THE GEOLOGY OF PART OF ELLEF RINGNES ISLAND IN THE CANADIAN ARCTIC

By

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Department____________________

Date____________________

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INTRODUCTION

LOCATION

Ellef Ringnes Island is located in the Queen Elizabeth Group Islands in the northwestern part of the Canadian Arctic Archipelago. (Fig. 1). The island, centered on latitude 78°N. and longitude 103°W., is approximately 2000 miles north of Winnipeg, Manitoba. The area mapped includes 600 square miles in the vicinity of the Isachsen Meteorological station. (Fig. 2).

MEANS OF ACCESS

Aircraft offer the most dependable means of access to Ellef Ringnes Island. These can be used only during the winter months when the ground is frozen and able to support the weight of the aircraft. Float planes for summer use would be of limited value as there are seldom large areas of water clear of floe ice for periods longer than a few days. Because of yearly variations in ice conditions, ships are not dependable.

TRAVEL CONDITIONS AND FIELD WORK

Cross country travel is difficult during all seasons of the year. Extreme cold and frequent blizzards restrict field work in the winter months. In April and May temperatures are below freezing but travel on foot and in vehicles is possible.

During the summer months vehicles are of little use because of the extremely muddy nature of the ground. Subsurface drainage is restricted by the permafrost table which does not exceed 26 inches in depth; as a result the surface soil may be partly or completely saturated. Walking, though difficult at times, is the only sure means of travel.

Fieldwork is hindered in cloudy and foggy weather because of difficulty in determination of location and orientation. The weakness of the earth's magnetic field and many local magnetic attractions make compass readings unreliable.

SCOPE AND PERIOD OF PRESENT INVESTIGATION

This report is based on field work by the author, as an employee of the Geological Survey of Canada, in the field seasons of 1952 and 1953. The detail of mapping varies considerably throughout the map area. The amount of detail depends upon travel conditions, accessibility, and weather. Twelve days were spent mapping the Isachsen dome in the summer of 1953.

Air photographs have made it possible to extend the geologic mapping between and beyond the regions traversed on foot. The limits of the areas mapped on foot are illustrated by dashed lines on the geologic map (Plate II). The dotted lines indicate geologic boundaries extended through the use of air photographs. An intrusive structure occurs 9 miles northeast of the Isachsen dome (Plate I). This was not examined, but air photographs show structural and physiographic features similar to those of the Isachsen dome.

EXPLORATION, HISTORY AND PREVIOUS WORK

Ellef Ringnes Island was discovered in 1901 by Isachsen and Hassel of the second Norwegian Arctic Expedition. Travelling by dog team from their base in Jones Sound, they surveyed the coastline and noted the major topographic features on a map published in 1904. A few geological specimens were collected and descriptions of them were published by Sverdrup (1904). It was not until 1916 that the island was again visited. In April, 1916, MacMillan (1918) stopped briefly at Cape Nathorst on the south coast of the island. In June of the same year Stefansson (1921) of the Canadian Arctic Expedition arrived on Cape Isachsen on the northern end of the island, then continued his explorations farther north. Returning from this journey in July, he mapped part of the coast bordering on Hassel Sound. In 1917 he continued exploration of this region and mapped parts of the western coast of the island. No further work was attempted until April, 1948, when a meteorological station was established at Isachsen (78° 47' N, 103° 32' W). This is a joint project of the Meteorological Division of the Canadian Department of Transport and the United States Weather Bureau (Rae, 1951). Supplies and equipment are transported by air from Resolute Bay on the southern coast of Cornwallis Island. In 1950, the Royal Canadian Air Force completed the aerial photography of Ellef Ringnes Island.

Except for the specimens collected by Isachsen and Hassel, no previous field work has been done on Ellef Ringnes Island.

Jenness (1952) described some physiographic features that he considered might be of glacial origin. Brown (1951) studied the air photographs of the Isachsen dome and proposed several hypotheses that might explain its origin.

CLIMATE

The climate of the Arctic Archipelago has been one of the chief obstacles to exploration. Long cold winters and short cool summers are common throughout the northern islands. Rae (1951) describes the climate as "......a modified marine type with extreme winter temperatures not as low and extreme summer temperatures not as high as in a continental area at the same latitude".

The Isachsen meteorological station was established in May 1948. It has been in continuous operation since that time. The accompanying table (Table 1) is a resume of temperature, precipitation, cloud cover and wind velocities as published by Rae. The data in the table are compiled for the period from May 1948 to December 1950. In his discussion of these data Rae points out the fact that there is a possible error in the charts as they were derived from records of less than 3 years duration.

The extreme temperatures recorded at Isachsen are minus 60 degrees Fahrenheit and plus 64 degrees Fahrenheit.

Table 1 Data on Climate at Isachsen Meteorological Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year	Range
Monthly and annual averages of daily mean temperatures (°F).	-37	-33	-26	-20	10	30	38	33	16	-5	-22	-31	-4	75
Monthly and annual averages of daily maximum temperatures (°F).	-31	-27	-19	-12	17	36	42	38	21	2	-11	-26	2	73
Monthly and annual averages of daily minimum temperatures (°F).	-43	-40	-32	-28	4	26	34	29	10	-11	-26	-35	-9	77
Average monthly and annual rainfall in inches.	0.00	0.00	0.00	0.00	0.00	T	0.44	0.36	T	0.00	0.00	0.00	0.80	
Average monthly and annual snowfall in inches.	0.7	0.6	0.6	0.5	3.2	1.4	2.9	1.3	7.4	1.4	2.0	0.5	21.5	
Average cloudiness in days per month. 0-20 % 30-70 % 80-100%	16 4 11	12 4 12	13 5 13	16 6 8	9 5 17	4 4 22	3 6 22	4 5 22	3 3 24	9 7 15	14 5 11	18 4 9		
Mean cloudiness (percent)	44	48	51	34	61	78	80	78	81	58	46	39		
Average wind speed (m.p.h.)	10.2	9.9	7.8	4.1	7.0	10.6	11.1	9.2	11.0	12.0	7.6	4.3	8.7	

The annual precipitation is less than in many desert regions. Of the average annual total of 2.95 inches, 0.80 is in the form of rain and 2.15 is in the form of snow. Rain occurs as a light drizzle in July and August and although heavy rains are uncommon, the writer observed several heavy rainstorms in July and August of 1953. The total rainfall in these two months was nearly 3 inches, almost 4 times the annual average. Snow falls in all months of the year with the heaviest falls recorded in May and September.

The average cloud cover for the summer months is nearly 80 percent. Fog and low cloud is common and often persists for several consecutive days.

The prevailing winds are from the north and northwest, except in the summer months when there is a strong south to southwest component. Although the mean velocity is not appreciably different from the rest of Canada, the apparent velocity is much greater. This is because there is no shelter from the wind nor anything to break its force.

TOPOGRAPHY AND DRAINAGE

The mapped region of Ellef Ringnes Island is largely a plain. However, part of the region, northeast of Deer Bay, is a deeply dissected plateau. The differences in relief and the stages of the erosion cycle are dependent to a considerable extent on the types of bedrock present.

In the plains area shale is the dominant rock, with minor amounts of limestone and poorly consolidated sandstone. The mature, stream dissected plains have an average elevation of about 400 feet. The surface is undulating with a local relief of 150 feet; only a few of the numerous streams that form a dendritic drainage pattern have eroded valleys that deep. The sedimentary strata have a low regional dip to the southeast. The more resistant beds form long, low, cuesta escarpments that cross the plains in a northeasterly direction.

The lower part of the Isachsen Sandstone, which crops out in the central part of the map area, produces a badlands type of topography. Although the average elevation is not much greater than that of the plains, the local relief may be as much as 350 feet. The major streams as well as many of the tributary streams have eroded deep, narrow canyons.

The plateau area, underlain by diabase, has an average elevation of approximately 1000 feet. Headward and downward erosion by the larger streams has deeply dissected the peripheral areas. Short canyons with steep gradients are 250 to 300 feet in depth. Drainage on the undulating plateau surface is poorly defined and drainage channels are non-existant over most of the plateau area.

The Isachsen dome (Fig. 3), located in the south central part of the island, stands 400 to 600 feet above the surrounding plain and approximately 1000 feet above sea level. Viewed from a distance the central part of the dome has the profile of an

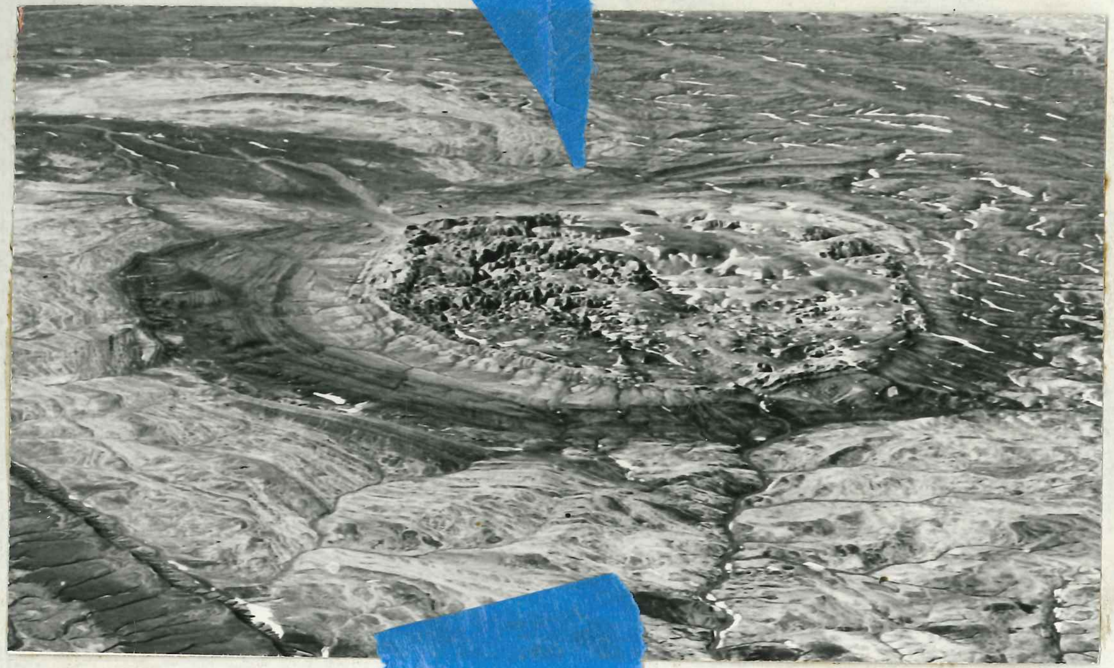

Fig. 3. Oblique view of the Isachsen Dome from the east. Note the upland region on the right side of the Dome and the extremely dissected part on the left. (R.C.A.F. photograph T428 - 118).

even topped tableland, dropping with steep sides to the adjacent plain. Well over half of this is highly dissected, with a maximum relief of about 500 feet (Fig. 5). This part of the core is drained by deeply incised streams forming a fine grained dendritic drainage pattern. On the other hand, a small part of the core is a rolling upland, much like the plateau northeast of Deer Bay. This part of the core is underlain by detached basalt sheets and blocks of all dimensions.

RAISED STRAND LINES

Raised strand lines have been noted in only two localities on Ellef Ringnes Island. A study of air photographs did not reveal their widespread development in any other area.

Strand lines occur on the southern end of one of the peninsulas extending southward into Deer Bay. The highest strand line has an elevation of 50 feet above sea level. This peninsula is mantled with coarse sand and gravel derived from basalt and gabbro. A second occurrence of strand lines is on the east side of Deer Bay. Here they are formed in angular gravels derived from a high diabase capped ridge.

Strand lines are preserved in those areas that are relatively free from the processes of erosion and mass wasting. Therefore they are found only in regions underlain by coarse sand and gravel. As these are of limited extent, few strand lines have been preserved.

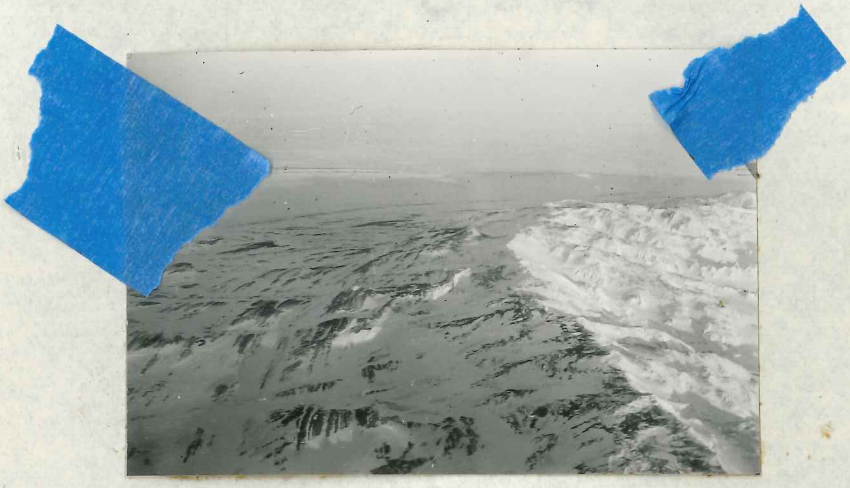

Fig. 4. Aerial view of the upwarped sedimentary rocks on the southeast side of the Isachsen dome. Dissected core on the right side of the photograph.

Fig. 5. Dissected core of the Isachsen Dome.

FLORA AND FAUNA

Ellef Ringnes Island is nearly barren of vegetation. Stefansson (1921) appropriately described the island when he wrote "......I did not see a blade of grass, and the district struck me as the most barren I had ever seen." Moss and lichen grow in the more protected parts of the upland and plateau areas. In sandy soil, generally underlain by sandstone, mosses, lichens and an occasional arctic poppy or clump of grass may be seen. Vegetation is somewhat more abundant in the areas underlain by clay, but only where drainage is better than average such as on the long low slopes on the valley sides where surface soil consists of a mixture of clay, sand and gravel.

Game is scarce on the island. During the course of field work the following animals were noted: cariboo, musk-ox, wolf, arctic hare, weasel and lemming. Fox and polar bear have been reported by the personnel at the weather station. Birds sighted include: ptarmigan, long tailed jaeger, snow bunting, glaucous gulls, brant (?) and several species of ducks.

Only a few insects were noted during the warmest part of July.

ACKNOWLEDGMENTS

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The writer thanks Y.O. Fortier of the Geological Survey of Canada for his valuable assistance in organizing the field work and for his suggestions and criticisms during the preliminary work on this report. The writer is indebted to J.A. Jeletzky, D.J. McLaren and W.L. Frye of the Geological Survey of Canada, and to J.D. Hale of the Forests Products Laboratory for their reports on the fossils collected on Ellef Ringnes Island.

The Royal Canadian Air Force provided transportation to and from Ellef Ringnes Island. The services and courtesies extended by the Air Force personnel are gratefully acknowledged.

The weather station at Isachsen on Ellef Ringnes Island was used as a base of operations for field work. Its facilities were made available by the Meteorological Division of the Canadian Department of Transport and the United States Weather Bureau, joint operators of the weather station. The writer acknowledges these services and is especially grateful to the personnel at the Isachsen weather station for their willing assistance and co-operation during the course of the field work.

Able assistance in the field season of 1953 was given by D.W. Bolyard.

GENERAL GEOLOGY

GENERAL STATEMENT

The sedimentary rocks exposed in the map area consist of a conformable sequence of marine claystones, sandstones and limestones of Lower Cretaceous and possibly younger age. At least some of the sandstone is of subaerial or shallow water origin as indicated by the presence of coal seams in the Isachsen and Hassel formations. The total stratigraphic section exceeds 6800 feet in thickness.

Diabase, basalt and gabbro occur north and northeast of Deer Bay. Dykes and sills intrude the Deer Bay formation and sills or flows overlie the lower part of the Isachsen formation.

The Isachsen piercement dome upwarps and intrudes the Isachsen, Christopher and Hassel formations. These formations form concentric rings around a central core composed of gypsum and anhydrite (Plate II). Diabase, basalt and limestone inclusions crop out within the core. Silurian or Devonian fossils are present in the largest limestone block.

Over 90 percent of the mapped area of the island is covered with surficial deposits, derived for the most part from the weathering of the underlying bedrock. As a result, contacts between the various lithologic units are poorly exposed. Therefore float mapping has been used to determine contacts in most areas.

In order to avoid the confusion that exists in the descriptive terminology applied to layered rocks, the classification proposed by McKee and Weir (1953) will be used in this report. Table II is an abridged outline of this classification.

TABLE II

COMPARISON OF QUANTITATIVE TERMS USED IN DESCRIBING LAYERED ROCKS

Terms to describe stratification	Thickness	Terms to describe splitting property
Very thick-bedded	Greater than 120 cm.	Massive
Thick-bedded	120 cm. (about 4 ft.) to	Blocky
Thin-bedded	60 cm. (about 2 ft.) to	Slabby
Very thin-bedded	5 cm. (about 2 in.) to	Flaggy
Laminated	1 cm. (about ½ in.) to	Shaly (claystone, siltstone) Platy (sandstone, limestone)
Thinly laminated	2 mm. (about .08 in.) or less	Papery

TABLE 3 STRATIGRAPHIC TABLE OF CENTRAL ELLEF RINGNES ISLAND

ERA	PERIOD	EPOCH	AGE	SUB-AGE	FORMATION	THICKNESS	DESCRIPTION	INTRUSIVE ROCKS
CENOZOIC	QUATERNARY	PLEISTOCENE (?) OR RECENT			Not designated	0-25'	Residual, soil, clay, sand and gravel. Stream deposits	Diabase, basalt and gabbro sills and dykes in Isachsen and Deer Bay formations. Similar diabase, basalt and gabbro occur as sheet and dyke-like bodies in the Palaeozoic rocks of the Isachsen dome
					Unconformity			
MESOZOIC	CRETACEOUS	LOWER CRETACEOUS TO LATER (?)	NEOCOMIAN OR LATER (?)	VALANGINIAN OR LATER (?)	Hassel Formation	1800'+	Thin-bedded, blocky to slabby, quartzose sandstone with interbeds of laminated shaly, silty claystone	
					Christopher Formation	1540'±	Black and grey, laminated, shaly, silty claystone. Minor thin-bedded limestone	
			NEOCOMIAN	INFRA-VALANGINIAN TO HAUTERIVIAN	Isachsen Formation	3000'±	Grey to red, thick-bedded to laminated, massive to flaggy quartzose sandstone. Minor laminated, shaly siltstone and claystone	
					Deer Bay Formation	600'+	Black, laminated, shaly, silty sandstone	
					Unconformity			
PALAEOZOIC	SILURIAN OR DEVONIAN	?	?	?	Not designated	400'±	Gypsum and anhydrite with minor limestone interbeds. Some limestone masses as inclusions	

CRETACEOUS OR LATER

Deer Bay Formation

The Deer Bay formation is named from its typical occurrence in the vicinity of Deer Bay where it extends over an area of approximately 130 square miles. Outcrops are few in number and seldom continuous for any distance. The base of the formation is not exposed therefore only the upper 600 feet have been mapped.

This formation is composed of black, laminated, shaly, silty claystone that is poorly consolidated and very closely jointed. Thick-to thin-bedded, slabby claystone layers occur throughout the formation and buff weathering thin-bedded limestone layers 4 to 30 inches in thickness are present near the top. Numerous calcite concretions averaging 3 inches in diameter are found in the lowest exposed section of the formation.

The Deer Bay formation contains a few poorly preserved fossils. Those were identified by J.A. Jeletzky of the Geological Survey of Canada. Poor preservation has made determinations difficult and in many cases his identifications are only tentative. He reports the following species present:

No. 21891[1] *Aucella* cf. *terebratuloides* Lahusen
Aucella ex gr. *Keyserlingi* (d'Orbigney)
Aucella sp. indet.

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[1] The numbers (21891, 21894, etc.) refer to Canadian Geological Survey fossil localities. The specimens are on file with the Paleontologic Division of the Canadian Geological Survey in Ottawa, Ontario.

No. 21894	*Aucella* cf. *terebratuloides* Lahusen (juvenile form) *Aucella* cf. *nuciformis* Pavlow *Aucella* cf. *werthii* Pavlow
No. 21896	*Inoceramus* sp. indet. (? cf. *I. stantoni* Anderson) *Aucella* nov. sp. ? (ex aff. *A. crassicollis* Keys or *A. crassa* Pavlow) Pelecepod, genus and species indet.
No. 21897	A representative of the family Oxyteuthidae Stolley, probably belonging to a new genus; is rather similar to *Oxyteuthis* ? sp. indet. of Blüthgen (1936) and to *Oxyteuthis* ? *temahaensis* (Stanton) *Acroteuthis* ex. gr. *subquadratus* Roemer.
No. 21898	*Aucella* cf. *crassa* Pavlow *Aucella* cf. *terebratuloides* Lahusen
No. 21899	A peculiar ammonite of the family Polyptychidae s. lato (? a new genus), which is similar to representatives of the genera *Dichotomites* Koenen, *Tollia* Pavlow and *Neogastropolites* Spath. Preservation is insufficient for an exact generic determination. *Aucella* cf. *keyserlingi* d'Orbigny
No. 21900	*Aucella* cf. *keyserlingi* d'Orbigny *Aucella* sp. indet. (cf. *A. bulloides* Lahusen) *Aucella* cf. *nuciformis* Pavlow
No. 24015	*Acroteuthis* ex gr. *subquadratus* (Roemer) *Acroteuthis* ex gr. *johnsoni* Blüthgen cf. *Acroteuthis elongatus* Blüthgen
No. 24019	Poorly preserved *Aucella* of early Lower Cretaceous affinities resembling *Aucella okensis* Pavlow var. *canadiana* Crickmay *Aucella* sp. indet. (cf. *A. volgensis* Lahusen)
No. 24021	*Aucella piriformis* Lahusen phase *crassicollis* Pavlow
No. 24023	*Anatina* (*Cercomya*) ? sp. indet. *Nucula* ? sp. indet.

No. 24029	Poorly preserved *Aucellas* of early Lower Cretaceous (late Infra-Valanginian) affinities resembling *A. volgensis* Lahusen, *A. terebratuloides* Lahusen, and *A. okensis* Pavlow
No. 24031	*Aucella terebratuloides* Lahusen *Aucella keyserlingi* (d'Orbigney) et. var. *Nucula* ? sp. indet. Pelecepod, genus and species indet.

Jeletzky concludes a probable Neocomian age for these collections, possibly ranging from Infra-Valanginian to Hauterivian.

Poorly preserved fragments of petrified wood are present throughout the Deer Bay formation. The largest piece found measured 10 inches in diameter and 4 feet in length (Fig. 7). J.D. Hale of the Forests Products Laboratory of the Department of Resources and Development describes the material as follows:

> "......the araucarian type of trachеary pitting serves to classify the specimen as a species of *Araucarioxylon*, the name proposed for an extinct genus known to have been well represented during the Cretaceous period. The only known living members of the araucarian conifers consisting of two genera, *Araucaria* and *Agathis*, are now confined to a natural range within the southern hemisphere."

Other specimens of petrified wood were described by W.L. Frye of the Geological Survey of Canada. These specimens are all of secondary xylem and therefore of little value as an indicator of age. He suggested that growth layers may be indicative of:

1. Climatic variations or cycles of extremely short duration.
2. Uniformly changing ecologic conditions.
3. A slow growing tree in a climate with regular variations or cycles.

Fig. 6. Rolling Topography of the Deer Bay Shale.

Fig. 7. Petrified log in Deer Bay formation.

Isachsen Formation

The Isachsen formation is named after Captain Isachsen, one of the discoverors of Ellef Ringnes Island. It crops out in a northeasterly trending belt across the island and as a concentric ring around the Isachsen dome. The formation is approximately 3000 feet in thickness. At the Isachsen dome, faulting and thinning have considerably reduced the exposed thickness which varies from 350 to 1500 feet.

The Isachsen formation is composed of a grey to red quartzose sandstone that weathers buff, rusty or grey. It is a fine to medium grained rock, well sorted and rounded, although in certain areas the beds contain scattered pebbles, seams and lenses of pebbles, and coarse grained sand. The cementing material is commonly ferruginous but locally it may be siliceous. Minor amounts of garnet, muscovite and magnetite are present throughout the formation. Generally the sandstone is thick-bedded and massive with thin-bedded, flaggy units of lesser extent. Cross-bedding does not occur extensively but is well developed locally. Black to grey, micaceous, laminated, shaly siltstones and claystones interbedded with flaggy sandstones occur in the lower 60 feet of the formation. Lignitic coal seams and lenses from a fraction of an inch to 3 inches in thickness are present in these lower beds but are not of widespread occurrence.

Concretions averaging 1 foot in diameter but occasionally as much as 12 feet in diameter occur in a fine grained thin-bedded part of the sandstone near the top of the formation. In the center of some of the broken concretions was what appeared to be a woody material, too friable to be of diagnostic value.

Fossils were found only in the lowest 100 feet of the formation. These were identified by J.A. Jeletzky as:

No. 24030	Aucella cf. A. bulloides Lahusen
	Aucella cf. A. terebratuloides Lahusen

He concluded that these could range from the Infra-Valanginian to the Hauterivian substages of the Neocomian stage.

The lower contact of the Isachsen sandstone has been arbitrarily placed at the lowest occurrence of sandstone above the Deer Bay formation. The upper limit at the highest outcrop of sandstone or the lowest outcrop of claystone of the overlying formation. This contact is not exposed but the attitudes of these two formations indicate that they are probably conformable.

Christopher Formation

The Christopher formation is named after Christopher Peninsula, a prominent geographic feature on the northeast coast of Ellef Ringnes Island. It crops out in a belt parallel to, and southeast of, the Isachsen formation. It also forms a

Fig. 8. Thin bedded Isachsen sandstone. Diabase plateau on the upper left.

Fig. 9. View southeast toward the Isachsen Dome. Christopher formation in foreground. Lighter colored bands in central part of the picture are Isachsen sandstone. Isachsen Dome forms the upland area on the upper part of photograph.

concentric ring around the Isachsen dome.

The lower part of the Christopher formation consists of black laminated, shaly, silty claystone, interbedded with a lesser amount of thin-bedded, slabby limestone. The limestone beds average 18 inches in thickness and are separated by 10 to 150 feet of claystone. The upper part of the formation is composed of a similar claystone which grades from black to grey near the top. These two parts of the Christopher are lithologically similar but differ in that the upper part contains no limestone. A similar sequence crops out around the Isachsen dome.

The thickness of the Christopher formation is about 1540 feet; in the vicinity of the Isachsen dome the thickness varies considerably as a result of thinning and faulting. The maximum thickness in the dome area is 1500 feet and the minimum is 600 feet.

Correlation of the Christopher formation to the north of the Isachsen dome and that in the immediate vicinity of the dome has been made on lithologic similarities. The lower part of the formation containing the limestone beds has been found in both localities. Time did not permit correlation of individual beds between these two areas.

Pelecopods and fragments of an ammonite were found on the surface just north of the Isachsen dome. These were identified by J.A. Jeletzkey as:

No. 24026 <u>Astarte</u> ? species indeterminable
<u>Artica</u> ? species indeterminable
<u>Mytilus</u> ? species indeterminable

No. 24024 <u>Polyptychites</u> species indeterminable
(cf. <u>P. barnstoni</u> Meek)

Although these fossils were not found in place they have probably been derived from the underlying Christopher. There is little evidence of solifluction in the locality where they were found and there are no streams that could have transported them. Further, the fragile nature of the pelecepods would prevent their being transported any great distance. Jeletzky noted that the <u>Astarte</u>, <u>Artica</u> and <u>Mytilus</u> were poorly preserved and could only be dated as of Mesozoic or Tertiary age. The <u>Polyptychites</u> is of probable middle Valanginian age.

The lower contact of this formation, as noted earlier, has been placed at the highest outcropping of Isachsen sandstone. The upper limit of the formation was placed at the highest outcrop of claystone or the lowest outcrop of sandstone belonging to the Hassel formation. The contacts are apparently conformable.

Hassel Formation

The Hassel formation, the youngest consolidated sedimentary formation mapped on Ellef Ringnes Island, is named after one of the discoverers of the island. It crops out northeast, east and south of the Isachsen dome, partially encircling the dome. Only the lower 1800 feet of this formation in the vicinity of the Isachsen dome were mapped.

Thin-bedded blocky to slabby quartzose sandstone constitutes about 70 percent of the formation. This sandstone is generally a poorly consolidated grey to white rock that weathers buff, yellow or grey. Grading and sorting within the beds are good; the grain size varies from fine to medium. Interbedded with the sandstone is a black to grey laminated, shaly, silty claystone. This is a fissile friable rock that seldom occurs in outcrops of more than a few square feet in area. A few thin beds of limestone are present. Lignite coal seams, varying in thickness from a thin film to 18 inches are present throughout the formation.

No fossils were found in the Hassel formation, but as little time was spent in mapping this unit, their presence may have been overlooked.

The contact relations with the underlying Christopher formation, as already described, has been placed at the highest outcrop of Christopher claystone or the lowest outcrop of Hassel sandstone.

Structure of the sedimentary rocks

The Cretaceous and later sedimentary rocks form the southeast limb of a broad gentle fold in the southeastern part of the map area. Regionally the dips are quite consistent and do not exceed 6 degrees. In the northwestern section the beds are essentially flat lying.

Structures related to the piercement dome and to the basic igneous rocks have resulted in local folding and faulting of the sedimentary formations. These will be discussed in the section of this report dealing with the Isachsen dome and with the basic igneous rocks.

Faulting was only noted in two outcrops in the Deer Bay formation. These are normal faults with a maximum vertical displacement of 10 feet. Narrow veins of slikensided calcite are present in the observed fault planes. Fragments of a similar slikensided calcite occur as long sinuous lines on the surface mantle of the Deer Bay formation. Therefore the presence of numerous other faults having no topographic expression is inferred. No estimate of the total displacement is justified from the information obtained in the area. Marker horizons are not sufficiently exposed or distinguishable to be of value in a reconnaissance survey. No faults were noted in the sedimentary formations younger than the Deer Bay formation, except those related to the Isachsen dome.

Jointing is persistent in all of the sedimentary rocks. Closely spaced jointing is present in the Deer Bay and Christopher formations. Joints are widely spaced in the Isachsen formation. In general two sets of nearly vertical joints are present in the sedimentary rocks.

DIABASE, BASALT AND GABBRO

General Statement

Diabase, basalt and gabbro occur over approximately 40 square miles in the northwestern part of the map area, north and northeast of Deer Bay. Dykes, sills and 'sheet-like bodies' intrude and overlie the Deer Bay formation. 'Sheet-like bodies' overlie the lower part of the Isachsen formation in the north-central part of the map area. Blocks and tabular shaped inclusions of diabase and basalt are present in the core of the Isachsen dome (Plate II).

No basic rocks were found intruding or overlying the Hassel and Christopher formations. A study of air photographs suggests that basic rocks may occur on the southern part of Ellef Ringnes Island.

Contacts between the intrusive and sedimentary rocks are exposed in few localities. The basic rocks are more resistant to weathering than the sedimentary rocks. As a result the basic rocks commonly stand as steep ridges and escarpments with talus and solifluction slopes extending to their bases. Contacts were established by float mapping. Although the contacts can often be determined within a few feet, the actual contact relations are unkown.

Dykes

Ring Shaped Intrusions Four ring shaped diabase dykes intrude the Deer Bay formation in the northwestern part of the map area. These form prominent ridges with a relief of 200 to 700 feet.

The smallest structure is on the seacoast in the northwestern corner of the map area. It is elliptical in plan with a northerly elongation. The larger diameter is 1½ and the smaller diameter is 1 mile. No contacts with the intruded rocks were found. Two larger but similar ring shaped structures occur in the same general area. The easternmost of these structures is not completely closed, it is horseshoe shaped with the open side to the south (Fig. 10). The diameters are 1½ miles by 3 miles. One contact is exposed on the southwestern inner side of the eastern structure. This contact strikes N20 W and dips 30 degrees east. The overlying rock is a baked silty claystone. Similar silty claystones occur in several localities on the inner side of this dyke but no attitudes could be determined. Frost heaving and weathering processes have destroyed the original attitudes.

A semi-circular shaped diabase intrusion occurs on the southern end of the large peninsula south of the intrusions described above. Little is known of this dyke as outcrops are few and poorly exposed.

Elongate Dykes The ridges that form the two peninsulas extending southward into Deer Bay are composed of diabase. Attitudes and widths could not be determined as no outcrops other than diabase occur in the immediate vicinity. The outcrops of diabase extend from sea-level to the ridge tops which attain a maximum elevation of 575 feet. The western sides of both peninsulas are precipitous slopes. The eastern sides are steep but do not form high cliffs. Scattered patches of silty claystone occur on the ridge crests and form long talus slopes on the sides. This rock does not crop out in place except on the northern end of the western peninsula where it strikes E-W and dips north at 10 degrees. Black fissile claystone, approximately horizontal, crops out 200 feet north of the eastern dyke.

Diabase and basalt dykes occur extensively in the Deer Bay formation in the region east of Deer Bay. These dykes vary in width from 18 inches to about 70 feet. All are steeply dipping to vertical.

Sheet-like Bodies Flat lying diabase sills or sheet-like bodies crop out over 26 square miles in the northern part of the map area. These are underlain by the Deer Bay formation and the lower part of the Isachsen formation (Fig. 11).

An elongate outcrop, centered on latitude 78° 51' N and 103° 42' W appears to be concordant with the Deer Bay formation.

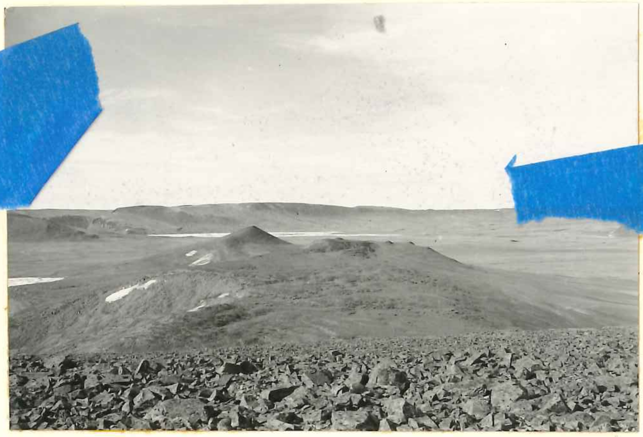

Fig. 10. Ring-shaped intrusion forms the ridge in the background. The conical shaped hills in the center of the photograph are erosional features. Note landslide scar on the left side.

Fig. 11. Horizontal Isachsen sandstone overlying the Deer Bay formation. Diabase capped plateau in the background.

East of this is a second elongate outcropping of diabase. This is concordant in the northern and eastern part but has discordant relationships in the southern and western portions. Here it has a low westward dip. At its extreme southwestern end several disconnected outcrops have the pattern of a steeply dipping dyke.

Still farther east a diabase sheet overlies the Isachsen sandstone. From a distance the contact appeared to be concordant; no contacts were exposed. The minimum thickness of this sheet varies from 45 feet in the west to 175 feet in the eastern exposures. No covering rocks are present in any of the areas traversed, therefore the amount of diabase and/or sedimentary rock stripped from the top is not known.

Petrography

<u>Diabase</u> The igneous rocks of the Deer Bay region and the northeastern plateau region consist almost wholly of diabase. The rocks are characteristically greenish black on the fresh surface and rusty brown on the weathered surface. There is little variety in the even textured, fine grained diabase over the whole area although locally the rocks are very fine grained to aphanitic. At exposed contacts the diabase grades into these very fine grained and aphanitic varieties. However as few contacts are exposed these varieties are considered to be border or contact phases wherever they are found. There are no inclusions in the diabase except near one contact where a small (3 cm.)

inclusion of baked claystone was found.

Microscopically there is little variation in the texture and mineralogy of the diabase. It is equigranular and holocrystalline with an average grain size of 0.5 mm. Labradorite and a pyroxene, augite or pigeonite, are the most abundant minerals.

Labradorite, varying in composition from An_{50} to An_{58} constitutes 45 percent of the rock. It is in the form of laths that average 0.5 mm. in length and 0.2 mm. in width. These are generally subhedral but a few euhedral grains are present. Some of the plagioclase crystals exceed 1.0 mm. in length and may be as much as 4.0 mm. in length (Fig. 12). Almost all of the crystals are twinned in accordance with the Albite twinning law. A few of the larger crystals are not twinned but show a zonal structure. This zoning is oscillatory with the cores slightly more calcic than the rims. The labradorite laths have no preferred orientation within the rock, they form a network of grains that sometimes swarm together to form a glomeroporphyritic texture.

The augite and pigeonite varieties of pyroxene are present in the diabase. Together they constitute 35 to 40 percent of the rock. No estimate has been made of the relative proportions of these two minerals. Diagnostic characteristics that would be of use in seperating them could not be determined with an ordinary petrographic microscope. The individual pyroxene minerals average 0.2 mm. in diameter but these often form

Fig. 12. Typical diabase. (Crossed nicols, x82).

glomeroporphyritic aggregates 1.0 to 1.5 mm. in diameter. The smaller grains are almost entirely anhedral, a few larger crystals averaging 0.5 mm. in diameter are subhedral. The majority of these subhedral grains that could be determined were found to be pigeonite. Twinning is common in the larger grains of both types of pyroxene. Where pigeonite and augite are in contact with one another and where sufficiently accurate determinations have been made, the pigeonite was rimmed by augite (Fig. 13). The contacts are almost always sharp. In view of the fact that (1) pigeonite forms most of the larger subhedral grains, and (2) augite appears to rim the pigeonite, it is suggested that at least some of the pigeonite crystallized at an earlier time than the augite. These conclusions are tentative as a more detailed examination with a universal stage will be required in order to prove this relationship.

Magnetite, the most abundant accessory mineral, averages 5 percent of the rock but may amount to as much as 10 percent. It occurs as skeletal crystals which are sometimes molded on the pyroxene, and as irregular grains in the matrix. Apatite is quite common but in very minor amounts. It forms slender needles in the interstitial matrix and also in late quartz whenever quartz is present. Minor amounts of chlorophaeite, quartz, biotite and green hornblende occur throughout the rock.

Fig. 13. Diabase. Pigeonite (P.), augite (A.), plagioclase (Pc.) and magnetite (M.). (Plane light x90)

Gabbro The gabbro occurs only within the diabase as irregular shaped masses 50 to 70 feet in diameter. Its contacts with the diabase are gradational within a distance of 6 to 12 inches. This rock is dark brown to black on the fresh surface and rusty brown on the weathered surface. In outcrop the gabbro appears to be deeply weathered but in thin section it has a fresh, unaltered appearance. The rock is typically medium to course grained. A fine grained matrix constitutes 10 to 15 percent of the rock. Plagioclase and pyroxene form the greater part of the rock.

The plagioclase is labradorite (An_{55}), 2 to 10 mm. in length, commonly twinned after the Albite Law. Apatite and indeterminable microinclusions are distributed throughout the plagioclase.

The pyroxenes present are augite and pigeonite; the relative amount of each was not determined. These form subhedral grains averaging 4 mm. in diameter and anhedral grains averaging 0.5 mm. in diameter.

Needle-like grains of apatite occur throughout the rock, as inclusions in the plagioclase and to a lesser extent, in the pyroxene.

Brown and green hornblende occur as subhedral grains within the matrix and more commonly as a reaction rim around the pyroxene. In the latter case it is in subparallel orientation with the pyroxene.

Magnetite forms 5 to 7 percent of the rock. It is always present in or around pyroxene and in close association with the hornblende. The grains are irregular in shape and quite variable in size.

Quartz is a minor constituent occurring as small irregular grains in the groundmass.

Graphic intergrowths of quartz and plagioclase fill many of the interstitial areas.

Chlorophaeite, a dark brownish red mineral, is present in the groundmass and as an alteration product of the pyroxenes. A small amount fills fractures in the plagioclase.

Basalt Basalt is a rather uncommon rock occurring as narrow dykes 2 to 10 feet in width. Few of these dykes are present. Their relation to the diabase and gabbro are not known as these rocks were nowhere found in contact. The basalt dykes are intrusive into the Deer Bay formation in the southern and eastern areas.

The basalt is aphanitic with a few scattered plagioclase (An_{50}) phenocrysts. Small calcite amygdules, 1 to 3 mm. in diameter, are common in the dyke rock. Inclusions of the intruded claystone are numerous in some of the dykes. These inclusions show no alteration although they are often rimmed with calcite.

Mode of Emplacement

The petrographic similarities of the igneous rocks suggest a common parent magma but their differing outcrop patterns suggest differing modes of emplacement.

The ring shaped structures are considered to be intrusive. This is substantiated by the presence of claystone overlying, but on the inner flanks of these structures. This claystone is slightly upturned in the contact areas, suggesting that it formed the cover or hanging wall of the dyke.

The relationship of the diabase above the Isachsen formation and above the Deer Bay formation is not clearly understood. In the plateau area the sandstone underlying the diabase thins to the westward. Farther west the diabase overlies the Deer Bay formation with apparently no sandstone present. The sandstone may actually thin to the west and finally pinch out. Evidence is lacking to prove or disprove this possibility. As a second alternative the diabase may be considered to be a flow extruded on a bevelled erosion surface. The uniformity in composition and texture of the diabase, the lack of internal structures such as flow structures, brecciation or flow contacts suggest that this is not the case. As a final possibility the diabase may be a slightly discordant sill in the west and a true sill farther east. This hypothesis is preferred after considering the possible relationship of the ring shaped structures, the elongate dykes and the sheet-like bodies.

The diabase of the above mentioned masses is similar both texturally and structurally, therefore they may be related in the following manner. The diabase was intruded along both vertical and low dipping fractures forming first the elongate dykes and the ring shaped dykes. The magma was channelled on encountering the more competent Isachsen formation or the upper part of the Deer Bay formation, thus forming the slightly transgressive sills and farther from the source, the true sills as occur in the northeastern part of the map area.

RECENT

Recent deposits are represented chiefly by residual soil, clay, sand and gravel, probably not exceeding 25 feet in thickness. Local fluvial deposits occur in the river valleys. Here, recent uplift has resulted in channel cutting, thus exposing some of these deposits. Delta deposits are present at the mouths of the larger rivers. Beach deposits consist of reworked sand and gravel derived from the residual soils and from the products of mass wasting. A large percentage of the clay and silt sized particles have been removed from these deposits.

Residual soil, clay, sand and gravel are of widespread occurrence. These are, for the most part, derived from the underlying bedrock. The thickness of the deposits varies from a few inches to a few feet, the maximum thickness is not known.

DEVONIAN OR EARLIER

The Isachsen Dome

General Statement The Isachsen dome is approximately elliptical in outline, 5 miles long and 4 miles wide (Plate II, Fig. 14). It consists of a central core composed of gypsum and anhydrite. Inclusions of limestone and of basalt, diabase and gabbro occur in the core rocks.

Lithology Gypsum and anhydrite make up the bulk of the core, with the anhydrite being the major constituent. The anhydrite is a compact, massive and fine grained rock that varies in color from light to dark grey. The gypsum is an alteration product of the anhydrite on which it often forms an encrustation. It is a porous, friable, earthy material, commonly white or light grey in color. The selenite variety of gypsum is present in almost all exposures, constituting 5 to 10 percent of the rock, although it may amount to 50 percent of the rock. It is generally fine grained but crystals 12 inches in length are not of rare occurrence (Fig. 18).

Limestone, unlike the Cretaceous limestone present outside the dome, occurs as isolated blocks within the central part of the dome. The largest of these measures 50 feet in width, 100 feet in length, and has an average exposed thickness of 10 feet. This rock is very fine grained and is light grey in color. Most of the blocks are extremely fractured and traversed by many calcite veinlets.

Poorly preserved fossils were found in the largest limestone block. Determinations of these were made by D.J. McLaren as:

> "Fragments of simple rugose corals.
> Small brachiopod, c.f. pentamerid.
> Small smooth brachiopod.
> Crinoid stems."

He further noted that: "The fauna shows little to suggest an age determination other than Palaeozoic. Serial sectioning of the ventral valve of a brachiopod fragment, however, showed some internal structure. In this, the thick shell and a heavy duplex spondylium suggest a pentamerid, but it cannot be assigned to a genus. It seems probable, therefore, that the age of the fauna is Silurian or Devonian."

The contacts of the gypsum-anhydrite core and the surrounding Isachsen formation were not seen in outcrop. The relation of the core rocks to the sedimentary rocks will be discussed under the structure of the Isachsen dome.

Diabase, basalt and gabbro occur near the periphery and in the upland part of the core of the Isachsen dome (Plate II). Three more or less rounded inclusions, 20 to 50 feet in diameter lie in the southern part of the core. Tabular shaped inclusions, as long as 2300 feet and as wide as 60 feet occur in three groups near the eastern and western parts of the core (Fig. 15). Inclusions within each group are diversely oriented but the

Fig. 14. Vertical view of the Isachsen dome. (R.C.A.F. photograph T-428C - 161)

longer inclusions show a general parallelism to the outer contact of the core. The upland, or northern part of the core has fewer outcrops and the occurrence of these outcrops suggest that they are all part of a more or less continuous but broken and detached sheet of basalt. There is more uniformity in texture and composition among the rocks of the rounded and tabular inclusions than in the sheet of the northern part of the dome. All varieties of basic rock present in the dome are represented in the Deer Bay region.

Structure The intrusion of the gypsum and anhydrite core has faulted and upwarped the overlying sedimentary rocks. The faults, shown on Plate II are radial and tangential to the outer contact of the dome. The majority of the radial faults are in the Isachsen formation and the lower part of the Christopher formation; few extend into the upper part of the Christopher formation or into the Hassel formation. Tangential faults have been inferred between the contact of the core and the Isachsen sandstone only where truncation of the sandstone has occurred. On the air photograph (Fig. 14) these faults are apparent on the eastern side of the dome, however because of the small number of outcrops in this area the faults could not be recognised on the ground. No faults were found within the central part of the dome.

Thinning of the sedimentary strata is most pronounced in the eastern and western bulges of the dome. The narrowing of the outcrop belt (Plate II) is partly due to steeper dips and

Fig. 15. Elongate dyke-like diabase inclusion in the Isachsen Dome. Upland area of the dome in the background.

to faulting of the sedimentary rocks, however, most of the thinning probably results from pinching and dragging of the less competent rocks at the time that the core rocks were intruded. Pinching is well exhibited in the Christopher formation where there is a change in dip of 30 degrees in 150 feet across the strike. Thinning may also have resulted from non-deposition or erosion, had the intrusion started in lower Cretaceous time. No evidence for or against this hypothesis was found.

The sedimentary rocks are sharply upturned and in some places overturned near their contact with the intrusive core rocks. At a distance of 1 to 3 miles from the core the effects of doming are not apparent and the sedimentary rocks assume the low regional dips found throughout the area.

Time did not permit the detailed mapping of the folding and faulting within the core of the dome. These reconnaissance observations suggested the presence of an overall internal structure within the dome. Whether or not this will correspond to that recently described by Balk (1949) will require more detailed observations.

The anhydrite occurs in layers of differing shades of grey. No mineralogical variation appears to be associated with the layering which is apparently due only to color changes. The layers have indistinct borders, and although they were not

Fig. 16. Layering in gypsum-anhydrite on eastern side of Isachsen dome.

Fig. 17. Layering in central part of core. Shown by faint lines dipping to the left. Relief about 400 feet.

observed in all outcrops their presence may have been masked by deep weathering or by an encrustation of gypsum. Layering is best exposed near the northern and eastern borders of the core (Fig. 16). In these areas the dips are steep but variable, generally decreasing toward the center of the core. Layering in the central part of the core is less distinct than that of the border areas (Fig. 17). The layers are much thicker, they are gently folded with the folding becoming much more pronounced as the outer contact of the core is approached. These folds are often diversely oriented; a change in strike of nearly 90 degrees occurs across a narrow canyon.

Selenite occurs within the folded and layered core in the following ways: (1) as irregular masses in the gypsum and anhydrite (Fig. 18), (2) as layers, 2 to 18 inches thick, parallel to the layering in the core, and (3) as irregular veins, 2 to 18 inches thick, that have no apparent relation to the layering.

Two limestone layers are present in the northern layered area of the core. One of these, 18 inches in thickness has been folded into a tight, recumbent, S-shaped fold. The second layer, 6 feet in thickness has been deformed into a crush breccia (Fig. 19).

<u>Origin</u> <u>of</u> <u>the</u> <u>Isachsen</u> <u>dome</u> A sedimentary origin of the gypsum-anhydrite cap rocks is suggested by the evidence found in the Isachsen dome. The fossiliferous limestone

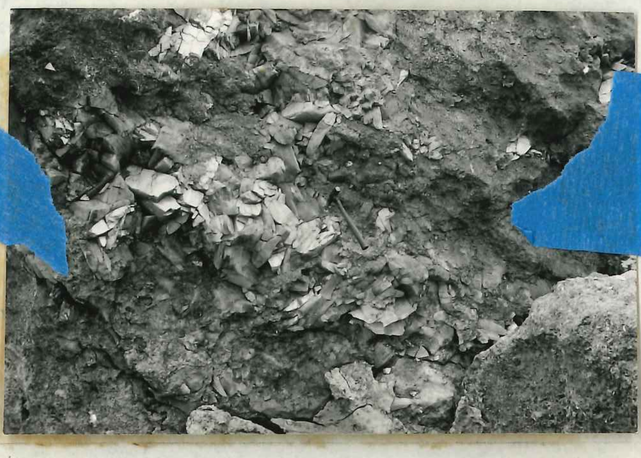

Fig. 18. Large selenite crystals in central part of the core.

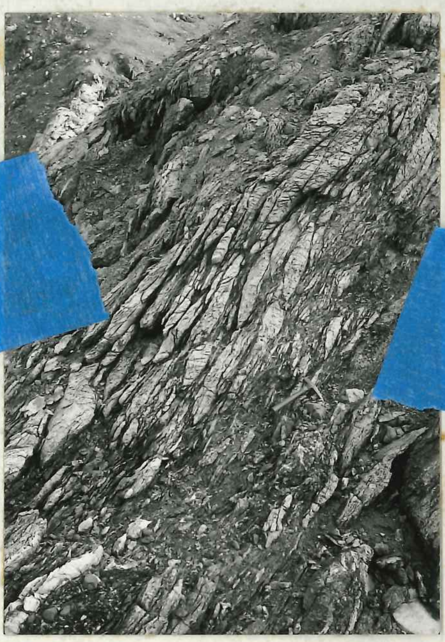

Fig. 19. Crush breccia on north side of Isachsen dome.

block present in the central part of the core is of undoubted sedimentary origin. This limestone is lithologically similar to the folded and brecciated limestone occurring in the anhydrite near the northern contact of the dome; these limestone layers are conformable with the layering of the anhydrite in this locality. The layering within the central part of the core appears to be a primary sedimentary feature, that of the border areas has been deformed but still appears to retain the original sedimentary layering.

The gypsum and anhydrite of the Isachsen dome are considered to be the capping of an underlying salt mass although no salt is exposed on the surface. The structural features in and around the dome suggest that this is a piercement structure. These conclusions are based on the following:

(1) The core rocks have upwarped and intruded the Cretaceous and later sedimentary rocks.

(2) Faulting and thinning of the Isachsen formation and Christopher formation have resulted from the intrusion.

(3) The presence of early Palaeozoic fossils is indicative of a deep source of the core rocks.

If the thickness of the sedimentary formations are assumed to remain nearly constant, then the base of the Isachsen formation has been upwarped approximately 5000 feet.

(4) The Isachsen dome has structural features similar to many salt domes described in the Gulf Coastal area of the United States (DeGolyer, 1926; Balk, 1949; Landes, 1951), Germany (Stille, 1925), Russia (Shameka, 1939) and Persia (Harrison, 1931).

(5) Gypsum and anhydrite alone have not been described as forming piercement structures; they occur only as the capping of an underlying salt mass.

No salt has been reported as occurring in the Arctic Archipelago but gypsum and anhydrite have been reported from several localities. Thorsteinsson (personal communication) has found over 200 feet of late Ordovician gypsum on Cornwallis Island. It has also been reported as occurring on Somerset Island, and on northwest Baffin Island among Ordovician and Silurian strata, and on Axel Heiburg Island in an area where Triassic fossils have been collected, and in Cambrian beds on Devon Island (Fortier, personal communication).

Age of the Isachsen dome The age of the Isachsen dome cannot be determined with the information available. It is younger than the Hassel formation which is of Lower Cretaceous or younger age. The presence of Silurian or Devonian fossils in the limestone blocks indicate that the limestone is at least that old.

WEATHERING AND MASS WASTING

WEATHERING

General Statement

The rate of weathering on Ellef Ringnes Island is dependent on temperature, water content of the soil or rock and the rapidity with which the products of weathering are removed in order that fresh surfaces may be exposed. The degree and method of weathering of the various rock types depends upon local topography, jointing, texture, and composition. Chemical weathering is quantitatively of little importance; mechanical weathering is by far the most prevalent. Weathering does not take place below the permafrost table. The maximum depth measured to the permafrost table was 26 inches, the usual depth is 12 to 18 inches.

Weathering of Basalt, Diabase and Gabbro

Local topography is an important feature in the weathering of the basic rocks. Weathering has proceeded to a more mature stage on the plateau surfaces and on the ridge crests where rock fragments are not transported rapidly. On steep slopes, where fresh surfaces are constantly being exposed, weathering is of little importance.

Joints provide avenues for the entry of meltwater, which hastens the rate of both mechanical and chemical weathering. Chemical weathering seldom exceeds 1/16 inch in depth.

Fig. 20. Weathered claystone. Claystone grading into clay at the surface. (Fossil locality No. 24019).

Fig. 21. Residual boulders on diabase ridge.

Grain size is an important factor in controlling the rate of mechanical disintegration as is shown in the fine grained diabase and basalt which are much less weathered than the coarse grained gabbro.

Weathering of Sedimentary Rocks

Weathering of sedimentary rocks is almost entirely mechanical. The claystones and sandstones are composed of minerals that are essentially stable at atmospheric temperatures, therefore the only changes are the result of disintegration. The limestone is extremely fractured. No solution cavities are evident; mechanical breakup is probably too rapid for their formation.

Results of Weathering

The end result of weathering in this area is the production of material that can be transported by fluvial or wind action, or by processes of mass wasting.

The most noticeable products of weathering are residual soils and residual boulders. Gradations from unweathered shale to clay have been noted in several localities (Fig. 20). Residual boulders are present on ridge tops and in the plateau regions (Fig. 21). All transitions from angular fragments to sub-rounded boulders are present. This rounding is essentially the result of disintegration and exfoliation. The areas between the boulders are composed of angular fragments of gravel and sand derived from the diabase.

MASS WASTING

General Statement

Mass wasting processes observed on Ellef Ringnes Island include mudflow, solifluction, slump, creep, rockslide, rockfall landslide and subsidence. All of these processes as well as several others have been described by Sharpe (1938). The above mentioned processes are often gradational into one another although quantitatively solifluction is by far the most widespread. Poor subsurface drainage resulting from the high permafrost table and a steady supply of water favor the development of mudflow and solifluction and are important, but not essential, to the development of other processes. The sparse vegetation allows these processes to develop at a much faster rate than in a more temperate climate with abundant vegetation. However this is somewhat offset by the short summer season in this area as the processes are either inactive or only of minor importance during the winter months.

Mudflow

Mudflows are common, but generally not of any great areal extent. None were observed as flowing over a front exceeding 10 feet in width and they seldom flow for more than 2 or 3 feet. Mudflows typically form below snow banks or at definite breaks in slope. In these areas a fine grained soil in an oversaturated condition provides optimum conditions for the formation of mudflows. Small flows were observed on the steep sides of a few of the gullies. These flows varied from 2 to 6 inches in width and were as long as 10 feet. Small mudflows formed in the stream beds at the time when the streams had almost stopped flowing. The saturated material flows a few inches, then the supply of water becomes too great and water transport dominates after breaking through the front of the flow. Then the process is repeated. A considerable quantity of silt and clay is moved in this manner, often forming small alluvial fans at the confluence of the tributary and major streams.

Solifluction

Solifluction is the process whereby masses of waste, saturated with water, flows as a viscous mass from higher to lower ground (Andersson, 1906). The rate of movement is imperceptible, although variations in the rate of movement of a broad sheet front give the front a lobed appearance. Solifluction fronts are common on Ellef Ringnes Island and are best developed below ridges and escarpments. These ridges and escarpments provide effective wind breaks and thus accumulate large amounts of snow in the winter months.

The melting of snow accumulated below these features provides sufficient water to completely saturate the soil on the lower slopes for most, if not all, of the summer. It is here that the greatest amount of solifluction occurs. The effects of solifluction are negligible in areas where the snow coverage is thin. In many of the wide valley floors 3 to 6 feet of snow may accumulate during the winter months, however, this melts rapidly in the early part of the summer and runoff is almost complete before the ground has had time to thaw more than a few inches. The effects of solifluction are of a minor nature in this type of valley.

Large areas such as around the Isachsen dome show only local effects of solifluction. This is due in part to the small accumulation of snow on the broad low hills. Solifluction only occurs in the deeper stream valleys and along steep ridges.

Subsidence

Subsidence of the surface mantle occurs as a result of the melting of ice lenses and layers in the soil. Deep thawing of the ground ice will take place when the insulating layer provided on the surface by the small amount of humus and vegetation is removed. This material may be removed by rill work or by stream action. The final result of the thawing of the ground ice is the subsidence of the surface mantle. Depressions 12 to 20 feet in length, 6 to 8 feet in width, and 1 to 3 feet deep have formed in this manner. The sides of some of these show discontinuous longitudinal cracks that are formed by the slumping of the surface mantle above a melting ice lense. Several ponds, up to 200 feet in diameter may have been formed by melting of ice lenses with the resulting subsidence of the surface soil.

Other Processes of Mass Wasting

Slump, creep, rockfall and rockslide are of widespread occurrence. These processes are gradational with one another but their relative importance could not be estimated. They are present on all slopes underlain by basic rocks which form steep slopes, but they are of minor importance in most areas underlain by sedimentary rocks where the slopes are generally low.

FORCES OF EROSION AND TRANSPORTATION

RIVERS AND STREAMS

The streams on Ellef Ringnes Island flow for only a short period of the year, usually commencing in early June. The maximum runoff occurs in mid July and gradually decreases until freeze-up in late August. The small streams are completely dry within 2 or 3 days after the first heavy frosts in the Fall and the larger streams diminish to mere trickles.

The permafrost table, which is at an average of 15 inches below the surface, acts as an effective barrier to the downward percolation of water. The amount of subsurface drainage varies with the type of soil, which is largely dependent on the type of underlying bedrock. Drainage is generally good in areas underlain by sandstone, whereas in areas underlain by claystone the drainage is poor. The claystone weathers to an almost impermeable clay which is partly or completely saturated with water for most of the summer.

Running water is the foremost agent of erosion and transportation. Almost all the products of weathering and mass wasting are eventually transported by rivers.

WIND ACTION

General Statement

Wind is an important agent of erosion and transportation and it is the only agent active during all periods of the year. The total effect of the wind is difficult to estimate. Locally it may be of prime importance. The monthly average and annual maximum and minimum wind velocities are given in table I.

Wind Action on Snow Free Areas

Wind action is effective on snow free areas during all months of the year. The snow is blown clear of the ridges (Fig. 22) in the winter months and sand, silt and clay soils are dried out. The removal of ice in the soil must be by sublimation as areas that were frozen solid in late August had a thin covering of loose soil by mid-September. In April and May the depth of the dry frozen ground is as much as five inches. This material, when bared of snow, is easily eroded (Fig. 23). Fragments of claystone 5 mm. in diameter are carried and rolled considerable distances. These fragments were noted on the sea ice at least 2 miles from their closest known source. Sand grains and even small pebbles are transported into the river valleys.

During the summer months the wind can only be effective on dry ground. Although the soil may be wet at a depth of two to 3 inches, the surface ½ to 1 inch is often dry enough to be eroded and transported. In August, 1952, a large dust cloud was noticed in one of the larger river valleys. This cloud had an estimated length of 5 miles and an estimated altitude of 500 feet. Small dunes composed primarily of silt and sand sized particles of claystone have formed in the large

Fig. 22. Wind swept ridges, April, 1953.

Fig. 23. Wind deposited clay, silt and claystone fragments interbedded with snow.

Fig. 24. Deflation area. All soil and much of the weathered material has been removed. Note polygonal markings and concentration of pebbles and cobbles on the surface.

delta of the river flowing into the northeast part of Deer Bay. These are 1 to 3 feet long, 1 to 2 feet wide and 2 to 10 inches in height. The dunes formed behind clumps of grass, oil drums and boxes.

Wind Action on Snow Covered Areas

The effect of the wind on snow covered areas is in transporting the snow and aiding in compacting the snow. Large drifts often stratified, form when the wind blows in a constant direction. Shifts in the wind direction may result in erosion and abrasion of the first formed drifts and the result is similar to a series of sedimentary strata bevelled by erosion.

Probably the most important role of the wind is in forming huge snow drifts in gullies, river channels and in the lee of high ridges and escarpments. This snow provides the water for streams and processes of mass wasting during the summer months.

GLACIATION

Divergent views have been expressed regarding the glaciation problem in the Arctic Archipelago. These have varied from complete continental glaciation to non-glaciation

(Schei, 1903). Recently Jenness (1952) and Hobbs (1945) have proposed a northern limit of continental glaciation. Hobbs placed his boundary between the areas containing many lakes and those areas that contain few or no lakes. Jenness determined his northern limit in a similar manner from a study of air photographs and from flights over the area.

Little field work has been previously done in the Queen Elizabeth group of islands. The information that is available is based on the accounts of the few expeditions that have penetrated this relatively inaccessible area, from air photographs and from the conclusions reached by Jenness and Hobbs.

The absence of characteristic glacial land forms, till, erratics and glacial groovings and striations strongly suggests that an active ice mass was never present. Although some of these features might be removed or otherwise obliterated by weathering or mass wasting, it is not probable that all evidence of Wisconsin glaciation would be lacking.

On Ellef Ringnes Island evidence of continental and local glaciation are not apparent. Observations over several hundred square miles as well as a study of air photographs did not reveal any depositional or erosional features.

Till like deposits were found in two localities, however similar but unweathered deposits were noted in several of the present river channels. These river deposits contain silt, sand and gravel composed of basic igneous rocks, quartz sand and a large amount of claystone fragments. The weathering of the claystone results in a mixture of clay, sand and gravel similar in many respects to till. These till-like deposits are considered to be weathered fluvial deposits.

Erratics consisting of quartzite pebbles and cobbles are present on many high ridges and in the plateau area. They are of rare occurrence in the valleys where only two cobbles were found. These erratics may have originated in the following ways:

(1) Ice rafting.
(2) Glacial transportation and deposition.
(3) From an overlying conglomeratic member of the Isachsen formation or possibly a younger formation.

The first two hypotheses do not explain the absence of these erratics, as well as locally derived diabase erratics, in the valleys. Also had these forces been active a greater diversity of erratic rock types might be expected. Although no cobbles were found in the Isachsen formation, pebbles as much as 2 inches in diameter occur in some of the gravel lenses. These appear to be of the same composition as the erratics. Therefore the final reason (3) is considered to be the most plausible.

Striations and polish were not seen on any of the outcrops. Weathering may well have destroyed any such features, especially on the sedimentary rocks which are generally poorly consolidated.

Precipitation may have been too low for an extensive and thick ice sheet to accumulate on Ellef Ringnes Island as was the case in central Alaska. Although the island was probably covered with ice during the Pleistocene epoch it is not likely that the ice attained sufficient thickness to flow. If this was the case, the ice probably did not exceed 250 feet in thickness; this being the estimated thickness for ice to flow on a horizontal surface (Bowman, 1916, p. 293). On Ellef Ringnes Island, where the highest observed strand line is 50 feet above sea level, the following equation proposed by Washburn (1947, p. 55) may be used to estimate the minimum thickness of the ice: $\frac{3.3}{0.92} = \frac{x}{50}$ where 3.3 equals the density of the esthenosphere, 0.92 equals the density of the ice, 50 is the elevation in feet of the highest observed strand line and x equals the thickness of ice causing the downwarping. Therefore the minimum thickness of ice would be 179 feet. Although this is an unproved assumption it is not unreasonable when compared to the above figure proposed by Bowman.

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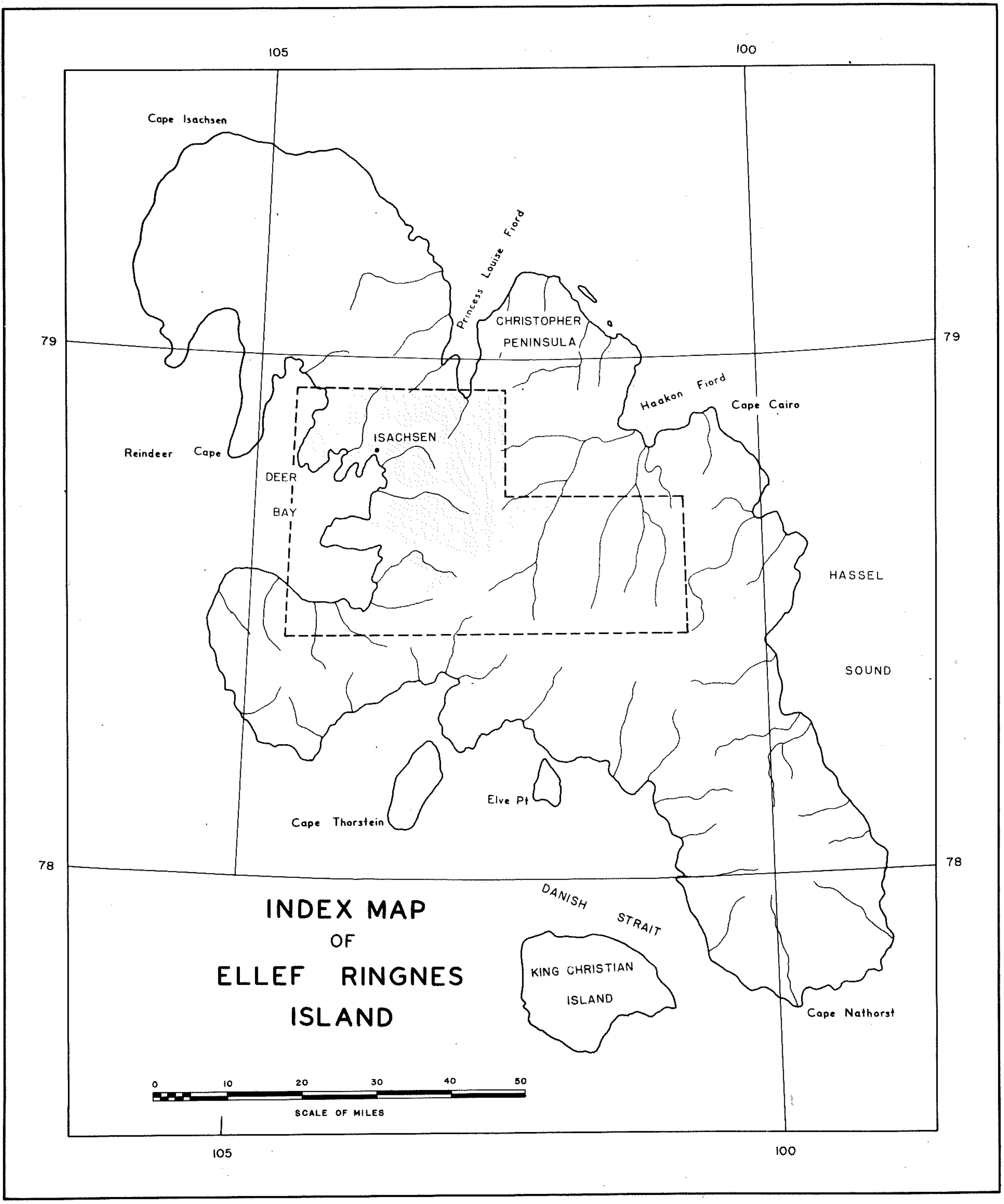

105
100
Cape Isachsen
Princess Louise Fiord
CHRISTOPHER PENINSULA
79
79
Haakon Fiord
Cape Cairo
ISACHSEN
Reindeer Cape
DEER BAY
HASSEL
SOUND
Elve Pt
Cape Thorstein
78
78
DANISH STRAIT
INDEX MAP OF ELLEF RINGNES ISLAND
KING CHRISTIAN ISLAND
Cape Nathorst
0
10
20
30
40
50
SCALE OF MILES
105
100

FIG. 2.

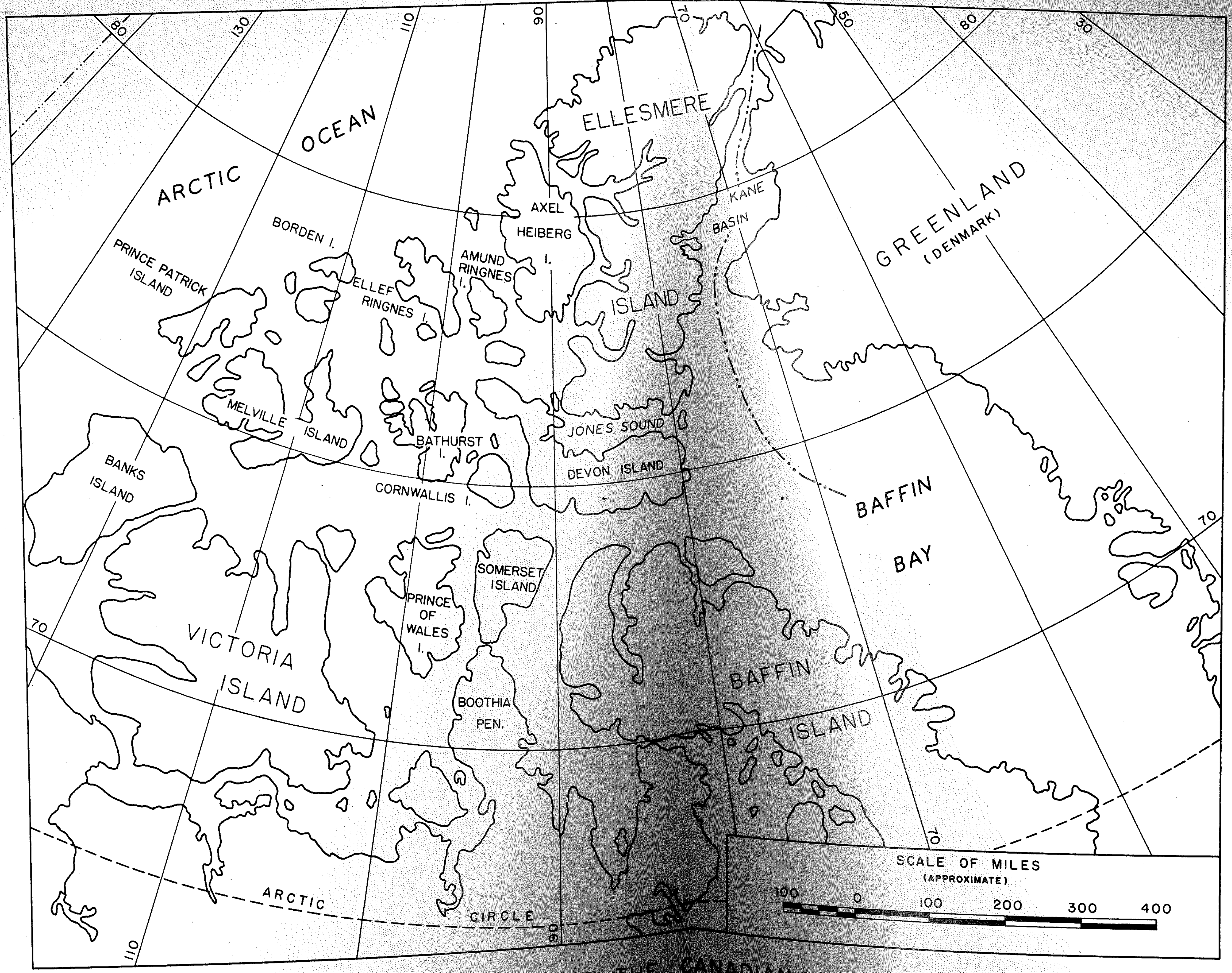


FIG. I. INDEX MAP OF THE CANADIAN ARCTIC

GEOLOGICAL MAP
OF
PART OF ELLEF RINGNES ISLAND

LEGEND

EARLY CRETACEOUS OR YOUNGER

× Basalt, diabasic gabbro

🟩 Hassel formation

🟩 Christopher formation

🟨 Isachsen formation

PROBABLY DEVONIAN OR EARLIER

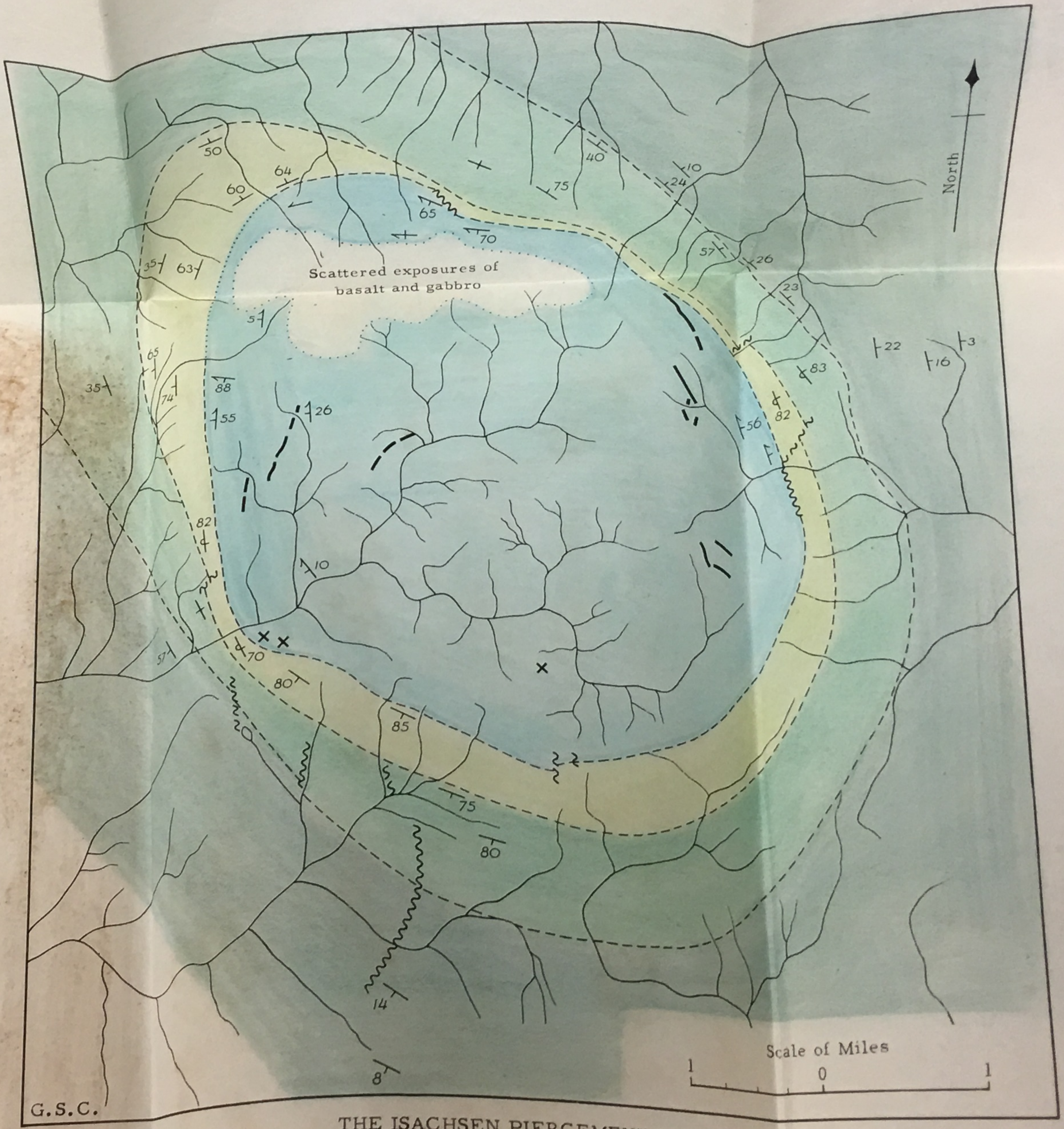
🟦 Anhydrite, gypsum, selenite, limestone

Geological boundary (approximate, assumed) . . .

Bedding (inclined, vertical overturned) . . . .

Stratiform foliation (inclined, vertical dip unknown) . . . .

Fault (defined, approximate) . . .



THE ISACHSEN PIERCEMENT DOME