto a 1:125 000 scale base. Open Files 2928 (Ward et al., 1994b) and this map are the first surficial geology maps produced for the area and complement surficial geology maps to the west (Kerr et al., 1995) and to the east (Dredge et al., 1995).

ACKNOWLEDGMENTS

Fieldwork was carried out in collaboration with Peter Thompson and Bruce Kjarsgaard of Continental Geoscience Division, GSC who were mapping the bedrock geology in Winter Lake and Lac de Gras map areas. Murray Gingras, Roger Paulen, and Barb Pierna were field assistants on this project. Polar Continental Shelf Project provided helicopter support, and DIAND maintained radio contact and expediting facilities based out of Yellowknife.

BEDROCK

The area lies within the central Slave Province of the Canadian Shield (McGlynn and Henderson, 1972). Folinsbee (1949) originally mapped the area. Thompson and Kerswill (1994) and Kjarsgaard (Kjarsgaard and Wyllie, 1993) have mapped portions of the Lac de Gras area in more detail. Bedrock consists primarily of Archean sedimentary, volcanic, and plutonic rocks that have been variably metamorphosed (Fig. 1). Subaquatically formed volcanics and related fine-grained turbidite sediments belonging to the Yellowknife Supergroup occur throughout the area. Two suites of granitic rocks occur: one is older than the Yellowknife Supergroup, and the second intrudes the Yellowknife Supergroup. These rocks have been folded, faulted, and metamorphosed to various degrees, and formed into phyllite, schist, gneiss, and migmatite. Sulphide mineralization has occurred along faults near sediment/volcanic contacts. Dyke swarms trending east, northeast, north, and northwest range in age from 2.23 to 1.27 Ga (LeCheminant and van Breemen, 1994). Kimberlite pipes range from Late Cretaceous to Early Tertiary in age (Pell, 1994): Early Cretaceous to Early Tertiary microfossils and fish remains preserved in mudstone xenoliths and a Rb/St age of 52 ± 1.2 Ma (Eocene), delimit the age of two pipes between Exeter Lake and Lac de Gras; a U-Pb date of 86 ± 2 Ma (Late Cretaceous) was obtained on a pipe just east of the map area.

Most rock outcrops show signs of glacial abrasion, faceting, and streamlining, but surfaces are commonly roughly weathered or lichen covered. All rock types have been subjected to intense frost shattering in the postglacial period, resulting in the frostheaving of large blocks, commonly above the level of the surrounding bedrock surfaces.

SURFICIAL MATERIALS

Till deposits

Till is the most extensive deposit in the area. Only one stratigraphic unit of till has been recognized and is attributed to Late Wisconsinan Laurentide ice. The till consists of a matrix supported diamicton, with the matrix ranging from silty sand to sand with low percentages of clay (Fig. 4). Grain size varied according to bedrock source and amount of meltwater associated with deposition: till derived from granitoid rocks was sandier than that derived from the Yellowknife Supergroup. Meltwater associated with till deposition also produces till with a very sandy matrix. In extreme cases, syn- and postdepositional reworking resulted in an openwork pebble-cobble lag. The clast content varied from 5 to 40% but was generally 25%. The upper 0.5 to 1 m of the till has been extensively modified by cryoturbation and solifluction. Surficial organics have been incorporated to depths of 70-80 cm, and primary deposition features such as layers or lenses have commonly been destroyed.

The till sheet has been divided into 3 units based on thickness and surface morphology: veneer, blanket, and hummocky. Till veneers are generally <2 m thick, contain exposures of bedrock, and conform to the underlying bedrock morphology. They are generally loosely compacted and their surfaces are characterized by high concentrations of cobbles and boulders; bedrock structure is commonly visible on the airphotos. Till blankets are generally 2-10 m thick and either drape the underlying bedrock, commonly as gently undulating till plains, or form low relief drumlinoid features. They are generally relatively compact and contain fewer boulders than veneers. Hummocky till deposits are 5-30 m thick and form hummocky topography with relief up to 15 m which totally obscures bedrock. They range from firmly compacted with moderate concentrations of boulders to loosely compacted with abundant boulders. Till veneers and blankets are pervasive throughout the area but hummocky till is restricted to two areas: a belt running across the northern shore of Lac de Gras; and the northeast corner of the map area.

Meltwater has variably affected all till units and is especially evident in some zones of hummocky topography, especially in the western edge of the Lac de Gras belt. Ice stagnation features such as gravelly rim and ridge areas, commonly associated with till plateaus, and ablation boulder pits in low areas characterize some hummocky moraine. Other areas, such as the area between Exeter Lake and Lac de Gras, have extensive boulder lags regardless of the till type.

Glaciofluvial deposits

Glaciofluvial deposits are geographically widespread but limited in extent and are predominantly in the form of eskers and related kames; proglacial outwash is very limited. Associated with the eskers are zones stripped to bedrock containing little if any surface sediment, commonly occurring on either side of large eskers or connecting esker segments. The eskers range from small, sinuous ridges to large, more linear features up to 45 m high, forming the major topographic relief in the area. Abundant nodes are present along their length and the ridges vary from sandy and flat topped to bouldery and sharp crested. An extensive network of small, generally northwest trending eskers feeds into a large, approximately east-west trending trunk esker along the southern shore of Yamba and Exeter lakes (Fig. 3). Another, slightly smaller esker trends east-west from MacKay Lake, through Courageous Lake, to Jolly Lake.

Esker sediments exposed in rare sections are predominantly immature sand (Fig. 4) with a thin capping of gravel. Much of the sand is very fine to fine grained and some silt layers are present. Abrupt changes occur in surface sediment from fine sand to boulder gravel. These eskers can provide a large volume of aggregate, although much of it may be sand. Associated with the esker systems, either adjacent to or on the washed zones, are small kame features. They range from streamlined forms parallel to meltwater flow, to slightly elongate forms perpendicular to flow, to irregular shapes. Their surfaces are strewn with abundant boulders associated with a very sandy till (Fig. 4), but pits dug indicate that they predominantly consist of sand.

The relative timing of esker development and till deposition is variable. Eskers are observed to have cut down into the till, to drape the till, and to be completely obscured by overlying till. As well, some eskers appear to be streamlined and moulded by the passage of ice suggesting development, at least in part, while the ice sheet was active. The angularity, bedforms, and fine grain size of the esker sediments suggest that much material was deposited into a low energy environment. Since there is no evidence for extensive glacial lakes in the area, the sediment must have been deposited in subglacial or englacial cavities. The bare rock zones, extending as much as 1 km beyond the flanks of esker ridges, probably represent erosion during both periods of high meltwater flow and the period of proglacial meltwater flow during deglaciation. The kames possibly represent glaciofluvial sands deposited during waning flow that were subsequently streamlined by ice after recoupling of the glacier bed. The flat topped esker segments likely represent deposition in open roofed ice walled channels during deglaciation.

Glaciolacustrine deposits

Evidence for short lived, isolated deglacial lakes or ponds occurs throughout the map area in the form of raised beaches, especially well developed on the flanks of eskers. Lake sediments, however, were only identified in a few localities and these were thin, very sandy and not aerially extensive. Glaciolacustrine units are too small to be shown at this scale of mapping.

Alluvial deposits

Alluvial deposits are rare because the low carrying capacity of streams and rivers in the area, based in part on the low relief and the proximity to several drainage divides; the deposits are too small to be shown at this scale of mapping.

Organic deposits

Thin peat deposits are common in depressions in the till and along poorly defined watercourses. Most of the ice wedge polygons throughout the map area are found within the organic units.

GLACIAL HISTORY

The area lies within the central part of the Keewatin Sector of the Laurentide Ice Sheet (Dyke and Prest, 1987; Dyke and Dredge, 1989). The Lac de Gras map area lies directly west of the M'Clintock Ice Divide, which was prominent during the Late Wisconsinan maximum (18 000 - 13 000 BP). After 13 000 BP the ice divide shifted eastwards into the District of Keewatin, and disappeared there about 7000 years ago. At its maximum, the northern margin of the Keewatin ice sheet extended north of the Arctic coast and as far west as Mackenzie Valley. Radiocarbon dates on marine shells beyond the boundaries of this map area suggest that ice still covered the area about 10 000 BP but that the ice margin lay east of Aylmer Lake by 9000 years ago.

Ice flow indicators

Some aspects of the glacial history and the dominant direction of glacial transport can be determined by the relative age and strength of striations. Although many rock outcrops are lichen-covered or have rough, weathered surfaces, striations could generally be found on fresh surfaces exposed by peeling back the turf or scraping off a thin till cover; as well, small pegmatite bodies that occur throughout the area commonly had well preserved striations. Several techniques were used to determine relative ages of striations. In some cases, age relationships could be determined directly by examining sets of cross-cutting striae, although in many places, the cross-cutting relationship was ambiguous. Numerous outcrops have been beveled by more than one flow; the ice flow sequence on these can be deduced from the orientations of the facets and corresponding presence or absence of striae. Similarly, striations on lee-sides (plucked faces) of roches moutonnées were assumed to postdate the flow that formed the original feature.

The striation data indicate that the earliest ice flow was to the southwest. The entire area was later affected by westward flow, which was followed by northwestward flow in areas northeast of Courageous Lake. Fine striations indicating local flow towards the trunk esker were also observed and likely represent late glacial events. All these striations probably represent the same glaciation because the surfaces they are found on are all relatively fresh (i.e., unweathered).

The orientation of drumlins and crag-and-tail features corresponds to the main flow directions determined by striations. Most drumlins occur in the southern half of the map area with concentrations occurring south of the central part of Lac de Gras, east of Seahorse Lake, and along Snake Lake.

While eskers are glaciofluvial forms relating to hydraulic gradients within the ice, they are indirect indicators of ice flow since they are commonly perpendicular to the ice margin, that is they parallel ice flow. Eskers south of Courageous and MacKay lakes are generally oriented east-west, corresponding to the dominant flow there. North of this to the trunk esker, eskers are oriented to the northwest, corresponding to the main ice flow. This trunk esker represents an interlobate position during deglaciation.

The concentration of Yellowknife Supergroup clasts in the till reflects the dominant glacial transport directions (Fig. 2). Highest concentrations (>80%) occur over outcrop and they decrease down-ice to <40% along the western margin of the map area. The low concentrations of clasts (<20-40%) in the northwest corner of the map area could represent misidentification because of the high metamorphic grade (migmatite) of the Yellowknife Supergroup in this area; it could also imply that the northwestward flow was not dominant in this area.

Glacial events

1. Striations indicate southwestward flow occurred across most of the map area (Fig.5a). Since the striations and the surfaces that they are found on are unweathered, they are assumed to postdate the last interglaciation. This ice flow is thus thought to relate to the buildup phase of the last glaciation.
2. The presence of drumlins and crosscutting striations indicates a later flow to the west over the entire area (Fig.5b). Some of the westward esker segments also likely formed at his time. This flow is tentatively placed during the main part of the Late Wisconsin Glaciation and may reflect flow from the M'Clintock Ice Divide which lay to the east (Dyke and Prest, 1987).
3. A shift to vigorous northwestward flow over much of the area as recorded by well preserved striations and drumlins (Fig.5c). Although weak striations occur to the south and west of Courageous and MacKay lakes and to the north of the trunk esker, this northwestward flow was not very active in these regions since streamlined forms are still oriented to the west. Many of the esker segments oriented to the northwest would have formed at this time. This shift in ice flow may be a response to ice recession and related ice lobing; however, the strength and preservation of the striations and the streamlined till forms indicate considerable erosion and till movement.
4. Striations indicate a late glacial flow towards the trunk esker (Fig.5d). The orientation of these striations implies that this esker is an interlobate feature. To the north of the trunk esker, southwestward flow was locally important in moving till. Also in the late stages of deglaciation, zones of stagnant ice formed in two areas in the northeast corner of the map area, corresponding to zones of hummocky till. Twigs recovered from an esker in hummocky till immediately to the east in the Aylmer Lake map area yielded an accelerator date of 8500 BP (TO-4241), indicating stagnation had occurred by this time. A few isolated moraines were identified in the area, but these could not be connected to relate to any ice margin.

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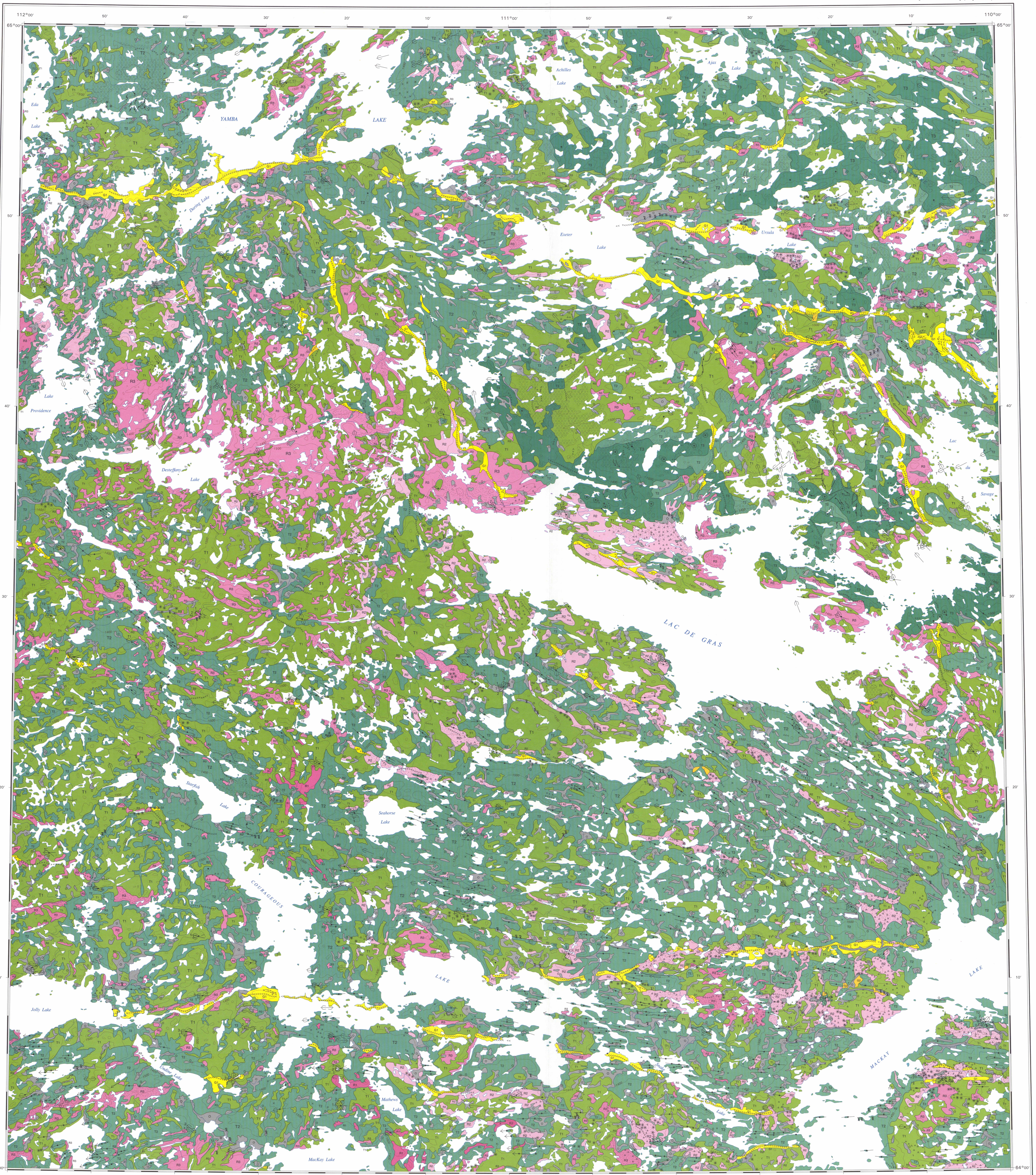


LEGEND

Coloured legend blocks indicate map units that appear on this map

QUATERNARY

HOLOCENE

NONGLACIAL ENVIRONMENT

O	***ORGANIC DEPOSITS:*** *peat and muck up to 2 m thick; formed predominantly by the accumulation of vegetative material in bogs; occurs in depressions and along valley bottoms; permafrost is commonly present; contains small palsas, ice-wedge polygons, and thermokarst collapse structures. Small unmapped organic deposits occur in most terrain units*
A	***ALLUVIAL DEPOSITS:*** *gravel to silt size sediment deposited by modern streams and rivers; deposits generally are stratified and moderately sorted; 1 to 5 m thick; occurs as floodplains, in places covered by icings*

PLEISTOCENE (WISCONSIN GLACIATION)

GLACIAL ENVIRONMENT

L	***GLACIOLACUSTRINE DEPOSITS:*** *silt and sand; cross-stratified to planar bedded; 1 to 8 m thick; deposited into temporary glacier-dammed lakes and ponds*
	GLACIOFLUVIAL DEPOSITS: *sand, gravel, and minor silt more than 1 m thick; sorting ranges from good to poor, and stratification from massive or cross-stratified to planar bedded; deposited by water flowing from, or in contact with, glacier ice*
G2	***Outwash:*** *rounded gravel and sand; massive to cross-stratified; probably less than 5 m thick; occurs as braided fans*
G1	***Esker sediments:*** *sand, silt, and gravel; in planar, cross-stratified, and massive beds; 1 to 40 m thick; forms ridges with both sharp-crested and flat-topped segments, mounds, and flanking aprons; deposited at or behind the ice margin; formed subglacially or in subaerially exposed ice-walled channels. Zones of washed rock, small transverse gravel ridges associated with this unit, isolated kame deposits, and circular rim ridges are shown by symbols*
	TILL DEPOSITS: *unsorted glacial debris (diamicton), consisting of a silty sand matrix containing pebbles, cobbles, and boulders, with minor lenses of sorted sediments; deposited beneath, or along the margin of, glaciers as lodgement till, meltout till, and gravity flow deposits*
T3	***Hummocky till:*** *from 5 to 30 m thick; forms irregular to rolling terrain with relief up to 15 m; some areas have abundant small meltwater channels and lag concentrations of boulders in depressions*
T2	***Till blanket:*** *from 2 to 10 m thick; occurs as till plains mimicking bedrock topography or as drumlinoids. Small rock outcrops in this unit are shown by symbols*
T1	***Till veneer:*** *less than 2 m thick; rock structure is generally visible on airphotos; unit includes patches of bedrock and till blanket*

PRE-QUATERNARY

	BEDROCK: *Precambrian granitic, gneissic, metasedimentary and metavolcanic rocks, mafic dykes and minor, younger (Tertiary?) kimberlite; may include patches of till veneer or glaciofluvial deposits; areas of shattered and frost-heaved rock, particularly on metasediments, are designated by symbols*
R3	*Granitoid rocks*
R2	*Metasedimentary rocks*
R1	*Volcanic rocks*

Geological boundary
Ice wedge polygon
Frost heaved and shattered rock
Raised beach
Lag concentration of glacially abraded boulders
Area of meltwater scour
Subglacial or proglacial meltwater channel
Esker (direction of flow known, unknown)
Kames and gravelly transverse ridges
Rim ridges and till plateaus
Moraine
Drumlinoid till form
Rock crag-and-till tail form
Roche moutonnée or whaleback
Striation (ice flow direction known, unknown; 1 = oldest)
Striation, poorly defined (ice flow direction known, unknown; 1 = oldest)
Small rock outcrop
Sample site
Thermokarst collapse activity

Fig. 1: Bedrock geology

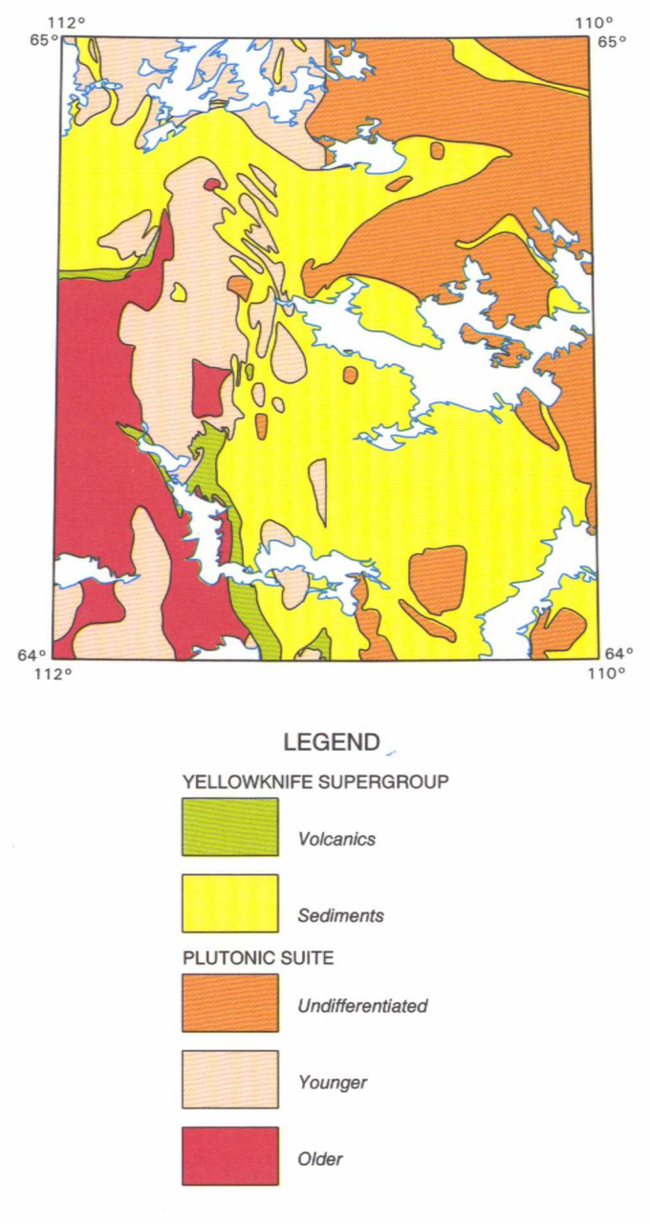


Fig. 5a: Glacial events

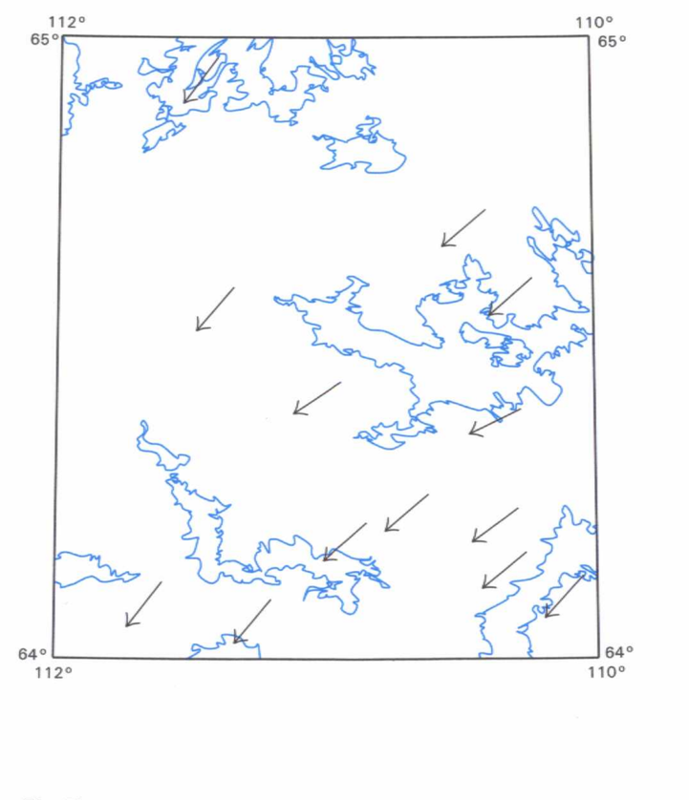


Fig. 5b

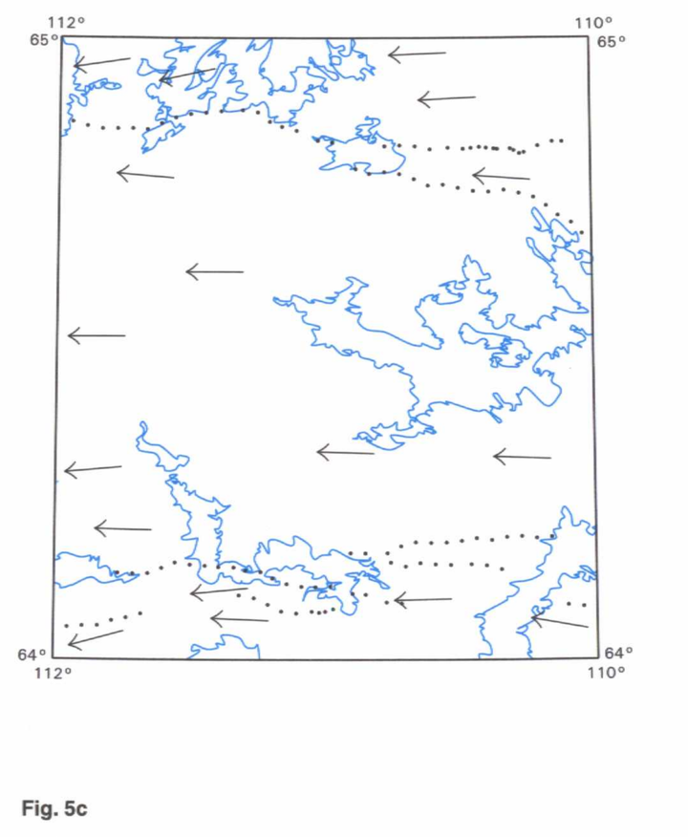


Fig. 2: Distribution of pebbles from the Yellowknife Supergroup

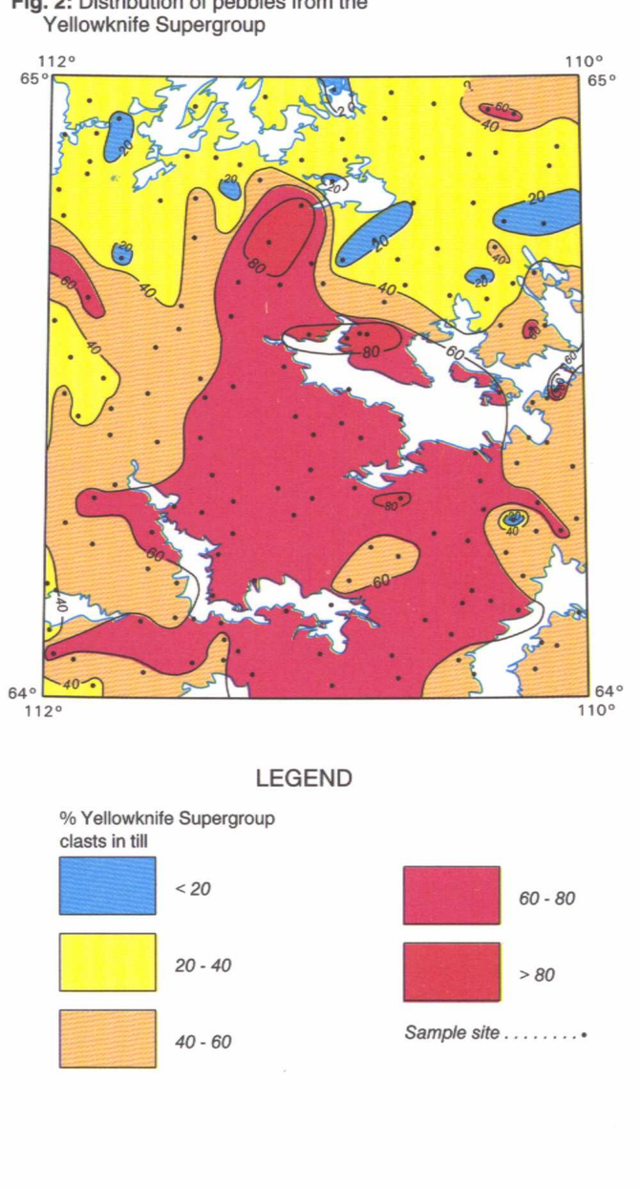


Fig. 5c

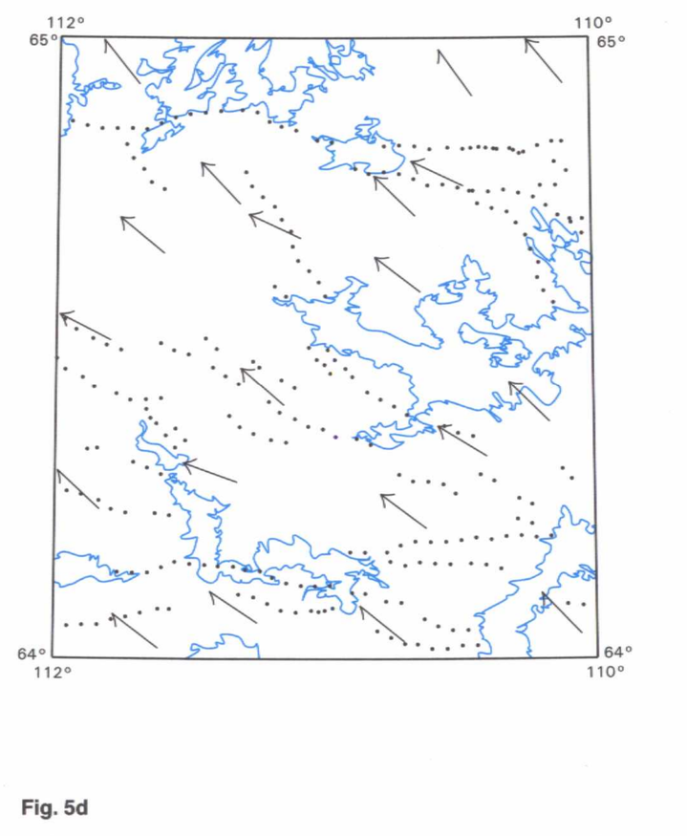


Fig. 3: Subglacial drainage systems, determined from eskers and meltwater scour zones

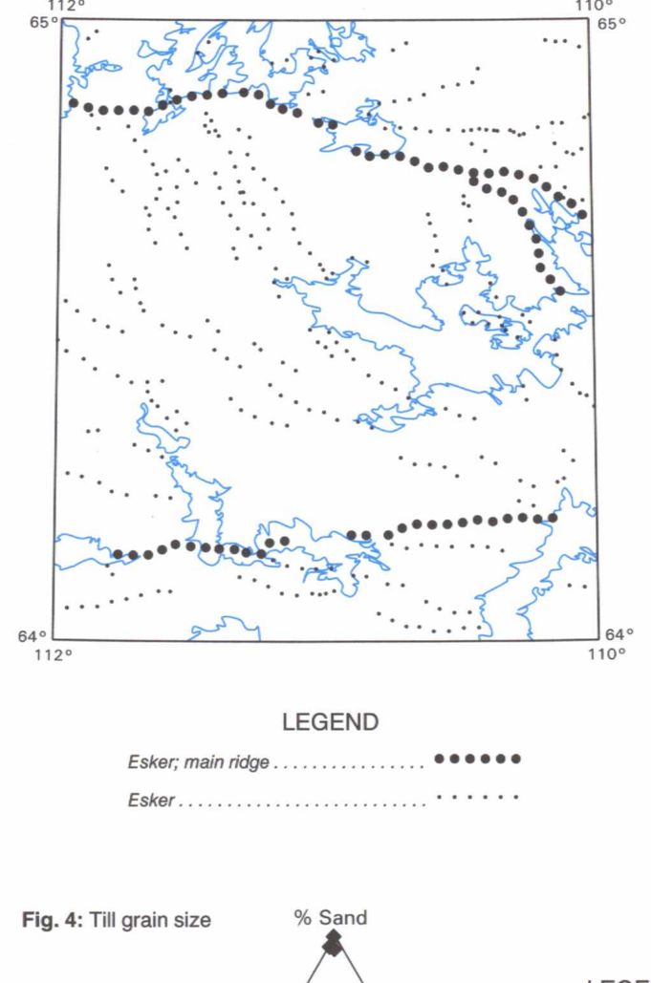


Fig. 5d

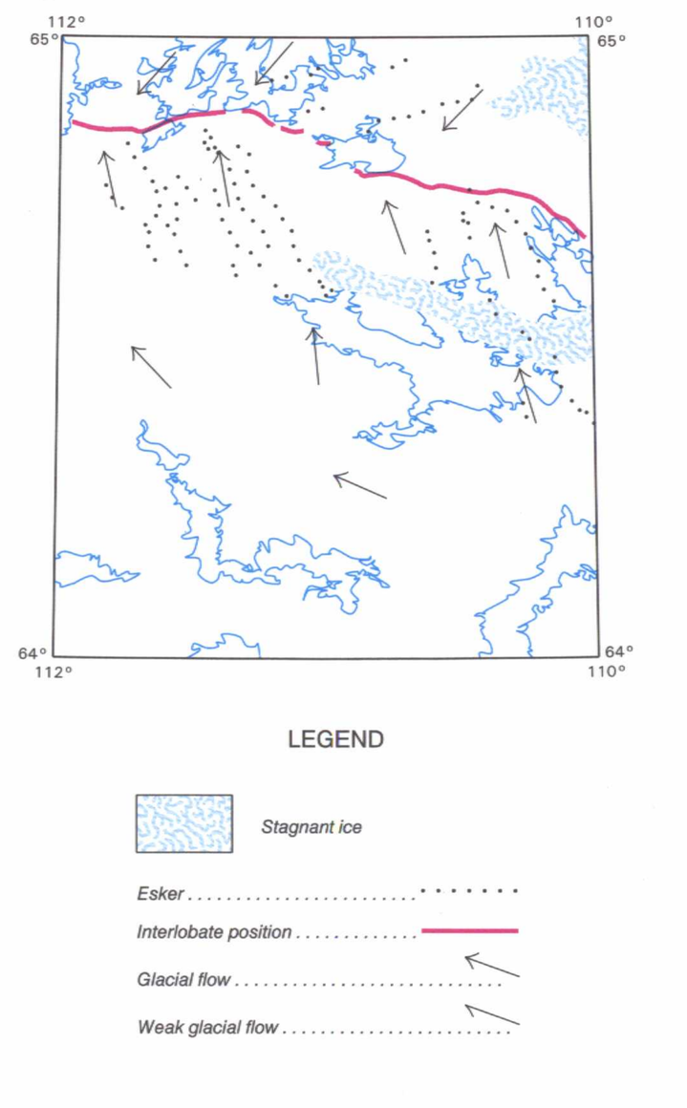
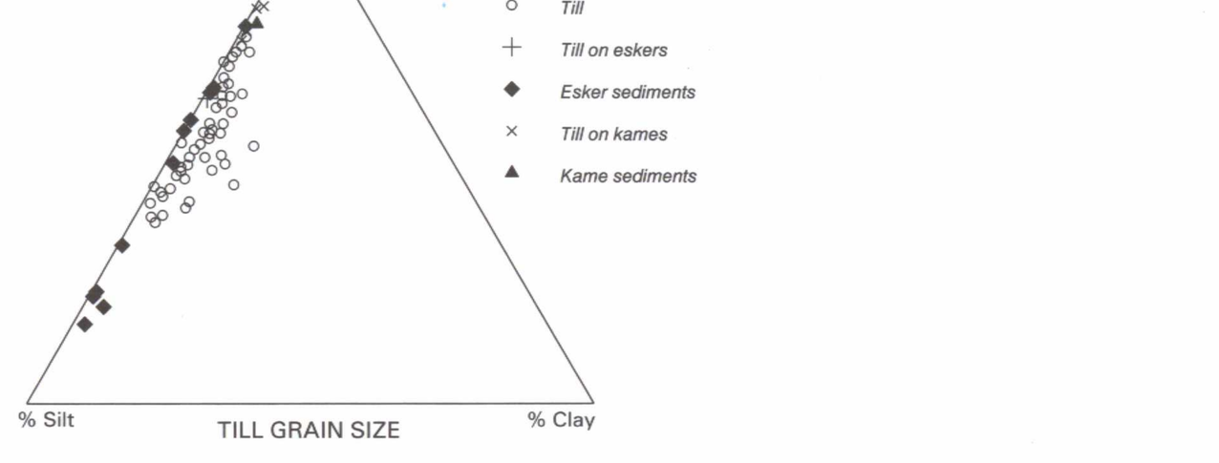


Fig. 4: Till grain size



Copies of this map may be obtained from the Geological Survey of Canada
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Published 1997

LOCATION MAP

MAP 1870A

SURFICIAL GEOLOGY

LAC DE GRAS

DISTRICT OF MACKENZIE
NORTHWEST TERRITORIES

Scale 1:125 000 - Échelle 1/125 000

Kilometres 2 0 2 4 6 8 10 Kilomètres

Universal Transverse Mercator Projection
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Projection transverse universelle de Mercator
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Geology by B.C. Ward, L.A. Dredge, and D.E. Kerr, 1993, with assistance from M. Gingras, R. Paulen, and B. Pierna

Additional striae observations by R.N.W. DiLabio, A. LeCheminant, B. Kjarsgaard, A. Peterson, and P. Thompson

Digital cartography by D.Kurfurst, Geoscience Information Division

Contribution to the Slave Province NATMAP Project

Logistical support was provided by the Polar Continental Shelf Project

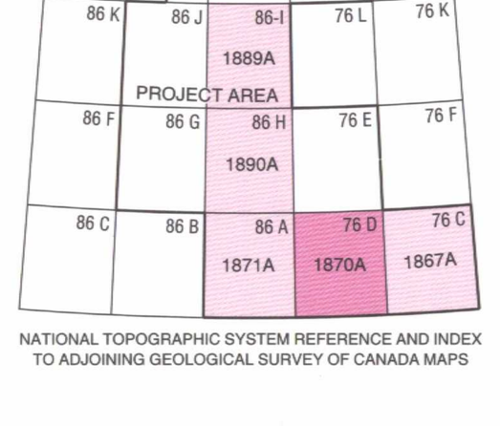
Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada

Digital base map data compiled by Geomatics Canada was assembled by the Geoscience Information Division

Copies of the topographical editions covering this map area may be obtained from the Canada Map Office, Natural Resources Canada, Ottawa, Ontario, K1A 0E9

Mean magnetic declination 1997, 25°10' E, decreasing 20.2' annually. Readings vary from 23°31' E in the SW corner to 26°27' E in the NW corner of the map

Elevations in feet above mean sea level



NATIONAL TOPOGRAPHIC SYSTEM REFERENCE AND INDEX TO ADJOINING GEOLOGICAL SURVEY OF CANADA MAPS

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Canada