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Investigation of Precambrian rocks in the Buksefjorden region, southern West Greenland

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1975 was the fourth of a six year mapping project of the Buksefjorden map sheet 63 V. 1 Nord. By the end of the season 85 % of the sheet had been completed. Four teams took part: J. G. S. continued mapping north of Buksefjorden and extended his area to Ameralik so as to include important fold closures; K. J. V. continued in the area between Alángordlia and Taserssuatsiait; K. C. extended his area south to Taserssuatsiait and P. C. began mapping south of the central Buksefjorden coast. Base for the operations was Midgård (Kalsbeek, this report).

Localities referred to in the text may be found on the map (fig. 26) and by reference to the Geodetic Institute 1:250 000 maps 64 V. 1 Godthaab and 63 V. 1 Faeringehaven.

Chadwick & Coe (1976) refer to the occurrence of amphibolite dykes of two generations within the period of development of the younger gneisses. Further observations have been made on these dykes and their distribution is shown in fig. 26. The term Neriunaq (for the earlier) and Qáqatsiaq are proposed for these dyke suites. All other terms are used in the established sense (McGregor, 1973) and with McGregor's original meaning, even though the terminology is in places inadequate. Similarly no changes have been made to the established chronology (Bridgewater *et al.*, 1974: Chadwick & Coe, 1975) and the uncertainties which have been expressed remain.

One innovation is in the terminology used for structural features. Hitherto the two main periods of deformation affecting the Nûk gneisses (together with older rocks) have been referred to as the isoclinal phase and the asymmetric phase of folding. These are now referred to as D_2 and D_3 (D_1 relating to earlier structures developed in Amîtsoq gneisses). Limitations imposed by use of the symbols D_2 and D_3 are considered to be less important than the advantages which are two fold, viz:

(a) D_2 and D_3 can be used for all aspects of the structure associated with a stage of deformation, including fold hinges, axes, axial-surfaces and foliations;

(b) D_2 and D_3 carry no implications about fold shape or attitude.

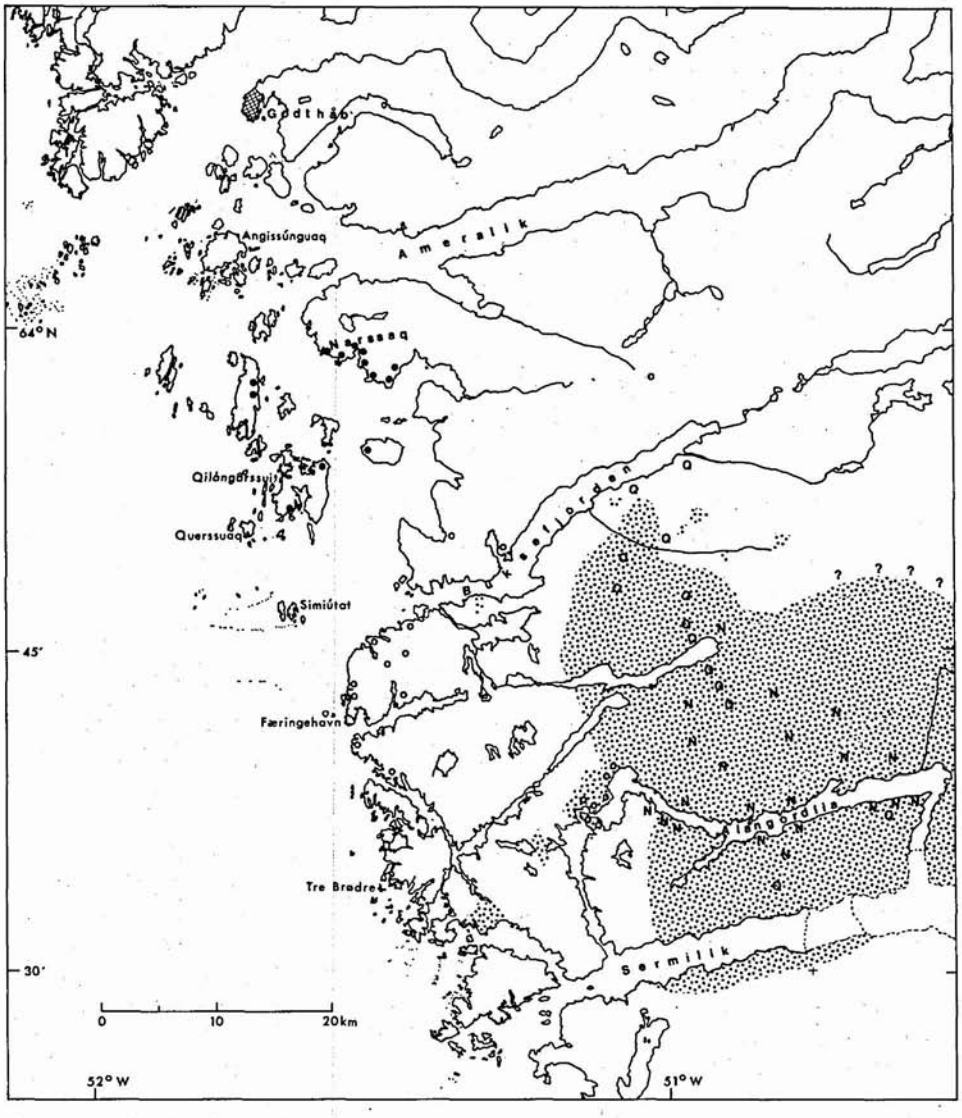

Fig. 26. Distribution of granulite facies rocks (small circle ornament) and amphibolite dyke (solid circle – Ameralik dykes; open circle – dykes of probable Ameralik affinity; N – Neriunaq dykes; Q – Qáqatsiaq dykes) in the Buksefjorden region, southern West Greenland.

Gneisses

Field work

The eastern limit of outcrop of Amîtsoq gneisses has been defined previously (Chadwick *et al.*, 1975). No changes have been made to this and the ground mapped in 1975 is believed to

be mostly underlain by Nûk gneisses. Attempts continue to establish criteria for distinguishing Nûk from Amîtsoq gneisses; a field criterion is discussed below, whilst chemical 'finger-printing' of Ameralik dykes has been established and the results will appear elsewhere (Chadwick & Wells, in preparation).

In the area between Buksefjorden and Ameralik, the gneisses have been divided into two main suites. The first, variable in mineralogy, contains numerous enclaves of amphibolite, many of which are sheet-like although not certainly originating as dykes. Members of the suite are typically well banded and with a foliation that pre-dates D_2 (Chadwick & Coe, 1976). The second suite varies in mineralogy from a leucocratic granodiorite (by far the most abundant member) to a rather mafic type, the latter probably owing this characteristic to large-scale contamination. The emplacement of the igneous parent was broadly synchronous with D_2 though minor activity continued during later tectonically stable conditions. Nappe-like structures developed whilst the intruded material was above its solidus so that the 'deformation' is in part a flow phenomenon. The intrusion may thus be envisaged as a large-scale laccolithic nappe, generated under the impetus of magmatic injection. The dissected nose of the nappe is preserved between Buksefjorden and Ameralik. Flow folds and comparable indications of highly mobile deformation preserved east of the head of Buksefjorden may indicate part of the root zone of the nappe, whilst to the south the structure plunges beneath outcrop level so that a root zone has not been found.

Between Buksefjorden and Ameralik certain gneisses have a fabric which pre-dates D_2. These must therefore be either surviving Amîtsoq gneisses or an early phase of Nûk gneiss. In the absence of certain Ameralik dykes their designation remains an open question, but an early Nûk age is favoured in view of their similarities to an extensive development of gneisses south and east of Buksefjorden. These in turn lack Ameralik dykes and are deemed to be Nûk because of their relations with amphibolites and supracrustal rocks of Malene aspect. We reaffirm our view that it is not possible on structural grounds to discriminate between Nûk and Amîtsoq gneisses.

Sheets of pale grey granodiorite occur in the area north of Buksefjorden but are much more abundant east of the head of the fjord and in the area south to the Qôrqut valley. A few sheets are found as far south as Taserssuatsiait. This lithology is very similar mineralogically to the leucocratic part of the granodiorite described above, but it rarely shows a banding and the fabric in many sheets is only poorly developed. Attempts have been made at a sub-division based on thickness, distribution and relation to the asymmetric phase of folding (D_3 in the current terminology). Further testing of this will follow.

Thus, in the area north of Taserssuatsiait, the Nûk gneisses can be divided into three main phases, and to the south of Taserssuatsiait an additional series occurs related to the Ilivertalik granite. Table 8 shows in descriptive terms the distribution of Nûk types in four subdivisions of the Buksefjorden map sheet. The sub-areas are necessarily arbitrary but future investigations may show that they are partly defined by the depth in the evolving crust. Once again we wish to assert our view that Nûk gneisses (*sensu lato*) were generated in a pulsating fashion over a long period of time and over a wide area probably extending beyond the limits of the Greenland Archaean block. Most of the precursors of the gneiss were granodioritic magma derived from depth, but locally this was modified by incorporation and reworking of older rocks.

Laboratory work

Laboratory evidence reinforces the field observations which indicate high temperatures in the syn-kinematic magma. Values for normative quartz, orthoclase, albite and anorthite plot well away from the experimentally determined piercing points on the Q–Ab–Or surface for the H_2O saturated Q–Ab–Or–An quaternary cotectic (James & Hamilton, 1969). In a non water-saturated system with a rapid rise to emplacement level a granodiorite melt will lose little heat through adiabatic cooling and hence may become effectively super-heated (Brown & Fyfe, 1970). Field evidence consistent with superheating exists in the form of basification of the magma by amphibolite contamination and local mobilisation of leucogabbro and anorthosite. Both are particularly likely when the host rocks are at a relatively high temperature and when the ratio of the volume of magma to that of the host rock is very high. The melt ceased to rise when it became moulded into a laccolithic form by the overlying anorthosite and it is the absence of this cover which resulted in the less ordered form of this phase of the Nûk further to the south-east.

Malene supracrustal rocks

Extensive tracts of Malene supracrustal rocks have been reported in the island complex to the west and south of Ameralik (e.g. western Qilángârssuit, Simiútat, Querssuaq), on the Narssaq peninsula and on the north side of Sermilik. Apart from these localities representatives of this division occur only as rafts in the seas of Nûk gneiss. The size and concentration of the rafts is obviously related to the abundance and type of intrusive Nûk gneiss. Thus in large outcrops of syn-kinematic grey granodiorite there is a paucity of large enclaves of Malene rocks. East of the head of Buksefjorden only small amphibolite rafts occur and these are widely spaced. Between Eqaluit and Qôrqut rare paragneisses (sillimanite-cordierite-quartz rocks) and rocks of doubtful parentage (garnet-rich and garnet-?sillimanite-quartz-K feldspar gneiss) are preserved in the gneiss, but the dominant type is amphibolite. North-east of Taserssuatsiait a metamorphosed differentiated gabbroic complex (2 km on the east–west axis) lies in the gneiss; margins are stoped and the complex is cut by concordant granite sheets and discordant sheets of pegmatite.

Throughout the area it is apparent that the supracrustal rocks were deformed prior to incorporation in their host gneiss; in places the deformation produced isoclinal folds and was accompanied by migmatisation. This amounts to circumstantial evidence of a period of deformation and metamorphism after the genesis of the Malene supracrustal rocks but prior to the injection of the Nûk parents. At present, however, it cannot be shown that this event was totally independent of the genesis of Nûk gneiss.

Neriunaq and Qáqatsiaq dykes

The distribution of both the earlier and later intra-Nûk dykes (Neriunaq and Qáqatsiaq dykes) is shown on figure 26. Neriunaq dykes range from pale amphibolite to granodioritic in character. They are relatively thin in relation to their length, the mean thickness of the group being about 1 m. Individuals have been traced over 50 m. One type 3 interference pattern (Ramsay, 1967) indicates emplacement prior to D_2 whilst in other examples, the state of

Table 8. Distribution of main Nûk gneiss types in the Buksefjorden region, southern West Greenland. Uncertainties surround the relations between the 'early' gneisses and the development of D_2, particularly when fold hinges cannot be seen. D_2 folding of discordant dykes (which can only locally be seen) clearly indicates the early nature of the gneiss

	'Early gneisses'	Gneisses synkinematic with D_2	Late leucocratic gneisses
Ameralik to Buksefjorden	Banded gneisses with fabric deformed by D_2 May include Amîtsoq gneisses or be exclusively Amîtsoq gneiss Rare	Grey granodiorite Most abundant	Granodioritic sheets, mainly pre-D_3 Rare
Buksefjorden to Qôrqut	Banded to speckled gneisses Mostly pre-D_2 Very abundant	Grey granodiorite Fairly abundant	Tonalite and granodiorite sheets pre- and post-D_3 Abundant
Qôrqut to Taserssuatsiait	Banded to speckled gneisses Mostly pre-D_2 Abundant	Grey granodioritic gneisses Rare	Tonalitic sheets Very rare
Taserssuatsiait to Sermilik	Banded gneisses Pre-D_2 May include Amîtsoq gneisses or be exclusively Amîtsoq gneiss	Grey granodiorite abundant, followed by Ilivertalik series	Late sheets pre- to post-D_3 Rare

deformation shows that injection occurred during the genesis of the isoclinal folds. Notwithstanding the subsequent deformation, the dykes rarely show boudinage and their continuity is broken only by shear zones.

Some members of the Qáqatsiaq group are composite intrusions. Two phases are present, a dark amphibolite and an earlier paler lithology. The lithotypes occur separately and also in single intrusions incompletely mixed. The mean dimensions of the Qáqatsiaq dykes exceed those of the Neriunaq suite, some members being traceable up to 1 km. The thinner members occur in small orthogonal swarms which trend north–south and east–west. Members of this group were emplaced sub-parallel to the axial surfaces of the D_3 folds. Few of them are bodily folded, although folded pegmatite bands are common within the dykes.

Fig. 26 also shows the distribution of Ameralik dykes and amphibolite dykes believed to be of Ameralik affinities but cutting gneisses for which there is no published isotope data. The Neriunaq and Qáqatsiaq dykes are either within or close to areas of granulite facies metamorphism. White gneiss sheets become relatively abundant in areas distant from the high-grade metamorphism whilst amphibolite sheets are absent.

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