NEPHELINE SYENITE AND IRON ORE DEPOSITS IN GREENLAND

By **Richard Bogvad***

THE voyages of exploration to Greenland at the beginning of the seventeenth century aroused interest in the possibilities of mineral wealth in the country. As a result King Christian IV in 1605 and 1606 equipped two expeditions to collect silver, which was supposed to have been found in large quantities, but only valueless mica was brought home. After this disappointment the matter was allowed to rest for barely a century, when fresh investigations were started; these have—sometimes with long intervals—been continued until today (2; 4). Much time has been devoted to the investigation of copper and graphite occurrences; coal (lignite) has been mined for two centuries, and marble has been quarried. But so far the only mineral found which can be profitably mined is cryolite from Ivigtut. Recently, however, nepheline syenite and iron ore deposits have been investigated.

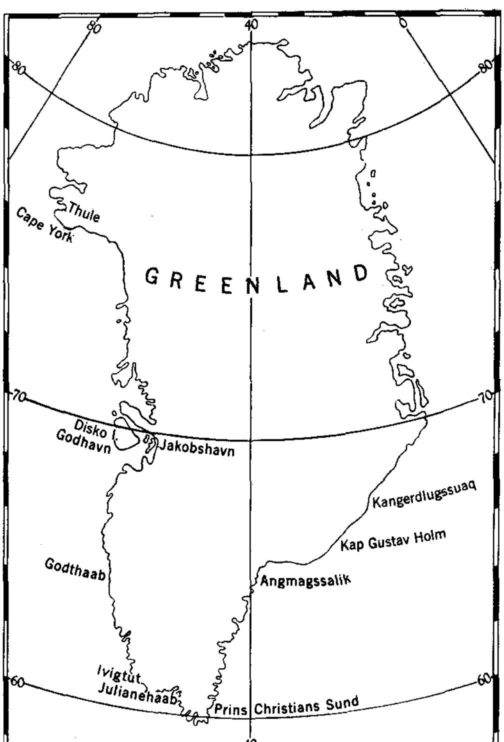

Fig. 1.

NEPHELINE SYENITE

In Greenland nepheline syenite[1] occurs in the Kangerdlugssuaq district on the east coast (18, p. 38; 19, p. 41); between the Arsuk and Ika fjords on the west coast (17, p. 387; 6); and between Julianehaab and Kagssiarssuk in southern Greenland (15, p. 35; 16, p. 132; 17; 20, p. 60). Only in the last-mentioned district, which can be divided into the Igdlerfigsalik and Ilimausak-Kangerdluarsuk massifs, are there large quantities of the zirconium-bearing mineral eudialyte[2]. K. L. Giesecke (10), who made the first systematic mineralogical investigation of Greenland from 1806 to 1813, visited the deposits in the Kangerdluarsuk district but

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[1]Igneous rocks characterized by the predominance of alkali felspar and nephelite, $NaAlSiO_4$.
[2]A silicate of sodium, zirconium, calcium, iron, and others.

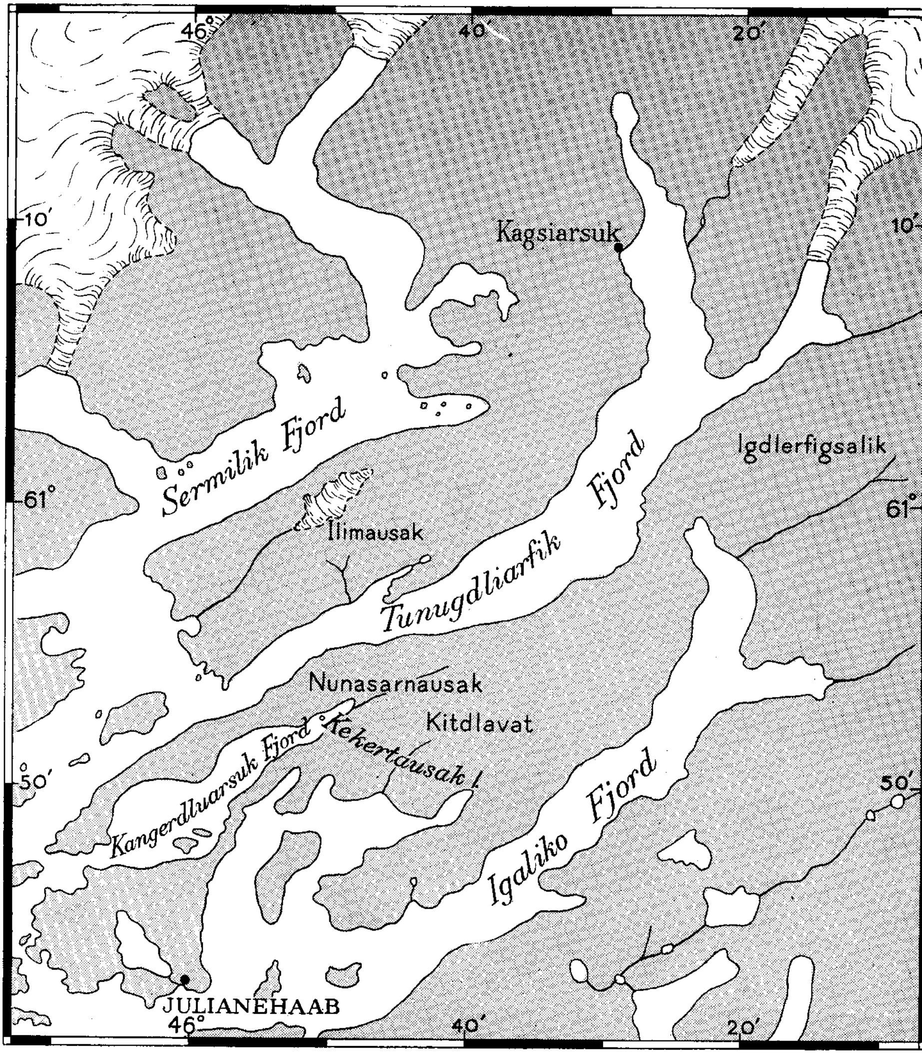


Fig. 2. Julianehaab district.

mistook the red eudialyte for garnet.

Steenstrup (15; 16) started geological investigations in this district in 1874, and, in 1888 and 1899, led two expeditions to the region. These expeditions were organized by the cryolite industry to collect eudialyte which, it was hoped, might prove useful in the production of gas (Welsbach) mantles (13). Working teams from Ivigtut blasted out the eudialyte from the pegmatite dyke on the small island of Kekertausak and collected loose blocks in the naujaite[3] talus near the coast at the head of Kangerdluarsuk. The material was carried to the ship in sacks and baskets or was packed in barrels and rolled down the mountain. During

[3]Naujaite, sodalite-foyaite, kakortokite, and lujavrite are varied types of nepheline syenite of peculiar mineralogical composition.

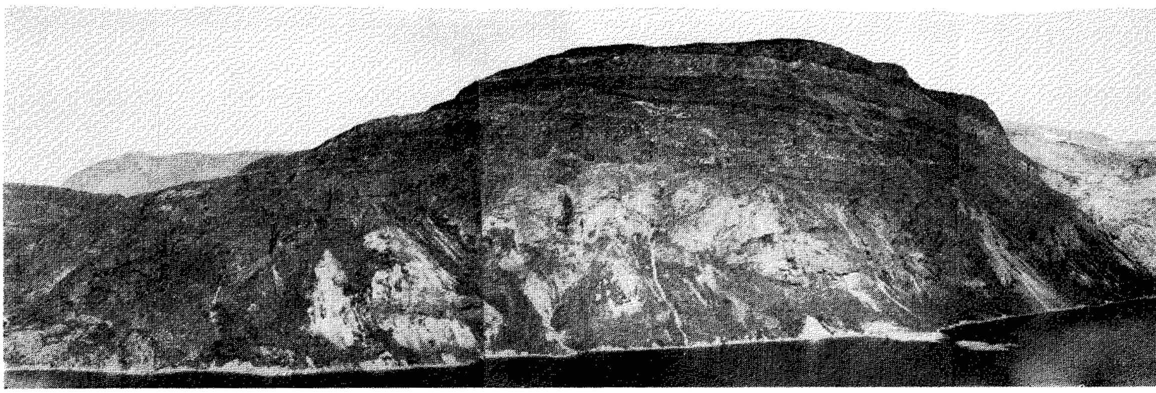


Fig. 3. At the head of Kangerdluarsuk Fjord. Extreme left, Julianehaab granite; the dark partly stratifie
coloured area in the centre is naujaite which farther to the right is replaced by lujavrite and the band

the two years some sixty metric tons of material containing eudialyte were obtained, the material being sorted by hand picking and magnetic separation. However, it proved to be impossible to find any market for the eudialyte product, although the magnetic product containing arfvedsonite[4] and other substances was used by the steel industry.

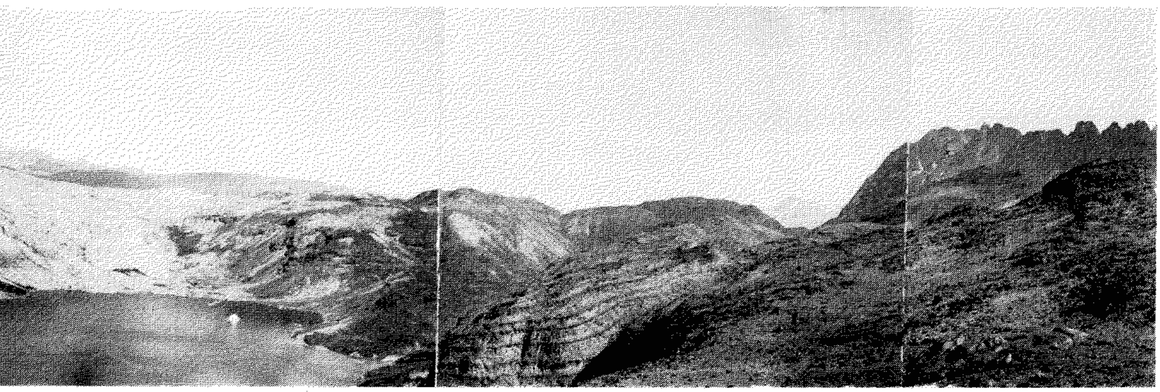
In 1900 Ussing and Bøggild made a thorough investigation of the nepheline syenite area, the geology of which has been reviewed in Ussing's classical report (17). E. Wegmann (20) visited the deposits in 1936 and, as a result of his investigations, suggested theories, which were in part new, concerning their origin. Later, in 1946, A. Noe-Nygaard made a preliminary investigation of the region for a new geological map.

Towards the end of the 1930's there was a renewed interest in eudialyte because of possible use in the porcelain industry. In 1939 the writer went to the Julianehaab district on behalf of the cryolite industry and, in agreement with the Greenland Administration, began investigations of the nepheline syenites to determine whether they might be profitably mined. All known localities were visited; no rich new deposits were found.

Kangerdluarsuk must be regarded as the best area for mining development (Fig. 3). The harbour conditions are fairly good and five different kind of rocks containing eudialyte are found. Naujaite-sodalite-foyaite[5], partly poor and partly rich in eudialyte, covers an area (from Kangerdluarsuk to Tunugdliarfik) of at least 30 sq. km. with a thickness of several hundred metres. The average content of eudialyte is only 2.5 per cent, although there are areas with a higher content. Kakortokite[5] covers some 10 sq. km. of thicknesses of up to 400 m. and consists of alternating black, red, and white sheets. Of black and white kakortokite there are more than one billion tons containing 4 to 5 per cent eudialyte. The red

[4]A silicate of sodium and iron chiefly, belonging to the amphibole group.

[5]See footnote 3.



ountain is Nunasarnausak, showing sandstone with diabase sills; the island of Kekertausak and the light kortokite; on the extreme right are the jagged granite peaks of Kitdlavat.

kakortokite occurs in sheets from ½ to 2 m. thick with an average of 20 per cent eudialyte. There are several easily accessible deposits of this rock exposed at altitudes of less than 100 m., and large quantities are found higher up in the mountains.

The war temporarily interrupted the investigation and not until 1946 was it possible to mine small quantities of the five types of rock mentioned. These were blasted from the deposits in Kangerdluarsuk (Fig. 4) and transported to Copenhagen, where the Cryolite Company has begun experiments to find out which type of rock is most useful, how the minerals can most easily be separated from each other, and which minerals may have economic uses. In 1948 samples were taken of most of the existing kakortokite sheets for spectrographic examination in order to discover the possible variation in the content of valuable elements from the lower to the upper strata.

Initially the experiments were exclusively concentrated on finding a nepheline-containing product poor in iron, since the porcelain industry in Denmark was interested in a product of this nature because of the progress made by the Canadian nepheline industry (8). The samples best suited for this purpose, white kakortokite and naujaite poor in eudialyte, were separated magnetically. The fractions poorest in iron, however, because of innumerable microlites of arfvedsonite, etc., contained from 0.14 to 0.23 per cent iron, which is too high a percentage for most uses in the porcelain industry. Furthermore, the nonmagnetic fractions constituted so small a part of the raw material that commercial competition with felspar would be impossible, if only because of the cost of transportation. Until a use can be found for the more valuable substances in the nepheline syenites from Greenland it will not be possible to produce a nepheline-containing by-product for the porcelain industry.

The eudialyte from Greenland contains about 14 per cent zirconium oxide, 0.1 to 0.2 per cent hafnium (11, pp. 21-22), and 1 or 2 per cent

Fig. 4. Mining nepheline syenite in Kangerdluarsuk. Near the top of the mountain the alternating sheets of kakortokite are conspicuous.

oxides of cerium, lanthanum, praseodymium, and others (3, p. 494). In previous analyses of the mineral we find reports of niobium (columbium) or tantalum contents. Recently spectrographic analyses of eudialyte from naujaite and kakortokite showed 0.1 to 0.6 per cent niobium and 0.03 to 0.1 per cent tantalum (Sture Landergren). In addition to these metals it will no doubt be possible to find still more interesting elements in such a peculiar chemical complex.

Even though the nepheline syenite deposits of the Julianehaab district are much smaller than the Russian deposits of the Kol'ski Poluostrov (Kola Peninsula) (7; 14) and, unlike the Swedish and Norwegian deposits at Alnön (9), Norra Kärr (1), and Fen (5), are far from any industrial centre, the possibility of economic importance should not be excluded.

Iron and Iron Ore

Greenland has both native iron and iron ore (2; 4). In the basalt mountains of the Disko district telluric iron occurs in blocks weighing up to 25 metric tons. The best known deposit is at Uifak on Disko Ø. Four blocks of meteoric iron have been removed from Kap York in the Thule district. Three of these, the largest of which weighed 100 tons, were taken to the U.S.A. by Robert Peary, and Knud Rasmussen brought back a fourth block to Denmark. Both these occurrences were early discovered by the Greenlanders who hammered the iron into knives, and harpoon and arrow points. Otherwise the native iron is of no practical importance.

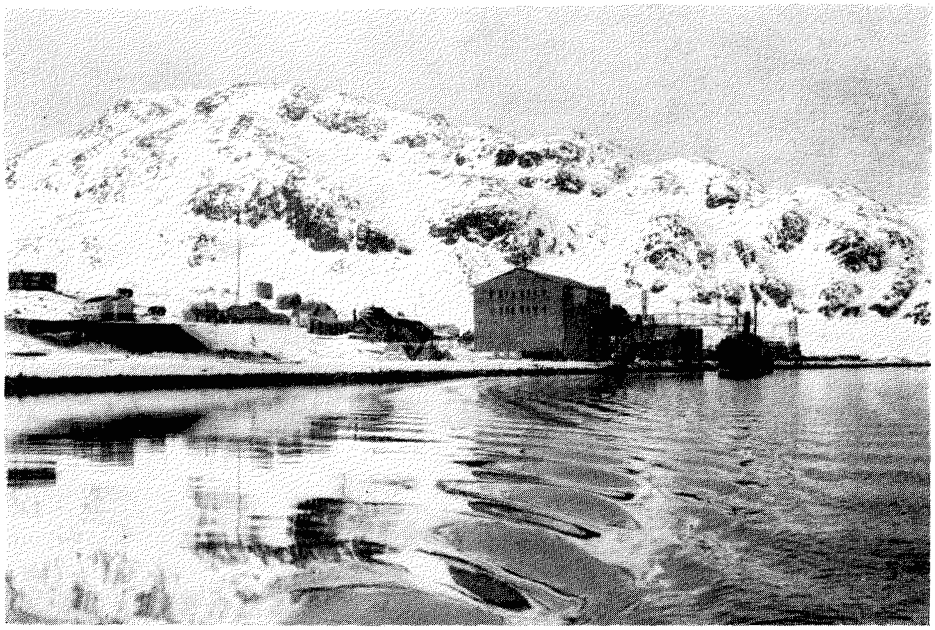


Fig. 5. The gneiss mountains at Ivigtut.

Of the comparatively poor Greenland iron ores pyrrhotite, pyrite, and siderite may be mentioned, but these have not been found in quantities sufficient to justify mining. Some siderite, which occurs as a by-product from the milling of cryolite, is used to produce a small amount of pig iron.

Magnetite is found in many places in Greenland but, with a few exceptions, only in insignificant quantities. Even the fair-sized deposit at Kap Gustav Holm, found by the writer on Knud Rasmussen's 7th Thule expedition to the east coast is without economic value because of the transportation problems. The deposit occurs in a mountainous area, situated 600 m. above sea level, and is approached by a difficult glacier. The only deposit so far known which may possibly be promising is that at Grønnedal in Arsuk Fjord near Ivigtut.

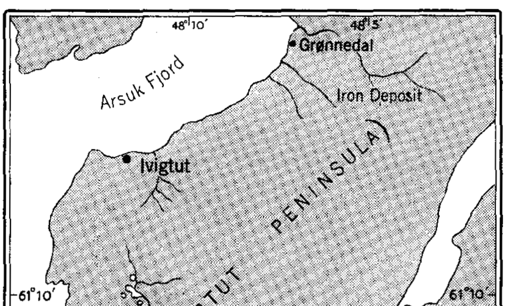


Fig. 6. Ivigtut district.

The heavily glaciated gneiss mountains of the Arsuk Fjord area (Fig. 5), which in addition to the cryolite deposit contain massifs of syenite and nepheline syenite, have been visited by many geologists in search of new

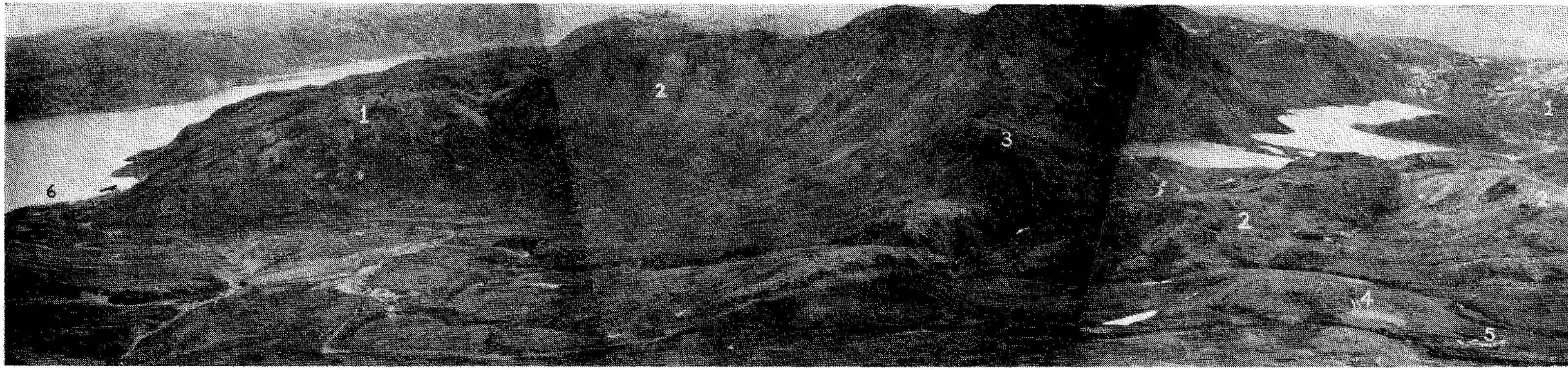


Fig. 7. Grønnedal; showing the new road from the coast. 1, gneiss; 2, nepheline syenite; 3, diabase; 4, trench; 5, houses under construction; 6, Arsuk Fjord.

Fig. 8. Grønnedal: 1, gneiss; 2, nepheline syenite and diabase; 3, camp of the magnetic survey.

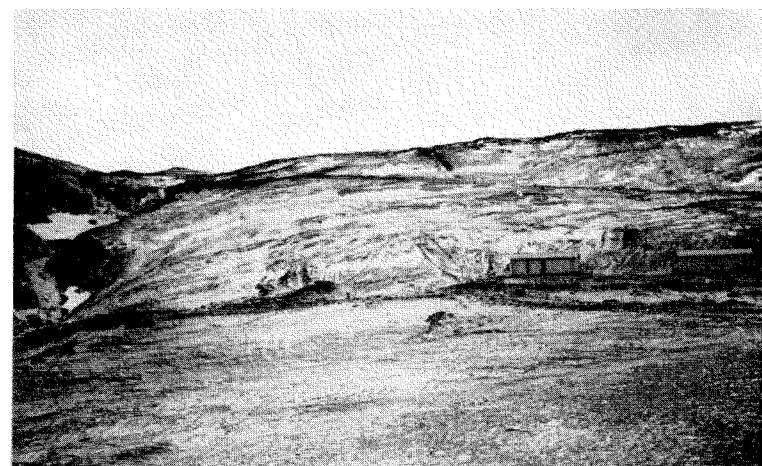


Fig. 9. Magnetite deposit in Grønnedal, showing one of the trenches in the background.

cryolite deposits. Even though the main features of the origin of the cryolite had been established they did not succeed in finding another "Ivigtut". The investigations were continued in 1938 when the writer introduced a special method for detecting fluorine in rocks, and the rock formations were systematically explored in the whole fjord district. During the course of this investigation several hand-sized pieces of pure magnetite were found between Ika Fjord and Grønnedal, in an area where long stretches of the stream beds are coloured a rusty red. It later appeared, however, that the deposit was identical with that found in 1880 by the Swedish geologist N. O. Holst (12, p. 27).

Immediately after the Second World War geological investigations of this area were resumed, and measurements with a simple magnetometer revealed two nearly adjacent areas with marked magnetic anomalies. In the years that followed these were more precisely delimited by a systematic magnetic measurement of the whole area, and several new deposits were found. This investigation (Fig. 8) was made by the Danish Meteorological Institute under the leadership of V. Laursen and J. Espersen. At the same time Greenlanders dug trenches in the places containing most iron, and average samples were taken of the ore. Finally, the writer, assisted by H. Ramberg from the Geological Survey of Greenland, mapped the geology of the area.

The Grønnedal deposit (Fig. 9) is situated 4 km. from the sea at an altitude of 300 to 400 m. Access is comparatively easy as the ground rises evenly from the American base at the coast, but a stream crosses the route. The magnetic iron ore occurs together with limestone and siderite along a dyke system of diabase approximately 500 m. thick, which intrudes or is enclosed in nepheline syenite. Samples of pure magnetite have been analyzed by A. H. Nielsen who gives the following values for some of the constituents: FeO, 26.03%; Fe_2O_3, 68.96%; TiO_2, 0.89%; MnO, 0.62%; S, 0.01% and P, 0.048%. However, average samples from the trenches contain considerably less iron and more phosphorus, namely from 24.0 per cent to 46.7 per cent iron and from 0.076 per cent to 1.54 per cent phosphorus.

Kryolitselskabet Øresund A/S (The Cryolite Company), in agreement with the Greenland Administration, plans to undertake diamond drilling at the iron deposit. A road has already been constructed and houses have been built for the drillers (Fig. 7). Work will commence some time in the spring of 1950 when the snow has melted at Grønnedal.

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Note: On the map of the Julianehaab district, Fig. 2, Kagssiarssuk in Tunugdliarfik Fjord is spelled Kagsiarsuk.