LOCATION AND GEOLOGY OF NUNATAKS IN NORTH-WESTERN COATS LAND

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INTRODUCTION

The isolation of Littlewood, Bertrab and Moltke nunataks (Filchner, 1922; Alberts, 1981) from other areas of exposed rock in Coats Land (Fig. 1) gives them a geological significance disproportionate to their small total area (< 0.1 km²). Bertrab Nunatak was visited briefly by one of the authors (PDM) in November 1978 and rock samples collected; the other nunataks and the surrounding area were observed from the air during the same visit. The observations made, combined with US satellite imagery, have enabled the authors to clarify some aspects of the geography and geology of these nunataks.

GEOGRAPHICAL POSITION

Fig. 1 B is drawn from Landsat image No. E-1188-09011-7 (January 1973) with some detail taken from US tricamera air photography. Ground control was provided by the survey of the coast adjacent to Moltke Nunataks (Blaiklock and others, 1966, sheet W77 32/34) and Doppler satellite positioning of Littlewood Nunataks (Sturgeon and

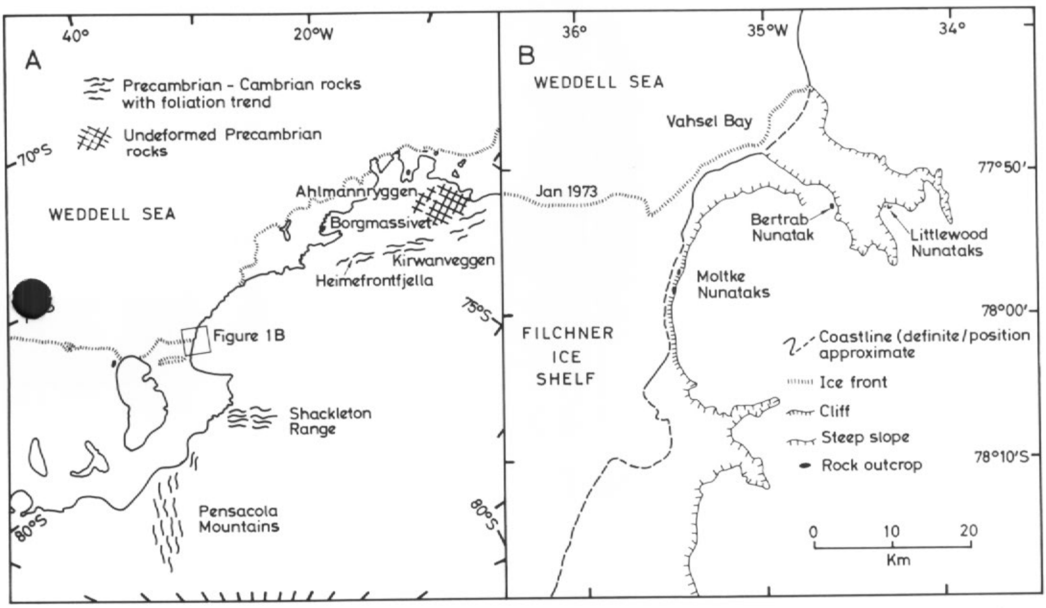

Fig. 1. A. The Weddell Sea sector of Antarctica, showing the area described and the nearest outcrops of Precambrian – lower Palaeozoic rocks. B. Sketch map of north-western Coats Land showing ice features and the position of rock exposure visible in 1978.

Renner, 1983). The outcrops shown in Fig. 1 B were the only ones visible in November 1978: Moltke Nunataks are windows in an ice cliff and only two of the four outcrops mapped 20 years previously were present; Littlewood Nunataks are a group of four low exposures as illustrated by Aughenbaugh and others (1965 Pl. 1a).

Earlier publications have shown discrepancies in the positioning of Bertrab Nunatak:

(i) Filchner (1922), 77° 55′ S, 34° 30′ W.
(ii) Teruggi (1955), 78° 00′ S, 34° 00′ W.
(iii) Aughenbaugh and others (1965), 77° 55′ S, 34° 32′ W and situated 'approximately 10 km to the south west [of Littlewood Nunataks]'.
(iv) Alberts (1981), 77° 55′ S, 34° 32′ W, but situated west-south-west of Littlewood Nunataks.
(v) HMSO (1982), 77° 55′ S, 34°32′ W.
(vi) Toubes Spinelli (1983) 77° 44′ S, 34° 48′ W.

The nunatak visited in 1978 was the one shown as Bertrab Nunatak in the sketch map of Aughenbaugh and others (1965, fig. 2). It is the largest of two areas of broken outcrop on the top and flank of an east-north-east facing ice scarp (Figs. 2 and 3). From Fig. 1B its co-ordinates are 77° 53′ S, 34° 38′ W, *c.* 7 km to the west of Littlewood Nunataks.

It was suggested by Aughenbaugh and others (1965) that the rock samples from Bertrab Nunatak described by Cordini (1959) actually came from one of the Moltke Nunataks. The morphology and geology of the nunatak illustrated by Cordini (1959, fig. 16) have recently been described in detail by Toubes Spinelli (1983), who quotes a position *c.* 15 km north of the co-ordinates given here. The description given by

Fig. 2. Bertrab Nunatak and satellite outcrops from the air, seen from the east-north-east.

Fig. 3. Bertrab Nunatak and satellite outcrops from the air viewed from the north-north-west.

Toubes Spinelli is consistent in detail with the features of the nunatak visited by PDM and despite the discrepancy in position, the authors suggest that it refers to the same locality.

In 1978 no exposure was seen from the air in the ice scarp near the position given by Toubes Spinelli, nor was rock visible along a continuation of the same scarp 10 km north-east of Littlewood Nunataks, where exposures are shown on *British Antarctic Territory 1:3000000* BAS (Misc) 2, Edition 1 (British Antarctic Survey, 1981). It is possible that, as in the case of Moltke Nunataks, some outcrops described before are no longer exposed but the authors are not aware of any other reports that corroborate the existence of these particular exposures.

Geology

The dominant lithologies at Bertrab and Littlewood nunataks are massive, brick red, oligoclase-phyric rocks of granitic composition (Teruggi, 1955; Cordini, 1959; Lounsbury and others, 1963; Aughenbaugh and others, 1965). At Bertrab Nunatak they are intruded by fine-grained basic and acid dykes (Cordini, 1959; Toubes Spinelli, 1983). Air observations made in 1978 show that Moltke Nunataks are also composed of massive brick-red rocks, apparently intruded by sheets of dark green or black rock.

A 'crystalline limestone' from Bertrab Nunatak described by Teruggi (1955) was suggested by Stephenson (1966) to be a local vein, but the authors concur with Cordini (1959, p. 118) that it is probably not present in outcrop.

The main lithology at Bertrab Nunatak is a massive brick red granophyre (average grain-size 0.7 mm) as described by Cordini (1959, pp. 141–43). The samples collected (Z. 1280. 1, 8, 9) were considered representative and, like those of Cordini (1959) and Teruggi (1955) but not that of Toubes Spinelli (1983, sample M. 1), all are oligoclase-phyric. Additional features noted in the BAS samples of the granophyre are:

(i) The presence of a few small (< 15 mm diameter) rounded, finer-grained enclaves in a sample from the top of the nunatak (Z. 1280. 9). These range in grain-size from < 0.1 to 0.5 mm, are generally even-grained and usually have a higher proportion of ferromagnesian minerals than the granophyre. Graphic textures and alkali-feldspar are normally absent. Plagioclase forms partially radiating aggregates in one enclave and an essentially mafic-free zone (1 mm wide) of plagioclase crystals in random orientation surrounds one of the larger biotite/chlorite-rich enclaves. A very fine-grained (< 0.1 mm) leucocratic enclave speckled with small grains of hornblende and biotite contains glomeroporphyritic aggregates of plagioclase.

(ii) Some of the plagioclase phenocrysts occur as glomeroporphyritic aggregates and sparse phenocrysts of hornblende are also present.

(iii) Plagioclase phenocrysts with multiple zoning (1–4 mm) and surrounded by a narrow corona of microperthite, although not common, occur in specimens from the top and bottom of the outcrop (Z. 1280. 1, 8).

The granophyre is intruded by a dyke-like body, 1–2 m in width, of flow-banded rhyolite (Z. 1280. 3–6), which the authors correlate with sample M. 2 of Toubes Spinelli (1983). Three specimens have a very fine-grained (< 0.1 mm), locally spherulitic groundmass and sparse subhedral, stubby phenocrysts (1–2 mm) of microcline-microperthite and, rarely, plagioclase. A fourth specimen has a mottled texture with very fine-grained veins of quartz cross-cutting clots of both microcrystalline and fine-grained (0.2 mm) quartzo-feldspathic minerals; small aggregates of olive-brown biotite are also present.

The granophyre is cut by a north-west trending, fine-grained basic dyke, believed to be the spessartite of Cordini (1959, p. 143) and Toubes Spinelli (1983, sample M. 4). It is an andesine-hornblende-biotite rock with a subhedral intergranular texture and rare anhedral phenocrysts (1–3.5 mm) of altered plagioclase; rare clots of blue-green hornblende (2–3 mm), surrounded by areas of plagioclase with only minor amounts of hornblende and no mica, are also present. Since the rock lacks many of the petrographic features typical of lamprophyres (Rock, 1977), i.e. it is sparsely porphyritic, has phenocrysts of plagioclase but not of mafic minerals and does not have a panidiomorphic texture, the rock is referred to here as an altered microdiorite rather than a lamprophyre. However, the chemical analysis published by Cordini (1959, table p. 140) suggests that it does have some alkaline affinities. Toubes Spinelli (1983) showed this dyke to be cut by a more porphyritic dyke of similar petrography and an acid sheet.

A highly altered dark rock (Z. 1280. 2) occurs within the granophyre near the north of the exposure but its field relationships were obscured by snow. It has abundant plagioclase phenocrysts (1–4 mm) replaced by epidote and some calcite, and less common chlorite pseudomorphs of a ferromagnesian mineral embedded in a matrix of feldspar microlites, chlorite, iron ore, epidote and sphene. Small areas (3–6 mm across) showing trachytic texture are probably microxenoliths. The sample has a larger inclusion with matrix and phenocrysts similar to those of the host and abundant, mainly chlorite-filled amygdales.

The ferromagnesian phases in all the samples show evidence of late- or post-magmatic alteration. In many, biotite appears to have formed during the recrystallization of hornblende. Except in the microdiorite, hornblende and other identifiable ferromagnesian minerals are partially or wholly replaced by chlorite; plagioclase is usually turbid and partially sericitized. Epidote and sphene are present as secondary minerals. There is no evidence, however, that the rocks have suffered regional metamorphism and the magmatic minerals show little evidence of deformation.

Discussion

Contrary to Aughenbaugh and others' (1965) conclusion that the 'rhyolite porphyry' from Littlewood Nunataks is the same as the 'granitic porphyry' described by Cordini (1959) from Bertrab Nunatak, the authors believe that the predominant rocks at the two localities are petrologically distinct. From the description given by Aughenbaugh and others (1965), it appears that the rhyolite forming Littlewood Nunataks is similar to the rhyolite intruding the granophyre at Bertrab Nunatak. However, the inference that the rocks are cogenetic is supported by a Rb/Sr isochron of 1023 ± 16 Ma (at $\lambda = 1.42 \times 10^{-11}$ a^{-1}) obtained by Eastin and Faure (1971) from the combined samples of Cordini (1959) and Aughenbaugh and others (1965).

It is possible therefore that the outcrops of the *c.* 1000-Ma-old 'Littlewood Volcanics' (Aughenbaugh and others, 1965) are mainly relatively high-level intrusive, rather than extrusive, rocks. The lack of deformation or metamorphism and a K-Ar age of 840 ± 30 Ma from Littlewood Nunataks (Aughenbaugh and others, 1965) indicate that the Cambro-Ordovician tectonic and thermal events recorded in many parts of east Antarctica (see reviews by Elliot, 1975, and James and Tingey, 1983) had little effect in the area.

Knowledge of the other Precambrian rocks cropping out around the Weddell Sea sector of the continent (Fig. 1A) has advanced greatly since the earlier work in the Bertrab–Littlewood nunataks area. The only large areas known to be free from the effects of lower Palaeozoic deformation are Ahlmannryggen and Borgmassivet, which have been part of a stable platform since the early Proterozoic (Neethling, 1972; Wolmarans and Kent, 1982). Extensive intrusive activity in this area (the 'Littlewood episode' of Neethling, 1972) occurred at the same time as at the Bertrab–Littlewood nunataks, although the products were in general more mafic and the initial strontium istope ratios higher (T. P. Elworthy, in Wolmarans and Kent, 1982; Barton and Copperthwaite, 1983).

In Kirwanveggen the oldest rocks dated are of acid igneous composition and give the same Rb-Sr age as the samples of Eastin and Faure (1982) from the Bertrab–Littlewood nunataks (T. P. Elworthy, in Wolmarans and Kent, 1982). The initial strontium isotope ratios are also the same and indicate minimal involvement of crustal material older than *c.* 1200 Ma. However, the dated event is a high-grade metamorphism. The situation appears similar in Heimefrontfjella (R. J. Pankhurst, in British Antarctic Survey, 1983, p. 29). In the Shackleton Range, early Proterozoic gneisses and younger supracrustal rocks were reworked in the late Precambrian and early Palaeozoic (Grew and Halpern, 1979; Pankhurst and others, 1983). No evidence of intrusive activity at *c.* 1000 Ma has been detected but there is evidence for a sedimentary provenance of that age. In the Pensacola Mountains a thick turbidite sequence contains interbedded basic lavas and is intruded by dolerite sills and minor felsic plugs and sills (Schmidt and Ford, 1969; Elliot, 1975); Eastin and others (1969) reported an age of 953 ± 175 Ma (? 973 Ma at $\lambda = 1.42 \times 10^{-11}$ a^{-1}) for the Gorecki rhyolite. No older 'basement' crops out in the area.

The 'Littlewood Volcanics' are thus part of a varied and widespread episode of magmatic and tectonic activity at *c.* 1000 Ma, the palaeogeography of which is now becoming better defined. During the late Precambrian and early Palaeozoic the area appears to have lain to the north of east-west trending zones of deformation within the continent, represented by Kirwanveggen and the Shackleton Range, and was to the east of the extrapolated trend of mobile belts along the continental margin, represented by the Pensacola Mountains. It may be part of the 'stable platform' of western Dronning Maud Land which Wolmarans and Kent (1982) suggested was continuous with similar areas in southern Africa before the breakup of Gondwana.

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