REPORT ON ANTARCTIC FIELDWORK

THE SCOTIA METAMORPHIC COMPLEX ON ELEPHANT ISLAND AND CLARENCE ISLAND, SOUTH SHETLAND ISLANDS

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Elephant and Clarence islands are part of the Scotia metamorphic complex (SMC) (Tanner and others, 1982), a subduction-accretion terrane (Smellie and Clarkson, 1975; De Wit, 1977; De Wit and others, 1977) of Mesozoic age (Tanner and others, 1982; Hervé and Pankhurst, 1984) in the South Shetland and South Orkney islands (Fig. 1). During four days over the New Year 1983–4 the authors made eight landings with inflatable boats operating from RRS *John Biscoe*. The object of the fieldwork was to make structural observations and detailed collections at a number of localities across the strike in order to investigate the relationship between deformation and metamorphism, and to collect samples for micropalaeontological analysis. A summary

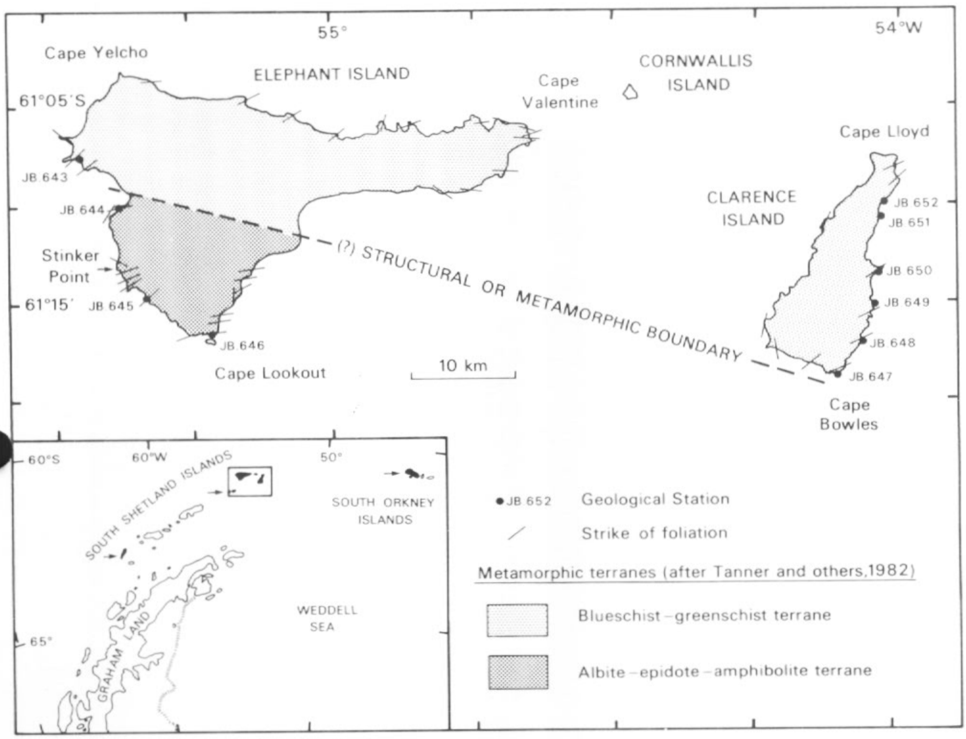

Fig. 1. Sketch map of Elephant and Clarence islands. Structural trends after Dalziel (1984) and from this report; metamorphic terranes and boundary as shown by Tanner and others (1982). Inset shows other outcrops of the Scotia metamorphic complex (arrowed) and the location of the Elephant Island group (outlined). No landings were possible at stations JB.651 and 652.

of field observations and some preliminary findings of the petrological study are reported here.

Previous Work

Earlier work (Tyrrell, 1945; Roxburgh and Burkitt, 1971; Dalziel, 1976, 1982, 1984; Tanner and others, 1982; Hervé and Pankhurst, 1984) has led to the division of Elephant and Clarence islands into a blueschist-greenschist facies terrane, composed of green and grey phyllites and schists (often graphitic), metacherts, marbles, metatuffs and grey psammites (teranne A), and an albite-epidote amphibolite facies terrane composed of coarser-grained mica-schists, metabasites, quartzites, marbles and calc-silicate rocks (terrane B), separated by a structural or metamorphic boundary (Fig. 1). Structures in the area have been described by Dalziel (1984), who found that the foliation and the dominant folds in both terranes strike into the north-east quadrant. The main folds (F_M) in terrane A deform only the original stratification; they and an associated foliation (S_M) are deformed by later, apparently conjugate folds (F_L). In terrane B, F_M deformed a tectonic fabric (S_E) and isoclinal folds (F_E), and a later crenulation is locally present. Detailed descriptions of both deformation and metamorphism are available for only two areas. At Cape Bowles (terrane A), Hervé and Pankhurst (1984) found that a very low grade (in the sense of Winkler, 1976) mineral assemblage formed during an early deformation was partially replaced by low grade assemblages during or slightly after the formation of the main folds in that area. Around Cape Lookout (terrane B) the main mineral fabric is associated with the second of two phases of penetrative deformation (Hervé and others, 1984). Tanner and others (1982), referring to the SMC as a whole, stated that in terrane A the main growth of metamorphic minerals was associated with an early penetrative deformation, whereas in terrane B it occurred during a static episode following the early deformation. Small tight folds, predating a widespread crenulation cleavage, are locally preserved within individual albite porphyroblasts in terrane A of Elephant Island (P. W. G. Tanner, in Furse, 1979, pp. 221–225).

The Present Study

The fieldwork aimed to make landings at equally spaced points across the strike on both islands and to observe the intervening ground from close inshore. Sea conditions dictated which coasts could be worked and prevented landings near the northern parts of both islands. Results from the localities visited will be described in order from north to south on each island; previous work (Tanner and others, 1982; Dalziel, 1984; see Fig. 1) suggests that this order may represent an offset north–south transect across the two terranes. Lithological descriptions include summaries of the mineralogy (confirmed by microprobe analysis), and structural observations are amplified with preliminary microfabric data.

Clarence Island

Lithology and mineralogy. Between stations JB.652 (the end of the offshore traverse) and JB.648 green and grey phyllitic rocks (the latter typically with numerous quartz veins) are interlayered on scales from a few millimetres to several metres. South of JB.648 green rocks were not seen and Cape Bowles (JB.647) is composed of grey, fine-grained psammitic schists and subordinate dark phyllites (see Hervé and Pankhurst, 1984) Chlorite, epidote, albite, quartz and accessory calcite form the bulk of most rock types. Phengite is generally abundant but is locally absent from green lithologies, actinolite is present in green lithologies at JB.649 and in phyllites at JB.647, and stilpnomelane occurs in grey laminae at JB.648, possibly at JB.650 and is also reported at Cape Bowles by Hervé and Pankhurst (1984). At JB.650 areas of quartzo-feldspathic material, or occasionally zeolite, 0.1–0.25 mm across, in a finer grained matrix are probably relict detrital or pyroclastic grains; clastic grains are also recognizable at JB.647. Sample JB.650.5 contains possible relict Radiolaria. Neither marbles nor metacherts were recognized along this coast. The only compositionally extreme lithology seen is a boudinaged 3 m-thick layer of epidote-actinolite-chlorite rock at JB.648.

Structure and metamorphic fabric. As reported by Dalziel (1984) and Hervé and Pankhurst (1984), compositional layering, a penetrative tectonic fabric (S_M of Dalziel; S_1 of Hervé and Pankhurst) and the axial surfaces of later folds with subhorizontal hinges (F_L of Dalziel; F_2 of Hervé and Pankhurst) dip toward the north-west at moderate angles. At JB.650, where the main lithologies are very fine-grained (< 0.02 mm), S_M is poorly developed except in thin phyllosilicate-rich laminae. At the three southern localities the grain-size is greater (0.1–0.2 mm) and a phyllitic S_M is well-developed. At stations JB.649 and 650 phengite crystals deformed by F_L have curved cleavages whereas at JB.648 phengite and stilpnomelane lying in S_M, and larger epidote laths, have recrystallized following deformation. At JB.647 the post-F_L actinolite and epidote growth described by Hervé and Pankhurst is seen.

Elephant Island

Lithology and mineralogy. At station JB.643, 5–10-m-thick grey and green units have cm-scale internal layering. The dominant lithologies in the western and eastern parts of the shore are grey phyllites (quartz-phengite-chlorite-epidote-calcite-albite ± spessartine), green albite-porphyroblastic rock (albite-chlorite-phengite-epidote-calcite-quartz ± actinolite) and less common white granoblastite (quartz-calcite-phengite-chlorite-epidote-albite). In the central part of the section green phyllites with conspicuous stilpnomelane (quartz-chlorite-phengite-epidote-stilpnomelane ± calcite ± albite), blue phyllites (quartz-blue amphibole-phengite-epidote ± chlorite ± calcite ± stilpnomelane ± spessartine) and impure marble layers (to 30 mm thick) are present.

At JB.644 the rocks are fine-grained grey-green albite porphyroblastic schists, locally with graphitic streaks. The compositional layering is indistinct but small differences in lithology are represented by modal variations within the assemblage quartz-albite-phengite-chlorite-amphibole (blue-green)-epidote-calcite, with small amounts of manganiferous almandine in most samples. The dominant lithologies at JB.645 are medium-grained albite-porphyroblastic schists (quartz-albite-almandine-biotite-phengite-chlorite-calcite ± epidote ± green amphibole), locally with cm-scale layers of garnetiferous quartzite (?metachert) and calc-silicate layers. Similar rocks have been described from Stinker Point (Fig. 1) by Dalziel (1972). The same minerals are present at JB.646, where there is greater modal variation and several lithologies of more restricted mineralogy; garnetiferous quartzite, marble and amphibolite are the most conspicuous subordinate lithologies. Oligoclase (An_{14}), apparently of metamorphic origin, accompanies albite in one sample (JB.646.23), which also contains paragonite.

Structure and metamorphic fabric. In most lithologies at JB.643 a phyllitic fabric (S_M) is the dominant parting direction. Its intersection with the compositional layering gives a pronounced ribbon lineation (L_M) which on most surfaces plunges at moderate angles to the west. S_M is deformed by later folds, which plunge and strike to the north-east and are equated with one of the late (F_L) fold sets of Dalziel (1984). The structures at JB.644, 645 and 646 are as described by Dalziel (1984) in terrane B as a whole. The foliation and the axial surfaces of the main folds at each locality (taken to be F_M of Dalziel (1984)) dip steeply to between north and north-west. The hinges of the main folds, and earlier isoclines at JB.646, plunge at moderate angles to the west.

Along this traverse a southward coarsening of the dominant fabric is accompanied by an increase in the size of the albite porphyroblasts from 0.5 to 1.0 mm diameter at JB.643 and 644 to 2.0 mm and 2.5 mm at JB.645 and 646 respectively. The greatest change in grain-size occurs not across the terrane A–B boundary between JB.643 and 644, but between JB.644 and 645. At JB.643 amphibole and phyllosilicates defining S_M have recrystallized after crenulation by F_L, and stilpnomelane commonly lies parallel to the axial surface of the crenulations. Albite porphyroblasts enclose crenulations, and randomly oriented phengite crystals larger than those in S_M are present in the external fabric. At JB.644 the schistosity is parallel to the axial surfaces of folds which deform an earlier fabric preserved as dusty inclusion trails within albite porphyroblasts. At JB.645 the cores of albite porphyroblasts preserve a similar fabric with tight crenulations but their margins contain inclusions similar in grain-size to the coarser external fabric and in some cases appear to be syntectonic. Similar features are seen in albite porphyroblasts at JB.646, where the syntectonic enlargement of the porphyroblasts appears to have taken place during the formation of the later of the two sets of folds.

Discussion

These observations allow us to confirm and qualify the conclusions of earlier work. Each locality in terrane A yielded samples in which the dominant fabric is associated with an early deformation, as described by Tanner and others (1982), but at Cape Bowles (JB.647) prograde metamorphism continued after the crenulation of this fabric (Hervé and Pankhurst, 1984) and at JB.643 (northern Elephant Island) a post-crenulation metamorphism dominates the microfabric of the albite-porphyroblastic lithologies. In terrane B the main metamorphism, including albite growth, post-dates a period of deformation, as stated by Tanner and others (1982). However this 'early' deformation is seen as crenulations of a yet older fabric and albite growth then continued during a later phase of deformation, which at Cape Lookout (JB.646) is apparently that termed F_M by Dalziel (1984).

In both islands there appears to be a southerly increase in the metamorphic grade. On Clarence Island the low grade metamorphism recognized by Hervé and Pankhurst (1984) supplants earlier assemblages only in the southern localities. At JB.643 (Elephant Island) rocks of two metamorphic facies are preserved, either for kinetic reasons or due to the presence of an unrecognized structural boundary. Albite-free, blue amphibole-bearing assemblages appear to have been stable before and after the crenulation of S_M whereas higher temperature and/or lower pressure albite-chlorite-actinolite-bearing assemblages in the porphyroblastic rocks post-date the crenulation. A more aluminous amphibole and Fe-bearing garnet appear at JB.644, biotite is present at JB.645, and oligoclase (indicating amphibolite facies metamorphism) is present at JB.646. This southward appearance of successively higher grade index minerals is accompanied by a reduction in the modal abundance of chlorite and epidote.

There is a marked change in grade and grain-size within the island group as a whole. Towards the south the successively higher metamorphic grades were attained near the end of fabric histories that become progressively longer and it appears that each locality has passed through the stage of development seen in the locality to its north. The change in metamorphism and fabric between stations JB.643 and 644 provides little evidence for the presence of a major boundary between metamorphic terranes A and B. However, that tectonic segmentation has disrupted the metamorphic zonation in the area is suggested by a report of biotite from northern Clarence Island (Barth and Holmson, 1939), and there is evidence of recent faulting in the region of the supposed terrane A – terrane B boundary (*Tectonic Map of the Scotia arc.* 1:3000000, BAS (Misc) 3. Cambridge, British Antarctic Survey, 1985). The results of this study suggest that any structure within the unexposed ground between these stations does not produce a significant discontinuity in the metamorphic zonation or history.

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