UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

HEAVY MINERALS ON THE CONTINENTAL SHELF OF THE NORTHERN BERING SEA

By

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Open-file report

1971

This report is preliminary
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U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-159

HEAVY MINERALS ON THE CONTINENTAL SHELF OF THE NORTHERN BERING SEA

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INTRODUCTION

This report was prepared as part of a research contract awarded to the Department of Oceanography of the University of Washington, by the Office of Marine Geology of the United States Geological Survey. The study is concerned with the northernmost part of the Bering Sea which is bounded by land masses - the Seward Peninsula, the Yukon lowland, St. Lawrence Island, and the coast of the Chukotka Peninsula, Siberia (Fig. 1). A great variety of rocks and minerals (metals including the economically useful ones) are present on these land masses (NELSON and HOPKINS, 1969; SAINSBURY et al., 1969; SAINSBURY, 1970a). An attempt is made in this report to study the nature and distribution of sediments with regard to grain-size, lithology of pebbles and cobbles and mineralogy of the sands and to relate the sediments to their respective provenances, and then trace the migration routes of the sediments. Based on the grain size, heavy minerals and color of the sediments, certain strandline relict deposits are also distinguished. Where possible, the relation between the economically useful metals - gold and copper, and certain mineral assemblages, is pointed out.

Geologic and oceanographic setting

The following information on the geology of the land surrounding the Northern Bering Shelf is taken from DUTRO and PAYNE (1957), NELSON and HOPKINS (1969), and SAINSBURY (1970a, b).

Quaternary alluvial, glacial and eolian deposits are common throughout the area. The Seward Peninsula and the Chukotka Peninsula were glaciated during the Pleistocene time and the glacial drift reached and extended well beyond the present shoreline (HOPKINS, 1967; PETROV, 1967; NELSON and HOPKINS, 1969; GRIM and MCMANUS, 1970). Seaward Peninsula is composed of pre-Cambrian and early Paleozoic metamorphic rocks (schistose and gneissic rocks), Paleozoic sedimentary rocks (limestone, slates, phyllites), Quaternary basalts, granitic plutons and numerous dykes (ranging in composition from diabase to rhyolite). The northern Chukotka Peninsula is underlain by a similar sequence of rock types; but here, the granitic plutonic rocks are more widespread and dominant than in Seward Peninsula. The southern Chukotka Peninsula is underlain by late Mesozoic volcanic and some plutonic rocks. Some metamorphic and sedimentary rocks are also present, exposed in structural highs. The western part of St. Lawrence Island is primarily composed of granitic rocks, the central part of Quaternary basalts, and the eastern part, again, of granitic rocks. The Yukon River drains Mesozoic and Tertiary sedimentary rocks, Mesozoic volcanics (mainly basalts, with some andesites, dacites and rhyolites) and some pre-Cambrian metamorphic rocks in the upper reaches of the river (DUTRO and PAYNE, 1957). Quaternary basalts are common in the Yukon drainage basin but compared to the other types of rocks, they are less significant. The presence of basalts on the southern shores of Norton Sound, however, is noteworthy. Much of the northern Bering Shelf is underlain by a prism of Tertiary sediments locally reaching thickness excess of 6,000 feet (SCHOLL and HOPKINS, 1969).

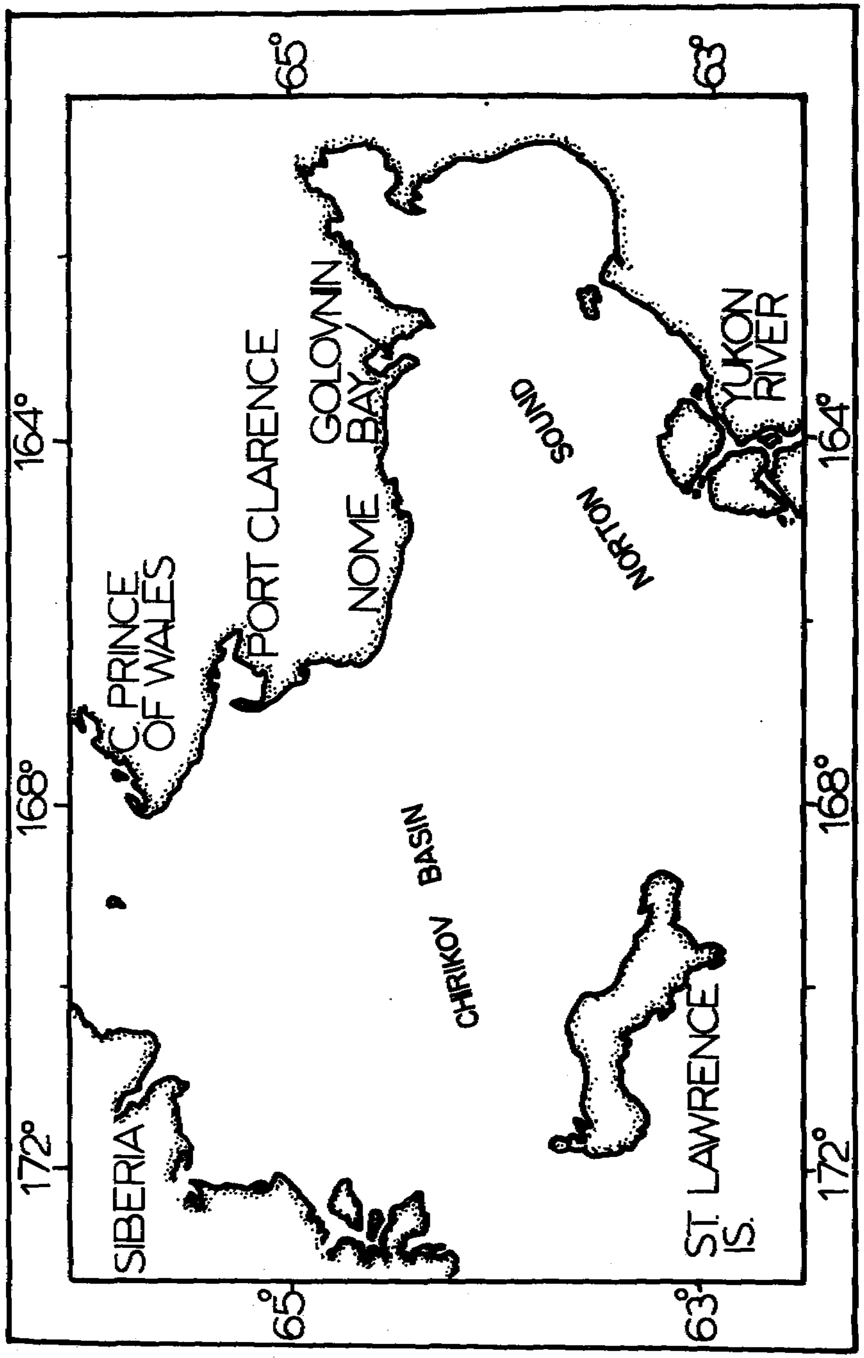

Fig. 1. Map showing the geographic divisions of the study area.

Studies on the grain size of the sediments and bathymetry of the area were reported by CREAGER and McMANUS (1967) and studies on seismic profiling by MOORE (1960) and GRIM and McMANUS (1970). The sediments in the nearshore areas off Nome, were studied in detail by NELSON and HOPKINS (1969) and several glacial drifts, outwash, alluvial and strandline deposits were distinguished by them. The occurrence and dispersal of particulate gold in the sediments of the Chirikov Basin has also been studied by NELSON and HOPKINS (1969). VENKATARATHNAM and McMANUS (1969) and VENKATARATHNAM (1969) briefly reported on the heavy minerals of the sands and lithology of pebbles of the sediments of the shelf. The present report is, however, a comprehensive account of the mineralogy of the sands, the grain-size distribution of the sediments, and the lithology of gravels and pebbles of the Northern Bering Shelf.

Bathymetry

Over most of the region, the water is less than 50 m deep. The bottom is relatively featureless except for some minor ridges and depressions (Fig. 2). Off Port Clarence at depths of 12 m and 20 m, and between the eastern part of the St. Lawrence Island and Yukon Delta, at depths of about 20 m, submerged ridges of depositional origin are present (GRIM and McMANUS, 1970). A broad shallow depression trending northwest-southeast occurs in the central part of the Chirikov Basin and this can probably be traced south-eastward into the westernmost part of Norton Sound. A few depressions and valleys of restricted areal extent are present off Seward Peninsula, in places off St. Lawrence Island and off Golovnin Bay. A broad depression with maximum depths exceeding 50 m extends from Anadyr Strait to Bering Strait. A recent bathymetric chart of the Chirikov Basin published by the U. S. COAST AND GEODETIC SURVEY (1969) provides many other details.

Currents

Strong currents of one knot or more move along much of the coastline, and bottom currents intermittently reach speeds of nearly three knots (150 cm/sec) in the eastern Bering Strait (FLEMING and HEGGARTY, 1966; Fig. 3). In the Nome region, Nelson and Hopkins reported current flowing intermittently and suddenly at speeds up to nearly two knots (100 cm/sec) either eastward or westward parallel to the coast. In the central parts of the Chirikov Basin, relatively low current speeds prevail and no currents stronger than 1/2 a knot (25 cm/sec) have been reported.

Moving ice covers the sea for about seven months of each year. Pressure ridges of ice occasionally become grounded in depths as great as 15-30 m below sea level and this grounded ice "bull dozes" the bottom sediment for short distances on the sea floor (NELSON and HOPKINS, 1969).

Rivers

The Yukon River is the largest river of the Bering Sea catchment basin with an annual runoff of 185 km^3/year (LISITSYN, 1966). This river enters

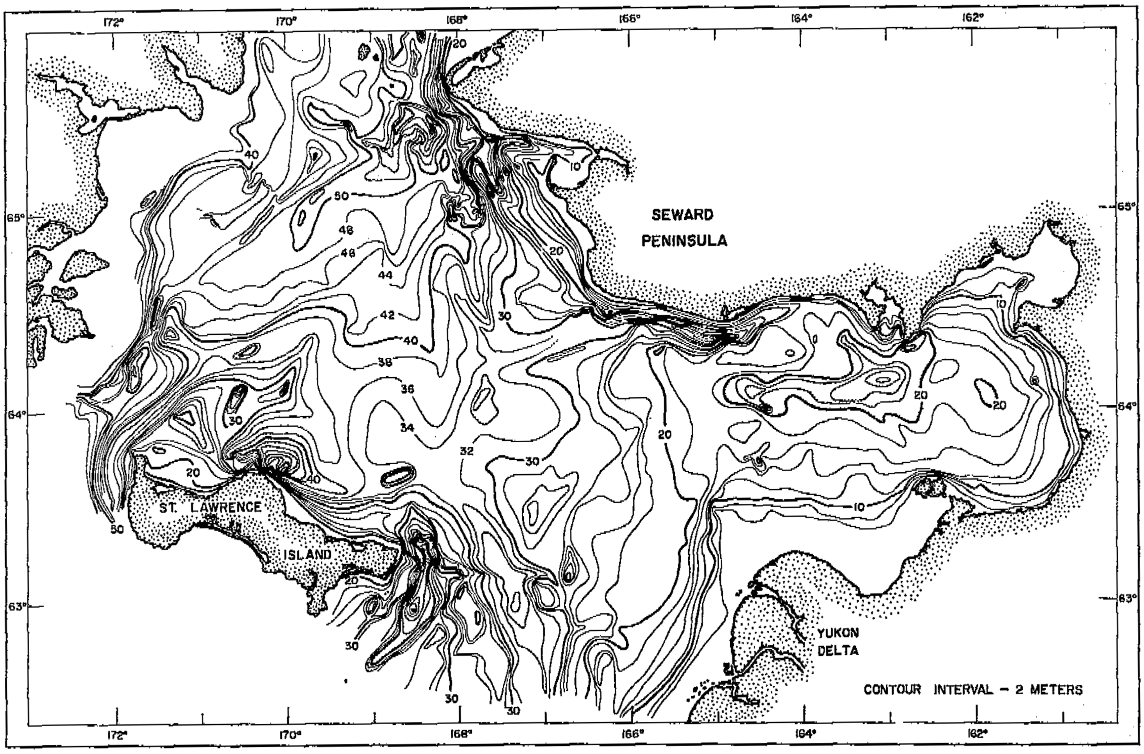

Fig. 2. Bathymetry of the Northern Bering Shelf. Contour intervals is 2 meters.

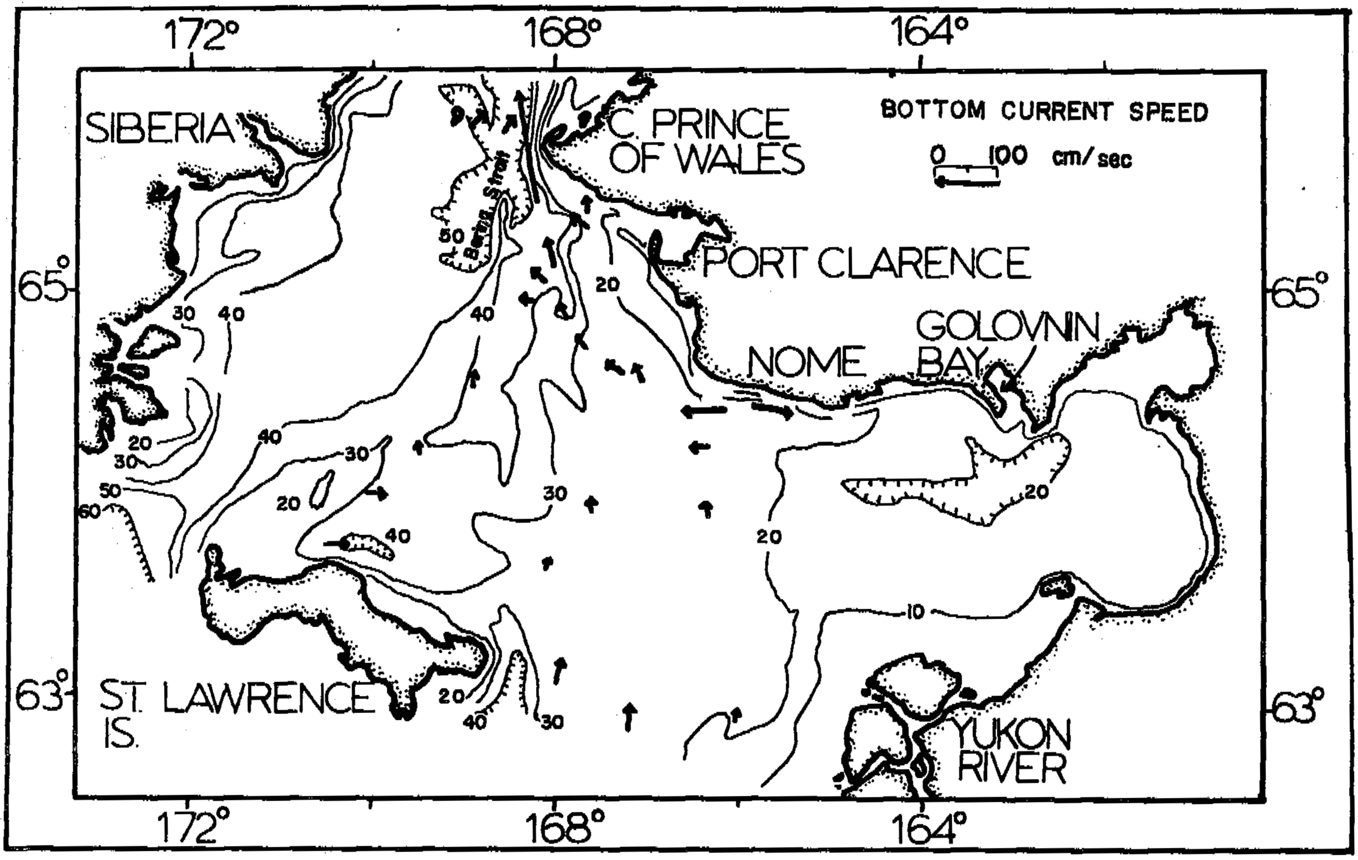

Fig. 3. Bottom currents of the Northern Bering Shelf. The arrow head points toward the direction in which the current is flowing, and the length of the arrow is proportional to the current speed. (NELSON and HOPKINS, 1969).

directly into the study area. Other rivers directly draining into the area are small and the data on their water- or sediment-discharges are not available. Two important rivers, the Anadyr and Kuskokwim with an annual runoff four to five times less than that of the Yukon, drain into the nearby Bering Sea areas south of the present study area (LISITSYN, 1966).

METHODS OF STUDY

Size analysis of sediment samples has been done by standard sieving and pipette techniques. The data from about 250 samples are used in the present study and include those of CREAGER and McMANUS (1967) and McMANUS et al. (1969; Fig. 4).

Heavy-mineral separation has been done on 204 samples in two size fractions of the sand 1-2.75ϕ and 2.75-4.0ϕ using methylene iodide (sp. gra. 3.14-3.17) as heavy liquid. The data on the heavy residues (the material with specific gravity >3.14 -3.17) of these two sizes, and the individual heavy minerals counted under the microscope are given in Tables I, II and III. An examination of about 120 samples of heavy minerals in two separate sizes, it was hoped, would help to evaluate the effects of grain size on the mineral composition. Special studies on the varietal characters of zircons of six samples have also been made to see how this particular mineral is different in the different areas. Light minerals of selected samples have also been examined by staining technique. A preliminary examination of lithology of the pebbles and gravels from all over the area has been made as an aid in determining whether the migration routes of sand and coarser material are the same or different.

RESULTS OF STUDY

Grain size distribution

Gravel (>2mm or -1ϕ) is locally abundant in several places and is a predominant component of the sediments off Cape Prince of Wales, off Nome-Port Clarence and off St. Lawrence Island (Fig. 5). The extent and trends of these gravels may provide information in certain cases as to the directions from which they were derived. The lithology, size, shape and roundness of pebbles and gravels in the nearshore areas off Nome have been studied in detail by HOPKINS (personal communication) and in part reported by NELSON and HOPKINS (1969). GRIM and McMANUS (1970) reported the occurrence of possible Pleistocene morainal sediments buried under the younger sediments extending part of the way between the Bering Strait and St. Lawrence Island.

Much of the Chirikov Basin is carpeted with sand (Fig. 6). In Norton Sound sand dominates only just off Golovnin Bay. Much of the area between St. Lawrence Island and Yukon Delta is also composed of sand, except for a narrow band of fine material near the Yukon River. The fine-grained sediments (silt and clay) are confined mostly to Norton Sound and Port Clarence Bay (Fig. 7). The distribution of fine sediments in the Norton Sound and in the eastern part of the Chirikov Basin, is an indication of the extent of the dispersal of the Yukon silts.

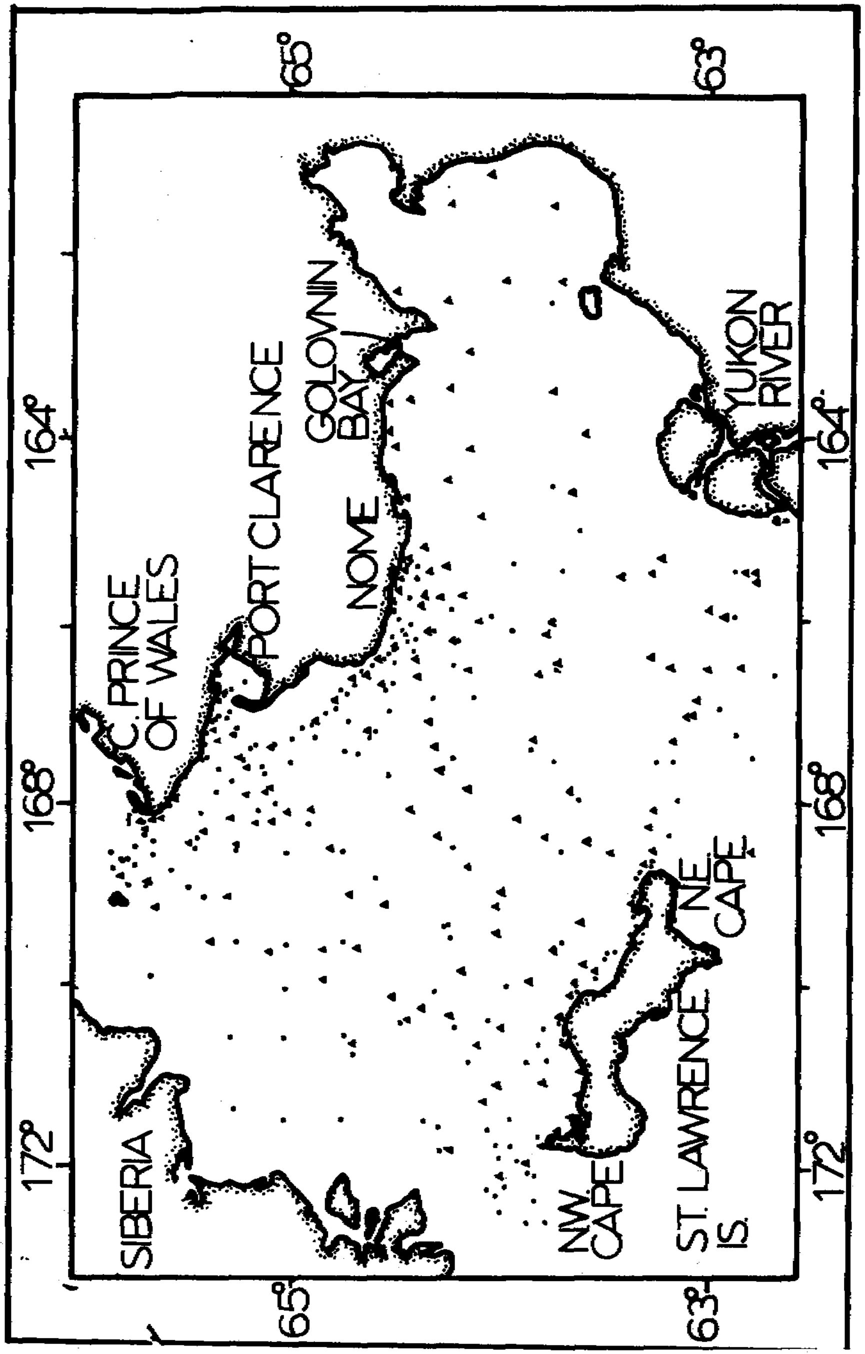

Fig. 4. Location of bottom sediment samples used in this study. All samples were analyzed for grain size. Only the samples indicated by the triangles had the heavy minerals separated.

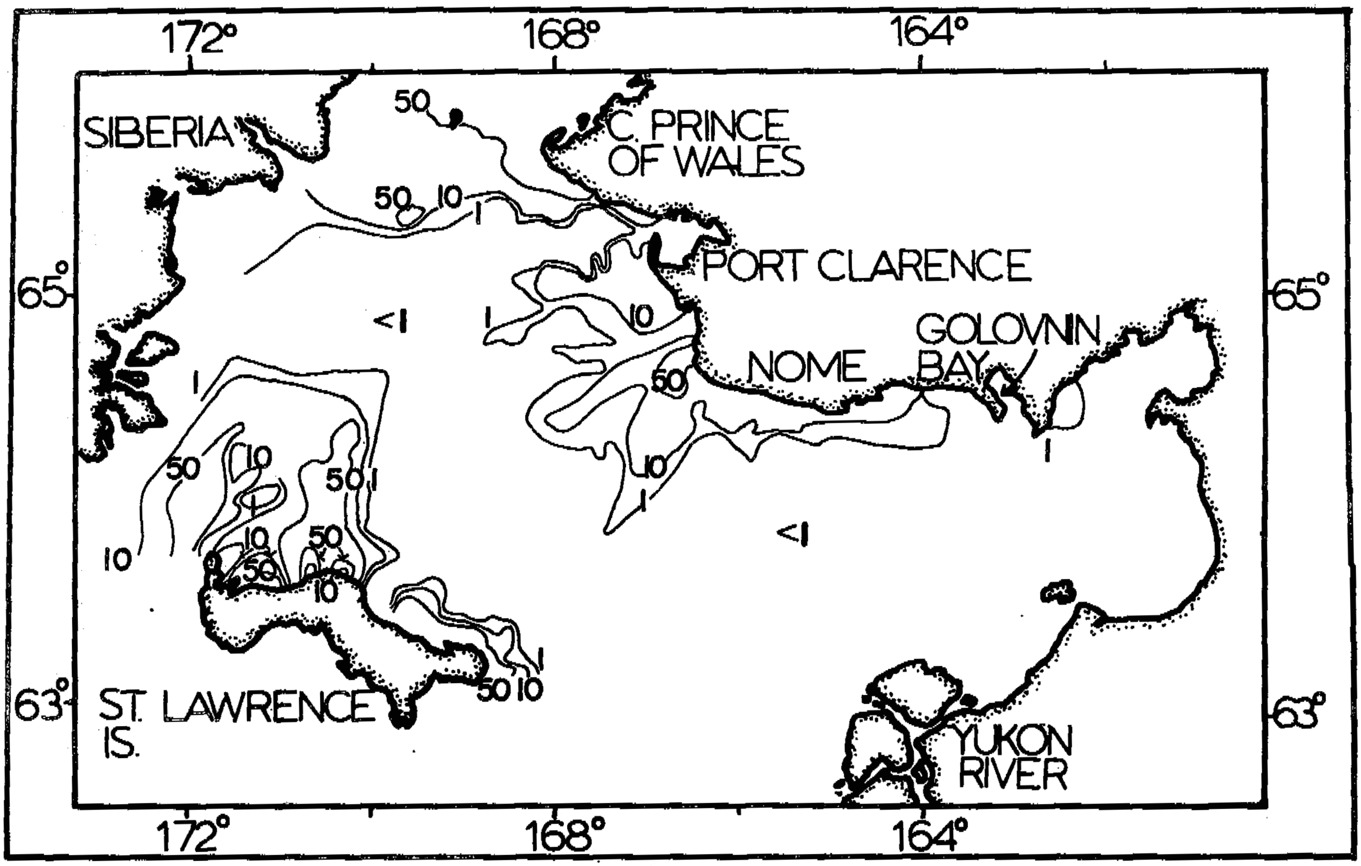

Fig. 5. Percentage distribution of gravel in bottom sediments.

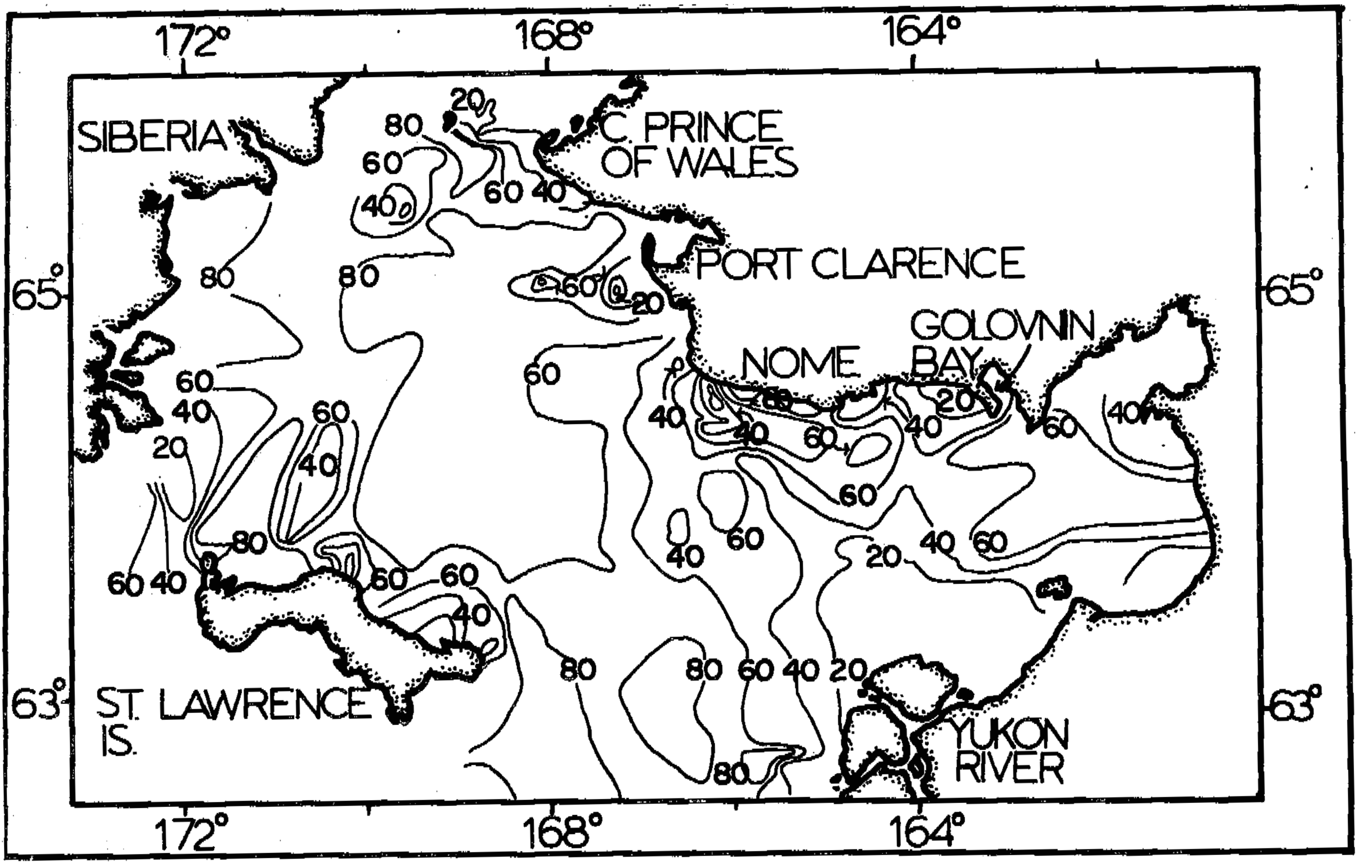

Fig. 6. Percentage distribution of sand in bottom sediments. Contour interval: 20%.

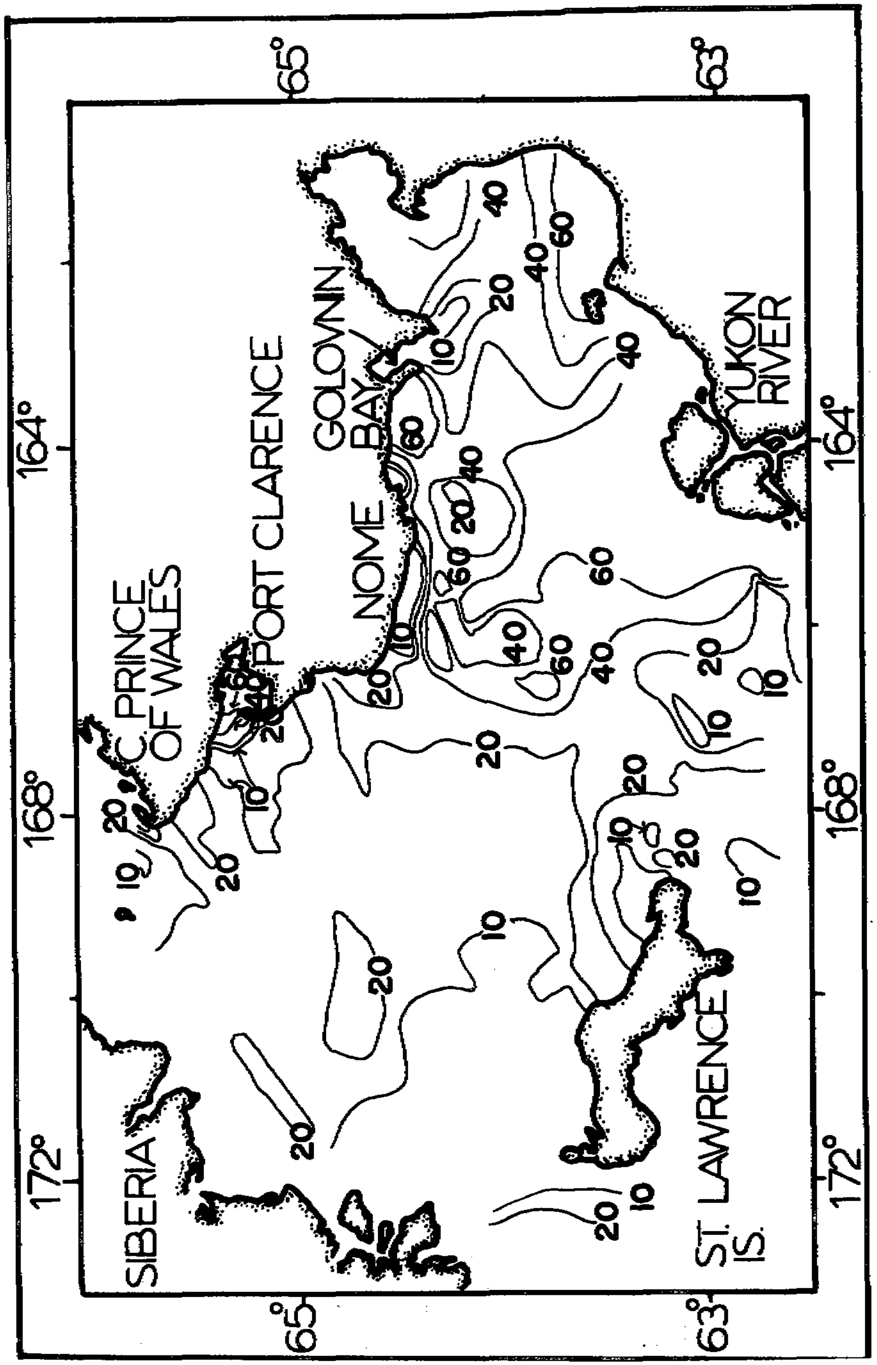

Fig. 7. Percentage distribution of mud (silt + clay) in the bottom sediments.

In much of the Chirikov Basin, the mean size of the sediments (FOLK and WARD, 1957) falls in the fine sand and very fine sand range, and in the Norton Sound, in the coarser silt range except off Golovnin Bay (Fig. 8). In general, the mean size increases towards the shores, the increase being definite in the areas of gravel sediments. Prominent modes in the sand grade material in the central part of the Chirikov Basin, fall between 2ϕ and 3ϕ and only rarely decrease to 3.5ϕ. In the areas of gravel sediments, the sizes of the sand modes increase to coarser than 2ϕ, and in the areas of fine sediments the sizes of the sand modes decrease (3ϕ-4ϕ). In some gravel-rich sediments off Nome and in the fine sediments of Norton Sound, material with distinct silt-size modes are frequently present.

Using the statistical parameters of FOLK and WARD (1957), well- to moderately-sorted sediments are present on the sand ridges and sometimes in the channels between the St. Lawrence Island and Yukon Delta, on the sand ridges off Port Clarence Bay, off Northwest Cape of St. Lawrence Island (28-36 m depth), and in a few restricted areas elsewhere (Fig. 9). Much of the area, however, is dominated by poorly sorted sediments; within these, usually, the gravel-rich sediments and the fine sediments near the Yukon River are more poorly sorted.

Positive skewness values are characteristic of the sediments in general (Fig. 10). Some of the well sorted sediments, but not all, are negatively skewed and in a few cases, the poorly sorted sediments are also negatively skewed. The maximum skewness values are found in the poorly-sorted sandy sediments and in the Yukon silts; the gravel-rich sediments in general are less positively skewed.

To summarize the grain-size characteristics, the mean size of the sediments increases in a general way towards the shores. The gravel-rich sediments, besides gravel modes, have coarse sand modes and coarse silt modes, and are extremely poorly sorted with usually high but not extreme positive skewness values. Well-sorted gravel-rich sediments are found in a few localities. On the basis of a detailed study of many samples, HOPKINS (personal communication) distinguished well-sorted gravel deposits besides the poorly sorted ones in the area off Nome. In the Chirikov Basin, the sandy sediments have fine sand modes; in a few places these sediments are well sorted and are both positively and negatively skewed. In much of the area the sandy sediments and the fine sediments of Norton Sound are poorly sorted, with extreme positive skewness values.

Color of the sediments

Usually the color of the sands is gray. Some sands, however, are reddish brown or brown with weathered angular grains. These sediments, which are also well sorted, occur as the submerged sand ridges (at 12 and 20 m) opposite Port Clarence, including the sand wave area there (JORDAN, 1962), and off Northwest Cape at 34-36 m.

Lithology of cobbles and pebbles

Off Nome, pebbles and cobbles of usually quartzites, micaceous quartzites, quartz-micaschists, garnet-hornblende schists, calc-silicate

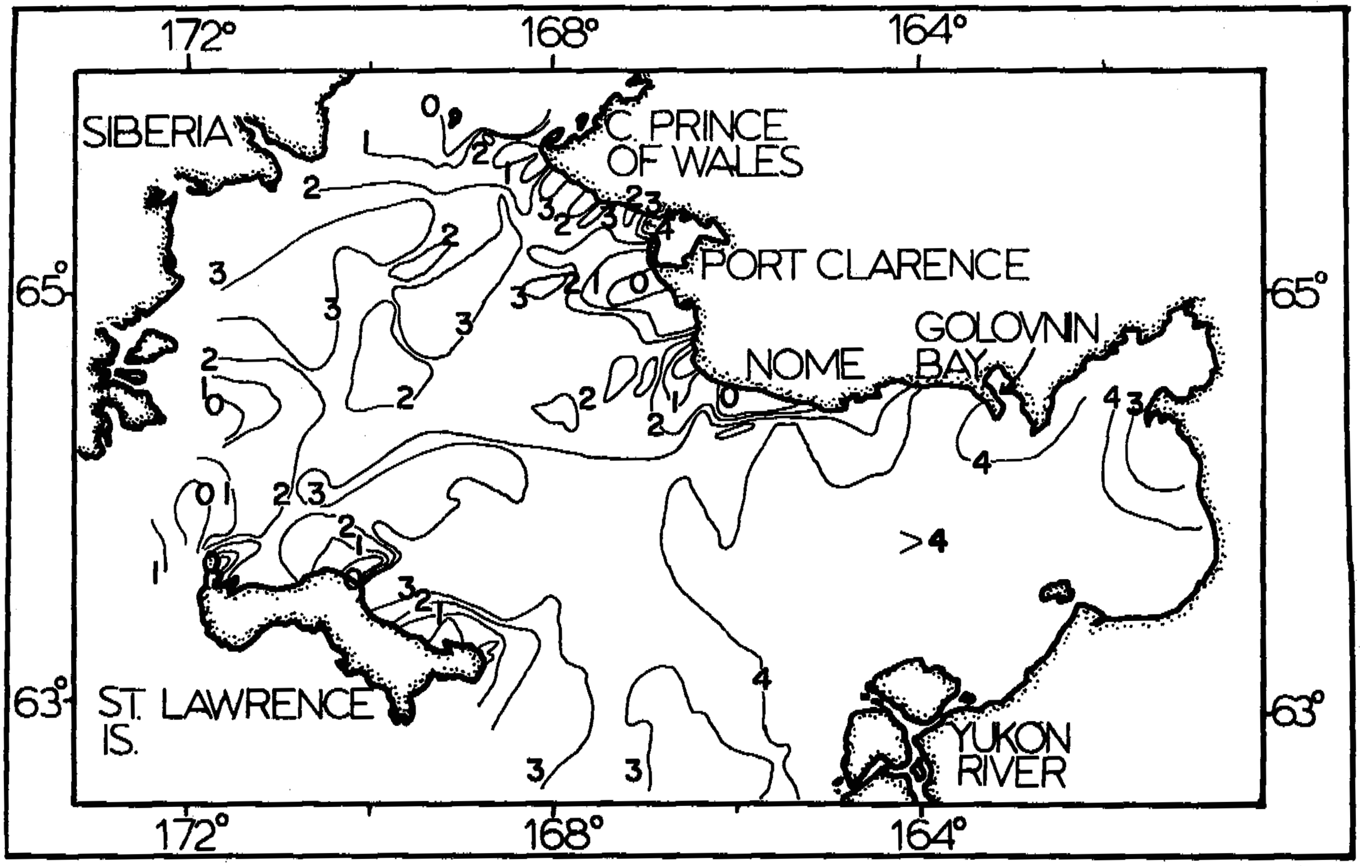

Fig. 8. Distribution of phi mean size in the bottom sediments

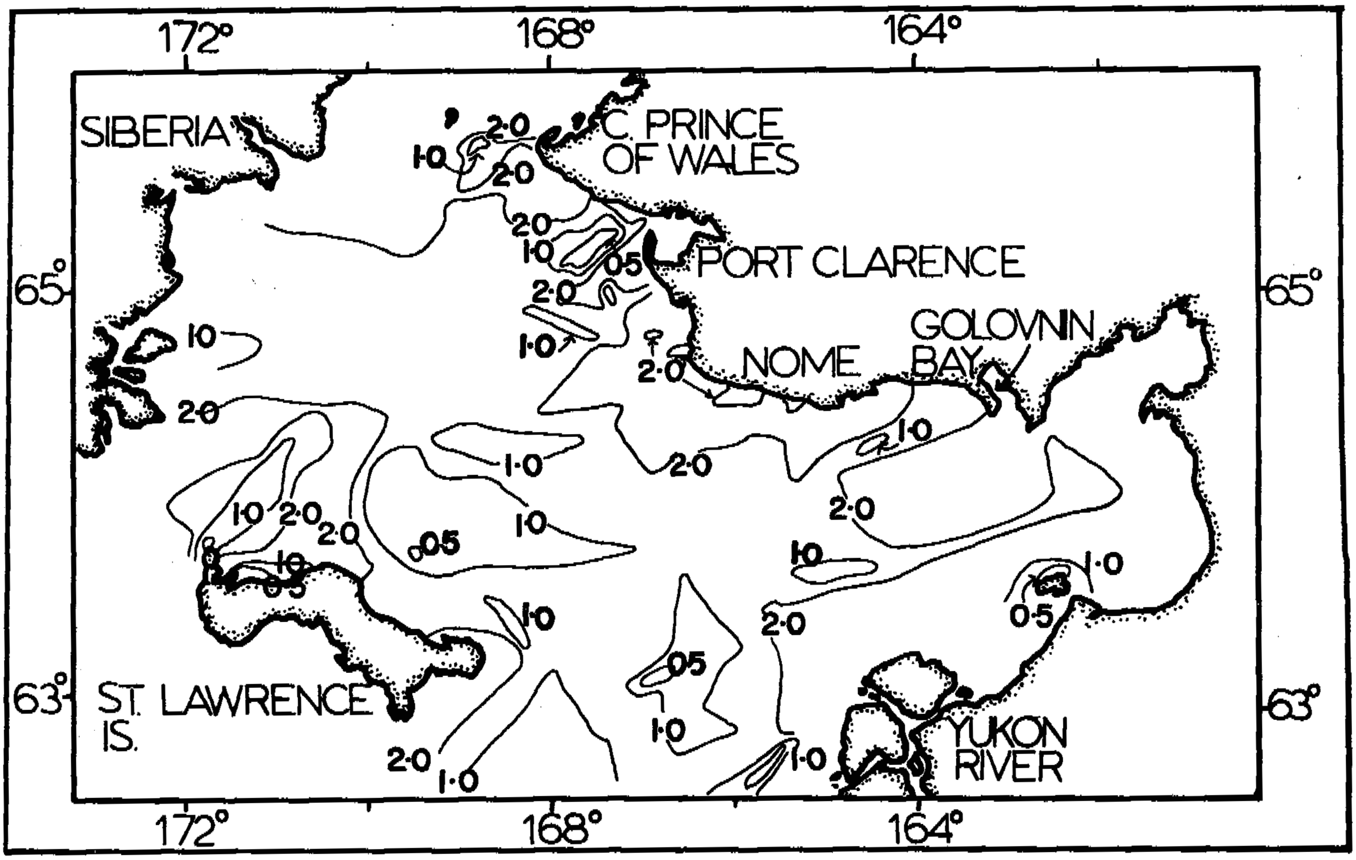

Fig. 9. Distribution of inclusive graphic standard deviation measure of the bottom sediments.

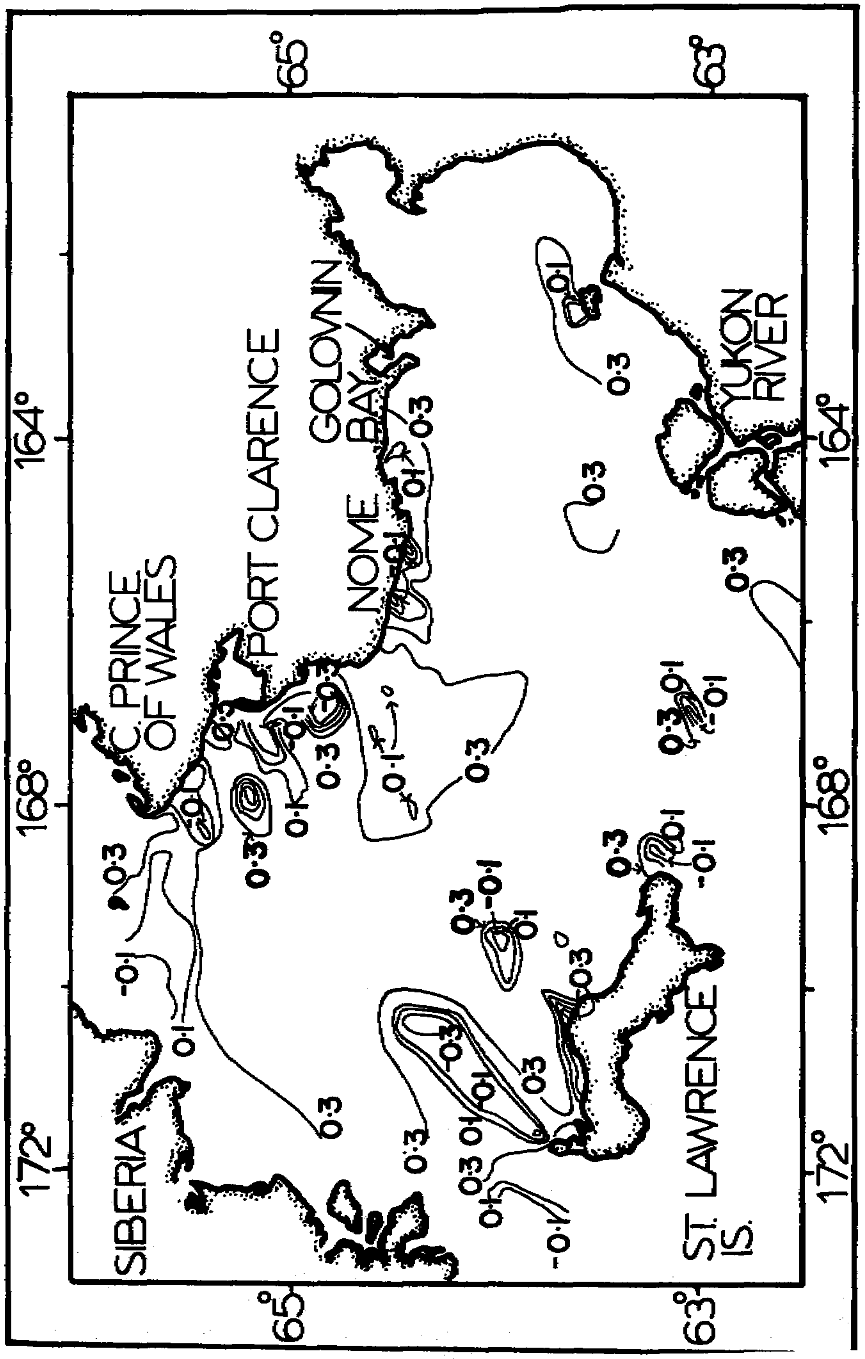

Fig. 10. Distribution of phi skewness values of the bottom sediments.

rocks and sometimes granitic rocks as off Sledge Island are present. Detailed studies on lithology, shape and roundness characteristics of the pebbles and gravels off Nome area by D. M. Hopkins of the U. S. Geological Survey, are in progress.

Off York in the shallower areas (34 m depth) angular gravels composed mostly of limestone, slate and some acid volcanics are present. In somewhat deeper areas, at 48-50 m, quartzites, acid volcanics (dacite, rhyodacite, quartz latite, andesite and divitrified glass), and some limestones, sandstone, cherts and granitic material are present. At both the above depths, schistose rocks are conspicuously absent.

Off Cape Prince of Wales in the Bering Strait, gravels and pebbles of granites and granitic gneisses, epidiorites, limestones and slates are common. Occasionally acid volcanics and olivine basalt are also present. In the western Chirikov Basin, at a location of about 64°20'N 170°15'W at 34-40 m depths, acid volcanics (andesite, dacite, quartz latite and rhyolite) and granophyre with some altered basalts and diabases, and granitic rocks are present. Occasionally fresh olivine basalt and sedimentary rocks such as limestone and sandstone are also present. Landward of this location toward the central part of St. Lawrence Island, pebbles of fresh olivine basalt become more dominant. In these areas, in contrast to the area off York, quartzites are absent, and limestones are infrequent.

Off the Northwest Cape in Anadyr Strait, acid volcanics and altered basalts (and diabases) with some granitic material are common. Fresh olivine basalts are absent. Pebbles of altered andesites and diabases have some metallic (copper) sulphides and some of the associated sands have copper flakes. These gravels are for the greater part angular. East of this area in the Chirikov Basin at depths of 34-36 m rounded pebbles of acid volcanics coated brown-red are characteristically present. The sands associated with these sediments are also brown-coated and the sediments as a whole are well sorted as mentioned earlier.

Heavy mineral composition of the sediments

On the basis of the amounts of heavy residues in the 2.75-4.0ϕ size-grade material, the Chirikov Basin is broadly divisible into three areas, two of which have relatively high concentrations and are separated by an area of low content trending approximately northwest-southeast along the broad shallow depression in the central part of the basin (Fig. 11). Compared to the Chirikov Basin, an area of low heavy mineral percentages occurs in Norton Sound, where relatively high concentration of heavy minerals are present only near Nome and Golovnin Bay. Between the eastern end of St. Lawrence Island and the Yukon Delta, there are relatively high contents of heavy minerals at depths of 20 m, corresponding to the minimum depths of the sand ridges there and at slightly greater depths in the nearby areas. Off Port Clarence, high amounts of heavy minerals are present on the submerged sand ridges and in the sand wave region. They are also abundant farther south and off Nome at about 28-36 m, which may correspond to a location of other ridges (see Fig. 2), and near St. Lawrence Island, off the Northwest Cape at 30-36 m depth in the area of brownish sediments, in the nearshore areas off the central part and off Northeast Cape.

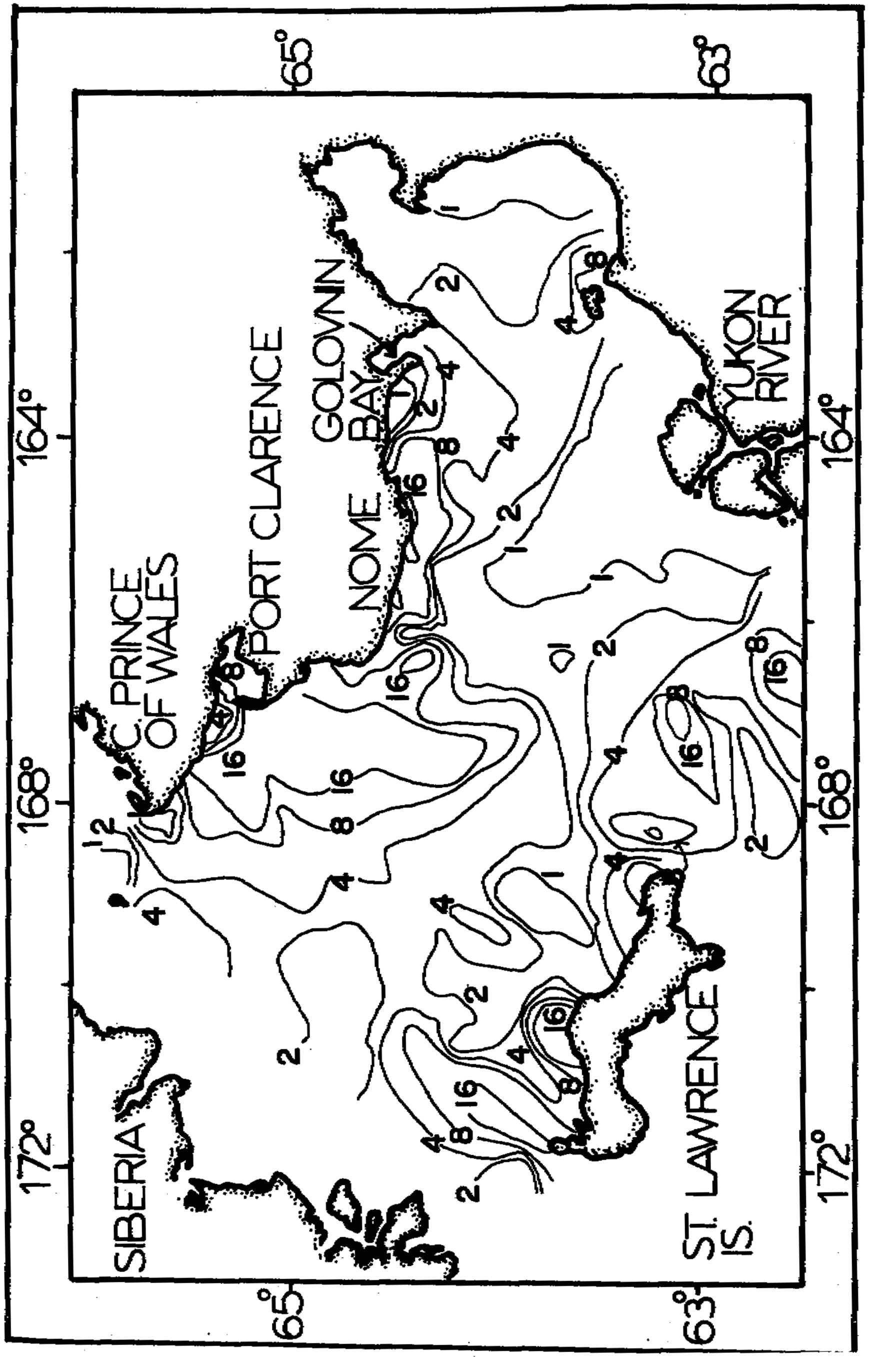

Fig. 11. Percentage distribution of total heavy minerals (>3.14 - 3.17 specific gravity) of the 2.75 - 4.0ϕ size sand.

In general, the distribution pattern of heavy mineral content in the 1-4ϕ size fraction is similar to that of the 2.75-4ϕ sand fraction (Fig. 12), although the concentrations are greatly reduced. This is because the amounts of heavy minerals in the 1-2.75ϕ sand grade are low in proportion (Table I). The areas of sand ridges off Port Clarence and off Nome, and between the St. Lawrence Island and Yukon Delta, tend to have high amounts of heavy minerals in 1-4ϕ size. Not all the samples with relatively high concentrations of heavy minerals in the fine sands, however, have high amounts in the 1-4ϕ size.

The heavy minerals identified and counted are: opaques, orthopyroxene (mostly hypersthene), clinopyroxene, amphibole (mostly hornblende), epidote, sphene, olivine, garnet, apatite, zircon, staurolite, kyanite, chloritoid and rock fragments. Of these minerals, clinopyroxene, garnet, orthopyroxene, rock-fragments and amphibole are usually present in high proportions.

Clinopyroxene. In 2.75-4ϕ size fraction, clinopyroxene is present in high concentrations off the Yukon River, in Norton Sound, in the westernmost part of Chirikov Basin, and off the central part of St. Lawrence Island (Fig. 13). The maximum abundance occurs off the central part of St. Lawrence Island and in the easternmost part of Norton Sound. Near Golovnin Bay, it is less common than in the rest of Norton Sound and drops to a minimum off Nome. Between Port Clarence and Cape Prince of Wales, there are two areas of alternately low and high percentages of clinopyroxene. A high percentage off the central part of St. Lawrence Island is bordered on either side by areas of lesser percentages. In the westernmost part of the Chirikov Basin, again, clinopyroxene tends to increase.

In the coarser sand fraction (Fig. 14), many of the samples off the Yukon River have very little heavy residues and hence counting of these size fractions is not reliable. Along a line of stations between the Yukon River and the eastern part of St. Lawrence Island, in the sandy sediments, clinopyroxene in the coarser fractions tends to be as high as in the finer fractions, and these percentages may also be representative for the coarser fractions of Norton Sound. In the rest of the area, the distribution is broadly similar to that in the fine sand.

Olivine. The distributions of olivine in both the coarse and fine sands are nearly the same (Fig. 15, 16). The small differences probably are not significant in view of the usual inadequate amounts of heavy minerals in the coarser fractions.

Olivine occurs in very low percentages throughout much of the region. However, it is common just off St. Lawrence Island and in the eastern part of Norton Sound, attaining maximum abundances off the central part of the St. Lawrence Island and in the areas near Stuart Island. The maximum abundance of olivine off St. Lawrence Island is not at the same location as the maximum abundance of clinopyroxene. Olivine is present in somewhat lower amounts in places near Cape Prince of Wales and Port Clarence.

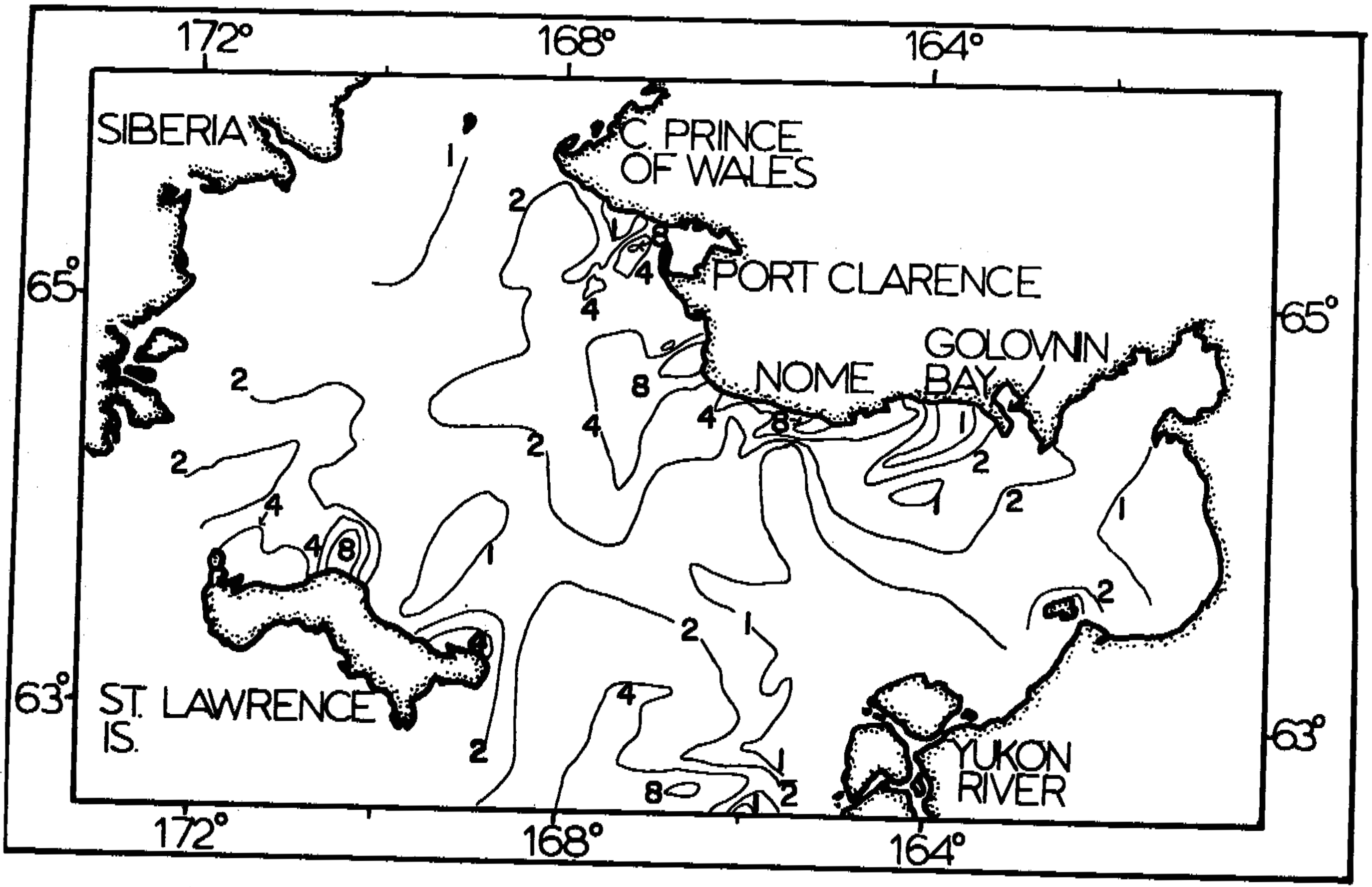

Fig. 12. Percentage distribution of total heavy minerals of 1 - 4ø sized sand.

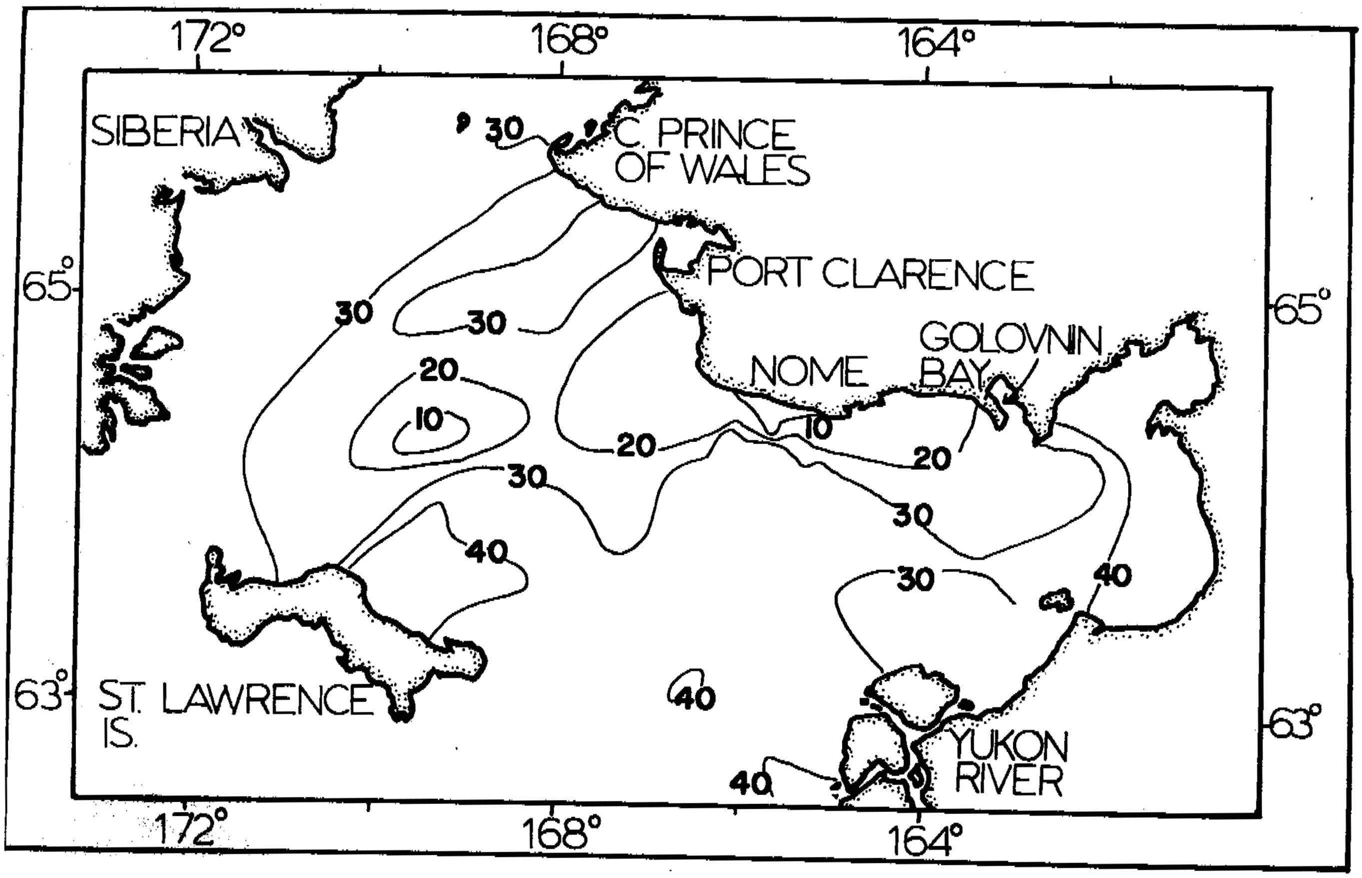

Fig. 13. Percentage distribution of clinopyroxene in 2.75 - 4.0ø sized heavy minerals.

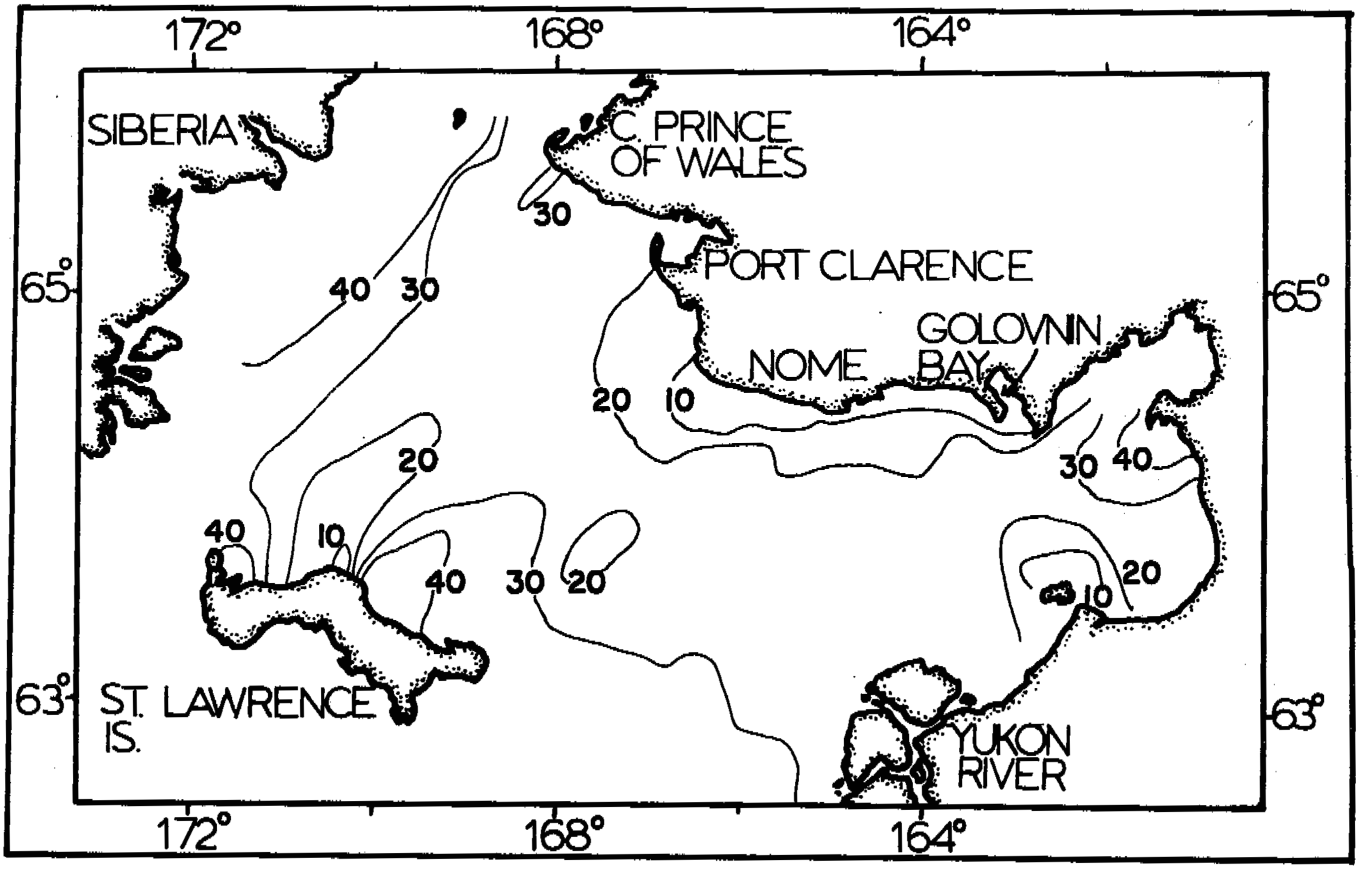

Fig. 14. Percentage distribution of clinopyroxene in 1 - 2.75ϕ sized heavy minerals.

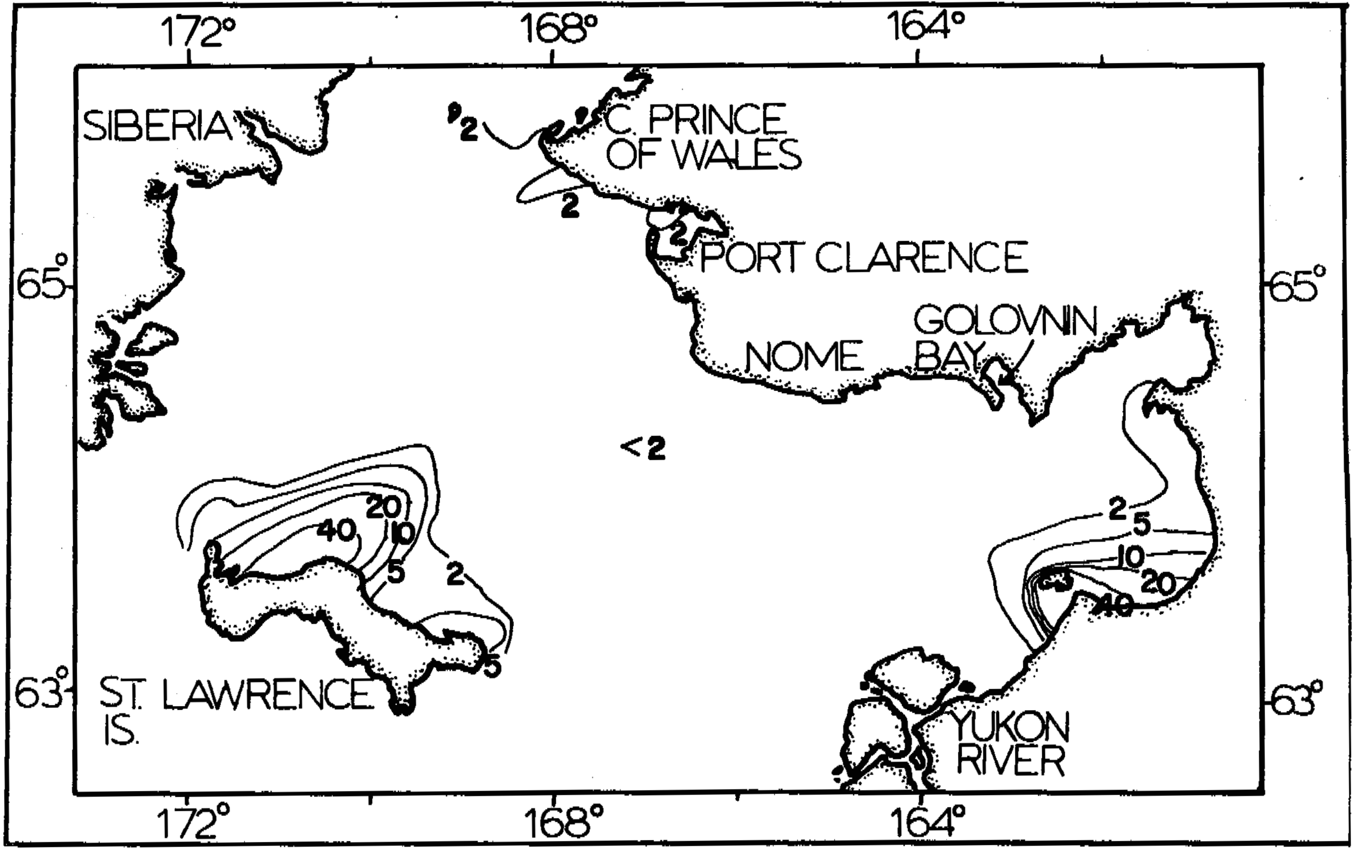

Fig. 15. Percentage distribution of olivine in 2.75 - 4.0ϕ sized heavy minerals.

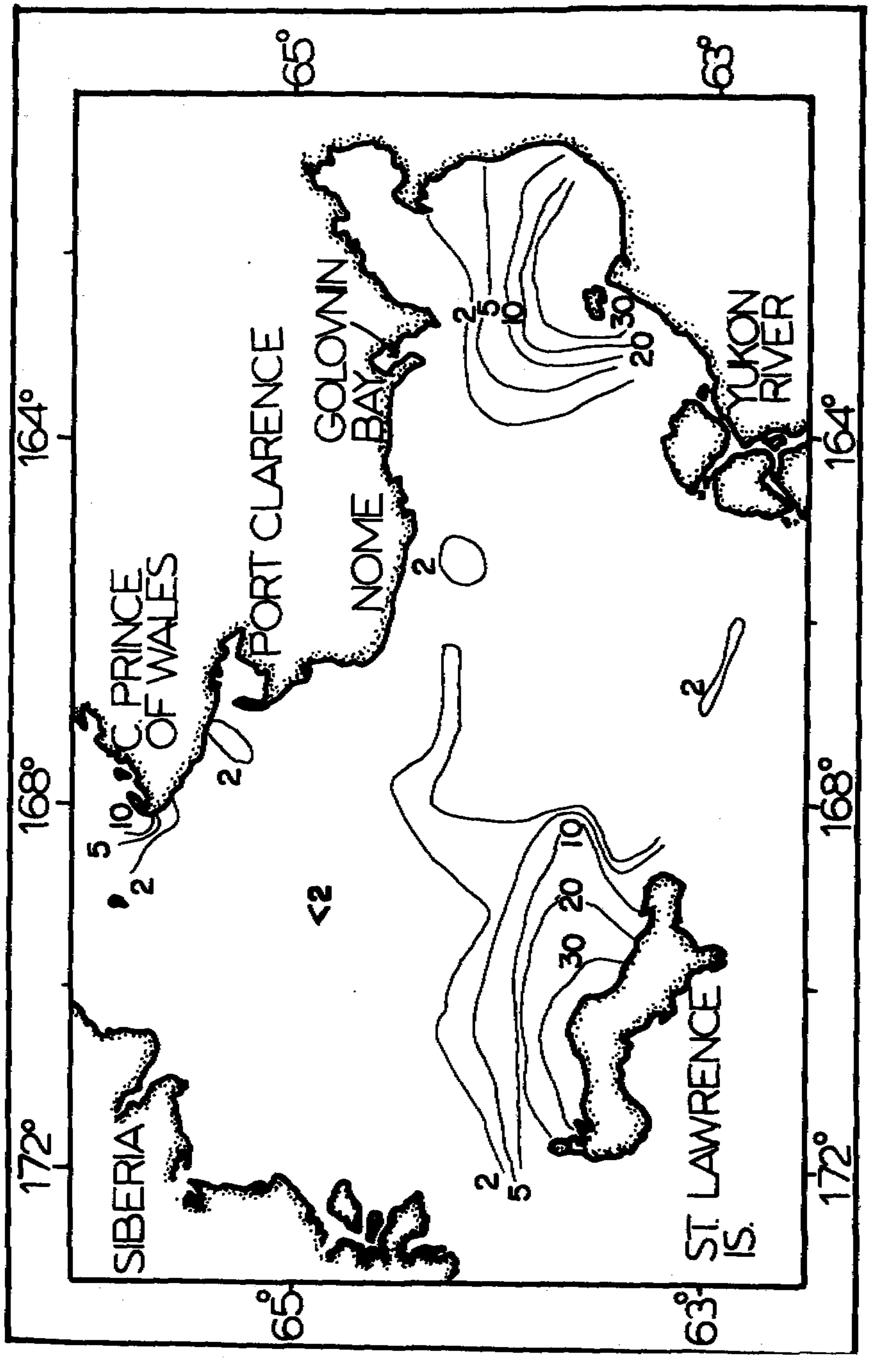

Fig. 16. Percentage distribution of olivine in 1 - 2.75φ sized heavy minerals.

Garnet. The garnet minimum occupies much of Norton Sound and the western Chirikov Basin (Fig. 17, 18). The maximum percentage of garnet is found off Nome with a gradual decrease away from the Nome area. The distribution of gold (NELSON and HOPKINS, 1969) off Nome is similar to that of garnet, the difference being that the decrease of gold away from Nome is rather abrupt and sudden. The distributions of garnet in both the fine and coarse sizes is similar. Between St. Lawrence Island and the Yukon delta, relatively high amounts of coarse garnet are present on one of the ridges. Finer-grained garnet occurs in the adjacent depression that is in somewhat bathymetric continuity with the area of very high garnet off Nome.

Opaque minerals. Opaque minerals attain their maximum abundance off Nome, Port Clarence, and in some places off Cape Prince of Wales (Fig. 19, 20). In these areas, the distribution of opaque minerals resembles that of garnet. The westernmost section of the Chirikov Basin, including areas off the Northwest Cape of St. Lawrence Island and part of Anadyr Strait, also contain high proportions of opaque minerals, among which are common metallic flakes that were identified by microprobe analyzer to be mostly copper and some copper-iron sulphide. The acid volcanic pebbles described earlier are associated with these sands. The opaque minerals are present in low proportions in much of Norton Sound, except its easternmost part.

Amphibole (hornblende). In the 2.75-4φ size fraction (Fig. 21), hornblende is relatively abundant opposite Golovnin Bay, in a restricted area off the Yukon River, in a few localized places off Nome, off Northeast Cape, and in the westernmost part of the Chirikov Basin. In the rest of the region, it occurs in relatively low percentages. In the 1-2.75φ fraction (Fig. 22), the percentage of hornblende is high off Golovnin Bay and in the westernmost section of the Chirikov Basin. In spite of the many low values in the Norton Sound off the Yukon River, it is sometimes present erratically in high amounts. This may be partly due to the small amount of material of 1-2.75φ size that causes an inadequacy of the samples for mineral-counting. Glaucophane has been observed occasionally in traces off Nome and Port Clarence.

Orthopyroxene (hyperethene). This mineral is more abundant in Norton Sound near the Yukon River, especially in the sandy sediments between the Yukon Delta and St. Lawrence Island (Fig. 23, 24). The sandy sediments farther away from the Yukon River in the Chirikov Basin, however, contain lesser amounts of orthopyroxene.

Epidote. Epidote in both the size fractions is maximum near Nome (Fig. 25, 26). In parts of Norton Sound somewhat farther from the Yukon River, in the central part of the Chirikov Basin and off the Cape Prince of Wales, the mineral is also present in relatively high proportions. The distribution of epidote in the coarse fraction off Nome is similar to that of garnet.

Chloritoid and staurolite. The distributions of these minerals are very similar (Fig. 27 - 30). In general, both chloritoid and staurolite are present in high amounts in the northern parts of the Chirikov Basin

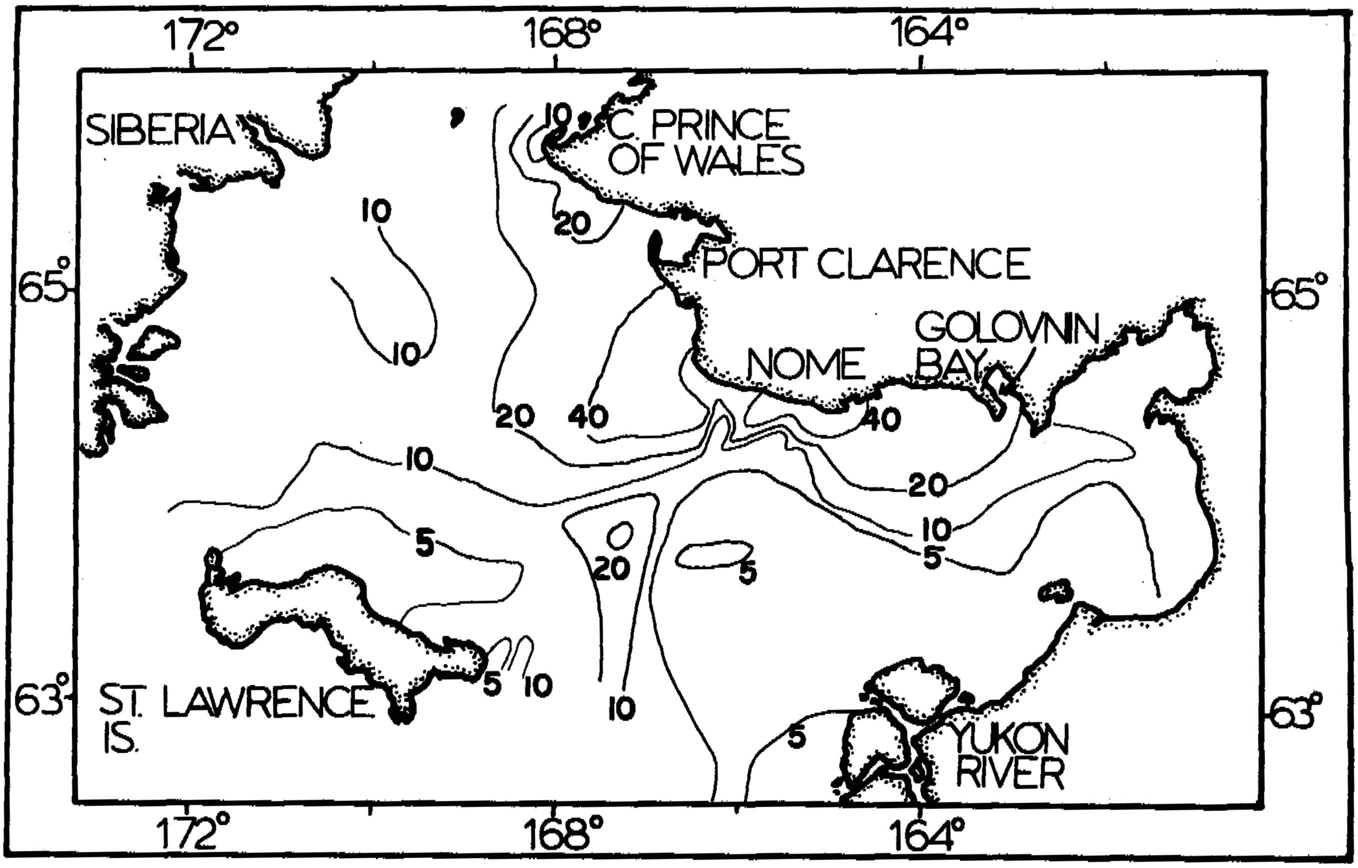

Fig. 17. Percentage distribution of garnet in 2.75 - 4.0ϕ heavy minerals.

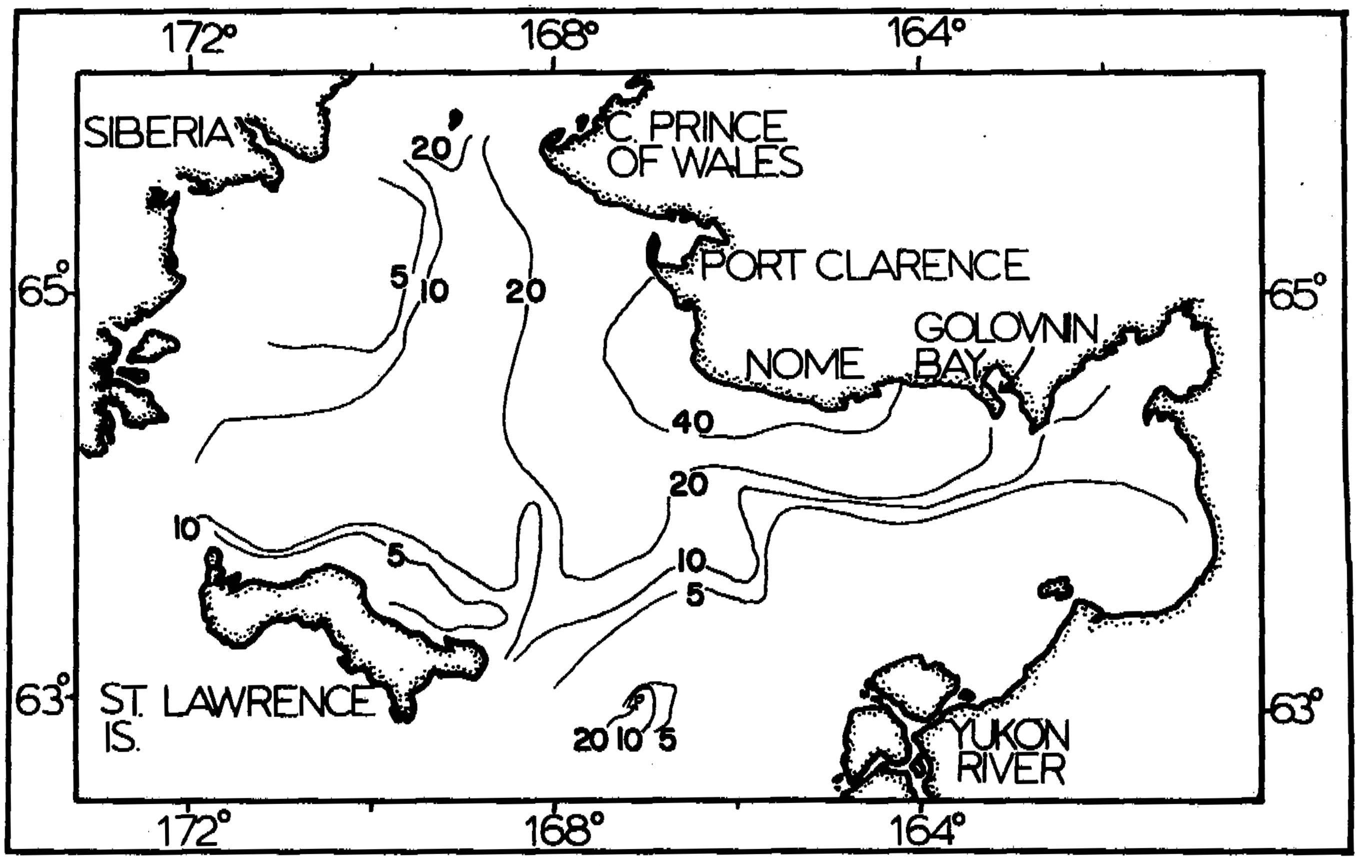

Fig. 18. Percentage distribution of garnet in 1 - 2.75ϕ sized heavy minerals.

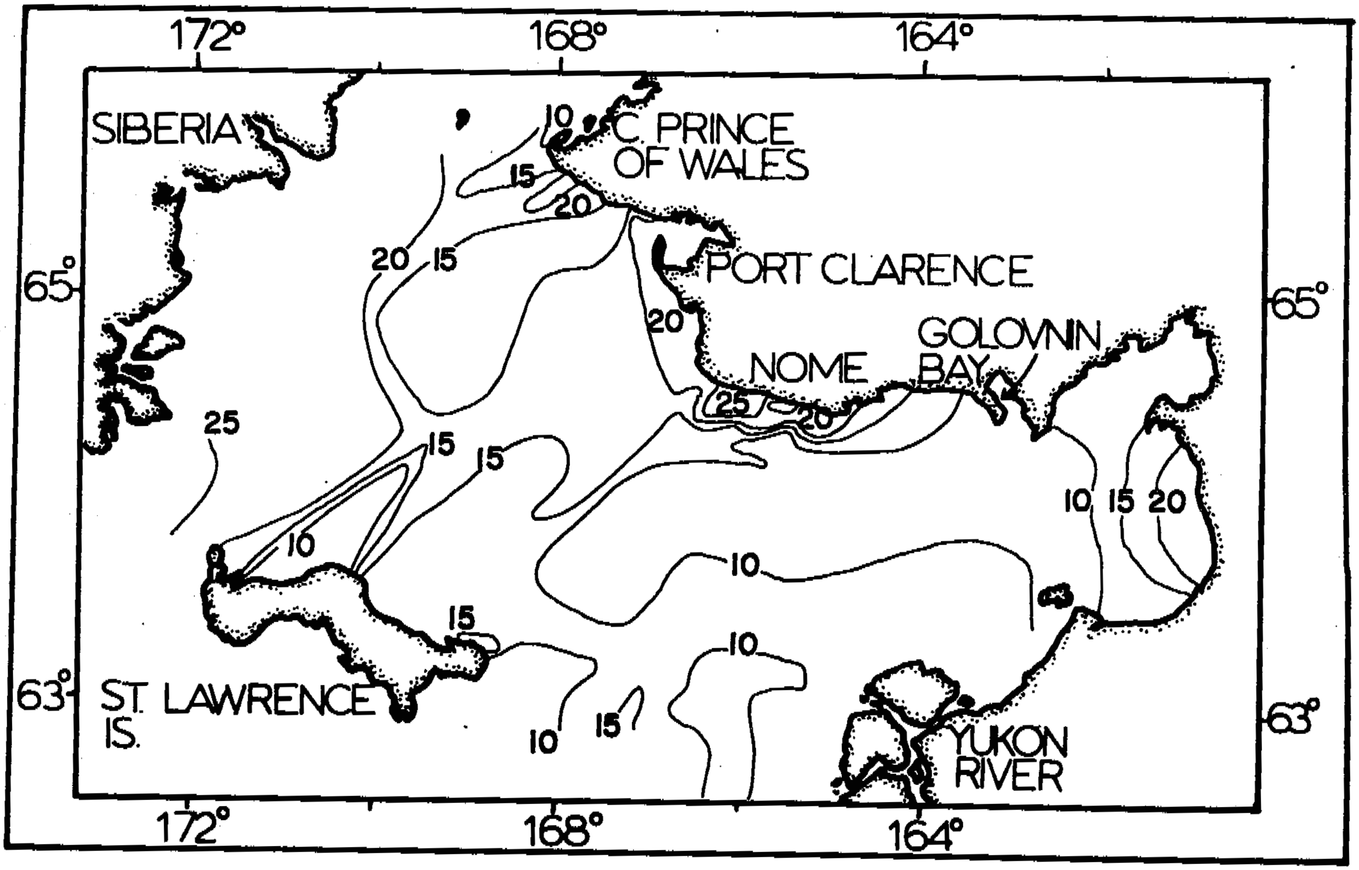

Fig. 19. Percentage distribution of opaque minerals in the 2.75 - 4.0ϕ sized heavy minerals.

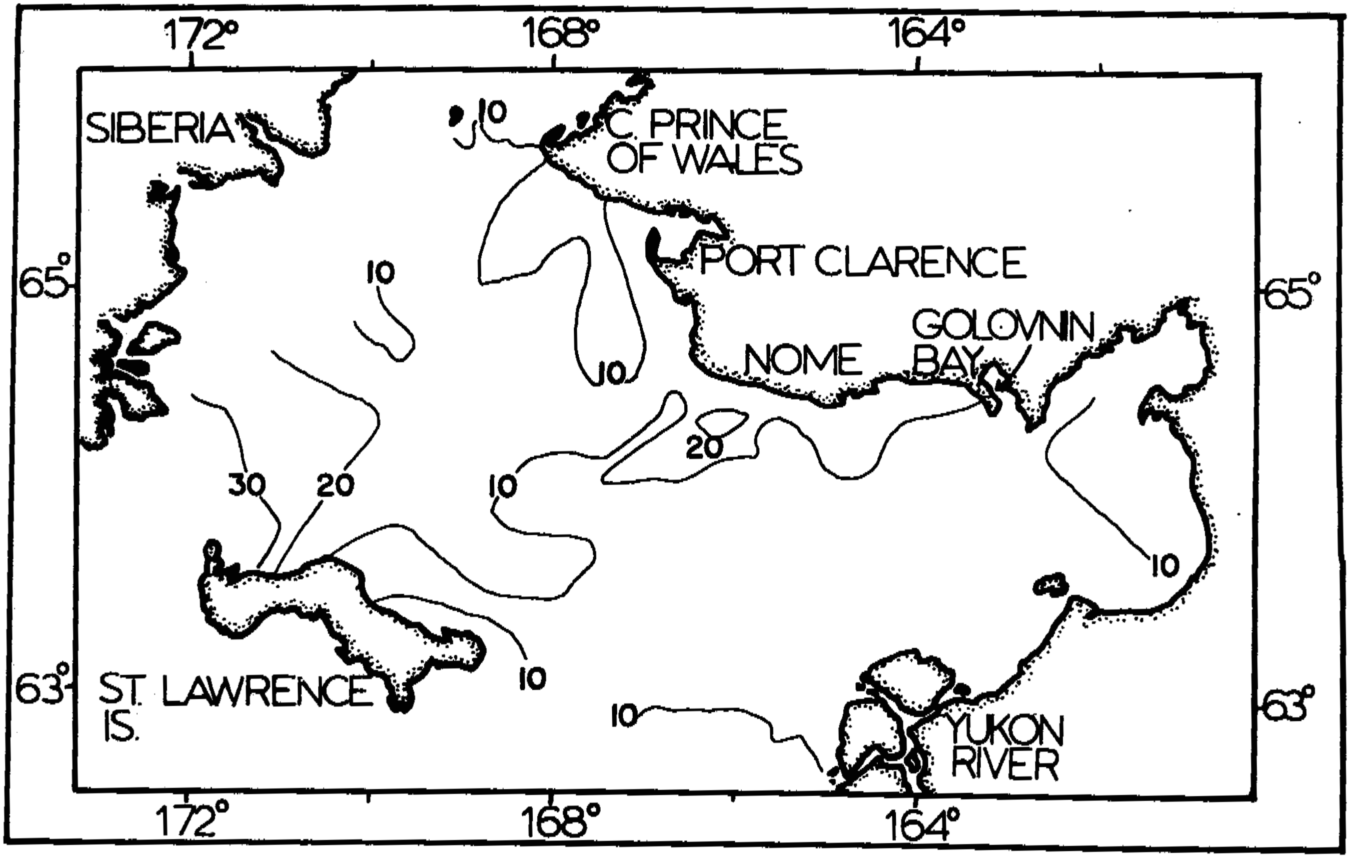

Fig. 20. Percentage distribution of opaque minerals in 1 - 2.75ϕ sized heavy minerals.

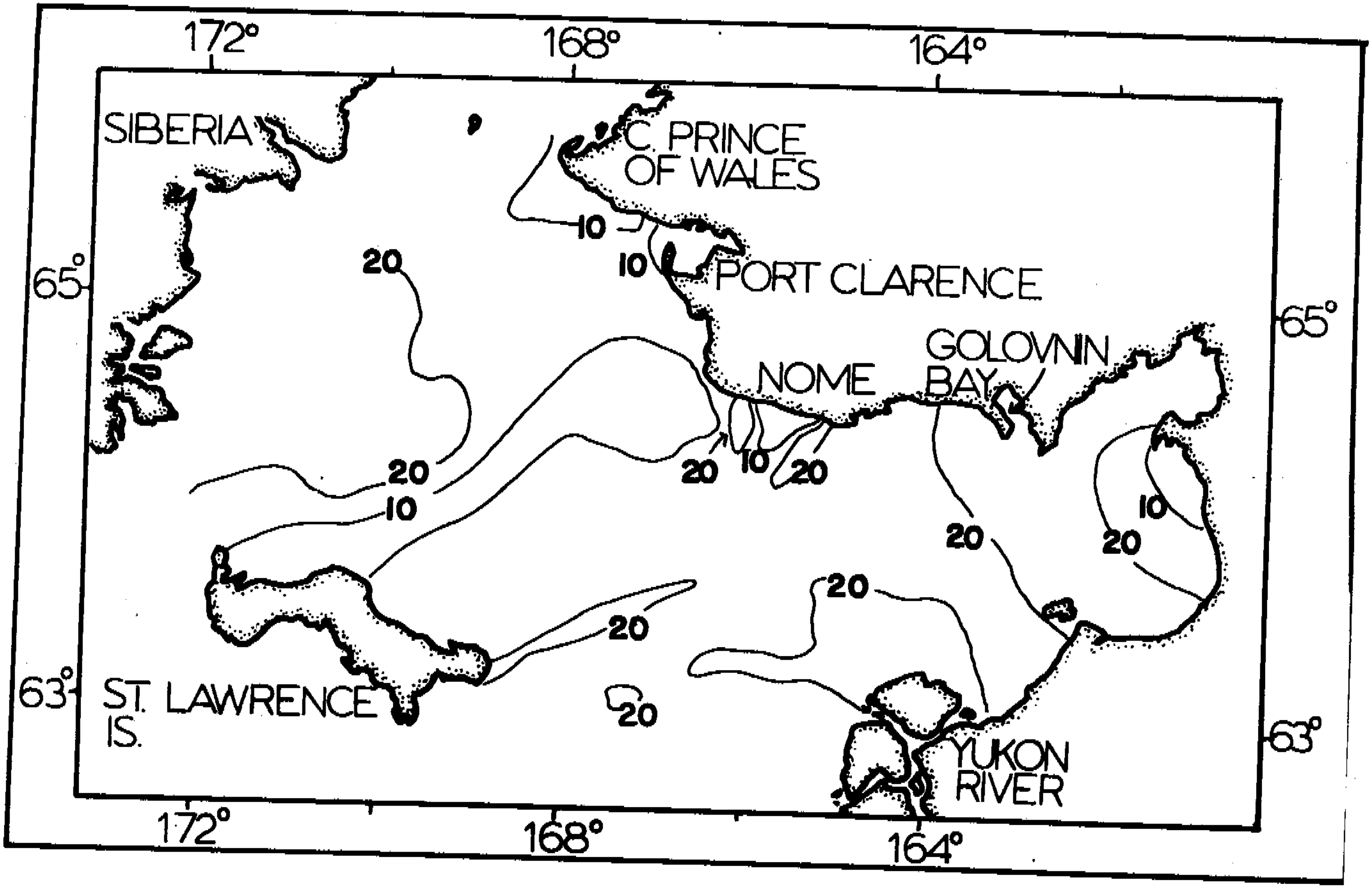

Fig. 21. Percentage distribution of amphibole in 2.75 - 4.0ϕ sized heavy minerals.

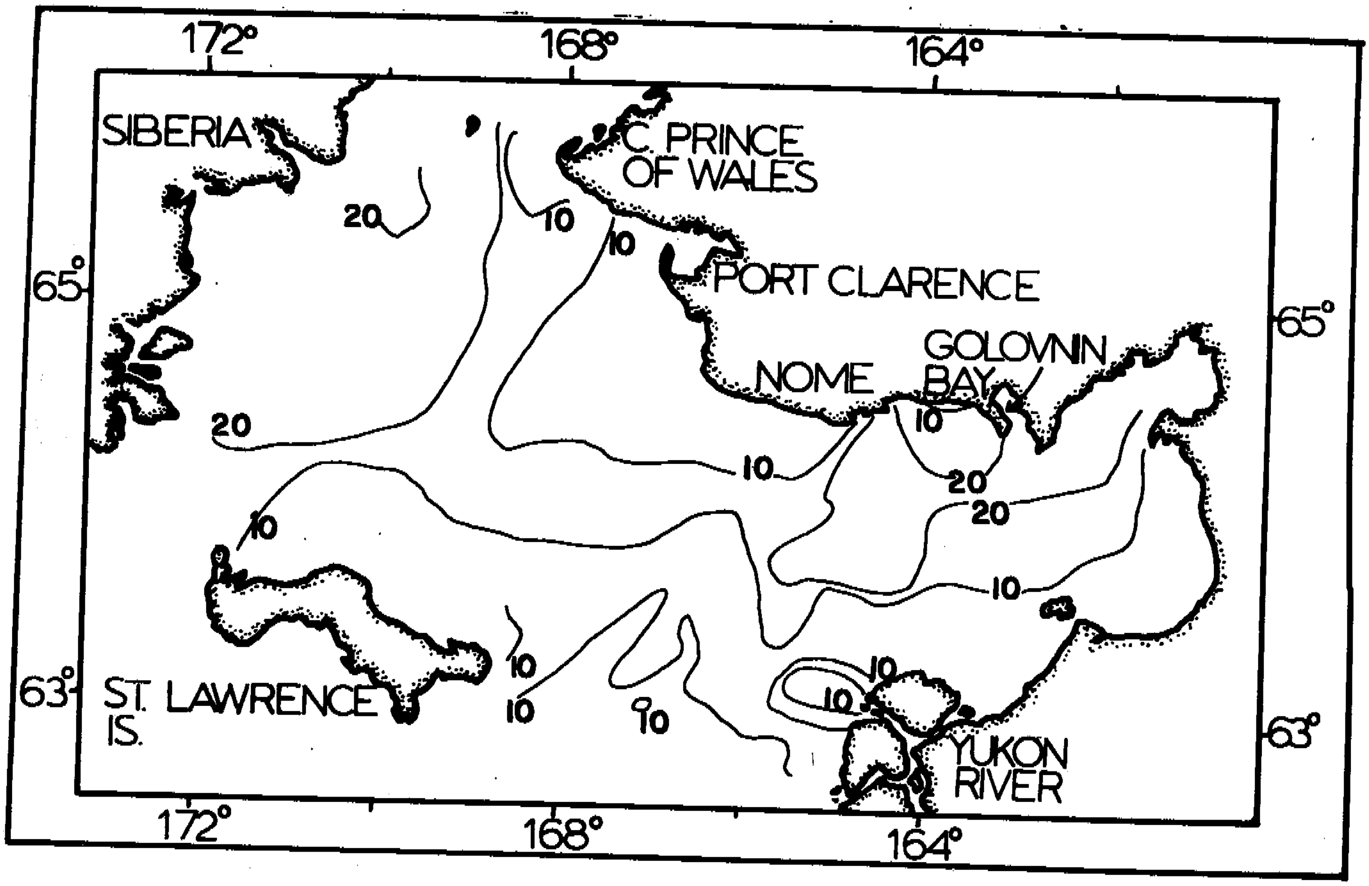

Fig. 22. Percentage distribution of amphibole in 1 - 2.75ϕ sized heavy minerals.

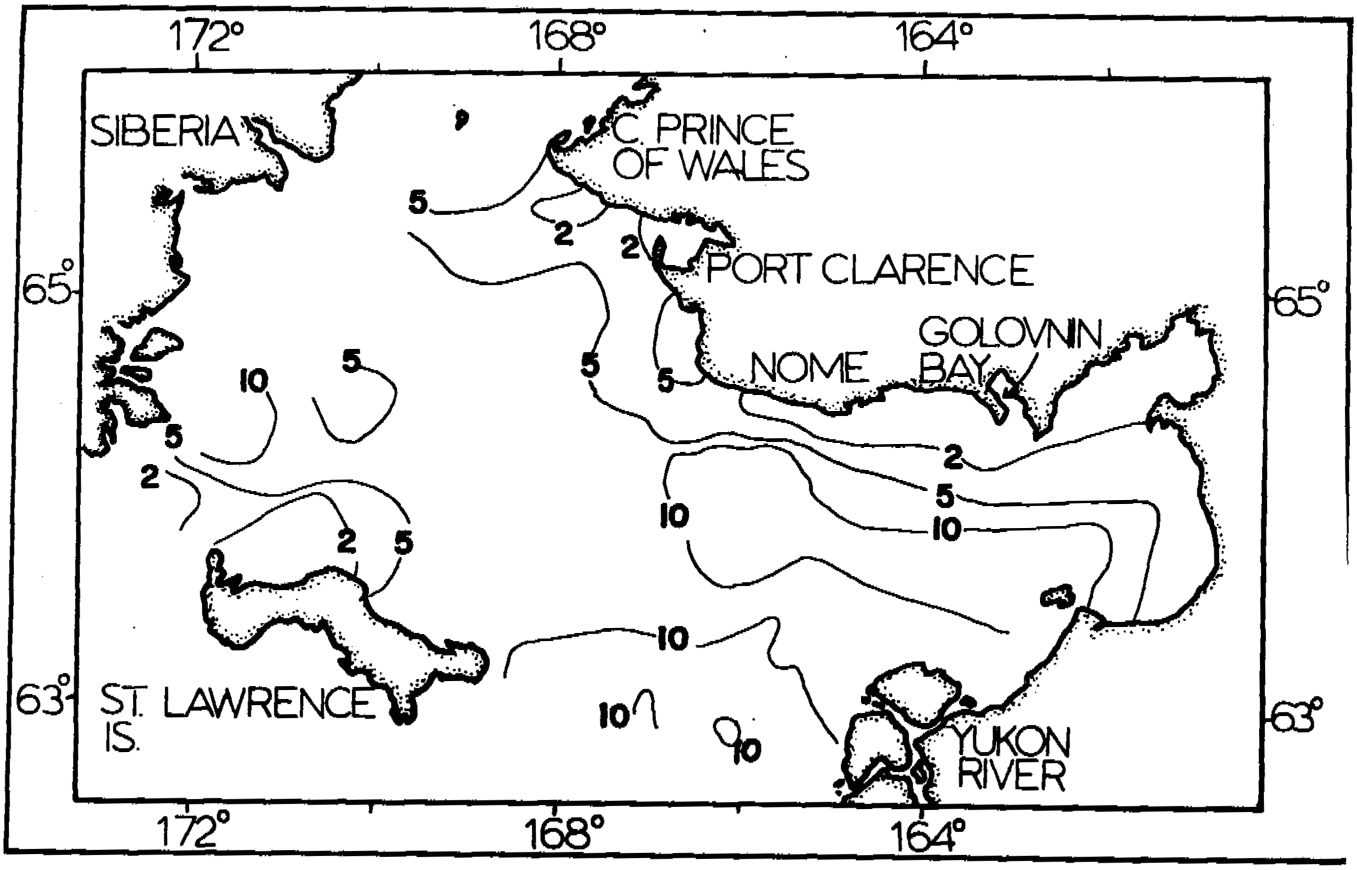

Fig. 23. Percentage distribution of orthopyroxene in 2.75 - 4.0ϕ sized heavy minerals.

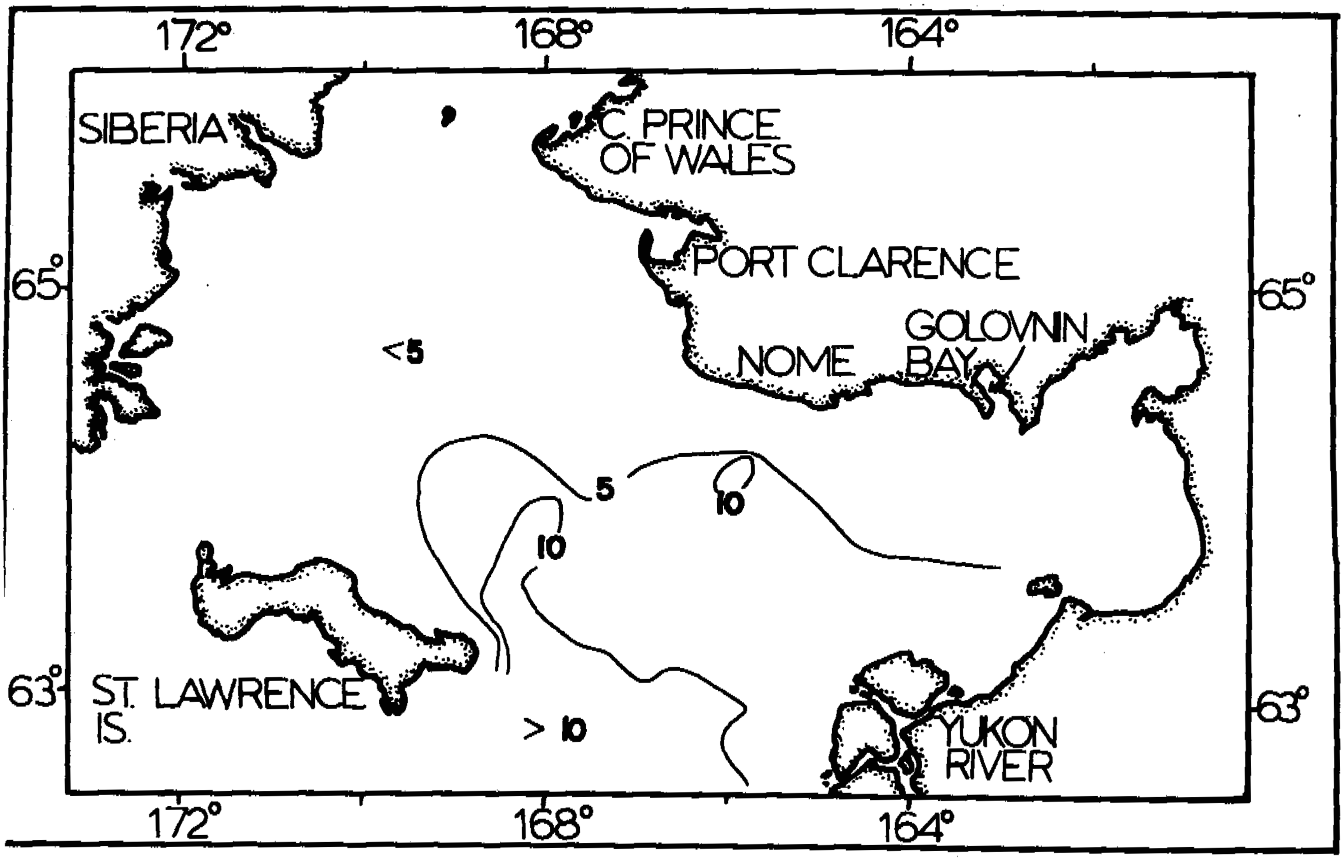

Fig. 24. Percentage distribution of orthopyroxene in 1 - 2.75ϕ sized heavy minerals.

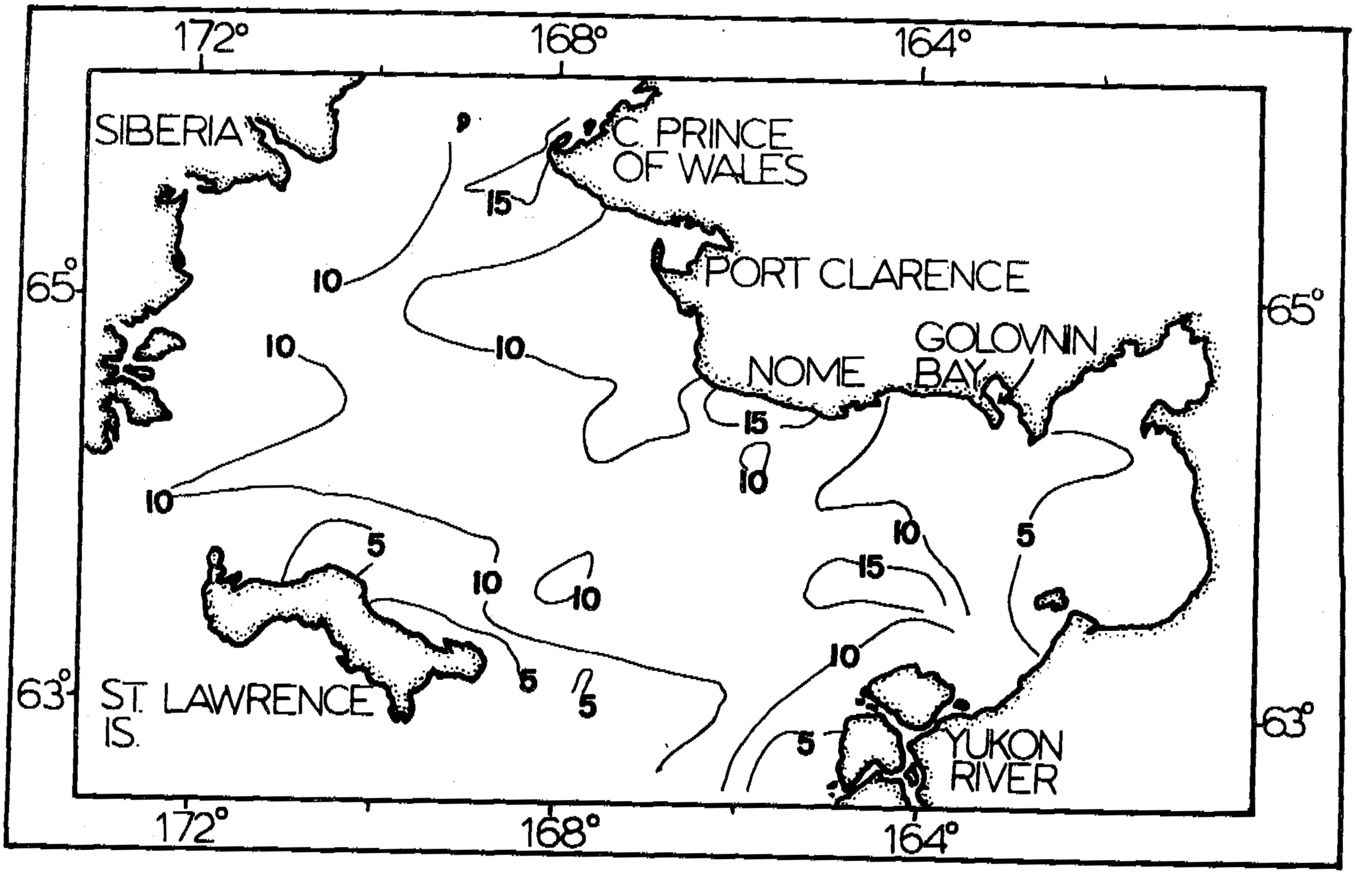

Fig. 25. Percentage distribution of epidote in 2.75 - 4.0ϕ sized heavy minerals.

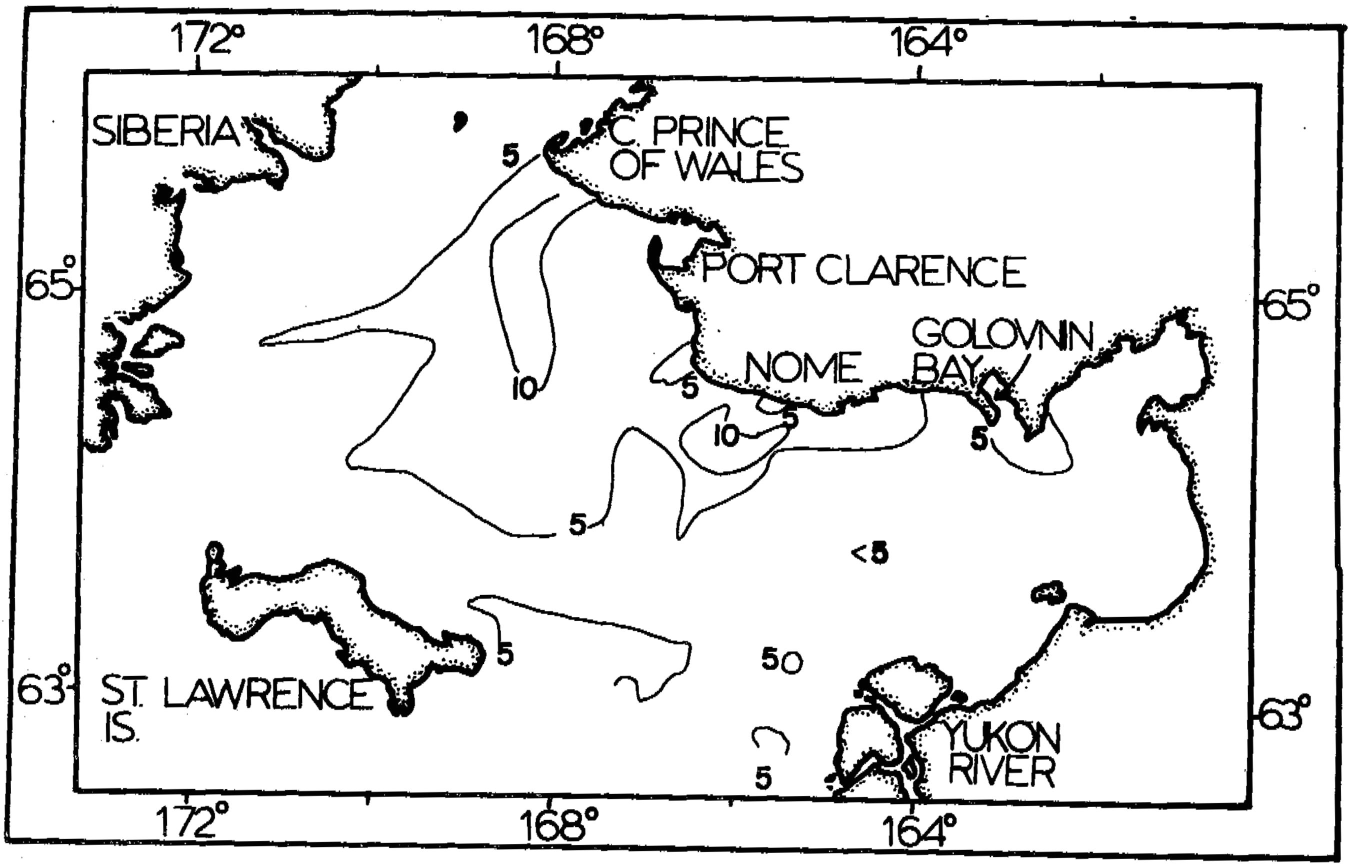

Fig. 26. Percentage distribution of epidote in 1 - 2.75ϕ sized heavy minerals.

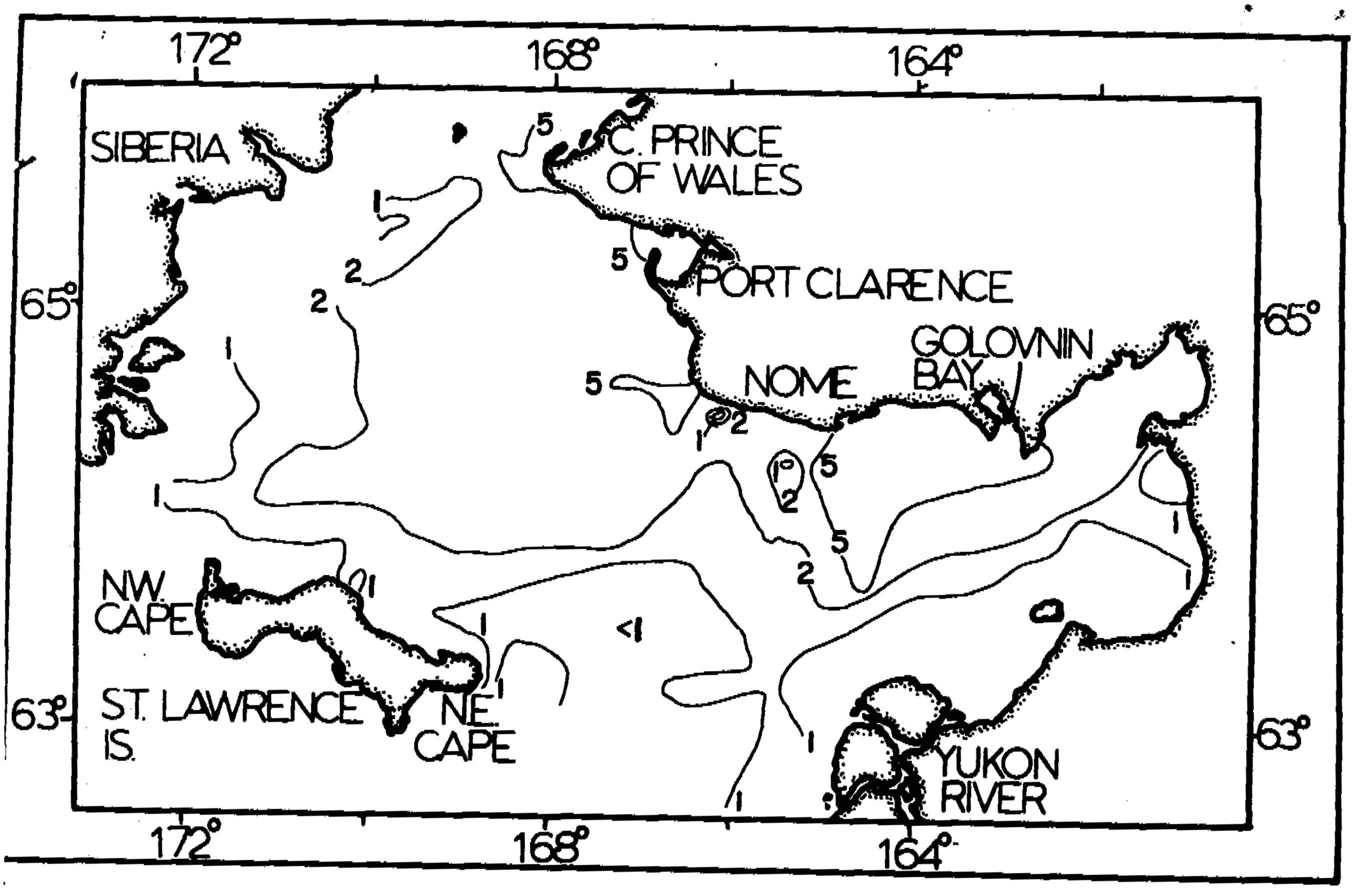

Fig. 27. Percentage distribution of chloritoid in 2.75 - 4.0ϕ sized heavy minerals.

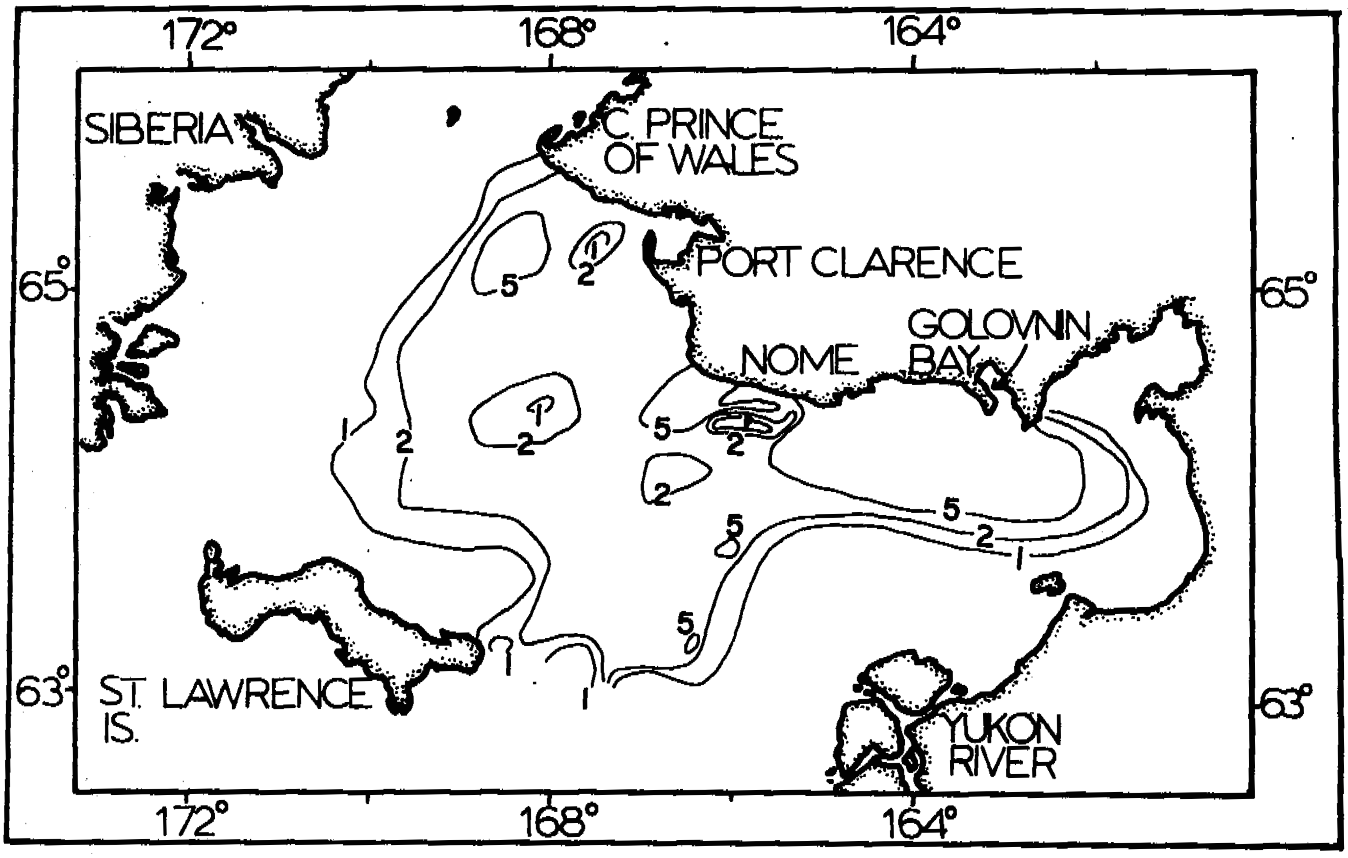

Fig. 28. Percentage distribution of chloritoid in 1 - 2.75ϕ sized heavy minerals.

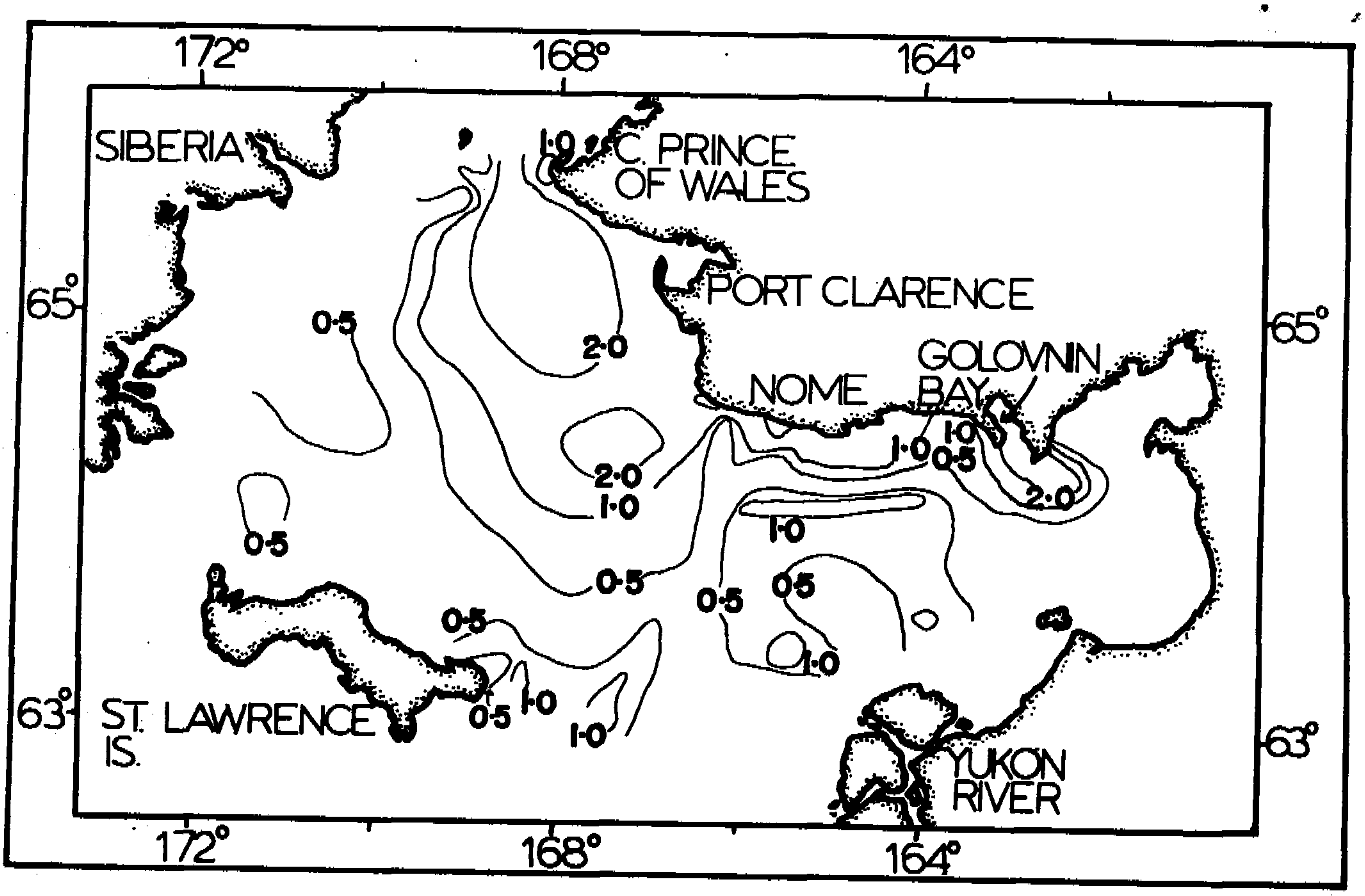

Fig. 29. Percentage distribution of staurolite in 2.75 - 4.0ϕ sized heavy minerals.

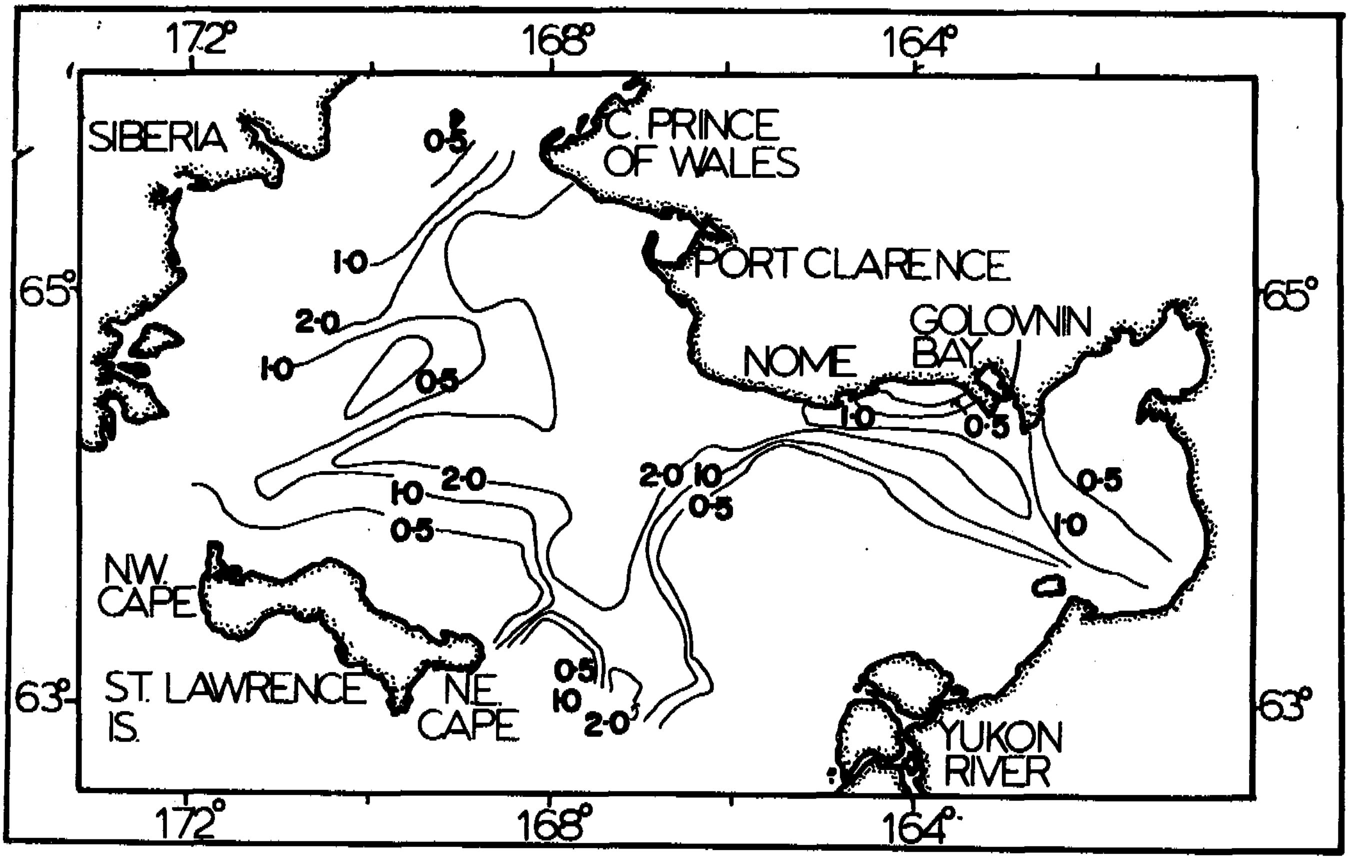

Fig. 30. Percentage distribution of staurolite in 1 - 2.75ϕ sized heavy minerals.

and Norton Sound. High amounts of both minerals, especially in the coarse fraction, are associated with the high garnet content of a ridge and channel between St. Lawrence Island and the Yukon Delta.

Rock fragments. The proportions of rock fragments in both the grade sizes, are higher in Norton Sound off the Yukon River and in the central part of western Chirikov Basin (Fig. 31, 32). In the coarser fraction, the rock fragments tend to be present in higher proportions.

Sphene. This mineral is present in relatively high proportions in the northern part of Norton Sound, off Golovnin Bay and off Nome, and in the northern part of Chirikov Basin (Fig. 33, 34). The distribution in these areas is more similar to that of garnet. Sphene is also concentrated in the Chirikov Basin near Northeast Cape, and off Northwest Cape. The presence of higher amounts of sphene unlike zircon off Nome is noteworthy.

Zircon. Zircon on the whole is a minor component of the heavy minerals (Fig. 35, 36). Its presence in relatively higher proportion in the easternmost part of Norton Sound, off Northeast and Northwest capes and off Cape Prince of Wales, is, however, charcteristic. The consistent low amounts of zircon in the high garnet and sphene areas off Nome is interesting.

In order to study the varietal characteristics of zircons, the total heavy residues for each of several samples were concentrated for zircons by means of a Franz separator. Though the absolute amounts of zircons thus obtained, are more than enough in all cases for the study of the varietal characters, the relative amounts in different areas are as already described for the counts of this mineral.

Zoning, color, authigenic growths, degree of euhedrism, roundness, inclusions, length and breadth of 200 unbroken grains have been noted. Characters other than length and breadth, have also been noted whenever possible, for the broken grains. Only the significant characters of the zircons are described here.

The samples analyzed are listed in Table IV. One sample is off Nome. One is from the beach at Northeast Cape on St. Lawrence Island and from a station off shore (68 ANC-147). Two samples are off Northwest Cape (68 SU-138, 68 ANC-90B). One sample is off Cape Prince of Wales (TT 018-37), and one sample is from the eastern section of Norton Sound (TT 018-9). The percentage of zircon grains with each characteristic are listed and are presented graphically in Fig. 37 and 38. The designation "subhedral" refers to grains euhedral on one end but broken on the other end; "anhedral" refers to grains broken on all sides.

The zircons in the Nome area (area of low zircon content) are more rounded and less euhedral. Among the rounded zircons, hyacynths (pink) are common. The elongation (length/breadth) maxima occur at 1.52 (prominent) and 2.12 (less prominent) values (Fig. 39, 40). Though the zircons off Cape Prince of Wales (an area of relatively high zircon content) are similar to those off Nome, there is a difference between the two. In

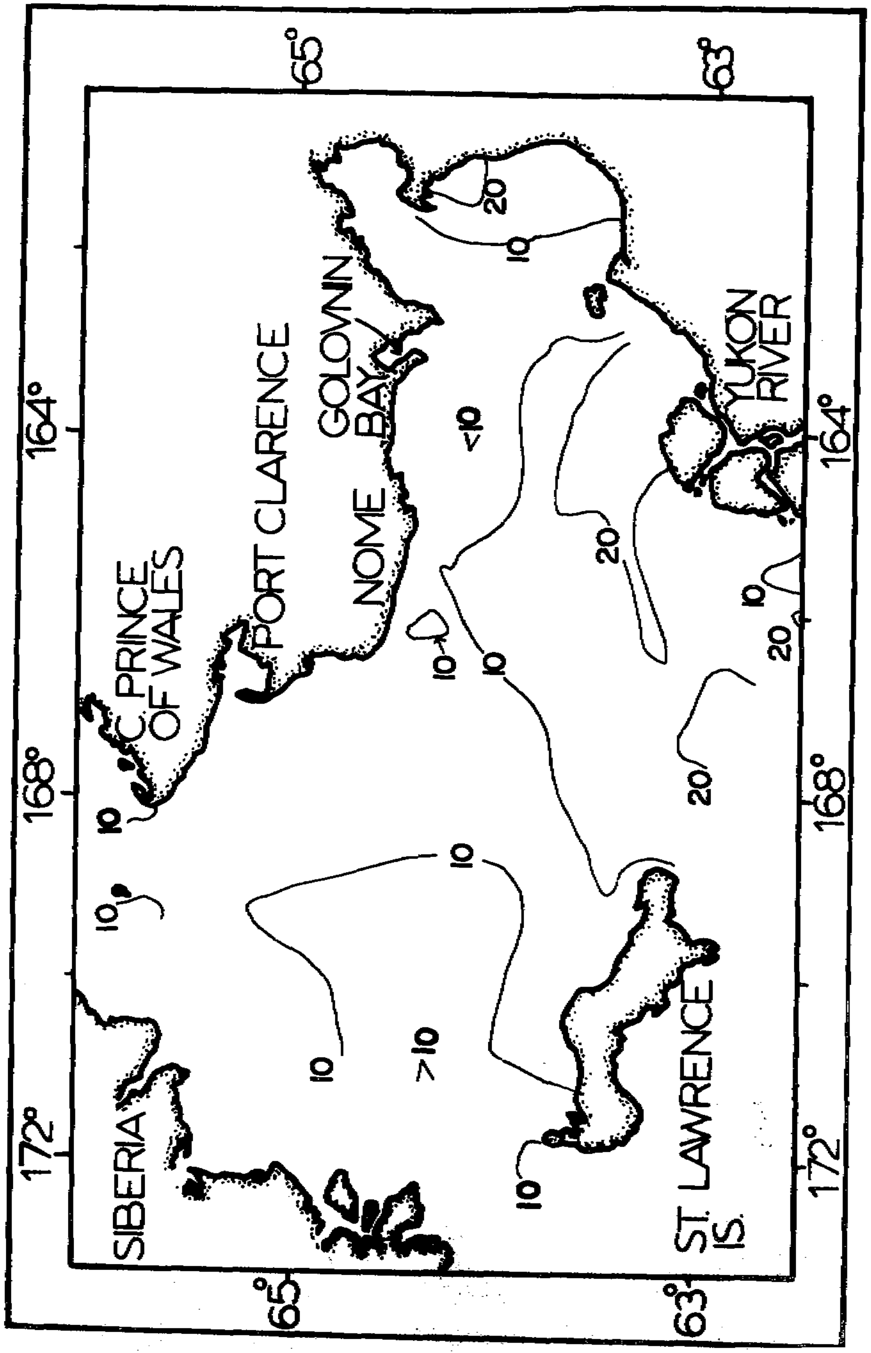

Fig. 31. Percentage distribution of rock fragments in 2.75 - 4.0ϕ sized heavy minerals.

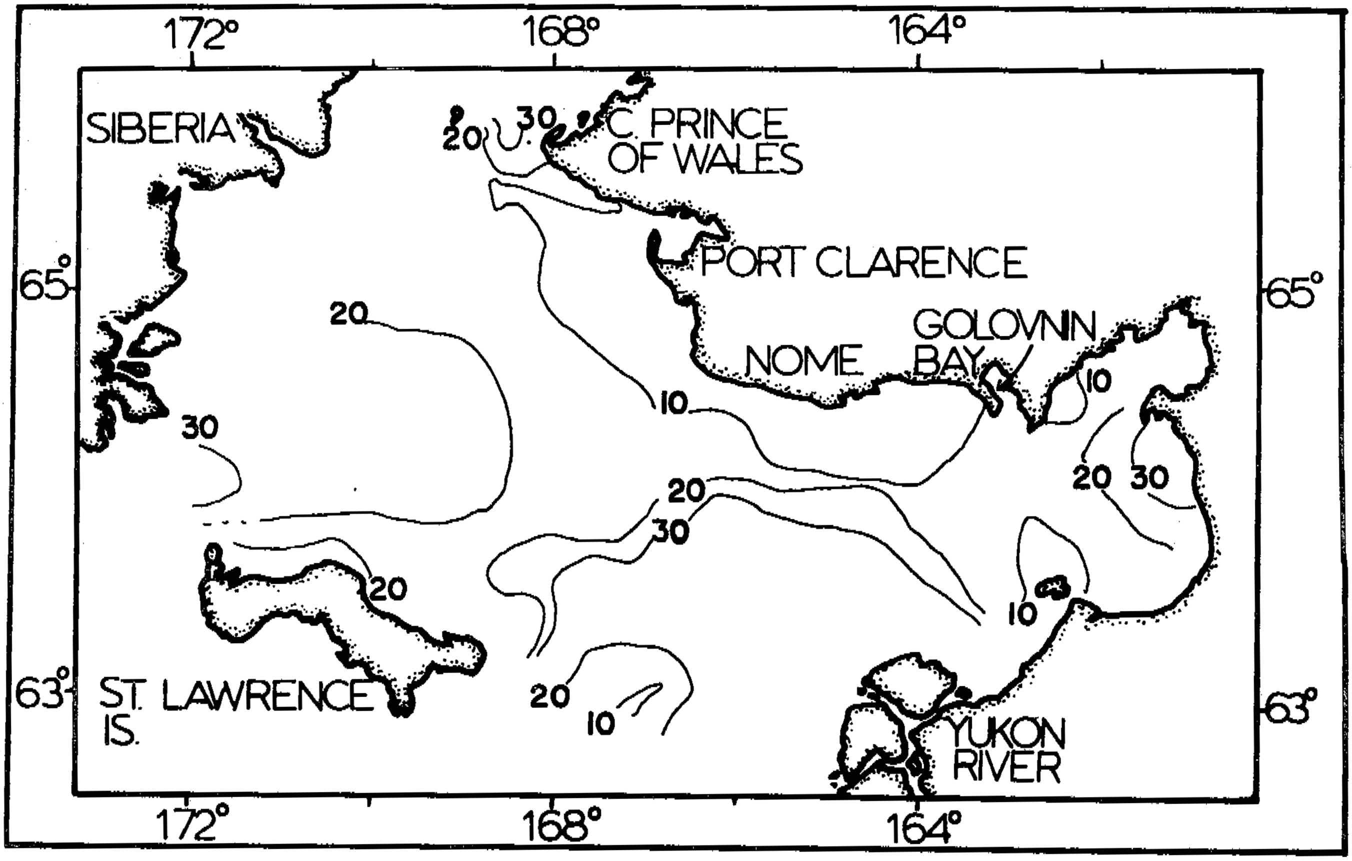

Fig. 32. Percentage distribution of rock fragments in 1 - 2.75ϕ sized heavy minerals.

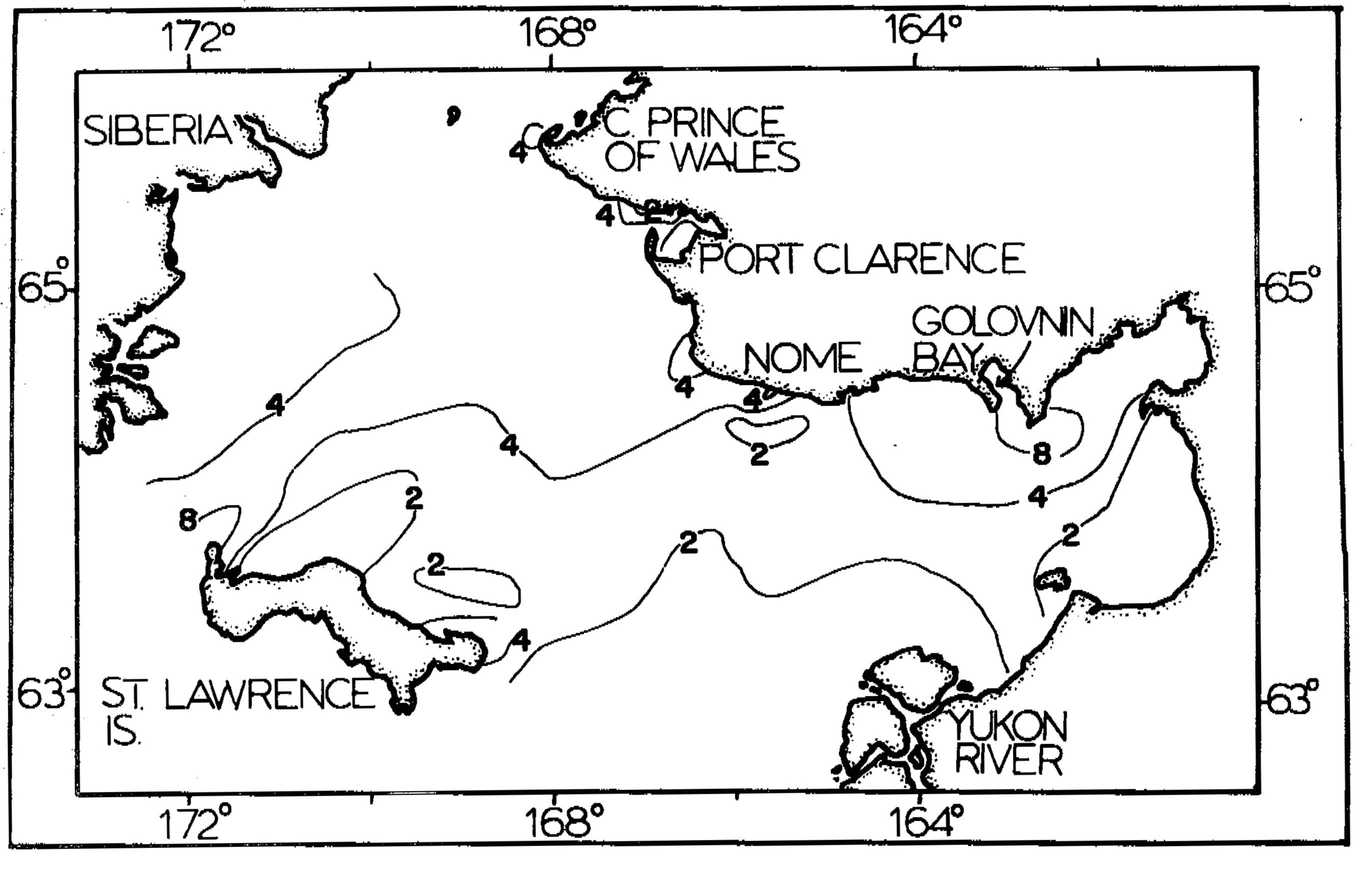

Fig. 33. Percentage distribution of sphene in 2.75 - 4.0ϕ sized heavy minerals.

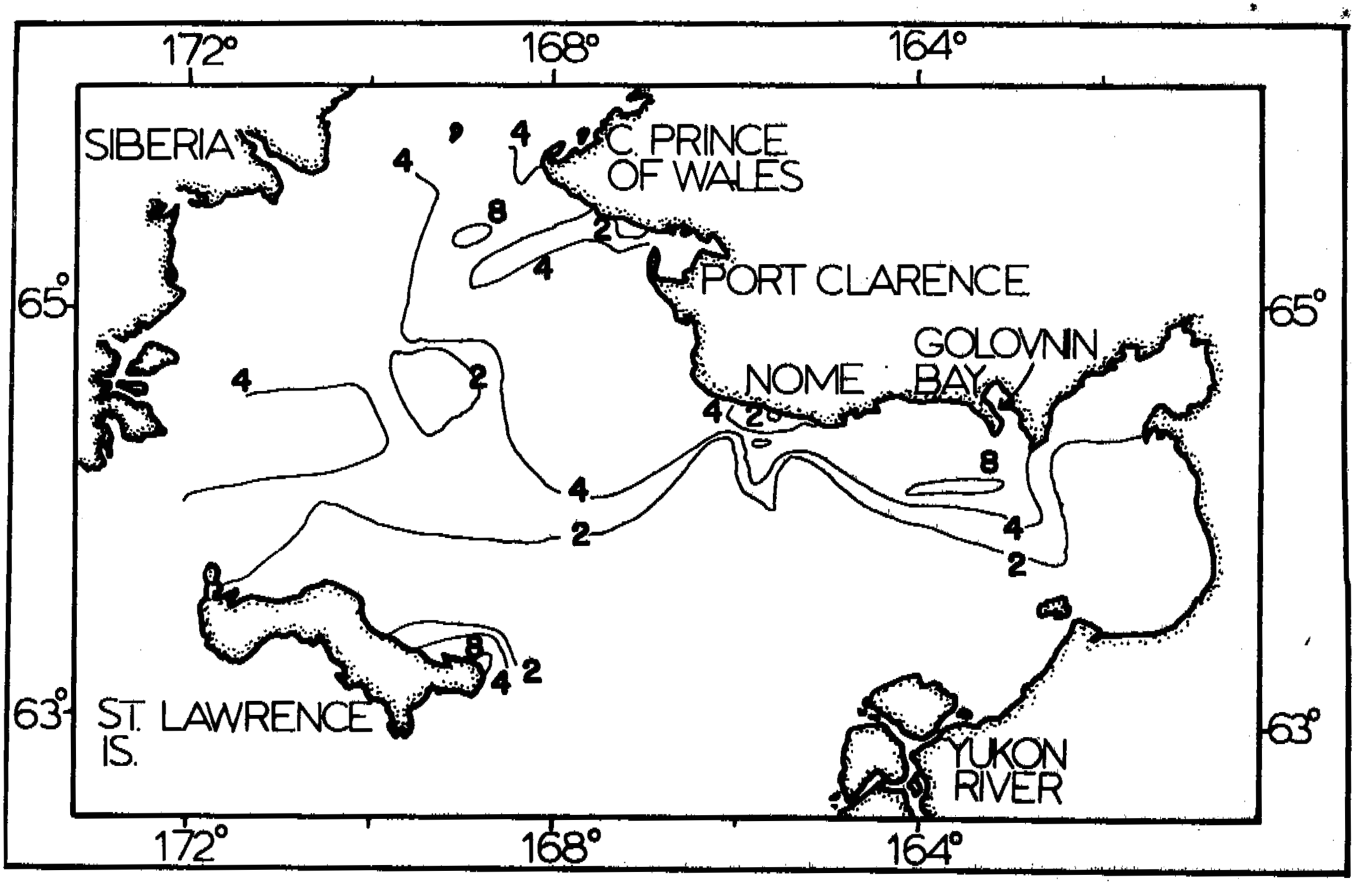

Fig. 34. Percentage distribution of sphene in 1 - 2.75ϕ sized heavy minerals.

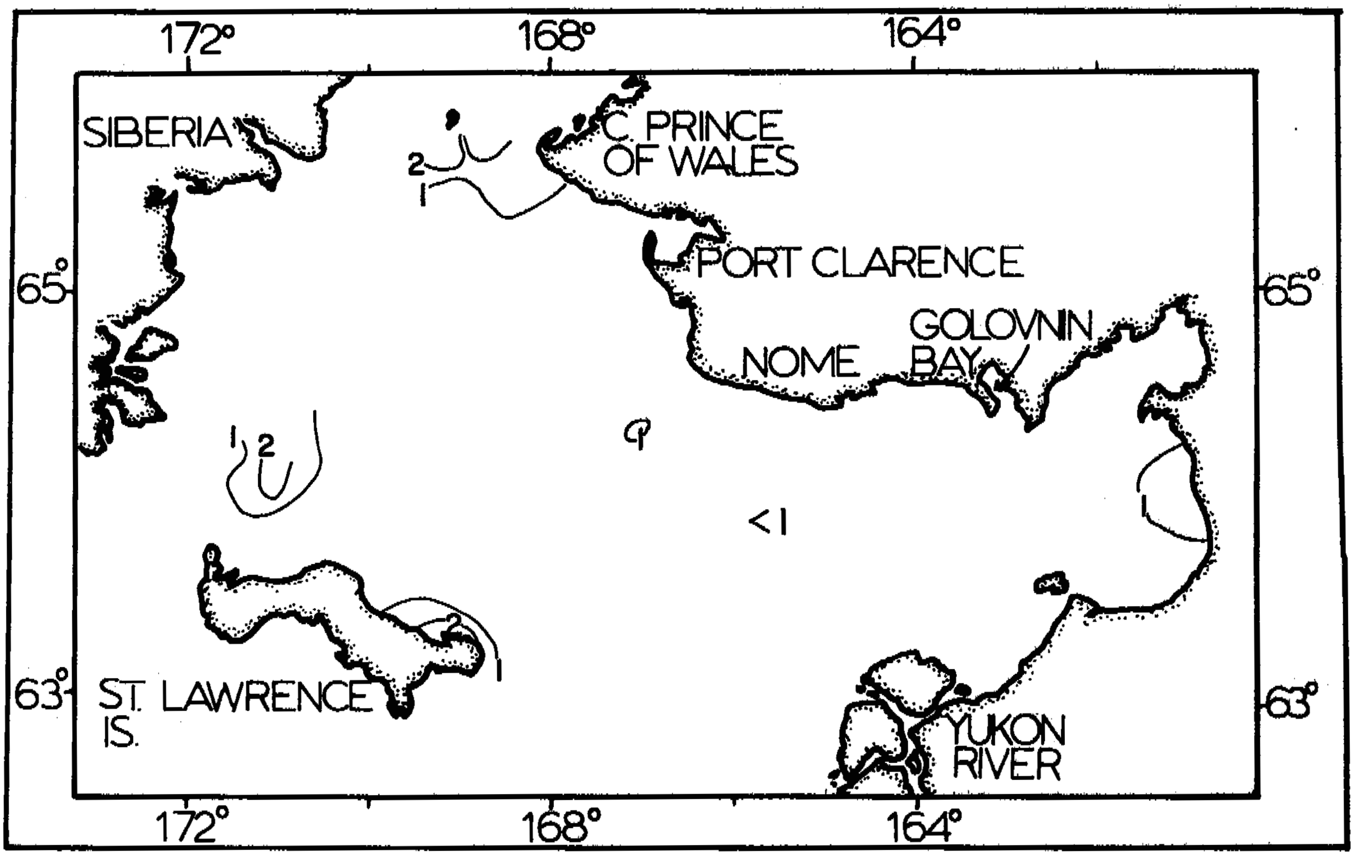

Fig. 35. Percentage distribution of zircon in 2.75 - 4.0ϕ sized heavy minerals.

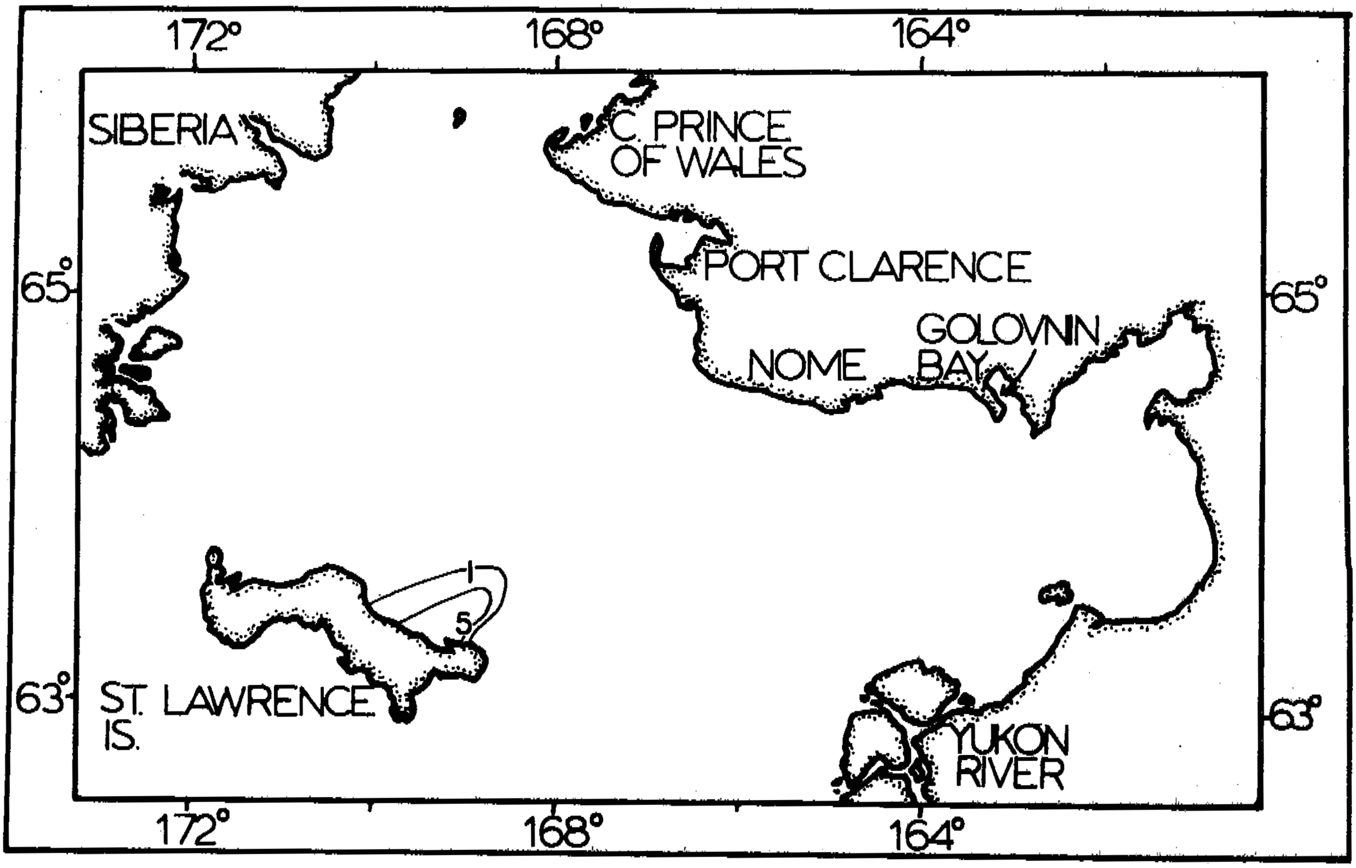

Fig. 36. Percentage distribution of zircon in 1 - 2.75ϕ sized heavy minerals.

Fig. 37. Zircon characteristics.

Fig. 38. Zircon characteristics.

Fig. 39. Zircon characteristics.

Fig. 40. Zircon characteristics.

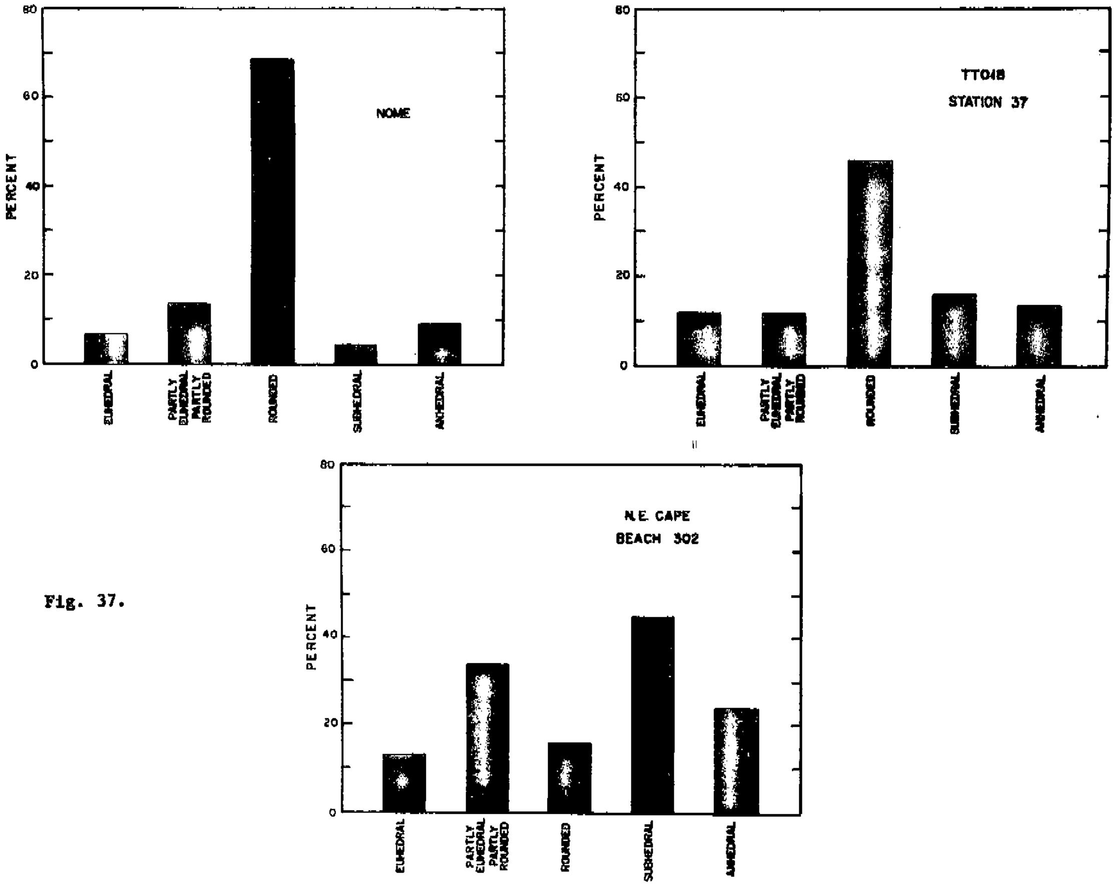
NOME
TT018
STATION 37
N.E. CAPE
BEACH 302
PERCENT
0
20
40
60
80
EUHEDRAL
PARTLY EUHEDRAL PARTLY ROUNDED
ROUNDED
SUBHEDRAL
ANHEDRAL

Fig. 37.

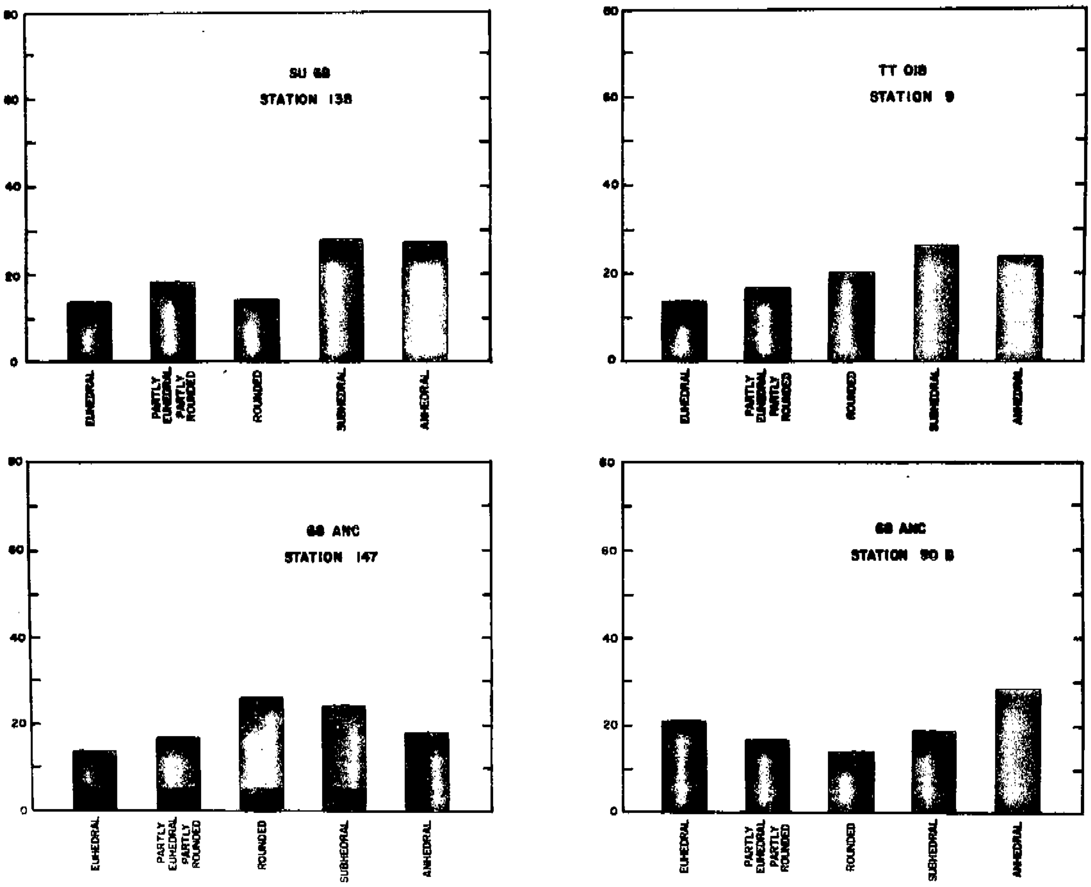
SU 68
STATION 138
TT 018
STATION 9
68 ANC
STATION 147
68 ANC
STATION 90 B
0
20
40
60
80
EUHEDRAL
PARTLY EUHEDRAL PARTLY ROUNDED
ROUNDED
SUBHEDRAL
ANHEDRAL

Fig. 38.

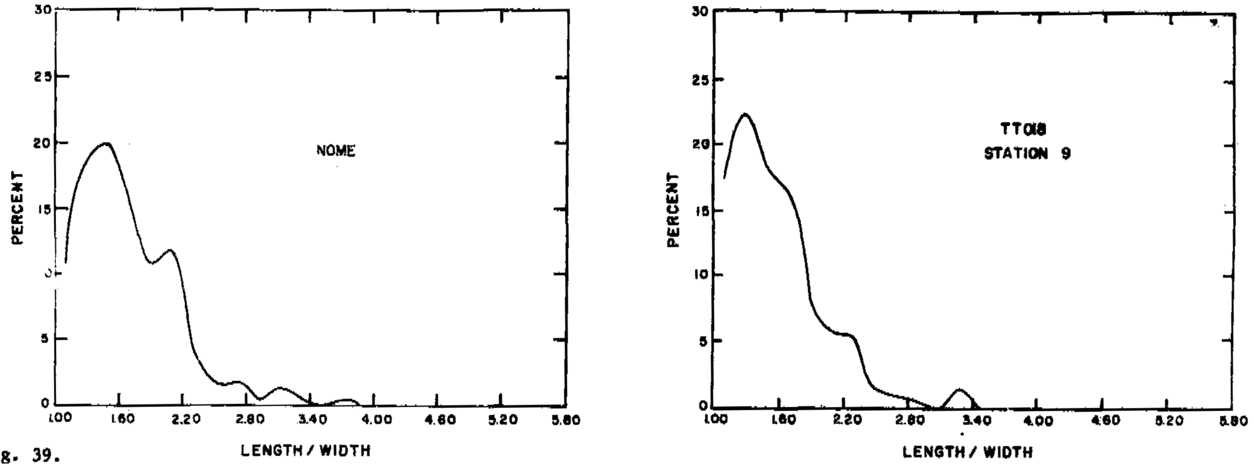
NOME
TT018
STATION 9
PERCENT
0
5
10
15
20
25
30
LENGTH / WIDTH
1.00
1.60
2.20
2.80
3.40
4.00
4.60
5.20
5.80

Fig. 39.

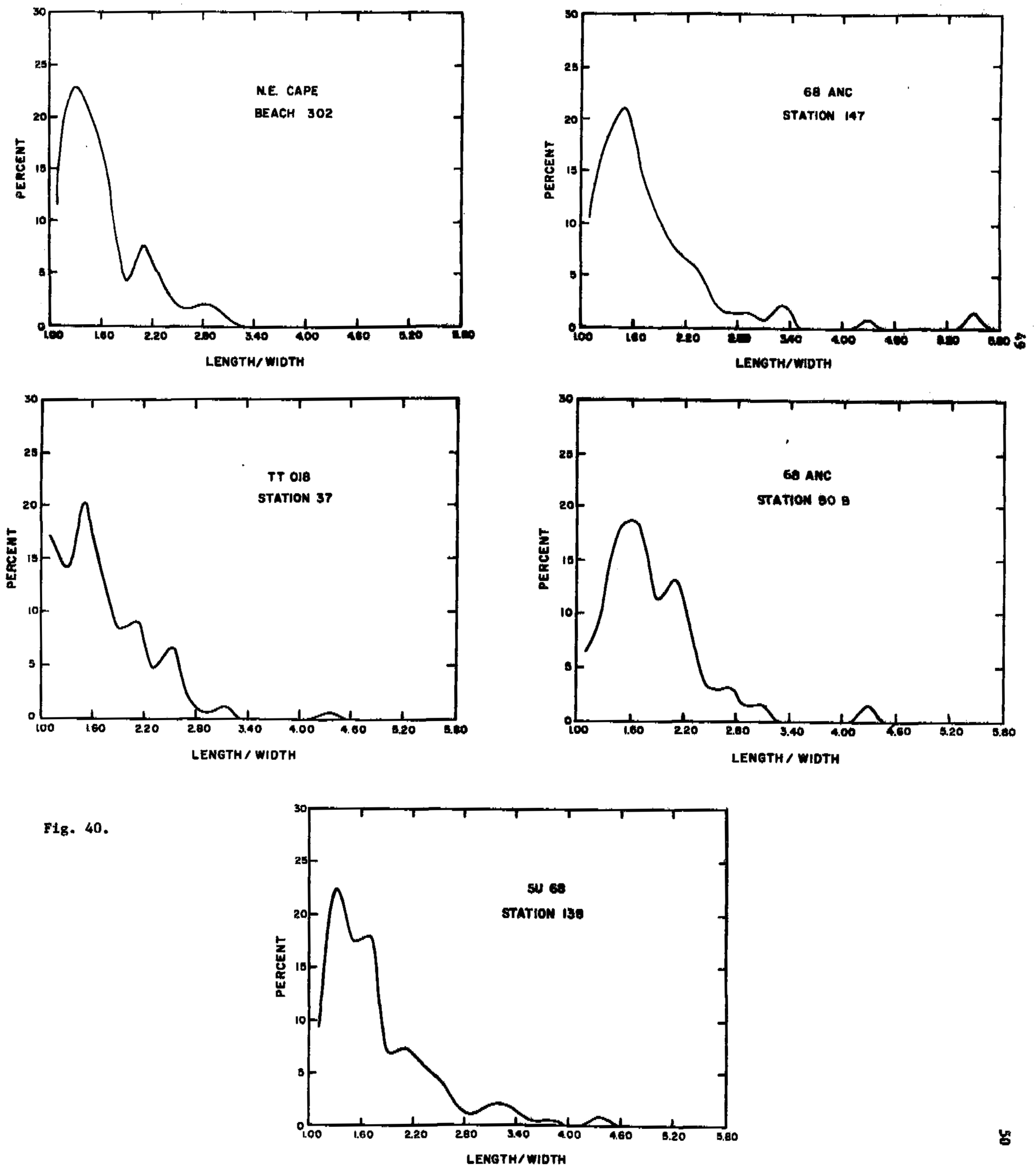
N.E. CAPE
BEACH 302
68 ANC
STATION 147
TT 018
STATION 37
68 ANC
STATION 80 B
SU 68
STATION 138
PERCENT
0
5
10
15
20
25
30
LENGTH/WIDTH
1.00
1.60
2.20
2.80
3.40
4.00
4.60
5.20
5.80

Fig. 40.

the former area, the zircons are more euhedral than in the latter area. Many of the zircons off Northeast Cape are euhedral and only a few rounded. A few hyacynths have been observed. In the case of Northwest Cape, there are also many euhedral zircons, but unlike those of Northeast Cape, they are zoned. The occurrence of elongation maxima also looks distinctive (Table IV). The zircons of the easternmost part of Norton Sound are similar to those of Northeast Cape in their euhedrism and in their lack of zoning. The elongation maxima of the former area, however, are different.

Light minerals. Selected samples were examined for light mineral composition, in particular quartz, K-feldspar, and plagioclase (Tables V and VI). The distribution of quartz in both the coarse and fine sands are similar; the percent of quartz in the coarse fraction tends to be higher (Fig. 41, 42). Quartz is the most dominant component in the northern part of the Chirikov Basin and Norton Sound, and from these areas it decreases southward. It is interesting to note that in the area of channels and ridges between the Yukon Delta and St. Lawrence Island the percent of quartz in the coarse fractions tends to be high compared to the adjacent areas.

K-feldspar is more concentrated in the finer sand fraction (Fig. 43, 44). The percent K-feldspar is maximum off Northwest and Northeast capes and in the adjacent areas of the Chirikov Basin. K-feldspar is also present in relatively high proportions in the fine sands just off Golovnin Bay and Cape Prince of Wales in the Bering Strait.

Plagioclase is also concentrated more in the fine fraction (Fig. 45, 46). In both the size fractions, plagioclase is present in maximum proportions off the central part of St. Lawrence Island and minimum off Nome - Port Clarence. Off the Yukon River, the percent of plagioclase is very high compared to the central parts of Chirikov Basin. In the coarse fractions, however, the small amount of material in each sample makes this conclusion less certain.

DISCUSSION

Based on the distribution of sediment characteristics, especially the mineral content, ten sedimentary provinces can be distinguished in the northern Bering Shelf (Fig. 47): 1) Yukon province is characterized by high amounts of clinopyroxene, hypersthene, rock fragments, and plagioclase. The sediments of this province are, to a great extent, poorly sorted fine-grained sediments. The sand modes associated with these sediments are often in the 3-4ϕ range. The sediments between the Yukon and the eastern part of the St. Lawrence Island are relatively coarser and sand-predominant. These sediments, except in the areas of channels and ridges, have a mineral content similar to that of the fine sediments of Norton Sound. 2) Stuart Island province is characterized by abundance of olivine and is confined to the beaches and nearshore areas of Stuart Island in Norton Sound. 3) East-Norton Sound province consists of high amounts of clinopyroxene and opaques, distinct types of zircon and some olivine. 4) Golovnin Bay province has considerable amounts of clinopyroxene and garnet, maximum percent of hornblende, high amounts of sphene, quartz and K-feldspar. The amounts of clinopyroxene are usually less than that of Yukon province and the garnet less than that of the adjacent Nome province. Staurolite and chloritoid are high in the northern part of Norton Sound near Golovnin Bay as also in

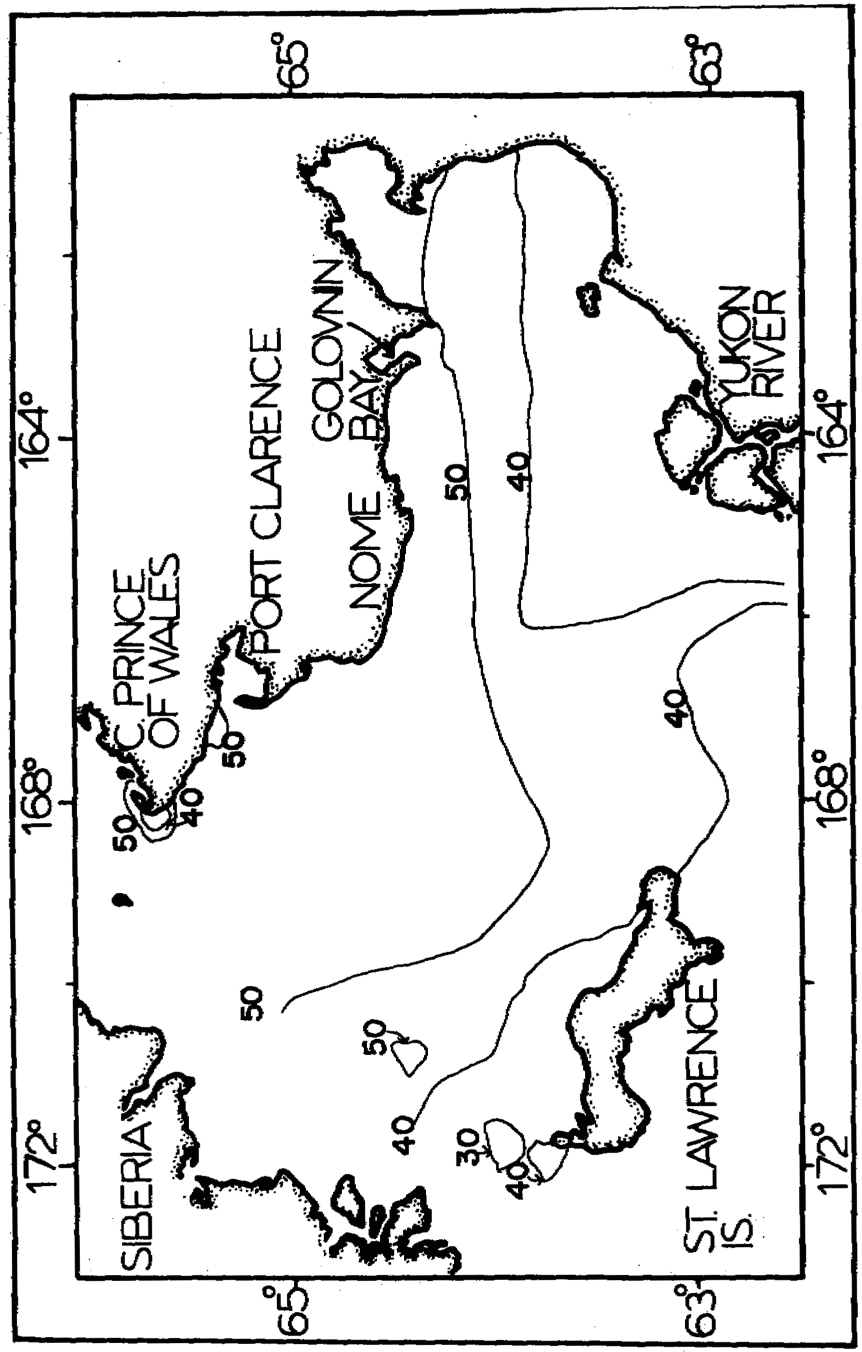

Fig. 41. Percentage distribution of quartz in 2.75 - 4.00ϕ sized light fraction.

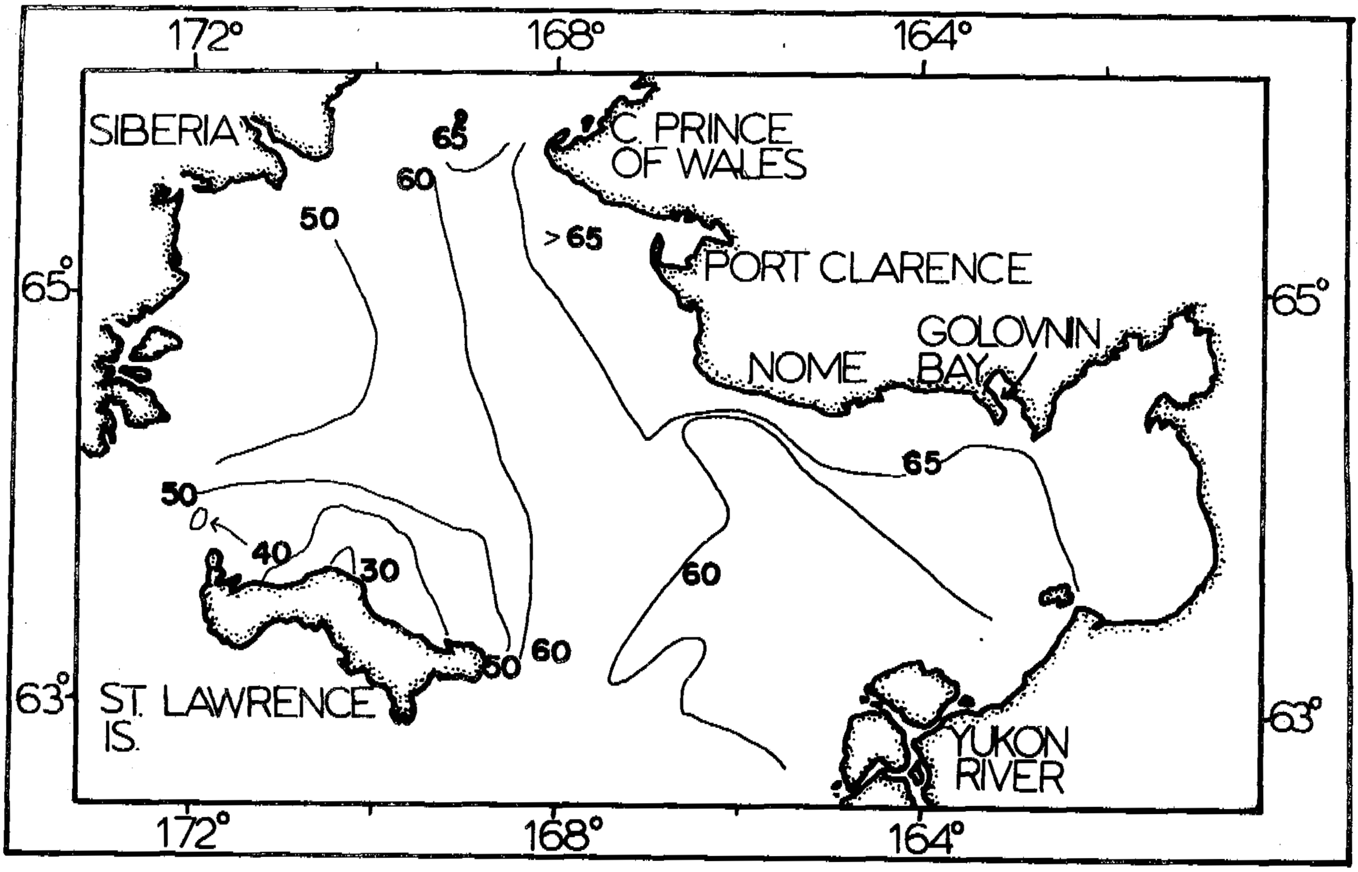

Fig. 42. Percentage distribution of quartz in 1.0 - 2.75ϕ sized light fraction.

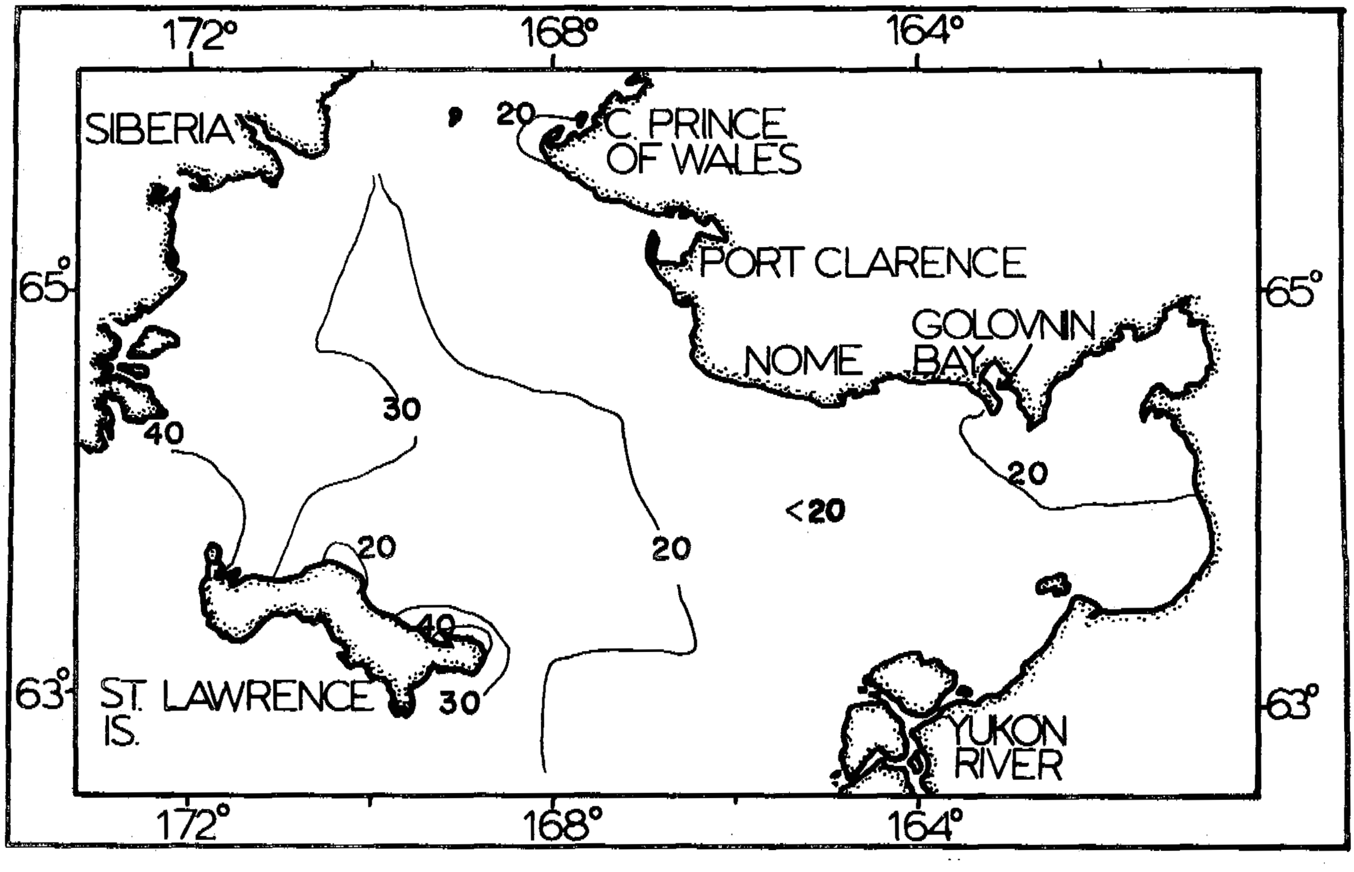

Fig. 43. Percentage distribution of K-feldspar in 2.75 - 4.0ϕ sized light fraction.

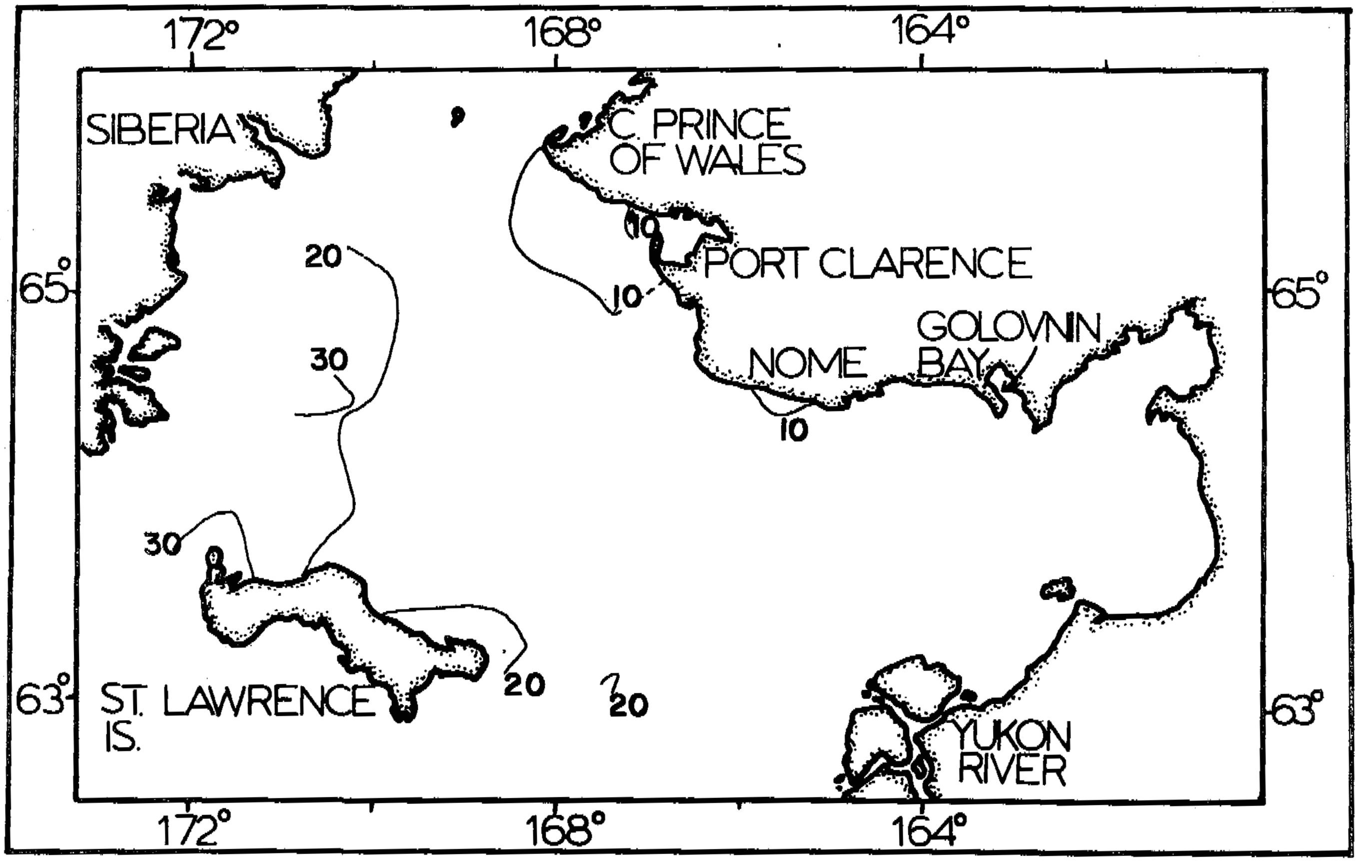

Fig. 44. Percentage distribution of K-feldspar in 1 - 2.75ø sized light fraction.

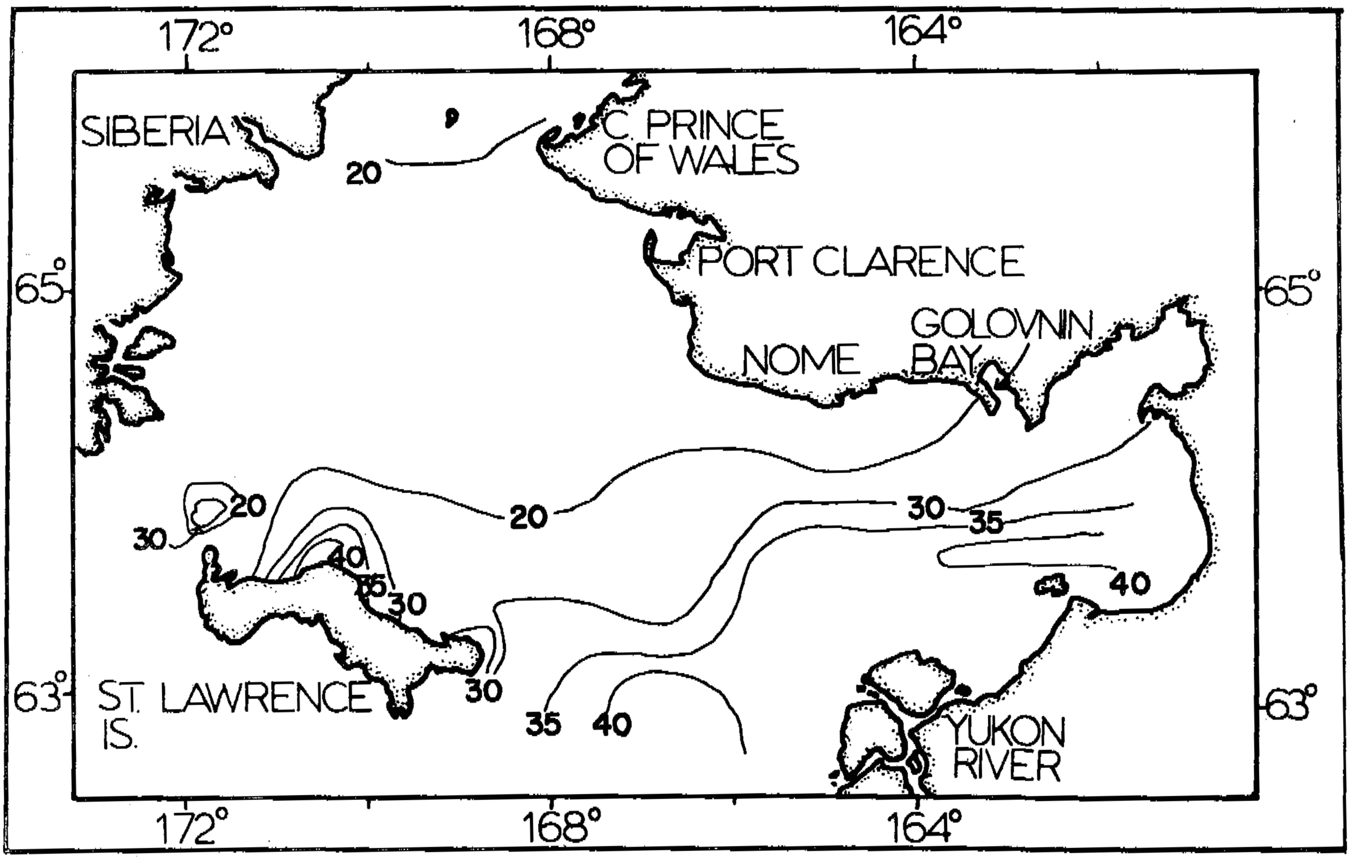

Fig. 45. Percentage distribution of plagioclase 2.75 - 4.0ø sized light fraction.

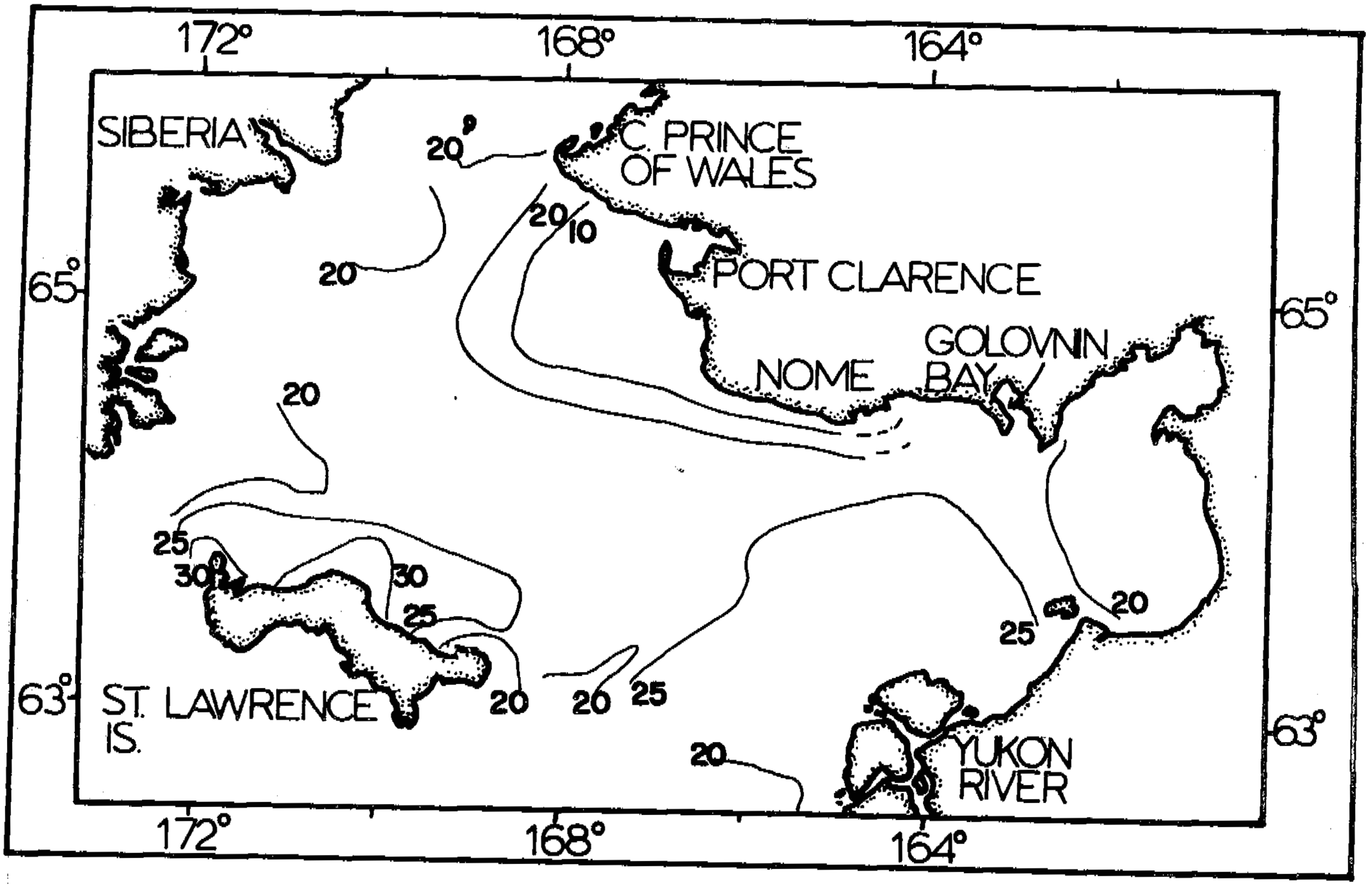

Fig. 46. Percentage distribution of plagioclase in 1 - 2.75ϕ sized light fraction.

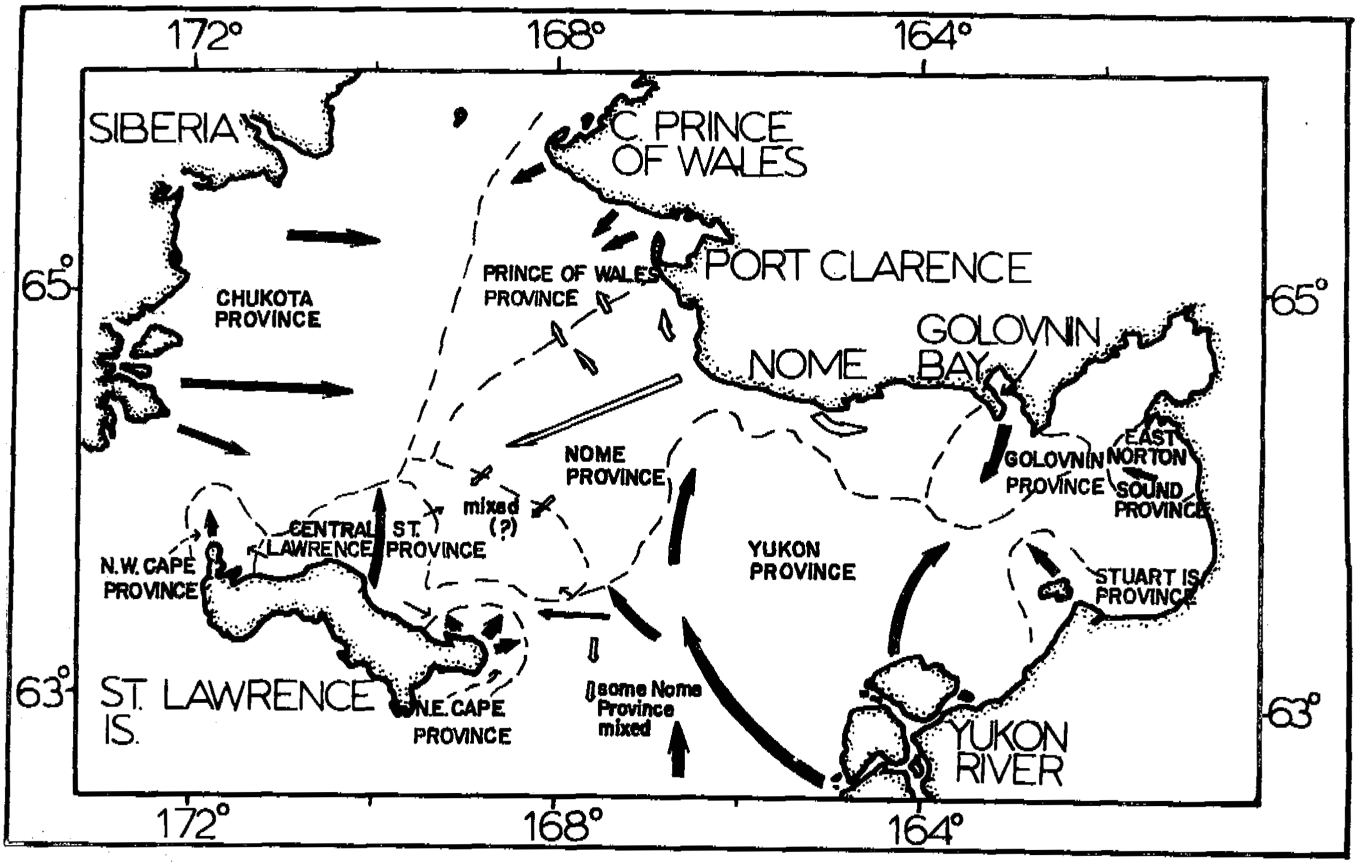

Fig. 47. Sedimentary provinces and dispersal routes of the sediments based principally upon heavy minerals.

the northern part of Chirikov Basin off Nome and Port Clarence-Cape Prince of Wales. The sand content of the Golovnin Bay province sediments is high. 5) Nome province is characterized by high percent of garnet (maximum) and opaque minerals and sphene. The percent of zircon is very low, but the types of zircons are distinctive. Of the light minerals, quartz is the dominant component. Poorly sorted coarse sediments are common in this area. Often pebbles of schistose rocks and quartzites are associated with these sediments. 6) Prince of Wales province: At least one (possibly more) sedimentary province can be distinguished off Port Clarence-Cape Prince of Wales. Considerable proportions of clinopyroxene, garnet and some opaques and olivine, high amounts of zircon and sphene characterize the sediments here. The sediments of this province are usually coarse (excluding Port Clarence Bay). The pebble lithology indicates at least two sub-provinces within the major province - one in the Bering Strait and the other off York. 7) Chukotka province is based on relatively few samples analyzed from the western part of the Chirikov Basin. The sediments, however, seem to be characterized by high percent of hornblende and clinopyroxene, opaques with often metallic flakes (mostly of metallic copper and some of iron-copper sulphide) and sphene. The sediments are usually sandy, although gravel predominates at places. Pebbles and cobbles of acid volcanics with occasional presence of copper sulphides are associated with these sediments. 8) Northwest Cape province: With the number of samples analyzed, it may be difficult to distinguish this province from Chukotka province. However, the higher proportion of K-feldspar and zircon in the adjacent areas off the Cape may be characteristic. Zircon types in this area appear distinctive. 9) Central St. Lawrence Island province has olivine as the dominant component with high proportions of clinopyroxene. Pebbles of olivine-basalts are common. 10) Northeast Cape Province: High amounts of hornblende, considerable amount of clinopyroxene, and high percent of zircon, sphene, and K-feldspar distinguish this province. Distinctive types of zircon are found in these sediments.

An attempt has been made to evaluate whether the different mineral assemblages are an effect of sorting by size and density or the effect of derivation from the source rocks. The plots of mean size of sediments versus the percent of the major heavy minerals are shown in Fig. 48-57. Except for a suggestion of a small increase in amphibole (hornblende) content with decrease in grain size, no systematic and discernible trends are apparent. Even in the case of hornblende, size variation does not seem to have any systematic influence upon samples with high amounts of the mineral, i.e. upon the samples used to delineate some provinces. Also, supporting the lack of sorting effect upon province definitions, the varietal characters of zircons, which indicate that at least those provinces where this mineral has been studied in detail, are different.

Not all minerals present in high percent in the different provinces, are necessarily exclusive to the respective provinces, nor have they been derived from a single suite of rocks. Where dilution of the sediment in a province by the sediments from other provinces is suspected, it is so indicated in Fig. 47.

Detailed knowledge of the mineralogy of the rocks on the land is lacking. It is therefore difficult to precisely relegate the sediments of the different provinces to their respective sources.

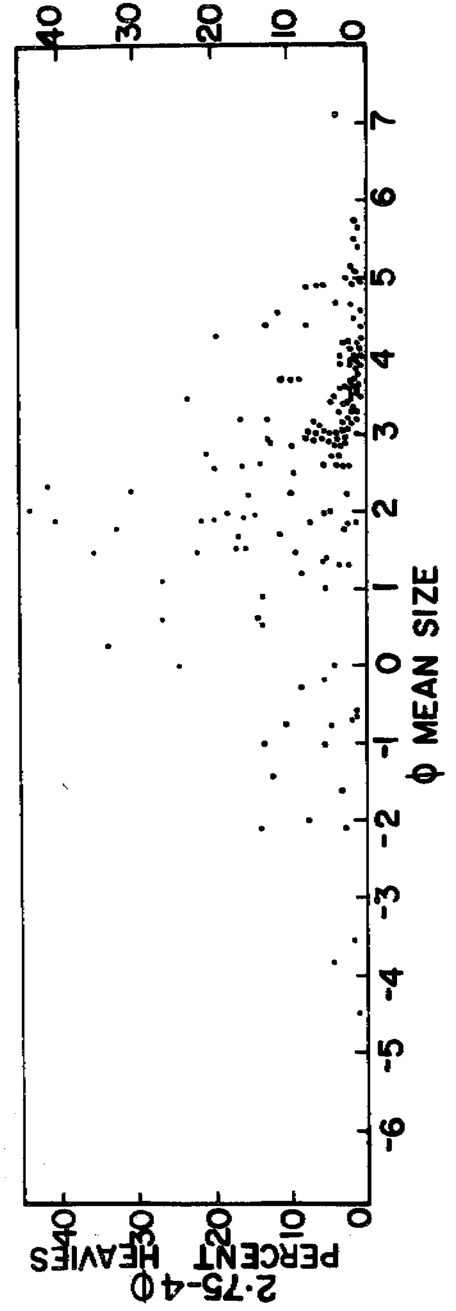

Fig. 48. Mean size of the sediment versus percent total heavy minerals in 2.75 - 4.0φ sized heavy mineral fraction.

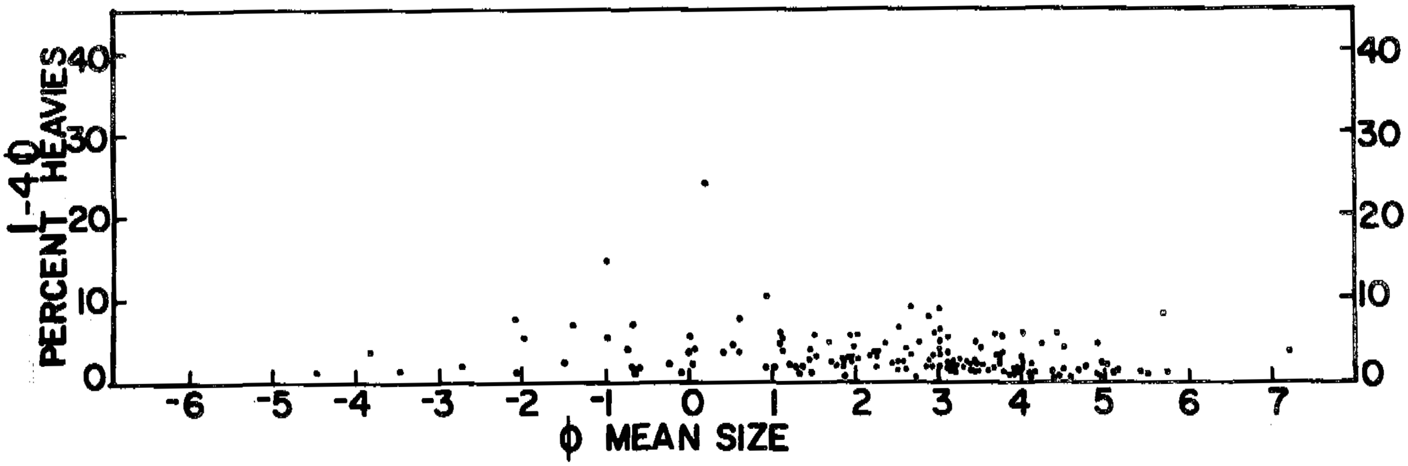

Fig. 49. Mean size of the sediment versus percent total heavy minerals in 1.0 - 4.0ϕ sized heavy mineral fraction.

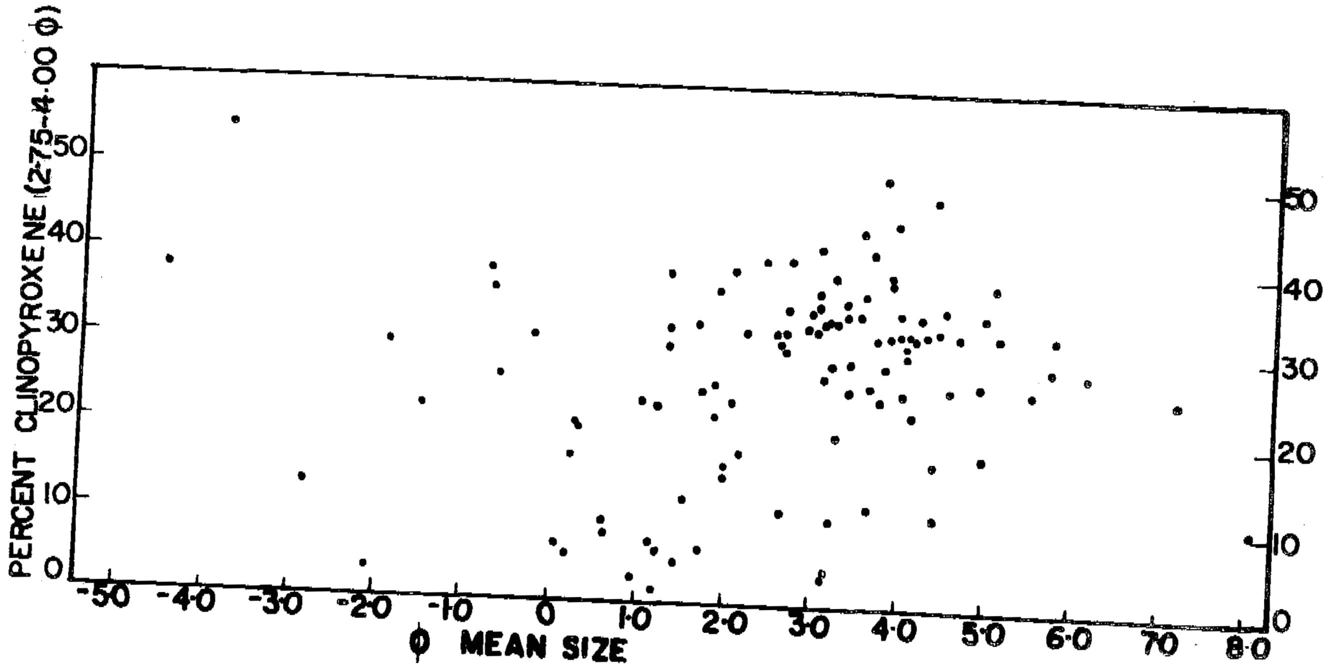

Fig. 50. Mean size of the sediment versus percent clinopyroxene in 2.75 - 4.0ϕ sized heavy mineral fraction.

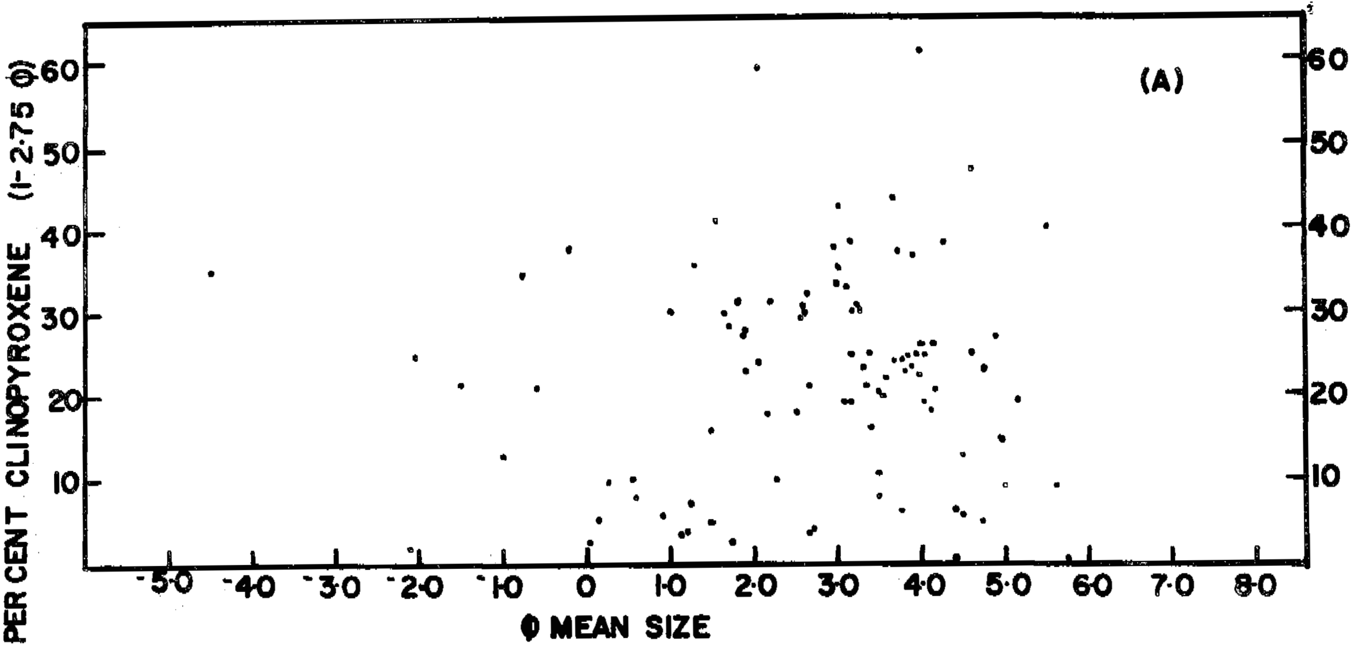

Fig. 51. Mean size of the sediment versus percent clinopyroxene in 1 - 2.75ϕ sized heavy mineral fraction.

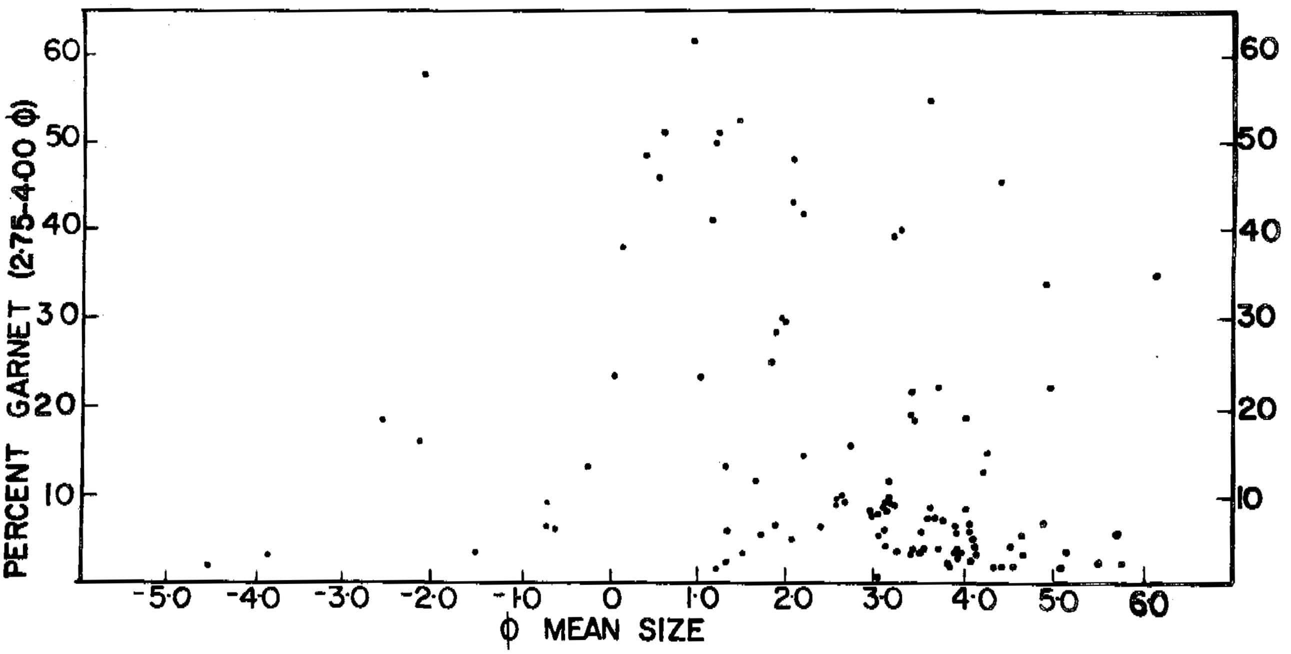

Fig. 52. Mean size of the sediment versus percent garnet in 2.75 - 4.0ϕ sized heavy mineral fraction.

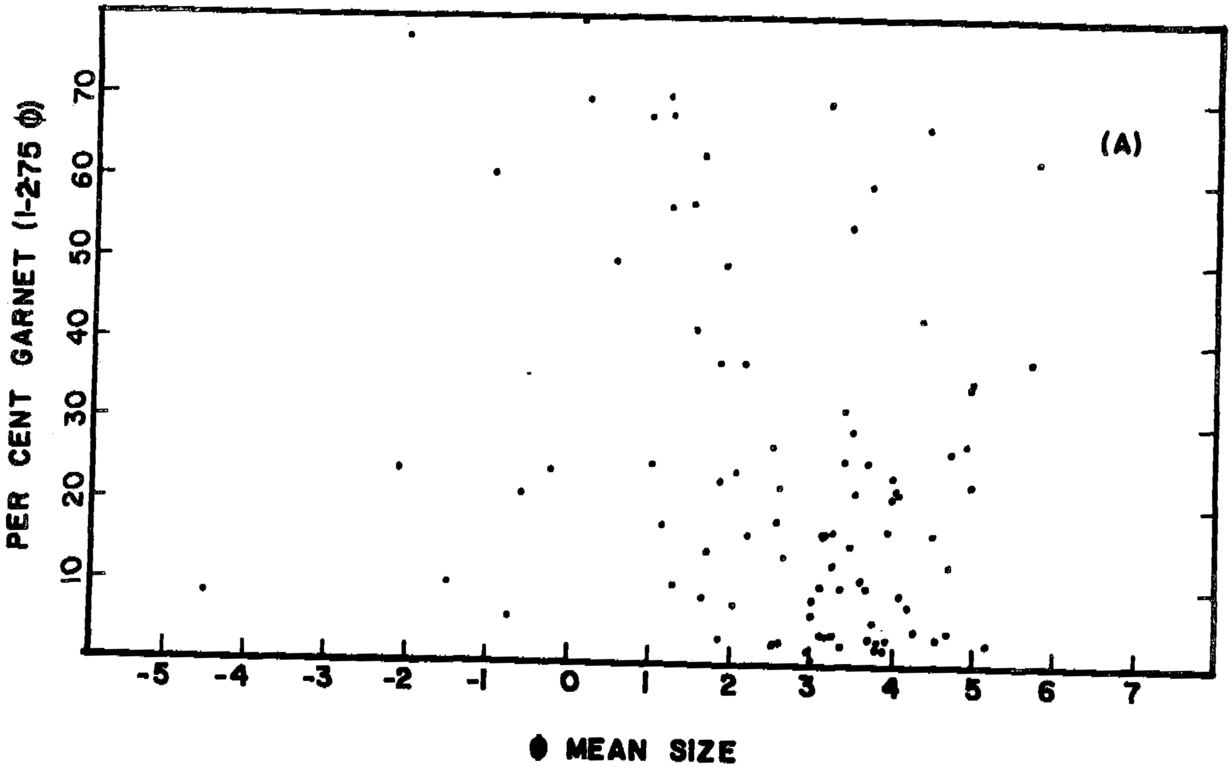

Fig. 53. Mean size of the sediment versus percent garnet in 1 - 2.75ϕ sized heavy mineral fraction.

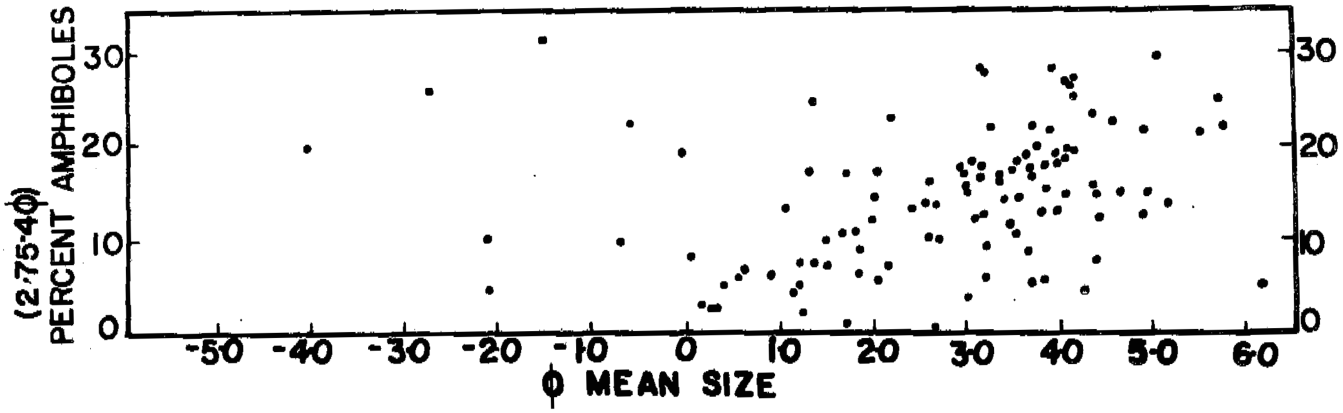

Fig. 54. Mean size of the sediment versus percent amphiboles in 2.75 - 4.0ϕ sized heavy mineral fraction.

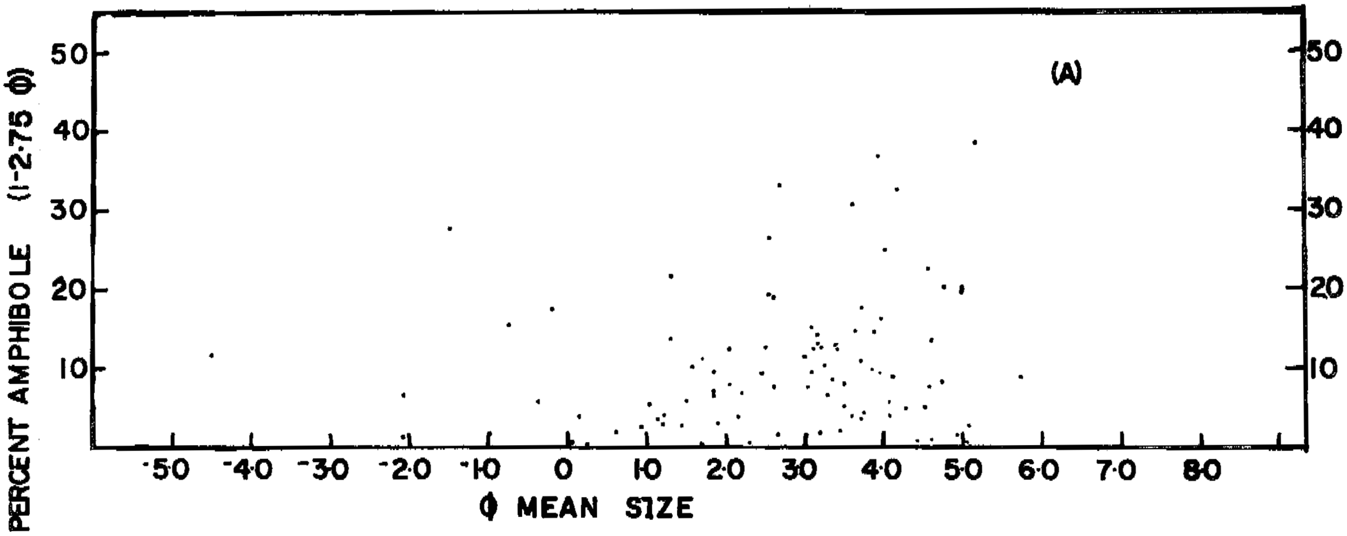

Fig. 55. Mean size of the sediment versus percent amphibole in 1 - 2.75ø sized heavy mineral fraction.

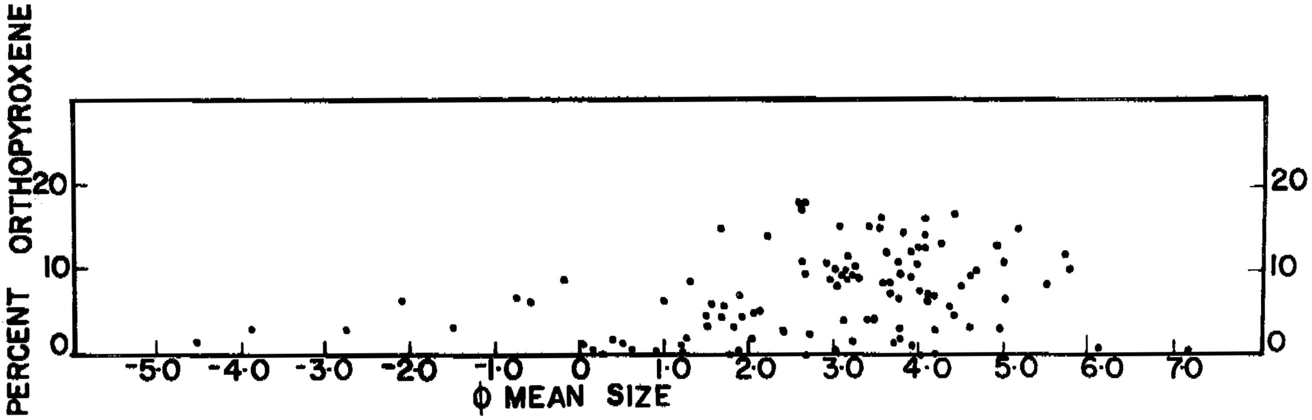

Fig. 56. Mean size of the sediment versus percent orthopyroxene in 2.75 - 4.0ø sized heavy mineral fraction.

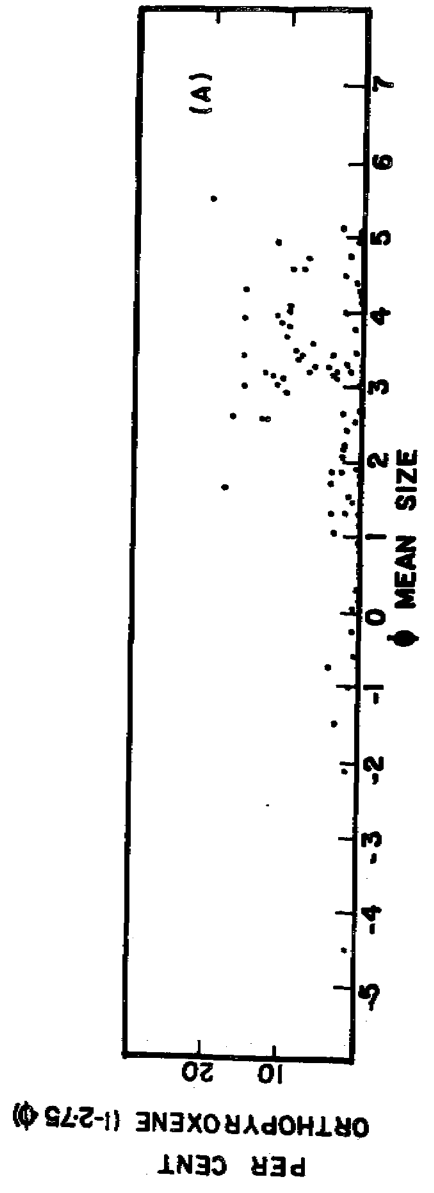

Fig. 57. Mean size of the sediment versus percent orthopyroxene in 1 - 2.75ϕ sized heavy mineral fraction.

In view of the presence of different rocks in the drainage basin of the Yukon River and in view of the nearness of this river, the Yukon province is believed to be wholly the result of Yukon silt deposition. The Quaternary basalts of Stuart Island and adjacent mainland are responsible for olivine-rich sand near Stuart Island and the Quaternary basalts of central St. Lawrence Island for the olivine-rich sediments in the nearby areas. The dominant presence of granitic and some volcanic rocks on the Northwest and Northeast capes, cause the two provinces off these capes. These provinces may also have received some sediment from other adjacent ones. The Chukotka province with characteristic acid-volcanic rocks, high amounts of amphiboles, clinopyroxene, opaques and sphene, must have been derived from Southern Chukotka peninsula. The sediments of Prince of Wales province have been derived from the terrain of dominant sedimentary rocks (limestones, sandstones) and some granitic, volcanic and metamorphic rocks on Seward Peninsula. Some of the sediments of this province may have been derived from northern Chukotka peninsula and from Nome province. The differences between the Nome and Golovnin Bay provinces, are presumably due to the differences in the source rocks on the nearby land areas (see DUTRO and PAYNE, 1957). The sediments of the easternmost part of Norton Sound may have been similarly derived from yet another source of rocks.

Working solely with the sediment texture, CREAGER and McMANUS (1967) concluded that much of the sand of the Chirikov Basin is related to the lowered sealevels, whereas the finer sediments of Norton Sound reflect modern conditions. The present study confirms this and provides many details on the nature and sources and dispersal of these sediments (Fig. 47).

In Norton Sound, the different provinces, particularly the Yukon, the East-Norton Sound, and Golovnin Bay provinces, can be related to modern processes. The Nome province not only reflects a modern dispersal but also the influence of dispersal during conditions of lowered sea levels. HOPKINS (1967) distinguished several strandline deposits in the nearshore areas off Nome from which some of the samples analyzed in the present study, were collected. Ice rafting in a limited way could be important in the nearshore area off Nome.

In the northern part of the Chirikov Basin, along the coast from Nome to Cape Prince of Wales, the heavy minerals occur not only in sediments presently affected by waves and strong currents, but also in sands at water depths too great for water motion to exert a dominant influence on sand dispersal. Because the mineral assemblages characterizing the sedimentary provinces do not change significantly with depth in the northern part of the Chirikov Basin and because the bedrock that could supply these minerals lies buried under a thick pile of sediments of later age, the same provenance must have supplied the material in any given area to the locations both within and below the influence of modern nearshore processes. This suggests that much of the sand in the northern part of the Chirikov Basin was deposited during the conditions of lowered sea levels.

Off the coast between Port Clarence and Nome, higher concentrations of heavy minerals (sp. gravity 3.14-3.17) are found at depths of 12 m, 20 m and 30-34 m than in the nearshore areas that have been sampled. These high contents occur near the submerged ridges which characteristically contain brown or red coated sands and might reflect still stands of sea level at these depths. The percent of garnet in the central part of Chirikov Basin decreases significantly, but is still higher than in the Yukon province and the provinces off St. Lawrence Island. This may reflect the deposition of these sediments by a weaker mechanism than would be present at still stands, or may reflect mixing of the sediment from the different provinces.

HOPKINS (1967) distinguished beaches at 11-13 m, 20-22 m depths off Nome east of the above mentioned high heavy-mineral areas. CREAGER and McMANUS (1967) distinguished a stillstand at 36 m depth in the southeast Chukchi Sea and they extrapolated this stillstand to the Northern Bering shelf also.

At least part of the sediments of Chukotka province and Northwest Cape are also relict deposits that possibly reflect glacial transport of material from Chukotka peninsula prior to reworking by the transgressing sea. LISITSYN (1966) listed the characteristics of ice-rafted and algae-transported sediments under present sea level conditions and submarine moraines deposited under past sea level conditions. Applying LISITSYN'S (1966) criteria, it may be inferred that the usually poorly sorted angular boulders, cobbles and pebbles of acid volcanic rocks in Anadyr Strait and off Northwest Cape are morainal deposits. Also, off Northwest Cape at 34-36 m depth, a linear zone of well-sorted reddish brown colored sands with high amounts of heavy minerals and with small rounded pebbles of acid volcanic rocks described, might indicate a beach deposit.

The high concentration of heavy minerals off the eastern end of St. Lawrence Island at depths of 20 m in the regions of ridges may also represent former strandlines, although additional study is required here. The relatively high content of garnet on a ridge and in a channel compared to the adjacent areas in this region, may indicate derivation of sediments in part from the Nome area.

Because of considerable reworking of the sediments to be expected throughout the Chirikov Basin during sea level fluctuations and because of influx of fine-sized material, only a few strandline deposits may be detectable. The sediments in the broad-valley like feature in the central part of the Chirikov Basin represent an area of low heavy mineral content as in Norton Sound, but the minerals do not appear to have been derived to any great extent from the Yukon River. The valley-like depression may not therefore, have a direct relation to the Yukon at a time of lowered sea level.

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TABLE I

Weight percentages of material
with specific gravity >3.15 in the different
size fractions of the Northern Bering Shelf.

Sample	1.0-2.75ϕ % Heavies	2.75-4.0ϕ % Heavies	1.0-4.0ϕ % Heavies	Mean Size
68 ANC-St54A	2.3	2.9	2.6	1.84
69 ANC-St88	80.6	18.7	78.0	1.72
97	0.9	5.8	3.1	2.66
St101	2.8	5.8	4.6	4.92
102	0.2	3.2	3.0	3.99
103	0.5	0.6	0.6	4.41
104	0.3	1.5	1.4	3.38
105	0.5	1.5	1.4	3.96
106	0.2	1.4	1.3	4.49
107	0.4	4.0	2.1	3.43
108	1.3	2.0	2.0	3.56
111	0.04	2.7	2.4	3.36
112	0.2	13.6	4.0	2.60
113	0.1	5.5	1.9	2.94
114	0.1	0.7	0.7	3.89
115	0.5	1.6	1.5	3.94
116	0.01	1.7	1.1	5.14
117	0.6	1.6	1.4	4.66
118	0.8	2.0	1.9	4.08
119	0.0	0.4	0.4	4.38
120	0.0	0.5	0.4	4.57
121	0.0	1.1	0.8	5.50
122	1.1	12.7	1.5	3.19
TT 043-Sta53a Box Core	0.3	19.8	0.5	1.87
GRO 45, Sta57 Van Veen	6.1	14.9	6.3	1.92
GRO31, Sta10	1.0	5.6	1.2	-.19
GRO89, Sta48	1.1	18.1	1.6	1.99
GRO51, Sta29 Van Veen	0.7	22.2	1.1	1.48
GRO83, Sta45	1.4	41.2	4.5	2.34
GRO91, Sta49	2.3	14.6	9.0	2.66

TABLE I

Sample	1.0-2.75ϕ % Heavies	2.75-4.0ϕ % Heavies	1.0-4.0ϕ % Heavies	Mean Size
TT 043-GR093, Sta50 Van Veen	1.5	32.3	2.0	1.76
GR097, Sta52 Van Veen	0.8	9.8	1.7	2.24
68 ANC 50B	1.40	3.87	3.19	7.18
76B	.71	3.62	1.50	2.66
79	.35	1.35	1.23	3.46
81	.30	1.47	1.34	3.63
90	1.93	11.15	2.41	1.70
102	.99	5.37	4.94	3.01
121	1.70	1.77	1.23	4.37
147	.17	2.77	1.91	3.14
148	.63	1.77	1.75	3.67
159	.30	1.98	1.75	3.15
164	.60	4.88	1.92	2.89
169	.32	6.68	2.15	3.10
172	.72	8.52	2.17	1.22
204	2.79	4.86	2.88	1.98
207	4.04	5.30	4.21	1.96
212	3.01	20.72	5.82	1.52
215	1.15	7.31	2.26	1.85
220	.39	2.59	1.93	3.10
222	.54	4.35	2.38	3.42
224	2.11	38.06	5.38	2.05
225	2.46	6.64	3.13	2.17
210B	3.55	12.30	3.80	0.40
V6779	3.24	11.40	5.12	1.23
99	2.91	11.39	4.82	1.20
116	8.48	22.80	10.41	0.93
120	3.69	13.86	5.61	1.16
124	2.79	8.30	3.68	0.16
Greene 3-5	97.26	94.32	97.19	
17-2d	29.27	10.53	25.74	
25B	1.35	29.81	1.49	
49-3A	.33	1.32	.60	
Nelson 302	7.15	12.34	7.41	
Su 133-68	1.71	1.15	1.35	
Su 138-68	.78	16.61	3.51	

TABLE I

Sample	1.0-2.75ϕ % Heavies	2.75-4.0ϕ % Heavies	1.0-4.0ϕ % Heavies	Mean Size
ANC 29	.46	2.45	2.28	
35	1.32	.64	.70	
36	.91	5.78	2.20	
51	1.11	4.91	3.09	
69	1.57	2.34	2.01	2.42
72	1.32	1.46	1.41	0.10
78	.60	2.22	2.02	3.52
82	.90	2.16	1.75	3.15
83	1.50	7.78	2.74	1.93
86	1.54	3.20	2.23	-1.52
87	1.32	1.54	1.45	-0.66
94	1.34	1.86	1.57	-3.54
98	5.48	12.29	6.87	-1.43
105	.74	7.26	6.12	3.02
108	3.43	9.99	7.79	2.83
112	3.35	35.27	3.79	1.45
125	3.53	1.13	1.28	3.94
138	4.14	7.52	5.35	-2.04
150	.82	.79	.80	3.91
152	1.08	1.32	1.32	3.59
155	.46	1.22	1.20	3.28
158	.46	1.20	1.16	3.19
161	.54	3.80	2.39	2.89
163	.89	2.71	1.88	2.86
165	1.71	15.36	3.53	2.23
168	1.77	19.68	2.44	1.94
171	.95	7.52	1.94	1.34
173	.53	15.47	2.29	2.55
178	2.01	2.24	2.23	4.19
185	2.43	24.28	3.62	0.09
192	2.96	26.64	3.97	1.20
195	1.65	13.59	1.71	0.92
199	15.36	5.35	14.62	-1.05
216	.42	3.21	1.84	2.86
217	.49	3.31	1.99	2.86
219	.83	2.19	2.15	3.39
223	.76	30.29	3.03	2.25
AHP 4B	11.95	38.68	14.11	
8	3.93	5.03	4.01	
118C	9.32	32.46	10.02	
165	.81	1.74	1.11	
258A	5.44	6.81	5.74	

TABLE I

Sample	1.0-2.75φ % Heavies	2.75-4.0φ % Heavies	1.0-4.0φ % Heavies	Mean Size
AHP 276	1.91	3.43	2.66	
327	.15	2.33	2.20	
447A	3.12	3.71	3.43	
457	1.88	6.15	3.35	
Gr 34-9	12.98	.96	5.66	
35-1D	1.97	1.23	1.79	
AWF 306	3.54	16.05	5.24	3.19
312	2.75	14.40	3.65	0.61
322	7.93	4.82	7.23	-0.77
333	4.83	2.08	3.32	1.78
358	1.19	.63	.74	4.92
365	1.36	.97	1.09	5.42
397	1.72	.49	.58	4.95
413	3.44	11.95	4.17	4.57
Pr 21	.54	5.32	.56	
68 ANC 77B	1.45	4.72	2.49	2.04
84	6.14	2.54	1.07	
89	2.09	1.42	1.66	-0.62
93	1.04	1.27	1.16	-4.50
116	19.29	33.87	20.40	0.27
119	3.31	4.28	3.77	-3.84
144	2.91	10.22	4.00	-0.75
156	.52	2.03	1.97	3.22
227	2.15	9.23	2.76	1.46
228	3.87	23.07	4.87	3.46
230	.39	1.55	1.33	3.52
231	1.63	1.30	1.32	5.75
237	4.99	13.10	5.83	4.40
239	.50	1.67	.77	4.90
243	6.36	14.25	7.50	-2.10
246	.61	.84	.83	5.69
250	2.88	9.72	3.49	3.72
V57-67	6.02	26.53	7.53	0.60
71	3.44	13.6	4.30	0.54
82	5.77	4.17	5.26	0.05
TT 19-29	.56	2.7	1.18	-2.12
31	1.65	5.07	1.87	1.01
55	1.11	3.45	1.37	1.30
Su 135-68	3.73	.34	1.99	-2.78
NW 261-1	.14	.91	.63	4.06
2	.41	1.08	.87	3.00

TABLE I

Sample	1.0-2.75φ % Heavies	2.75-4.0φ % Heavies	1.0-4.0φ % Heavies	Mean Size
NW 261-3	.70	5.87	3.30	3.70
4	.46	2.55	2.20	4.18
5	.47	.90	.75	-
6	.00	.76	.70	-
8	-	3.17	1.43	3.88
10	.00	1.10	1.08	4.14
11	1.15	.92	.93	4.10
12	.30	3.34	2.64	3.25
13	.98	.80	.81	4.13
14	.51	1.10	1.06	5.13
15	6.94	20.74	9.93	2.75
16	3.54	11.05	5.59	3.69
17	1.10	10.25	5.90	2.94
18	.78	1.37	4.32	3.51
19	.06	2.57	1.58	2.93
20	.72	3.08	2.77	3.72
21	.16	2.35	2.14	3.71
TT018-6	.79	4.41	2.48	-
7	.68	1.21	1.17	-
8	.09	1.01	1.02	3.57
9	0.19	1.00	0.54	3.76
10	1.34	1.63	1.53	3.89
11	.30	1.20	1.09	4.08
12	1.33	2.48	2.07	5.07
13	.52	3.54	1.82	4.74
14	.96	.43	-	4.73
15	1.45	2.35	1.85	1.30
16	.42	4.54	3.63	3.06
17	.39	.45	.44	3.48
18	.29	-	-	4.58
19	.42	1.00	.95	3.84
20	.14	6.26	3.89	3.03
21	.34	3.83	1.61	3.01
22	3.36	16.01	6.50	2.58
23	2.01	18.47	4.72	4.26
24	.75	6.47	3.69	3.14
25	.27	6.92	3.02	2.94
26	1.74	16.58	4.09	1.67
29	1.76	2.17	1.91	1.82
30	.15	4.21	.28	2.71
31	2.33	41.26	2.94	1.89
32	.96	9.42	2.27	2.49
	2.54	-		
33	1.02	7.60	2.34	4.94

TABLE I

Sample	1.0-2.75ϕ % Heavies	2.75-4.0ϕ % Heavies	1.0-4.0ϕ % Heavies	Mean Size
TT018-35	.39	3.06	1.36	2.56
36	.92	1.67	1.52	- .69
37	1.67	5.35	2.10	- .26
38	1.34	-		-2.28
39	-	1.53		1.37
40	.94	1.23	1.20	3.77
42	3.94	2.10	3.50	2.20
43	2.63	4.04	2.83	-
44	.42	1.61	1.28	3.54
45	.32	-		3.18
46	4.97	13.26	5.41	-1.01
47	.43	1.45	1.16	3.28

TABLE II

Percentages of the heavy minerals on opaque-free basis
in the 2.75-4.0ø size fractions

Station	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Fragments	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
68 ANC																				
-159	9.80	4.05	5.07	22.64	1.01	0	28.72	21.28	3.38	1.35	8.78	3.04	11.82	3.38	11.49	-	.34	-	4.39	
V67-116	.29	3.14	2.00	4.29	-	0	6.29	13.43	4.00	-	7.71	54.00	61.71	1.14	4.29	-	2.00	-	3.71	
68 ANC																				
-172	1.89	23.11	3.07	4.48	-	0	7.55	15.33	4.48	2.36	6.60	20.52	27.12	.71	7.31	1.18	4.07	.23	4.72	
TT-019																				
-29	6.38	30.10	3.83	8.93	-	0	12.76	13.02	4.34	2.81	7.14	9.18	16.32	1.28	8.16	-	1.28	-	3.57	
-31	6.36	23.66	1.39	12.13	-	0	13.52	11.13	5.57	1.99	3.98	19.48	23.46	.40	4.57	1.39	2.98	-	4.97	
-55	7.99	31.96	3.63	13.80	-	0	17.43	9.44	4.84	.24	5.33	8.23	13.56	1.45	7.51	.73	.48	.24	4.12	
68 ANC																				
-50B	.49	25.24	4.85	2.43	-	0	7.28	7.77	8.25	1.46	8.25	22.33	30.58	1.46	7.77	.97	1.46	.97	6.31	
-76	9.66	34.87	1.89	11.97	-	0	13.86	15.12	3.99	.21	3.78	6.09	9.87	.63	8.61	.84	.21	.42	1.68	
-169	4.34	26.82	4.21	8.17	-	0	12.38	13.41	4.98	1.15	6.90	15.84	22.74	.89	6.26	-	3.07	-	3.96	
-77	4.98	39.10	6.63	10.66	-	0	17.29	8.06	5.45	.95	5.21	8.77	13.98	1.42	7.11	.24	.24	.24	.95	
-79	6.56	28.23	4.17	22.47	-	0	26.64	12.92	3.78	.60	3.78	2.98	6.76	1.39	9.34	.80	.40	.20	2.39	
-84	3.47	22.69	7.41	24.31	-	0	31.72	10.88	4.68	.23	3.47	7.87	11.34	1.62	11.11	-	.69	.23	1.16	
-89	6.25	26.36	5.98	16.58	-	0	22.56	11.41	3.26	.54	3.53	5.43	8.96	2.17	13.59	1.09	-	-	3.80	
-90	5.76	24.75	4.75	12.54	-	0	17.29	9.83	5.76	2.37	5.08	10.57	15.59	.34	12.88	2.37	1.02	-	2.03	
-212	3.41	12.15	3.20	3.62	.21	0	7.03	9.59	6.61	.21	4.05	40.09	44.14	.85	7.68	.85	1.71	.21	5.54	
-215	7.02	21.85	3.99	5.10	-	0	9.09	12.44	5.90	.48	6.70	21.05	27.75	.32	9.25	.48	1.44	-	3.99	
-81	7.47	25.09	4.63	14.60	-	0	19.22	13.88	4.63	.89	4.63	3.38	8.07	1.96	13.17	.18	.36	-	5.16	
-239	13.00	26.56	7.69	14.29	-	0	21.98	9.71	2.20	.55	2.38	4.95	7.33	2.01	13.19	.37	.55	-	2.56	

TABLE II

Station	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Fragments	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
68 ANC																				
-210	1.82	17.09	1.82	3.27	-	0	5.09	9.82	4.00	-	5.45	43.27	48.72	-	5.09	.36	1.09	.73	6.18	
-204	3.73	16.00	2.93	9.07	-	0	12.00	13.07	6.93	.27	4.80	25.07	29.87	.27	9.60	-	2.13	.53	5.60	
N.W-261																				
-1	14.20	30.66	5.56	13.17	-	0	18.73	12.14	2.67	1.44	4.32	2.67	6.99	2.06	10.08	-	.21	-	.82	
-3	1.50	20.30	11.15	11.31	-	0	22.46	7.82	7.32	.83	3.99	18.47	22.46	1.33	6.66	-	1.66	.17	7.49	
-4	3.11	22.60	11.44	16.10	-	0	27.54	9.89	10.59	.14	5.65	7.34	12.99	1.27	5.23	.14	1.55	-	4.94	
-5	3.04	51.98	1.52	2.74	-	0	4.26	4.26	.91	2.13	3.95	5.17	9.12	.31	22.80	.91	-	-	.31	
-8	14.87	31.68	3.72	13.98	.18	0	17.88	9.91	3.07	.18	2.65	4.07	6.72	1.59	12.74	-	.18	-	1.24	
-10	7.11	34.10	5.23	14.64	-	0	19.87	12.76	3.77	.21	3.14	1.46	4.60	1.26	15.06	-	-	-	1.26	
-11	6.71	31.94	7.18	12.73	-	0	19.91	14.12	1.85	.93	3.94	1.39	5.33	.69	17.59	-	-	-	.93	
-12	10.18	32.74	4.65	17.48	.22	0	22.35	13.27	1.55	.66	.88	2.88	3.76	1.33	13.50	.44	.22	-	-	
-13	7.14	31.85	5.79	19.88	-	0	25.67	11.00	1.74	-	.40	2.90	3.30	1.35	16.02	.58	.19	-	1.16	
-21	11.47	31.37	5.23	11.47	.17	0	16.87	16.69	2.19	.67	2.02	2.36	4.38	.51	13.83	-	.17	-	1.85	
68 ANC																				
-237B	4.93	10.59	4.19	3.69	-	0	7.88	11.58	4.43	.25	7.14	38.42	45.56	1.72	8.62	.49	1.48	-	2.46	
-246	12.08	28.26	8.45	16.67	.24	0	25.36	12.32	1.45	.48	3.62	2.66	6.38	.72	10.14	-	.48	-	2.42	
-231	10.29	32.10	6.17	16.26	-	0	22.43	10.91	1.03	-	1.23	1.23	2.46	2.26	15.02	.20	-	-	3.09	
-228	3.39	8.78	2.79	2.59	-	0	5.38	10.38	4.99	.20	3.59	51.50	55.09	1.80	4.39	.20	1.40	-	3.99	
-250	1.94	11.66	5.62	4.75	-	0	10.37	16.90	3.02	3.67	5.18	41.68	46.86	.22	5.62	-	1.73	-	3.60	
GR25-B	-	2.87	-	2.87	-	0	6.32	5.17	-	-	17.82	57.47	75.29	1.15	6.32	-	1.15	.57	1.15	3.45
GR49-3A	-	4.00	.40	1.60	-	0	3.20	8.80	4.80	.80	22.80	37.20	60.00	.80	7.60	-	4.40	.40	5.20	1.20
NELSO																				
302	2.67	39.04	5.08	16.31	-	0	21.39	1.07	5.61	8.56	3.74	2.67	6.41	.28	8.56	6.15	-	-	.28	-

TABLE II

Station	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Fragments	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
68 ANC																				
-230B	14.91	34.16	2.48	14.60	.62	0	17.70	12.73	2.80	.62	3.73	2.48	6.21	.93	8.39	-	-	-	1.55	-
-227	4.56	10.72	1.34	8.06	.27	0	9.92	9.38	5.63	-	10.19	36.19	52.59	.54	4.83	.27	1.61	.27	5.90	.27
-225	5.11	15.91	.85	6.25	.28	0	7.38	9.38	4.83	-	7.95	34.09	42.04	.57	7.39	1.14	2.84	.28	3.13	-
-224	6.15	12.07	3.35	5.03	-	0	8.66	7.82	4.75	-	7.82	36.31	44.13	.56	9.50	.56	3.07	1.12	1.68	.28
-243	.24	3.87	1.21	3.15	-	0	4.60	15.50	2.42	-	6.78	51.09	57.87	.97	6.05	-	4.12	-	4.36	.24
-224	5.07	11.73	2.67	2.93	-	0	5.60	7.20	7.73	.53	5.33	42.93	48.26	-	8.00	.53	2.93	-	2.40	-
-222	4.54	28.73	3.02	11.23	.22	0	14.47	12.53	4.75	.22	4.97	14.47	19.44	1.08	9.72	.43	1.51	.22	2.38	-
-148	8.67	41.45	3.86	13.73	.24	0	17.83	10.84	2.41	.96	1.93	1.93	3.86	1.93	10.60	.48	-	-	.96	-
-144	6.50	38.63	2.89	16.24	.36	0	19.49	3.25	6.49	7.58	2.89	3.61	6.50	.72	8.30	.72	-	-	1.81	-
-147	9.87	28.21	3.47	13.71	.37	0	17.55	10.60	.91	.37	2.19	4.02	6.21	.37	13.71	.73	1.10	-	.37	-
-220	9.40	33.25	2.41	13.98	.24	0	16.63	12.53	3.86	.24	3.86	4.82	8.68	2.41	9.16	.24	.72	-	2.89	-
-119	3.31	54.41	1.47	3.31	.74	0	5.52	3.68	.37	24.63	1.47	1.47	2.94	.37	2.94	.37	-	-	1.47	-
-116	-	20.63	1.79	.90	-	0	2.69	1.35	.90	71.30	-	.90	.90	-	1.79	.45	-	-	-	
SU-138																				
-68	2.91	40.12	3.78	9.59	-	0	13.37	6.10	11.34	8.72	3.78	2.91	6.69	.29	9.88	.58	-	-	-	
-135	2.63	13.16	2.63	23.68	-	0	26.31	19.74	7.89	-	9.21	9.21	18.42	1.32	10.53	-	-	-	-	
-133	.61	27.66	1.22	3.95	-	0	5.17	7.60	3.34	2.74	10.03	25.23	35.26	.30	7.90	.61	2.43	-	6.38	
68 ANC																				
-102B	.85	35.23	.57	2.84	.28	0	3.69	9.94	1.14	36.36	.57	.57	1.14	-	11.36	-	.28	-	-	
-121	2.95	47.79	1.77	11.50	.29	0	13.56	9.14	2.36	15.04	2.06	.29	2.35	.88	5.07	-	.29	-	.59	
-93	1.64	38.11	6.97	13.11	-	0	20.08	10.25	4.10	1.64	8.20	3.69	11.89	.82	10.25	-	-	-	1.23	
-156	9.09	38.49	5.61	.39	.19	0	6.19	15.09	3.48	1.16	4.64	3.29	7.93	3.48	11.41	-	.39	.58	2.71	

TABLE II

Station	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Fragments	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
G17-2D	-	-	-	-	-	-	-	-	-	-	18.18	36.36	54.54	-	-	-	45.45	-	Trace	-
V67-67	.53	3.69	3.43	3.69	-	0	7.12	16.09	6.07	-	8.71	42.48	51.19	.79	7.65	-	2.37	-	3.96	.53
V67-71	1.34	3.06	3.77	2.40	-	0	6.19	17.12	7.19	-	5.82	40.41	46.23	1.03	6.85	.68	5.48	-	4.79	-
V67-79	.50	1.49	.74	1.49	-	0	2.23	18.56	7.43	-	8.17	43.32	51.49	1.49	3.71	-	3.22	-	9.90	-
V67-82	1.02	6.85	2.28	6.09	-	0	8.37	31.73	5.33	-	6.35	17.26	23.61	.76	8.63	-	1.02	-	12.44	.25
V67-99	1.05	3.68	1.58	3.42	-	0	5.00	23.95	3.68	-	8.16	42.63	50.79	.53	5.00	-	1.32	-	5.00	-
V67-124	.54	5.43	.82	2.17	-	0	2.99	28.26	7.34	-	7.07	30.98	38.05	1.09	6.25	.54	3.80	-	5.71	-
V67-120	-	7.16	1.02	3.33	-	0	4.35	30.95	6.65	.26	5.37	36.06	41.43	1.28	2.56	.26	.26	.26	4.60	-
68 ANC																				
-270B	4.83	14.76	4.07	10.43	-	0	14.50	16.03	5.09	-	1.27	29.26	30.53	.57	7.12	-	1.27	-	5.34	-
TT18-19	9.52	38.57	3.81	8.57	.71	0	13.09	14.29	.71	.71	.24	2.14	2.38	.95	18.81	-	.71	-	.24	
-26	14.86	32.77	2.36	8.45	-	0	10.81	7.01	4.39	1.01	1.01	11.82	12.83	.68	11.47	.34	2.03	-	1.69	
-20	10.12	36.47	3.76	10.82	.47	0	15.05	7.76	.71	1.18	1.88	3.76	5.64	1.65	20.71	-	-	.47	.24	
-25	10.97	32.38	3.92	13.32	-	0	17.24	6.27	1.31	1.57	1.57	6.79	8.36	.52	19.32	-	.52	-	1.57	
-24	11.63	33.14	3.49	8.43	.58	0	12.50	11.05	2.91	.58	1.45	8.43	9.88	.29	16.28	.29	.58	-	.87	
-23	15.68	32.06	1.05	3.83	-	0	4.88	6.62	1.05	1.05	1.05	13.94	14.99	-	20.56	.70	1.74	-	.70	
-22	17.57	31.93	1.49	8.66	.25	0	10.40	6.19	1.73	1.98	.50	8.66	9.16	.25	20.30	-	.25	.25	-	
-21	8.43	32.05	6.57	8.92	.24	0	15.67	8.43	.96	.96	.72	7.23	7.95	1.20	22.65	.96	.24	-	.48	
-29	2.62	36.63	-	10.97	-	0	10.97	7.33	3.14	.27	25.37	-	25.37	.27	7.33	-	1.31	.27	4.71	
-30	2.29	40.28	-	9.60	.46	0	10.06	9.15	4.13	-	15.79	-	15.79	1.15	10.07	.46	1.60	.92	3.90	
-33	6.57	34.43	-	15.06	-	0	15.06	6.11	4.76	.45	22.49	-	22.49	-	9.52	-	3.62	.22	2.94	
-36	4.57	36.37	-	9.75	-	0	9.75	15.56	5.24	-	9.37	-	9.37	.38	8.44	-	.18	-	9.56	
-37	8.86	31.04	-	12.90	-	0	12.90	10.26	4.06	.24	13.60	-	13.60	.48	10.74	2.15	.95	-	5.07	

TABLE II

Station	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Fragments	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
TT18-39	4.58	29.99	-	9.65	-	0	9.65	14.74	2.54	-	6.10	-	6.10	.77	15.25	.25	1.02	-	14.98	
-47	6.38	37.00	-	17.73	-	0	17.73	8.29	4.48	-	7.39	-	7.39	1.57	13.45	.22	.90	.22	2.46	
- 9	3.29	50.40	-	8.94	-	0	8.94	1.89	.97	2.51	8.94	-	8.94	1.89	18.38	1.89	-	-	1.40	
-10	1.04	44.76	-	28.78	-	0	28.78	1.74	7.29	.42	6.25	-	6.25	1.38	3.81	-	-	.35	4.86	
-11	12.55	31.16	-	27.20	-	0	27.20	2.39	2.69	.30	2.69	-	2.69	1.49	6.57	-	-	.30	.90	
-12	11.11	37.86	-	29.69	-	0	29.69	1.83	1.59	7.95	2.04	-	2.04	.68	6.34	-	-	.23	.23	
-16	15.05	41.68	-	18.43	-	0	18.43	3.99	1.05	1.05	6.08	-	6.08	2.32	8.38	-	.21	.21	1.68	
- 8	16.17	43.76	-	14.88	-	0	14.88	7.54	1.65	.19	4.41	-	4.41	.92	6.99	-	-	.36	2.40	
- 6	15.90	43.69	-	17.80	-	0	17.80	6.64	1.90	.47	3.33	-	3.33	-	8.53	-	-	-	1.89	
-15	5.81	38.53	-	25.06	-	0	25.06	3.72	3.72	1.40	2.56	-	2.56	.46	10.90	.23	.23	6.04	.92	
-40	6.74	44.61	-	19.92	-	0	19.92	5.59	2.08	2.29	3.53	-	3.53	2.49	7.47	-	-	.21	1.45	
-43	14.77	31.58	-	23.20	-	0	23.20	6.75	3.07	.77	14.77	-	14.77	1.78	12.24	.77	.25	2.03	-	
-46	8.07	19.74	-	10.50	-	0	10.50	5.57	3.25	.26	40.33	-	40.33	1.42	6.25	.27	1.26	.26	3.07	
68 ANC																				
- 54	5.01	25.89	1.79	4.35	0.57	0	6.65	16.41	6.15	1.28	1.28	27.17	28.45	0.25	6.63	0.57	1.28	1.03	4.35	0.57
69ANC107	3.17	17.71	6.34	7.40	-	0	12.67	6.87	8.20	1.33	3.97	30.41	34.38	0.54	6.34	-	1.06	0.27	6.34	-
-102	7.32	25.05	8.72	9.57	-	0	18.29	9.57	3.94	0.56	5.63	13.79	19.42	0.28	6.75	-	1.41	-	7.32	-
-103	16.58	32.27	4.14	10.94	-	0	15.09	10.06	1.78	0.30	1.18	0.88	2.07	1.78	15.98	0.30	0.88	-	2.66	0.30
-104	15.26	35.73	3.36	13.44	-	-	16.80	8.55	1.83	-	0.31	3.36	3.67	1.53	14.04	-	1.22	-	1.22	-
-105	12.59	32.18	4.97	8.19	-	-	13.16	12.87	2.93	-	1.17	7.61	8.78	0.59	12.59	0.30	1.17	0.30	2.34	-
-106	8.95	35.24	4.19	8.37	-	-	12.56	14.63	4.19	1.20	0.30	3.58	3.88	1.50	15.52	-	0.59	-	1.79	-
-107	4.70	25.30	3.83	7.65	0.30	-	11.77	11.18	5.29	4.42	0.30	21.78	22.08	0.30	8.83	0.30	1.48	1.48	2.94	-
-108	8.52	36.57	4.95	13.19	-	0.28	18.42	8.25	2.20	-	2.75	4.95	7.70	0.28	12.65	-	0.54	-	4.67	-

TABLE II

Station	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Fragments	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
69 ANC																				
-111	12.40	34.10	2.48	13.95	-	-	16.43	8.68	1.86	1.55	1.24	2.48	3.72	0.31	20.47	-	0.31	-	0.31	-
-112	11.16	30.60	5.74	10.20	0.31	-	16.26	7.07	1.59	0.31	2.23	7.97	10.20	0.31	20.09	0.63	0.31	0.31	0.63	0.63
-113	9.09	34.48	3.70	13.48	0.31	-	17.48	10.97	1.26	-	0.94	7.21	8.15	0.31	17.24	0.31	-	0.31	-	-
-114	12.34	28.31	4.81	16.86	-	0.30	21.97	7.53	1.80	0.60	1.80	2.11	3.91	0.60	21.38	-	0.30	-	1.10	-
-115	11.90	34.49	4.88	13.73	-	0.61	19.22	11.28	2.75	1.22	1.22	2.44	3.66	-	14.95	-	-	-	0.59	-
-116	14.95	32.44	4.23	9.87	-	-	5.29	14.11	1.41	0.85	0.85	2.82	3.67	0.56	16.93	-	0.29	-	0.56	-
-117	11.09	32.12	3.99	11.09	0.29	0.29	15.07	11.94	1.14	0.56	1.42	3.13	4.56	-	20.19	-	1.14	0.29	1.14	-
-118	16.17	29.55	4.46	10.03	-	0.28	14.77	11.15	2.57	0.55	0.28	5.85	6.13	0.55	15.89	-	0.84	-	1.67	-
-119	5.68	16.71	6.68	16.38	-	0.67	23.74	3.07	0.85	-	-	2.07	2.07	1.00	18.72	-	-	-	2.67	-
-120	9.46	25.89	5.98	16.43	-	0.50	22.90	6.48	1.50	-	-	2.00	2.00	1.00	25.39	-	-	-	5.48	-
-121	8.57	25.71	7.66	13.53	-	0.45	21.64	7.21	1.81	-	-	2.70	2.70	0.45	29.77	-	1.36	-	0.90	-
-122	1.67	10.00	3.67	5.67	-	-	9.34	21.33	3.99	0.34	1.67	38.00	39.67	0.66	6.33	-	3.00	0.33	0.33	-
- 88	-	6.37	-	0.67	0.33	-	1.00	0.33	0.67	90.19	0.33	-	0.33	-	1.00	-	-	-	-	-
- 97	-	11.02	0.38	-	0.38	-	0.76	2.28	0.34	81.70	-	-	-	-	3.80	-	-	-	-	-
68 ANC																				
- 54	0.51	25.89	1.79	4.35	0.51	-	6.65	16.41	6.15	1.28	1.28	27.17	28.45	0.25	6.63	0.51	1.28	1.03	4.35	0.51
69 ANC																				
-101	3.17	17.71	6.34	7.40	-	-	12.67	6.87	8.20	1.33	3.97	30.41	34.38	0.54	6.34	-	1.06	0.27	6.34	-
-102	7.32	25.05	8.72	9.57	-	-	18.29	9.57	3.94	0.56	5.63	13.79	19.42	0.28	6.75	-	1.41	-	7.32	-
-103	16.58	32.27	4.14	10.94	-	-	15.09	10.06	1.78	0.30	1.18	0.88	2.07	1.78	15.98	0.30	0.88	-	2.66	0.30
-104	15.26	35.73	3.36	13.44	-	-	16.80	8.55	1.83	-	0.31	3.36	3.67	1.53	14.04	-	1.22	-	1.22	-
-105	12.59	32.18	4.97	8.19	-	-	13.16	12.87	2.93	-	1.17	7.61	8.78	0.59	12.59	0.30	1.17	0.30	2.34	-

TABLE II

Station	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Fragments	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
69 ANC																				
-106	8.95	35.24	4.19	8.37	-	-	12.56	14.63	4.19	1.20	0.30	3.58	3.88	1.50	15.52	-	0.59	-	1.79	-
-107	4.70	25.30	3.83	7.65	0.30	-	11.77	11.18	5.29	4.42	0.30	21.78	22.08	0.30	8.83	0.30	1.48	1.48	2.94	-
-108	8.52	36.57	4.95	13.19	-	0.28	18.42	8.25	2.20	-	2.75	4.95	7.70	0.28	12.65	-	0.54	-	4.67	-
-111	12.40	34.10	2.48	13.95	-	-	16.43	8.68	1.86	1.55	1.24	2.48	3.72	0.31	20.47	-	0.31	-	0.31	-
-112	11.16	30.60	5.74	10.20	0.31	-	16.26	7.01	1.59	0.31	2.23	7.97	10.20	0.31	20.09	0.63	0.31	0.31	0.63	0.63
-113	9.09	34.48	3.70	13.48	0.31	-	17.48	10.97	1.26	-	0.94	7.21	8.15	0.31	17.24	0.31	-	0.31	-	-
-114	12.34	28.31	4.81	16.86	-	0.30	21.97	7.53	1.80	0.60	1.80	2.11	3.91	0.60	21.38	-	0.30	-	1.10	-
-115	11.90	34.49	4.88	13.73	-	0.61	19.22	11.28	2.75	1.22	1.22	2.44	3.66	-	14.95	-	-	-	0.59	-
-116	14.95	32.44	4.23	9.87	-	-	14.10	14.11	1.41	0.85	0.85	2.82	3.67	0.56	16.93	-	0.29	-	0.56	-

TABLE III

Percentages of heavy minerals on opaque-free basis in the 1-2.75ϕ size fractions.

Cruise	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Frag.	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
68 ANC 54	2.66	27.66	3.73	5.32	.53	-	9.58	4.78	1.59	-	.53	3.19	3.72	-	32.98	-	12.77	.53	3.73	-
69 ANC 101	0.32	14.38	9.48	10.79	-	-	20.26	3.26	8.50	-	.32	34.31	34.64	-	8.17	0.65	1.31	1.63	6.86	-
69 ANC 102	2.78	61.11	9.72	15.27	-	-	24.99	2.78	-	1.38	-	23.61	23.61	-	29.16	-	-	-	8.33	-
69 ANC 103	very	little	heavy	minerals		examined														
104	15.76	21.19	3.27	11.42	-	-	14.68	7.61	-	-	-	10.32	10.32	-	20.09	-	1.09	.55	2.72	-
105	9.35	26.32	4.68	11.11	-	.58	16.37	4.09	1.75	-	1.17	15.80	16.96	1.34	19.89	-	2.34	-	1.75	-
106	2.78	5.55	-	5.55	-	-	5.55	5.55	-	-	-	16.67	16.67	-	52.78	-	-	-	11.11	-
107	8.48	10.34	4.05	8.48	-	.31	12.83	2.19	3.14	-	1.57	30.16	31.73	-	16.24	-	4.40	-	4.40	-
108	6.82	19.32	1.13	3.41	-	-	4.54	4.54	-	1.13	1.13	20.45	21.59	-	32.96	-	3.41	1.13	4.54	-
111	8.83	23.53	2.94	5.89	-	-	8.83	5.89	-	-	-	2.94	2.94	-	44.12	-	-	-	5.89	-
112	16.93	31.98	2.50	5.02	.31	-	7.83	4.39	1.57	-	-	22.26	22.26	-	11.92	-	2.20	-	0.94	-
113	10.25	37.50	1.28	8.34	-	-	9.62	2.89	1.28	.32	-	2.25	2.25	-	35.26	-	-	-	0.64	-
114	15.79	36.84	-	-	-	-	-	15.79	-	-	-	-	-	-	31.58	-	-	-	-	-
115	11.68	25.22	1.81	7.21	-	-	9.02	4.51	2.70	-	-	3.60	3.60	-	42.35	-	-	-	0.90	-
116	3.22	19.35	6.45	32.26	-	-	38.71	6.45	-	-	-	3.22	3.22	-	29.04	-	-	-	-	-
117	7.47	25.28	3.45	9.77	.57	-	13.79	6.32	2.88	2.88	-	4.59	4.59	-	36.20	-	-	-	.57	-
118	9.76	24.40	2.44	3.65	-	-	6.09	3.65	-	-	-	21.95	21.95	-	25.62	-	2.44	-	6.10	-
119	-	-	-	-	-	-	-	-	-	-	-	42.9	42.9	-	57.1	-	-	-	-	-
120	-	12.5	12.5	12.5	-	-	25.0	-	-	-	-	-	-	-	37.6	-	-	-	25.0	-
121	20.0	40.0	-	-	-	-	-	-	-	-	-	-	-	-	40.0	-	-	-	-	-
122	-	4.09	.32	1.26	-	0.57	2.15	4.42	3.16	-	-	69.48	69.48	-	8.53	-	3.47	-	4.42	-
88	-	2.32	-	-	-	-	-	-	-	97.28	-	-	-	-	0.33	-	-	-	-	-
97	0.30	3.57	0.89	-	0.89	-	1.78	.30	-	90.18	-	-	-	-	4.16	-	-	-	-	-
Nelson-302	1.59	21.27	.95	8.25	-	-	9.20	1.90	1.27	23.17	4.76	7.30	12.06	-	14.60	14.60	.32	-	-	-
GR49-3A	-	6.09	-	2.54	-	-	2.54	17.77	3.55	-	3.55	34.01	37.56	1.02	16.24	-	7.11	-	7.11	1.02
GR49-25B	-	4.49	-	3.27	-	-	3.27	4.08	-	-	.82	59.59	60.41	-	11.84	.82	9.80	1.22	4.08	-
GR49-17-2D	4.92	-	-	4.92	-	-	4.92	-	-	-	-	50.82	50.82	-	16.39	-	9.84	-	13.11	-
68 ANC 250B	-	6.67	.81	3.23	-	-	4.04	8.08	5.66	.20	.20	59.39	59.59	-	7.27	-	2.22	.20	6.06	-
246B	-	8.82	-	8.82	-	-	8.82	17.65	5.88	-	-	38.24	38.24	-	5.88	-	14.71	-	-	-

TABLE III

Cruise	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Frag.	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
68 ANC 243	-	1.73	.58	1.16	-	-	1.74	4.05	.87	.87	1.16	76.01	77.17	-	8.09	-	4.34	-	1.16	-
239	11.54	26.93	-	1.92	-	-	1.92	11.54	5.77	-	1.92	23.08	25.00	-	13.46	-	-	-	3.85	-
237	1.08	6.49	.81	.54	-	-	1.35	6.22	4.32	1.62	-	66.76	66.76	-	9.73	-	1.89	-	.54	-
231	-	-	-	-	-	-	0.00	12.50	-	-	-	62.50	62.50	4.17	16.67	-	4.17	-	-	-
230	4.51	20.08	2.46	2.46	.41	-	5.33	15.98	-	2.05	-	29.10	29.10	.41	14.75	-	1.63	-	4.92	1.23
228	1.00	7.75	1.25	1.00	-	-	2.25	9.25	5.75	-	1.00	53.50	54.50	-	10.50	-	2.25	.25	6.50	-
227	1.15	4.90	2.88	-	-	-	2.88	6.05	5.76	.58	.29	57.06	57.35	-	9.51	-	2.88	-	8.93	-
225	2.24	17.46	.75	3.24	-	-	3.99	4.99	5.99	.75	.75	36.66	37.41	-	17.96	-	5.49	.50	3.24	-
224	5.02	23.85	3.97	3.77	.42	-	8.16	6.69	5.65	2.93	.42	23.64	24.06	1.05	14.44	-	5.23	-	2.93	-
222	4.08	24.94	3.40	8.39	.45	-	12.24	9.75	4.76	1.36	.91	24.72	25.63	.23	11.11	-	2.95	.45	2.49	-
220	10.55	32.61	0.47	8.87	-	-	15.34	9.11	2.16	2.16	1.92	8.39	10.31	-	14.63	-	.96	-	2.16	-
215	3.91	27.09	4.47	2.51	-	-	6.98	9.78	5.59	2.51	2.23	20.67	22.90	.28	17.32	-	1.68	1.12	.84	-
212	1.76	15.62	2.77	3.27	-	-	6.04	6.30	7.81	-	2.02	39.55	41.57	.25	9.57	-	6.30	-	4.03	.76
172	3.04	30.89	4.05	4.81	-	-	8.86	8.86	6.58	1.01	.25	24.56	24.81	-	10.38	-	1.77	0.00	3.80	-
169	4.55	25.68	4.77	11.14	.45	-	16.36	11.14	5.45	.68	-	11.82	11.82	-	8.86	-	2.95	.91	11.36	-
159	3.83	19.13	3.28	9.29	-	-	12.57	9.29	2.19	-	3.28	13.11	16.39	-	29.51	-	4.37	-	2.73	-
156	7.04	24.62	2.51	10.05	-	-	12.56	5.53	3.02	2.01	.50	16.08	16.58	-	24.12	-	1.01	-	3.52	-
148	10.26	38.46	-	-	-	-	0.00	-	-	15.38	-	10.26	10.26	-	25.64	-	-	-	-	-
147	12.89	38.14	2.58	11.86	-	-	14.44	6.19	.52	1.55	.52	3.61	4.13	.52	14.43	7.22	-	-	-	-
144	4.10	34.70	2.73	12.02	.82	-	15.57	1.09	8.47	7.38	1.09	5.19	6.28	-	20.22	.55	.27	-	1.37	-
121	.75	46.82	-	1.12	-	-	1.12	1.12	-	39.70	-	-	0.00	-	10.49	-	-	-	-	-
116	.30	9.82	-	-	.89	-	.89	-	-	87.80	-	-	0.00	-	1.19	-	-	-	-	-
102	.71	42.76	3.33	4.28	1.43	-	9.04	1.90	1.66	35.63	.95	.24	1.19	-	6.89	-	-	.24	-	-
93	1.21	35.08	2.82	9.27	-	-	12.09	3.63	3.63	-	1.61	7.26	8.87	-	35.08	-	-	-	.40	-
90	4.29	28.22	3.37	7.67	.31	-	11.35	4.29	2.15	3.68	2.45	11.96	14.41	-	29.75	-	1.53	-	.31	-
89	.68	20.55	2.40	3.77	-	-	6.17	4.79	2.40	5.14	1.37	19.86	21.23	-	35.62	-	1.03	1.71	.68	-
84	2.97	21.29	4.95	22.77	-	-	27.72	1.98	7.18	.74	.50	9.90	10.40	-	20.79	.74	.50	5.69	-	-
81	4.55	22.08	9.74	21.43	-	-	31.17	3.25	-	-	1.95	9.09	11.04	-	24.68	-	-	-	3.25	-
79	2.12	34.04	2.66	17.55	-	-	20.21	5.32	2.93	.53	1.60	11.44	13.04	-	19.15	-	1.06	.80	.80	-

TABLE III

Cruise	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Frag.	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
68 ANC 77	-	58.90	4.93	9.86	-	-	14.79	1.10	3.84	.55	.82	7.12	7.94	-	12.88	-	-	-	-	-
76B	2.54	21.12	7.12	25.95	-	-	33.07	2.04	6.87	1.02	-	13.74	13.74	-	16.93	-	.51	1.27	1.02	-
V67-124	.26	5.24	1.31	2.88	-	-	4.19	4.95	3.40	-	1.83	62.83	64.66	.26	8.38	-	2.36	-	6.28	-
120	-	3.32	1.81	1.81	-	-	3.62	4.53	3.02	-	.30	70.09	70.39	.30	4.53	-	5.14	-	5.14	-
116	-	5.77	1.05	1.57	-	-	2.62	7.09	4.72	-	-	68.77	68.77	.52	6.04	-	2.62	-	1.84	-
99	.25	3.78	.50	2.52	-	-	3.02	5.79	1.26	.50	2.02	66.25	66.27	1.51	6.55	-	2.27	.76	6.05	-
82	-	2.29	.76	-	-	-	.76	4.58	3.82	-	-	74.81	74.81	-	4.20	-	6.11	-	3.44	-
79	-	7.14	.51	3.71	-	-	4.28	8.29	2.29	.57	-	56.57	56.57	.29	12.80	-	4.00	-	3.71	-
67	-	7.87	-	1.97	-	-	1.97	5.57	2.95	.66	1.64	61.31	62.95	-	10.16	-	4.26	-	3.61	-
71	-	9.68	1.43	1.43	1.72	-	2.86	9.68	4.66	.72	.72	49.46	50.18	.36	12.19	-	2.87	-	6.09	-
NW 261-1	-	18.75	3.13	-	1.56	-	4.69	4.69	-	12.50	21.88	-	21.88	25.00	6.25	-	-	-	6.25	-
4	-	25.96	9.62	23.08	-	-	32.70	5.77	-	.96	1.92	5.77	7.69	-	16.35	-	-	-	10.58	-
3	-	24.22	6.47	11.27	-	-	17.74	4.56	5.76	1.20	-	25.42	25.42	-	10.07	.24	2.40	.48	7.91	-
5	.75	53.38	-	2.26	-	-	2.26	-	.75	3.01	-	7.52	7.52	-	32.33	-	-	-	-	-
10	0	0	0	0	0	0	0	0	0	0	0	0	0.00	-	0	0	0	0	0	0
11	-	18.18	-	9.09	-	-	9.09	-	-	3.03	-	9.09	9.09	-	57.58	-	-	-	3.03	-
12	6.62	29.27	4.88	5.57	-	-	10.45	5.57	.70	1.39	-	4.18	4.18	.35	36.59	.35	1.74	-	2.79	-
13	-	20.69	-	-	-	-	0.00	-	-	-	-	-	0.00	-	79.31	-	-	-	-	-
21	-	37.04	-	11.11	-	-	11.11	3.70	-	-	-	3.70	3.70	-	37.04	-	-	7.41	-	-
TT-19-29	1.83	24.70	2.74	5.18	-	-	7.92	4.57	2.13	7.01	-	24.09	24.09	-	25.30	-	1.83	-	.61	-
-31	3.53	29.71	2.35	3.53	-	-	5.88	2.06	4.71	-	.59	24.41	25.00	-	27.65	-	.59	-	.88	-
-55	1.20	40.67	5.02	16.27	.48	-	21.77	1.44	4.07	1.20	-	17.22	17.22	-	11.96	.48	-	-	-	-
TT018-18	7.89	29.32	5.26	12.78	-	-	8.04	6.39	1.13	.75	1.13	2.63	3.76	-	31.58	-	-	-	1.43	-
-22	12.42	29.53	4.03	14.77	.34	-	19.14	4.36	.67	1.34	.67	2.35	3.02	.67	26.85	-	1.34	-	.67	-
-6	13.43	34.36	2.04	6.37	-	-	8.41	8.43	0.91	0.91	0.46	2.73	3.19	-	26.62	-	1.60	-	2.04	-
-9	1.21	24.31	1.82	3.04	-	-	4.86	2.73	-	6.07	0.31	5.47	5.78	-	53.48	0.31	-	-	-	-
-12	0.43	8.90	-	0.84	-	-	0.84	1.68	-	83.90	-	0.43	0.43	-	2.98	-	1.27	-	-	-
-13	1.95	23.06	10.00	10.28	-	-	20.28	3.05	8.05	5.28	0.83	14.72	15.55	-	14.45	-	3.05	0.28	5.00	-
-14	-	4.65	1.74	3.48	-	3.48	8.71	2.91	5.26	-	-	26.74	26.74	-	9.30	-	-	-	42.44	-
-15	4.25	35.46	5.32	8.51	-	-	13.80	6.38	4.61	7.09	0.71	9.57	10.28	-	15.60	0.71	1.41	-	0.36	-

TABLE III

Cruise	Orthopyroxene	Clinopyroxene	Amphiboles					Epidote	Sphene	Olivine	Garnet			Apatite	Rock Frag.	Zircon	Staurolite	Kyanite	Chloritoid	Rutile
			Brown	Green	Oxy	Colorless	Total				Colorless	Pink	Total							
TT018-17	9.20	11.50	1.15	6.90	-	-	8.05	8.05	-	1.15	1.15	13.79	14.94	-	42.52	1.15	3.44	-	-	-
-19	10.91	24.55	-	10.00	-	-	10.00	3.64	0.91	2.73	-	2.73	2.73	-	44.55	-	-	-	-	-
-10	-	23.37	8.97	27.99	-	-	36.96	1.01	3.79	0.88	0.38	2.02	2.40	-	8.98	-	0.26	0.26	0.88	-
-21	11.29	33.33	1.29	10.25	-	-	11.54	5.39	1.79	2.05	1.02	7.69	8.71	-	23.85	-	1.29	-	0.77	-
-23	15.88	38.21	1.49	3.72	-	-	5.21	6.45	0.50	1.24	-	4.96	4.96	0.24	21.84	-	1.99	-	3.47	-
-24	12.03	30.33	4.52	10.52	-	-	15.04	6.30	0.50	-	0.25	3.53	3.78	-	27.57	0.50	-	-	4.01	-
-26	18.01	29.59	1.65	8.77	-	-	10.42	8.77	0.54	0.82	0.82	7.95	8.77	-	19.45	-	0.54	-	3.02	-
-29	-	30.96	3.41	3.09	-	0.31	6.81	1.55	1.24	2.17	0.93	36.84	37.77	0.62	9.28	-	6.51	0.31	2.79	-
-31	0.52	22.59	2.34	0.52	-	-	2.86	1.82	4.68	2.07	2.07	47.54	49.61	-	8.83	-	5.71	0.78	0.52	-
-32	2.08	17.70	4.43	8.07	-	0.26	12.76	10.93	6.26	1.30	0.26	27.08	27.34	-	9.89	-	5.73	1.04	4.95	-
-33	0.85	22.66	6.23	13.60	-	-	19.83	10.20	7.08	0.56	1.14	21.54	22.68	0.29	9.35	-	2.83	0.29	3.40	-
-35	0.90	30.43	4.22	22.29	-	0.30	26.81	3.75	9.53	1.0	3.07	14.99	18.06	-	12.27	-	2.39	-	0.34	-
-37	1.26	37.34	2.53	15.20	-	-	17.73	0.63	4.43	1.58	1.58	27.47	24.05	-	11.71	-	0.95	0.32	-	-
-42	2.50	31.25	0.83	6.26	-	-	7.09	3.74	4.16	14.16	2.91	13.32	16.24	-	19.58	0.83	0.42	-	-	-
-43	-	30.54	3.90	15.92	-	-	19.82	4.23	5.53	1.30	2.60	8.44	11.04	-	25.98	-	0.65	0.98	-	-
-46	1.59	12.69	1.91	1.27	-	-	2.18	4.44	5.72	-	0.32	60.32	60.64	-	2.23	-	5.40	-	4.13	-
-47	4.24	30.31	5.15	1.44	-	-	6.59	7.27	4.24	1.22	1.51	11.22	12.73	0.91	14.55	-	0.91	-	1.22	-

TABLE IV

SOME CHARACTERISTICS OF ZIRCONS

Station	Euhedral	Partly Euhedral Partly Rounded	Rounded	Subhedral	Anhedral	Elongation Maxima
Nome Area	6·1	13·4	68·6	4.2	7.7	1·52*, 2·12
Northeast Cape Beach	13·0	24·2	17·4	44·7	24·2	1·52*, 2·12
SU-138	12·6	18·1	14·0	28·1	28·5	1·32*, 1·60*, 2·12, 2·92
ANC-90B	21·1	17·1	13·9	19·5	28·5	1·60*, 2·12, 3·12
TT018-37	12·5	11·8	46·5	16·2	12·9	1·52*, 2·12, 2·52
TT018-9	12·9	17·4	20·3	26·0	23·0	1·32*, 2·32, 3·28
ANC-147	13·5	17·5	26·7	23·5	18·7	1·52*, 3·28

* prominent

TABLE V

Percentages of quartz and felspars in the light material with specific gravity < 3.15 in the 2.75-4.0ϕ size fractions of a few typical samples

Station No.	Quartz	Plagioclase	Orthoclase
ANC-116	32.1	48.15	19.75
SU-138	40.29	9.95	49.76
ANC-144	41.59	17.11	41.30
ANC- 93	38.30	18.09	43.62
ANC-147	43.87	30.86	25.28
-243	68.91	5.45	13.46
TT-19-55	63.10	21.03	15.13
TT-19-29	38.63	18.05	25.63
TT-19-31	55.83	24.72	17.22
ANC- 94	16.34	35.95	45.10
- 83	43.87	19.94	36.20
- 84	52.49	17.62	29.89
- 89	46.69	19.87	33.44
- 77	58.20	19.14	21.88
TT-18-30	66.84	16.05	13.95
TT-18-31	71.51	13.66	13.95
ANC- 50	66.67	14.29	16.48
ANC-237	62.36	14.39	12.92
ANC-228	62.90	16.71	19.16
-225	60.91	16.15	20.68
-220	56.51	17.45	23.44
TT-18 (16)	40.88	38.69	17.52
BSP II-12 (N.W)	44.01	32.39	21.13
TT-18 (20)	30.32	50.69	14.58
TT-18-15	36.91	20.47	39.26
TT-18-26	45.25	32.67	21.41
TT-18-25	43.24	33.33	21.98
TT-18-24	44.88	36.74	15.81
TT-18-23	43.68	38.79	14.94
TT-18-22	41.24	48.39	8.99
TT-18 (29)	46.00	16.00	16.80
BSP II-10 (N.W)	31.46	38.11	18.41
TT-18-12	31.90	48.75	17.92
BSP-3 (N.W)	55.64	21.82	19.64
BSP II (4) (N.W)	45.79	26.74	25.64
TT-18-13	45.31	29.69	20.94

TABLE VI

Percentages of quartz and felspars in the light material with specific gravity < 3.15 in the 1-2.75ϕ size fractions of a few typical samples

Station No.	Quartz	Plagioclase	K Felspar	Shell Fragments
ANC-5013	72.0	10.3	17.7	-
TT-018-29	68.2	16.0	15.8	-
TT-018-30	85.8	7.2	7.0	-
TT-018-31	88.1	5.1	6.8	-
TT-018-15	57.3	17.0	25.2	.5
TT-018-16	61.2	17.1	21.8	-
TT-018-20	59.6	23.2	17.1	-
TT-018-25	65.2	21.3	13.5	-
TT-018-24	66.25	18.10	15.6	-
TT-018-26	61.5	24.3	14.3	-
TT-018-23	54.0	25.0	21.0	-
TT-018-22	63.0	23.0	14.0	-
TT-018-12	68.3	19.9	11.9	-
N.W-261-10	59.0	26.1	14.7	-
N.W-261- 4	65.6	18.6	15.8	-
N.W-261- 3	62.3	24.2	13.6	-
ANC- 116	29.3	39.0	18.2	13.3
SU-138	42.10	23.8	33.7	.27
ANC-144	44.3	16.7	34.0	5.3
ANC- 94	36.7	36.2	25.8	1.2
ANC- 83	44.7	22.7	32.2	.3
ANC-147	51.0	28.2	20.6	.3
ANC-243	89.6	6.9	3.5	-
TT-019-31	64.5	21.7	13.9	-
TT-019-55	72.0	17.2	10.5	.3
TT-019-29	67.1	20.4	11.1	.6
ANC- 93	51.0	17.8	23.9	7.4
ANC- 84	56.9	22.0	16.0	5.0
ANC- 89	56.5	17.8	25.1	.7
ANC- 77	56.5	28.5	14.9	.2
ANC-237	58.92	23.21	17.85	-
ANC-228	55.6	23.8	20.5	-
ANC-225	63.4	22.3	14.3	-
ANC-220	61.8	22.5	15.16	.41