BASEMENT-SUPRACRUSTAL ROCK RELATIONSHIPS ON THE SOUTHERN MARGIN OF THE FOXE FOLD BELT, CENTRAL BAFFIN ISLAND, DISTRICT OF FRANKLIN

Contract 94753

Clinton R. Tippett[1]
Regional and Economic Geology Division

Tippett, Clinton R., Basement-supracrustal rock relationships on the southern margin of the Foxe Fold Belt, central Baffin Island, District of Franklin; in Current Research, Part A, Geol. Surv. Can., Paper 79-1A, p. 101-105, 1979.

Abstract

Along the southern margin of the Foxe Fold Belt on central Baffin Island, exposures of the supracrustal Aphebian Piling Group alternate with elongate west-northwest-trending domal culminations of remobilized Archean basement. This pattern is the result of a combination of compressional folding and active gneiss doming (D3). An earlier deformation involving recumbent isoclinal folding of the basement-cover interface produced interdigitation of thin tongues of basement and cover in a finite strain regime of strong horizontal flattening with the principal elongation oriented west-northwest (D2). High grade metamorphism preceded and accompanied the earlier deformation, reaching to progressively higher stratigraphic levels to the south, such that the postmetamorphic domes are encircled by apparent aureoles of high grade rocks which eventually merge into a uniform upper amphibolite facies terrane. Andalusite, sillimanite, and cordierite occur with increasing grade in this low pressure metamorphic belt which attained granulite facies conditions in the southernmost exposures of the study area. Within the Piling Group a single complex zone of amphibolite and ultramafic rocks of uncertain origin with associated calcsilicate gneiss, rusty schist and massive sulphide occurs near the base of a thick pile of metagreywacke and above an impure quartzite of variable thickness which generally blankets the basement complex.

Introduction

The 1978 field season was the second in a project initiated in 1977 (Tippett, 1978) to map a detailed 1:50 000 scale cross-section through the southern margin of the Foxe Fold Belt on central Baffin Island near DEW line site FOX 3 (Fig. 20.1). The project forms the basis of a doctoral study at Queen's University, sponsored by the Geological Survey of Canada under the supervision of W.C. Morgan. This year's work was conducted in conjunction with a helicopter-supported 1:250 000 scale mapping operation in the Ekalugad Fiord map area.

Regional Geology

The Aphebian Piling Group and the underlying Archean basement complex are folded together in a complex synclinorium which runs approximately east-west through central Baffin Island (Jackson, 1969, 1971) and forms part of the Foxe Fold Belt (Jackson and Taylor, 1972). Along the southern margin of the belt, basal Piling quartzite and schist generally blanket the basement complex and are overlain by a thick metagreywacke and metasiltstone sequence containing near its base a diverse assemblage of amphibolite, ultramafic rocks, calcsilicate gneiss, and rusty schist (Morgan et al., 1975, 1976; Tippett, 1978). Regional metamorphic grade gradually increases outward from the core of the synclinorium so that domal basement complex culminations are progressively surrounded southward by larger structurally produced high grade aureoles of recrystallization and migmitization which merge in the south to produce an overall upper amphibolite facies terrane (Fig. 20.1).

Stratigraphy

Minor additions and revisions to the stratigraphy given in Tippett (1978) are discussed below. Domes are numbered for convenience (Fig. 20.1) but their numbers do not correspond to those used previously (Tippett, 1978).

1. Basement Complex

Slabs of basement complex lithologies collected in 1977 were stained for K-feldspar. The results confirm that the composition of the granitoid gneiss ranges from granitic to trondhjemitic while clustering around a quartz monzonitic composition. Gneissic layers of highly different composition, however, commonly are interlayered on a 1 to 10 cm scale. Mafic-rich boudins and schlieren generally contain hornblende and plagioclase with accessory biotite, garnet, pyroxene, and sphene. Ultramafic rocks are rare in the basement complex of the study area and are unique to the core of Dome 6. Pegmatites, probably mobilizates from the gneiss, are generally quartz monzonitic and are characterized by their orange colour.

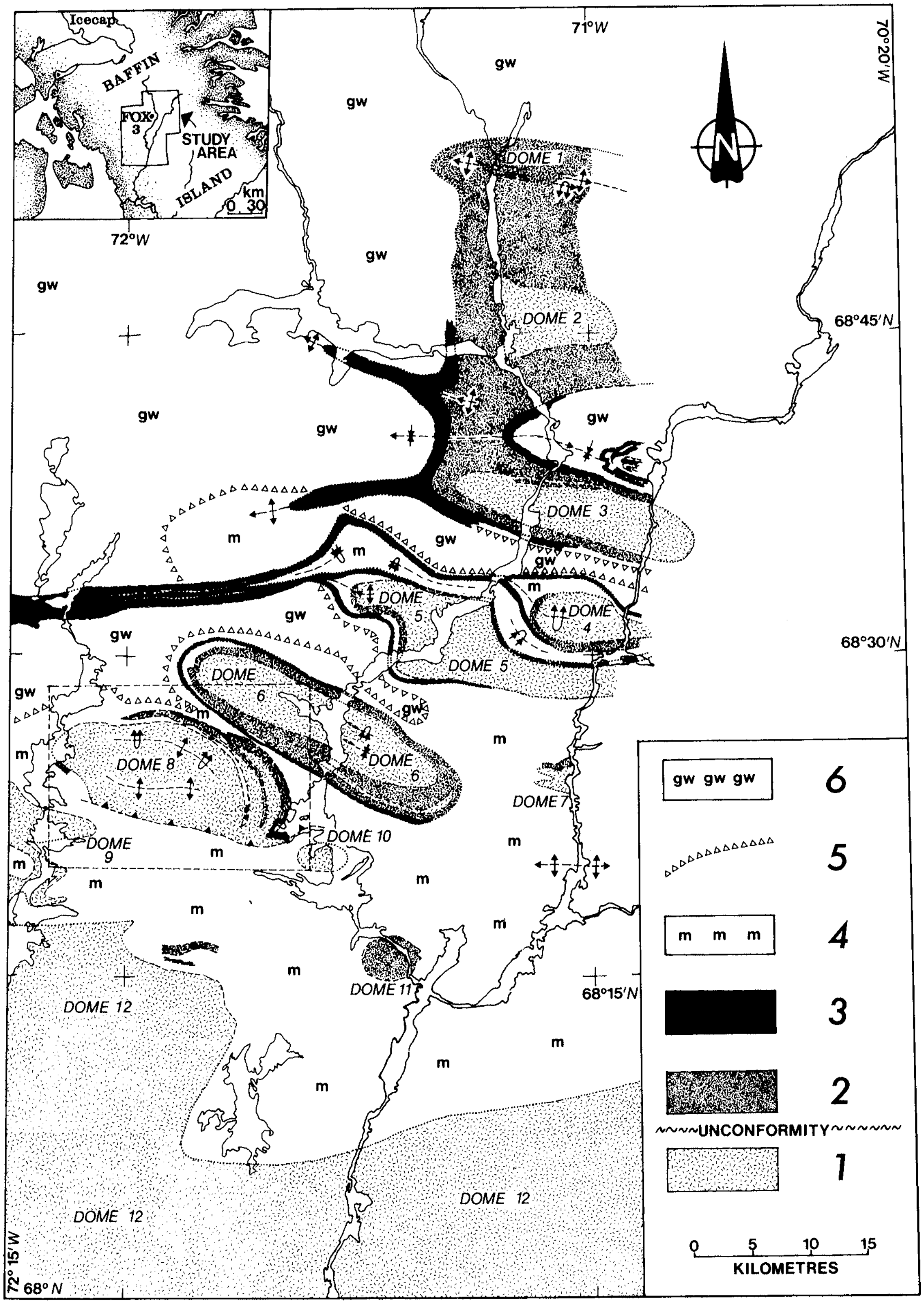
The southernmost granitoid basement complex (Dome 12, Fig. 20.1) is a mixture of megacrystic granitoids (K-feldspar up to 2 by 8 cm) and equigranular garnetiferous granitoids that form an anastomosing network of sills and dykes on all scales. Although they lack the layering of the gneiss present in domes farther north, the preferred orientation of biotite and K-feldspar augen define a schistosity dipping north under the paragneiss, suggesting an analogous structural position. Any interpretation of the complex must account for the following:

(i) Mafic-rich blocks, schlieren, and other possible restites do not contain pelitic index minerals (for example, sillimanite, which is ubiquitous in migmatitic paragneiss to the north). They are composed of hornblende, biotite, plagioclase, garnet, K-feldspar, and pyroxenes and consequently are unlikely to be high grade equivalents of the paragneiss.

(ii) The contact between the migmatitic paragneiss and the granitoid complex is sharp and therefore cannot simply represent a metamorphic transition.

(iii) North of the western section of the complex (Fig. 20.1), highly deformed quartzite and amphibolite within migmatitic paragneiss are part of the basal Piling Group.

[1] Department of Geological Sciences, Queen's University, Kingston, Ontario K7L 3N6



1. basement complex
2. impure quartzite and schist unit
3. amphibolite and ultramafic rock unit
4. migmatitic paragneiss
5. metamorphic front separating greywacke (6) from its metamorphic equivalent – migmatitic paragneiss (4), teeth pointing towards the low grade side; and
6. greywacke and siltstone

Figure 20.1. *Location and geology of the study area, excluding diabase dykes. Geology based on Tippett (1978), Morgan et al. (1976), Chernis (1976), reconnaissance data and David Shaw (pers. comm., 1978). Domes have been numbered 1 to 12 to facilitate reference to them. Axial surface traces of some D3 folds are illustrated. The area east of the coded study area was mapped during 1978 as part of the adjoining project. The block outlined in the west-central part of the figure is shown in detail in Figure 20.2.*

Megacrystic granitoids in this extensive southern terrane are interpreted as recrystallized basement gneiss which has been intruded by equigranular garnetiferous granitoids, although the latter are probably autochthonous on the scale of the whole complex.

Granitoids, which make up Dome 10, are also regarded as remobilized basement, although their marginal autoclastic zone and the absence of basal Piling Group lithologies suggest detachment from the basement complex and intrusion into the migmatitic paragneiss.

2. Impure Quartzite and Schist Unit

In the southern part of the study area, this basal unit is very thin or is absent (except for Dome 11) whereas to the north, a thick quartzite mantles Domes 1 and 2. Quartz-sillimanite faserkiesel characteristic of the quartzite south of Dome 6 are not developed to any extent elsewhere and appear to be typical only of medium grade metamorphism.

3. Amphibolite and Ultramafic Rock Unit

This unit is made up of hornblende- and tremolite/actinolite- rich ultramafic rocks and hornblende- plagioclase amphibolite with minor associated calcsilicate gneiss, rusty schist, and massive sulphide (Tippett, 1978). Internal stratigraphy and thickness change abruptly along strike so that the unit is often composed of a series of lenses rather than a continuous layer. Thick sections are restricted to the central and west-central portions of the area, with apparent stratigraphic pinching out to the north, east, and south. Interfolds of basal quartzite within the unit north and west of Domes 3 and 5 are interpreted to indicate that only one major stratigraphic unit of amphibolite and ultramafic rocks is present in the Piling Group, located at or close to the base of the metagreywacke-metasiltstone unit. Rusty quartzite associated with ultramafic rocks and calcsilicate gneiss northeast of Dome 3 (Chernis, 1976) may be recrystallized chert, as distinct from the basal quartzite.

4. Metagreywacke-Metasiltstone Unit

Petrographic examination of low grade rocks from this unit indicates a general deficiency of K-feldspar although scattered K-feldspar-rich layers are present. Clastic quartz, plagioclase, and K-feldspar suggest weathering of a granitoid terrane for a source area, an interpretation strengthened by the lack of clast compositions or textures which are

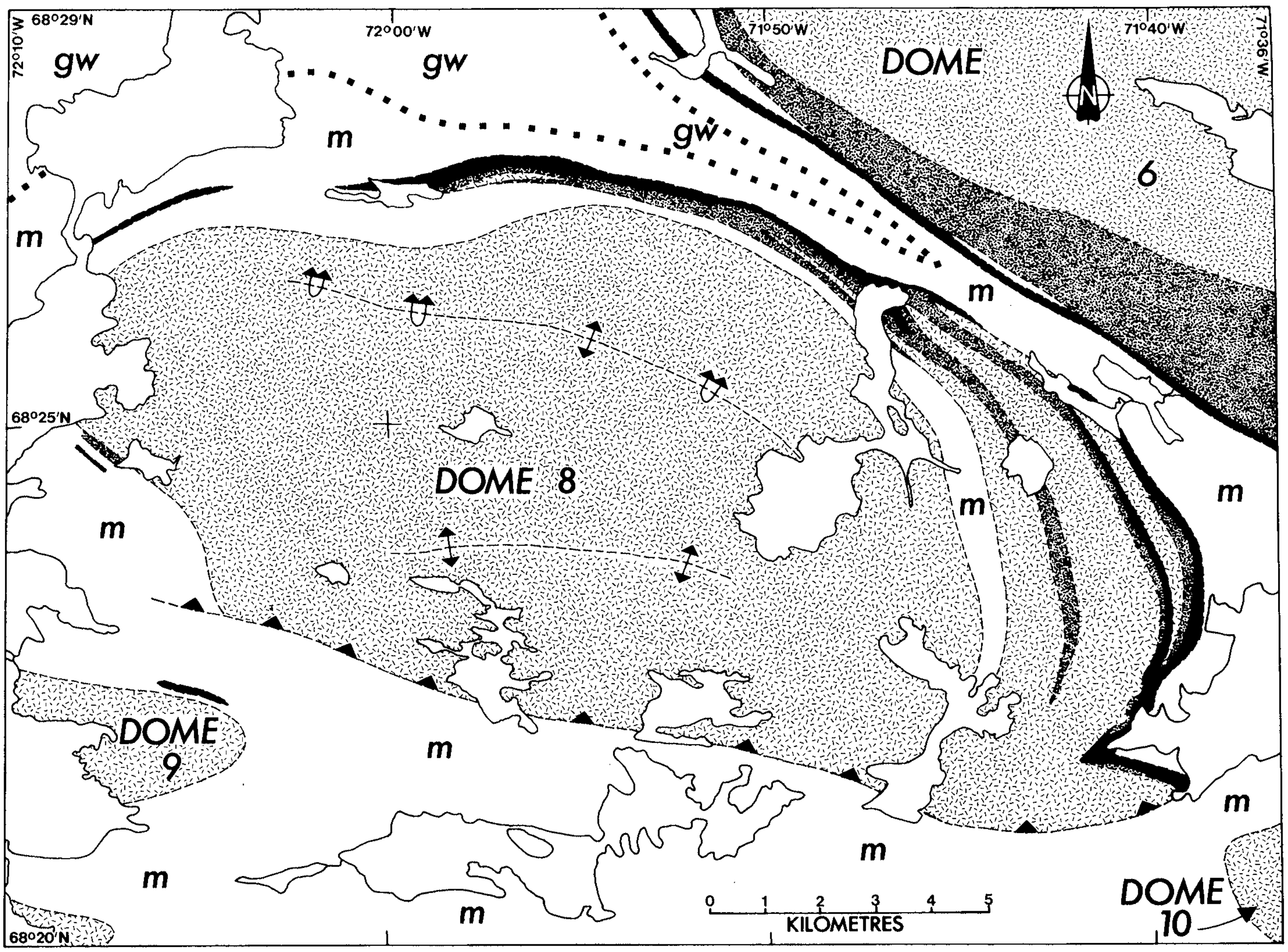


Figure 20.2. Detailed geology of Dome 8 and vicinity, excluding diabase dykes, illustrating D2 interfolding of basement and cover along its northeastern margin. Axial surface traces of D3 folds within the core of this composite dome are depicted. Legend as for Figure 20.1 with the exception of the greywacke-migmatitic paragneiss front.

recognizably volcanogenic or sedimentary. Concentrically zoned concordant calcsilicate nodules are probably metamorphosed carbonate concretions.

At higher grades of metamorphism the greywacke and siltstone are transformed into migmatitic paragneiss with the abruptness of the transition probably due to allochthonous mobilizate which has moved into the zone of incipient migmitization. Calcsilicate nodules containing garnet, diopside, and amphibole are locally preserved. Alternations of blocky biotite and biotite-garnet paragneiss with sillimanite paragneiss mimic compositional layering in the lower grade rocks. Mobilizate composition is predominantly quartz monzonitic with a range from granitic to trondhjemitic. Initial identification as predominantly trondhjemite was due to the identical white colour of K-feldspar and plagioclase plus poor twinning in the latter. Accessory muscovite, tourmaline, and garnet are typical of low grades while biotite, garnet, and rarely cordierite occur in higher grade mobilizate. Restites commonly contain the assemblage quartz-plagioclase-biotite and are deficient in K-feldspar due to a combination of low original content and depletion of K-feldspar into the mobilizate.

Isolated blocks of amphibolite and, more rarely, ultramafic rocks are present at various localities in the migmatitic paragneiss but, lacking markers to unravel structures in the unit, it is difficult to determine whether they were originally more continuous and/or limited to discrete horizons.

Metamorphism

Metamorphic assemblages specific to narrow P and T ranges are rare in the study area due to generally unfavourable bulk compositions. The breakdown of muscovite in the presence of quartz is the most important reaction in the supracrustal rocks given the widespread occurrence of that mineral at low grade.

North of Dome 3, the coexistence of andalusite and sillimanite in a quartz segregation close to several occurrences of quartz-muscovite-sillimanite-K-feldspar schist implies low metamorphic pressure as does andalusite-garnet-biotite-muscovite schist west of Dome 5. Faserkiesel in medium grade quartzite are made up of quartz and sillimanite and occur in a matrix of quartz-K-feldspar or quartz-K-feldspar-plagioclase. Similar nodules of muscovite-sillimanite-quartz in matrices of K-feldspar-quartz-biotite occur in slightly migmatitic medium grade paragneiss. Possibly an ionic equilibria similar to that suggested by Eugster (1970) involving the breakdown of K-feldspar would be an appropriate explanation.

The extent of partial melting in migmatitic paragneiss varies up to 90 per cent in the southernmost exposures, while averaging 40 to 60 per cent. Mobilizate and restite occur together both as thick sheets and as closely interfingering phases, implying a generally autochthonous origin with some mobilizate movement. The assemblage garnet-biotite-sillimanite is typical of schist layers in the migmatitic paragneiss. In the southernmost migmatitic paragneiss the development of cordierite gives rise to the assemblage sillimanite-biotite-cordierite-garnet-quartz-plagioclase-melt.

Whereas clinopyroxene is present locally in amphibolite of the basement complex and in supracrustal ultramafic rocks as far north as Dome 3, its occurrence with orthopyroxene in mafic-rich rocks of Dome 12 suggests the attainment of granulite facies conditions in that area.

The limited degree of partial melting in all domes, with the exception of Dome 12, must be due to the lack of a vapour phase given the highly migmatized paragneiss adjacent to them. This is confirmed in part by an increase in melting of the basement gneiss near the contact with the metasediments. Differentiation of nearly homogeneous gneiss in the central part of domes into well layered gneiss near their margins, especially in Domes 6 and 8, is problematic as it implies some sort of deformation-induced differentiation, possibly aided by a vapour phase.

Retrogression of most minerals to varying degrees is pervasive, limiting the use of mineral composition data. The peak of metamorphism and migmitization was either pre- or syn- D2 such that, given the intensity of D3 and the posttectonic polygonization of mineral grains indicated by their strain-free nature, it is probable that assemblages re-equilibrated under conditions different from those of their formation. Zones of highly altered red and orange coloured paragneiss with green biotite have widespread but non-systematic distribution.

Posttectonic pegmatites locally crosscut both the basement complex and the supracrustals. Small amounts of melt therefore were being redistributed, if not generated, until well after D3.

Structure

The evolutionary scheme described in Tippett (1978), involving early recumbent basement-cover interfolding with the development of a subhorizontal schistosity at lower levels, superceded by compressional folding and active gneiss doming, was supported by this year's work.

In the previously established nomenclature, D1 refers collectively to pre-Piling Group deformation of the basement complex. Second phase lineations (L2) defined by mineral elongations trend roughly west-northwest throughout most of the area. Although presumably related to the isoclinal interfolding of basement and cover, the lack of measurable D2 fold hinges makes it difficult to determine their true geometrical significance. Some boudins folded by D3 have axes perpendicular to L2 while S0-S2 intersections are west-northwest-trending. The most likely interpretation is that D2 isoclines have hinges which are curvilinear to an extreme and pass through 180°. Such a geometry is the logical result of an extremely intense deformation in which hinges with various original orientations rotate towards the principal extension direction as recorded by the mineral lineations. The geometry in three dimensions of the basement-cover interface is extremely complex and is probably dominated by thin mushroom-shaped tongues stretched out along west-northwest axes and very strongly flattened in the schistosity (S2).

Compressional D3 folding alone appears to have affected the low grade metagreywacke west of Domes 5 and 6 in addition to the previously documented areas, while being superimposed on the penetrative second phase schistosity in the wide belt of migmatitic paragneiss north of Dome 12. Minor D3 folds with "cascading" vergence diagnostic of active gneiss doming are developed marginally to most domes. Possible exceptions are Dome 1, whose narrowness and sharp closure suggest a compressional origin, and Dome 10 which seems to be intrusive.

The tectonic evolution of Dome 12 may be more complex in that, as part of an extensive granitoid terrane which dominates the geology far to the south (Garth Jackson, pers. comm., 1978), it may have been responsible for much of the D3 deformation not only immediately north of it but also well into the core of the fold belt. It is certainly a much larger feature than the other domes and since its dominant north-dipping fabric in the study area appears to be continuous with S2 in the migmatitic paragneiss, its evolution may be similar to that of the other domes, although on a larger scale.

Details of the geometry of Dome 8 are portrayed in Figure 20.2. D2 interfolding of basement and cover is well developed on the northeast margin of this dome, although the lack of symmetry of Piling Group lithologies around the outer basement tongues is suggestive of low angle thrust faulting. It is a composite dome as indicated by the D3 fold structures within it and by the re-entrant in its southeastern corner. Along the southern margin, a thrust fault displaces the gneiss over the migmatitic paragneiss. There is locally a discordance of 10 to 20° in fold trends across the break and the paragneiss is more strongly deformed in its vicinity. This structure may be the result of the predominantly southward sense of overturning of most of the domes in the study area.

The age of isoclinal interfolding of the amphibolite-ultramafic rock unit and the quartzite west of Dome 5 is uncertain. The geometry illustrated in Figure 20.1 provides the simplest explanation. The thick amphibolite north of Dome 5 is presumed to contain the fold hinge which plunges west off the nose of Dome 4. This implies that these folds are D3. However, if the interfolding is D2, there is no logical reason for the hinges of the folds to relate to the positions of the domes and a much more complex choice of patterns results.

Investigation of the amphibolite and ultramafic rock unit northeast of Dome 3 suggests that it is a simple syncline containing a folded S2 but without major D2 closures. The apparent difference in thickness of paragneiss between its south limb and Dome 3 and its north limb and Dome 2 may be partly caused by steeper dips to the south but is probably also due to more extreme flattening on that limb.

Economic Geology

Massive sulphides form an integral, although minor, component of the amphibolite and ultramafic rock unit. Two new pyritiferous zones have been noted. The first is in a continuation of the belt containing the showing previously reported (Tippett, 1978), being part of an extensive gossan near 68°32'30"N, 71°57'30"W. It is made up of a 1 m layer containing 50 per cent pyrite and 50 per cent black fine grained gangue. The second is a layer several tens of centimetres thick of massive pyrite with 1 to 2 per cent finely disseminated chalcopyrite located north of Dome 8 near 68°27'N, 71°52'W.

References

Chernis, P.J.
1976: Stratigraphy, structure and metamorphism of the Piling Group at Dewar Lakes, Baffin Island, N.W.T.; unpubl. B.Sc. thesis, Carleton University, Ottawa, Ontario, 64 p.

Eugster, H.P.
1970: Thermal and ionic equilibria among muscovite, K-feldspar and aluminosilicate assemblages; Fortschritte der Mineralogie, v. 47, p. 106-123.

Jackson, G.D.
1969: Reconnaissance of north-central Baffin Island; in Report of Activities, Part A, Geological Survey of Canada, Paper 69-1A, p. 171-176.

1971: Operation Penny Highlands, south-central Baffin Island; in Report of Activities, Part A, Geological Survey of Canada, Paper 71-1A, p. 138-140.

Jackson, G.D. and Taylor, F.C.
1972: Correlation of major Aphebian rock units in the northeastern Canadian Shield; Canadian Journal of Earth Sciences, v. 8, p. 1650-1669.

Morgan, W.C., Bourne, J., Herd, R.K., Pickett, J.W., and Tippett, C.R.
1975: Geology of the Foxe Fold Belt, Baffin Island, District of Franklin; in Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A, p. 343-347.

Morgan, W.C., Okulitch, A.V., and Thompson, P.H.
1976: Stratigraphy, structure and metamorphism of the west half of the Foxe Fold Belt, Baffin Island; in Report of Activities, Part A, Geological Survey of Canada, Paper 76-1A, p. 387-391.

Tippett, C.R.
1978: A detailed cross-section through the southern margin of the Foxe Fold Belt in the vicinity of Dewar Lakes, Baffin Island, District of Franklin; in Current Research, Part A, Geological Survey of Canada, Paper 78-1A, p. 169-173.