U, Th AND K CONTENTS AND METAMORPHISM OF ARCHAEAN ROCKS FROM SOUTH-WEST GREENLAND

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Granulite facies rocks, from the Nordland area, West Greenland, contain six times less U than the amphibolite facies rocks of the Frederikshåb area, and half of the amount of K. The rocks of the Frederikshåb area did not form by retrogression of granulite facies rocks. This study is based on analyses of sand samples which adequately represent the inhomogeneous bed rock.

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Within the Archaean gneiss block of southern Greenland there are several areas of granulite facies rocks, the largest of which are up to 100 km across (Geological Survey of Greenland, 1970). The regional granulite facies metamorphism has been dated recently at 2850 ± 100 m.y. (Black et al. 1973), and this metamorphism makes dating of earlier events extremely difficult. Outside the areas of granulite facies rocks, dating of events earlier than 2850 m.y. may also meet with difficulties (R.T. Pidgeon, personal communication, 1972), and it is possible that either (1) the rocks here are retrograded from granulite facies, or (2) a thermal event at lower temperatures than granulite facies upset earlier isotopic equilibria.

Investigations by Heier (1973) and others have shown that (high pressure) granulite facies rocks have lower concentrations of U and Th than their lower metamorphic equivalents, and that retrograded granulite facies rocks retain their abnormal Th/U and U/K ratios. This phenomenon was used here to find which parts of the amphibolite facies rocks, which make up most of the Archaean block, formed by retrogression of granulite facies rocks, and which parts did not. It was hoped that this study might indicate the areas of the Archaean block most suitable for dating events earlier than 2850 m.y.

According to Heier (1973) the low U and Th concentrations in granulite facies rocks are due to U and Th depletion during the metamorphism. Although Heiers interpretation is still open to some discussion, it has been provisionally adopted in this paper. The conclusions reached in this study,

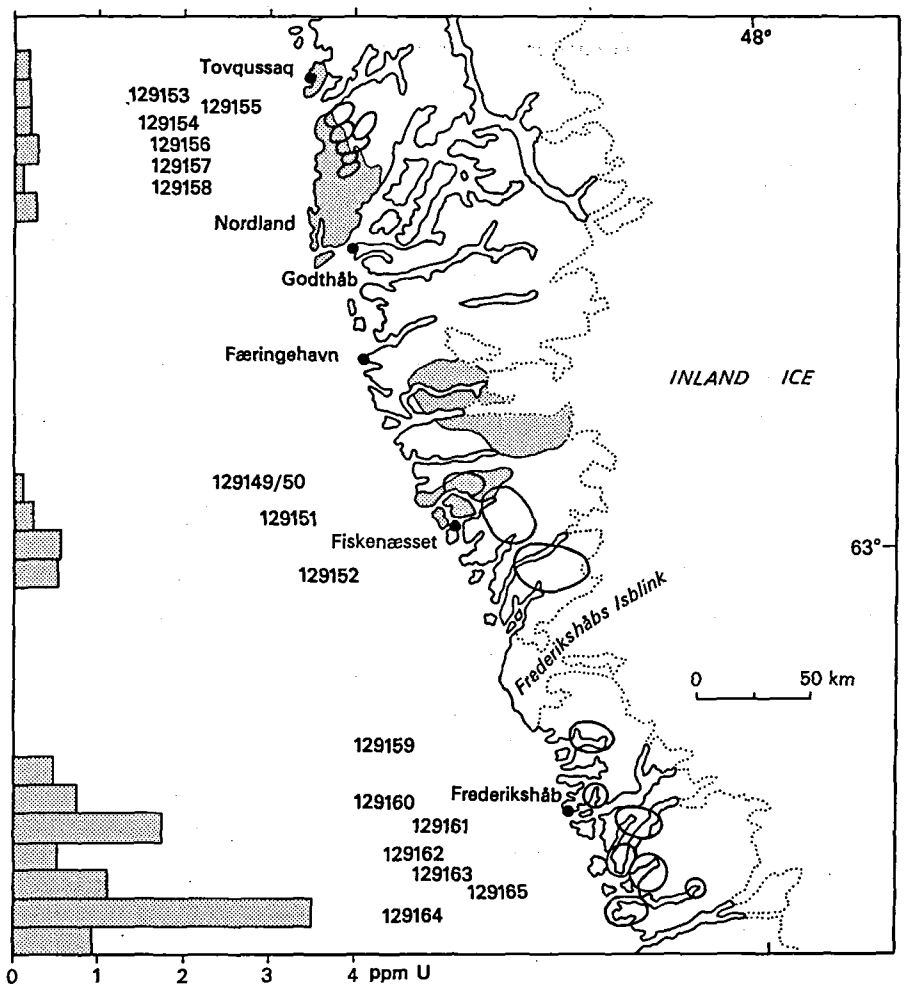

Fig. 1. Localities of the analyzed samples. The ellipses delimit the areas within which the sands for each composite sample were collected. Sands for samples 129149 and 129150 were collected within the same area. Granulite facies areas are shaded. The U contents of the samples are shown along the left hand margin of the figure.

however, are independent of the ultimate cause of the low U and Th concentrations.

The analyses for this study were carried out on composite sand samples. Chemical weathering plays only a minor role in Greenland, due to the cold climate and sparse vegetation, and it has been shown that chemical analyses of sand samples closely correspond with the chemical composition of the surrounding bed rock (Kalsbeek et al. in press). Differences between the

Table 1. U, Th and K contents of composite sand samples from the Archaean terrain of southern Greenland. The number of samples in each composite sample is given in brackets after the six figure reference number. Hy: the percentage of hypersthene in the heavy fraction of the sands. N.d.: not analyzed. All averages are weighted arithmetic means.

For the Fiskenæsset area U, Th and K contents of rock samples are shown for comparison. The rock samples were collected according to a grid in the same subareas as the corresponding sand samples. Standard deviations are given in brackets.

A: NORDLAND

	Hy	U(ppm)	Th(ppm)	K(%)	Th/U	Ux10⁴/K
129153 (10)	31	0.151	1.8	0.63	11.9	0.24
154 (12)	33	0.162	1.4	0.63	8.6	0.26
155 (9)	20	0.168	n.d.	0.89	–	0.19
156 (7)	24	0.197	»	0.67	–	0.29
157 (4)	43	0.122	»	0.53	–	0.23
158 (5)	19	0.231	»	1.05	–	0.22
average	28	0.17		0.72		

B: FISKENÆSSET

	Hy	U(ppm)	Th(ppm)	K(%)	Th/U	Ux10⁴/K
1: sands						
129149/50						
(23)	17	0.164	2.6	1.02	15.8	0.16
151 (10)	5	0.58	3.8	1.39	6.6	0.42
152 (24)	1	0.55	n.d.	1.38	–	0.40
average	8	0.40		1.24		
2: rocks						
A (13) cf. 149/50		0.24 (0.12)	–	1.51 (0.80)	10.3 (4.2)	0.20 (0.12)
B (21) cf. 151		0.37 (0.36)	–	1.32 (0.90)	11.1 (6.5)	0.37 (0.40)
C (20) cf. 152		0.40 (0.18)	4.6 (3.4)	1.69 (0.91)	12.0 (7.5)	0.28 (0.13)
average		0.35		1.50		

C: FREDERIKSHÅB

	Hy	U(ppm)	Th(ppm)	K(%)	Th/U	Ux10⁴/K
129159 (6)	n.d.	0.50	n.d.	1.15	–	0.43
160 (4)	»	0.72	»	1.66	–	0.43
161 (8)	»	1.76	»	1.34	–	1.31
162 (12)	»	0.53	»	0.87	–	0.61
163 (24)	»	1.11	4.0	1.69	3.6	0.66
164 (16)	»	0.91	2.8	1.15	3.1	0.79
165 (2)	»	3.49	n.d.	2.27	–	1.54
average		1.03		1.36		

two are mainly due to loss of much of the biotite from the gneisses in the sands. Also for U and K a good agreement between sand sample and rock sample analyses from the same area has been found (table 1B). For these reasons sand samples (with certain restrictions) are well suited for regional geochemical pilot studies, especially since the bed rock is very inhomogeneous, which makes it difficult to select representative rock samples and results in a large spread in chemical compositions of individual rock samples. Standard deviations for U, Th and K concentrations in rock samples are shown in table 1B.

Composite sand samples were studied from: (1) the Nordland area, which mainly consists of granulite facies rocks; (2) the Fiskenæsset area, in which both granulite and amphibolite facies rocks occur; and (3) the Frederikshåb area, in which no granulite facies rocks have been found (fig. 1). Assuming (as an approximation) that the analyses of the sands are representative of the bed rock in the areas, table 1 indicates that the granulite facies rocks of the Nordland area contain six times less U than the amphibolite facies rocks of the Frederikshåb area, and approximately half of the amount of K. The differences are significant at 95 % level.

The Th/U and U/K ratios for the Frederikshåb area are normal for crustal rocks, and it seems therefore reasonable to interpret the U, Th and K values as "original" concentrations. The Th/U and U/K ratios for the Nordland sands are clearly abnormal and indicate that there has probably been a depletion of U. It seems reasonable to correlate this depletion with the granulite facies metamorphism in the area. It is possible that the low K concentrations in the Nordland area are also due to depletion during the granulite facies metamorphism, since in other respects the bulk composition of the sands are not much different (table 2). These results indicate that most of the rocks in the Frederikshåb area did not take part in the granulite facies metamorphism (with the exception perhaps of the area nearest Frederikshåbs Isblink where the composite samples 129159 and 129160 still show relatively low U and U/K values).

In the Fiskenæsset area the metamorphic grade decreases from granulite facies in the north-west to (low) amphibolite facies in the south-east. A detailed study of the relationship between the metamorphic grade and the U, Th and K contents of rock samples in the Fiskenæsset region is in progress, and it shows that U depletion has taken place over the whole area. This is corroborated by the analyses of the sand samples. U concentrations are clearly lower than for the Frederikshåb samples but not as low as in the Nordland sands. Also the sands from the southern part of the area (composite sample 129152) have rather low U and U/K values. This may indicate that the whole area was once in granulite facies, but for most of the area no field or thin section evidence for this granulite facies event

Table 2. Average compositions of Nordland sands (A: 47 samples) and Frederikshåb sands (B: 72 samples). Note marked difference in K_2O contents.

	A	B
SiO_2	65.26	65.76
TiO_2	0.32	0.51
Al_2O_3	15.74	14.93
Fe_2O_3 (total)	4.03	4.71
MgO	2.51	2.01
MnO	0.08	0.09
CaO	5.31	4.34
Na_2O	4.41	4.08
K_2O	0.88	1.74
P_2O_5	0.14	0.14

has been found, and field evidence in the southern part of the area (Andersen & Friend, 1973; Kalsbeek & Myers, 1973) even tends to exclude the possibility that a granulite facies metamorphism has taken place. The possibility must therefore be considered that U depletion locally may have taken place at a lower metamorphic grade than granulite facies.

It may be concluded that, of the areas studied here, the southern part of the Frederikshåb district seems most suited for isotopic studies of possible rocks older than 2850 m.y. The other areas, however, may not a priori be excluded since isotope work in the Godthåb region (Black et al. 1971; Moorbath et al. 1972; Pankhurst et al. 1973) indicates that most of the rocks there did not take part in the 2850 m.y. granulite facies metamorphism but that severe U depletion has taken place in some of the rocks at a much earlier time.

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Dansk sammendrag

Granulit facies bjergarterne fra Nordlandet, Vest Grønland, har seks gange mindre U end amfibolit facies bjergarterne fra Frederikshåb distriktet, og halvt så meget K. Bjergarterne fra Frederikshåb distriktet er sandsynligvis ikke opstået ved retrograd omdannelse af granulit facies bjergarter. Undersøgelsen er baseret på analyser af sandprøver, som giver et godt indtryk af gennemsnitssammensætningen af de uhomogene faste bjergarter.

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