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The possibility of ilmenite placers in the Thule district, North Greenland

A preliminary examination of the heavy fractions of some sands

by

Martin Ghisler and Bruno Thomsen

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THE POSSIBILITY OF ILMENITE PLACERS IN THE THULE DISTRICT NORTH GREENLAND

A preliminary examination of the heavy fraction of some sands

by

MARTIN GHISLER and BRUNO THOMSEN

With 3 figures and 1 table

1971

Abstract

The mineralogical composition of the heavy fractions of 19 sand samples from the Thule district reflect the local bedrock geology, which ranges from sedimentary rocks (Thule Group, probably Proterozoic) over different types of gneisses to intermediate and basic intrusives (probably belonging to the basement). One sample, taken from a 1 m thick black sand layer, contains 60–70 weight % of pure ilmenite, the source rocks of which are regarded as diabases intruding the Dundas Formation (Thule Group) in the area immediately to the east. Ilmenite placers may occur in the raised beaches reaching 125 feet above the present sea level, and also the possibility of off-shore deposits should be taken into consideration. The climate and access to the area are briefly discussed.

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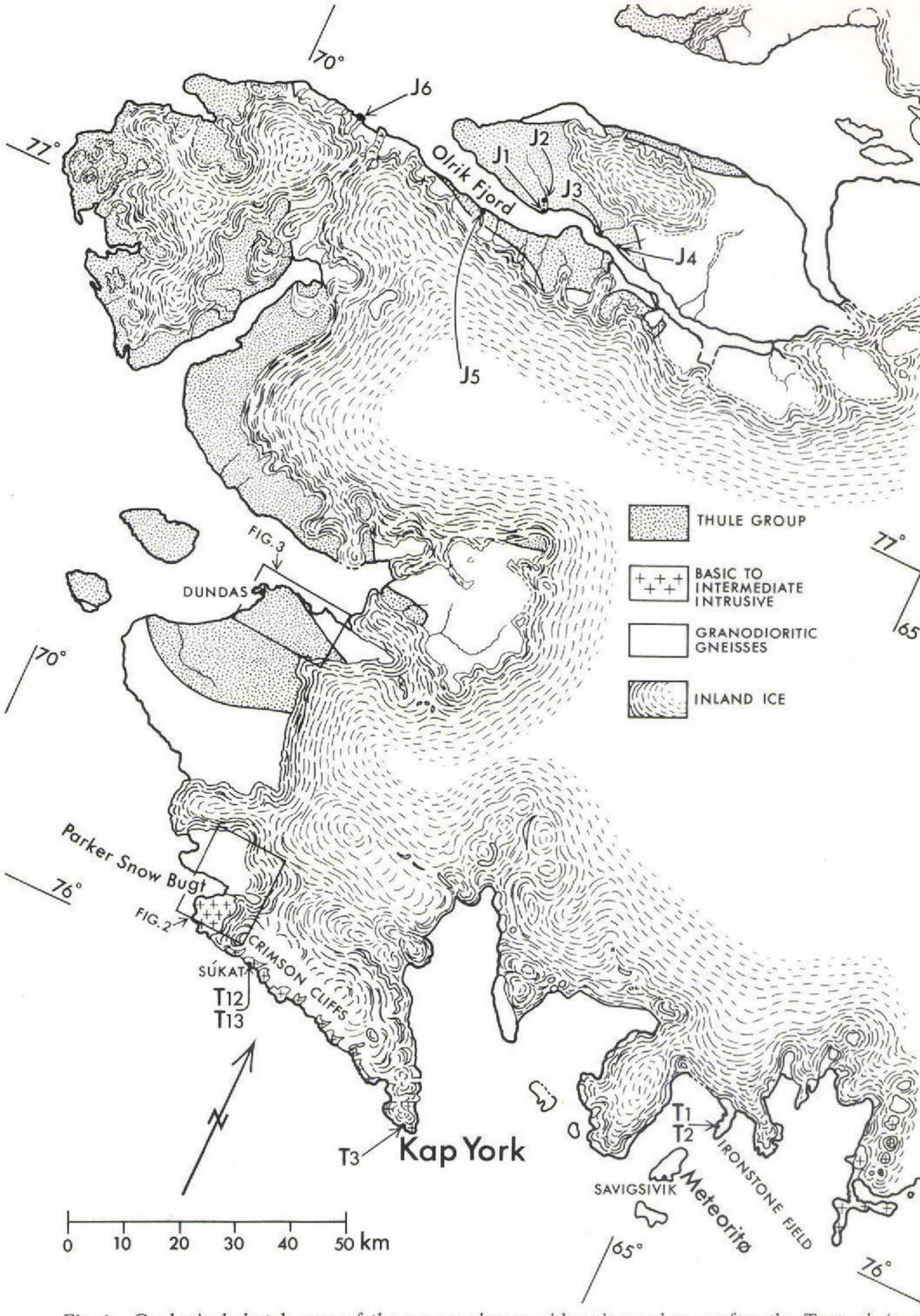

Fig. 1 Geological sketch map of the area under consideration redrawn after the Tectonic/geological map of Greenland (Geological Survey of Greenland, 1970), indicating sample locations.

INTRODUCTION

The samples discussed in this report were collected in the summer of 1950 by the second author and Knud Jakobsen (Botanical Institute, University of Copenhagen) during geological reconnaissance by the northern party of the Geological Survey of Greenland under the direction of Professor A. Rosenkrantz. During recent re-examination one of the samples was found to be very rich in ilmenite. Because of the economic aspects of this discovery the heavy fractions of all the 19 samples collected in the Thule district were examined. The first author studied the opaque portion, whereas the second author is responsible for the investigation of the translucent minerals.

SAMPLING AND METHOD OF INVESTIGATION

The 19 samples collected derive from five areas as indicated on figs 1–3. They are mostly samples of delta sand (16) of suitable grain size, each representing material taken in different places within the alluvial cones of the rivers and a few metres above high tide level. Two samples were collected from beaches, taken both above and below high water level. One sample of river sand originated from above the alluvial cone.

From each sample (weighing 500 g to 1 kg) 50 g were separated, and the fraction 60–250 μ was removed for the investigation. 5–10 g were used for the mineral separation by heavy liquids (specific gravity 2.9). In order to determine the weight percentage, the heavy fraction was weighed and split into two portions, one to make a polished section, the other to make two slides, using a mounting medium having a refractive index of 1.66.

Normally a total of 200–400 grains were counted in the two slides, treating the opaque minerals as one group. The relative composition of the opaque minerals was found by counting 100–200 grains under reflected light in the polished section. For further details on the preparation of samples and method of investigation the reader is referred to Thomsen (1957).

Table 1, Heavy fraction percentages by number of grains

GGU sample No.	Sample code used here	Heavy fraction > 2.9 (Weight %)	Magnetite	Titanomagnetite	Ilmenite	Ilmenite/haematite	Chromite	Sulphides	Tourmaline	Zircon	Garnet	Rutile	Anatase	Titanite	Sillimanite	Epidote	Hornblende	Actinolite/ Tremolite	Diopside	Augite	Hypersthene	Olivine	Apatite
13826	T 1 D	10	5		+	+		+		+	3			4	1	9	73	2	1	2		+	+
13828	T 2 D	10	10			+		+		7	1			7	+	16	57	1	1	+			+
13829	T 3 B	44	14	16	2	1		+							+	31	20	1	12	1	1		
13844	T 12 D	17	8	1	4			+			+					1	12		33		39		1
13846	T 13 B	53	8	3	5	+	+				+					1	6		32	1	43		
13831	T 4 D	13	+	+	+			+			1			+		20	76	1				1	
13832	T 5 D	18	2	+	3			+		1	1			2	3	6	80	1	1		+	+	+
13834	T 6 D	8	3	1	+			+		+	+		+	1	7	14	68	1	2	+	2		
13836	T 7 D	20	18	4	4	+		+		+	+			3	+	10	45	+	4	1	10	+	
13838	T 8 D	31	33	7	1	3		+								2	11		20	1	20	1	
13839	T 9 D	25	15	8	4	1		+		1	2			1	1	20	16		10		18	2	
13840	T 10 D	13	11	1	5			+		1	1	+		2		9	62	1	1	1	1	1	2
13842	T 11 D	95	+	3	70			+						+		2	3		5	2	14		
13856	J 1 D	2	7	2	4				1	5	4	+	1	1	1	4	55	1	3	1	8		1
13857	J 2 R	3	12	4	6	+		+	1	+	3	+		1		3	55	+	4	5	4	1	
13858	J 3 D	1	(18)	+	(4)				2	3	2	+	2			1	52	1	6	2	5	2	
13859	J 4 D	8	29	+	4			+		1	5	1		1		2	49	+	4	1	2	+	
13860	J 5 D	28	28	5	8	+		+			2			+		1	47	1	4	2	1	1	+
13861	J 6 D	16	3	+	2	+				1		+		3	2	3	80	3	1	1			

D: delta sand sample B: beach sand sample R: river sand sample +: present < 1%

DESCRIPTIONS OF MINERALS OBSERVED

Magnetite with a homogeneous appearance is the most common of the opaque minerals in nearly all the samples. Martitisation of magnetite is frequently seen, and every gradation from incipient martitisation to pure haematite is observed. As martitisation is found almost exclusively in originally homogeneous magnetite, martite was counted as belonging to the magnetite group.

Titanomagnetite is rather common in all samples investigated. The heterogeneous groundmass of magnetite nearly always contains distinct lamellae of ilmenite, and commonly also exsolutions of spinel. The magnetite groundmass is very often completely altered to turbid titanite, whereas the ilmenite remains unaltered as described by Jensen (1967) for heavy beach sands from Denmark.

Ilmenite (with 0.17 % vanadium) is the predominant mineral in one section (T 11) and comes next after magnetite amongst the opaque minerals in most of the remaining samples. It is characteristically pure, normally without exsolutions of haematite, but occasionally with round silicate inclusions. It is fresh and unaltered, in a few cases with rims of titanite. Ilmenite with exsolutions of haematite is found in half of the samples as a few grains, but is listed separately because of its genetic significance.

Chromite occurred as a few grains in one sample only.

Sulphides were found in nearly all sections, but only as single grains. Pyrite, often rimmed by limonite, is the most common, with subsequent chalcopyrite and pyrrhotite.

The non-opaque, translucent minerals are not much different in their properties from current textbook descriptions such as Milner (1962). The minerals found in the sand samples from the Thule district are very similar to the minerals found in the area north of Holsteinsborg described by Thomsen (1957). Accordingly only a few remarks will be made here on the properties of the minerals observed in the slides.

Actinolite-tremolite, R. I. < 1.66, birefringence higher than in hornblende. Actinolite is slightly pleochroic with faint green colours, whereas tremolite is colourless.

Anatase. R. I. high. Basal sections with tabular contours. The colour varies from yellow to grey, sometimes nearly opaque.

Apatite, R. I. < 1.66. The grains are corroded due to treatment by acids during the preparation process. Colourless.

Augite has brownish colour with a purple tint, weakly pleochroic.

Biotite grains are brown, fresh and unweathered. It was observed in varying amount in all slides except two (T 11–12). The mineral is not recorded in table 1 because the preparation technique used does not allow a correct quantitative assessment.

'Chloritic matter' is not recorded in the table. R. I. < 1.66. It occurs as green flakes scarcely distributed in nearly all the sections, in major amounts only in samples T 2 and T 6 (ca. 10 %).

Diopside, R. I. near or above 1.66. Colour from faint green to darker green with weak pleochroism.

Epidote is found as pure, unweathered grains yellowish in colour with weak to strong pleochroism, as well as microcrystalline aggregates with faint yellow colours. The other minerals belonging to the epidote group (clinozoisite and zoisite) were not observed with certainty.

Garnet varies from colourless to different shades of red and reddish brown. Inclusions are common.

Hornblende. Both colour and pleochroism vary considerably from green to greenish blue. Different varieties certainly occur, but they have all been recorded in the same group. Brown pleochroic hornblende was observed in some samples.

Hypersthene, normally with a distinct pleochroism from an intensive reddish or reddish brown colour to deep green, but colourless and weakly pleochroic grains occur. Inclusions are common, mostly opaque. Schiller structures were observed in some slides.

Olivine, R. I. near or a little above 1.66. In the mounting medium applied ('Clearax') olivine has a milky appearance.

Rutile, very high R. I. Colours brown to yellow, with distinct pleochroism. The grains often appear nearly opaque.

Sillimanite, R. I. near 1.66. Occurs as colourless, single grains or as fibrous aggregates.

Titanite, R. I. as well as birefringence very high. Slightly pleochroic. Dispersion rather distinct.

Tourmaline, R. I. below 1.66. Pleochroism from nearly colourless to brown. The grains are well rounded.

Zircon, R. I. high. Colours from brown to grey, with a faint pleochroism. Occurs mostly as more or less rounded prismatic grains.

DISCUSSION OF RESULTS

The mineralogical compositions of the heavy fractions are presented in table 1. A geological sketch map showing the main units of the area under consideration is given as fig. 1, mainly based on the Tectonic/geological map of Greenland (Geological Survey of Greenland, 1970). A review of the geology of North Greenland was recently given by Dawes (1971), and a more detailed geological description covering the main portion of the area was earlier given by Davies *et al.* (1963). The composition of the sand samples is briefly discussed in relation to the geology of each subarea.

Ironstone Fjeld

The bedrock of this peninsula (fig. 1), where some of the world's most famous meteorites were found, consists of gneisses belonging to the Precambrian basement of the Thule district. The composition of the sands (T 1–2) correspondingly shows a low amount of heavy minerals, with magnetite as the predominant opaque mineral. Sillimanite, zircon and garnet are characteristic constituents.

Kap York peninsula

The coast from Kap York to Parker Snow Bugt is, according to the geological map (fig. 1), built up of intermediate to basic intrusives belonging to the basement On the map published by Davies *et al.* (1963) the intrusion is termed 'diabase' whereas the accompanying text describes it as quartz diorite with hypersthene, (p. 41) and as quartz gabbro (p. 27). As the biotite and chlorite contents are negligible, the amount of mafic minerals in the samples originating from this intrusive indicates an intermediate rather than a basic source rock; also the dominance of magnetite over ilmenite together with the characteristic occurrence of ilmenite-haematite exsolutions according to Stumpfl (1958) point towards an intermediate composition for the peninsula as a whole. However, differences in composition and grain size are found from place to place, e. g. the sample from Kap York (T 3) is more coarse grained and much richer in opaque material than the sands taken at Súkat outside Crimson Cliffs. Though the latter (T 12–13) shows different amounts of heavy minerals due to the sorting effect along the beach, the mineralogical composition is very similar, suggesting intermediate

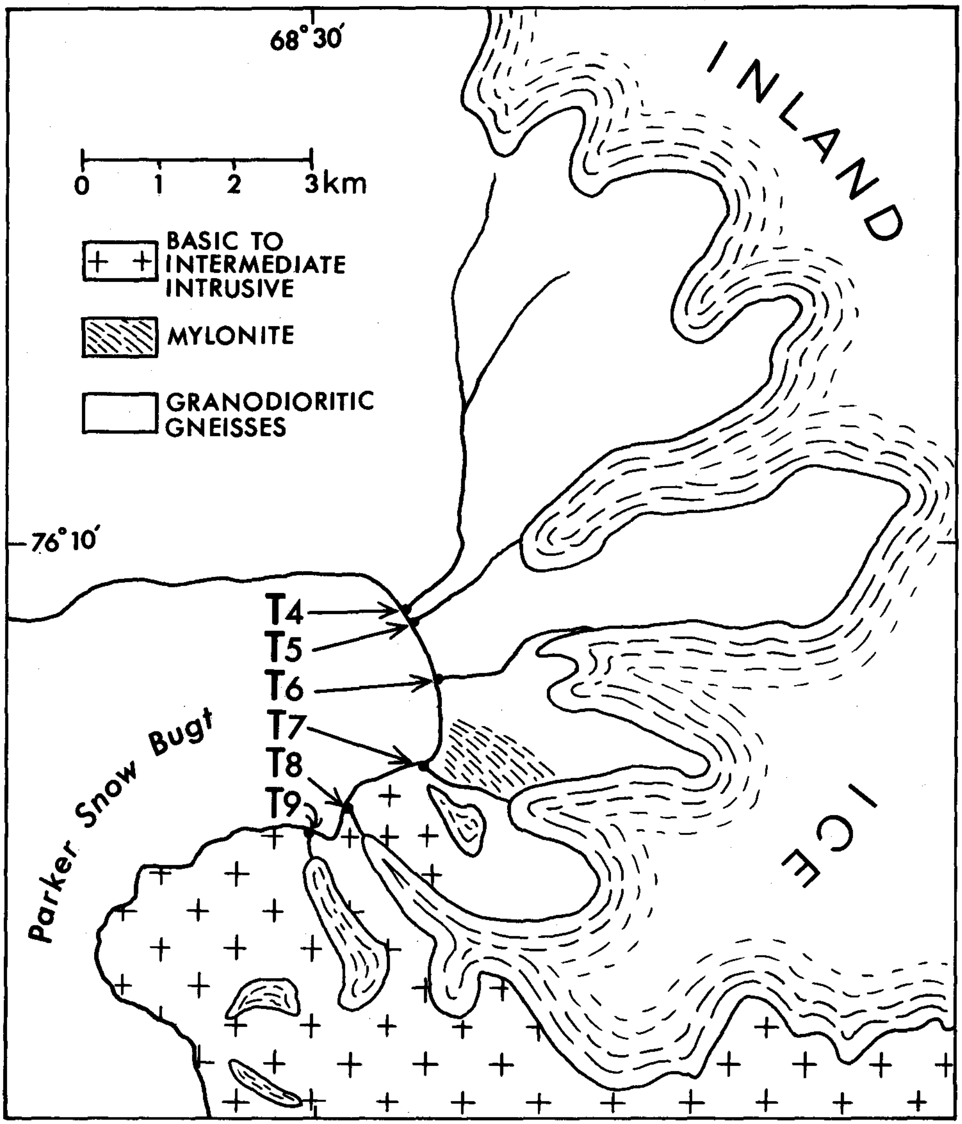

Fig. 2 Geological sketch map of Parker Snow Bugt, mainly after Davies *et al.* (1963), indicating sample locations.

source rock material. If the two beach samples T 13 and T 3 are compared, they show striking differences. T 3 is strongly altered, probably due to deuteric processes. This is seen from the following characteristics: 1) the titanomagnetite is thoroughly altered, 2) there is a high content of minerals belonging to the epidote group, 3) the sample is relatively rich in hornblende, and 4) poor in pyroxenes. As the epidote is regarded mostly as formed by the break-down of the plagioclase, the amount of mafic minerals of T 3 originally was only half that of T 13, thus suggesting an even more acid composition of the intrusive at Kap York.

Parker Snow Bugt

From this area six samples (T 4–9) were taken from north to south (fig. 2). The sands from the alluvial cones at the eastern part of the bay resemble each other in composition (T 4–6). A low portion of heavy minerals corresponds to the fact that the rivers drain source rocks which are dominantly gneisses. It is astonishing, however, that minor mineralogical variations in these samples reflect the different gneiss types of the back land described by Davies *et al.* (1963). The river where T 5 was collected drains an area of grey banded gneisses with amphibolite lenses, and accordingly contains the greatest concentration of heavy minerals, the highest hornblende percentage, and the most ilmenite. T 4 is richest in epidote, a characteristic component of the porphyroblastic gneiss to the north. T 6, which has received its mineral grains from a red granitic gneiss, shows the lowest heavy fraction percentage, but the highest amount of magnetite. A characteristic constituent of T 5 and T 6 is sillimanite; Davies *et al.* (1963) describe quartz-muscovite schists associated with the gneisses here, but do not mention this mineral. T 5–6 however makes it reasonable to assume the occurrence of sillimanite schist too.

The sands from the south side of Parker Snow Bugt are completely different (T 8–9). They are coarser grained and contain a much higher amount of heavy minerals. The composition of the opaque fraction and remaining minerals, as mentioned earlier, indicates a source from intrusives of intermediate composition. Near T 8 a dolerite dyke cutting the intrusive was observed. The location of T 7 at the transition between the gneisses and the intrusive explains the relative mineral proportions in this sample, which is a mixture of the foregoing groups. The high amount of magnetite (very fine grained) originates from an extended mylonite zone, loose blocks of which have been examined and found to be very rich in magnetite.

North Star Bugt

The great dominance of ilmenite together with subordinate coarse-lamellar titanomagnetite makes T 11 the only sample, which according to Stumpl (1958)

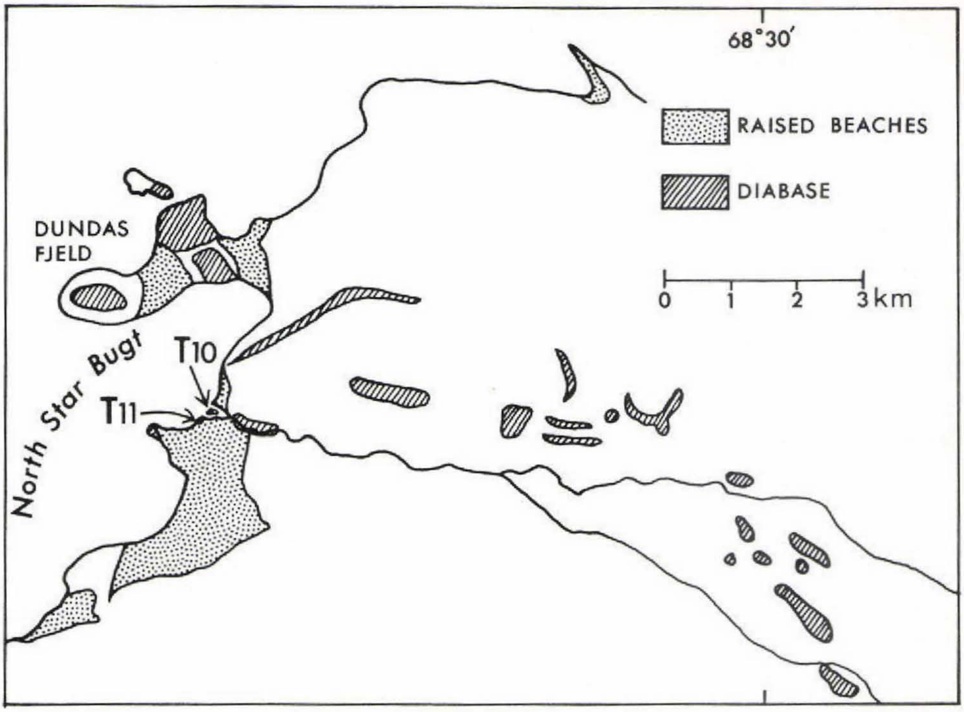

Fig. 3 Geological sketch map of North Star Bugt and environs after Davies *et al.* (1963), indicating sample locations.

cleary indicates a basic plutonite as source rock. Hypersthene being the most important mafic silicate mineral, points in the same direction. Skeletal ilmenite occurs intergrown with pyroxene grains. The ilmenite is completely fresh and even the titanomagnetite is only little altered compared with the other samples. The diabase dykes and sills (fig. 3) intruding the Proterozoic Dundas Formation (Davies *et al.*, 1963) in the back land, may have supplied the minerals necessary to form this black sand. Little is known of the mineralogy of these intrusives. The most detailed description is given by Munck (1941), who mentions the diabases to be rich in 'iron ore' (7–12 vol. %). Davies *et al.* (1963) describe a number of samples from both dykes and sills, but the opaque minerals were obviously not studied under reflected light. Augite is reported to be the dominant mafic mineral of the dykes, which are numerous and reach a maximum width of 100 m, with opaque material mostly called magnetite as an important constituent. The sills showing a thickness of 3–15 metres are interbedded with black shales and form 120 metres of the total thickness of the formation, which is about 730 m thick. A sample taken within 3 km east of the T 11 location contains the following important mafics: "augite, abundant skeletal and euhedral magnetite, euhedral hypersthene in large fresh grains" (Davies *et al.* p. 42). According to this description (the 'magnetite' in fact being mostly ilmenite), it seems reasonable to assume these sills (and dykes), by Dawes (1971) regarded as having a probable age of 800–1000 m. y., to be the source rocks for T 11, which was taken at the border of the alluvial cone of the main river entering the North Star Bugt. The extremely high content of heavy minerals and constant grain size of 0.2–0.4 mm indicates processes of river or beach concentration.

It is difficult to explain the composition of T 10 taken from the middle of the same delta. It obviously consists of unsorted material, but also the mineralogical composition of the heavy minerals is quite different. Magnetite dominates over ilmenite, both minerals being thoroughly altered. The river, however, drains an extensive area, and a certain portion of its load even orginates from the rocks under the ice cap. More detailed field work is necessary to explain the great difference between T 10 and T 11, but the presence of raised beaches (fig. 3) as mentioned later may be the key to solving this problem.

Olrik Fjord

The bedrock north and south of Olrik Fjord (fig. 1) consists of sediments belonging to the Thule Group (Troelsen, 1950) and basement gneisses.

The samples J 1–3 are extremely poor in heavy minerals and very similar in composition. Their source rocks are sandstones and quartzites of the Wolstenholme Formation (Kurtz & Wales, 1950) the lowest part of the Thule Group. The occurrence of tourmaline, zircon and garnet is characteristic, and the opaque minerals indicate that the sediments overlie basement rocks with magnetite dominating the ore minerals. The opaque fraction of J 3 was strongly altered and the relative amounts given in table 1 accordingly are somewhat uncertain. J 4 is richer in heavy minerals, reflecting the fact that its composition is the result of the breakdown of both sediments and gneisses.

J 5 taken on the south side of Olrik Fjord differs considerably from the samples to the north. The bedrock consists of black shales and dolomites belonging to the Dundas Formation, but much of the sand obviously is derived from the basement not far to the south. The absence of tourmaline and zircon is characteristic when compared to J 1–3. The high amount of heavy minerals and relative importance of ilmenite and titanomagnetite compared to J 4 is due to the nearby occurrence of dolerite dykes.

Gneisses are the environments of J 6, and the composition of this sample resembles the sands originating from the gneisses east of Parker Snow Bugt (T 4–6), with respect both to mineralogy and to the amount of the heavy fraction.

CONCLUDING REMARKS

The heavy fractions of the sand samples investigated quite well reflect the composition of rocks from which they are derived, but there is only one sample (T 11) that attracts the eye of an economic geologist. 60–70 weight % of this sample consists of pure ilmenite. The sample was collected from a layer of black sand about 1 m thick near the mouth of the main river entering North Star Bugt. The extent of this layer is unknown, and unfortunately now hidden or disturbed as a result of human activity. As shown on fig. 3 the coast here is built up of a raised beach, which according to Davies *et al.* (1963), shows the 125 foot level as the highest preserved marine limit. As the ilmenite seems to originate from numerous diabase intrusives occurring in the badly exposed area between the coast and the inland ice, there may exist recent or buried ilmenite placers along or in the raised beaches. The possible occurrence of off-shore deposits should also be taken into consideration.

Access to the area is difficult. North Star Bugt is only reasonably free of pack ice for two months a year. The climate is rough, the temperature varies from $-30°$ C to $+7°$ C in average with minimum temperatures down to $-42°$ C. The average actual snow fall is 82 cm per year, but much snow of the area comes as snow blown off the the ice cap. The area is within the region of continuous permafrost. For three and a half months the sun remains below the horizon, but accordingly stays above for three and a half months during the summer. Natural conditions are thus not too friendly, but on the other hand many facilities are already present at this place earlier termed "Ultima Thule".

Acknowledgements

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