GRØNLANDS GEOLOGISKE UNDERSØGELSE
BULLETIN No. 68

CONTRIBUTIONS TO THE MINERALOGY OF ILÍMAUSSAQ
Nos 3–7

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BIANCO LUNOS BOGTRYKKERI A/S
1967

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GRØNLANDS GEOLOGISKE UNDERSØGELSE

ON THE HISTORY OF EXPLORATION OF THE ILIMÁUSSAQ ALKALINE INTRUSION, SOUTH GREENLAND

CONTRIBUTION TO THE MINERALOGY OF ILÍMAUSSAQ, No. 3

BY

HENNING SØRENSEN

WITH 10 FIGURES IN THE TEXT
AND 3 APPENDICES

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
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Abstract

The history of exploration of the Ilímaussaq alkaline intrusion is briefly reviewed. Geological and mineralogical investigations were first carried out by K. L. GIESECKE in 1806. Later K. J. V. STEENSTRUP, N. V. USSING, C. E. WEGMANN and a number of others have undertaken studies in and around the intrusion.

The intrusion is mainly composed of peralkaline (agpaitic) nepheline syenites and is rich in rare elements and rare minerals. A number of minerals were first discovered in this intrusion, viz. *ænigmatite*, *arfvedsonite*, *britholite*, *chalcothallite*, *epistolite*, *eudialyte*, *igdloite* (= lueshite), *ilimaussite*, *naujakasite*, *polylithionite*, *rinkite*, *schizolite*, *sodalite*, *sorensenite*, *steenstrupine*, *tugtupite* and *ussingite*.

Renewed geological and mineralogical activity has taken place in Ilímaussaq during the last few years in connection with an examination of the economic geology of the area. A series of publications is in preparation. It was therefore considered to be of some value to present an account of the work until now and to prepare a list of the minerals so far identified and of the papers dealing with the intrusion. The bibliography, together with that prepared by BØGGILD (1953), contains the titles of all the papers on the mineralogy, geochemistry and geology of the intrusion known to the writer.

INTRODUCTION

N. V. USSING's monograph on the Ilímaussaq alkaline intrusion, Julianehåb district, South Greenland, published in 1912, a year after his untimely death, represents the end, and the culmination, of the first period of exploration of the Ilímaussaq intrusion.

In USSING's memoir (1912, pp. 5–7) a brief account is given of the history of exploration up to 1911. More information can be found in USSING's preface to the first edition of BØGGILD's "Mineralogy of Greenland" and in later papers by BØGVAD (1949) and GARBOE (1959, 1961).

The present paper is designed as the introduction to a new series of papers on the mineralogy of Ilímaussaq, of which two papers have already appeared and a number of papers are in preparation.

The paper contains a short outline of the history of exploration, a list of the minerals identified so far in Ilímaussaq, the plans for further activities in Ilímaussaq and a list of papers dealing with the minerals of Ilímaussaq.

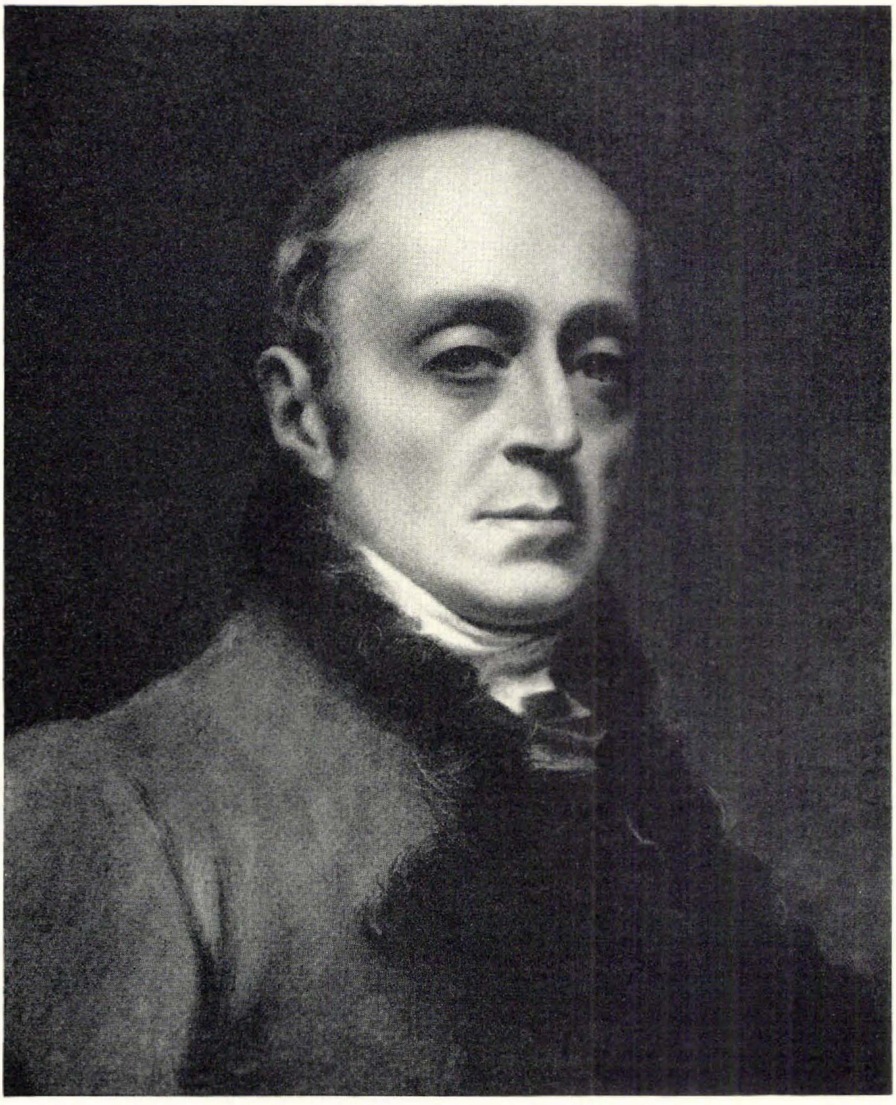

Fig. 1. KARL LUDVIG GIESECKE (1761–1833). Copy after painting by Sir HENRY RAEBURN.

THE PERIOD 1806–1911

a. K. L. GIESECKE

The Ilímaussaq intrusion was discovered by K. L. GIESECKE who visited the region twice, in 1806 and 1809, during his extensive mineralogical expedition in Greenland in the years 1806–1813 (see the diaries of GIESECKE published in Medd. om Grønland vol. 35, 1910). GIESECKE recognized the presence of syenites in the area, but did not understand the true nature of the remarkable nepheline syenites which were later named lujavrite, naujaite and kakortokite by USSING.

GIESECKE's long stay in Greenland was caused by the Napoleonic wars. A part of his collections was captured by British warships and landed at Leith. There it was taken over by the Scottish mineralogist R. ALLAN. On this material the mineral status of *arfvedsonite* and *sodalite* was established by BROOKE in 1823 and by THOMSON in 1812, respectively. (*Allanite* was also established on material from the east coast of Greenland).

The greater part of the mineral specimens was deposited in the mineral collections in Copenhagen and other continental cities. *Eudialyte* was established by STROMEYER in 1819 on material collected by GIESECKE. Specimens of this mineral were very probably brought to Europe earlier than GIESECKE's expedition but they were described as hyacinth or garnet (see BØGGILD, 1953, p. 250). GIESECKE mentioned the mineral as garnet.

GIESECKE's collections were studied in the years to come by a number of eminent mineralogists such as BERWERTH, BREITHAUPT, BRÖGGER, DAMOUR, DOELTER, KOBELL, RAMMELSBERG and ROSENBUSCH.

Specimens collected by Greenlanders and sent home by missionaries and government officers also fell into the hands of mineralogists. *Ænigmatite* appears to have been established as a mineral species on such material by BREITHAUPT in 1866.

b. K. J. V. STEENSTRUP

Apart from the visit of H. J. RINK, 1853–1854, who collected a number of very fine specimens for the mineral collections in Copenhagen, very little happened in Ilímaussaq until the expeditions of K. J. V.

STEENSTRUP in the years 1874–1899. STEENSTRUP visited Ilímaussaq in 1874, 1876 and 1877 and made very extensive collections of rocks and minerals. A considerable part of the collection was lost when the Christiansborg Palace in Copenhagen was destroyed by fire in 1884. In order to replace the lost material STEENSTRUP revisited Ilímaussaq in 1888 and 1899.

In 1876 a systematic scientific investigation of Greenland commenced on behalf of the Danish government. The first expedition was directed

Fig. 2. KNUD JOHANNES VOGELIUS STEENSTRUP (1842–1913).

by STEENSTRUP, who, accompanied by GUSTAV HOLM and ANDREAS KORNERUP, undertook scientific investigations in the Julianehåb district. One of the results of this work was a topographical and geological map of the district on which the Ilímaussaq intrusion was demarcated for the first time (STEENSTRUP, 1881).

In 1888 and 1899 STEENSTRUP, on behalf of the Cryolite Company, excavated and collected a total of 59 tons of eudialyte-rich rocks at the head of Kangerdluarssuk fjord. Traces of this activity are still to be seen in the cave in a pegmatite vein on Qeqertaussaq and hoops for the barrels in which eudialyte hand picked from the scree slopes of Kangerdluarssuk was sent to Copenhagen.

The eudialyte-rich specimens were treated at the cryolite factory in Copenhagen, unfortunately without positive results.

The specimens brought home by STEENSTRUP were examined first of all by LORENZEN who established the new minerals *steenstrupine*,

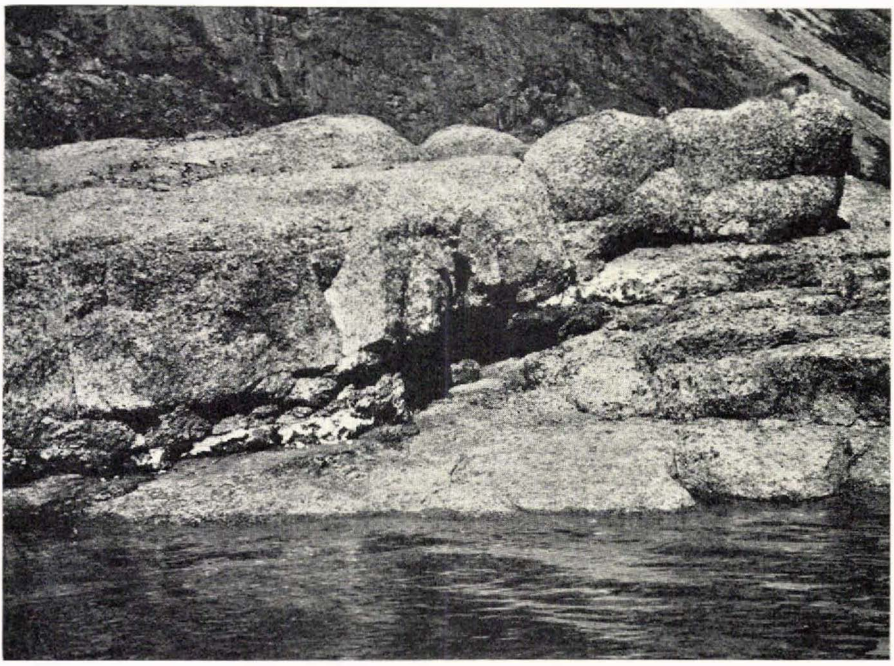

Fig. 3. Eudialyte-rich pegmatite in naujaite, Qeqertaussaq. The cave is a result of STEENSTRUP's excavations.

Fig. 4. JOHANNES LORENZEN (1855–1884).

polylithionite and *rinkite* and presented the first thorough treatment of the *arfvedsonite* and *ænigmatite* (LORENZEN, 1881 and 1893). USSING

(1898) made an intensive study of the feldspars of the alkaline rocks in his doctorate thesis and further studied the other rock-forming minerals. USSING also studied the rock specimens brought home by STEENSTRUP, the first descriptions of these rocks appearing in ROSENBUSCH's Mikroskopische Physiographie (1896) and Elemente der Gesteinslehre (1898).

STEENSTRUP's extremely rich collections have to a very large extent served as a basis for the exchange of minerals maintained by the Mineralogical Museum in Copenhagen up to now, and they are not yet exhausted in spite of rather extensive exchanges for about three quarters of a century. Many of the specimens from Ilímaussaq or, as the area often is termed in mineralogical textbooks, the Kangerdluarssuk region, found in mineral collections all over the world come from K. J. V. STEENSTRUP.

c. GUSTAV FLINK

The famous A. E. NORDENSKIÖLD paid a visit to Ilímaussaq in 1883 and collected the specimens in which LORENZEN found the first *astrophyllite* to be identified in this region.

In 1897 GUSTAV FLINK, on behalf of the "Commission for the Direction of Geological and Geographical Exploration in Greenland", undertook mineralogical investigations at Narssârssuk, Ilímaussaq and Ivigtut. FLINK examined especially the minerals from Narssârssuk; his extensive collections from Ilímaussaq were studied by O. B. BØGGILD and C. WINTHER who established the new minerals *britholite*, *epistolite*, *naujakasite* and *schizolite* on the basis of this material. Naujakasite was first described as late as in 1933.

d. N. V. USSING

The activity of the Commission for the Geological and Geographical Exploration of Greenland was continued in 1900 by N. V. USSING who mapped the Ilímaussaq and Igaliko intrusions and studied a number of the other alkaline intrusions of South Greenland (Nunarssuit, Grønnedal and Ivigtut). USSING was accompanied by O. B. BØGGILD, who in 1912 succeeded USSING as professor in mineralogy at the University of Copenhagen. USSING revisited Ilímaussaq in 1908.

The results of USSING's geological and petrological work in Ilímaussaq were published in 1912 in the above-mentioned memoir. A very detailed description, covering 376 pages, is given of the major rock types of Ilímaussaq and Igaliko and of their geological setting. The geological maps and sections give a fair picture of the geology of the region even if they are based on very primitive topographical maps. There are 29 chemical rock analyses.

Fig. 5. Niels Viggo Ussing (1864–1911) on the left and Ove Balthasar Bøggild (1872–1956) on the right with their Greenlandic assistants in Ivigtut, 1900.

Ussing demonstrated that the main rock types of Ilímaussaq are: augite syenite, alkali granite, pulaskite, foyaite, sodalite foyaite, poikilitic nepheline sodalite syenite (naujaite), banded trachytoid eudialyte

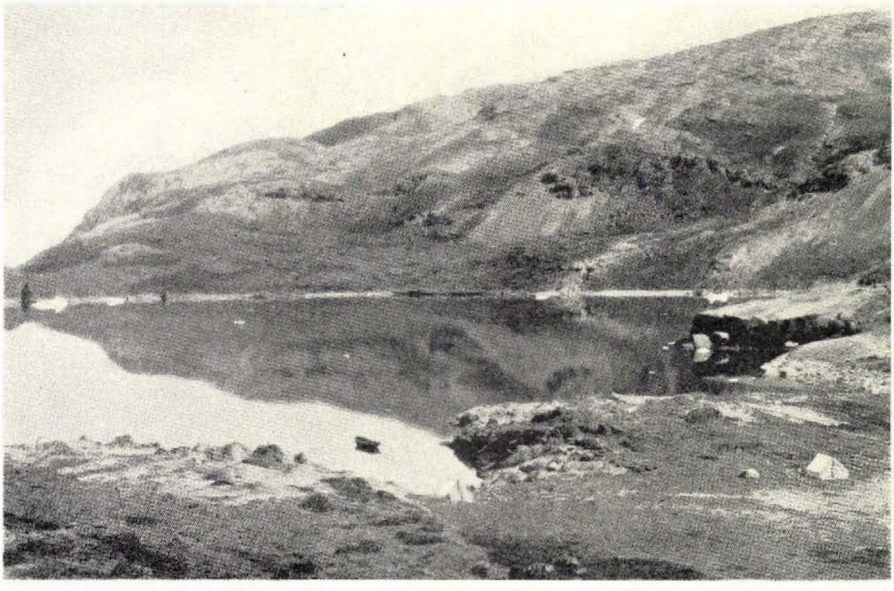

Fig. 6. Ussing's camp at Tuperssuatsiaq.

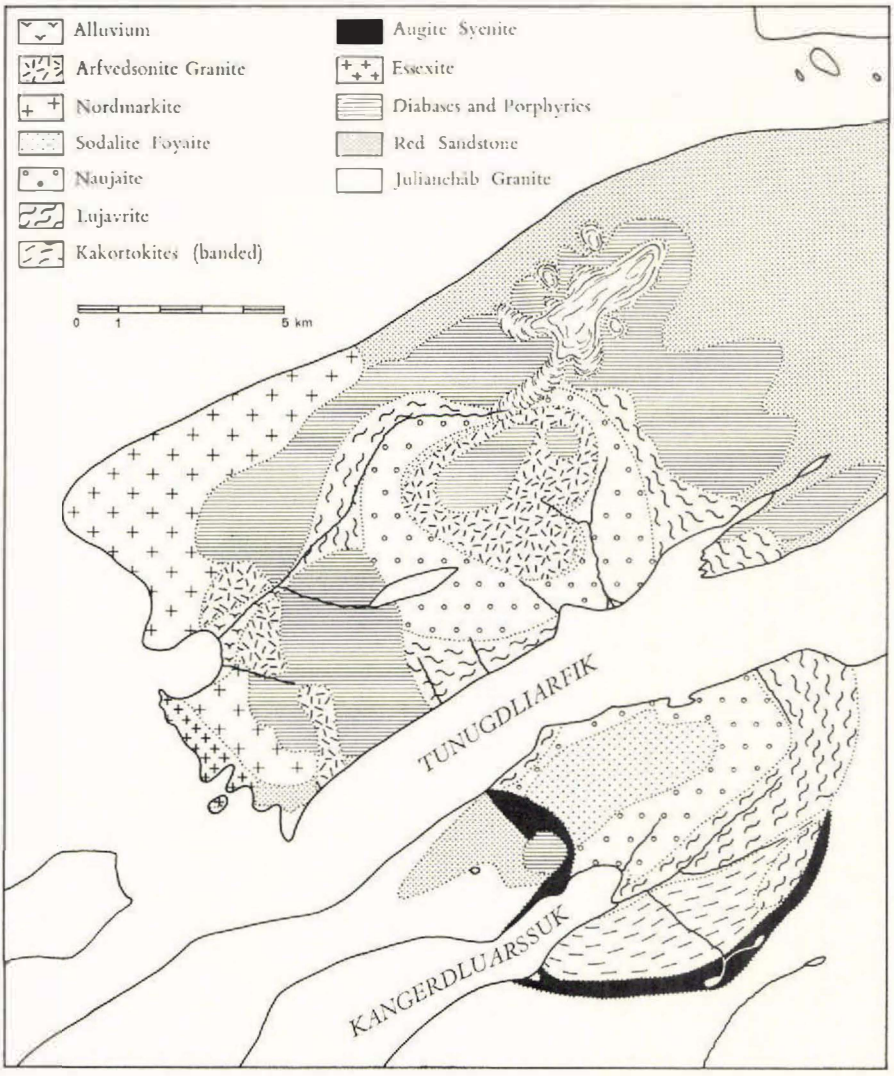

Fig. 7. USSING's geological map of Ilímaussaq modified with regard to contours and names of localities. The original map was printed in colour as plate 3 in USSING's memoir.

nepheline syenites (kakortokites) and fine-grained lujavrite. The last-named four rock types are *agpaitic* nepheline syenites, a term established by USSING in this memoir (see also SØRENSEN, 1960). USSING also included the gabbro (essexite), nordmarkite and alkali granite of Narssaq in the Ilímaussaq intrusion. These rocks are now regarded as members of earlier intrusions.

USSING discussed processes such as *overhead stoping*, *magmatic differentiation*, the origin of *igneous layering*, *assimilation*, *feldspar solid*

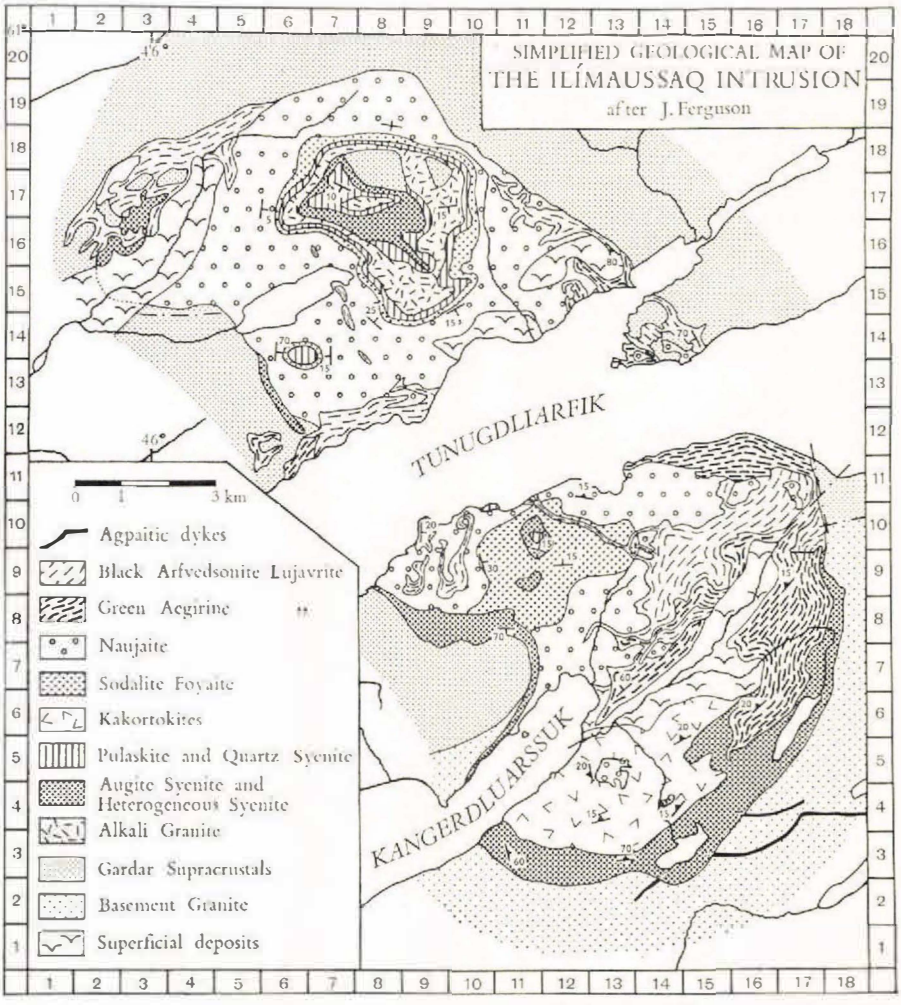

Fig. 8. Simplified geological map drawn in 1964 on the basis of the map at 1:20,000 prepared by JOHN FERGUSON.

solution series, and produced a general view of the evolution of the intrusion which has been generally accepted, although sometimes in a slightly modified form, by later workers in the region.

BØGGILD established the new minerals *erikite* and *ussingite* on specimens collected during USSING's expeditions. USSING (1912, p. 172) expressed the suspicion that erikite is a mixture of *monazite* and *hydronephelite*. This has been confirmed later (DANØ and SØRENSEN, 1959).

THE PERIOD 1911–1955

The work of USSING made such an impression on Danish geologists and was considered to be so complete that very little happened in Ilímaussaq for almost half a century. Only few mineralogists visited the region in this period, in particular S. M. GORDON in 1923. The results of GORDON's work in Ilímaussaq are recorded in three papers from 1923, 1924 and 1927.

In 1936 C. E. WEGMANN accompanied by S. SØLVER studied the geology of South Greenland and established a geological chronology for the region. The Ilímaussaq massif was referred to the Gardar period, which is characterized by continental sandstone, volcanic rocks and plutonic complexes. On the basis of structural examinations WEGMANN suggested that the Ilímaussaq massif was formed by metasomatic processes. This idea has not been confirmed by later work in the area.

In 1939 R. BØGVAD (1949, 1950) visited Ilímaussaq on behalf of the Cryolite Company. His investigations were interrupted by the war but resumed in 1945. In 1946 a considerable quantity of eudialyte-rich naujaite and kakortokite was quarried. The material was examined in the cryolite factory in Copenhagen, but neither a eudialyte fraction nor a fraction consisting of feldspar, nepheline and sodalite found any technical application. The feldspar fraction contained more than 0.14% Fe because of innumerable microlites of arfvedsonite and ægirine and could not be used by the porcelain industry.

The only use found so far for the material brought home by STEENSTRUP and BØGVAD was for the production of a small quantity of Zr-Hf oxychloride from eudialyte for the Niels Bohr Institute after the discovery of hafnium.

In 1946 the re-organized *Geological Survey of Greenland* (G. G. U.) began reconnaissance work in Ilímaussaq with a visit paid by A. NOE-NYGAARD and R. BØGVAD assisted by K. ELLITSGAARD-RASMUSSEN, who is now director of the Survey, and by the present author.

Further reconnaissance work was carried out in 1951 by J. BONDAM and H. PAULY. In addition a number of short visits were paid in the intrusion in the period 1946–1955.

In the years 1911–1955 a small number of papers dealing with the mineralogy of Ilímaussaq were published, first of all by BØGGILD, and also by GOSSNER, HÄGELE, MACHATSCHKI, KUNITZ, MUSSGNUG, SCHALLER, STRUNZ and others.

THE PERIOD 1955 TO THE PRESENT

In 1955 the Danish government decided that the possible uranium resources of Greenland should be evaluated. On the recommendation of the Geological Survey of Greenland the field work was started in the Ilímaussaq intrusion, which was the richest known occurrence of radioactive minerals. The expedition was directed by Colonel V. V. MOURITZEN and consisted of military personnel. The present author acted as geological adviser during the first week of the field work and F. L. JACOBSEN during the remaining part of the field season. In 1956 this preliminary radiometric surveying of the intrusion was concluded, this time with J. BONDAM as geologist attached.

The preliminary work resulted in the discovery of a number of occurrences of radioactive lujavrite. The further examination was then taken over by the *Geological Survey of Greenland*, the just-founded *Atomic Energy Commission* and for a shorter period by the *Cryolite Company*. Detailed field and laboratory work in 1956–57 led to a drilling program in 1958 and again in 1962. The geological director of this work was J. BONDAM. An account of the first stage of the work is published by BONDAM (1959 & 1960) and BONDAM & SØRENSEN (1958). At the same time a geological re-mapping of the intrusion was undertaken by J. FERGUSON, resulting in the publication of a new map in 1964. E. I. HAMILTON (1964) undertook geochemical examinations in the northern part of the intrusion, while H. SØRENSEN (1962) studied the mode of occurrence of steenstrupine in selected areas.

Papers on the mineralogy of Ilímaussaq have been published during this period by DANØ & SØRENSEN (1959), BUCHWALD & SØRENSEN (1961), BONDAM & FERGUSON (1962), OEN & SØRENSEN (1964) and SØRENSEN (1960, 1962, 1963).

In 1962 the Geological Survey of Greenland (G. G. U.) completed the general field work in Julianehåb district and moved further north to the Frederikshåb district. It was then decided that studies in the Ilímaussaq intrusion should be taken over by the *Mineralogical-geological Institute of the University of Copenhagen*. The present author undertook

Fig. 9. Dyrnæs, the base of the present geological activity in Ilimaussaq. The snow-covered mountains in the background are Ilimaussaq (to the left) and Nàkâlàq (centre). The dark mountain on the extreme left is Kvanefjeld. (BJARNE LETH NIELSEN phot.).

to direct this work. The new activity started in 1964 with staff members and research students of the institute as participants. This work is supported economically by the Atomic Energy Commission (A.E.K.) and by G.G.U. The field base *Dyrnæs* built by A.E.K. for the drilling program in 1958 and used as a main base for the activities of G.G.U. in Greenland until 1963, now serves as a base for the present field work in Ilimaussaq.

The main points in the present program of work are as follows:

1. Detailed mapping and mineralogical, petrological, tectonic and geochemical studies of the occurrences of uranium-, thorium-, niobium- and beryllium-bearing rocks in the Kvanefjeld area in the northern part of the intrusion.

2. Detailed studies of the hydrothermal beryllium mineralization of the Taseq plateau.

3. Mineralogical, petrological and geochemical studies of selected areas at various other places in the intrusion.

4. An examination of the contents of trace elements in selected samples of the rock types of the intrusion and of the distribution of trace elements among some of the minerals in a few rock types.

5. Experimental studies of the melting of a few rock types.

6. Hydrogeological studies in the Narssaq river valley as a contribution to the *International Hydrological Decade.*

Co-operation has been established with scientists in other institutes, first of all the Research Station Risø of the Danish Atomic Energy Commission, and also with scientists from other countries.

Fig. 10. The Soviet-Russian mineralogists E. I. SEMENOV and V. I. GERASSIMOVSKY at Ilimaussaq, 1964. (BJARNE LETH NIELSEN phot.).

DANISH-SOVIET-RUSSIAN CO-OPERATION

As was emphasized already by USSING, the rocks and minerals of Ilímaussaq bear a close resemblance to those of the Khibina and Lovozero massifs in the Kola peninsula which had been first described by W. RAMSAY a few years before USSING's first visit to Ilímaussaq. Soviet-Russian scientists have worked intensively in Kola since A. FERSMAN directed the first post-Revolution expedition there in 1920. As a result the worlds biggest apatite occurrence, which has been mined since 1932, and a considerable number of new minerals were discovered. Nine of these minerals have later been found in Ilímaussaq, and of the minerals first described from Ilimaussaq only ilimaussite, naujakasite and sorensenite have not yet been found in Kola. One mineral, tugtupite (beryllosodalite), was described simultaneously and independently from Ilímaussaq and Lovozero.

There are some pronounced geochemical differences between the two Kola massifs and Ilímaussaq; first of all titanium is an important element in Kola, while its place is taken to a very large extent by niobium in Ilimaussaq. Apart from this the mineralogical and petrological similarities are striking. A number of rare minerals such as beryllite, chkalo-

vite, epistolite-murmanite, gerassimovskite, lovozerite, nenadkevichite, ramsayite, spherobertrandite, steenstrupine, tugtupite, tundrite and ussingite have only been found in these agpaitic massifs.

When the present program of examination of Ilímaussaq was started it became clear that a contact with the Soviet-Russian scientists would be most useful for us and of mutual interest. This contact was established through Professor V. V. SHCHERBINA and the late Academician A. A. POLKANOV in 1958–1959 and resulted in an exchange of specimens and publications with the *Fersman Mineralogical Museum* and the *Vernadsky Institute* in Moscow. In 1960 Professors V. I. GERASSIMOVSKY and O. VOROBIEVA visited Copenhagen in connection with the International Geological Congress and in 1963 the writer visited some of the Institutes in Moscow, staff members from which work in Kola, namely the *Vernadsky Institute*, *IMGRE*, *IGEM* and the *Fersman Museum*. In the summer of 1964 Professors V. I. GERASSIMOVSKY, the Vernadsky Institute, and E. I. SEMENOV, IMGRE, visited Copenhagen and went to Ilímaussaq. In the summer of 1966 the present author was invited by the *Presidium of the Academy of Sciences* of the U.S.S.R. to visit institutes in Moskva, Leningrad and Apatity and to make excursions in the Khibina alkaline intrusion. The apatite mines were also visited. The first result of the Soviet visit to Ilímaussaq in 1964 was the discovery of three new minerals and four Kola minerals which will be described in the first papers of the new series on the mineralogy of Ilímaussaq.

THE NEW SERIES OF PAPERS ON THE MINERALOGY OF ILÍMAUSSAQ

15 members of the scientific staff and research students of the Mineralogisk-geologisk Institute now work on the mineralogy, geochemistry and geology of Ilímaussaq. This fairly intensive activity may be expected to result in a number of publications. Two have already been printed, nine have been delivered to the press and three mineralogical and a few petrological and geological papers are in preparation. In view of the likelihood of a large number of papers on the mineralogy of Ilímaussaq appearing in the near future, it was thought it would be most practical to give each paper a number to show that it belongs to a related series. The majority of the papers is planned to be published in Meddelelser om Grønland, a few in other periodicals.

In order to mark the commencement of the publishing of the new series, the minerals found in Ilímaussaq until now are listed in appendix 1.

In appendix 2 a list of papers dealing with the mineralogy, geology, petrology and geochemistry of Ilímaussaq is presented.

In appendix 3 a list of the papers of the new series is presented.

Acknowledgements

The present series of investigations in Ilímaussaq have been supported by a number of authorities, institutions and single persons. It is a great pleasure to acknowledge this help here.

The field work is supported by *Grønlands Geologiske Undersøgelse* (G.G.U.) which maintains the Dyrnæs base and provides the field equipment, the field assistants, the provisions and the motor boats used in the field. The economical basis of the field work is provided by *Atomenergikommissionen* (A.E.K.) which also placed Dyrnæs at our disposal and has provided us with jeeps, a drilling machine, beryllometers, geiger counters and laboratory equipment.

The laboratory examinations are mainly carried out at *Mineralogisk-geologisk institut, Københavns Universitet* and also in the laboratories of A.E.K. and G.G.U. Laboratory equipment has been provided first of all by the *University of Copenhagen*, and in addition by A.E.K., *Statens*

almindelige videnskabsfond and *Carlsbergfondet.* Laboratory investigations are also carried out at *IMGRE* and the *Vernadsky Institute*, Moscow, and at the *Kola Branch of the Academy of Sciences of the U.S.S.R.*

The visit by V. I. GERASSIMOVSKY and E. I. SEMENOV in 1964 was made possible by a grant from *Rask-Ørsted Fondet;* my visits in the U.S.S.R. by grants from *Københavns Universitets Jubilæumsfond*, *Atomenergikommissionen* and the *Academy of Sciences of the U.S.S.R.*

For all this help, without which the present series of investigations could not have been initiated, I wich to extend my sincere thanks. Special thanks are due to Departementschef H. H. KOCH, afdelingschef CHR. THOMSEN, to the former head of the chemical department Dr. C. F. JACOBSEN and the head of the electronic department, J. RASMUSSEN, all Atomenergikommissionen; to the Directors of Mineralogisk-geologisk institut, Professor A. NOE-NYGAARD and of Grønlands geologiske undersøgelse, K. ELLITSGAARD-RASMUSSEN; to the *Presidium of the Academy of Sciences* of the U.S.S.R.; and to our colleagues in the above-mentioned institutes and laboratories.

Mrs. A. DEMIN has translated the Russian manuscripts into English. C. PULVERTAFT has kindly corrected the English text.

APPENDIX 1

List of the Minerals Found in the Ilímaussaq Alkaline Intrusion

Acmite-ægirine: GIESECKE; ALLAN (1813).
ægirine-augite: USSING (1898).
ænigmatite: BREITHAUPT (1866); LORENZEN, (1881).
albite: USSING (1898).
alkalifeldspars: USSING (1898).
allanite: SEMENOV & SØRENSEN (1966).
analcime (eudnophite): DES CLOIZEAUX (1884).
antigorite: FERGUSON (1964).
apatite: USSING (1898).
apophyllite: BØGGILD (1953).
arfvedsonite: BROOKE (1823).
arsenopyrite: BØGGILD (1953).
astrophyllite: LORENZEN (1884).
augite-diopside: USSING (1912).
avicennite (?): SEMENOV, SØRENSEN, BESSMERTNAJA & NOVOROSSOVA (1967).
barkevikite: USSING (1898).
bastnäsite: HANSEN.
bertrandite: ANDERSEN (1967).
beryl (?): HAMILTON (1964).
beryllite: ANDERSEN (1967).
biotite-lepidomelane: USSING (1898).
bornite: BØGGILD (1905).
breithauptite: OEN & SØRENSEN (1964).
britholite: WINTHER (1901).
calcite: GIESECKE.
cancrinite: USSING (1898).
cerussite: SEMENOV.
chabazite: BØGGILD (1953).
chalcedony (?): SØRENSEN (1962).
chalcocite: BØGGILD (1905).
chalcopyrite: SEMENOV.
chalcothallite: SEMENOV, SØRENSEN, BESSMERTNAJA & NOVOROSSOVA (1967).
chkalovite: SØRENSEN (1960).
chlorite: FLINK (1898).
cookeite: SEMENOV.
corundum: USSING (1912).
crocidolite: GIESECKE.
dahllite (staffelite): BØGGILD (1915).

diaspor: USSING (1898).
elpidite: USSING (1912).
epididymite: HAMILTON (1964).
epidote: FLINK (1898).
epistolite: BØGGILD (1901).
erikite (= monazite or rhabdophanite): BØGGILD (1904), DANØ & SØRENSEN (1959), SEMENOV.
eudialyte-eucolite: STROMEYER (1819).
eudidymite: SEMENOV & SØRENSEN (1966).
fayalite: USSING (1912).
fluorite: GIESECKE.
galena: GIESECKE.
gelbertrandite: SEMENOV.
genthelvite: BOLLINGBERG & PETERSEN (1967).
gerassimovskite: SEMENOV, KAZAKOVA & ALEKSANDROVA (1967).
graphite (?): GIESECKE, RINK.
"Green mineral": USSING (1912), SØRENSEN (1962).
grossularite: FLINK (1898).
gudmundite: OEN & SØRENSEN (1964).
halloysite: SEMENOV.
hematite: USSING (1898).
hemimorphite: SØRENSEN (1962).
hisingerite: SEMENOV.
hornblende: USSING (1898).
hydronephelite: USSING (1898).
hydrargillite: SEMENOV.
igdloite (lueshite): DANØ & SØRENSEN (1959).
ilimaussite: SEMENOV, KAZAKOVA & BUKIN (1967).
ilmenite: USSING (1912).
ilvaite: LORENZEN (1881).
joaquinite SEMENOV.
katapleiite: USSING (1898).
katophorite: USSING (1912).
leucophane: BØGGILD (1905).
leucosphenite: HAMILTON (1964).
limonite: GIESECKE.
löllingite: FLINK (1898).
lovozerite: DANØ & SØRENSEN (1959).
lueshite (see igdloite).
magnetite: USSING (1898).
malachite: BØGGILD (1905).
Mn-chlorite: SEMENOV.
maucherite: OEN & SØRENSEN (1964).
microcline: BREITHAUPT (1858).
molybdenite: USSING (1912).
monazite (see erikite).
montmorillonite: SEMENOV.
murmanite: BUCHWALD & SØRENSEN (1961).
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natrolite: KOBELL (1838).

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nepheline: Steenstrup (1881).
neptunite: Bøggild (1905).
niccolite: Oen & Sørensen (1964).
niobophyllite: Hansen, Semenov.
nontronite: Semenov.
orthoclase: Ussing (1898).
pectolite: Semenov.
plagioclase: Ussing (1912).
polybasite-pearceite: Oen & Sørensen (1964).
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quartz: Ussing (1898).
ramsayite: Sørensen.
rhabdophanite (see erikite).
riebeckite: Ussing (1898).
rinkite: Lorenzen (1893).
rinkolite: Semenov.
rosenbuschite: Ussing (1912).
rutile: Semenov.
schizolite: Winther (1901).
siderite: Giesecke.
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skutterudite: Oen & Sørensen (1964).
sodalite: Thomson 1812).
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sphene: Hamilton (1964).
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stannite: Oen & Sørensen (1964).
steenstrupine: Lorenzen (1881).
stilbite: Ferguson (1964).
thorianite (?): Bondam & Sørensen (1959).
thorite (?): Buchwald & Sørensen (1961).
tugtupite (beryllosodalite): Sørensen (1960).
tundrite: Semenov, Kazakova & Aleksandrova (1967).
ussingite: Bøggild (1913).
villiaumite: Bondam & Ferguson (1962).
vrbaite: Semenov, Sørensen, Bessmertnaja & Novorossova (1967).
vudjavrite: Semenov.
zircon: Ussing (1898).
zirfecite: Semenov.

APPENDIX 2

Bibliography

This list of references, together with those in BØGGILD's "Mineralogy of Greenland", contains the titles of all the papers on the mineralogy, geochemistry and geology of the Ilímaussaq intrusion known to the writer.

Every reference which provides the first record of a mineral in Ilímaussaq is listed. The names of the minerals are given in parantheses after the reference.

With the exception of papers providing the first record of a mineral, papers published before 1953 and listed in BØGGILD's "Mineralogy of Greenland" are excluded from the present bibliography. A few papers published before 1953 but omitted by BØGGILD are however included here.

All recent papers on Ilímaussaq are given in the list. The list includes papers presenting new data on minerals from Ilímaussaq and papers in which Ilímaussaq minerals and rocks are compared with those from other intrusions, especially Khibina and Lovozero of the Kola peninsula.

Finally the bibliography contains the titles of some papers in which minerals first described from Ilímaussaq are mentioned from other intrusions. This is with the exception of ænigmatite, arfvedsonite, eudialyte and sodalite which have proved to be of very widespread occurrence.

The writer would be most grateful to be informed of any relevant papers which are not listed in this bibliography nor in that of "Mineralogy of Greenland".

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APPENDIX 3

Contributions to the Mineralogy of Ilímaussaq

List of papers:

No. 1. E. I. SEMENOV, V. I. GERASSIMOVSKY, N. V. MAKSIMOVA, S. ANDERSEN & O. V. PETERSEN, 1965: Sorensenite, a new sodium-beryllium-tin-silicate from the Ilímaussaq intrusion, South Greenland. Medd. Grønland 181,1, 1–19.

No. 2. E. I. SEMENOV & H. SØRENSEN, 1966: Eudidymite and epididymite from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland 181, 2, 1–22.

No. 3. H. SØRENSEN, 1967: On the history of exploration of the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland 181, 3, 1–33.

No. 4. H. BOLLINGBERG & O. V. PETERSEN, 1967: Genthelvite from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland 181, 4^1, 1–9.

No. 5. S. ANDERSEN, 1967: On beryllite and bertrandite from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland 181, 4^2, 11–27.

No. 6. E. I. SEMENOV, M. E. KAZAKOVA & R. A. ALEKSANDROVA, 1967: The Lovozero minerals – nenadkevichite, gerassimovskite and tundrite – from Ilímaussaq, South Greenland. Medd. Grønland 181, 5^1, 1–11.

No. 7. E. I. SEMENOV, H. SØRENSEN, M. S. BESSMERTNAJA & L. E. NOVOROSSOVA, 1967: Chalcothallite – a new sulphide of copper and thallium from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland 181, 5^2, 13–26.

No. 8. O. V. PETERSEN, 1966: Crossed axial plane dispersion in epididymite. Amer. Min. 51, 916–919.

No. 9. O. V. PETERSEN, (in press): The mineralogy of naujakasite. Medd. Grønland 181, 6, 1–17.

No. 10. E. I. SEMENOV, M. E. KAZAKOVA & V. J. BUKIN (in press): Ilímaussite, a new rare earth-niobium-barium silicate from Ilímaussaq, South Greenland. Medd. Grønland 181, 7^1.

No. 11. E. I. SEMENOV, H. SØRENSEN & Z. T. KATAEVA (in press): On the mineralogy of pyrochlore from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland 181, 7^2.

No. 12. J. HANSEN: A study of radioactive veins containing rare-earth minerals in the area surrounding the Ilímaussaq alkaline intrusion in South Greenland. Medd. Grønland 181, 8.

Papers in preparation

E. KROGH ANDERSEN, M. DANØ & O. V. PETERSEN: A tetragonal natrolite from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland.
H. SØRENSEN, M. DANØ & O. V. Petersen: Tugtupite from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland.

Færdig fra trykkeriet den 31. oktober 1967.