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Department of Geology,
The University,
Exeter EX4 4QE,
Devonshire,
U.K.

Mapping of Archaean rocks in part of the Ivisârtoq sheet

Kenneth Coe and Steve Robertson

Parts of Kangiussap nunâ were mapped in the 1981 field season at a scale of 1:20 000 as the start of the Ivisârtoq project (Chadwick & Crewe, this report). This area was surveyed on reconnaissance scale in 1975 and brief accounts were published (Walton, 1976; Allaart *et al.,* 1977). These accounts proved to be of value in predicting the type of geology to be expected, but in the course of the mapping contradictions were revealed and some of the speculative views expressed were found to be unacceptable. Problems centre on establishing

satisfactory criteria for slotting all granitic types into established divisions. It is hazardous not only to attempt this without isotope geochemistry, but also to correlate units across the whole area. The reasons for this are three-fold: the deformation was probably not uniform; coeval units are mineralogically not uniform; established field criteria for recognition of Amîtsoq gneisses (presence of Ameralik dykes) are irregularly developed or not preserved. Thus whilst a sequence of events can be established in any sub-area, it is not often possible to assign a gneiss body to one of the major groups (Amîtsoq or Nûk), and because of the irregular deformation it is not always possible to distinguish between Nûk gneisses and rocks of Qôrqut affinity. It does not follow from this, as suggested by Walton (1976), that the Qôrqut granite started to develop in Nûk times.

Notwithstanding these difficulties an attempt has been made to describe the geology using terminology established for the Godthåb district (McGregor, 1973) and already used for the reconnaissance work in this area. We should emphasise that this report is based on field observations only and the use of the terms Amîtsoq, Nûk, Qôrqut and Malene is provisional pending results of isotope studies. Integrated field criteria are used in deciding to which group we assign any quartzo-feldspathic gneiss; doubts must exist about gneisses which lack some of the features of the rocks of the type areas.

We are reporting here only observations on the geology which seem to represent significant progress.

Amîtsoq gneisses

In well exposed coastal areas near the east end of Kangiussaq* fjord older and younger gneisses could be distinguished. The former are represented by well banded, complexly folded hornblende-bearing diorite/tonalite and the latter by paler biotite gneiss which is foliated but banded only by the development of irregular quartz-feldspar veins. In other parts of the ground these characteristics are maintained and their significance enhanced by secondary characteristics, in particular the type of enclaves found in each. It is assumed on the basis of the structural complexity and the rare presence of enclaves of iron formation, that the older are Amîtsoq gneisses and the younger Nûk. The older gneisses have extensive development in the peninsula north of Kangiussaq and the western part of the peninsula to the south. Nowhere, however, have typical Ameralik dykes been preserved, even in disrupted fragments. Only one small amphibolite enclave with feldspar clots was found. The wide straight Ameralik dykes of the Isukasia area to the north are represented to the south (in the type area of Ameralik) by very abundant thin dykes. Their absence in Kangiussap nunâ is puzzling.

In strips of Amîtsoq gneiss in the extreme western part of Kangiussap nunâ pegmatitic textures have replaced the banding and foliation. Areas of pegmatite have ill defined margins and usually poor foliation is preserved. The textural change is gradational and interpreted as quasi *in situ* melting of the gneiss. A similar development in adjacent Nûk gneisses shows that this may be a high grade transformation late in the plutonic history and related to the evolution of the Qôrqut granite. As similar observations have been made by Chadwick & Crewe (this report) the phenomenon may be widespread.

* See fig. 15 for position of geographical names.

Nûk gneisses

The younger gneisses referred to above proved to be voluminous and could be substantially sub-divided on the basis of mineralogy, state of deformation, and primary field relations. The divisions make a chronological sequence, all members of which are believed to be of Nûk age although, as stated above, in the absence of isotope data there are doubts about the dividing lines between Nûk gneisses and members of the Qôrqut granite suite. The divisions, oldest to youngest, are as follows:

Nûk 5 Pale aplitic gneiss (granodiorite)
Nûk 4 Variably foliated gneiss (granodiorite)
Nûk 3 Foliated gneiss (granodiorite)
Nûk 2 Multiphase foliated to banded gneiss (granodiorite/tonalite)
Nûk 1 Pale banded gneiss (tonalite)

Divisions 2 to 5 occur in sheets of variable width, often preserving intrusive contacts, and it is from examination of the contacts that relative ages are established. The multiphase nature of Nûk 2 is very obvious from the small scale internal variations, granodiorite to tonalite. Sometimes internal contacts are preserved. Deformation is heterogeneous but in places poorly developed banding is thrown into asymmetric folds with development of a new axial foliation. This leads to rapid textural variation from banded to foliated gneiss. Both Nûk 1 and Nûk 2 are cut by foliated acid gneisses which are also multiphase and vary from granodiorite to tonalite (Nûk 3). Cross-cutting relationships establish the age difference between Nûk 3 and Nûk 2, although the foliation directions are parallel and may have been contemporaneously induced. Nûk 4 is also tonalitic or trondhjemitic to granodioritic in composition. It is found in sheets that are usually flat lying and vary from undeformed to weakly foliated. The sheets are thick (up to 150 m) mappable units, so that contacts are less commonly observed, but observations have been made of flat marginal foliations. The inclusion of Nûk 5 with the other divisions must be tentative. It is represented by late grey sheets which are little deformed, sometimes showing only a poor biotite orientation parallel and close to contact surfaces. The sheets range in thickness from 2 to 20 m and dip at angles up to 40 degrees. It is possible that these sheets should be correlated with the granitic dykes at Qârusuk on Bjørneøen. In each Nûk division there is a pegmatite development. This is usually represented by injected migmatising sheets, but sometimes (as for instance in Nûk 5) it is only present as a textural variety of the main gneiss.

Although throughout the sequence the strain is variable it is probably a valid generalisation that the later divisions show progressively less deformation. It is an equally valid generalisation (but only a generalisation, since there are exceptions) that the later divisions contain progressively fewer enclaves of amphibolites and other Malene types.

The sheet intrusive form of most of these rocks and the state of deformation indicate syntectonic emplacement into hosts which were behaving in a brittle fashion. In this respect the gneisses are fundamentally different from Nûk gneisses in the type area to the south.

Qôrqut granite

The youngest quartzo-feldspathic rocks are granite and pegmatite sheets emplaced into all older rocks, and especially developed in the south-east of the area and north of Pâtusôq. The

pegmatite fraction is often very coarse grained and occasionally magnetite bearing. Notwithstanding the presence of a weak foliation this is judged to be Qôrqut in age. Lithologically and in relation to older rocks it is identical to Qôrqut rocks described by Brown *et al.* (1981). Some of the Nûk gneisses show features which overlap with the Qôrqut granite; the younger divisions in particular have similar field features. It was this similarity that contributed to the confusion in the reconnaissance work.

Relations between major units

Whilst the general concept of thrust interleaving between Amîtsoq gneisses and Malene rocks cannot be refuted from observations made in Kangiussap nunâ there is little evidence to support it, most masses of Malene rock occurring as enclaves in the Nûk gneisses. Neither was it possible to find evidence for uncomformable relations between these two major divisions; a diligent search for the conglomerate reported by Walton (1976) was not rewarded except by identification of tectonic breccias. However, relations between amphibolites and acid gneiss in the western part of Kangiussap nunâ suggest a cover basement relationship which is equally cogent. High, well exposed ground is underlain mainly by amphibolite and ultramafic rocks. The amphibolite is variable in mineralogy with bands up to 1 m wide in which olivine survives. The amphibolite is penetrated by pegmatite veins which cut across steep folds. Within the amphibolite is a single example of an enclave of gneiss. This is hornblende-bearing, tightly folded and on grounds of lithological similarity should be correlated with the Amîtsoq gneisses. In places the contact between the gneiss and amphibolite is faulted but veins of amphibolite in the gneiss confirm the xenolithic origin. The observation indicates that at least locally the parent magma of the Malene amphibolite was injected into and through the ancient Amîtsoq continent.

Sheeted contacts between Amîtsoq and Nûk gneisses are common in the eastern part of Kangiussaq. At the western end of the peninsula south of the fjord however, there are spectacular displays of stoped contacts. Enclaves of folded banded gneiss varying from hand sample size to masses 20 m across occur in the paler gneiss.

Dykes

Amphibolite dykes cut gneisses of all ages, and cannot hence, be used as time markers. In the Amîtsoq gneisses there are migmatised bodies not more than 1 m wide, usually broken into tectonic pods, which collectively cannot be traced more than about 15 m. In younger gneisses, although usually more coherent, they are thinner, averaging only 20 cm. Sometimes they are boudiné but they are not usually migmatised. The latest phase cut by such an amphibolite is probably Nûk 4. In this case, the dyke which can be traced without a break for 30 m is of unusually dense, fine-grained, biotite-bearing amphibolite. Simultaneous emplacement of basic dykes and granitic sheets is locally shown by complicated lobate interfaces. The duration of this period of basic sheet emplacement cannot be measured but it is certainly intra-Nûk.

After the acid plutonic activity more basic dykes were emplaced in one of four dominant directions, each direction presumably representing one generation. Trends are N–S, 060°, 090°, and 120°. All are basaltic in character but some have primary amphibole as a

prominent phase as a result of injection into active shears. One of the north–south dykes shows strong fractionation, being ultramafic at 400 m above sea level but dolerite at 800 m.

Geological history

The plutonic development of the area can be interpreted in conventional terms up to the end of Nûk 1. Thereafter, it seems that Nûk gneiss parents were injected as sheets into host rocks which were deforming in a brittle fashion suggesting a high crustal level of activity. The sequence Nûk 2 to 4 forms a broad dome in Kangiussap nunâ, the older phases being in the north and west and dipping steeply to north and west, whilst the younger phases occupying more central areas have a more horizontal attitude. Qôrqut granite and pegmatite is centrally placed so that the whole structure is a large dome which may have been located over a long lived thermal source which produced repeated injections of magma during deformation of gradually diminishing intensity. A precise model constrained by petrographic and structural data will be constructed later.

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Department of Geology,
The University,
Exeter EX4 4QE,
Devonshire,
U.K.