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A SEDIMENTARY PETROLOGICAL INVESTIGATION OF A NUMBER OF SAND SAMPLES FROM THE SOUTH COAST OF GREENLAND BETWEEN UNARTOK AND TOKULINEK

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WITH ONE PLATE

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The following pages are the result of the continuation of CROMMELIN's work (Lit. 1). The sand samples collected by C. E. WEGMANN, come from an area which partly lies to the south-east of CROMMELIN's area and partly overlaps it. The material was given for examination to Prof. Dr. C. H. EDELMAN at Wageningen and examined by the present writer during a stay in the Geological Laboratory at Wageningen.

1. Geology of the solid rock.

The southern point of Greenland consists of a folded granulite-series, as WEGMANN discovered in the summer 1937. The rock contains both garnet and hypersthene and very much resembles the rock of Angmagssalik described by WAGER and called by him "Hypersthene-granite gneisses of Charnokite affinities" (Lit. 4). In numerous places in this series quantities of gneiss and granite are found of the type of the migmatite rocks from the area of Julianehaab (rich im amphibole) analogous to those already examined by CROMMELIN. The younger granites are often syenitic and they are also rich in amphibole. In many places they disintegrate easily (as to the division of these younger granites, see Lit. 5). Thus we have three main groups: 1) the granulite-series, 2) the Julianehaab-series, 3) the series of the younger granites and syenites with the young basic veins. It is hard to say which of the two first-mentioned series is older. The granulite series itself is older than the granitisation which has given rise to the Julianehaab-series; on the other hand the granulite-series has been subject to alteration which is younger than the Julianehaab granite: we are in a Praecambrian area with highly polymetamorphic rocks. Moreover, we have not to do, as usual, with boundaries, but with aureoles of different alteration stages.

2. Method of investigation.

Preparations were made of the 40 sand samples, both of the light and of the heavy fraction (EDELMAN-DOEGLAS method, as described by

CROMMELIN, Lit. 1, p. 7). $HCl\text{-}HNO_3$ preparations were made only of the heavy fractions, KOH preparations of the heavy as well as of the light fractions. The investigation was therefore based on 120 preparations, 3 of each locality, viz. one $HCl\text{-}HNO_3$ preparation of the heavy fraction, and two preparations boiled with KOH. Of each of these 40 $HCl\text{-}HNO_3$ preparations, which are by far the most interesting, because they enabled me to divide the area into sedimentary-petrological provinces, 100 grains were counted. Of the heavy fraction of the KOH preparations the percentage of the minerals attached by HCl and HNO_3 was estimated, likewise by counting 100 grains. These minerals proved to be only biotite and apatite; I have not been able to show olivine in any of my preparations. I counted only 50 grains of the preparations of the light fraction and I rounded off in the way described by CROMMELIN (Lit. 1, p. 8). It may be remarked that in the KOH preparations biotite was found almost entirely in the heavy fraction, in contrast to what CROMMELIN found. The cause of this is probably the fact that I used bromoform of different spec. weight.

3. Localities according to WEGMANN.

(All samples in this series are marked **b**).

1 b. Beach sand Kunermiut.

Collected in the large harbour south of the narrowing. The sand has been washed by the waves out of a Quaternary terrace. In the erraticum of the terrace ketilidic rocks occur by the side of younger ones. The neighbourhood, however, consists entirely of younger granites.

2 b. Beach sand at the foot of the Anoritôk.

Between the younger granites and the foot of the Anoritôk in a bend of the Sermilikfjord lies a basin filled with Quaternary. The beach sand has been washed out of this.

3 b. Beach sand at the former settlement of Sermilik.

At the connection between the Sermilikfjord proper and the southern arm, opposite the island of Amitsok, lies the forsaken settlement of Sermilik with small accumulations of Quaternary. In the high grass on the beach (Marehalm) sand accumulates.

4 b. Beach sand near Iglokasik.

On the continent near the bend at the boundary of the younger granites and the older basement rocks lie fairly large accumulations of Quaternary. The sample comes from the one farthest to the north. In the erraticum is a much larger quantity of Ketelidic rocks, viz. garnet gneiss, than of younger rocks.

38 b. Sand from the spot where the hot water appears in the lower basin (newly dug-out channel).

The sand has been washed by the spring out of the moraine and the postglacial sediments and was exposed to the influence of the hot water. Bleaching of the biotite.

40 b. Micaceous sand from the outlet of the upper basin of Unartok.

In the cushions of sea-weed, which grow densely in the hot water, much biotite accumulates which looks yellow like gold; it is probably altered through the influence of the organic elements in the hot water. At any rate a large part of the mica comes from the crumbling rock.

4. The heavy fraction of the HCl—HNO_3 preparations.

In examining the minerals of the heavy fraction of the HCl-HNO_3 preparations it appeared possible to divide the material into 3 groups: a) Amphibole-group (Nos. 1 b, 2 b, 3 b, 38 b and 40 b); b) Hypersthene-Garnet-group (Nos. 4 b—10 b, 12 b—14 b, 19 b—31 b, and 34 b—37 b); c) the mixed groups (Nos. 11 b, 15 b—18 b, 32 b, and 39 b).

A sand sample is considered to belong to the Amphibole-group, when the quantity of amphibole was more than 30 and the quantity of hypersthene (as well as garnet) less than 20.

To the Hypersthene-Garnet-group I reckoned all samples in which the quantity of amphibole was less than 30, the quantity of hypersthene or garnet always more than 40.

The remaining samples are taken together in the mixed group. The groups do not, however, so strictly satisfy the conditions put by Edelman for a sedimentary petrological province as e.g. in the Netherlands. The variations within such a province are too great for that.

a. Amphibole-group.

The Ti-augite of 1 b and 2 b may be derived from basic veins, although these were not mentioned in describing the locality. Crommelin, too, mentions the Ti-augite of this neighbourhood (locality 33). The amphibole may derive partly from the Julianehaab-granites, partly from younger granites. The high percentage of Titanite in 40 b is striking (cp. Crommelin, locality 30). Taking into consideration Crommelin's results, this Amphibole-group appears to resemble very much a sedimentary petrological province extending from the former settlement of Sermilik far into the north-west. The amphibole, however, derives certainly from two quite different rocks, viz. from younger granites and from Julianehaab granites. But in none of the samples I have succeeded

Table 1.

Locality	Opaque	Transparent minerals										
		Zircon	Sillimanite	Gr. Amphibole	Br. Amphibole	Augite	Ti-Augite	Hypersthene	Garnet	Epidote	Saussurite	Titanite
1 b................	18	..	1	36	5	..	10	13	4	7	6	..
2 b................	6	..	1	53	..	..	11	2	1	10	16	..
3 b................	..	..	..	21	29	50	..	..	..	..	..	..
38 b................	20	..	..	63	..	..	3	..	2	7	4	1
40 b................	4	..	..	75	..	..	..	..	..	9	2	10

in inferring from the varieties of the amphibole, from which rock this mineral comes. The number of samples is too small for this and the petrography of both rocks too little known with regard to this.

To this group may also be reckoned CROMMELIN's samples 30—34 and probably also his samples 2—6, while further northwards, between Igaliko and Julianehaab the minerals of the alkali rocks begin to play a part. Also in the samples described by CROMMELIN it is probable that the amphibole derives both from Julianehaab granites and from younger granites. An exception is Sample 29 from Lichtenau, described by CROMMELIN, so coming from the same area. We shall come back to it later on.

b. Hypersthene-Garnet-group.

It will be clear that the minerals hypersthene and garnet come from the folded granulite series of South-Greenland. The question arises whether the Garnet-Hypersthene province also comprises the localities 36 and 37 of Frederiksdal, described by CROMMELIN.

In examining more closely CROMMELIN's sample no. 37 I found a rock-fragment consisting of hypersthene, oligoclase and quartz, of the paragenesis of the granulite-series, so that it is certain that part of the hypersthene from the area of Frederiksdal comes from the granulite-series. CROMMELIN attached importance to the descriptions of TÖRNEBOHM (Lit. 3), who in the neighbourhood of Frederiksdal mentions gabbro's containing hypersthene which therefore might also have yielded hypersthene. Now the situation of CROMMELIN's samples Nos. 36 and 37 in the middle of the Garnet-Hypersthene province makes it not at all improbable that the sands Nos. 36 and 37 should also be reckoned to the Garnet-Hypersthene province.

It is, however, improbable that the sample from Lichtenau also comes from acid granulites. CROMMELIN's table namely shows that

Table 2.

Locality	Opaque	Transparent minerals									
		Zircon	Sillimanite	Gr. Amphibole	Br. Amphibole	Augite	Ti-Augite	Hypersthene	Garnet	Epidote	Saussurite
4 b	16	..	..	2	..	..	1	52	27	..	2
5 b	3	..	..	..	4	2	..	23	62	..	6
6 b	1	..	..	4	18	1	..	24	40	1	11
7 b	18	2	..	..	..	..	..	45	35	..	..
8 b	5	..	2	1	2	..	2	15	69	1	3
9 b	2	..	..	5	..	..	..	11	77	..	5
10 b	13	1	..	4	1	10	..	53	12	4	2
12 b	6	..	..	..	..	..	..	81	13	..	..
13 b	3	..	..	..	..	..	..	95	..	..	2
14 b	6	..	..	..	1	1	..	65	27	..	..
19 b	5	..	..	..	4	..	..	85	6	..	..
20 b	15	..	..	..	4	..	..	65	15	..	1
21 b	8	..	..	..	4	1	..	72	11	..	4
22 b	17	..	..	..	..	..	..	61	22	..	..
23 b	9	..	..	..	..	..	..	80	10	..	1
24 b	7	..	..	4	5	..	..	70	9	..	5
25 b	6	..	..	..	..	..	..	74	20	..	..
26 b	8	..	..	..	1	..	..	74	17	..	..
27 b	4	..	..	..	..	..	..	95	1	..	..
28 b	7	..	..	2	..	..	..	85	5	..	1
29 b	5	..	..	..	..	..	..	17	78	..	..
30 b	57	..	..	1	..	..	..	41	1	..	..
31 b	5	..	..	4	1	..	..	90	..	..	..
34 b	4	..	..	11	..	2	..	83	..	..	..
35 b	2	..	..	4	1	24	..	62	4	..	3
36 b	12	1	..	..	6	3	..	72	4	1	1
37 b	19	..	..	2	1	2	..	57	19	..	..

sample No. 29 contains, besides hypersthene, a considerable percentage of olivine and in the light fraction a fairly considerable quantity of basic plagioclase. Therefore we have here several arguments in favour of the origin from basic rocks.

We shall now consider the localities of the group individually. The large quantity of garnet in 4 b is in accordance with the description of the locality. The same holds good for 5 b. The small quantity of augite and hornblende might be in accordance with the presence of younger rocks. In 6 b there is a fairly considerable admixture of other rocks than the Hypersthene-Garnet granulites, for the percentage of amphibole is fairly high (the sample might also be reckoned to the mixed group). This admixture probably comes from younger granites in the erraticum and from migmatites. The younger dykes mentioned by Wegmann for 7 b seem to play no part in the composition of the sand. The Ti-augite in 8 b probably comes from the basic inclusions and dykes. In the same way the augite of 10 b will probably not come from the Hypersthene-Granite series. As 10 b does not contain Ti-augite the diabases at the foot have played no part in the formation of the sand. For 12 b, 13 b and 14 b it is improbable that other rocks than those of the Hypersthene granulite series have had any influence in the formation of the sand. The younger granite mentioned for 14 b may have furnished the very slight admixture of amphibole. As regards 19 b no remarks need be made. The slight quantity of augite and hornblende in 20 b may come from syenite (see Lit. 1, p. 16—17) and from migmatites. Hardly anything may be noticed of a strong mixture of other material in sample No. 21 b; it contains only little amphibole. The samples Nos. 22 b and 23 b show the Hypersthene-Garnet-combination to a very large extent. Nothing is to be seen of a strong admixture of regional moraine-material mentioned by Wegmann for 23 b. 24 b too is a fairly pure Hypersthene-Garnet sand, the admixture of amphibole is only moderate. The samples Nos. 25 b—30 b show hardly any admixture. That 23 b and 26 b resemble each other very much agrees with Wegmann's remarks. As in the neighbourhood of 27 b only younger granite is outcropping, this sand must come from a more regional moraine. The quantity of hypersthene is overwhelming, whereas amphibole is wholly absent. As regards sample No. 28 b younger granites will not have had any influence either in the formation of the sand. 31 b, but especially 34 b, have a clear admixture of amphibole, which agrees with the description of the localities. According to Wegmann the augite of sample No. 35 b comes from basic dykes. In 37 b the slight quantity of augite probably comes from syenite, the amphibole probably from young granite.

c. The mixed group.

We shall divide the mixed group into two parts, viz. in the samples that mineralogically as well as regionally form a transition between the the Amphibole-group and the Garnet-Hypersthene-group, and the samples that only mineralogically form a transition between these two main groups.

To the first group belong 15 b, 16 b, 17 b, 18 b and 39 b. To the second 11 b, 32 b and 33 b. As has already been said, 6 b might be reckoned here too.

As has been said, the mixed group lies between the areas of the pure Amphibole-province and the Garnet-Hypersthene-province. The

Table 3.

Locality	Opaque	Transparent minerals										
		Zircon	Sillimanite	Gr. Hornblende	Br. Hornblende	Augite	Ti-Augite	Hypersthene	Garnet	Epidote	Saussurite	Andalusite
15 b	4	..	..	56	2	..	..	27	1	..	10	..
16 b	10	..	1	18	9	2	2	30	10	4	14	..
17 b	11	..	..	21	10	..	1	28	22	2	5	..
18 b	11	1	..	25	10	1	..	31	12	5	4	..
39 b	8	..	1	26	4	6	..	36	11	4	3	1

islands 15 b—18 b lie on the so-called plain of abrasion, i. e. they belong to an extensive rock-plateau extending outside the coast-line. They are low flat islands consisting only of "roches moutonnées" (see photo), about like the South Finnish "scharen" or like the islands belonging to the beach-terrace (strandflat) of the Norwegian coast. There is no doubt that the ice has moved over these islands. In many places the hollows between the hills are still filled with moraines, here and there also with the washed out products of it. But everywhere there still lie many erratic blocks. From these it may be seen that the ice at any rate came from the area of the Tasermiut-fjord. So we have really to do here with a mixture from a large valley-area, which is not the case with most other samples. 39 b should also be reckoned to this group, although it cannot be settled definitely for this sample whether the material comes only from the Tasermiut Glacier or whether there are admixtures from the North as well. For the Tasermiut Glacier had at least three great mouths, of which one lies to the North and one to the South of the present outlet filled with water.

Table 4.

Locality	Opaque	Transparent minerals								
		Zircon	Gr. Amphibole	Br. Amphibole	Augite	Ti-Augite	Hypersthene	Garnet	Epidote	Saussurite
11 b	8	2	33	..	..	..	25	24	7	1
32 b	15	1	26	2	2	..	45	8	..	1
33 b	8	..	28	18	1	1	17	1	5	21

Thus the samples 15 b—18 b and 39 b are of great importance for future investigation. In 39 b I point out the presence of andalusite, a mineral which is mostly lacking in the sands of South Greenland and, if present, is always rare.

The samples of Table 4 lie within the area of the Garnet-Hypersthene-province. As the Garnet-Hypersthene-series does not form a closed area, many rocks containing amphibole occur in this area; for there are many amphibolites, and—as has already been said—amphibole occurs both in the younger granites and in the Julianehaab granites. It also occurs in the ketilidic series, which are older than the Julianehaab granites. According to the degree of alteration they belong to one or to the other series, but there is no sharp dividing line between these series. This, however, is often the case in the basement rocks.

5. The heavy minerals of the KOH preparations.

The minerals that occur in the KOH preparations, but not in the heavy fraction of the HCl-HNO_3 preparations, are apatite and biotite.

This table of minerals does not tell us much new. There is little regularity in it. The quantity of mica is sometimes very large, sometimes

Table 5.
KOH preparations. (Both minerals per 100 grains).

Locality	Biotite	Apatite	Locality	Biotite	Apatite
1 b	..	1	21 b	2	..
2 b	2	..	22 b	..	..
3 b	..	..	23 b	6	..
4 b	..	..	24 b	1	..
5 b	5	..	25 b	2	..
6 b	37	1	26 b	..	..
7 b	32	1	27 b	..	..
8 b	27	2	28 b	2	..
9 b	10	2	29 b	..	..
10 b	4	1	30 b	..	..
11 b	28	3	31 b	8	1
12 b	1	2	32 b	32	..
13 b	1	2	33 b	9	..
14 b	5	..	34 b	2	2
15 b	5	..	35 b	6	..
16 b	6	1	36 b	9	2
17 b	1	1	37 b	1	1
18 b	1	1	38 b	..	2
19 b	1	..	39 b	7	3
20 b	3	3	40 b	32	17

it is entirely absent. These differences are not in accordance with the division into provinces as made by us, but they are irregular.

The high percentage of apatite in 40 b is evidently connected with the fact that it is a sample that is oozed out.

6. The light fraction.

The quantitative proportions of the light fraction cannot be so accurately determined as those of the heavy fraction (cp. CROMMELIN, Lit. 1, p. 8). For that reason the method of counting is analogous to that of CROMMELIN (i. e. 50 grains were counted and the sum was put at 10).

Table 6.

Locality	Quartz	Orthoclase	Microline	Plagioclase	Vol. % light fraction	Vol. % heavy fraction	Locality	Quartz	Orthoclase	Microline	Plagioclase	Vol. % light fraction	Vol. % heavy fraction
1 b.....	5	3	+	2	94	6	21 b.....	3	5	+	2	66	34
2 b.....	3	5	+	2	98	2	22 b.....	3	6	..	1	78	22
3 b.....	5	2	..	3	53	47	23 b.....	4	5	..	1	97	3
4 b.....	4	3	..	3	78	22	24 b.....	2	7	..	1	96	4
5 b.....	5	4	..	1	88	12	25 b.....	3	5	..	2	95	5
6 b.....	4	5	+	1	94	6	26 b.....	4	6	..	+	94	6
7 b.....	4	4	..	2	89	11	27 b.....	3	5	..	2	95	5
8 b.....	3	6	..	1	98	2	28 b.....	4	5	..	1	94	6
9 b.....	3	5	..	2	90	10	29 b.....	4	4	..	2	69	31
10 b.....	5	5	..	+	87	13	30 b.....	4	3	+	3	48	52
11 b.....	2	6	..	2	98	2	31 b.....	3	5	..	2	95	5
12 b.....	4	4	..	2	74	26	32 b.....	3	6	..	1	94	6
13 b.....	2	1	..	7	61	39	33 b.....	5	5	..	+	97	3
14 b.....	4	4	..	2	90	10	34 b.....	3	5	..	2	96	4
15 b.....	4	5	..	1	92	8	35 b.....	4	5	..	1	94	6
16 b.....	3	5	..	2	88	12	36 b.....	3	6	..	1	95	5
17 b.....	4	4	..	2	96	4	37 b.....	3	6	+	1	92	8
18 b.....	4	5	..	1	96	4	38 b.....	3	6	+	+	93	7
19 b.....	3	4	..	3	85	15	39 b.....	6	3	..	1	95	5
20 b.....	3	6	..	1	98	2	40 b.....	2[1])	3	..	+	not determined.	

[1]) With 4 biotite.

The last two columns represent the percentages of volume for the light and the heavy fraction. The biotite is here disregarded, because it is always (except in 40 b) below 1 (which in the table should have been marked by +).

The light fraction of 40 b on the other hand contains 42 percentages of weight of biotite. Moreover, the proportion of heavy to light fraction cannot be determined of this sample, because many micas remain floating in the bromoform.

From this table it appears that the sands are in general very "acid" (much quartz and orthoclase, while plagioclase is nearly always acid). Naturally this is because the sands come especially from acid rocks. Further, they are considerably "lighter" than those of CROMMELIN. The division into provinces cannot be seen from this table.

7. Description of rock-fragments from the sand.

In several sand samples also small rocks occur which we shall comprise in our examination. Several fragments, however, were so small that it was impossible to make slides of them. These fragments were ground and the grit was examined under the microscope. Thus the following mineral combinations were spotted in one fragment:

From	3 b	hornblende + a good deal of acid plagioclase
—	4 b	hypersthene + orthoclase + quartz; biotite + amphibole + oligoclase + apatite
—	7 b	biotite + zircon + opaque + quartz + orthoclase; garnet + biotite + quartz + orthoclase
—	8 b	green glimmer + zircon etc.
—	10 b	hypersthene + orthoclase + biotite + quartz + oligoclase
—	11 b	biotite + quartz + orthoclase
—	12 b	quartz + felspars + green glimmer
—	14 b	opaque (+ amphibole) + orthoclase
—	16 b	much epidote + orthoclase + quartz + acid plagioclase
—	18 b	quartz + biotite + acid plagioclase
—	23 b	opaque + hypersthene + biotite + quartz + orthoclase
—	24 b	hypersthene + biotite + quartz + acid plagioclase + orthoclase
—	29 b	garnet + biotite + orthoclase + quartz
—	32 b	hypersthene + biotite + opaque + orthoclase + quartz + brown-green hornblende + zircon.

The fragments 4 b, 10 b, 23 b, 24 b and 32 b are fragments of hypersthene-granulite, 7 b and 29 b garnet-granulite. Hypersthene and biotite are regularly occurring parageneses in these granulites, also garnet and biotite. From 32 b it appears that amphibole may occur also in the hypersthene-granulites, so that it would not be right to ascribe any occurrence of amphibole to Julianehaab granites or young granites. As has already been remarked, CROMMELIN's sample No. 37 from Frederiksdal also contains a fragment of hypersthene-granulite.

Of the larger pieces slides were made of which I give the description here, although they yield few new aspects as long as there is not yet a complete petrography of the solid rocks of South Greenland.

1 b. Biotite-granite with much orthoclase (often perthitic and coarse-cristalline). Plagioclase does not occur.

2 b. The rock fragment consists of quartz, plagioclase, masses of sericite, biotite (strongly altered in chlorite) and epidote-minerals, which are often bright-yellow or colourless.

3 b. Diopside-biotite-diorite. Hypidiomorphic granular rock, consisting of diopside of low bi-refringence, biotite, intermediary plagioclase and some quartz and opaque grains.

4 b. Fields of quartz vary with biotite and acid plagioclase. Garnet occurs much, ore less. Several veins and fields are filled with sericite.

7 b. Hypersthene-garnet-granulite. We have here to do with a rock of granitic texture. The quantity of quartz is considerable; the second material occurring in fairly large quantity is orthoclase which is partly perthitic. Plagioclase occurs occasionally, fairly basic; along the border of such a plagioclase lies a rim of myrmekite. The rock is fairly rich in garnet which occurs as not very large cristals and is strongly cleft. Hypersthene also occurs; it forms fairly large cristals and shows a beautiful pleochroism (from grey-green to red-brown). Biotite is very common (pleochroitic from dark to light brown); there are many alterations to chlorite. Chlorite also occurs between the spaces of the other cristals and is dark-green.

This is an example of the Hypersthene-Garnet granulite which is regional in the entire south point of Greenland, as Dr. Wegmann discovered.

8 b. Biotite-granite with much quartz, much microcline and orthoclase and little plagioclase. The biotite is pleochroitic from red-brown to light-brown.

15 b. Chief minerals are: plagioclase, orthoclase and quartz (a little more rare). The plagioclase (basic oligoclase) forms roundish inclusions in orthoclase. These minerals are fairly fresh. Further two biotite-cristals occur which along their borders are altered into chlorite.

16 b. Granite-pegmatite. Chief minerals are orthoclase, oligoclase, and quartz. Orthoclase is most common and forms large cristals (5 mm). Oligoclase and quartz form xenomorphic inclusions in

the orthoclase. The plagioclase is particularly rich in epidote minerals of stem-like habitus and in other places specks of chlorite-scales occur.

29 b. Biotite-granite. The slide consists chiefly of quartz and orthoclase with microcline. The quantity of plagioclase (acid) is small. Occasionally there appear myrmekites along the borders of an orthoclase-cristal. The orthoclase is often perthitic. Biotite occurs only once.

38 b. Metamorphic rock, consisting of amphibole (pleochroitic from blue-green to green-brown), chlorite, plagioclase dotted with epidote, and zoisite. The epidote forms strings. Dark ore is often bound to titanite. The titanite is fine-grained. So the amphibole of the sand like the epidote and the titanite, will probably come from these and similar rocks.

8. The localities Imarsivik and Godthaab.

Two samples were collected by members of the brigade of air-photogrammetry. One came from Godthaab (West-Greenland) and one from Imarsivik (East-Greenland).

Table 7.

Locality	Heavy fraction in mutual percentages													Vol. % heavy fraction	Vol. % light fraction	Light fraction			
	Opaque	Zircon	Gr. Hornblende	Br. Hornblende	Augite	Ti-Augite	Hypersthene	Garnet	Epidote	Saussurite	Piedmontite	Biotite	Apatite			Quartz	Orthoclase	Microcline	Plagioclase
Godthaab..	1	1	58	2	2	..	3[1])	1	26	4	1	..	1	6	94	8	2	..	..
Imarsivik..	2	..	28	5	15	..	22	2	8	15	..	3	..	15	85	6	3	..	1

[1]) With 1 enstatite.

When we add to this that the plagioclase is acid, it appears from the light fraction that both sands derive from acid rocks (much quartz and orthoclase). The hypersthene from Imarsivik appeared to be bound to one rock with green augite and green hornblende. This appeared from the examination of one cobble from this locality.

This small cobble was of very dark appearance and as regards light minerals it contained only one piece of acid plagioclase.

The geology of the neighbourhood of both localities is not yet known and therefore these results are rather important. According to WEGMANN both samples are fairly strongly mixed.

9. Observations on minerals.

Pyroxenes: As appears from the above, hypersthene is the most generally occurring pyroxene. The average R. I. of the localities 12 b, 13 b, 19 b and 20 b is 1.69. Schiller-structure is very common, the characteristic pleochroism is mostly present (orange-yellow to blue-green, brown-yellow to blue-green), but it is most beautiful near Imarsivik (from wine-red to dark-green); sometimes they are almost colourless (in 10 b).

Of the ordinary diopsides the larger pieces are mostly beautifully green (35 b), sometimes even malakolite-like. In 3 b there is a practically colourless augite with a slight angle of extinction and low bi-refringence.

Many Ti-augites have a perfect extinction between crossed nicols, as CROMMELIN also found; there are, however, also more "classical" Ti-augites (2 b).

Amphiboles: The division into brown and green amphibole is subjective; they are mostly brown-green (sometimes pleochroitic from dark blue-green to light brown-green, e.g. in 1 b and 2 b), in larger individuals only the borders are transparent.

Garnet: As it appeared to be of importance for later examination of the sediments of the Davis Strait to find out whether possibly different varieties of garnet occur, the R. I. of all samples was determined (also when the percentage of garnet was smaller than 1 %); this R. I. was constant, viz. over 1.76. To determine with accuracy the spec. weight of small garnet-grains with such a heavy spec. weight, is not so easy. It is, however, probable that we have here to do with an almandite (Lit. 2, p. 234). In 17 b I found an orange garnet, but nearly all garnets are faintly pink or colourless.

Biotite. The biotite is mostly beautifully red-brown and then belongs to the heavy fraction. The biotites of 40 b, however, are nearly always brown-green, and even green, in consequence of the bleaching influence of the hot spring-water. This biotite has apparently got a smaller spec. weight, for it does not sink entirely in the bromoform, on the contrary it remains largely floating.

Felspars: The orthoclase is often perthitic. The plagioclases are almost always oligoclase; only rarely they are more basic.

Quartz: The greater part of the quartzes is colourless. Especially those of 1 b—3 b are as clear as glass. In many other samples also milky and bluish quartzes occur (only visible in strong light). I found these especially in the samples 22 b—27 b, but also in the other samples belonging to the Garnet-Hypersthene province. In natural light, however, the differences in tints of these and "normal" quartzes are very subtile.

Only in larger grains these differences are slightly better visible. They become hardly more distinct under a mercury vapour-lamp. By means of this instrument I found that the samples 19 b and 21 b—27 b showed the most distinct milk-quartzes, while the quartzes of the samples 1 b—3 b were practically the clearest. I may, however, point out that also in the samples that are rich in milk-quartzes the "normal" clear quartzes occur.

Zircon: The fairly rare zircon mostly occurs as long-drawn little columns rich in inclusions. The colour is usually pink (pleochroitic from pink to brown).

Sillimanite: The sillimanite belongs to the fibrous variety; it is fairly rare.

Epidote: It is sometimes pleochroitic from canary-yellow to colourless (e. g. in 10 b). All transitions to saussurite occur. I found piedmontite only once (locality Godthaab).

Kyanite: The kyanite mentioned in these tables is very problematic. Only once I have been able to show kyanite with any certainty, viz. in 17 b. Its R. I. was slightly less than 1.72, its extinction angle normal (30°).

Ores: The only sample rich in ore is 30 b. The greater part of the opaque grains is attracted by the horseshoe magnet. Polished sand gives, as regards the ore grains, a dull silvery reflection. From these data it appears that we have to do with magnetite.

In order to examine the presence of tin-stone the entire heavy fraction was put in a zinc-tray filled with hydrochloric acid. As none of the grains had a white precipitation it is not probable that tin-stone occurs in any of the samples.

10. Conclusions and summary.

According to EDELMAN a sedimentary petrological province is a complex of sediments, forming a natural unity according to distribution, age and origin, in other words a sedimentary petrological province is a certain association of minerals in space and time. CROMMELIN found in the area described by him that all samples were types in themselves and that there was no question of a regional connection. This is a result of the fact that the sands lie all of them still very close to their origin; they are to a high degree a reflection of the geology of the surrounding solid rocks. So when the petrographic composition of the solid rocks varies strongly from place to place, the composition of the sand will also strongly vary from place to place, so that in that case we cannot speak of a sedimentary petrological province, because it is then also impossible to speak of a certain association of minerals in space and time.

My sands, too, lie close to the solid rock from which they have arisen; the sand grains are in general still very angular. If we should speak in the above of sedimentary petrological provinces, this is because the original rock must have a fairly constant composition over a fairly large extension (in the South-East garnet and hypersthene as chief minerals, in the North-West amphiboles). That is also the reason why nothing was to be seen of a strong mixture — mentioned by WEGMANN — of the localities 21 b, 22 b, 23 b, 24 b, 25 b and 26 b: if the neighbourhood over a large extension consists of Garnet-Hypersthene-formations, nothing will be noticed of a mixture, even if it exists. If such an area of mixture lies on the border between two different types of solid rocks, various things will of course be noticeable of the mixture. With regard to this we may specially point out the mixed group I, with the text belonging to it.

As regards the origin of the chief minerals we may add the following: the amphibole comes from the Julianehaab granites and the ketilidic migmatites as well as from the younger granites. Perhaps some amphibole may here and there come from the Garnet-Hypersthene series.

That the rocks round Kap Farvel are rich in garnet was already well-known; they are, however, also rich in hypersthene (cp. section 2: Geology of the solid rock).

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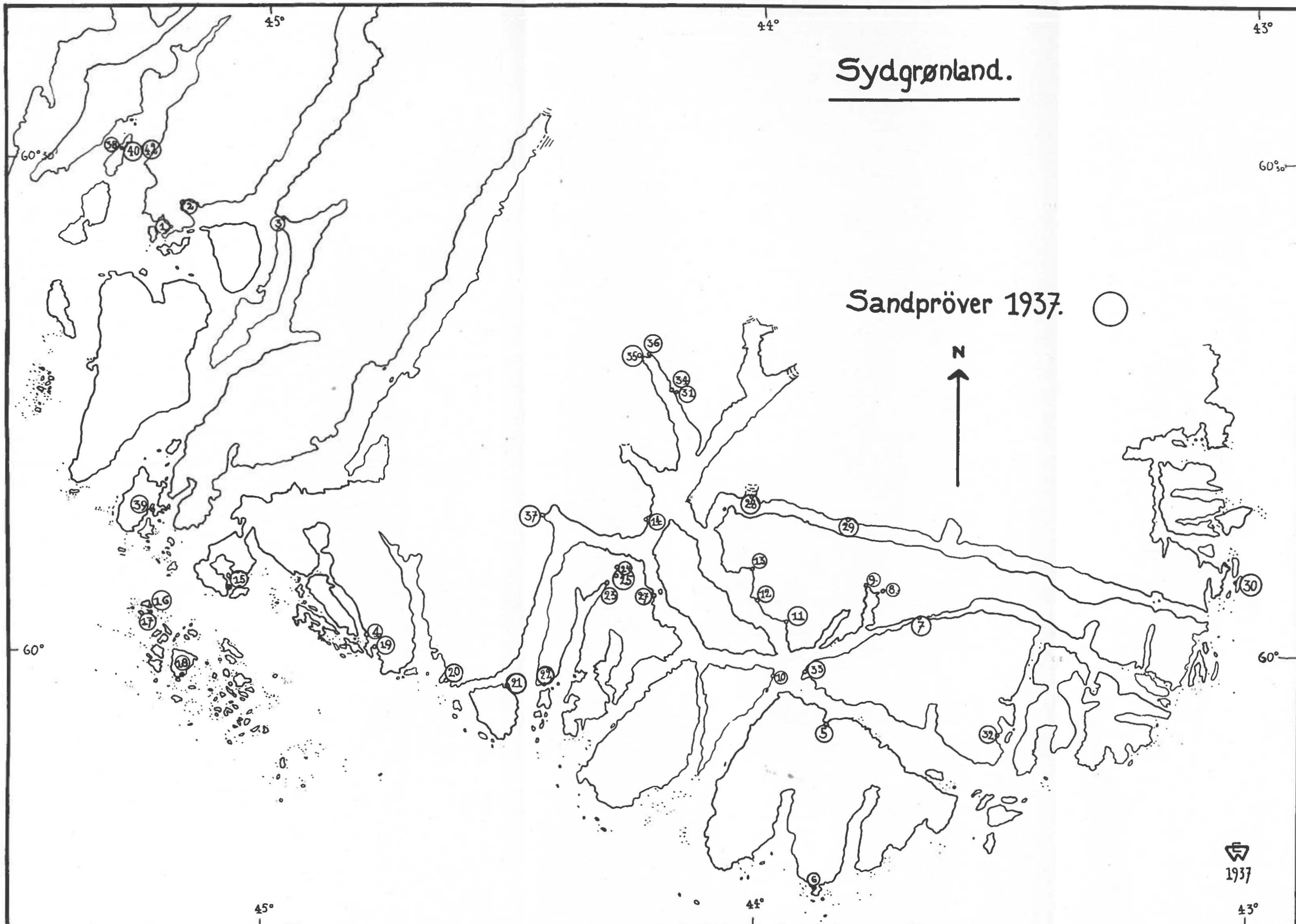
Sydgrønland.
Sandpröver 1937.
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