GRØNLANDS GEOLOGISKE UNDERSØGELSE
RAPPORT NR. 40

The Geological Survey of Greenland
Report no. 40

The composition of sands from the Fiskenæsset region, South-West Greenland, and its bearing on the bedrock geology of the area

by

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KØBENHAVN 1971

Grønlands Geologiske Undersøgelse

(The Geological Survey of Greenland)
Østervoldgade 10, DK-1350 Copenhagen K

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THE COMPOSITION OF SANDS FROM THE FISKENÆSSET REGION, SOUTH-WEST GREENLAND, AND ITS BEARING ON THE BEDROCK GEOLOGY OF THE AREA

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Abstract

A study of sand samples has shown that most of the material of the sands has only undergone short transportation and that their composition gives a good impression of the composition of the rocks in the area. Therefore, the study of sands may be used for prospecting and for regional geochemical studies in this part of Greenland.

Eighty-six sand samples were studied. Most of the sands were taken from river beds and minor streams and contain 45–60 vol. % of plagioclase, 20–35 vol. % of quartz, 5–20 vol. % of dark minerals and less than 15 vol. % of potash feldspar.

Hypersthene occurs especially in the northern part of the area, and the amount gradually decreases towards the south. The bulk composition of the rocks seems to be much the same throughout the whole area.

INTRODUCTION

In the summer of 1970, the Geological Survey of Greenland (Grønlands Geologiske Undersøgelse, GGU) started systematic mapping in the Fiskenæsset area, on the southern part of Greenland's west coast (Kalsbeek, 1971). The area being mapped lies, roughly, between 62°45′ and 63°30′N, and 49°30′ and 51°W; it is some 3500 km^2 in size, and consists mainly of gneisses with bands and lenses of amphibolite, and contains persistent layers, locally up to 2 km wide, of meta-anorthosite and meta-gabbro-anorthosite, which mainly consist of a very calcic plagioclase (often An 70–90) and hardly contain quartz (Ghisler & Windley, 1967; Windley, Herd & Bowden, in press). Lenses of these anorthositic rocks also occur locally in the gneisses. The rocks belong to the Archaean basement of SW Greenland (Pulvertaft, 1968). In the northern part of the area the rocks belong to the hornblende-granulite facies, and in the southern part, supposedly due to retrograde metamorphism, to the amphibolite facies (Windley, 1969). In the southern part of the area, a belt of lower grade, clearly supracrustal, rocks occurs within the gneisses.

The area has been intensely glaciated and erratic boulders are found everywhere. Sand and gravel terraces occur commonly along the valley sides and it is generally not clear whether this material is glacial in origin or not. Till has not been found. In the river beds sand and gravel banks are common, and many rivers form deltas in the numerous lakes.

The writer has collected and studied a number of sand samples from the beds of rivers and the shores of some lakes

1) to see whether fluvial sands can be used to get an impression of the bedrock geology in this part of Greenland or whether glacially transported material makes this impossible.
2) to get, through the presence or absence of hypersthene in the sands, an impression of the distribution of granulite facies rocks in the area.
3) to get an impression of the overall composition of the rocks throughout the area, and to see whether the retrograde metamorphism, which is supposed to have taken place in the southern part of the area, also caused changes in the bulk composition of the rocks.

Samples were collected at 47 localities (indicated on fig. 2). At 33 localities 2 samples were taken, several tens to a few hundreds of metres apart. At 11 localities 1 sample was taken and at 3 localities three. One of the 3 samples taken at locality 2 (see fig. 2) was a black sand, containing more than 60% of mafic mi-

nerals. With this exception it was tried to choose representative samples of the sand at each locality. One of the samples collected at localities 34, 38 and 41 as well as the samples from localities 10, 11 and 18, were taken from terraces. In total 86 samples were collected.

The samples were studied in the following manner: Splits of approx. 15 grammes of the sands were boiled with concentrated HCl, washed to remove the finest materiel, dried, and then cemented with 'Araldite'. Thin sections of the resulting 'sandstones' were prepared.

1) With the help of a 'Swift' point counter, the volumetric percentages of quartz, plagioclase, potash feldspar and total mafic minerals were determined. The very calcic plagioclase of the anorthositic and gabbro-anorthositic rocks could easily be recognized in the thin sections because of the high relief, and the percentage of this calcic plagioclase was determined separately.

In general 1000–1800 points were counted, in one thin section per sample, of which roughly half fell on araldite. To ensure the correct identification of the feldspars, staining techniques were used.

2) The thin sections were searched for hypersthene, antiperthite and epidote. In a very subjective way it was noted whether these minerals were present in larger or smaller amounts or whether they were absent.

3) The An contents of a number of plagioclase grains, in as many thin sections as possible, were determined by measuring X': (010) in sections perpendicular to *a*. No further determinations were made on the very calcic plagioclase from the anorthositic rocks.

This report is of a preliminary nature. A full report, containing the primary data on which this account is based, will be published when more data, e.g. on the chemical composition of the sands, on the grain sizes and on the composition of the heavy fraction, have been collected.

RESULTS OF THE INVESTIGATION

Most of the sands investigated are medium to coarse grained and consist of poorly rounded grains. Grains larger than 1½–2 mm generally consist of rock fragments. Most of the sands contain 45–60 vol. % of plagioclase, 20–35 vol. % of quartz, 5–20 vol. % dark minerals and less than 15 vol. % of potash feldspar. Sands of such a composition have rarely been described, but their occurrence in this part of Greenland is to be expected because of the nature of the bedrock, and the rapid erosion, the arctic climate and the very sparse vegetation which hinder chemical weathering.

Fig. 1 shows histograms of the amounts of the main minerals. Plotting on normal probability paper shows that the minerals are essentially normally distributed. Four samples (from localities 8 and 42) of sands very rich in An-rich (anorthosite) plagioclase have been specially indicated as well as the sample of black sand. Table 1 A gives the average composition of all samples, with the exception of these five, and the standard deviations of the amounts of quartz, plagioclase, potash feldspar and total dark minerals. Table 1 B gives the average values of the differences in the contents of quartz etc. in samples taken at one locality. These differences include both real sample differences and analytical errors. The table shows that the relative spread is largest for the total dark minerals ($\triangle$ 4.3; s = 5.56 with mean 11.8).

Table 1. Composition in vol. % of sand samples from the Fiskenæsset area (A, C, D, E) compared with gneisses from the Qasigialik area (F).

	A Sands All samples (81)	B $\triangle$ (40)	C Sands Group I (29)	D Sands Group II (35)	E Sands Group III (17)	F Gneisses Qasigialik (47)
Quartz	28.7 (4.75)	3.4	26.1 (3.98)	28.9 (4.13)	32.7 (4.50)	27.5 (4.91)
Plagioclase	52.3 (5.57)	4.3	54.1 (5.78)	50.7 (5.98)	52.4 (3.09)	53.9 (8.08)
K-feldspar	7.2$_5$ (3.55)	1.7	6.3 (3.80)	8.7 (3.29)	9.9$_5$ (2.58)	5.9 (8.31)
Mafic min.	11.8 (5.56)	4.3	13.6 (5.05)	11.7 (5.91)	8.9$_5$ (4.61)	

For further explanation see the text. The standard deviations of the percentages are given between parentheses.

Table 1 F gives the average amounts of quartz, plagioclase and potash feldspar in biotite gneisses from the Qasigialik area, some 150 km towards the south

(Kalsbeek, 1970) and it can be seen that the composition of the sands in the Fiskenæsset area compares well with the bedrock gneisses in the Qasigialik area. Since the bedrock geology of the Qasigialik area and the Fiskenæsset area are much the same, this agreement is of interest. It must, however, be emphasized that the Qasigialik area also contains hornblende-rich gneisses and amphibolites which are not included in the average of table 1 F, and that the gneisses have biotite as the predominant mafic mineral, whereas biotite is rare in the Fiskenæsset sands. The comparison between the sands of the Fiskenæsset area and the

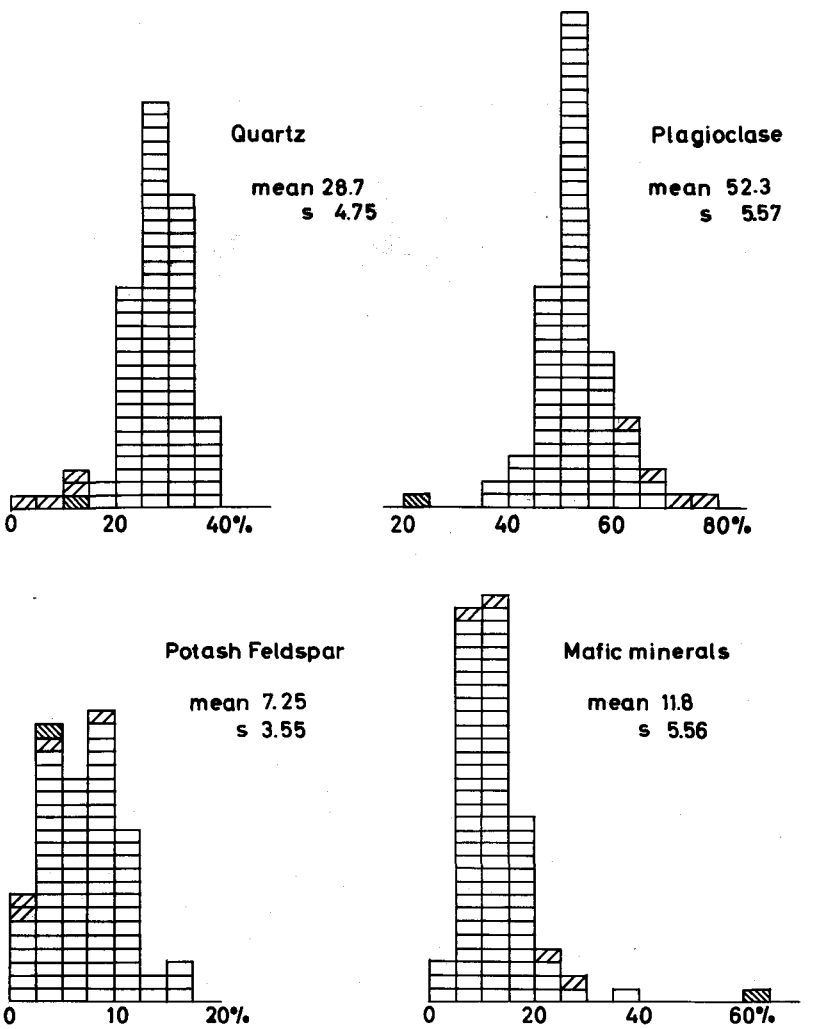

Fig. 1. Histograms of the volume percentages of quartz, plagioclase, potash feldspar and total mafic minerals in 86 sand samples from the Fiskenæsset area. Each sample is represented by one brick. The single sample of black sand and 4 samples rich in very calcic plagioclase from the anorthositic rocks have been indicated by crosshatching.

gneisses of the Qasigialik area is therefore not completely correct and a comparison between the dark minerals would even be misleading.

Among the dark minerals in the sands hornblende predominates. Biotite, though a common mineral in the gneisses, is rather rare in the sands. Ortho- and clino-

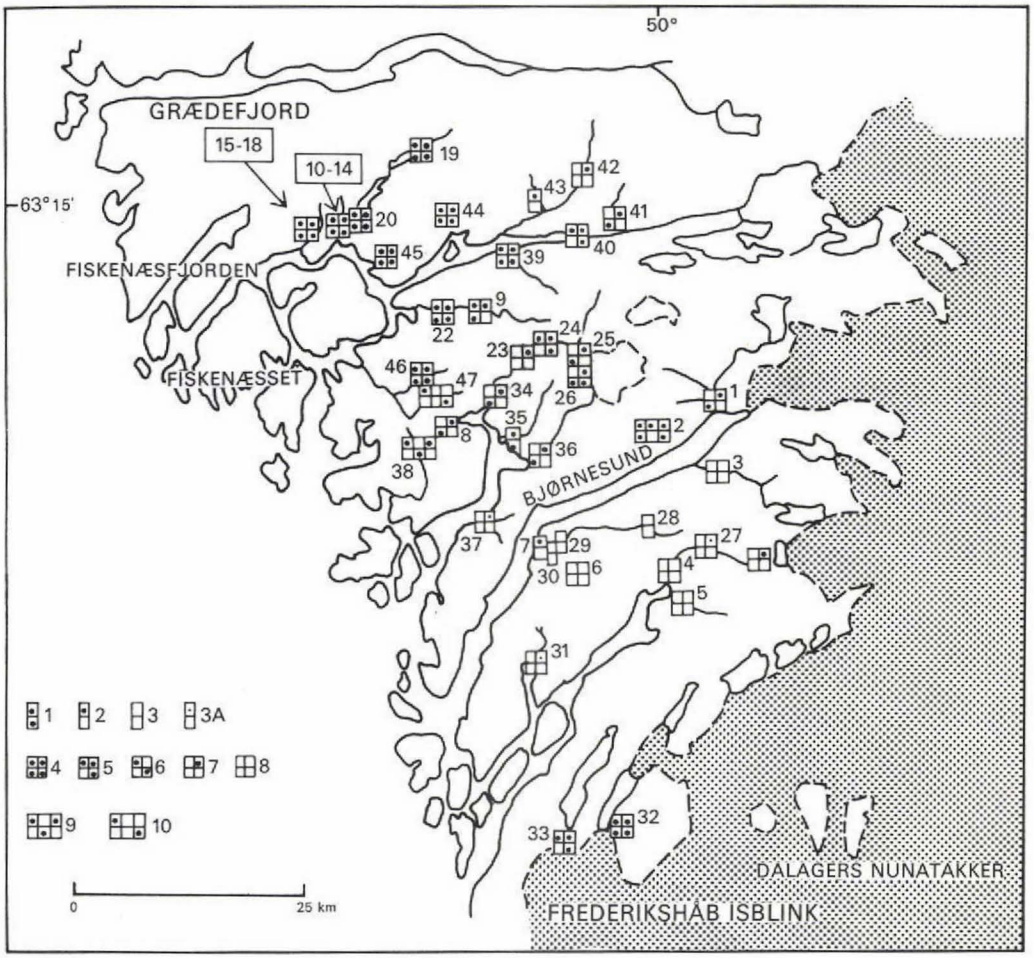

Fig. 2. Distribution of hypersthene in sands from the Fiskenæsset area. The numbers 1 – 47 indicate the localities where sand samples were collected.

The hypersthene content in thin sections of each sample is visually estimated as: many, few or without hypersthene grains. This division is subjective but is supposed to be reproducible; see text p. 8. 1–3: samples with many, few and without hypersthene grains. 3 A: samples with only one or two small hypersthene grains. 4–8: where two samples were taken from the same locality the estimated hypersthene contents of both are shown (e.g. 5: one of the samples contains many, the other only few hypersthene grains). 9, 10: localities where three sand samples were taken, and their hypersthene contents. Samples belonging to classes 1 and 4 were combined in group I, samples of classes 3, 3A and 8 in group III, all other samples in group II.

pyroxene, epidote, garnet, olivine and opaque minerals occur in variable amounts in most samples.

Through a subjective estimate of hypersthene contents it is possible to subdivide the sand samples into three groups: I. hypersthene-bearing sands (several tens, perhaps up to a hundred hypersthene grains per slide), II. hypersthene-poor sands (a few hypersthene grains, sometimes perhaps up to 20 grains per slide), and III. sands (almost) without hypersthene (no hypersthene found or only one or two small grains per slide).

Fig. 2 shows the distribution of hypersthene in the area. It shows that hypersthene occurs in fairly large amounts in the northern part of the area and that the amount gradually decreases southwards. It has been found that epidote occurs especially in the sands without or with small amounts of hypersthene. Antiperthite occurs only in very small amounts and is preferentially found in the hypersthene-bearing sands.

Table 1 C, D and E gives the average amounts of quartz, plagioclase, potash feldspar and dark minerals in the samples belonging to the three groups of sands. Small differences in average composition between the groups occur, and, very roughly, those differences that are larger than approx. 2% can be shown to be statistically significant.

Fig. 3 shows the distribution of the very calcic (anorthosite) plagioclase. Its occurrence is clearly related to the occurrence of mapped meta-anorthosite layers.

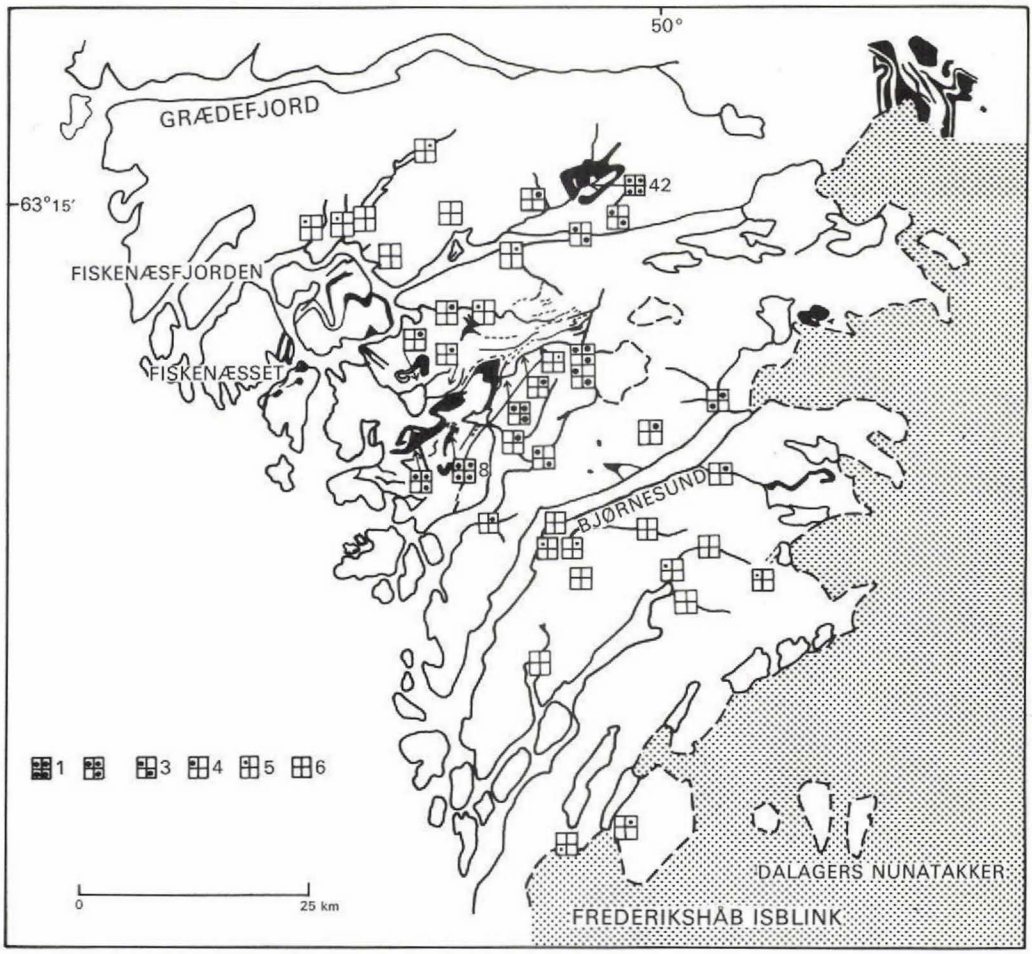

Fig. 3. Distribution of very calcic (anorthosite) plagioclase in sands from the Fiskenæsset area. The occurrence of mapped anorthositic rocks is shown in black; in the western part of the area mainly after mapping of GGU, in the eastern part of the area mainly after mapping of the geologists of A/S Platinomino. Large parts of the area have not yet been surveyed in detail.

1 : > 25 vol. % of An-rich plagioclase
2 : 5–25 % » »
3 : 2–5 % » »
4 : 0.5–2 % » »
5 : 0–0.5 % » »
6 : no An-rich plagioclase found.

Fig. 4 shows a histogram of 197 measured An contents of plagioclase grains, the An content of the very calcic anorthosite plagioclase not being included. Most values spread between An_{10} and An_{50}. Plagioclase with An > 50 is rare and is probably derived, at least partly, from basic dykes occurring in the area. This plagioclase often shows Carlsbad twins. Plagioclase with An < 10 is probably of secondary origin. A comparison between the An contents of plagioclase grains in the hypersthene-bearing sands, the hypersthene-poor sands and the sands (almost) without hypersthene shows that there are small differences (table 2). Only the difference between the first and the third group is significant at the 95% level.

Table 2. Anorthite content of plagioclase grains in sands from the Fiskenæsset area.

	mean An	s	number of measurements
Group I	28.5_8	5.09	60
Group II	27.3	6.45	82
Group III	26.4_7	4.13	45

For further explanation see the text.

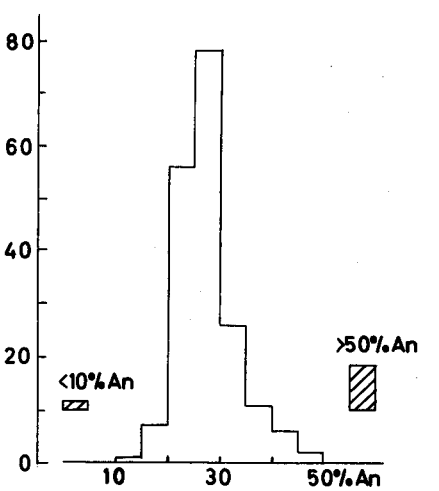

Fig. 4. Histogram of the An contents of 197 plagioclase grains from the Fiskenæsset sands. The composition of the very calcic plagioclase from the anorthositic rocks is not shown in the diagram.

CONCLUSIONS

1) Most of the sands seem to be mainly of local origin. This is shown by the distribution of the An-rich plagioclase which is clearly related to the occurrence of mapped meta-anorthosites (fig. 3). Four samples (from localities 8 and 42) consist of ca. 50 % of An-rich plagioclase and the quartz contents are only about 10% compared with an average of 29% over the whole area. This indicates that more than 60% of the material of these samples must have been derived from the nearby anorthositic rocks. Two of these samples (loc. 8) were taken from a small local stream but the two others (loc. 42) from a fairly large torrent. The regular distribution of the hypersthene also favours a local origin of the sands.

Sands from a few terraces (localities 10, 11, 18, 34, 38, 41) have been investigated and prove to have practically the same composition as the sands in nearby river beds, and these also have probably not been transported for long distances.

Sands from localities 32 and 33, collected directly in front of Frederikshåbs Isblink, probably contain material transported over long distances. These samples contain fair amounts of hypersthene as well as some anorthosite plagioclase which do not seem to come from nearby. Also the samples collected at locality 40, where there is a direct connection with the inland ice and the water is very turbid, may contain foreign material.

2) Apart from the scarcity of biotite, the average composition of the sands (table 1) probably gives a reasonable estimate of the average composition (disregarding the meta-anorthosites) of the rocks in the area. This is illustrated by the good agreement between the composition of the sands and the composition of the gneisses in a comparable area in the old gneiss block of SW Greenland (table 1 F). Both areas are largely quartz-dioritic to granodioritic in composition.

These two conclusions are of practical importance since they show that sands, collected properly, may be used for prospecting purposes and to give geochemical information on the rocks in the area where the sands have been collected.

Assuming the correctness of these two conclusions, the investigation of the sands further shows that:

3) The hypersthene content of the rocks gradually decreases from north to south (fig. 2). North of Fiskenæsfjorden most sands contain fairly large amounts of hypersthene, but these amounts decrease towards the east. Between Fiskenæsfjorden and Bjørnesund generally less hypersthene is present, but locally larger amounts have been found. South of Bjørnesund hypersthene is rare. Sand samples taken at the front of Frederikshåbs Isblink, however, contain fair amounts of hypersthene.

It is not known where this hypersthene comes from; it may well come from a great distance.

4) The overall composition of the sands with different hypersthene contents is roughly the same (table 1 C, D, E), but minor differences occur. Several of these differences are statistically significant and they probably show that the area is mineralogically not quite homogeneous. The possibility of a large potash metasomatism during the retrograde metamorphism that is supposed to have taken place in the southern part of the area, seems to be ruled out by the results of this investigation.

5) The measured An contents of plagioclases in the hypersthene-bearing sands are, on an average, approx. 2 % higher than the An contents of the plagioclase in the sands without hypersthene. The difference is significant at a 95 % level and may be due to the fact that conversion of hypersthene into hornblende requires CaO.

Acknowledgement

The writer is indebted to Mr. M. Ghisler of A/S Platinomino for information on the occurrence of anorthositic rocks in the Fiskenæsset area, shown on fig. 3.

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