An Anorthosite Occurrence from West Greenland.

By

K. Ellitsgaard-Rasmussen and Me Mouritzen.

Abstract.

In the summers of 1946 and 1947 an anorthosite occurrence was discovered and visited on the west coast of Greenland. A short petrographic description of the occurrence has been given. A complete chemical analysis of the rock with pertaining data, and a chemical analysis of clinozoisite with pertaining optic data as well have been stated.

Introduction.

During the work carried out by the Geological Survey of Greenland on the west coast of Greenland in 1946 a white mountain was observed from Itivdlinguaq at Sdr. Strømfjord, situated north of the water-shed between the Itivdleqfjorden and Itivdlinguaq 66°30′ latitude N, 52°30′ longitude W. Its Greenlandic name is Qaqortorssuaq (i.e. the big white (mountain)). In the summer of 1947 the mountain was visited via Itivdleqfjorden, and samples were brought back. In the spring of 1953 these samples were taken out for further examination. The work has been carried out at the Mineralogical-Geological Institute of the University of Copenhagen. Mr. C. A. Jensen has prepared the thin sections.

Mode of occurrence.

To all appearances the anorthosite occurs as a scull-cap on the 1301 m high mountain. The contact with the surrounding gneiss was visited at a single place in a riverbed at the west side of the mountain. There was found to be a continuous transition to the gneiss. On the three sides of the mountain gneiss was found developed into the usual structural varieties characteristic of pre-Cambrian crystalline basement in amphibolite facies. According to aerial views there is also gneiss on the fourth side (the northern one) of the mountain. The orientation of the gneiss is E/W to NE/SW with steep inclination and lineation. To the south the mountain forms a steep wall (fig. 1) of the white anorthosite, and below that is gneiss. From the field work and the aerial views (the Geodetic Institute, Copenhagen) it is possible to ascertain the volume of the occurrence to a minimum of about 3 or 4 cubic kilometres. On the steep wall to the south previously mentioned can be seen a dyke with boudinage structure. As far as the

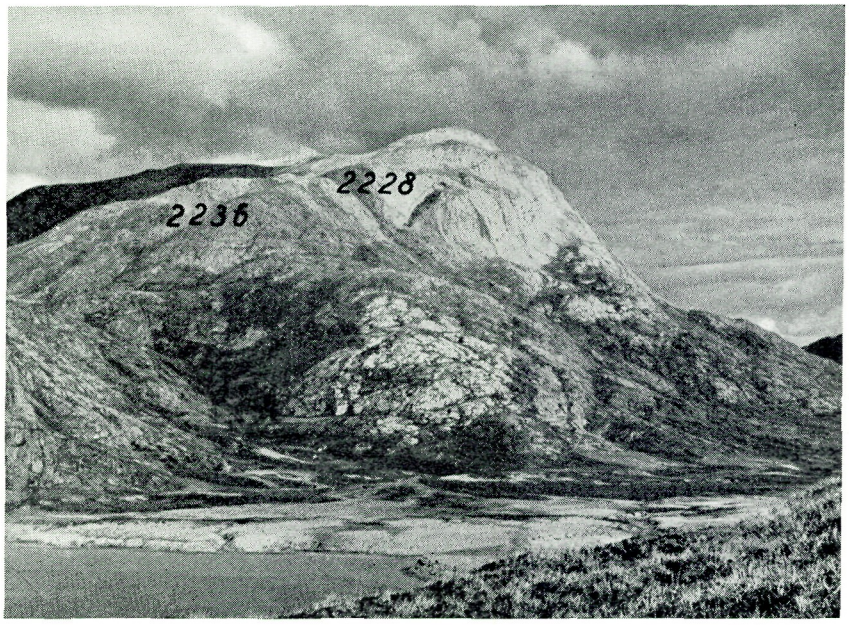

Fig. 1. Qaqortorssuaq seen from south west. K. E.-R. phot.

geological structure is concerned the position of the mountain must be on the boundary between two pre-Cambrian orogens; to the north the late Nagssugtoqidian orogen, and to the south the early Kangamiut complex (RAMBERG, 1948). In the Kangamiut complex are undeformed dyke-swarms, while such cannot be found in the late Nagssugtoqidian orogen. Consequently the white anorthosite mountain must be situated north of the borderland between the two complexes.

Megascopic characteristics.

The anorthosite is a fine- to medium-grained rock, sometimes with large idioblastic phenocrysts. In colour it is white to greyish, in the purest varieties. A marblelike appearance is typical. There are some almost completely replaced amphibolitic xenoliths. The anorthosite disintegrates with division in big square blocks, but the rock does not crumble; the blocks are quite fresh, which is in agreement with the great height of the mountain. The specific gravity varies from 2,74 to 2,84.

Microscopic characteristics.

As essential constituents have been found plagioclase and clinozoisite, and as accessories: clinozoisite, hornblende, muscovite, biotite, chlorite, calcite, scapolite, and quartz. The purest variety contains about 95 % plagioclase, 4 % clinozoisite, and 1 % muscovite (2228). A clinozoisite-

anorthosite variety (2236) consists of about 80 % plagioclase, 18 % clinozoisite, and 2 % biotite. The texture is especially xenoblastic-granular, sometimes granular-porphyroblastic. In the latter case the plagioclases are xenomorphic (-blastic), and the clinozoisites idioblastic. Also in the amphibolitic xenoliths and boudinages is seen xenoblastic-granular texture.

Plagioclase. The plagioclase grains are always xenomorphic (-blastic). The composition varies somewhat and suggests inhomogenity within the complex. In a perfectly white variety (2228) zonal structure has been found with about 75 to 80 % An in the central zones, and down to 60–65 % An in the peripheral ones. Manebach and albite twins have been observed. The plagioclase grains are all entirely full of small idioblastic clinozoisite crystals. Other samples show inversely zonal structure with about 55 % An in the central zone, and up to 75–80 % An in the periheral one (2236). These plagioclases contain no clinozoisite xenocrysts, but then the rock has big autoblasts of clinozoisites. Plagioclases often show marked distinction between the central part and inversely composed mantle. Here is observed albite and Carlsbad twins. These observations make it clear that the average composition of plagioclases is labradoritic-bytownitic. Individuals with undulatory extinction are very frequent.

Clinozoisite. The clinozoisite occurs partly as automorphic xenocrysts in the plagioclases, partly as essential autoblasts the size of a centimetre, and partly as accessory interstitielly idioblastic to slightly corroded crystals. It is a colourless clinozoisite with abnormal interference colours. At 5900 Å are $N_g = 1{,}725 \pm 0{,}002$, $N_m = 1{,}722$, $N_p = 1{,}717$. $N_g - N_p = 0{,}008$. $\alpha \wedge c = 0° \pm \frac{1}{2}°$. $+2V = 92° \pm 1°$ measured by universal stage. The chemical data of the clinozoisite (2236) are given on p. 441.

Hornblende and other accessories. The hornblende is light green and slightly pleocroitic. It occurs in a few per cent. of the peripheral parts of the complex and in the scattered xenoliths. Muscovite, biotite, chlorite, calcite, quartz, and scapolite rich in Ca occur as scattered accessories in the anorthosites.

The mica minerals often show a distinct parallelism.

Characteristics of the boudin dyke.

The boudin dyke is a greenish mesocratic rock with xenomorphic-granular texture (no relic ophitic texture has been observed). The plagioclases are inversely zonal with about 75 % An in the central zone and with more anorthosite in the peripheral ones. The hornblende is slightly greenish pleocroitic.

The chemical composition deviates somewhat from the average analyses of anorthosite. In JOHANNSEN, Vol. 111, 1946, p. 201, is mentioned a number of average results of chemical analyses of anorthosites. They show 5 or 6 % less of Al_2O_3 than the present anorthosite and about 2 % less of CaO. Of the few analyses dealt with in JOHANNSEN but few have a composition identical with the anorthosite mentioned in this paper. COUYAT, 1908, p. 340, describes an anorthosite with bytownitic plagioclase

Chr. Halkier phot.

Fig. 2. Anorthosite. Xenomorphic-granular texture. Nic. cross. × 80.

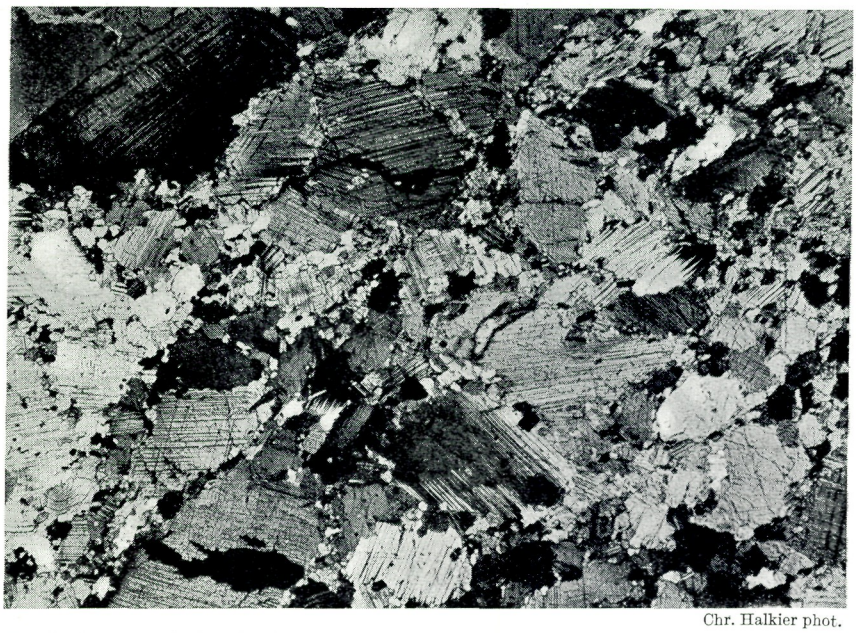

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Fig. 3. Anorthosite. Mechanical deformed xenomorphic-granular texture. The plagioclases have zonal structure. Clinozoisite is seen as an interstitial accessory. Nic. cross. × 80.

Anorthosite. Qaqortorssuaq. G. G. U. 2228. 1947. Anal. M. M.

	Weight %	Mol.
SiO_2	48,43	.807
TiO_2	Trace	
Al_2O_3	33,21	.326
Fe_2O_3	0,35	.003
FeO	0,09	.001
MnO	Trace	
MgO	0,13	.003
CaO	15,55	.278
Na_2O	2,11	.034
K_2O	0,04	.000
P_2O_5	Nil	
H_2O+	0,13	.007
H_2O-	0,04	.002
	100,08	

sal.:	Q	2,6
	ab	17,8
	an	77,6
	C	1,4
	Σ	99,4
fem.:	mt	0,2
	hm	0,3
	en	0,3
	Σ	0,8

$\frac{sal.}{fem.} = 124$

Norm. plag.: $Ab_{20}An_{80}$

A	51,6
C	43,0
N	5,3
	99,9

Modal mineral assemblage:

	Vol. %	abt. Weight %
Plagioclase	96,0	95
Clinozoisite	3,4	4
Muscovite	0,6	1
	100,0	100

Modal. plag.: $Ab_{25}An_{75}$–$Ab_{40}An_{60}$

Specific gravity: 2,74.

and hornblende from Egypt, and LACROIX, 1911, p. 819, likewise describes an anorthosite with a corresponding chemical composition. The specimen of rock carries bytownite with a little olivine and bronzite. In spite of the fact that these two specimens of rock are closest in their chemical relationship to the anorthosite of Qaqortorssuaq and have the same composition of plagioclase, they do not carry clinozoisite. Quantitatively the other chemical components deviate but little from each other. In fig. 4 the analysis has been plotted into an ACN-diagram ($A = Al_2O_3+Fe_2O_3$, $C = CaO$—$(FeO+MgO+MnO)$, and $N = Na_2O+K_2O$). The mineral assemblage of this analysis is in entire agreement with the chemical composition which even allow a plagioclase with 90 % An to occur together with clinozoisite which appears from the diagram. The normative plagioclase composition is $Ab_{20}An_{80}$.

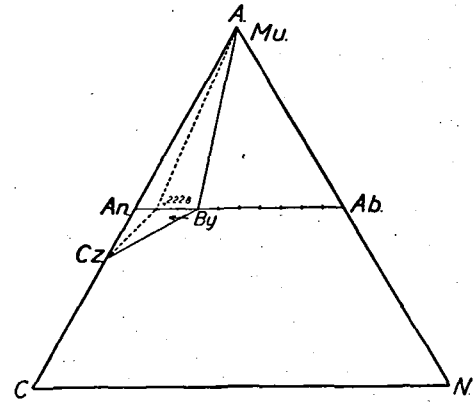

Fig. 4. ACN-diagram showing the mineralogical composition of the anorthosite as compared with the chemical composition, and the Ab-An-relationship of the plagioclase.

Clinozoisite. Qaqortorssuaq. G. G. U. 2236. Anal. M. M.

SiO_2	38,97	
TiO_2	Trace	
Al_2O_3	30,23	
Fe_2O_3	5,48	→5,00*)
FeO	0,32	→0,30
MnO	0,11	
MgO	Nil	
CaO	23,69	
Na_2O	0,60	
K_2O	0,08	
P_2O_5	Trace	
H_2O^+	0,51	
H_2O^-	0,12	
	100,11	

The optic data of the clinozoisite analysed (G. G. U. 2236) are given on p. 438.

Genesis.

There can be no doubt that the anorthosites are strongly marked by metamorphism. Indicative of this is the boudin dyke on the south side, the undulating plagioclase grains, and the metamorphic mineral assemblage, the interesting point of which is especially the relationship of clinozoisite-plagioclase. Whether the anorthosite occurrence is primarily of a pure magmatic origin and therefore an intrusive complex of the locality, or whether it has its origin genetically attached to a cycle of sedimentation is impossible to decide. The research work in Greenland is however still so imperfect that for that very reason the problem must at present be left unsolved. Furthermore the occurrence may possibly be looked upon in relation to other anorthosites that have been found of late on the west coast of Greenland.

But the mineralogical and chemical composition reflects a metamorphically developed interaction between clinozoisite and plagioclase. From this interchanging reaction can be seen that the mineral assemblage is not exclusively conditioned by the extreme chemical composition. Where there is inverse zonal plagioclase (bytownite), there will be no clinozoisite as xenocrysts, but they occur as independent autoblasts. Conversely, where plagioclase is zonal, idioxenocrysts will be abundant. In both cases the composition of the plagioclase is bytownitic in the most basic case. This comparatively rare paragenesis: bytownite-clinozoisite is no doubt meta-

*) By the separation of clinozoisite from anorthosite it proved impossible to avoid impurities of biotite and plagioclase grains. The presence of these two minerals may cause a slight error in the chemical quantitative determination. In case K_2O is completely deducted the content of Fe_2O_3 will be 5,00 %, and FeO, MnO 0,30 %. The real Fe_2O_3 content is thus between 5,48 % and 5,00 %, while the FeO, MnO content is between 0,43 % and 0,30 %.

morphically developed on the basis of the unusual chemical composition. Many observations from localities of pre-Cambrian rock show that a gradually basic plagioclase is developed at rising temperatures, but in case of mafic constituents being present the result will be dark minerals, so that the clinozoisite composition disappears already at a labradoritic composition of the plagioclase. There is no clinozoisite in the boudin dyke, and in the abovementioned analyses of COUYAT and LACROIX there is a little more magnesium and iron which involves the presence of olivine and pyroxene instead of clinozoisite. The plagioclase rich in Ca shall not be regarded as an evidence of a very high temperature in the complex (amphibolite facies) as we have an unusual, chemical composition, and a basic plagioclase is not so sensitive to changes of temperature as an acid one. This paragenesis has, by the way, been dealt with thoroughly on a real and theoretical basis by for instance RAMBERG, 1943, ROSENQVIST, 1943, 1952, and STRAND, 1943. The only thing said in the present written work about the development is that the complex has been exposed to a rise in temperature and relief of pressure and the reverse process. As to the question of age between these two processes it is impossible to decide anything definately. A thorough research work must be carried out first. The only thing is that the inverse zonal plagioclase is found developed near the contact to the gneiss, and the zonal one is placed more centrally in the complex, which may suggest that a rise in temperature from below have taken place in a late phase.

RESUMÉ.

Paa Vest Grønland ved Itivdlinguaq i bunden af Itivdleqfjorden n.f. Sdr. Strømfjord besøgtes i somrene 1946 og 1947 under Grønlands Geologiske Undersøgelses arbejde en hvid anorthosit, der er usædvanlig i kemisk og mineralogisk sammensætning. Mineralogisk bestaar den af basisk plagioklas og clinozoisit, og i kemisk henseende er den mere aluminium- og calciumrig, end anorthositer er i gennemsnit. De sparsomme feltiagttagelser tillader ikke at tage stilling til forekomstens oprindelse.

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Færdig fra trykkeriet den 18. januar 1954.