THE ACQUISITION AND EVALUATION OF GRAVITY DATA IN THE CANADIAN ARCTIC ARCHIPELAGO

by

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INTRODUCTION

The Canadian Arctic Islands are, for the most part, ideally suited both geologically and physiographically for the use of gravity data to evaluate regional and specific geological situations. The terrain is generally favorable; the geology, although not simple, maintains a high degree of consistency over large distances; density differences between the different structural or age units are fairly strong; and finally, much competent geological and geophysical field data is publicly available.

The Canadian Government, through its Polar Continental Shelf Project, initiated the acquisition of gravity data in the Canadian Arctic Islands about 1958. This data is, in the main, on a square grid approximately 8-10 miles over the sea ice surrounding the islands. In addition, there are limited data available for some of the land in the Arctic as, for example, across the ice cap on Meighen Island and across typical dome structures in the Isachsen Area. Some 9,000 such stations have been observed north of Latitude 70°N. Private industry in the last two field seasons has sponsored the acquisition of some 2,700 gravity observations on the ice, and a further 17,300 gravity observations on land. The location of this recent gravity data as acquired by both industry and government and the 1971 coverage proposed by industry and government is shown in Figure 1.

Acquisition of Gravity Data

Much of the private industry gravity surveying in the Canadian Arctic Islands has taken place in the last three years; gravity surveying had been commonly used in the Mackenzie Delta Area for several years prior to 1968. The government work, as noted, commenced in 1960 and has been available to industry on a continuing basis in the form of maps, reports and computer print outs since 1961. The operations of industry have been on several of the Arctic Islands and on inter-island ice. Most of the ice work has been carried out in the Sverdrup Basin, extending from Massey Strait between Axel Heiberg and Amund Ringnes on the east, southwards through Norwegian Bay, westward through the Belcher Channel, and including Hassel Sound between Amund and Ellef Ringnes Islands, south of King Christian Islands, across the south tip of Lougheed Island, and on both east and west sides of Sabine Peninsula.

The form of coverage has varied from gravity meter observations along seismic lines, to lines of gravity data across known structures at regular intervals, to a grid coverage on spacings from 1 mile to 8 miles, to lines of data on the ice across the suspected geological strike, to grids of data on the ice at intervals from 4 kilometers to 8 miles. The government

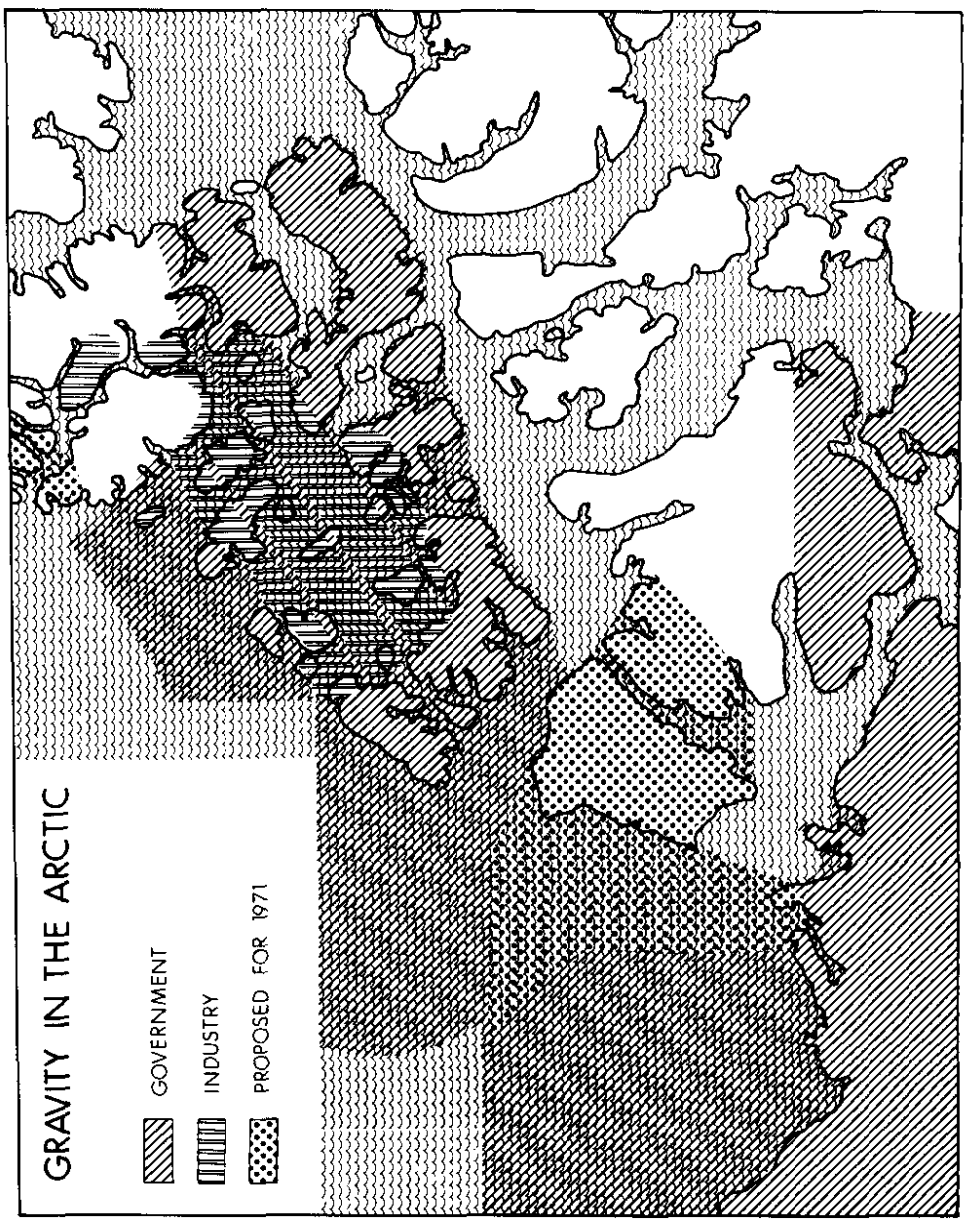

GRAVITY IN THE ARCTIC
GOVERNMENT
INDUSTRY
PROPOSED FOR 1971

Fig. 1

surveys, for example, have been regionally based and have served to bring out the broad gravity features. These surveys have not been as accurate in respect to the location of the station or the determination of the elevation or depth as have been the private surveys which have been oriented towards more specific geological targets.

Having given a broad background picture respecting the acquisition of gravity data in the Canadian Arctic Islands, we may now go on to the specifics of how these various data have been acquired. For each gravity observation, whether on land or on ice, the acquisition of the gravity meter observation is standard and straightforward, with the one exception that ice work is generally carried out using meters with additional damping. The relation of any particular observation to a known base station is again made in the usual fashion with traverse intervals kept to the three or four hour time period.

In the case of ice surveys, the horizontal location is one of the measurements which may introduce basic inaccuracies into the final gravity data. There have been three electronic positioning systems used for the ice surveying by government and industry. The Polar Continental Shelf Project used a Decca Lambda System; this is a navigation system familiar to most explorationists which uses three fixed transmitting positions to generate a hyperbolic system of lanes. It is a low frequency (wave length 1,000 - 10,000 meters) system with accuracy reported as a percentage of lane width and expected to average, depending on the station's distance from the transmitter positions and relationship to a base line, between $\pm$ 100-500 meters.

Contractors working for the petroleum industry have used the Cubic Autotape range-range system and the Motorola RPS Radar Positioning System, also range-range, for their work. Both of these systems are a relatively high frequency and are thereby not as badly affected by the ice-sea water interface refraction phenomena as lower frequency systems. Of the two, the Motorola System has a higher frequency and is apparently the less affected from the phenomena noted. The Autotape and RPS System will give a position accurate and generally repeatable to $\pm$ 10 meters.

All the systems depend on a tie to a previously defined land point. Fortunately, in the Canadian Arctic Islands there is a good network of horizontal control points throughout, these having been accurately surveyed by Canadian Government agencies. For each of these triangulation points, a plat exists giving a full description of the ground position, the geophysical position both in latitude and longitude, and in Universal Transverse Mercator co-ordinates, and a portion of an aerial photograph showing the surface characteristics of the station. The experience has been that these stations are readily located on the ground from the descriptions just noted. The importance of horizontal location can be emphasized by noting that an error of 100 meters will introduce an error into the gravity data of 0.05 milligals.

The last important measurement to be made in making a gravity observation on the ice is that of water depth. It is assumed that for inter-

island ice there is very little rafting or other thickening of the ice sheet, and therefore no allowance is made for the gravity effect of changes in the ice thickness. This has been supported by actual measurements, 6 - 20 feet has been the observed range of thickness over 3 years in the Sverdrup Basin. This measurement has been made in one of two ways, first by the use of specially adapted echo sounders whose transducers are positioned on a scraped and oiled ice surface. The echo sounder techniques has been found to work in the inter-island ice in over 90 per cent of cases, if discretion is taken by the operator in selecting a position for his transducer to new or one-year ice. This has become a matter of experience of observation, and between the helicopter pilot and operator there are very few places on any type of grid that new or suitable ice cannot be recognized. In those locations where ice conditions are such that an echo sounding cannot be made, then a hole is drilled through the ice with an electrical or gasoline-driven ice auger and a calibrated plumb line lowered to the bottom. In the late spring and early summer when surface ice conditions are such that proper acoustic coupling between transducer and ice surface cannot be obtained, then surveys are carried out using seal air holes or open leads in the ice as positions for plumbing or sounding. As a matter of operating practice, a hole is bored in the ice and plumbed at a location convenient to a particular area of survey. This location is flagged, ranged with the navigation system, and used as a checkpoint for calibration of the echo sounders. It has been found that these devices will repeat to within 1 per cent.

In relation to the acquisition of ice data, the gravity meter surveys on the islands of the Arctic are relatively simple and differ little from gravity surveys in any other remote area.

Land surveys have been carried out in the Arctic Islands using helicopters, tracked vehicles, and operators on foot, to carry the meter. Gravity observations are made in the normal fashion and tied to the Dominion Observatory Base Station Network. Elevations are obtained either by standard surveying methods or by using two survey altimeters in the vehicle for dual measurements at each station, and corrections for barometric changes, made from recording microbarograph data from locations close to a particular traverse and as well, from a check barograph at the base camp. Wet and dry bulb temperature measurements are made, as appropriate, so that the temperature and relative humidity affects on barometric devices may be determined.

The location of the station on the ground has been variously obtained by standard survey methods, as when stations are taken in conjunction with seismic survey; by the use of semicontrolled photomosaics laid to existing government topographic maps; or, by controlled photomosaics where photogrammetric methods are used to establish a precise horizontal control for the aerial photographs and airborne profile records for the establishment of basic elevation control.

Compilation of land data is by normal methods, and if topographic affects are considered to be of importance, then changes in local topography out to about 550 feet are estimated by the operator in the field. If the topography is severe, as may be the case in the eastern portion of

the Arctic, then topographic maps can be used for the larger terrain corrections.

The overall accuracy of land gravity surveying using altimetry for elevation and photos for location is expected to be between .3 and .5 milligals. Better accuracy is obtained from ice surveys, between .15 and .30 milligals, because a more accurate method of positioning and a more precise technique for measuring water depth is available.

Physiography

Figure 2 gives as simple a picture as possible of the area. It has been divided into four (4) main physiographic regions. These are:—

(a) *The Arctic Coastal Plain,* which is low-lying and very flat, much of it consisting of unconsolidated sand and gravel flats whose maximum elevation is less than 200 feet above sea level, and upon which topographic relief rarely exceeds a few tens of feet.

(b) *Lowlands,* which are characterized by topography of a very subdued appearance, partially dissected by meltwater streams, with long, low ridges and a gently, shelving coastline. Surface elevations usually remain less than 600 feet above sea level, and local relief seldom exceeds 100 feet.

(c) *Uplands,* these consist of broad ridges whose summits may attain elevation as high as 1,500 feet or so above sea level, with local relief of as much as 500 feet in some areas. Sometimes the ridges are edged by scarps or cut by streams to depths of 100 feet or more.

(d) *Plateux,* these have surfaces that (at least in the western part) are generally smooth or gently undulating, youthfully dissected, and with average elevations of about 1,000 feet above sea level. Local relief is generally a few hundreds of feet. (Source G.S.C. Memoir 332)

The terrain, therefore, generally is favorable to gravity surveying throughout most of the islands. The practical difficulties arise mostly in connection with working on the sea ice between the islands, and in the rugged topography of parts of Axel Heiberg and Ellesmere Islands.

General Geology

One of the most attractive features about the Arctic islands as far as interpreting geophysics is concerned is the large amount of very competent geological survey work that has been done there. There is available an extensive list of reports by the Geological Survey of Canada, which include some work on almost every island in the archipelago. This provides a very solid framework upon which to build interpretations. At this point it is appropriate to give a very brief summary of the main features, as extracted from the G.S.C. papers, emphasizing particularly those points which have had an influence upon the regional geophysical studies which are to follow.

The map shown in *Figure 3,* taken essentially from a paper by Thorstinsson and Tozer, shows the main structural provinces of the high

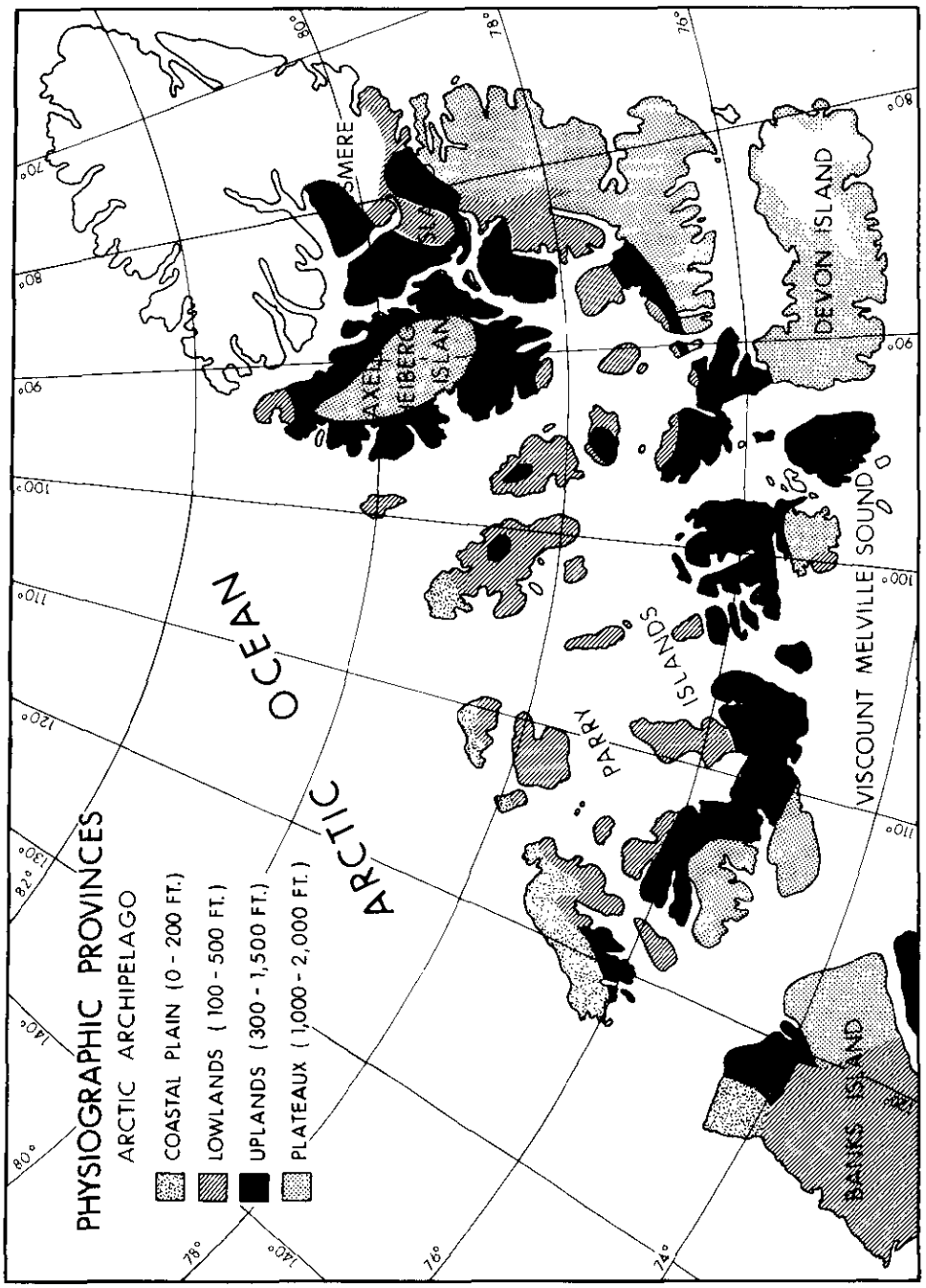

PHYSIOGRAPHIC PROVINCES
ARCTIC ARCHIPELAGO
COASTAL PLAIN (0 - 200 FT.)
LOWLANDS (100 - 500 FT.)
UPLANDS (300 - 1,500 FT.)
PLATEAUX (1,000 - 2,000 FT.)
ARCTIC OCEAN
DEVON ISLAND
VISCOUNT MELVILLE SOUND
PARRY ISLANDS
BANKS ISLAND
80°
78°
76°
74°
70°
90°
100°
110°
120°
130°
140°

Fig. 2

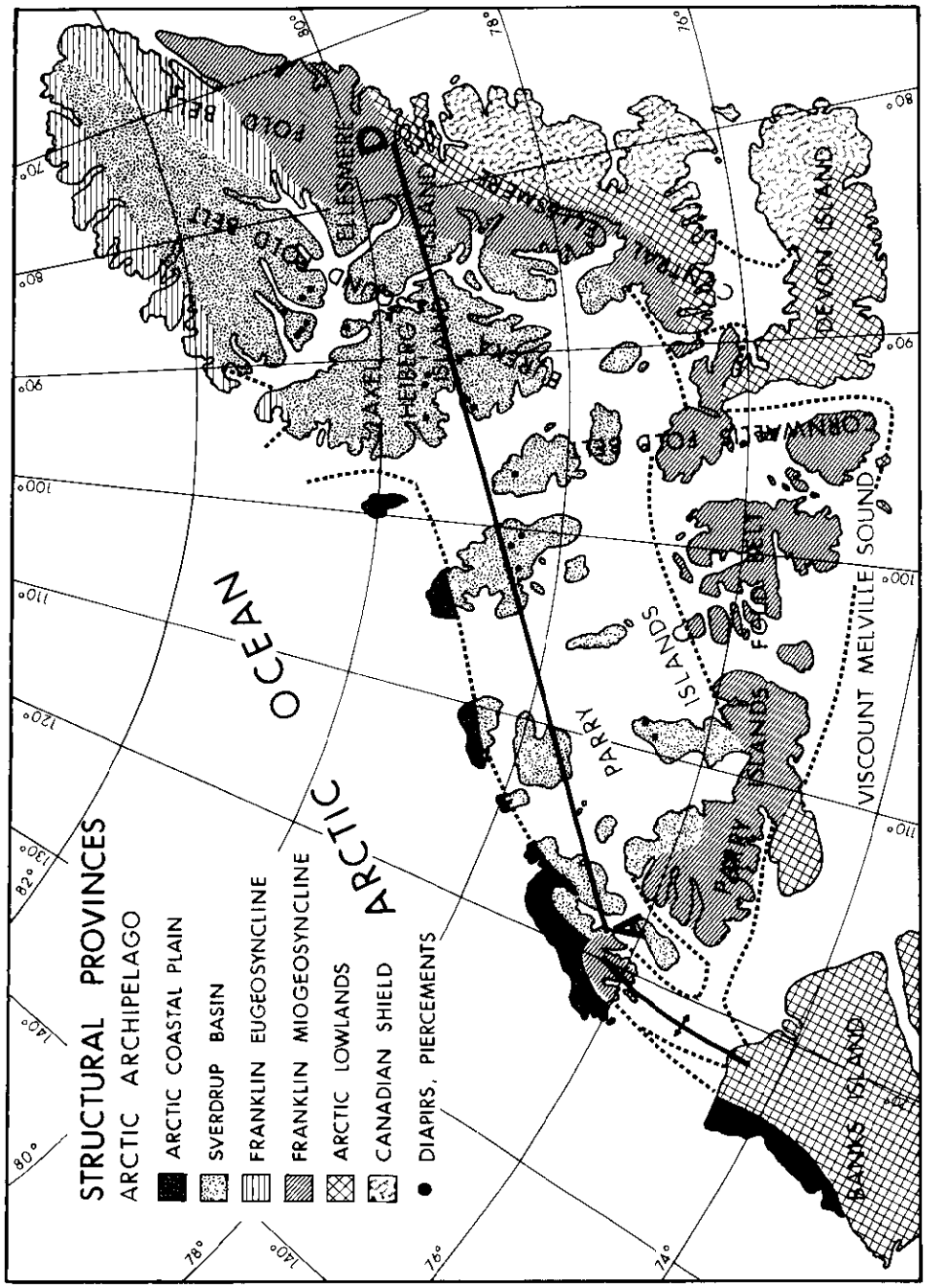

STRUCTURAL PROVINCES
ARCTIC ARCHIPELAGO
ARCTIC COASTAL PLAIN
SVERDRUP BASIN
FRANKLIN EUGEOSYNCLINE
FRANKLIN MIOGEOSYNCLINE
ARCTIC LOWLANDS
CANADIAN SHIELD
DIAPIRS, PIERCEMENTS
ARCTIC OCEAN
ELLESMERE ISLAND
AXEL HEIBERG ISLAND
DEVON ISLAND
CORNWALL
PARRY ISLANDS
VISCOUNT MELVILLE SOUND
BANKS ISLAND
FOLD BELT

Fig. 3

Arctic. The area that is now occupied by the Arctic Archipelago was the site of widespread sedimentary deposition during the Paleozoic Era, and again, in the northern part, during the whole of the Mesozoic and the early part of the Cenozoic Eras. This activity is normally described in terms of subsiding troughs which developed off the northern rim of the Precambrian Shield both during the Paleozoic and again during the Mesozoic. The Paleozoic subsidence, which was the more widespread, produced what is known as the Franklin Geosyncline, the Mesozoic depression, which was more local, produced the Sverdrup Basin, lying within the geosyncline.

Over most of the exposed area, the rocks of the Franklin Geosyncline can be divided into a shaley graptolite facies and a calcareous or shelf type facies. As pointed out by Tozer, it is reasonable to assume that the graptolite beds were deposited in a deep trough (or troughs) flanked by shelf areas that are characterized by shallow water and carbonate type depositions. This type of sedimentary regime is typical of a miogeosynclinal environment, and the southern part of the Franklin Geosyncline is generally regarded as being of this type. In northern Ellesmere and Axel Heiberg islands, the appearance of volcanic rocks in the succession and a widespread occurrence of metamorphism suggest a eugeosynclinal facies, and therefore we infer that the axial region of the Franklin Geosyncline must have been at about this position. If one assumes that the eugeosynclinal rocks extend southwest from Ellesmere Island beneath the younger rocks of the Sverdrup Islands, then the main axis of the Franklin Geosyncline must have followed this trend. The available evidence supports this concept, but the northwesterly side of the geosyncline, which is nowhere now in evidence, can only be postulated as "tectonic lands" now submerged beneath the Arctic Ocean.

Turning briefly to a tectonic history of the area, it appears that at least three major events have taken place, each one of which has imprinted its signature upon the present structure.

The first and earliest event that we know about was related to the Boothia uplift and produced the north-trending folds on Cornwallis and Bathurst Islands. Field evidence indicates that these movements were post-upper Silurian and pre-middle Devonian in age. They were not intense and they were rather local in extent. They resulted in broad, shallow syclines separated by more tightly folded anticlines.

Apart from this interruption, deposition apparently continued in the geosyncline from the Cambrian almost to the end of the Devonian Period.

The second and more widespread event occurred between the Upper Devonian and Middle Pennsylvanian Periods, and effectively brought sedimentation within the Franklin Geosyncline to an end. This was the orogeny that produced the Parry Islands and Central Ellesmere Fold Belts, which extended along the south rim of the geosyncline all the way from western Melville Island to northern Ellesmere Island, except for a short interruption by the Cornwallis Fold Belt.

It is not known, of course, whether or to what extent these structures extend northward beneath the younger rocks of the Sverdrup Basin; perhaps it should be one of the aims of gravity surveying to find this out.

A new period of sedimentation began in the Middle Pennsylvanian, which continued essentially uninterruptedly into early Tertiary time. These young sediments were deposited into a new depression called the Sverdrup Basin which gradually subsided along an axis extending from the north tip of Sabine Peninsula on Melville Island through the Sverdrup Islands to northern Ellesmere Island. The subsidence was much more intense on the side east of the Boothia uplift than it was on the west side. In contrast to the carbonates and shales that were deposited in the Franklin Geosyncline, most of the sediment within the Sverdrup Basin is sandy, especially near the margins, although it becomes more shaley toward the centre. Near the base of the sequence some carbonates and evaporites are exposed on Ellesmere and Axel Heiberg Islands. There are no marked angular unconformities within the succession, but several formations were transgressive to the south and southwest, and there is an overstep of a Lower Tertiary formation to the east. Much of the sediment therefore probably comes from the south and east, although some of it — of a more marine facies — appears to have come from the northwest.

This brings us to the third and final important tectonic event, which happened during the Tertiary Period and brought to an end the long period sedimentation into the Sverdrup Basin. This may in some respects have been the most intense of the three orogenies, because it produced not only folding but thrust faulting throughout much of the archipelago, and left as its major mark the Eureka Sound Fold Belt. Thrust faults occur with particular intensity along the southeastern rim of the basin. Evaporites were intruded at about this time to form piercement domes and diapirs along the axis of the Sverdrup Basin.

The area has remained fairly quiet since the violent Tertiary orogenies. The post-Tertiary period produced a series of normal faults, chiefly in the western part of the Sverdrup Basin which had earlier escaped the worst of the Tertiary compression. These are responsible for some of the present topography, as well as for the Eglinton Island Graben between Prince Patrick and Melville Islands, and perhaps also for a number of the remarkably straight stretches of coastline that appear elsewhere among the islands.

Interpretation of Data

From the above picture of the regional geology of the archipelago, we can set out rational objectives for regional and detailed gravity surveys. Anticipating a difference in mean density between the rocks of the Franklin Geosyncline and those of the Sverdrup Basin, and also between the Sverdrup Basin sediments and the evaporites, it seems reasonable to expect that gravity surveys might be able to do the following:

1. delineate the major basins in the archipelago, and in particular determine the main architectural features of the Sverdrup Basin — its depth, shape and contours;

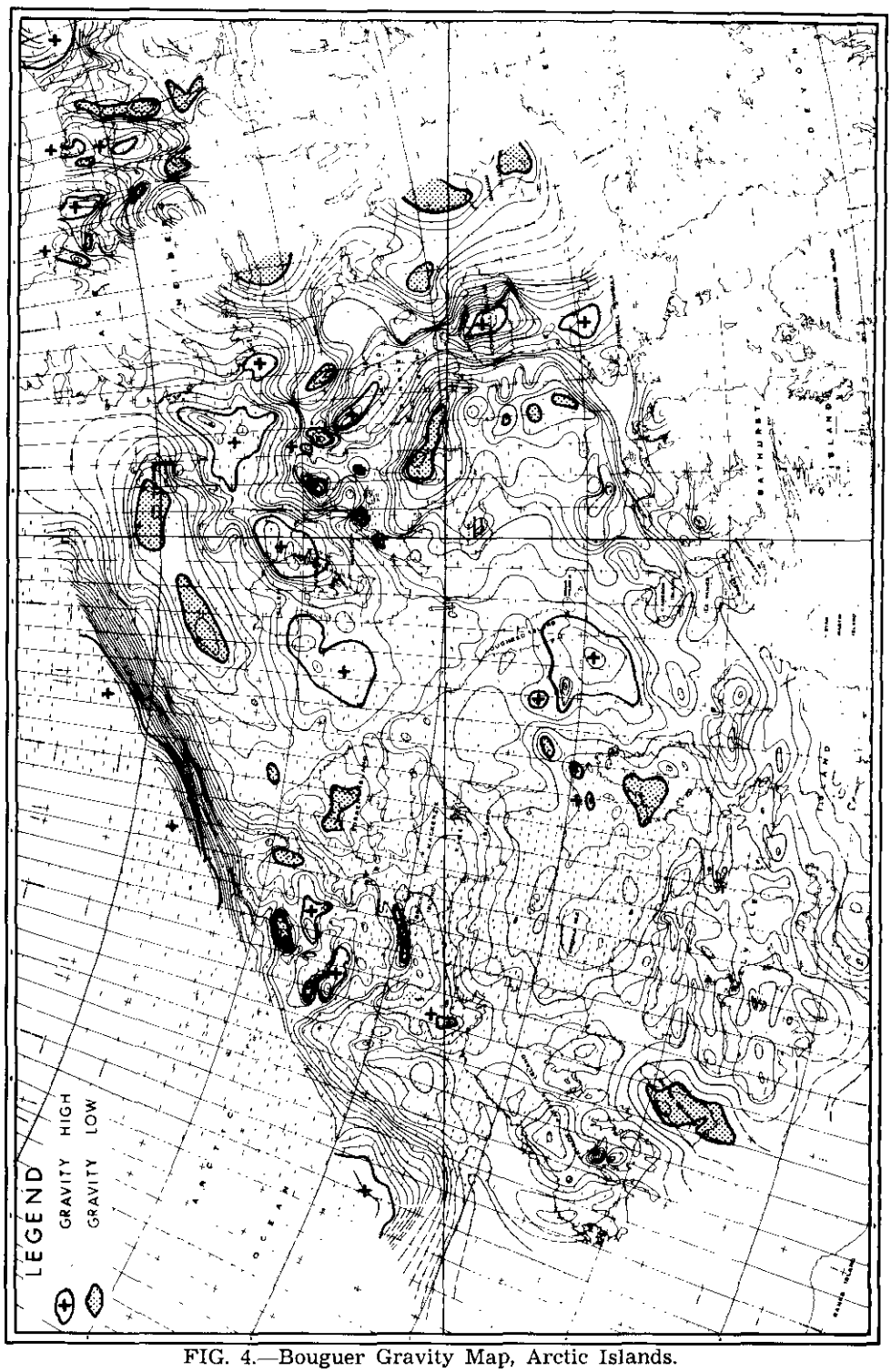


FIG. 4.—Bouguer Gravity Map, Arctic Islands.

2. indicate the presence or otherwise of folds in the Paleozoic rocks beneath the Sverdrup Basin;

3. outline important sedimentary structures in the Sverdrup Basin or along its margins; and

4. outline the forms and the depth extent of piercement structures within the Basin.

The first objective, and to some extent the second, can be met at least partially, from gravity data which are already in the public domain (*Figure 4*). Through the years 1960 to 1968, field parties of the Department of Energy, Mines and Resources' Dominion Observatory have measured gravity at more than 9,000 points in the archipelago, most of them on sea ice using fixed wing aircraft and helicopters. These data are published and may be purchased at a very nominal price. Figure 4 is a map of the Bouguer gravity field in the archipelago drawn from data that were available to 1970 and prior to the recent publication by the Observatory. The mean spacing between stations is roughly 8 - 12 miles, and is sufficiently small to enable us to determine the major changes taking place in sedimentary thicknesses throughout the area. A discussion of the interpretation of these data will follow.

The third and fourth objectives, namely the determination of sedimentary and piercement structures require detailed gravity surveys and are not further discussed except to say that the general industry experience has been favorable in this regard.

To point out some of the more obvious features of the Bouguer gravity field, notice the strong expression of a northward extension of the Cornwallis Fold Belt, which we may consider to be a part of the Boothia Uplift system. Notice also the Eglinton Graben anomaly and the very positive effects which coincide with the gabbroic intrusions of Ellef Ringnes Island. These occur just where a eugeosynclinal axis had been postulated from surface geology, which fits in very nicely with the classical concept of geosynclinal development. The Sverdrup Basin is not very clearly visible on this map, at least not where its axis is thought to be.

To interpret this map, the average densities of the different rock types must be known, and postulating these figures are the most critical assumptions that must be made in the whole interpretation process. Piecing together all of the information obtainable, both published and unpublished, and using data from boreholes, surface samples and seismic observations, it is concluded that two major density breaks occur within the sedimentary column. The first is either at the base of the Triassic or at the Permo-Pennsylvania unconformity that marks the bottom of the Sverdrup Basin, although the base of the Triassic was selected because the Permo-Pennsylvanian rocks appear to turn into carbonates in the deeper parts of the basin. (Thorstinsson & Tozer, 1960). This break marks a transition from the rocks of the Franklin Geosyncline to the sandy and largely unfossiliferous rocks of the Sverdrup Basin.

The second major break occurs within the shelf facies of the Franklin Geosyncline. It is observed on Melville and Prince Patrick Islands, where

it occurs within the Middle Devonian and marks a transition from rather porous, clastic, shelf rocks to comparatively dense shales, argillites and dolomites which will be referred to as the "Paleozoic Basement". Below the Paleozoic Basement there do not appear to be any further significant density changes, even at the Precambrian surface. The only exceptions to this statement occur within the two zones of basic intrusions that pass through northern Ellef Ringnes Island and through Cornwall and Amund Ringnes Islands, both of which must be dealt with as local interpretation problems.

In summary therefore, the sediments in the archipelago are made up of three major units for the purpose of interpreting the regional gravity data. These are: (1) rocks of the Sverdrup Basin, being the least dense; (2) clastic sediments of the Franklin Miogeosyncline; and (3) the Paleozoic Basement, consisting predominantly of shales and limestones. There are not thought to be any further density subdivisions beneath the Paleozoic Basement that are sufficiently widespread to constitute a fourth unit.

INTERPRETATION OF GRAVTY DATA

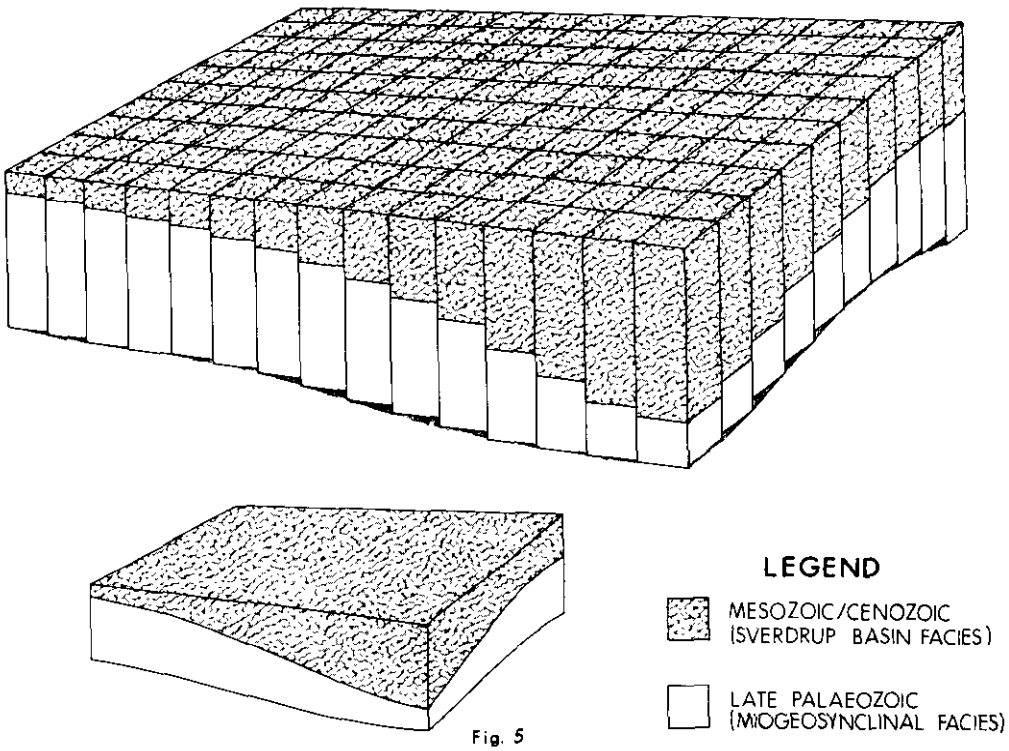


Fig. 5

The densities attributed to these three units are derived from a variety of different kinds of data as previously noted — that is from exposed thicknesses of the different units where these have been measured in the

field, and from the effects of topography upon the gravity field. Due to the sketchiness of these controls, there is a good deal of personal judgment in the ultimate choice of density values, and it is well to keep in mind that these values can very easily be changed. As the density differences are changed, so also are the sizes of the structures that are interpreted from the gravity field. What normally happens is that the density differences that are assumed are correct in some places and incorrect in others, so that depths obtained from gravity interpretations are not, as a rule, to be taken too literally. On the other hand, the relative changes in those depths — i.e. the thickening and thinning of the sections — are generally to be believed.

The algorithm that was used for computing depths from a grid of gravity values is shown in *Figure 5*. It should be mentioned here that the computer program is self-adjusting, so that it will continue making alterations in the depths of the prisms until all of the gravity values are fitted to within a specified tolerance, or else it can prove the fit no further. Two density contrasts were allowed within the section, which is the maximum that the computer can accommodate at the present state of the programming art.

The results of this treatment are now presented. *Figure 6* is an isopach map of the Mesozoic/Cenozoic rocks as interpreted from the gravity data. If one refers to the map of Bouguer gravity, one will remember that the axis of the Sverdrup Basin was not very evident. This is an example of one of the subtleties of interpretation. The gravity field must first be dismantled and the positive masses beneath the Paleozoic Basement properly accounted for. Then the Sverdrup Basin shows up very clearly in the residual field.

Next in *Figure 7* is shown an isopach map of the clastic rocks of the Franklin Miogeosyncline. These are thought to belong mainly to the Middle and Upper Devonian Period. They may also include some of the Permo-Pennsylvanian strata of the Sverdrup Basin, should these have a density that is closer to the value assumed for the Devonian clastics than to the value assumed for Mesozoic. It now becomes clear that the very prominent lows in the gravity field south of Ellef Fingnes Island are the expression of a Paleozoic rather than a Mesozoic basin. It is also interesting to see how cleanly this basin is severed by the Boothia Uplift, indicating that this feature was positive throughout much of Paleozoic time. The termination of the clastic rocks probably marks the transition from miogeosynclinal to eugeosynclinal type facies.

Figures 8 and 9 give a comparison between the gravity interpretation and surface mapping through the axial part of the Sverdrup Basin. The section runs from Mould Bay on Prince Patrick Island to Canyon Fiord on Ellesmere Island. *Figure 8* was taken from a paper by Thorstinsson and Tozer (1960) and shows a reconstructed section using the base of the Tertiary as datum, and therefore shows how the Sverdrup Basin might have looked at the beginning of the Tertiary Period prior to the great orogeny. For that reason, it is not really possible to compare the two drawings quantatively. They do show, however, that the general shape

MESOZOIC AND TERTIARY
ISOPACH MAP
0 - 5,000 FEET
5,000 - 10,000 "
10,000 - 15,000 "
15,000 - 20,000 "
OVER 20,000 "
ARCTIC OCEAN
AXEL HEIBERG ISLAND
ELLESMERE ISLAND
DEVON ISLAND
VISCOUNT MELVILLE SOUND
BANKS ISLAND
80°
78°
76°
74°
70°
80°
90°
100°
110°
120°
130°
140°

Fig. 6

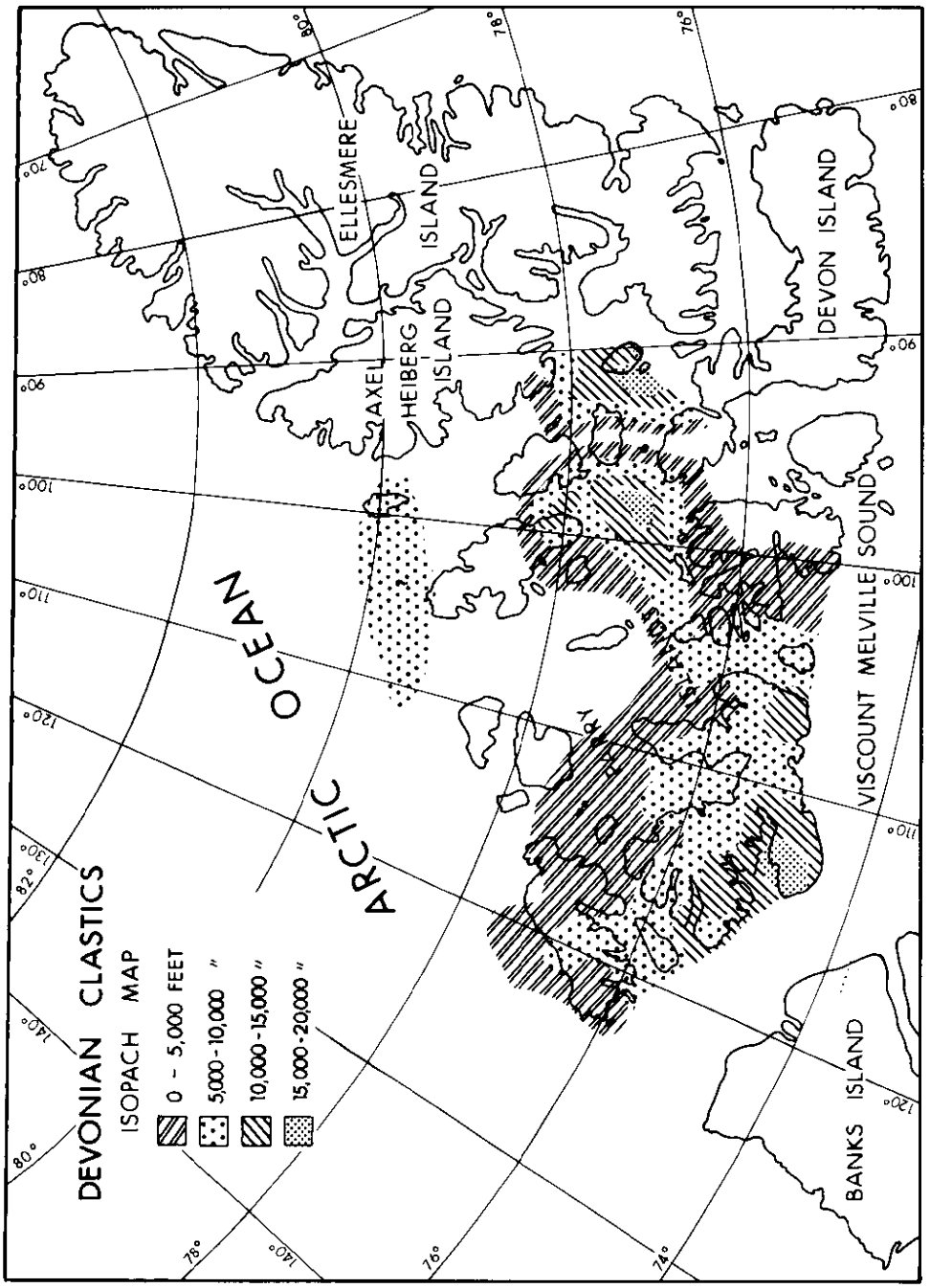

DEVONIAN CLASTICS
ISOPACH MAP
0 - 5,000 FEET
5,000 - 10,000 "
10,000 - 15,000 "
15,000 - 20,000 "
ARCTIC OCEAN
ELLESMERE ISLAND
AXEL HEIBERG ISLAND
DEVON ISLAND
VISCOUNT MELVILLE SOUND
BANKS ISLAND
SOUTH
82°
80°
78°
76°
74°
70°
80°
90°
100°
110°
120°
130°
140°

Fig. 7

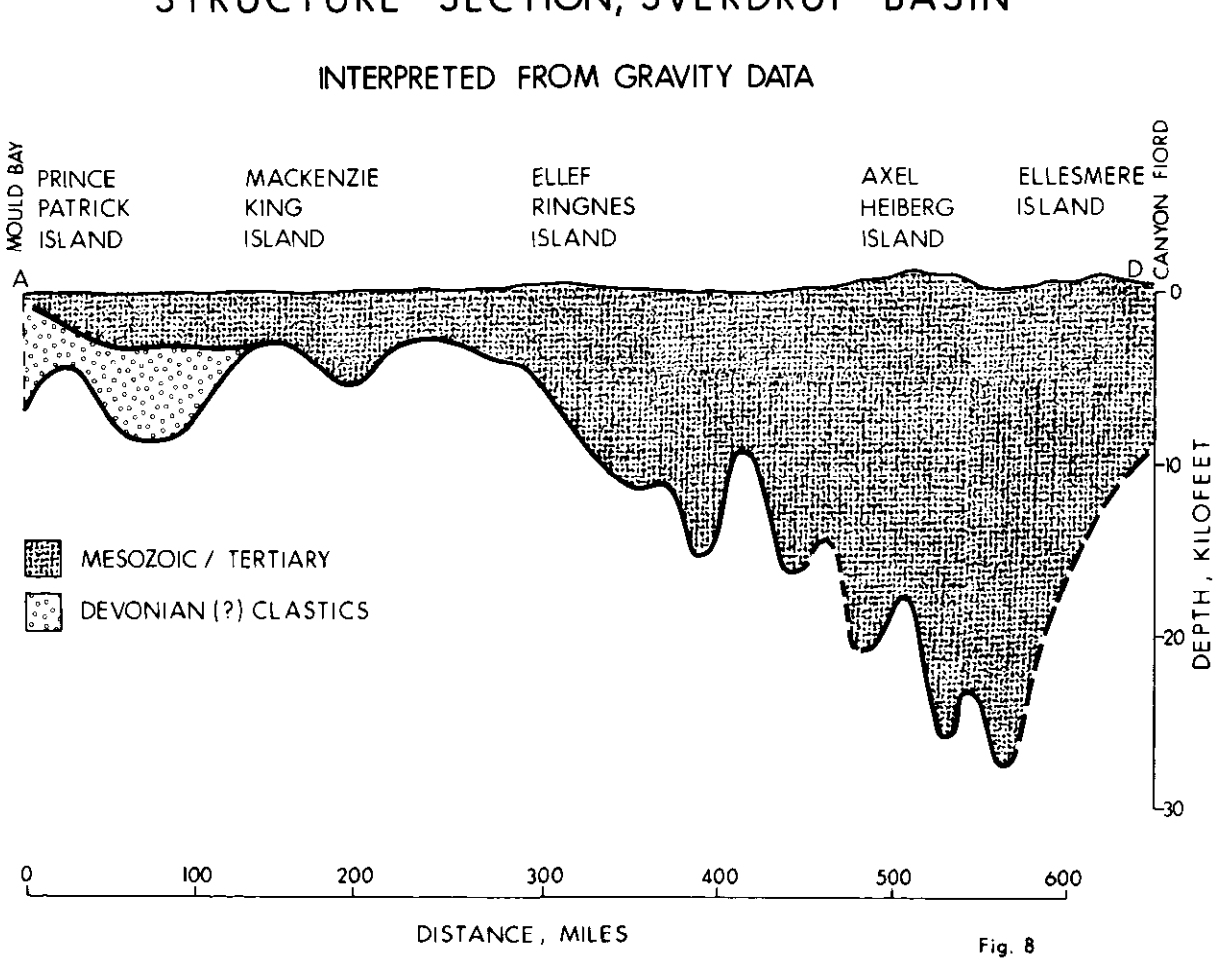
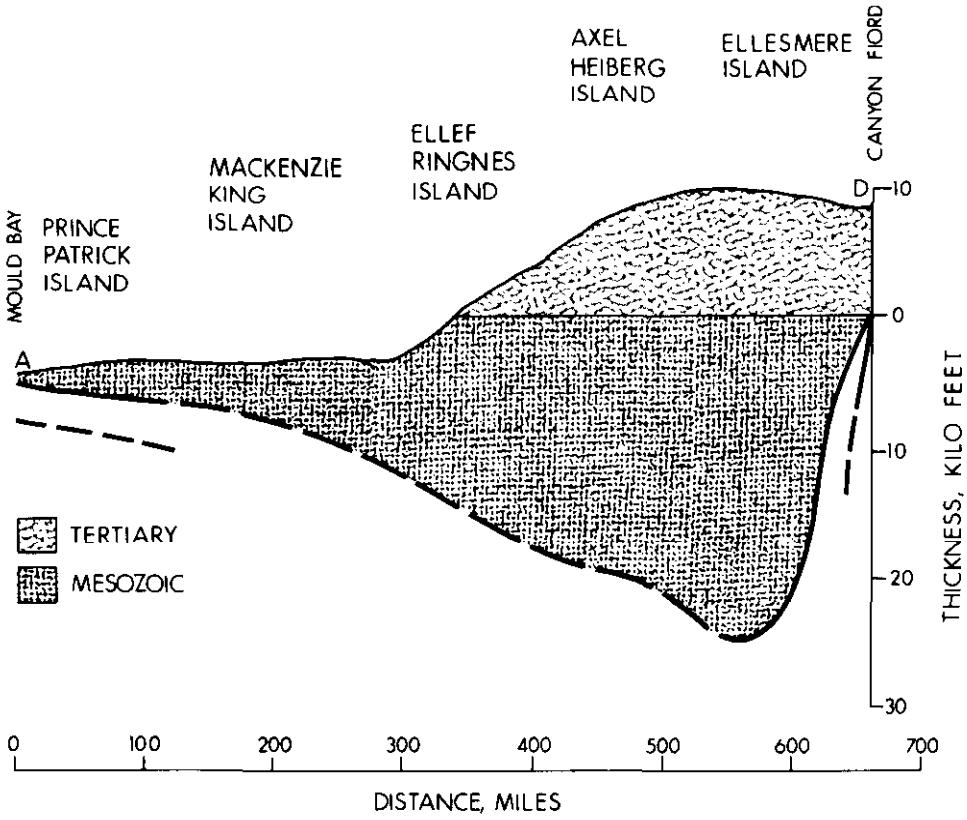

STRUCTURE SECTION, SVERDRUP BASIN
INTERPRETED FROM GRAVITY DATA
MOULD BAY
PRINCE PATRICK ISLAND
MACKENZIE KING ISLAND
ELLEF RINGNES ISLAND
AXEL HEIBERG ISLAND
ELLESMERE ISLAND
CANYON FIORD
A
D
MESOZOIC / TERTIARY
DEVONIAN (?) CLASTICS
0
10
20
30
DEPTH, KILOFEET
0
100
200
300
400
500
600
DISTANCE, MILES

Fig. 8



THICKNESS SECTION SVERDRUP BASIN

(THORSTEINSSON & TOZER, 1960) Fig. 9

and dimensions of the Sverdrup Basin as worked out by Thorstinsson and Tozer are confirmed by gravity. In addition, the gravity interpretation shows something of the magnitude and intensity of the Tertiary folding. You will note that there is some discrepancy between the total thickness as indicated by gravity on the one hand and by surface mapping on the other. This might be real, of course, but it could also be eliminated by slightly reducing the density differences between the main units or, what really amounts to the same thing, by allowing for an increase in the amount of shale within the deeper parts of the basin. This ambiguity between total depth and density difference will have to remain unsettled until the interpretation is tested either by drilling or by seismic profiling. However, it is the structural configuration of the basin that is probably the more interesting feature at this stage, and this is relatively insen-

sitive to density changes that take place gradually over many tens of miles.

The question may be asked "what has been learned from a regional gravity study?" The first thing is that the Sverdrup Basin is not at all simple in form. It consists of at least two more or less parallel troughs which have been strongly deformed by Tertiary folding and thereby fragmented into a series of pockets separated by ridges. The Mesozoic rocks appear to attain their greatest thickness, and have also suffered the greatest amount of deformation, east of Ellef Ringnes Island. The western part of the basin is quite shallow and relatively underformed. It contains fairly uniform and rather meagre deposition, and has a structural style that is characterized by gravity faulting rather than by compressive folding.

Also it points out that the clastic rocks of the Franklin miogeosyncline appear to terminate towards the axial region of the geosyncline. The distribution of Upper Devonian facies has been interpreted and is shown in *Figure 10,* also of Middle Devonian facies, as shown in *Figure 11.* The picture that is revealed by these two drawings is one of a shallow sea that became progressively more shallow through Devonian times and finally dried up altogether toward the close of the Upper Devonian period. Sedimentation apparently came predominantly from the south and east, but some may have come from land masses to the north and west whose existence can only be postulated. There may have been at least two narrow openings into the Arctic Ocean in this chain judging from the shape of the facies boundary. The subsidence which followed during the interval from the Middle Pennsylvanian to the beginning of the Tertiary Period was apparently very uneven, and led to the formation of a Mesozoic basin of rather a complex form. This complexity of shape was further increased by later Tertiary folding of considerable intensity which took place along roughly north-south axes, and which appears to have broken up the basin into a number of pockets separated by ridges.

These conclusions can be put forward with a fair degree of confidence from the combined study of gravity data and geology. Inferences of a more particular sort which we might also draw from these data are more conjectural, and involve assumptions or hypotheses that are not scientifically demonstrable or arise from some personal bias. Nonetheless, quite a lot of potentially useful information about the Sverdrup Basin and its geological setting has been gained from a fairly modest investment, in interpretation effort. Gravity surveying has thus established itself beyond much reasonable misgivings as an effective method for interpolating gross sedimentary geology across regions of the Arctic Archipelago where it cannot be mapped.

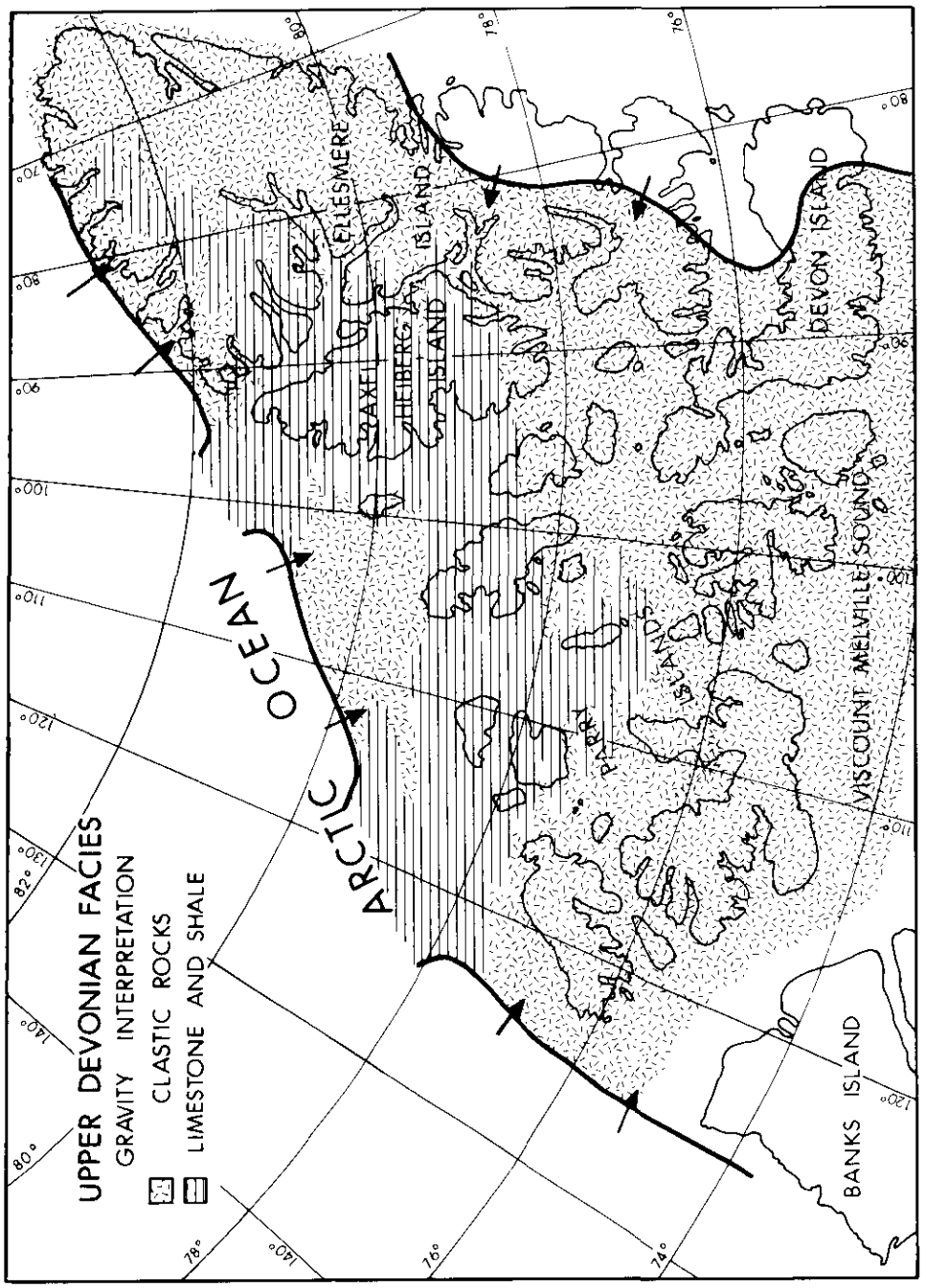

UPPER DEVONIAN FACIES
GRAVITY INTERPRETATION
CLASTIC ROCKS
LIMESTONE AND SHALE
ARCTIC OCEAN
ELLESMERE ISLAND
AXEL HEIBERG ISLAND
DEVON ISLAND
PRINCE PATRICK ISLAND
VISCOUNT MELVILLE SOUND
BANKS ISLAND

Fig. 10

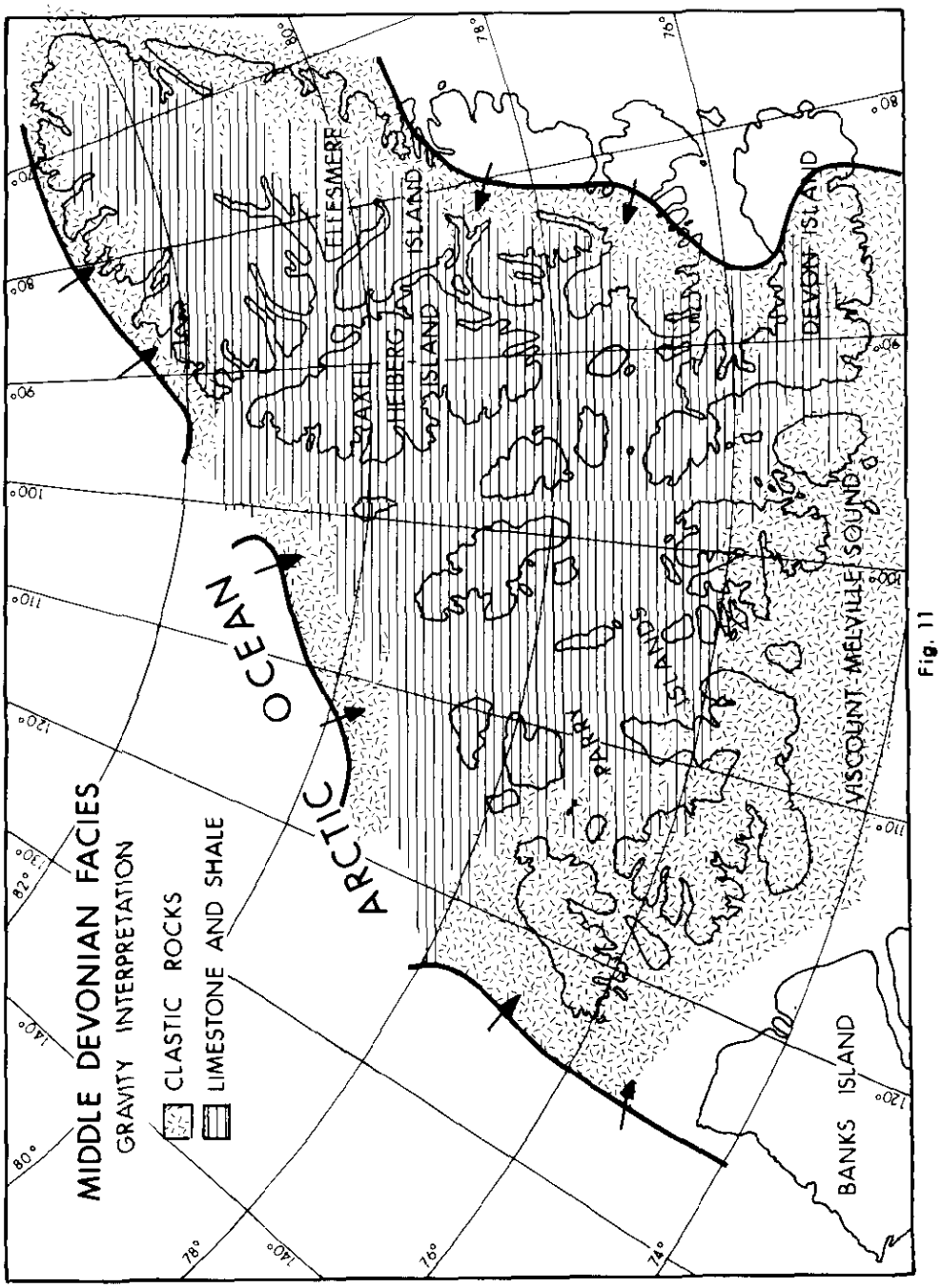

MIDDLE DEVONIAN FACIES
GRAVITY INTERPRETATION
CLASTIC ROCKS
LIMESTONE AND SHALE
ARCTIC OCEAN
ELLESMERE ISLAND
AXEL HEIBERG ISLAND
DEVON ISLAND
VISCOUNT MELVILLE SOUND
PARRY ISLANDS
BANKS ISLAND
80°
78°
76°
74°
100°
110°
120°
130°
140°

Fig. 11