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AGE AND ORIGIN OF ROCKS LIFTED BY TRAWL FROM THE SOUTH-WEST GREENLAND SHELF

BY

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WITH 1 FIGURE IN THE TEXT

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INTRODUCTION

During a visit to Leningrad in 1961 my friend, Professor V. D. DIBNER, told me that isotopic age determinations had been made on material derived from the fishing banks off West Greenland and that the age of two rock samples had been found to be 2,450 m.y. and 2,300 m.y., respectively. The West Greenland rock samples hitherto subjected to isotopic age determinations had turned out to be much younger. Whether the rocks treated in the present paper were found *in situ*, or they had been transported by glaciers from the interior of Greenland, has not yet been finally settled.

I asked Professor DIBNER to write a paper (intended to form part of a symposium on the whole of Greenland) on the surface of Greenland below the inland ice in accordance with our present knowledge, including the results of the Victor-Expeditions and others. As this symposium has for various reasons been somewhat delayed, and I thought it of importance that the age determinations made should be published as soon as possible, the present paper appears already now.

LAUGE KOCH

The shelf along the South-West Greenland periphery (between Kap Farvel and the Arctic circle) extends in a general north-north-west direction and has a width of 50–100 km. There may be distinguished a row of banks submerged to depths of 20–30 to 100 m and divided from each other by submarine valleys with depths up to 250 m and more. These valleys are situated on the west-south-west prolongations of certain fiords. Besides, we can notice the marginal trough of 150–250 to 400–500 m depth, extending along the east slopes of Fiskenæs-, Fyllas-, Banan- and Lille Hellefiske Banke. The trough divides these banks from the coast between 63° and 65° N. The bottom sediments of the banks are usually represented by unsorted sands, along the borders of which there may be found areas of blocks and boulders.

Here the preliminary results of the study of the clastic materials collected by one of the authors (V. D. DIBNER), during the voyage of the Soviet fish trawler "Sever" ("North") into Davis Strait (autumn 1960) will be discussed. The trawling was undertaken on the eastern part of the so-called Banan Banke and on its slope in the coordinates of 64° 22′–35° N′ and 53° 10′–26° W′ (approximately on the Godthaab traverse) and at depths of 45 to 350 m. The debris and blocks, sometimes angularly rounded pebbles (of 5–6 to 15–20 cm in diameter) of different gneisses, granite gneisses, basic igneous rocks and terrigenous sediments were lifted here. Microsections were made from all the samples of these rocks and were examined by V. A. VAKAR. Six samples were investigated in the laboratory under the leadership of A. J. KRYLOV, where age determinations by means of potassium-argon method were made (Table 1). The sedimentary rock samples were investigated by palinologist M. A. SEDOVA and the heavy fractions of these rocks were studied by S. S. RONKINA.

Preliminary results of all these investigations are as follows.

I. The oldest age of the regional metamorphism (2450 and 2330 m. y.) is attached to two-mica and biotite granite gneisses[1]) respectively, both of which are characterised by the absence of any traces of superposed dynamic metamorphism. In this case as well as in other samples the age determinations were made on the whole mass of

[1]) See § 1 and 2 of the table.

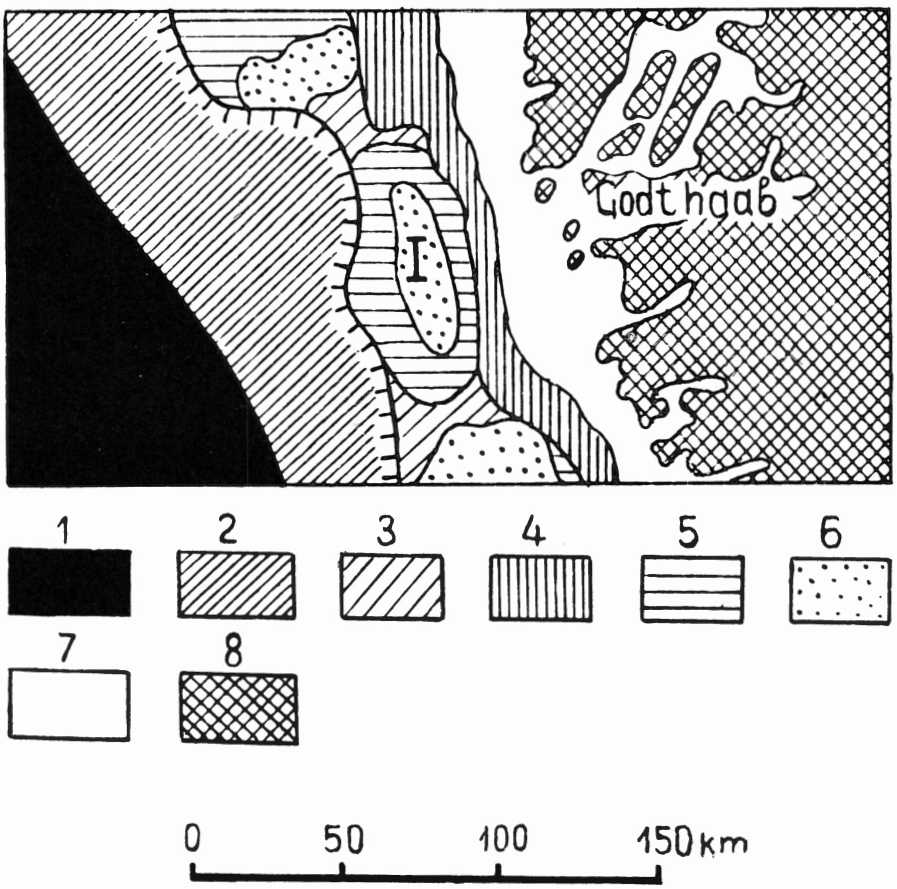
rock. For this reason all the data may be somewhat low. Because of this the above mentioned two-mica and biotite granitic gneisses may be roughly correlated with the Rhodesian tectonic-magmatic cycle which took place 2600–2700 m. y. ago. In the light of a recent classification this is the Middle-Upper Archean boundary.

II. Biotite granitic gneisses with clear traces of superposed dynamic metamorphism[1]) have originated contemporaneously with those of the first group of rocks and under the same conditions. This is proved by the similar composition and character of metamorphism of both groups of rocks. But the second group of rocks was recrystallised by strong superposed dynamic metamorphism, which perhaps determined the age of the metasomatic minerals, including the biotite and other potassium-bearing minerals. Thus superposed metamorphism may have reduced the apparent age of these rocks down to 1620 and 1800 m.y. These datings would then correspond to the time of the last important diastrophism of the rocks of this area. Keeping in mind such reductions of our age data these rocks may be connected with White Sea tectonic-magmatic cycle (1800–1900 m.y.), which was widely displayed in different parts of the Earth (Fenno-scandia, Canada and elsewhere) and corresponds to the Archean boundary. In the Julianehåb district (several hundred km southward from Banan Banke) there are granite massifs, the age of which is determined as 1590 + 70 m.y. These granites intrude the metamorphic Ketelidian formation (widespread on the Greenland west coast) thereby fixing an upper limit for its age (4). Thus we may suppose the biotite granitic gneisses with clear traces of superposed dynamic metamorphism to be related to the Ketelides, the formation of which was connected with White Sea tectonic cycle.

III. The age of quartz diabase[2]) is 1840 m.y. It is close to the age of the biotite granitic gneisses which experienced the secondary dynamic metamorphism. The absence of cataclastic and other traces of superposed dynamic metamorphism allows us to suppose the intrusion of this metadiabase and of the similar meta-gabbro-diabase to have taken place at the end of the White Sea diastrophism. That is why both of these have not experienced this diastrophism.

IV. Amphibole-biotite and biotite-amphibole gneisses[3]) not subjected to the dynamic metamorphism are probably the rocks called by A. KORNERUP (3) "hornblende gneisses", which underlie the "usual

[1]) See § 3 of the table.
[2]) See § 5 of the table.
[3]) See § 4 of the table.



Banan Banke (I) on the South-West Greenland shelf.

Legend.

1 – the deep floor of Davis Strait (more than 1500 m deep).
2 – continental (island) slope (200–1500 m).
3, 4, 5, 6, 7 – shelf.
3 – transversal hollows dividing one bank from another.
4 – marginal hollow evidently caused by a fault (150–500 m).
5 – the peripheral part of the shelf (100–200 m).
6 – banks (50–100 m).
7 – the off-shore shallow-water and fjord bottoms.
8 – continent.

gray gneisses" of the Godthaab area. There are only indirect data concerning the ages of the samples of these rocks (see below).

V. Hypersthene-amphibole andesite-basalts[1]) may probably be correlated, judging by their freshness, to the plateau basalts armouring

[1]) See § 6 of the table.

Table I. Age and Petrographic Composition of Rocks Lifted by Trawl from Banan Banke.

Short characteristics of the petrographic groups	"Argon" age determinations			
	Sample number	K %	Ar $\frac{cm^3}{r}$ 10	Age (m.y.)
§ 1. Two-mica microcline granitic gneisses. The rock has coarse gneiss-like texture and blastogranitic irregular grained structure with inconsiderable traces of the healed cataclastic debris. It consists of oligoclase, microcline, quartz, and biotite (partly chloritizated) and muscovite, as well as accessory minerals—apatite, zircon and magnetite	140 A	1,97	37,8	2450
§ 2. Biotite granitic gneiss. This rock is very similar to the sample 140 A in its texture, structure and composition, but differs from it by the absence of muscovite (samples 140 б, A_1, A_3, б, г, з; 147 б).....	140 б	1,65	28,7	2330
§ 3. Biotite granitic gneisses with clear traces of superposed dynamic metamorphism. The rock is of coarse gneissic texture and blasto-granitic irregular grained structure. It consists of oligoclase, microcline, quartz, biotite and muscovite (in less degree). Intensive wavy quartz extinction is typical as well as twin curving, plagioclase seritization, biotite plate curving and its chloritization, and also the distinct cataclastic structure healed by the aggregates of the same minerals (samples 140 $б_1$, 140 N). According to the degree of superposed dynamic metamorphism the biotite paragneisses with intensely wavy quartz resemble this rock (samples 126, 138).	140 $б_1$ 140 N	1,84 3,97	20,85 38,4	1800 1620

(continued)

Table I (cont.).

Short characteristics of the petrographic groups	"Argon" age determinations			
	Sample number	K %	$Ar\frac{cm^3}{r}10$	Age(m.y.)
§ 4. Melanocratic amphibole-biotite and biotite-amphibole gneisses. The rocks are composed of average plagioclase, quartz (sometimes with weak wavy extinction), biotite and amphibole. There may be found local accumulations of sphene. Traces of superposed dynamic metamorphism are absent (samples 140 A_4, B, B_4, ж, л).	–	–	–	–
§ 5. Middle coarse-grained quartz metadiabase. The rock has a subophitic structure, considerably hidden by secondary processes, and consists of completely albitized plagioclase and pseudomorphs of actinolite, chlorite and biotite according to the coloured mineral (pyroxene?). Quartz is found in the form of separate grains or as a constituent of micropegmatite, which forms specific hieroglyphs. Cataclastic and other traces of superposed dynamic metamorphism are absent 147 A).	147 A	0,77	9,12	1840
An intensively changed gabbro-diabase with micropegmatite is a rock similar to the above mentioned one, and differs from it only by its coarser grain size (sample 140 B_1).....	–	–	–	–
§ 6. Hypersthene-amphibole andesitic-basalt. The rock is characterized by fluidal texture and pilotaxitic structure. It consists of amphibole, rhombic pyroxene (hypersthene), basic and average plagioclase (sample 147 ж)...	–	–	–	–

(continued)

Table I (cont.).

Short characteristic of the petrographic groups	"Argon" age determination			
	Sample number	K %	$Ar\frac{cm^3}{r}10$	Age (m.y.)
§ 7. Hornblende gabbro-diorite. It is a very fresh rock free from any traces of the greenstone change and of dynamic metamorphism. It consists of basic plagioclase (labrador-andesine) and amphibole with the crystals biotitized along the periphery, and also of grains of secondary mineral-zoisite.....	–	–	–	–
§ 8. Diamictite is a poorly graded terrigenous lithicized rock[1]. It consists of alternating layers of silt-psammite and silt-pelite, cemented. Debris is represented by quartz grains, which compose some rock areas almost completely, by oligoclase, amphibole, pyroxene, chloritized biotite, granitoids etc. There may be found quartz pebbles, siliceous and granitic-gneiss pebbles and small lenses of highly siliceous-quartz gritstones and conglomerates.....	147 E	1,17	12,77	1740 (the age of clastic component)

[1] The term, with this meaning, was proposed recently by R. FLINT (1).

the Early Paleocene fresh-water deposits and interbedded sometimes with these deposits, which are developed widely on Disko island and on Nûgssuaq and Svartenhuk peninsulas (3, 6).

VI. The age of the hornblende gabbro-diorite[1]) remains unknown. Judging by the extreme freshness of this rock, it is relatively young.

VII. The composition of diamictites[2]) resembles that of the poorly graded terrigenous deposits of the Late Cretaceous and Paleocene,

[1]) See § 7 of the table.
[2]) See § 8 of the table.

which are widely developed on Disko island. These deposits occur here on a deeply weathered crust of gneisses and underlie the young plateau-basalts (2, 5, 6).

The petrography of the pebbles found in such deposits both in the Disko island area and on the Banan Banke, points to denudation of the gneiss as the source of these pebbles. The composition of the gneisses may be related to the heavy fraction of diamictites, which according to S. S. Ronkina consists of intensively ferruginous hornblende (54,8%), hypersthene (8,8%), monoclinic pyroxene (9,6%), including titanaugite and aegirine, epidote (18,3%), garnet (2,3%), ilmenite (2,2%), sphene (1,6%) and separate grains of prehnite, staurolite, rutile, zircon and orthite. Pyrite is an anthigenous mineral (samples 147 E etc.). Such heavy minerals provide a direct indication of the formation of the Banan Banke diamictites from the destruction of biotite-amphibole and amphibole-biotite gneisses.

This is why the age of the clastic part of the diamictites (1740 m.y.) is at the same time the age of the melanocratic gneisses which are the source of the diamictite formation. Thus it may be concluded that the melanocratic gneisses may be related to the Ketelides, in spite of the absence of dynamic metamorphism, as well as to signs of the biotite granitic gneisses which have been subjected to the secondary dynamic metamorphism. Such a relationship being confirmed by direct age determinations would testify once more to the insecurity of the method of basing sequences on the degree of metamorphism, which can change intensively from one place to another.

The data directly concerning the geological age of the diamictites are the results of the palinologic investigations undertaken by M. A. Sedova. She found in sample 147E the pollen[1]) of *Ginkgoaceae* (5), *Pinaceae* (7), *Taxodiaceae* (3), angiosperms pollen (5); and also separate grains (1–2) of *Dacrydium*, *Podozamites*, *Yuglans*, spores *Gleichenia* (3); and separate spores (1–2) of other ferns (*Coniopteris*, *Schizaeaceae*, *Schizaea*, *Filicales*); and also spores of *Sphagnum*, *Lycopodium* and *Selaginella*. Owing to the presence of the spores of *Schizaceae* and of the pollen of *Coniopteris* and angiosperms, this complex may be supposed to be of Late Cretaceous age. A younger complex of spores and pollen was found in the sample 147G. It consist of the pollen of *Pinus* sp. (10), *Pinus* of subgenus *Diploxylon* (3), *Pinus* of subgenus *Haploxylon* (2), *Taxodiaceae* (4), *Moraceae* (3), *Extratripollenites* (7); and also of the separate pollen grains (1–2) of *Tsuga*, *Picea*, *Myrica*, *Yuglans*, *Carya*, *Betula*, *Corylus*, *Ostrya*, *Querqus*, *Legaminosae*, *Myrtaceae* and the spores of *Lycopodium* and of the ferns *Polypodiaceae*, *Polypodium*, *Gleichenia*

[1]) In brackets the amount of pollen and spores grain is given.

and *Filicales*. Judging by the presence of angiosperms pollen in this complex (*Extratriporopollenites* and *Myrtaceae*), it may be most probably related to the Paleogene.

After the "Sever" voyage, when the coarse debris was first lifted from the South-West Greenland shelf, in the summer of 1961, two more voyages of the Soviet ships were undertaken into the eastern part of Davis Strait. For this reason the collection of coarse debris was continued by the scientists of the Polar Institute of marine fishery and oceanography (ПИНРО, Murmansk). On the South-West Greenland shelf between 60°30′ N and 66°10′ N the geologist V. D. RVACHEV lifted 15 bottom samples, and in the coordinates between 65°28′ N and 54°45′ W the hydrologist Y. Y. SVETLOV lifted one trawl sample. This material is not yet completely studied, but the first look through it, accomplished by the kind permission of P. S. VINOGRADOVA, the chief of the Marine Geology Laboratory (ПИНРО), us leads to make the following principle conclusion: among the abundant various gneisses, granitic gneisses, granitoids and basic igneous rocks typical of this part of Greenland, sedimentary rocks like the diamictites of Banan Banke are altogether absent. This suggests that one debris of the Banan Banke and of the other banks of South-West Greenland is of local origin and not transported by icebergs. Otherwise the diamictite and basalt debris would be found in increased amounts northward, towards Disko island; but this does not take place. It is quite natural, because the Irminger Current which conditions the whole hydrological-meteorological regime of South-West Greenland, is known to have a south-north direction here, that is towards Disko island and not from it. This current transports into the Davis Strait the icebergs from the eastern Greenland coast, where outcrops of the continental Cretaceous deposits are known only in the Koldewey area (76° N). During the 3500 km transport from thls area towards Banan Banke, the moraine enclosed in the icebergs must be inevitably melted out.

Thus it may be supposed that the coarse debris of the Banan Banke is of glacial origin, that is, it was deposited in the shape of edge moraine during the Pleistocene glaciation, similar to the process now operating on the banks around the Antarctic. This supposition could have a firm basis if Paleogene-Cretaceous diamictites and above-lying basalts were known on the adjoining part of the coast (in Godthaab area). But this is not known yet. Besides, the moraine deposits of the Banan Banke might include not only the coarse debris but also the heavy compact clay which in most places underlies the plastic bottom sediments in the shelf areas of the Polar Seas. Such clay generally prevents the trawl from moving, sticks to its boards and is lifted with them on to the deck of the ship. But this phenomenon was not observed.

Summing up, we can conclude that the coarse debris of the Banan Banke is eluvium or talus from the bedrocks, sometimes rounded a little by the waves. This latter process could have taken place during a stage of lower sea level: most probably at the beginning of Holocene time, that is, during the interval, before the maximum of the post-glacial transgression.

If such be the case, the rock debris from Banan Banke points not only to the presence of Ketelids in this area, but also to traces of old metamorphic sequences which are weakly developed along the borders of the Baltic and Canadian shields. There are found here also Paleogene-Cretaceous diamictites and basalts which crop out on the continent considerably northward. These younger rocks have originated nearly in situ and have been preserved here probably in connection with the subsequent tectonic subsidence of the Banan Banke region along the fault which may be supposed to lie between the banks of the outer shelf periphery and the area of shallow waters (see figure on p. 7).

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