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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

PAPER 56-8

ISACHSEN AREA ELLEF RINGNES ISLAND DISTRICT OF FRANKLIN NORTHWEST TERRITORIES

(Report and Map 15-1956)

By

W. W. Heywood

OTTAWA
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Price, 50 cents

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INTRODUCTION

LOCATION

Ellef Ringnes Island is part of the Queen Elizabeth Islands, in the northwestern part of the Canadian Arctic Archipelago. The island, centred on latitude 78° north and longitude 103° west has an area of over 5,000 square miles. The area mapped comprises 600 square miles in the vicinity of the Isachsen meteorological station.

ACCESS, TRAVEL CONDITIONS AND PRESENT WORK

Aircraft offer the only dependable means of access to Ellef Ringnes Island. They are used primarily during the winter, when landings may be made on level areas of frozen ground or on the sea ice.

Cross-country travel in the area is difficult during all seasons of the year. Vehicles could be used in the winter but would be of limited value in the summer because of the extremely muddy nature of the ground. Walking, though difficult at times, was found to be the only sure means of travel.

Reconnaissance geology of the central part of Ellef Ringnes Island was conducted during the field seasons of 1952 and 1953. The detail in which mapping was done varies considerably, depending upon travel conditions, accessibility, and weather. Twelve days were spent mapping the Isachsen dome in 1953.

EXPLORATION, HISTORY, AND PREVIOUS WORK

Ellef Ringnes Island was discovered in 1901 by Isachsen and Hassel of the 2nd Norwegian Arctic Expedition in the 'Fram'. Travelling by dog team from their base in Jones Sound, they surveyed the coast-line 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).[1] It was not until 1916 that the island was

[1]Dates in parentheses are those of references cited at the end of this report.

again visited. In April of that year, 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, before continuing his exploration farther north. Returning from this journey in July, he mapped part of the coast bordering on Hassel Sound. In 1917 he continued his 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 a few specimens collected by Isachsen and Hassel, no previous field work has been done on Ellef Ringnes Island. Jenness (1952), after a study of air photographs, described some physiographic features that he considered as possibly being of glacial origin. Brown (1951) studied the air photographs of the Isachsen dome and proposed several hypotheses to 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 has been in continuous operation since May, 1948. The following table summarizes the climatic data. In his discussion of these data, Rae points out that they may be in error as they were derived from records of less than 3 years' duration.

TABLE I

CLIMATIC DATA FOR ISACHSEN

		Jan.	Feb.	Mar.	Apr.	May	June	July	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	Tr.	0.44	0.36	Tr.	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%	16	12	13	16	9	4	3	4	3	9	14	18		
	30-70%	4	4	5	6	5	4	6	5	3	7	5	4		
	80-100%	11	12	13	8	17	22	22	22	24	15	11	9		
Mean cloudiness (per cent)		44	48	51	34	61	78	80	78	81	58	46	39		
Average wind speed (mph)		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	

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 derived from sandstone, mosses, lichens, and an occasional Arctic poppy or clump of grass may be seen. Vegetation is somewhat more abundant in areas underlain by shale, but only where drainage is better than average, such as on the long, low slopes on 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: caribou, 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.

TOPOGRAPHY AND DRAINAGE

The part of Ellef Ringnes Island mapped is largely a plain except that northeast of Deer Bay, which is a deeply dissected plateau (see Plate II B). 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, but only a few of the numerous streams that form a dendritic drainage pattern have eroded valleys to that depth. The sedimentary strata have a low regional dip to the southeast and the more resistant beds form long, low, cuesta escarpments that cross the plains in a northeasterly direction (Plate III B).

The lower part of the Isachsen sandstone, which outcrops 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 1,000 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 (Plate II B). Drainage on the undulating plateau surface is poorly defined and drainage channels are non-existent over most of the plateau area.

The Isachsen dome, located in the south central part of the island, stands 400 to 600 feet above the surrounding plain and approximately 1,000 feet above sea-level. Viewed from a distance the central part of the dome has the profile of an even-topped table land, dropping with steep sides to the adjacent plain. Well over half of this is highly dissected, with a maximum relief of about 500 feet (Plate VI B, VII A). 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.

ACKNOWLEDGMENTS

J. A. Jeletzky, D. J. McLaren, and W. L. Fry of the Geological Survey of Canada, and J. D. Hale of the Forests Products Laboratory reported on the fossils collected. Professors Howard A. Coombs and J. Hoover Mackin of the Geology Department, University of Washington, made many valuable suggestions. Able assistance in the field season of 1953 was given by D. W. Bolyard.

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 cooperation during the course of the field work.

GENERAL GEOLOGY

The sedimentary rocks exposed in the area consist chiefly of a conformable sequence of marine and non-marine shales, sandstones and limestones of Lower and possibly Upper Cretaceous age. The total stratigraphic thickness exceeds 6,800 feet.

Diabase, basalt, and gabbro occur north and northeast of Deer Bay. As dykes and sills they intrude the Deer Bay formation and as sheets they overlie the lower part of the Isachsen formation.

The Isachsen piercement dome has upwarped and intruded the Isachsen, Christopher and Hassel formations. These formations form concentric rings around a central core composed of gypsum and anhydrite. Diabase, basalt, and limestone inclusions outcrop within the core. Late Palaeozoic fossils are present in the largest limestone block.

Over 90 per cent of the part of the island mapped is covered with surficial deposits, derived for the most part from the weathering of the underlying bedrock (<u>see</u> Plate V B). As a result, contacts between the various lithological units are poorly exposed, and in most places, float mapping has been used to determine contacts.

Table of Formations

Era	Period or Epoch	Formation and thickness (feet)	Lithology
Cenozoic	Recent		Residual soil. River deposits. Raised beaches. Clay, sand, gravel
Cenozoic or Mesozoic			Diabase, basalt and gabbro
Mesozoic	Upper or Lower Cretaceous	Hassel formation 1,800 +	Sandstone, interbedded shale
	Lower Cretaceous	Christopher formation 1,540 +	Black and grey shale, minor thin-bedded limestone
		Isachsen formation 3,000 +	Grey to red sandstone, minor shale, thin coal seams in lower part
		Deer Bay formation 500 +	Black shale, silty shale
Palaeozoic	Permian or Carboni-ferous		Limestone
	Permian or earlier		Gypsum and anhydrite

PALAEOZOIC

Palaeozoic rocks occur only in the Isachsen piercement dome. This dome is approximately elliptical in outline, 5 miles long and 4 miles wide (Plate I).

Permian or Earlier

Gypsum and anhydrite make up the bulk of the core, with the anhydrite being the major constituent. The anhydrite is a compact, fine-grained rock that varies in colour from light to dark grey. The gypsum is an alteration product of the anhydrite on which it commonly forms an encrustation. It is a porous, friable, earthy material, commonly white or light grey in colour.

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 colour changes. The layers have indistinct borders. Although they were not observed in all outcrops their presence may have been masked by deep weathering or by an encrustation of gypsum.

The selenite variety of gypsum is present in all exposures, commonly constituting 5 to 10 per cent of the rock, although in places amounting to 50 per cent. It is generally fine grained but crystals 12 inches in length are not rare. Selenite occurs in the following ways: (1) as irregular masses in the gypsum and anhydrite; (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.

Permian or Carboniferous

A very fine-grained, light grey limestone, unlike the cretaceous limestone outside the dome, occurs as isolated blocks within the central part of the Isachsen piercement dome. The largest of these measures 50 feet wide, 100 feet long, and has an average exposed thickness of 10 feet. Most of the blocks are extremely fractured and are 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, cf. pentamerid.
> Small smooth brachiopod.
> Crinoid stems."

He further noted that: "The fauna shows little to suggest an age determination other than Palaeozoic".[1]

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[1]During the 1955 field season collections made from one other dome on Ellef Ringnes Island have been dated as Pennsylvanian or Permian. The collection from the Isachsen dome may well be of the same age.

LOWER CRETACEOUS

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 great distance (Plate II A). The base of the formation is not exposed, therefore only the upper 600 feet have been mapped.

This formation is composed of black, laminated shale and silty shale that is poorly consolidated and very closely jointed. Thick- to thin-bedded massive shale beds occur throughout the formation anf buff weathering thin-bedded limestone beds 4 to 30 inches thick are present near the top. Numerous calcite concretions and rosettes occur throughout the formation but are most common in the lower part of the exposed section.

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. J. D. Hale of the Forest Products Laboratory of the Department of Resources and Development(now the Department of Northern Affairs and National Resources)describes the material as follows: "...... the araucarian type of tracheary 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. Fry of the Geological Survey of Canada. These specimens are all of secondary system 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; or (3) a slow growing tree in a climate with regular variations or cycles.

The Deer Bay formation contains poorly preserved fossils. As a result determinations are difficult and in many cases are only tentative. The following forms were identified by J. A. Jeletzky of the Geological Survey of Canada.

Aucella cf. terebratuloides Lahusen
Aucella ex. gr. keyserlingic (d'Orbigny)
Aucella cf. nuciformis Pavlow
Aucella cf. werthii Pavlow
Aucella n. sp. ? (ex. aff. A. crassicollis Keys or A. crassa Pavlow)
Aucella cf. crassa Pavlow
Aucella piriformis Lahusen phase crassicollis Pavlow
Aucella ex. gr. crassicollis Keyserling
Aucella cf. A. bulloides Lahusen
Acroteuthis ex. gr. subquadratus (Roemer)
Acroteuthis ex. gr. johnseni Blüthgen cf. Acroteuthis elongatus Blüthgen
Inoceramus sp. indet. (? cf. I. stantoni Anderson)
Arctica sp. indet.?
Anatina (Cercomya) ? sp. indet.
Nucula ? sp. indet.
A peculiar ammonite of the family Blyptychidae s. lato (? a new genus), which is similar to representatives of the genera Dichotomites Koemen, Tollia Pavlow, and Neocraspedites Spath. Preservation is insufficient for an exact generic determination.

From the above Jeletzky concludes that the Deer Bay formation ranges in age from the Infravalanginian to the Valanginian substages of the Neocomian stage (early Lower Cretaceous).

Isachsen Formation

The Isachsen formation is named after the Isachsen Peninsula. It outcrops in a northeasterly trending belt across the island and as a ring around the Isachsen dome. The formation is generally about 3,000 feet thick.

This formation is composed of a grey to red quartzose sandstone that weathers buff, rusty, or grey. It is a fine- to medium-grained rock, with grains 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 is siliceous. Minor amounts of garnet, muscovite and magnetite are present throughout the formations. Generally the sandstone is thick bedded and massive with thin-bedded, flaggy units of lesser extent (Plate III A). Cross-bedding does not occur extensively but is well developed locally. Black to grey, micaceous, laminated, shaly siltstones and claystones are interbedded with flaggy sandstones in the lower 60 feet of the formation. Lignitic coal seams and lenses from a fraction of an inch to 3 inches thick are present in these lower beds but are not widespread.

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 centre of some of the broken concretions there is what appears to be a woody material, too friable to be collected.

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

Aucella cf. *A. bulloides* Lahusen
Aucella cf. *A. terebratuloides* Lahusen

He concludes that these could range from the Infravalanginian to the Valanginian substages of the Neocomian stage (early Lower Cretaceous).

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 is at the highest outcrop of sandstone or the lowest outcrop of shale of the overlying Christopher formation. This contact is not exposed but the attitudes of the 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 outcrops in a belt parallel to, and southeast of, the Isachsen formation. It also forms a ring around the Isachsen dome.

The lower part of the Christopher formation consists of black, laminated, fissile shale and silty shale, interbedded with a lesser amount of thin-bedded, slabby limestone. The limestone beds, averaging 18 inches thick, are separated by 10 to 150 feet of shale. The upper part of the formation is composed of a similar shale which grades from black to grey in colour near the top. These two parts are lithologically similar but differ in that the upper part contains no limestone. A similar sequence outcrops around the Isachsen dome. The thickness is normally about 1,540 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.

No fossils were found in situ in the Christopher formation.[1]

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[1]During the 1955 field season collections were made from the Christopher formation on Ellef Ringnes and Axel Heiburg Islands by various members of the Geological Survey of Canada. They contain ammonites that have been examined by H. Frebold, who states that the collections from Axel Heiburg Island are definitely of Albion (Lower Cretaceous) age and that those from Ellef Ringnes Island are probably also Albion.

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 shale or the lowest outcrop of sandstone belonging to the Hassel formation. The contacts are apparently conformable.

LOWER OR UPPER CRETACEOUS

Hassel Formation

The Hassel formation, the youngest consolidated formation in the map-area, is named after Hassel Sound. It outcrops northeast, east, and south of the Isachsen dome, partially encircling the dome; 1,800 feet of this formation in the vicinity of the Isachsen dome were mapped, but its upper contact was not reached.

Thin-bedded, blocky to slabby, quartzose sandstone constitutes about 70 per cent 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, silty shale. 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.[1]

[1]During the 1955 field season fossils were collected by H. Greiner of the Geological Survey from beds above the Hassel formation. They include specimens of Inoceramus dated by F. H. McLearn as Upper Cretaceous. The Hassel formation is therefore of Lower or Upper Cretaceous age.

The contact with the underlying Christopher formation, as already described, has been placed at the highest outcrop of Christopher shale or the lowest outcrop of Hassel sandstone. It is apparently conformable with the underlying Christopher formation.

DIABASE, BASALT, AND GABBRO

Diabase, basalt and gabbro occur over approximately 40 square miles in the northwestern part of the area, north and northeast of Deer Bay. Dykes intrude the Deer Bay formation and sheets overlie the lower part of the Isachsen formation in the north-central part of the area. Blocks and tabular inclusions of diabase and basalt are present in the core of the Isachsen dome. No basic rocks were found within the Christopher and Hassel formations.

Contacts between the intrusive and sedimentary rocks are exposed in few localities (Plate IV B). The basic rocks are more resistant to weathering than the sedimentary rocks and commonly stand as steep ridges and escarpments with talus and solifluction slopes extending to their bases. Contacts were established by float mapping. Although they can often be determined within a few feet, the actual contact relations are for the most part unknown.

Four prominent ridges, circular to semicircular in outline, occur in the northwestern part of the area. Diabase is present along the crests of the ridges whereas shale is exposed in the basin-shaped, central valleys and similar shale is present outside the ridges.

The smallest of these structures is near the sea-coast in the northwestern part of the area. The ridge, forming a roughly circular enclosure, has a diameter of 1 1/2 miles, slightly elongated in a northerly direction. No contacts are exposed and no local determinations of the altitude of the diabase nor of the shale can be made, however, regionally the shale is flat-lying.

To the southeast is a larger but generally similar structure. The ridge is shaped approximately like a horseshoe, open to the south (Plate IV A). The east-west diameter is 1 3/4 miles and the north-south diameter is 3 miles. This ridge has an average elevation of about 700 feet, attaining a maximum elevation of 825 feet. Within the central area, flat-lying shale is exposed to an elevation of 250 feet, no outcrops occur above this elevation but talus composed of shale fragments is present in several localities to an elevation of 500 feet. The diabase extends from the top of the ridge down to sea-level on the southwest side of the structure and to 100 feet above sea-level on the southeast side. The contact between the diabase and the shale can be seen at one locality only. This is on the southwest inner side of the diabase, where the contact of the diabase is concordant with shale beds and dips 30 degrees towards the centre of the horseshoe.

Two similar ridges, essentially similar to those described above occur on the peninsula in the northwest part of the area. Little is known of these as outcrops are few and poor.

The regular geometric shape of the diabase occurrences suggests that erosion was controlled by bedrock structures. The diabase may have intruded the shale as ring dykes or as undulating sheets.

The ridges that form the two peninsulas extending southward into Deer Bay are composed of diabase. Altitudes 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 slopes are steep but do not form high cliffs. Scattered patches of silty shale occur on the ridge crests and form long talus slopes on the sides. This rock does not outcrop except on the northern end of the western peninsula where it strikes east and dips north at 10 degrees. Black fissile shale, approximately horizontal, outcrops 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.

Flat-lying diabase sheets outcrop 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.

An elongate outcrop, centred on latitude 78°51'N and 103°42'W, appears to be concordant with the Deer Bay formation. East of this is a second elongate outcropping of diabase. This is concordant in the northern and eastern parts but has discordant relationships in the southern and western portions where it has a low westward dip (Plate V A). At its extreme southwestern end several disconnected outcrops have the pattern of a steeply dipping dyke.

Two miles east a similar diabase sheet overlies the Isachsen formation. From a distance the two sheets appear to be the eroded remnants of a once continuous sheet. The minimum thickness of this sheet overlying the Isachsen varies from 45 feet in the west to 175 feet in the eastern exposure. Although the contact is not exposed, the outcrop pattern suggests that it is concordant (Plate II B). 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.

Diabase, basalt, and gabbro inclusions occur near the periphery and in the upland part of the core of the Isachsen dome. Three more or less rounded inclusions, 20 to 50 feet in diameter, lie in the southern part of the core. Tabular inclusions as long as 2,300 feet and as wide as 60 feet occur in three groups near the eastern and western parts of the core. Within each group they are diversely oriented but the longer ones show a general parallelism to the outer contact of the core. The northern upland part of the core has fewer outcrops and the occurrence and arrangement of these outcrops suggest that they were once part of a more or less continuous sheet of basalt, now broken and detached. 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 represented in the Deer Bay region are present in the dome.

Petrography

The igneous rocks of the Deer Bay region and of the northeastern plateau region consist almost wholly of diabase. The rocks are charateristically 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. The normal diabase grades into very fine-grained and aphanitic varieties at exposed contacts with sedimentary rocks. Although few contacts are exposed, these varieties are considered to be border or contact phases wherever they are found. Only one small (3 cm.) inclusion of baked shale was found in the diabase.

In thin section there is little variation in texture and mineralogy of the diabase. It is a holocrystalline, ophitic rock with an average grain size of 0.5 mm. Lath-shaped labradorite crystals and anhedral pyroxene, augite or pigeonite, but commonly both, are the most abundant minerals. Magnetite is the most common accessory mineral. Minor amounts of apatite, biotite, green hornblende, chlorophaeite and quartz are present.

Gabbro occurs only within the diabase as irregular 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 is has a fresh, unaltered appearance. The rock, typically medium to coarse grained, is composed essentially of plagioclase and pyroxene. The plagioclase is labradorite in subhedral crystals 2 to 10 mm. in length. Anhedral to subhedral pyroxene (augite and pigeonite) average 4 mm. in length. Accessory minerals are apatite, hornblende, magnetite, quartz and chlorophaeite.

Mineralogically this rock is similar to the enclosing diabase but it differs in that it does not have the ophitic texture of the diabase.

Basalt is a rather uncommon rock occurring only as a few narrow dykes 2 to 10 feet wide. Their relation to the diabase and gabbro is not known as these rocks were nowhere found in contact. The basalt dykes intrude the Deer Bay formation in the southern and eastern areas, but they were not noted in the younger formations.

The basalt is aphanitic with a few scattered plagioclase (labradorite) phenocrysts. Calcite amygdules, 1 to 3 mm. in diameter, are common in the dyke rock. Inclusions of the intruded shales are numerous in some of the dykes and show no alteration although they are commonly rimmed with calcite.

Method of Emplacement

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

Those rocks with circular outcrops are considered to be intrusions because the inner shale beds dip towards the centre of the structures.

The relationship of the diabase above the Isachsen formation to that above the Deer Bay formation is not clearly understood. In the plateau area the sandstone underlying the diabase thins to the west. Farther west the diabase overlies the Deer Bay formation with apparently no sandstone present. The sandstone which thins to the west may finally pinch out, but 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 and 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.

QUATERNARY GEOLOGY

Weathering

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 depend upon local topography, jointing, texture and composition. Chemical weathering appears to be of minor importance; the effects of mechanical weathering are by far the most prevalent. Weathering is probably of a very minor nature below the permafrost table. This is usually 12 to 18 inches deep and has been measured at a maximum depth of 26 inches.

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 (Plate VIII A). On steeper slopes, where fresh surfaces are constantly being exposed, chemical weathering is of little importance.

Joints provide avenues for the entry of meltwater which hastens the rate of both mechanical and chemical weathering. The latter seldom exceeds 1/16 inch in depth. Grain size is an important factor in controlling the rate of mechanical disintegration as is shown by the fine-grained diabase and basalt which are much less weathered than the coarse-grained gabbro.

Weathering of sedimentary rocks is almost entirely mechanical. The shales and sandstones are composed of minerals that are essentially stable at atmospheric temperatures; therefore, the only changes in the rock are the result of disintegration. The fractured limestone contains no evidence of solution cavities, probably because mechanical break-up is too rapid for their formation.

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 between unweathered shale and clay have been noted in several localities. Residual boulders are present on ridge tops and in the plateau regions (Plate VIII A), where all transitions from angular fragments to subrounded 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

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 from melting snow and ground ice, favours the development of mudflow and solifluction, and are important but not essential to the development of the other processes. The sparse vegetation allows these processes to proceed at a much faster rate than in a more temperate climate with abundant vegetation. However, this is somewhat offset by the short summer season as the processes are either inactive or only of minor importance during the winter months.

Mudflows are common but generally not of any great areal extent. None was observed with a front exceeding 10 feet. Mudflows typically form below snowbanks 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 in width from 2 to 6 inches and were as long as 10 feet. Small mudflows form in the stream beds at a time when the streams almost stop flowing. The saturated silt and clay 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 tributary and major streams.

Solifluction is a process whereby a mass of waste, saturated with water, flows as a viscous mass from higher to lower ground (Andersson, 1906). The rate of movement is very slow and variations in the rate of movement of a broad sheet give the front a lobed appearance. Solifluction fronts are common on Ellef Ringnes Island and are best developed on slopes below ridges and escarpments. These ridges and escarpments provide effective wind breaks and permit the accumulation of large amounts of snow on their lower slopes (Plate III B). The melting of the snow provides sufficient water to completely saturate the soil on the lower slopes for most, if not all, of the summer, and it is here that the greatest amount of solifluction occurs. The effects of solifluction are negligible in areas where snow coverage is thin and in many of the wide valley flows where as much as 3 to 6 feet of snow may accumulate during the winter months. This melts rapidly in the early part of the summer and run-off is almost complete before the ground has had time to thaw to a depth of more than a few inches.

Large areas around the Isachsen dome show only local effects of solifluction, due in part to the small accumulation of snow on the broad low hills. In this locality solifluction occurs only in the deeper stream valley and along steep ridges.

Subsidence of the surface mantle occurs as a result of the melting of lenses and layers of ice in the soil. Deep thawing of the ground ice will take place when the thin insulating cover of humus and vegetation is removed probably 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 long, 6 to 8 feet wide, and 1 foot to 3 feet deep have formed in this manner. The sides of some of these show discontinuous longtitudinal cracks that are formed by the slumping of the surface mantle above a melting ice lens. Several ponds, up to 200 feet in diameter may have been formed by the melting of ice lenses with the resulting subsidence of the surface soil.

Other processes of mass wasting such as slump, creep, rockfall and rockslide (Plate IV A) are of widespread occurrence. These processes are often gradational into one another and their relative importance could not be estimated. They are present on all slopes underlain by basic rocks which form steep slopes but are of minor importance in most areas underlain by sedimentary rocks where the slopes are generally low.

Fluvial Action

The streams of Ellef Ringnes Island flow for only a short period of the year. Flow usually commences in early June, reaches a maximum in mid-July and gradually decreases until freeze-up in late August. The small streams are completely dry within a few 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 and poor in areas underlain by shale. The shale weathers to an almost impermeable clay that is partly or completely saturated with water for most of the summer.

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

Wind Action

Wind is the only agent of erosion and transportation that is active all year. Locally it may be of prime importance but its total effect is difficult to estimate. The monthly and annual wind velocities are given in Table I.

Wind action is effective on snow-free areas during all months of the year. The snow is blown clear of the ridges in the winter months, and sand, silt, and clay soils are dried out. It was observed that soils frozen to a solid mass in late August were covered with loose soil in mid-September. By April and May, the depth of such loose and dried soil was as much as 5 inches. Temperatures were below freezing during this period, therefore the ice must be removed from such soils by sublimation. The dried soil, when bared of snow, is easily eroded by the wind. Fragments of shale up to 5 mm. in diameter are carried and rolled for considerable distances and were noted on the sea ice at least 2 miles from their closest known source. Sand grains and even small pebbles are transported from the ridges into the river valleys.

During the summer months the wind can be effective only on dry ground. Although the soil may be wet at a depth of 2 to 3 inches, the surface 1/2 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 and 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 shale have formed in the large delta of the river flowing into the northeast part of Deer Bay. These are 1 foot to 3 feet long, 1 foot to 2 feet wide and 2 to 10 inches high. The dunes formed behind clumps of grass, oil drums and boxes.

The effect of wind during the winter is in transporting the snow and aiding in its compaction. Large drifts, often stratified form when the wind blows in a constant direction. Shifts in the wind direction result in erosion and abrasion of the first formed drifts and the result is similar to a series of sedimentary rock 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 stream erosion 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, Hobbs (1945) and Jenness (1952) have proposed a northern limit of continental glaciation. Hobbs placed his boundary between the areas that contain many lakes and those that contain few or no lakes. Jenness determined his northern limit from a study of glacial features shown on air photographs and noted from flights over the area.

Little field work has been done previously 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 landforms, till, erractics and glacial groovings and striations strongly suggest 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 Pleistocene glaciation would be lacking.

On Ellef Ringnes Island evidences 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, these are considered to be weathered equivalents of similar but unweathered deposits that 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 shale fragments. The weathering of the shale results in a mixture of clay, sand, and gravel similar in many respects to till.

Loose pebbles and cobbles of quartzite are present on many of the high ridges and in the plateau area. They are of rare occurrence in the valleys where only two cobbles were found. These may have attained their present position by ice-rafting, glacial transport or they may be residuals derived from the weathering of an overlying conglomerate. Although no cobbles were found in the sedimentary formations, quartzite pebbles up to 2 inches in diameter and similar to the erratics, occur in some of the gravel lenses of the Isachsen formation.

Glacial 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.

Emerged Strand Lines

Emerged strand lines were noted on the southern end of one of the peninsulas on the north side of Deer Bay and on the eastern side of Deer Bay. In these areas the land slopes gently to the sea from higher ridges composed of basic igneous rocks. The highest strand line is at an elevation of 50 feet above sea-level.

The raised beaches are composed of coarse sand and angular to subrounded gravel derived from basalt, diabase and gabbro. Gently sloping gravel beaches are not common in the area mapped. It is probably that erosion and mass wasting have destroyed evidence of raised strand lines in soils composed of sand, silt, and clay.

STRUCTURE

Cretaceous Sedimentary Rocks

The Deer Bay shale and the Isachsen sandstone are essentially flat lying in the north and northeast parts of the area. Southeastward the Deer Bay shale and the younger sedimentary rocks have a regional southeasterly dip not exceeding 6 degrees.

Local folding and faulting have occurred in the sedimentary rocks in the vicinity of the piercement dome and in areas containing basic igneous rocks. These will be discussed in the section of this report dealing with the Isachsen dome and the basic igneous rocks.

Faulting was noted in only two outcrops in the Deer Bay formation. These are normal faults with a maximum vertical displacement of 10 feet. Narrow veins of slickensided calcite are present in the observed fault planes. Fragments of a similar slickensided calcite occur as long sinuous lines on the surface mantle of the Deer Bay formation. This suggests that other faults, having no topographic expression, may be present. No faults were noted in the sedimentary formations younger than the Deer Bay formation, except in the vicinity of the Isachsen dome.

Jointing is common 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.

Isachsen Piercement Dome

The intrusion of the gypsum and anhydrite core has faulted and upwarped the overlying sedimentary rocks. The Isachsen and Christopher formations are sharply upturned and in some places overturned near their contact with the intrusive evaporites. At a distance of 1 mile 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.

Faults, both radial and tangential to the outer contact of the core, occur in the Cretaceous sedimentary rocks. The majority of the radial faults are in the Isachsen 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 (Plate I) 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 recognized on the ground.

The variable width of the outcrop belt of the Isachsen and Christopher formations around the piercement dome (<u>see</u> geological map) is due in part to variable dips of the formations but much of the narrowing is a result of the intrusion of the evaporites. Measured thicknesses of the Isachsen formation exposed between the anhydrite gypsum core and the Christopher shale vary from 308 feet to 1,745 feet. Non-deposition, or erosion of the Isachsen formation, or mechanical squeezing during intrusion, may possibly have resulted in this local thinning. The author cannot demonstrate whether these processes were operative or not.

The layering within the gypsum-anhydrite core has been described above. This layering is best exposed near the northern and eastern borders of the core (Plate VI A). In these areas the dips are steep but variable, generally decreasing towards the centre of the core. Layers are thicker in the central part of the core and are less distinct than in the border areas (Plate VI B). Folding varies from broad gentle folds in the central area to tight, intricate folds near the outer contact of the core (Plate VII A). These folds are diversely oriented; a change in strike of nearly 90 degrees occurs across a narrow canyon.

Two limestone beds, conformable with the layering of the gypsum-anhydrite, are present in the northern layered area of the core. One of these, 18 inches thick, has been folded into a tight, recumbent, S-shaped fold. The second layer, 6 feet thick, has been deformed into a crush breccia (Plate VII B).

No faults were found within the central part of the dome.

Time did not permit detailed mapping of folding and faulting within the core of the dome. Reconnaissance observations suggest the presence of an overall internal structure but a more detailed study will be required to demonstrate this.

ORIGIN AND AGE OF THE ISACHSEN PIERCEMENT DOME

It is most likely that the gypsum-anhydrite core rocks and their layered structure are of primary sedimentary origin. This is supported by the conformity of the gypsum-anhydrite layering with the limestone bands.

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 sedimentary rocks; (2) faulting of the Isachsen and Christopher formations has resulted from the intrusion; (3) the presence of Palaeozoic fossils is indicative of a deep source of the core rocks. At the periphery of the core, Isachsen beds have been upwarped at least 3,700 feet above their position a mile or so away.

The age of the Isachsen structure cannot be determined from the information available beyond the fact that it is younger than the Hassel formation which is of Upper or Lower Cretaceous age.

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Plate I. Vertical view of the Isachsen dome. North to top of picture. (R. C. A. F. photo T428C-161.)

Plate II A. Low rolling topography in area underlain by Deer Bay shale.

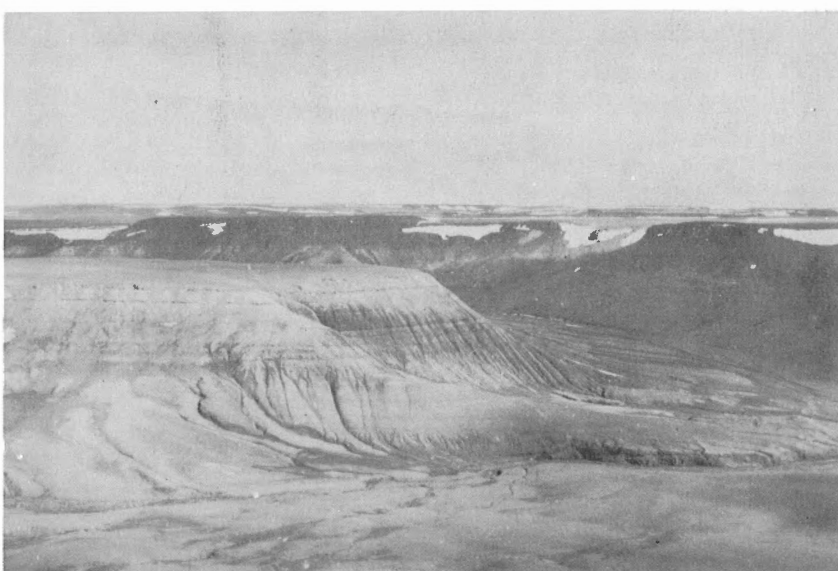

Plate II B. Horizontal Isachsen sandstone conformably overlying Deer Bay shale. Diabase capped plateau in the background.

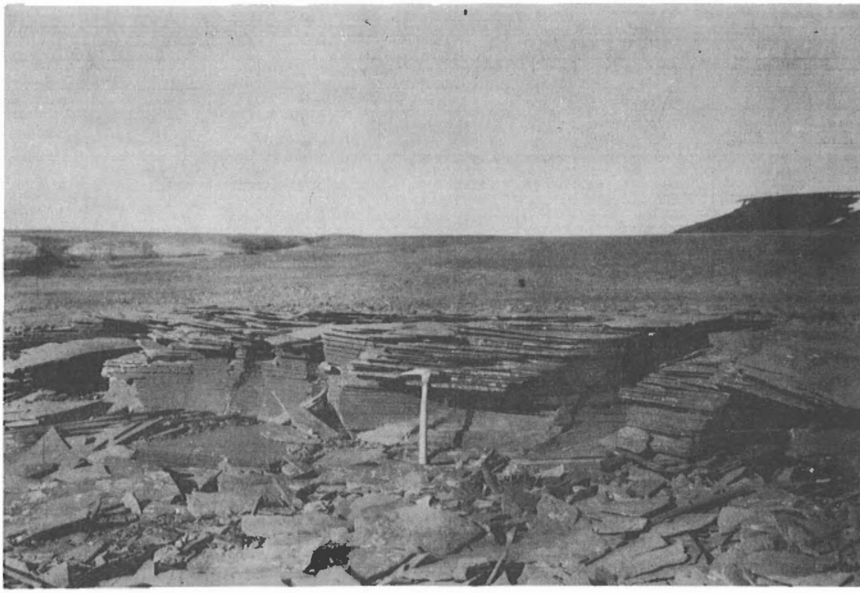

Plate III A. Thin-bedded platy sandstone of the Isachsen formation.

Plate III B. Escarpment near base of the Christopher formation.

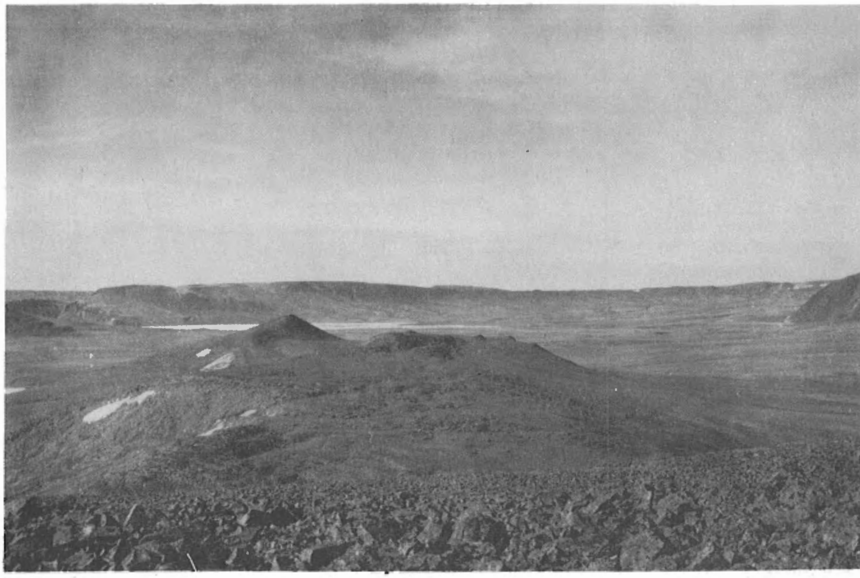

Plate IV A. Horseshoe-shaped diabase ridge on north side of Deer Bay. Note landslide scar in left foreground.

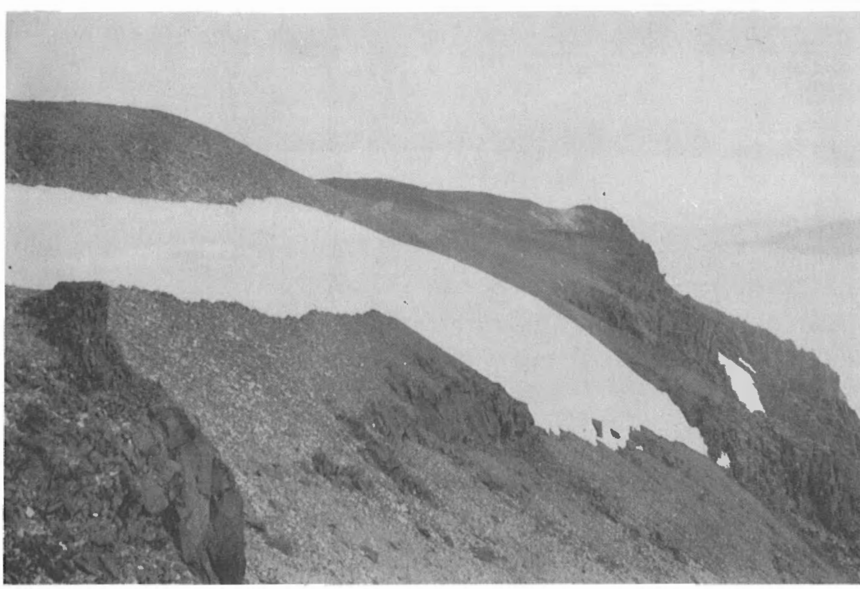

Plate IV B. Slightly indurated silty shale of Deer Bay formation overlying diabase at western side of the ridge shown in Plate IV A.

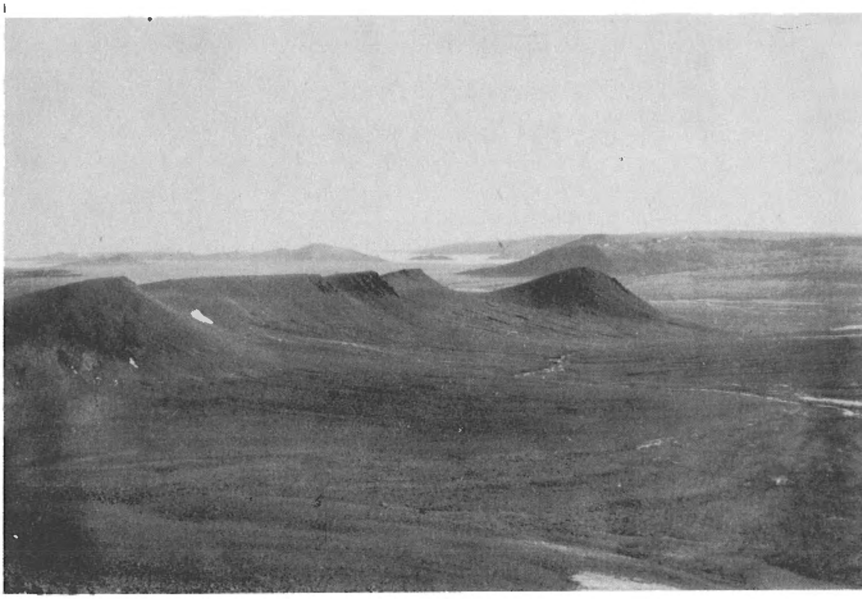

Plate V A. Diabase sill in Deer Bay formation.

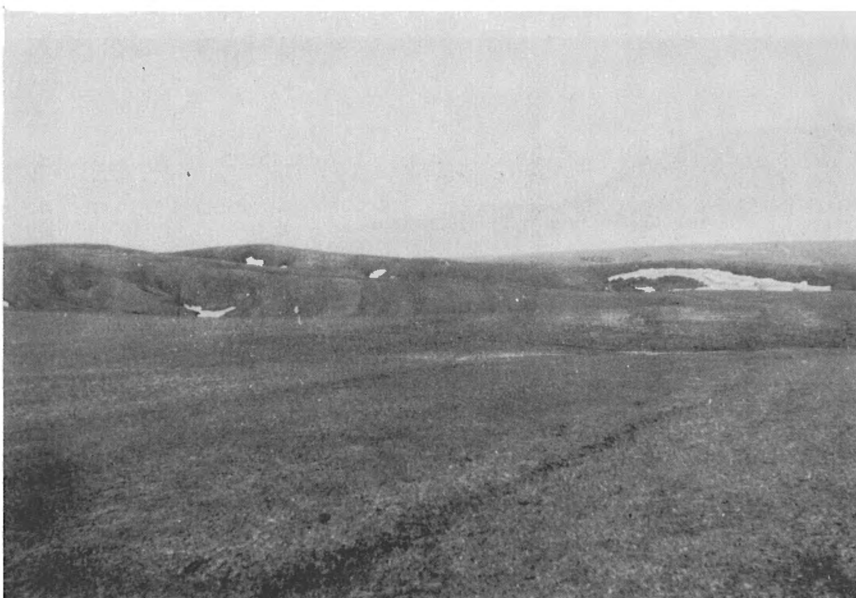

Plate V B. Christopher formation at northern side of the Isachsen dome. The banding in the soil mantle is a surface expression of the underlying sedimentary rocks.

Plate VI A. Layered gypsum and anhydrite on the eastern side of the Isachsen dome.

Plate VI B. Deeply dissected anhydrite core showing layering dipping to the left. Relief approximately 400 feet.

Plate VII A. Folded anhydrite near western margin of the Isachsen dome.

Plate VII B. Limestone crush breccia at northern end of the Isachsen dome.

Plate VIII A. Residual boulders on diabase capped ridge.

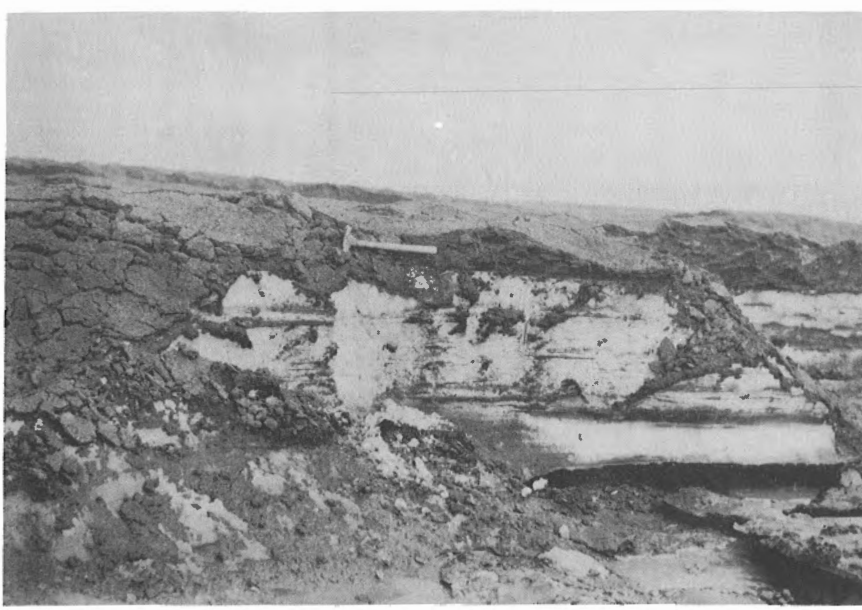

Plate VIII B. Wind-deposited clay, silt, and shale fragments on, and interbedded with, wind-drifted snow.

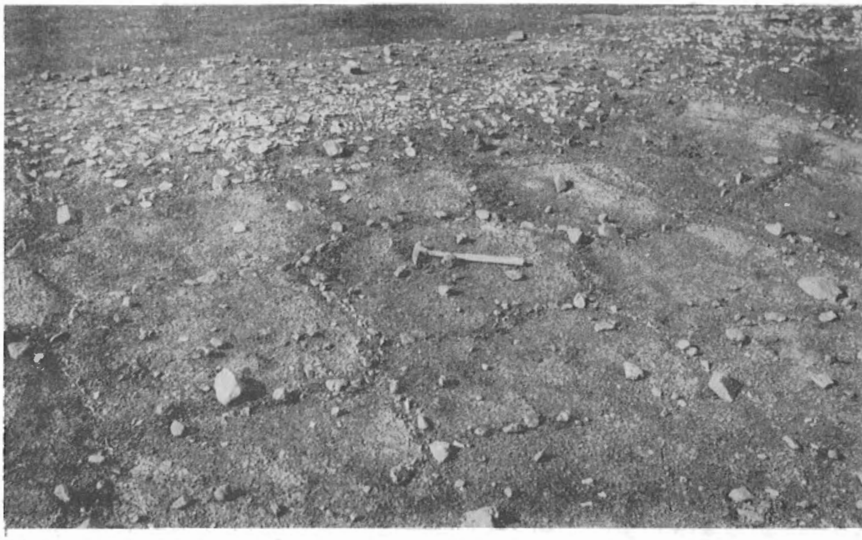

Plate IX A. Polygonal structures on wind-swept ridge. The soil cover has been removed exposing fissile shale of the Deer Bay formation.

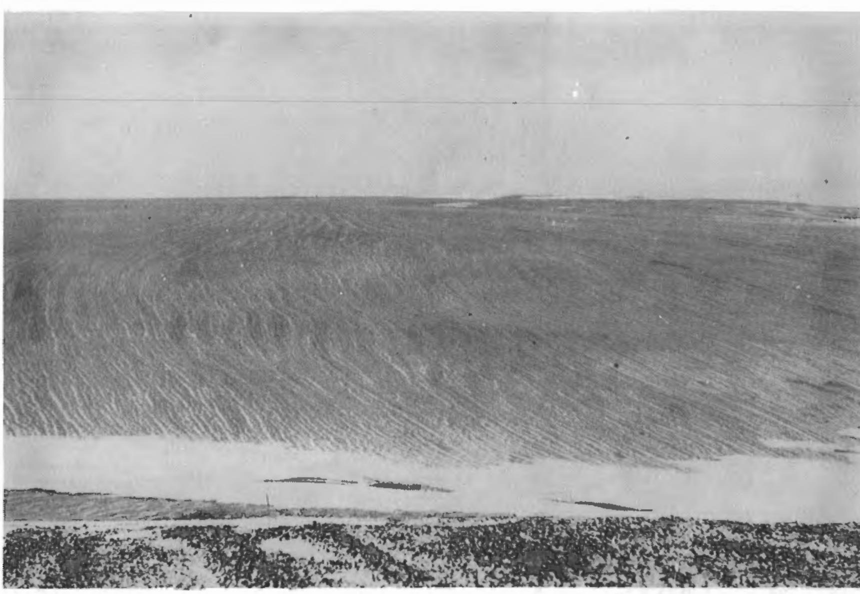

Plate IX B. Soil stripes.

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