THE GEOLOGY OF MATTHEWS ISLAND, SOUTH ORKNEY ISLANDS

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ABSTRACT. The Mesozoic Spence Harbour Conglomerate unconformably overlies a contorted and brecciated group of quartz-mica-schists and graphite-schists on Matthews Island, South Orkney Islands. A basic dyke which cuts the conglomerate is described petrographically.

MATTHEWS ISLAND (lat. 60°45′S., long. 45°09′W.), which is the largest and northernmost of the Robertson Islands group, is situated off the south-eastern tip of Coronation Island, South Orkney Islands (Fig. 1A). It is separated from the larger island by a narrow gap known as The Divide (now bridged by a small sand bar) and it has a considerably lower relief than that of Coronation Island (Fig. 2); this suggests that The Divide is the site of an old glacially eroded fault plane. Matthews Island itself is a low arcuate ridge with four rocky peaks (186–351

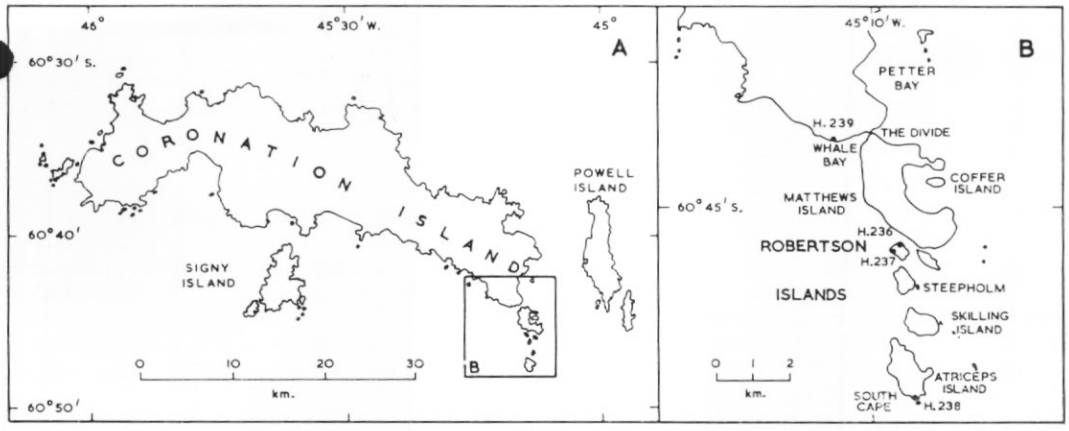

Fig. 1. A. Sketch map of the western South Orkney Islands, indicating the relative positions of the Robertson Islands and Coronation Island.
B. Sketch map of the Robertson Islands showing the place-names and station numbers.

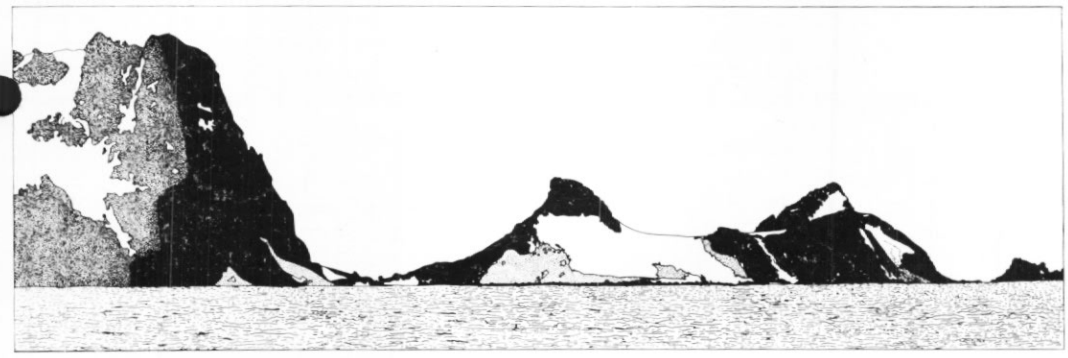

Fig. 2. Panorama of Matthews Island (centre) and the south-eastern tip of Coronation Island (left) viewed from the west; The Divide is the narrow gap between the two islands. Note the difference in topography on either side of The Divide and the areas of scree (light stipple) beneath the ice cover on Matthews Island. The graphite-schists (H.2207) were collected at the rock/scree junction on the north-western coast of Matthews Island. (Drawn from photographs by K. D. Holmes.)

m. in height) projecting through a permanent cover of ice and snow. During 1949 this ice formed 30 m. high ice cliffs at the east coast of the island (unpublished field notes of D. H. Maling) but now it is shrinking and most of the ice rests on rock at sea-level (Holmes, 1965). Lateral moraines were recorded at several ice/rock junctions during 1965.

Although it is small and of relatively low topography, Matthews Island has been visited by scientists on several occasions. Geological specimens were not collected until D. H. Maling visited the Robertson Islands during July and August 1949 and again when K. D. Holmes and D. W. Matthews spent a few days on Matthews Island at the beginning of 1965.

Geology

The Robertson Islands are composed of a succession of contorted and brecciated quartz-mica-schists, belonging to the metamorphic complex of the South Orkney Islands (Matthews, 1959; Matthews and Maling, 1967; Thomson, 1968), overlain unconformably by a sequence of Mesozoic conglomerates and sandstones. The conglomerates are assumed to be equivalent to the Spence Harbour Conglomerate of Coronation Island (Pirie, 1905; Matthews, 1959), but their relationship to the schists is obscure since the only recorded contacts of the two rock successions in the Robertson Islands are scree-covered and inaccessible (stations H.236, 237 (Fig. 1B) and 2207 (Fig. 3)). A discovery of stratigraphical importance is the dolerite dyke which cuts the conglomerate at one locality on Matthews Island; previously the dykes of the South Orkney Islands were thought to pre-date the conglomerates (Matthews, 1959, p. 429; Adie, 1964, p. 127).

Schists

Station H.2207 (Figs. 2 and 3), a small scree-covered outcrop on the north-western coast of Matthews Island, is the only known locality for metamorphic rocks on the island. The outcrop occurs between 45 and 90 m. above sea-level where a (?) thrust separates the schists from the overlying conglomerates and it is bounded on one side by a post-thrust fault. The schists, which have a varying lithology (e.g. *quartz-mica-schists* and *micaceous graphite-schists*), are generally irregularly contorted, but approximately 30 m. below the (?) thrust plane the contortions become tight isoclinal folds with an axial lineation striking at 150° (unpublished field notes of D. W. Matthews).

Non-fissile schists underlie the Spence Harbour Conglomerate on the northern and western coasts of the small island south-west of Matthews Island. These are either dark greenish grey brecciated schists (H.236.1) which resemble conglomerates in the hand specimen or they are extensively sheared thinly laminated *quartz-albite-chlorite-muscovite-schists* (H.237.1 and 2) which have been retrogressively metamorphosed and which contain relict garnet porphyroblasts. The thinly laminated schists are comparable to the non-fissile quartz-albite-muscovite-biotite-schists of Coronation Island (H.239.1) (the latter, however, have only undergone slight retrograde metamorphism) and they are also similar to the schists and semi-schists of Powell Island (Thomson, in press). Unfortunately, the absolute age of the metamorphic complex is not known, although earlier workers have always referred it to the (?) Precambrian.

Spence Harbour Conglomerate

The conglomerates of Matthews Island form a sequence of massive beds (2–3 m. in thickness in the north) separated by thin, often discontinuous bands of sandstone and siltstone. The conglomerate units gradually decrease in thickness and grain-size southwards, where they pass into thick sandstones and siltstones separated by 1 m. thick beds of fine-grained conglomerates. These sediments dip gently to the east and south-east with the result that the conglomerates crop out at sea-level on the south coast of Matthews Island but not below an altitude of 45–90 m. on the north-west coast.

In appearance and detrital content, the *conglomerates* resemble the Spence Harbour Conglomerate of Coronation Island (Matthews, 1959) and they have been referred to this formation. They are typically pebble grade (the clasts are 20–60 mm. in diameter) and pale grey in colour but cobble conglomerates are widespread in northern Matthews Island and boulder-sized clasts are also restricted to the north (Fig. 3). Bedding in the conglomerates is indicated by horizons

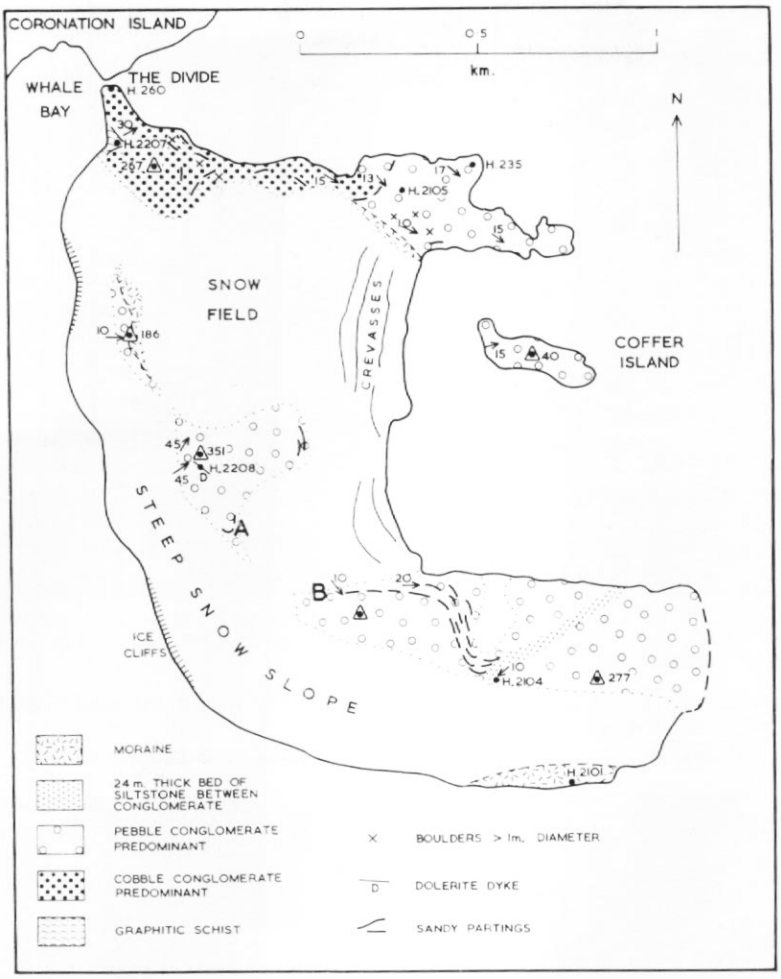

Fig. 3. Geological sketch map of Matthews Island showing the distribution of rock types and the approximate positions of the geological stations. Heights are in metres. Localities A and B are described in the text. (Compiled from a field map by K. D. Holmes.)

of coarse detritus passing into 0·3–0·6 m. thick bands of finer-grained debris. Most of the detritus is schistose (Fig. 4). Flat, rounded or sub-angular clasts of quartz-mica-schist, graphitic quartz-mica-schist and micaceous quartzite predominate in the specimens studied in the laboratory but a few clasts of amphibolite, marble and pink garnetiferous gneiss (identical to specimens from Saunders Point, Coronation Island) were recorded during the field work; all of the schist clasts observed are similar to the fissile micaceous schists of Coronation Island and they are unlike the brecciated schists immediately beneath the conglomerate. The conglomerates also contain abundant small rounded pebbles of vein quartz and most of them have a sandy matrix composed of quartz, mica, garnet and small schist fragments; the conglomerate at station H.2104 is unusual because it has a calcareous cement. Carbonized and pyritized plant stems are common only in the cobble conglomerates (unpublished field notes of K. D. Holmes), and sporadic limonite-staining of the phenoclasts is restricted to the northern outcrops. Coal

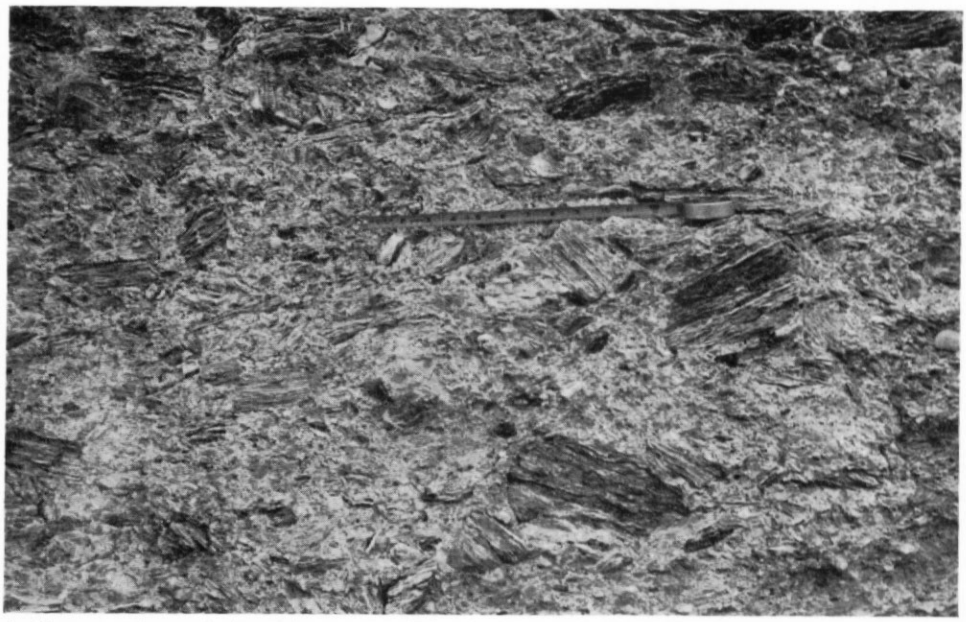

Fig. 4. Close-up of a typical conglomerate unit in the Spence Harbour Conglomerate of Matthews Island. Note the abundance of flat sub-angular fragments of schist. The scale is 12 in. (0·30 m.) in length. (Photograph by K. D. Holmes.)

horizons, approximately 1·5 cm. in thickness, occur in some of the more sandy beds (unpublished field notes of K. D. Holmes).

Sandstone and *siltstone* beds between the conglomerates are usually thin (Fig. 5) but an

Fig. 5. A thin parting of flaggy sandstones between pebble conglomerates on Matthews Island. The scale is 12 in. (0·30 m.) in length. (Photograph by K. D. Holmes.)

unusually thick sequence (24 m.) of laminated sandstones and siltstones occurs in southern Matthews Island (Figs. 6 and 7). This is by far the thickest known sequence of fine-grained sediments in the younger rocks of the South Orkney Islands. The rock specimen from this locality (H.2104) is a fine-grained (0·1–0·2 mm.) micaceous sandstone with a calcareous cement, whereas the sandstones from farther north are non-calcareous and slightly coarser-grained (0·5–1·5 mm.). Most of the sediments are well-sorted but pebble-size clasts occur sporadically in the sequence at station H.2104. The detritus, which was derived mainly from the metamorphic complex of Coronation Island, comprises irregular and sub-angular grains

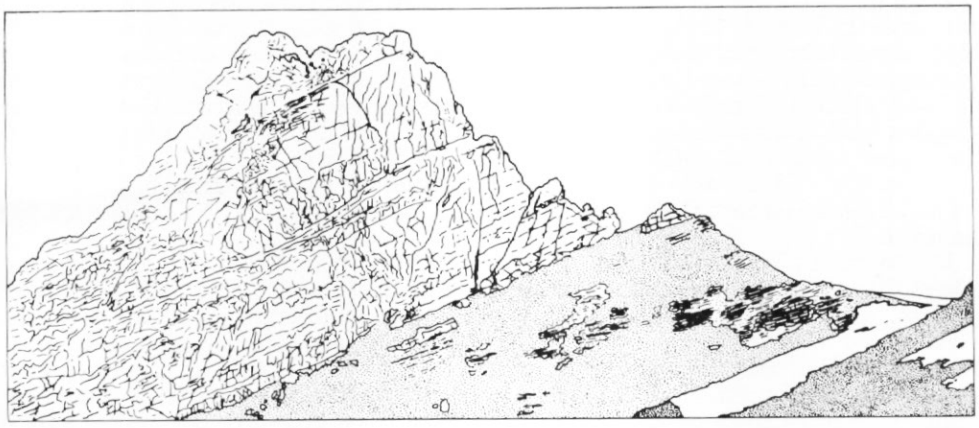

Fig. 6. The 24 m. thick sequence of sandstones and siltstones overlain by massive conglomerates at station H.2104, Matthews Island. The fine-grained sediments are partially covered by scree (stipple). (Drawn from photographs by K. D. Holmes.)

Fig. 7. Close-up of the flaggy and laminated sediments shown in Fig. 6. The hammer shaft is 38 cm. in length. (Photograph by K. D. Holmes.)

of quartz and flakes of muscovite (commonly including specks and clots of graphite) associated with less common fragments of garnet, epidote, plagioclase, chlorite, biotite, apatite and clinozoisite.

Although sedimentary structures are generally absent from the Spence Harbour Conglomerate and no current bedding was observed anywhere, ripple marks striking at 160° were recorded in certain beds of flaggy sandstone at locality A (Fig. 3). Fossils are similarly rare and the only ones that have been found *in situ* (Fig. 3, locality B) are fragmentary plant remains. Blocks of micaceous sandstone (derived from station H.2104) in the moraine at station H.2101 have yielded a few fragmentary ammonites, a small number of poorly preserved bivalves and some fossil plants (stems and roots). The ammonites are possibly Cretaceous in age (personal communication from M. R. A. Thomson), whereas the plant-bearing sandstone boulders are lithologically similar to the plant-bearing sandstones on Powell Island which have been tentatively assigned to the Lower Jurassic (Thomson, 1971). Another poorly preserved invertebrate fauna was collected from a thin shale bed beneath the Spence Harbour Conglomerate of Coronation Island (this shale has so far only been seen at one locality) and it has been referred to the Upper Cretaceous (Matthews, 1959, p. 429). However, the lack of well-preserved fossils from any of the South Orkney Islands prevents a direct correlation of the Powell Island and Spence Harbour Conglomerates, and it is not possible to give a definite age to any of the rocks.

K. D. Holmes estimated that there were possibly more than 200 m. of conglomerates on Matthews Island but the thickness of the sediments elsewhere in the Robertson Islands is not known. The conglomerates dip gently to the east and the south in the southern islands and horizontal beds have been recorded in a few places (unpublished field notes of D. H. Maling). The coarse conglomerates at South Cape, Atriceps Island (Fig. 1B), contain large schist blocks 1–15 m. in diameter; it seems as if the gradual decrease in grain-size of the sediments which Holmes noticed on passing from the northern to the southern coast of Matthews Island does not continue throughout the Robertson Islands.

Minor intrusion

The only intrusive rock recorded on Matthews Island is a vertical dolerite dyke (approximately 9 m. in width) situated on the ridge a short distance south of the island's highest peak (351 m.). This dyke, which cuts the conglomerates, has a west–east trend similar to that of one at Cape Hansen, Coronation Island, and it is petrographically similar to this and the other dolerite dykes of Coronation Island. Like the latter, the Matthews Island dyke is a dark greyish green colour due to secondary chlorite and it decreases in grain-size from its centre (1–2 mm.) to the chilled margin (0·1–0·5 mm.); feldspar and pyroxene phenocrysts, although uniform in size (1–2 mm.) throughout the dyke, are concentrated mainly in the chilled margin.

The dolerite has an intergranular texture with small well-defined laths of *plagioclase*, originally labradorite (An_{60}), and interstitial crystals of pyroxene associated with secondary and accessory minerals. The phenocrysts occur either singly or as glomeroporphyritic aggregates. Both the groundmass plagioclase and the phenocrysts have been replaced by a cloudy aggregate of light green chlorite associated with some sericite, calcite and albite or they have been patchily albitized. A few of the phenocrysts are zoned and most of the feldspar is twinned according to the Carlsbad or albite laws; phenocrysts completely enclosing smaller crystals of plagioclase and pyroxene are rare. The *pyroxene* is a colourless or very pale brown augite ($2V\gamma = 55°$; $\gamma:c = 38°$) which occurs as irregular crystals in the groundmass or as long thin prismatic phenocrysts. Although it is much fresher than the plagioclase, it is marginally altered to either a colourless fibrous *amphibole* ($\gamma:c = 15°$) or a tabular green hornblende ($\gamma:c = 18°$) and chlorite. Several large crystals have been pseudomorphed by a slightly pleochroic yellow-green *chlorite* and originally these were identified as pseudomorphed orthopyroxenes. However, a few of the augite phenocrysts have a central band of this yellow-green chlorite and, in the absence of relict crystals, the dolerite is assumed to be deficient in orthopyroxene.

The light green chlorite in the groundmass is associated with small flakes of brown *biotite* and minute specks of iron ore. Skeletal crystals of *titanomagnetite* are present in the dolerite specimens from the centre of the dyke and these have been partially replaced by a corona of "leucoxenic sphene"; the dolerite from the marginal part of the dyke has partially haematitized

iron ore. Altered fibrous, sometimes fern-like aggregates of *quartzo-feldspathic* material fill the interstices of the coarser-grained dolerite specimens, whereas small interstitial grains of quartz are present in the porphyritic margin of the dyke. Fresh lamellar sheaves of a colourless *zeolite* infill cavities in all of the dolerite specimens.

The microscopic characteristics of the dyke are those of a tholeiite (Yoder and Tilley, 1962, p. 353) but the chemical criteria for distinguishing between tholeiites and alkali-basalts have not yet been considered.

Summary

Although the relationship between the Mesozoic Spence Harbour Conglomerate and the schists of the metamorphic complex is not clearly defined in the Robertson Islands, the two formations appear to be separated by an undulating and south-easterly dipping plane of unconformity. The schists from stations H.236 and 237 are similar to the Powell Island schists (Thomson, in press) and more particularly to the *para*schists from the adjacent south-east coast of Coronation Island. However, the specimens were collected from within a (?) thrust or fault zone and they have undergone retrograde metamorphism to chlorite-bearing schists. The age of the schists is not known.

The Spence Harbour Conglomerate is essentially a pebble conglomerate which decreases in grain-size from the north to the south of Matthews Island. Both pebble and cobble conglomerates are interbedded with bands of sandstone and siltstone, and these are particularly important in the south-east of the island where they attain a maximum thickness of 24 m. Fossils collected from the sandstones include a poorly preserved marine invertebrate fauna of possible Cretaceous affinities and apparently older fragmentary plants. The plants indicate a proximity to land during the deposition of the Spence Harbour Conglomerate and the fact that most of the detritus was derived locally from eastern Coronation Island supports this view. Lithologically, the Spence Harbour Conglomerate is similar to the Powell Island Conglomerate (Thomson, in press) but the lack of invertebrate fossils in the latter precludes a direct correlation between the two formations.

A basic dyke intruding the conglomerates of Matthews Island is tholeiitic and petrographically similar to the dykes intruding the metamorphic complex of Coronation Island.

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