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N86-28551

REGIONAL VARIATION IN THE AMÎTSOQ GNEISSES RELATED TO CRUSTAL LEVELS DURING LATE ARCHEAN GRANULITE FACIES METAMORPHISM, SOUTHERN WEST GREENLAND.

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INTRODUCTION: Regional mapping by the Geological Survey of Greenland has shown that large areas of southern West Greenland preserve middle to late Archean granulite facies assemblages (Chronology, Table 1). From mineralogical and textural evidence further large areas were affected by granulite facies metamorphism but were subsequently retrogressed under amphibolite facies conditions prior to the intrusion of the c. 2550 Ma Qôrqut granite complex (McGregor et al., this volume). In Godthåbsfjord (Fig. 1) however, the rocks appear to have been only metamorphosed under amphibolite facies conditions in the mid and late Archean.

Table 1. Relevant events in the regional chronology.

8) Intrusion of post-tectonic Qôrqut granite complex, 2550 Ma

7) Deformation, retrogression of granulite facies rocks under amphibolite facies conditions (A on Fig. 1) and intrusion of granitoid sheets, 2700-2600 Ma

6) Granulite facies metamorphism ([G] on Fig. 1). In south, c. 2800 Ma, in north, c. 3000 Ma.

5) Intrusion of the Nûk gneisses. 2900-3050 Ma.

4) Deposition of Malene supracrustal rocks.

3) Intrusion of the Ameralik dykes.

2) Intrusion of the Amîtsoq gneisses (predominantly 3750-3700 Ma tonalites) accompanied and followed by deformation, metamorphism and granite sheet injection. 3750-3400 Ma.

1) Deposition of a supracrustal sequence, represented by the Akilia association and the Isua supracrustal belt. 3800 Ma.

Airborne radiometric surveying (Secher, 1977, & pers. comms.) shows there is considerable areal variation in γray (combined K-U-Th-Rb) radioactivity, which persists even after 'stripping' of anomalous concentrations associated with descrete potassic granitoids of various ages, such as the Qôrqut granite complex. This leads to a relatively simple regional pattern for radioactivity: Terranes that have never experienced granulite facies metamorphism are more radioactive than those that have (Fig. 1).

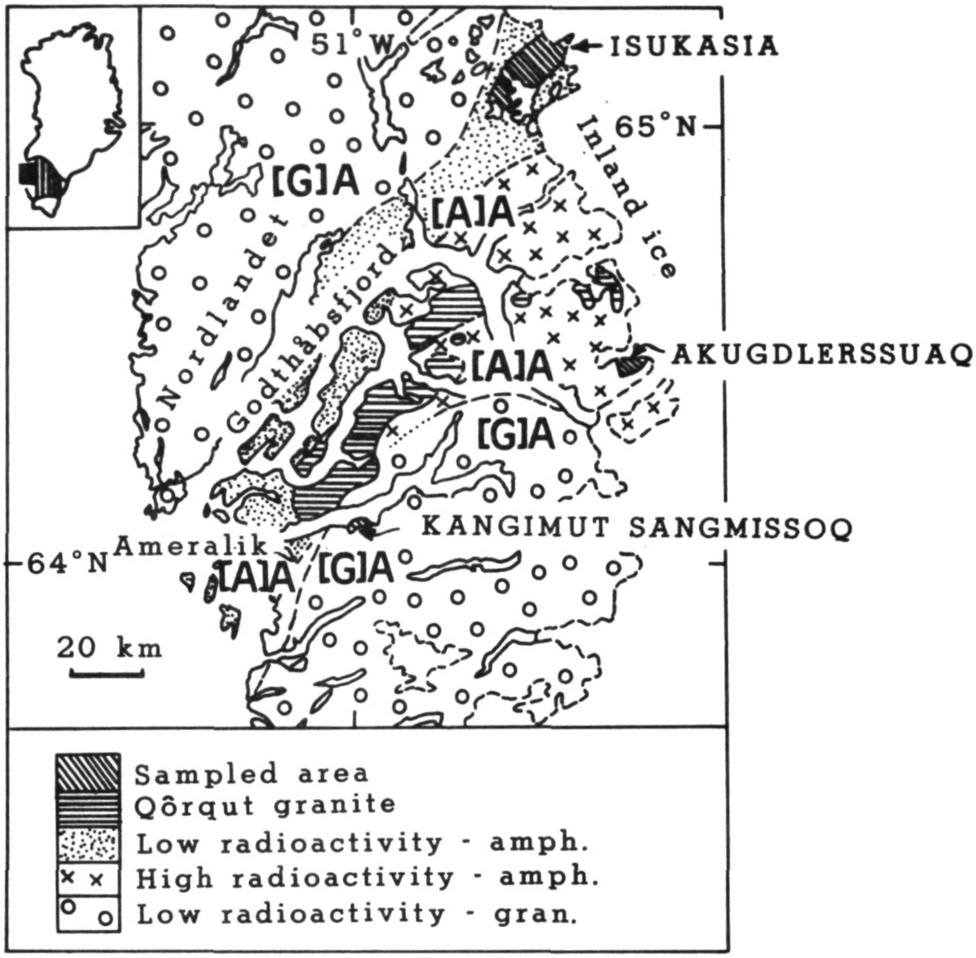

Figure 1. Radioactivity/metamorphic facies zones of study area. [G] - affected by 3000-2800 Ma granulite facies metamorphism [A] - affected by 3000-2800 Ma amphibolite facies metamorphism. A - amphibolite facies metamorphic conditions between 2800-2550 Ma.

The northwestern terrane (Nordlandet) underwent granulite facies metamorphism at c. 3000-2900 Ma, as opposed to at c. 2800 Ma for the granulite rocks in the southeast (e.g. Taylor et al., 1980) This paper compares the southern [G] and the [A] zones (Fig. 1) to see if variation in content of radioactive minerals can be related to the c. 2800 Ma granulite facies event. This is done by examining Amîtsoq grey gneisses, mostly derived from tonalites, from three localities: (1) Kangimut sangmissoq [G], low radioactivity, (2) Akugdlerssuaq [A], high radioactivity and (3) Isukasia [A], moderate to low radioactivity (Fig. 1).

FIELD RELATIONS: Late Archean ductile deformation accompanied retrogression of granulite facies rocks ([G] followed by A). Most obvious are 'straight zones' up to 1 km wide with a steeply dipping LS fabric with amphibolite facies assemblages, and more or less contemporaneous non-cylindrical southerly-plunging folds with wavelengths of up to 15 km. In areas of low deformation granulite facies rocks are patchily retrogressed, with amphibolite facies assemblages mimicking textures developed under granulite facies metamorphism. These textures are obliterated or strongly modified in the zones of strong deformation described above. Granitoid sheets intruded during formation of these structures are between 2700 and 2600 Ma old (McGregor et al., 1983), giving the time of retrogression. The boundaries between the regions of different metamorphic history (Fig. 1) are complicated on a 10 to 20 km scale due to the folding, and in some places the boundary between the southeastern granulite facies terrane and the amphibolite facies terranes of Godthåbsfjord could be a tectonic break. This could explain why well preserved, type Amîtsoq gneisses of outer Ameralik are found juxtaposed with granulite facies rocks slightly further into the fjord (Fig. 1). However, the zonal facies arrangement appears valid on the regional scale (200km).

It is likely that 2700-2600 Ma deformation juxtaposed regions that were at different crustal levels during the c. 2800 Ma granulite facies event, so that 2800 Ma granulte facies rocks outcropping in the south were probably overlain by amphibolite facies terranes equivalent to those found in Godthåbsfjord. Rb-Sr data on retrogressed granulites to the north of Godthåbsfjord (Garde et al., in press) shows that c. 3000 Ma gneisses there were 'reset' under amphibolite facies conditions at c. 2850 Ma. This suggests that during the c. 2800 Ma granulite facies event in the south, that c. 3000 Ma granulite facies terrane to the north was not at great depth, and formed a metastable granulite facies block in the middle-crustal level amphibolite facies terranes.

The character of the quartzofeldspathic components of the three areas sampled in this study is outlined below.

Kangimut sangmissoq: The dominant lithology here is buff-coloured, medium to coarse-grained, somewhat inhomogeneous to nebulitic tonalitic gneisses that contain remnants of plagioclase-phyric amphibolite dykes that lithologically and geochemically resemble poorly-preserved Ameralik dykes from the type area, 10 km to the west. The gneisses contain granulite facies assemblages but show widespread retrogression under amphibolite facies conditions. The Kangimut sangmissoq rocks are part of a large raft intruded first by massive tonalites that resemble main phases of the Nûk gneisses s.s., emplaced between 3050 and 2900 Ma (Baadsgaard & McGregor, 1981), and then by 2700-2600 Ma (post granulite facies) granitoid sheets (Roberts, 1979; McGregor et al., 1983). The Kanigmut sangmissoq gneisses are interpreted as containing an appreciable component of Amîtsoq gneisses (McGregor et al., this volume). Isotopic data on these rocks, when considered in isolation, do not conclusively show that these rocks are early Archean (S. Moorbath, P. Taylor & H. Baadsgaard pers. comms. & Collerson et al., this volume).

Akugdlerssuaq: The gneiss complex is dominated by amphibolite facies schlieric and nebulitic gneisses with disrupted amphibolite dykes (with discordances only rarely preserved), and containing enclaves of banded amphibolite and banded iron formation (Akilia association) These are cut by coarse-grained granite and pegmatite sheets, that in places can be hard to distinguish from, and grade into, in situ neosome. The complex was then cut by sharp-margined sheets of tonalitic to granitic composition, and was further deformed under amphibolite facies conditions (Nutman, 1982). The gneisses are interpreted as containing an Amîtsoq component, that was affected by two episodes of late Archean migmatisation. Rb-Sr and Pb-Pb isotopic studies from this and adjacent areas show that the isotopic systematics of Amîtsoq gneisses was strongly disturbed in the late Archean and that the grey sheets are 2700-2600 Ma old (Robertson, 1983; S. Robertson & M. Brewer, pers. comms; Bridgwater, Nutman & Larsen, unpublished data). Isukasia: The gneisses consist of 3750-3700 Ma tonalites veined by c. 3600 Ma granite sheets and comparatively rare c. 3400 Ma pegmatite dykes (Nutman et al., 1983; Baadsgaard et al., in prep.). In the late Archean there was heterogeneous deformation, but no significant migmatisation. The Amîtsoq gneisses of this area widely preserve their early Archean characters, whilst in the other areas discussed above late Archean tectonometamorphic overprinting and migmatisation have obliterated their early Archean characters.

GEOCHEMISTRY: This study considers grey gneisses that have undergone different metamorphic histories. From field work the samples are identified as derived from >3600 Ma tonalitic and banded Amîtsoq grey gneisses. However from the point of view of element migration discussed here, this age identification is unimportant since similar features are developed in polymetamorphic suites of Nûk gneisses at localities adjacent to those chosen for this study.

There is marked variation seen in the composition of these rocks in areas of different metamorphic history (Table 2) For example Akugdlerssuaq, where metamorphic grade was not above amphibolite facies and which forms part of the belt of high radioactivity (Fig. 1), there is a gain of LREE, Th, Rb, Pb, and K relative to both rocks from the low radioactivity, granulite facies terrane (e.g., Kangimut sangmissoq) and the well preserved, low radioactivity, amphibolite facies terrane to the north (e.g. Isukasia).

Table 2. Significant regional variation in composition of Amîtsoq grey gneisses (expressed as average abundance - more than 15 samples per group).

	K_2O	Rb	Pb	Th	Ce
Isukasia [A] , moderate radioactivity	1.61	85	17	4	37
Akugdlerssuaq [A] , high radioactivity	2.36	104	22	11	141
Kangimut sangmissoq [G] low radioactivity	0.57	9	8	1	29

There seems to be a good correspondence between metamorphic history and regional variation of radioactivity and geochemistry. It is suggested that the amphibolite facies, high radioactivity zone represented by Akugdlerssuaq could be an enriched zone, containing LIL elements expelled from underlying granulite facies terrane, represented here by Kangimut sangmissoq. The amphibolite facies, low radioactivity rocks of Isukasia are interpreted as a part of a crustal level above the enriched zone, not significantly metasomatised and intruded by granitoids during the granulite facies metamorphism at depth. Accepting this explanation implies redistribution of LIL elements on the scale of several kilometres during granulite facies metamorphism. In a heterogeneous, polyphase gneiss complex, this must have involved isotopic mixing between lithologies of different ages and origins, leading to modification of the isotopic signatures of the units (McGregor et al. & Collerson et al., this volume) It is apparent that enrichment of LIL elements in the gneisses from the enriched zone (Akugdlerssuaq) could in part be introduced via the injected granitic and pegmatitic sheets, that form at the most 10% of the gneisses complex at Akugdlerssuaq, and at other comparable localities such as Nordafar (see Collerson et al., this volume). However, the likely reason for concentration of these sheets is their derivation as either melts or hydrous fluids from the area undergoing granulite facies metamorphism (Bridgwater et al., in press; Schiøtte et al., in press).

DISCUSSION: The regional variation of Amîtsoq gneiss compositions combined with structural interpretations suggest that the c. 2800 Ma crust of the region was stratified, with granulite facies terrane at depth, (e.g., Kangimut sangmissoq) overlain by enriched amphibolite facies containing LIL elements expelled from the granulite facies terranes (e.g., Akugdlerssuaq) and capped by non-enriched, relatively undisturbed amphibolite facies terrane (e.g., Isukasia). Such stratification has also been discussed for other areas (e.g. Newton et al., 1981; Condie et al., 1982; Schiøtte et al., in press). Development of such a layer cake structure with a zone rich in LIL elements imposes important controls on subsequent anatexis and granitoid generation.

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