PETROGRAPHY OF METAMORPHIC ROCKS FROM THE INACCESSIBLE AND LARSEN ISLANDS, SOUTH ORKNEY ISLANDS

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ABSTRACT. The regionally metamorphosed rocks of the Inaccessible Islands are largely hornblende-plagioclase-epidote-(biotite)-schists. Their metamorphic grade lies between the albite-epidote-amphibolite and amphibolite facies, although diopsidic rocks belonging to the latter facies have been collected from the southernmost islands. The *para*schists from the Larsen Islands and Monroe Island belong to the greenschist facies and include muscovite-chlorite-(graphite)-schist, talc-schist and impure quartzite; these rocks are intruded by quartz-dolerite dykes. All of these rocks are similar to others described previously from the South Orkney and South Shetland Islands.

THE Inaccessible Islands (lat. 60°34′S., long. 46°44′W.) form the westernmost extension of the South Orkney Islands group (Fig. 1A), lying approximately 22 miles (35 km.) west of Coronation Island. There are three main islands, each less than 0·5 miles (0·8 km.) in size, and about 12 smaller islets which trend in a north-north-west to south-south-east direction. The northern large island reaches a height of 525 ft. (160 m.), the central island 740 ft. (225 m.) and the southern island 960 ft. (292 m.). The Larsen Islands (lat. 60°36′S., long. 46°05′W.) and Monroe Island (lat. 60°36′S., long. 46°03′W.) are separated from the western tip of Coronation Island by Sandefjord Bay (Fig. 1A), which is 0·5 miles (0·8 km.) wide.

On 8 December 1965, a party from R.R.S. *Shackleton* took advantage of calm weather and made landings on four of the Inaccessible Islands, from each of which P. K. Harrington collected about 12 rock specimens. This was the first substantial rock collection from these islands and, since none has been officially named, the landing points and collecting localities referred to here have been designated stations II.1, 2, 3 and 4 (Fig. 1B). During a visit in January 1967, Harrington collected nine specimens from two of the Larsen Islands (Fig. 1C, *L.2* and *L.4*) and two localities on Monroe Island (Fig. 1C, *L.1* and *L.1′*).

PREVIOUS WORK

Previous to 1965 only one rock specimen (chlorite-epidote-schist) from the Inaccessible Islands had been described in the literature (Tilley, 1935; p. 389) and this was assumed to be representative of the rocks forming these islands. The collecting locality (Discovery Investigations station 1094 (slide No. 36057)) is shown in Fig. 1B. However, the commonest rock type in the present collection is hornblende-plagioclase-epidote-(biotite)-schist, and the little chlorite that is present is generally a product of retrograde alteration of hornblende, garnet or biotite.

Tilley (1935, p. 386) has also described rocks from the Larsen Islands and he recorded the occurrence of "low-grade quartz muscovite chlorite biotite phyllites intimately penetrated by quartz veins and lenticles carrying albite". Apart from the absence of biotite, many of the rocks described here appear to be very similar to those described by Tilley. In addition, two altered doleritic dykes occur near landing point *L.2* (Fig. 1C). No dykes have previously been recorded in the Larsen Islands, although there are two specimens of altered quartz-dolerite in the collection from Sandefjord Bay, Coronation Island (Discovery Investigations station No. 1091, slide Nos. 38840 and 38892).

FIELD COLLECTIONS

The present collection includes specimens taken from the following localities in the Inaccessible Islands (Fig. 1B):

i. The north-east shore of the northernmost large island (station II.1).
ii. The small islet off the north-west point of the central large island (station II.2).
iii. The northern shore of the central large island (station II.3).
iv. The north-east shore of the southernmost large island (station II.4).

At (i), (iii) and (iv) the area covered by the collection was limited to the immediate vicinity of the landing point. The foliation apparently dips southward at angles between 30° (II.3 and 4) and 50° (II.1).

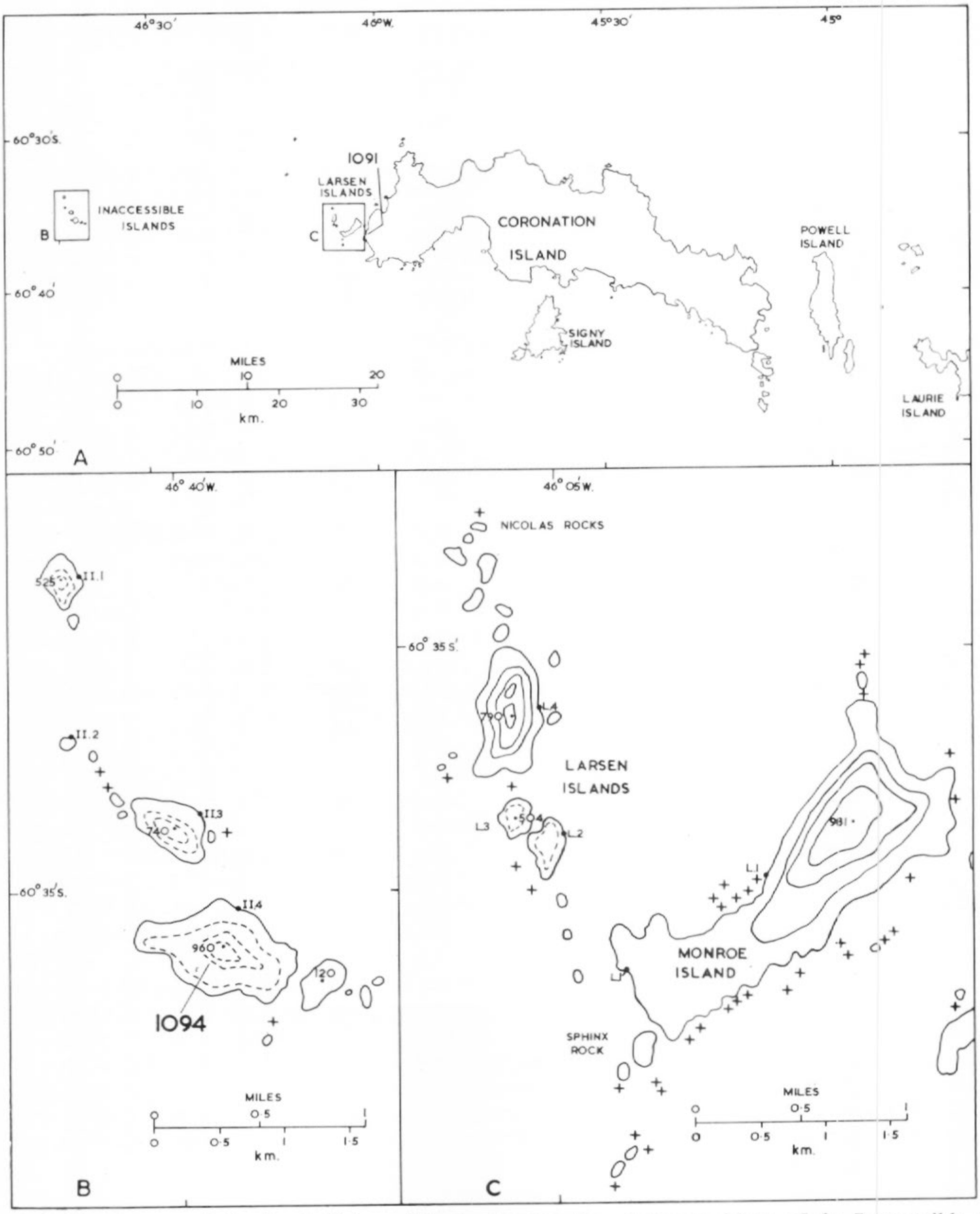


Fig. 1. A. Sketch map of the South Orkney Islands showing the relative positions of the Inaccessible and Larsen Islands. The position of Discovery Investigations station No. 1091, at Sandefjord Bay, is also shown.
B. Sketch map of the Inaccessible Islands showing the physiography and station numbers. The position of Discovery Investigations station No. 1094 is also shown.
C. Sketch map of the Larsen Islands and Monroe Island showing the physiography and station numbers. The contours are at 250 ft. (76 m.) intervals.

Collecting localities at Monroe Island and in the Larsen Islands (Fig. 1C) were as follows:

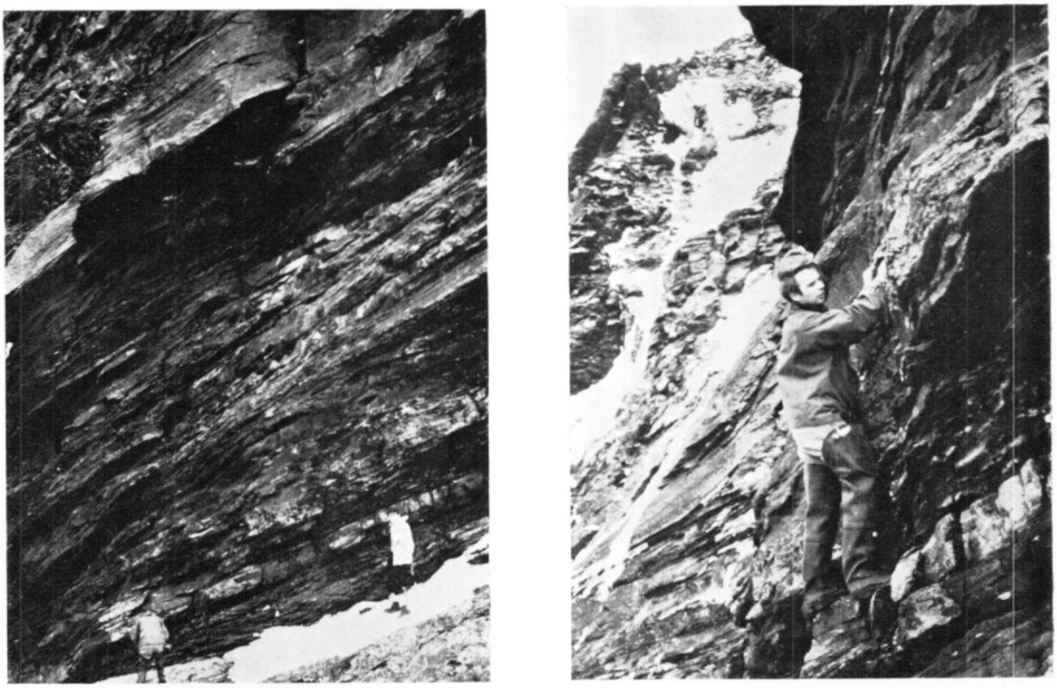
i. *L.1* on the north-west coast and *L.1′* on the west coast of Monroe Island.
ii. *L.2* on the north-east coast of the southernmost of the Larsen Islands.

iii. *L.4* on the north-east coast of the northernmost of the Larsen Islands.
No landing was made at *L.3*, but a probable dyke with the same attitude as the two dykes at *L.2* was noted in the north-east of the island.

Petrography

Inaccessible Islands

The commonest rocks collected from station II.1 are hornblende-plagioclase-epidote-(biotite)-schists and garnetiferous quartz-plagioclase-hornblende-(biotite)-schists. The vicinity of the landing point was described by Harrington as "a series of banded rocks overlying a more massive variety (Fig. 2a and b). The former are differentially weathered and consist of outstanding massive schistose bands and more shaly eroded bands. The thicknesses of individual units are of the order of six inches to one foot . . . ."



a b

Fig. 2. a. The collecting locality at station II.1, Inaccessible Islands, showing a series of relatively soft and weathered hornblende-plagioclase-epidote-(biotite)-schists interbedded with more resistant felsic bands. (Photograph by P. K. Harrington.)
b. A closer view of the collecting locality shown in Fig. 2a. Individual units vary from 6 in. to 1 ft. (15 to 30 cm.). (Photograph by P. K. Harrington.)

The nematoblastic texture of the *hornblende-plagioclase-epidote-(biotite)-schists* (II.1.1, 6,7) is similar to that of the rocks at station II.2 (cf. Fig. 3d). Aligned hornblende crystals (α = straw-brown, β = blue-green, γ = green-brown; $\gamma{:}c = 22°$) form the bulk of the rock and they are sometimes twinned. Epidote and rutile may be included in the hornblendes, which are frequently altered to biotite. Over small areas, biotite often replaces hornblende as the main mafic mineral. Granular epidote crystals are concentrated in parallel bands up to 1 mm. thick, or are included in sub-circular or elliptical areas of plagioclase ($Ab_{73}An_{27}$) (cf. Fig. 3c), together with minor quartz, hornblende and biotite. The saussuritized plagioclase often has vermicules of albite associated with it, and it contains blebs of quartz. Zoning is

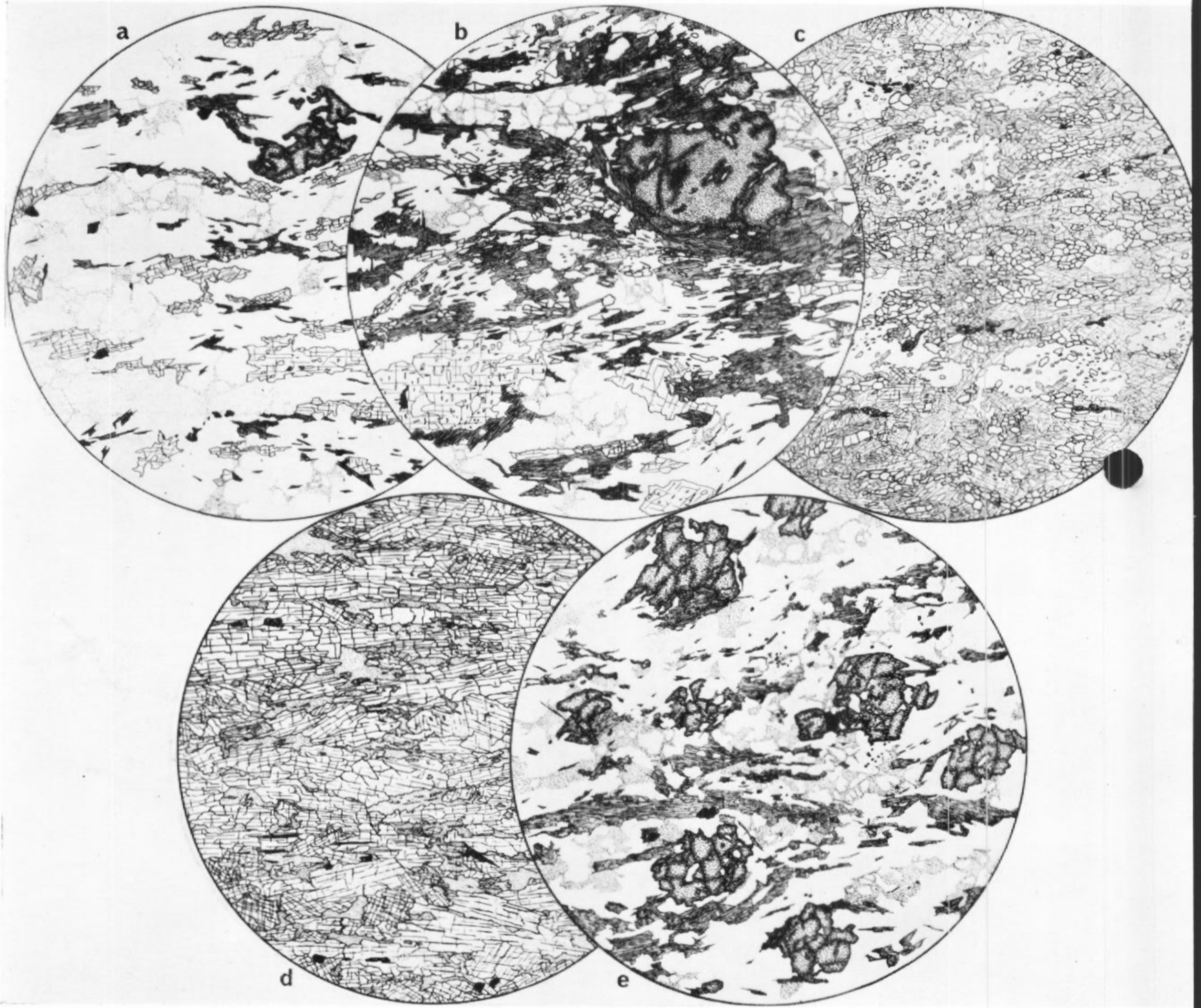


Fig. 3. Micro-drawings of schists from the Inaccessible Islands (×16·5).
a. Garnetiferous quartz-plagioclase-hornblende-(biotite)-schist (II.1.2).
b. Garnetiferous biotite-plagioclase-quartz-hornblende-schist showing large porphyroblasts of garnet and hornblende filled with small inclusions of quartz (II.1.4).
c. Hornblende-plagioclase-epidote-schist showing poikiloblastic plagioclase porphyroblasts and strings of rutile. Drawn in the *ab* crystallographic plane of the hornblende crystals (II.2.1).
d. A non-chloritic part of a hornblende-plagioclase-chlorite-schist showing the general texture of the hornblende-plagioclase-schists. The hornblende-plagioclase-epidote-(biotite)-schists have a similar texture but the plagioclase is usually poikiloblastic. Drawn in the *ac* crystallographic plane of the hornblende crystals (II.2.5).
e. Quartz-plagioclase-biotite-garnet-schist (II.4.6).

confined either to the margins of the plagioclase porphyroblasts or to the area immediately adjacent to an inclusion. Closely associated with the abundant iron ore (ilmenite, iron pyrites and haematite) are elongated aggregates of dark brown rutile with small amounts of sphene. Occasionally there are larger sphene crystals, and rutile is absent. Apatite and calcite are accessory.

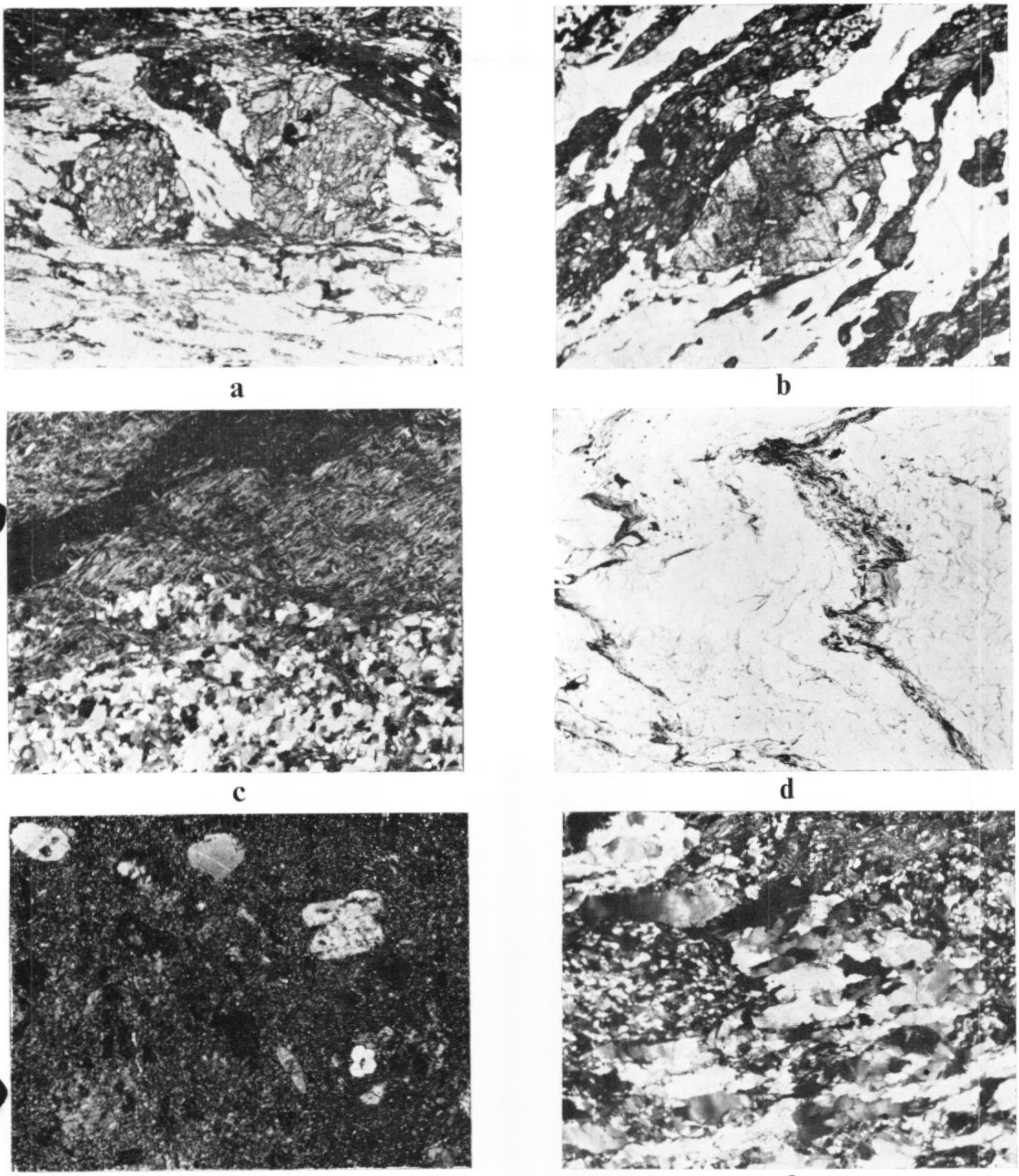


Fig. 4. a. Garnetiferous biotite-plagioclase-quartz-hornblende-schist with quartz-filled garnet porphyroblasts; station II.1, Inaccessible Islands (II.1.4; ordinary light; ×12).

b. A rhombic porphyroblast of (?) zoisite with quartz inclusions in a quartz-plagioclase-hornblende-garnet-schist; station II.4, Inaccessible Islands (II.4.7; X-nicols; ×38).

c. Muscovite-rich band in a quartzose muscovite-chlorite-graphite-schist showing the herringbone texture. The band contains a thin segregation of chlorite (black); station *L.1′*, Monroe Island (L.*1′*.1; X-nicols; ×6·4).

d. Contorted segregations of graphite in an impure quartzite, with subordinate muscovite and iron pyrites; station *L.2*, Larsen Islands (L.2.1; ordinary light; ×4·8).

e. An altered doleritic dyke rock with black pseudomorphs after plagioclase and fresh twinned phenocrysts of pigeonitic augite; station *L.2*, Larsen Islands (L.2.2; X-nicols; ×5·9).

f. An impure quartzite showing fine-grained crush zones containing muscovite, chlorite, calcite and some plagioclase; station *L.4*, Larsen Islands (L.4.2; X-nicols; ×6·9).

The *garnetiferous quartz-plagioclase-hornblende-(biotite)-schists* (II.1.2,3,5,9; Fig. 3a) contain varying proportions of nematoblastic hornblende set in a fine-grained quartz-plagioclase mosaic. The plagioclase ($Ab_{69}An_{31}$) forms small rounded crystals, the majority of which are untwinned and unzoned. Cloudiness is due to innumerable specks of iron ore. Subrounded or elongated crystals of quartz often possess an undulatory extinction. The xenoblastic hornblende crystals (α = straw-brown, β = olive-green, γ = blue-green; $\gamma{:}c = 15°$) average 0·50 by 0·15 mm., although larger crystals reach 2·5 by 0·5 mm. and they usually contain numerous small inclusions of quartz and plagioclase. The orientation of the inclusions is generally controlled by the cleavage of the host hornblende. Narrow bands of bent and ragged biotite flakes, sometimes altered to chlorite, occur in some of the schists, with minor calcite and serpentine. Rare hypidioblastic almandine crystals (0·5 mm. in diameter) contain minute inclusions of quartz and dusty particles together with some chlorite. Idioblastic iron pyrites crystals are often surrounded by a narrow rim of haematite, and ilmenite forms skeletal crystals. Other accessory minerals include apatite, sphene, epidote and olive-green tourmaline. Micro-folding with a wave-length and amplitude of about 2 cm. is present in specimen II.1.5, and in a 1·5 mm. band the hornblende content decreases to below 5 per cent, resulting in an epidotic quartzite.

The coarser-grained *garnetiferous biotite-plagioclase-quartz-hornblende-schists* (II.1.4; Figs. 3b and 4a; Table I) show a tendency for segregation of mafic from felsic minerals, and quartz also forms narrow parallel veins. Numerous porphyroblasts of garnet, plagioclase and poikiloblastic hornblende considerably deflect the schistosity. The well-shaped garnet crystals (maximum diameter of 2 mm.) contain inclusions of quartz, plagioclase and epidote, which occasionally form sigmoidal lines but are usually orientated concentrically with the margins of the porphyroblasts. The elliptical areas of plagioclase are similar to those of the hornblende-plagioclase-epidote-schists but the inclusions are generally aligned (but not necessarily parallel to the schistosity). Biotite is the only significant non-porphyroblastic mafic mineral and bands of granular epidote are present particularly in these biotite-rich areas. The accessory minerals include calcite, apatite, iron pyrites, haematite and tourmaline.

Quartz veins are common in the schists and their interlocking quartz crystals (average 1 mm.) contain occasional plates of muscovite. Calcite inclusions and lenses of hornblende-plagioclase-epidote-schist are numerous.

The rocks from station II.2 are almost exclusively *hornblende-plagioclase-epidote-schists* (II.2.1,2,3,4,5,6,8; Fig. 3c; Table I) which may exhibit micro-folding. In specimen II.2.3 the plagioclase contains minute black inclusions which are concentrated in alternate twin lamellae and are orientated at right-angles to their length. Fan-shaped aggregates of anthophyllite crystals form a narrow band, and epidote (pistacite) crystals are sometimes yellow-green with a darker core. Larger crystals of clinozoisite (up to 1 mm.) are usually zoned.

Specimen II.2.4 contains an appreciable amount of calcite, and the actinolitic hornblende has altered to stellate aggregates of fibrous actinolite. Bands of epidote are very common but sericitized plagioclase is fairly infrequent.

Specimen II.2.5 is the only example of a *hornblende-plagioclase-chlorite-schist* (Fig. 3d; Table I) in the collection. Parallel, bladed actinolitic hornblende crystals (α = straw-brown, β = pale blue-green, γ = pale green; $\gamma{:}c = 20°$) are surrounded by recrystallized sodic andesine. Twinning in the plagioclase is generally indistinct or absent but multiple twinning is sometimes present. In certain bands the areas of plagioclase contain a high proportion of strongly aligned pale green chlorite (penninite). The frequently twinned penninite crystals (maximum 3·0 by 0·1 mm.) are often curved and strained, and in these chlorite areas hornblende has been replaced by biotite. Rutile crystals reach 1 mm. in length.

The *garnetiferous plagioclase-hornblende-quartz-biotite-schists* (II.2.9; Table I) resemble the rocks from station II.1 (II.1.4; Fig. 3b; Table I), but there are slight differences in the relative proportions of hornblende and biotite, and garnet is infrequent.

The *plagioclase-epidote-hornblende-diopside-schists* (II.2.7) have a prominent banding due to segregations of dark green amphibole and light green pyroxene. Lenses of plagioclase ($Ab_{67}An_{33}$; 1–4 mm.) are more frequent in the diopsidic bands and each one consists of a mosaic of smaller crystals. Both primary and secondary twinning are fairly widely developed and most of the plagioclase shows a patchy form of extinction. Besides general sericitization

TABLE I. MODAL ANALYSES OF METAMORPHIC ROCKS FROM THE INACCESSIBLE AND LARSEN ISLANDS, SOUTH ORKNEY ISLANDS

	II.2.1	II.2.5	II.3.4	II.2.9	II.1.4	II.4.6	II.3.3	L.2.1	L.2.3
Quartz	0·9	tr	0·4	16·4	23·5	36·1	3·2	72·2	1·0
Plagioclase	28·7	28·9	38·9	38·8	28·5	35·8	35·6	—	0·5
Hornblende	52·9	56·8	57·4	32·2	7·0	—	15·2	—	—
Diopside	—	—	—	—	—	—	21·8	—	—
Tremolite-actinolite	—	—	—	—	—	—	—	—	5·8
Epidote	14·8	0·2	—	tr	4·6	—	22·2	—	—
Chlorite	0·1	11·4	—	0·2	—	tr	—	4·7	0·9
Talc	—	—	—	—	—	—	—	—	68·0
Muscovite	—	—	—	—	—	1·0	—	13·4	—
Biotite	0·2	1·0	—	10·5	31·0	20·1	—	—	—
Garnet	—	—	—	1·2	4·0	6·7	—	—	—
Calcite	tr	tr	—	—	1·1	—	0·2	—	2·6
Sphene	0·5	—	1·2	—	—	tr	1·7	—	15·6
Rutile	1·9	1·6	0·5	0·1	—	tr	0·1	—	—
Apatite	—	tr	tr	tr	0·1	tr	tr	—	—
Tourmaline	—	—	—	—	tr	0·1	—	—	—
Iron ore	—	0·1	1·6	0·6	0·2	0·2	tr	0·8	—
Graphite	—	—	—	—	—	—	—	8·9	5·6

tr Trace.

II.2.1 Hornblende-plagioclase-epidote-schist; station II.2, Inaccessible Islands.
II.2.5 Hornblende-plagioclase-chlorite-schist; station II.2, Inaccessible Islands.
II.3.4 Hornblende-plagioclase-schist; station II.3, Inaccessible Islands.
II.2.9 Garnetiferous plagioclase-hornblende-quartz-biotite-schist; station II.2, Inaccessible Islands.
II.1.4 Garnetiferous biotite-plagioclase-quartz-hornblende-schist; station II.1, Inaccessible Islands.
II.4.6 Quartz-plagioclase-biotite-garnet-schist; station II.4, Inaccessible Islands.
II.3.3 Plagioclase-epidote-diopside-hornblende-schist; station II.3, Inaccessible Islands.
L.2.1 Impure quartzite; station *L.2*, Larsen Islands.
L.2.3 Talc-schist; station *L.2*, Larsen Islands.

there is minor alteration to calcite along crystal boundaries. The pale green diopside crystals (maximum 2 mm.) often appear to have formed from the hornblende. The accessory minerals are the same as in the hornblende-plagioclase-epidote-schists.

The rocks at station II.3 differ from those at stations II.1 and 2 in that diopsidic rocks predominate and hornblende-plagioclase-epidote-(biotite)-schists are absent. The small-scale folds have an estimated amplitude of 6 ft. (1·8 m.) and a wave-length of not less than 8 ft. (2·4 m.). In one part of the sea cliffs poorly developed vertical jointing is present in about 170 ft. (51·8 m.) of the schists. Near the northern end of this island an almost vertical fault with considerable throw displaces the schists.

The *hornblende-plagioclase-schists* (II.3.4; Table I) are similar to the non-chloritic parts of specimen II.2.5 (Fig. 3d; Table I) but they contain a higher proportion of plagioclase. This is twinned on both the albite and pericline laws, and it sometimes forms saussuritized porphyroblasts which deflect the bladed hornblende crystals.

Contortion of the schistosity in the *garnetiferous hornblende-plagioclase-schists* (II.3.2) has transformed the thin parallel feldspathic bands into stringers of discrete rounded areas 3–5 mm. in diameter. In thin section these rocks are similar to the hornblende-plagioclase-schists but the individual crystals are larger and there has apparently been further porphyroblastic growth. Xenoblastic garnets and stringers of elongated quartz blebs are sometimes surrounded by recrystallized plagioclase. The garnet-plagioclase areas often contain high concentrations of irregular patches of iron pyrites (Fig. 5). The actinolitic hornblende shows some alteration to sub-radiating crystals of penninite, although it more frequently grades into colourless cummingtonite, and the cleavage planes are often lined with vermicular iron pyrites.

Fig. 5. Micro-drawing of porphyroblastic plagioclase enclosing garnet crystals and irregular patches of iron pyrites; garnetiferous hornblende-plagioclase-schist; station II.3, Inaccessible Islands (II.3.2; X-nicols; ×16).

Quartz-plagioclase-biotite-garnet-schists (II.3.5) are locally present. In some respects these rocks are similar to the schist illustrated in Fig. 3e but there are generally fewer almandine garnets (average 0·5 mm. in diameter). They are slightly altered to chlorite and the cracks in them are sometimes filled with calcite. The lepidoblastic biotite flakes (α = light brown, $\beta = \gamma$ = dark red-brown) are replaced by tremolite-actinolite in one 12 mm. band. Individual flakes reach 4 mm. in size and they often contain numerous small inclusions of quartz, plagioclase, garnet, sphene and iron pyrites. The composition of the plagioclase is $Ab_{70}An_{30}$.

Some parts of the *plagioclase-epidote-diopside-hornblende-schists* (II.3.1,3; Table I) are composed almost entirely of small granular epidote (pistacite) crystals. The original diopside has been altered to a pale green, fibrous tremolite-actinolite, and interstitial calcite shows well-developed glide-twinning and includes epidote crystals.

Thin bands consist mainly of colourless diopside crystals (maximum 4·0 by 1·5 mm.), which are diablastically intergrown with zoned calcic oligoclase. There is minor alteration to tremolite-actinolite at the crystal interfaces and this occasionally penetrates the crystal cores. Epidote is infrequent in these areas.

A weakly schistose rock (II.3.1) from this station contains less epidote and diopside but more plagioclase, and prominent idioblastic apatite crystals may reach 1·5 mm.

There are also one or two *quartz vein* specimens in the collection.

At station II.4 *hornblende-plagioclase-epidote-schists* (II.4.1,8) are the most important rocks and they are similar to those at station II.2 (cf. Fig. 3c and d). Specimen II.4.1 contains occasional thin bands of biotite and the plagioclase is sericitized. About one-third of the plagioclase in specimen II.4.8 is twinned; much of the twinning is secondary, since later albite veins are formed from crystals whose twin lamellae pass into the plagioclase crystals of the rock. Albite veins are widespread in the schists and several of them are sheared.

The *garnetiferous quartz-plagioclase-hornblende-schists* (II.4.3) resemble similar but less schistose rocks from station II.3. Zones of slight deformation are indicated by the development of penninite and the undulatory extinction of the quartz and plagioclase.

The *quartz-plagioclase-biotite-garnet-schists* (II.4.6; Fig. 3e; Table I) are coarsely schistose. The felsic minerals are in the form of long parallel rods about 3 mm. in diameter and these are often partially surrounded by biotite. Small amounts of muscovite are present and the garnet porphyroblasts average 0·75 mm. in diameter. Tourmaline, rutile, sphene, apatite and iron ore are the accessory minerals.

A beach pebble from station II.4 is a *garnetiferous schist* (II.4.7), in which there are three bands rich in epidote, hornblende and biotite, respectively. The epidote (pistacite)-rich layer also contains clinozoisite which has anomalous and often patchy interference colours. Rhombic porphyroblasts, thought to be zoisite (Fig. 4b), are frequent in the hornblende-rich band. Rectangular in longitudinal section, they have straight extinction and contain a number of quartz inclusions. Under crossed nicols, an elongated darker area is usually visible along the longer axis of the rhomb but it fades out towards the crystal core. Occasional porphyroblasts are almost completely pseudomorphed by plagioclase.

The *epidote-hornblende-plagioclase-diopside-schists* (II.4.5) resemble the diopsidic rocks described from stations II.2 and 3 but epidote and hornblende are present in greater amounts, and calcite, sphene and rutile are rare.

Monroe Island

In a traverse from station *L.1* (Fig. 6) to *L.1'* on Monroe Island, Harrington recorded the general dip of the rocks as 40° to the south-east. In thin section the dark grey *muscovite-chlorite-graphite-schists* (L.1.1) are identical to one of the rocks (slide No. 36024) collected by Discovery Investigations at Sandefjord Bay (Fig. 1A, station No. 1091) (Tilley, 1935). Parallel, bladed or anhedral muscovite flakes (40 per cent) often reach 1 mm. in length and may be slightly curved. Pale green pleochroic penninite occurs interstitially and graphite

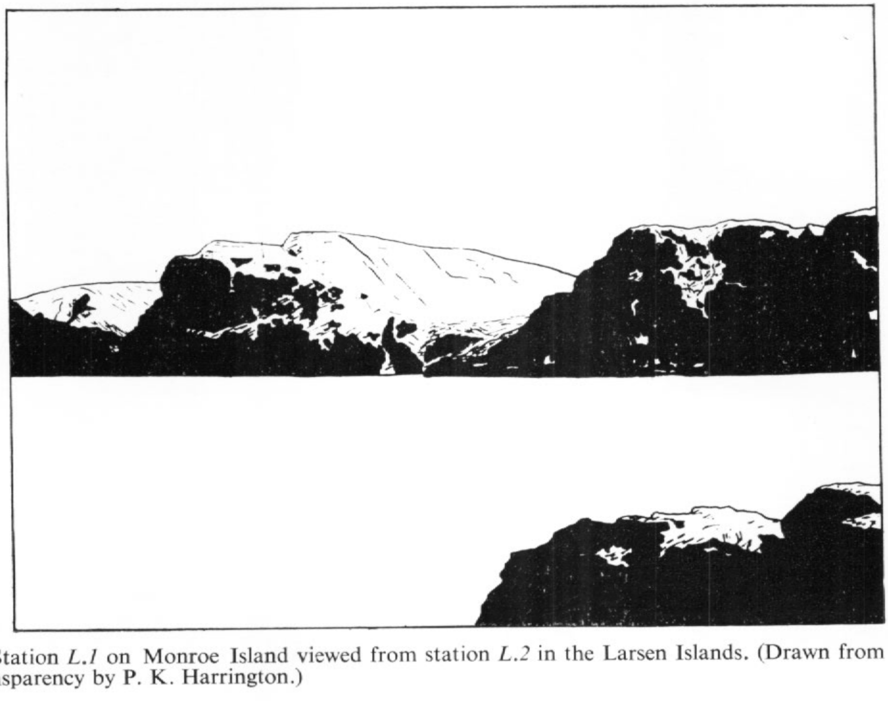


Fig. 6. Station *L.1* on Monroe Island viewed from station *L.2* in the Larsen Islands. (Drawn from a colour transparency by P. K. Harrington.)

forms irregular streaks (maximum thickness 0·15 mm.). The schistosity is deflected at intervals by veins or lenses of quartz, calcite, and twinned plagioclase and potash feldspar. Small amounts of chlorite and muscovite penetrate these areas along crystal boundaries. Frequent minute sphene crystals occur in close association with ilmenite, magnetite and iron pyrites, and isolated apatite crystals are also present.

Similar rocks are present at station *L.1'* but they contain a higher percentage of quartz forming a mosaic which includes single crystals, bands and knots of muscovite with small amounts of chlorite and calcite. Concentrations of muscovite and interstitial chlorite, to the exclusion of quartz, form narrow bands (6 mm.) in which the muscovite orientation results in a herringbone texture (Fig. 4c). The sphene crystals are larger than those in the more quartzose parts of the rock, and they contain cores of brown leucoxene and segregations of chlorite with purple-blue interference colours.

Larsen Islands

At station *L.2* in the Larsen Islands there are soft well-cleaved bands of talc-schist (L.2.3; Table I) interbedded with harder bands of impure quartzite (L.2.1; Table I), and dipping at about 40° to the south. The quartzite is often boudinaged (Fig. 7), forming lenses several feet in length with little or no cleavage.

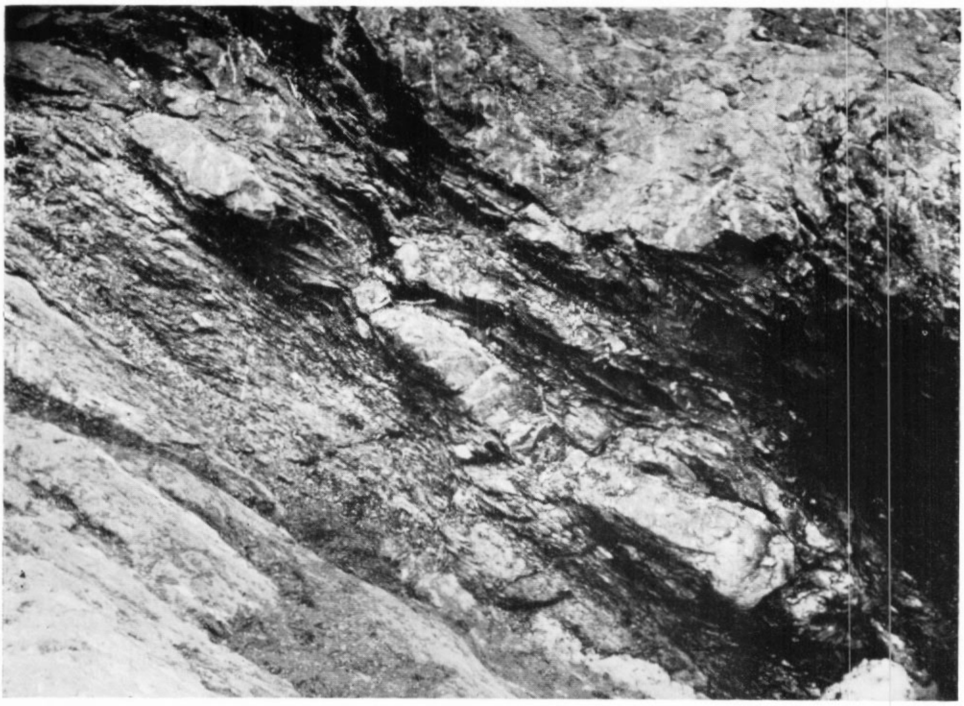


Fig. 7. Boudinaged impure quartzite in talc-schist at station *L.2* in the Larsen Islands (extreme left of the stippled area in Fig. 8). The 3 ft. (0·9 m.) band is terminated to the south-east by a dyke and to the north-west by an ice cliff. (Photograph by P. K. Harrington.)

Two slightly curved doleritic dykes cut the metamorphic rocks (Fig. 8) and dip at 80° to the west. The first dyke (Fig. 9a and b), which is 7 ft. (2·1 m.) wide, was examined closely by Harrington who found no evidence of a chilled contact. The second is 10 ft. (3 m. wide) and it occurs in an inaccessible part of the island 150 ft. (45·7 m.) to the south-east of the first one.

There are numerous quartz veins 0·75 in. (1·9 cm.) wide in the vicinity of the lower part of the north-western doleritic dyke (the stippled area in Fig. 8), but in several other localities

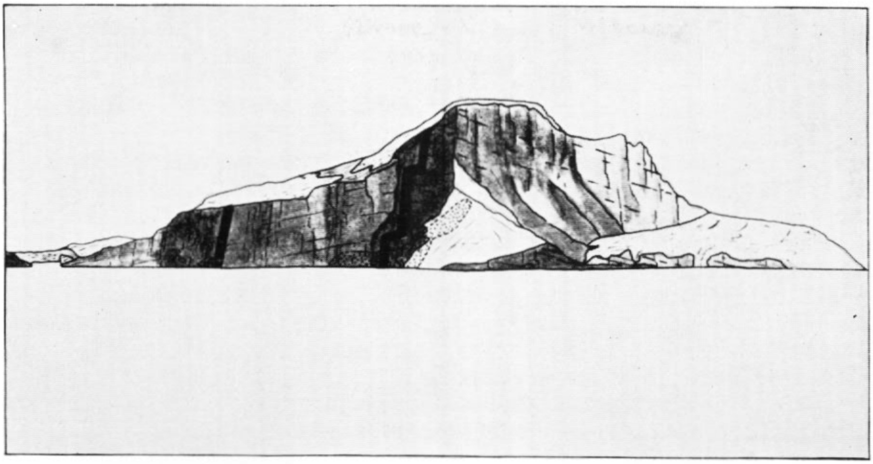
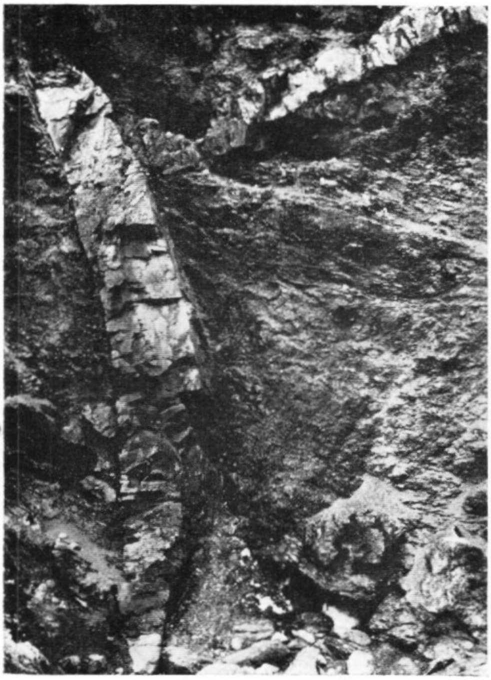


Fig. 8. Station *L.2* in the Larsen Islands viewed from the north-east. The area traversed is stippled. At the landing point the doleritic dyke is 7 ft. (2·1 m.) wide, and the dyke to the left of this is 10 ft. (3 m.) wide. (Drawn from a colour transparency and field sketch by P. K. Harrington.)



a

b

Fig. 9. a. A doleritic dyke at the landing point at station *L.2* in the Larsen Islands. The head of the figure in the left-hand corner of the photograph marks the approximate collecting locality of specimens L.2.1–3. (Photograph by P. K. Harrington.)

b. The lower part of the doleritic dyke shown in Fig. 9a. (Photograph by P. K. Harrington.)

they reach a width of 6 in. (15·2 cm.). They are orientated parallel to the cleavage and trend in a direction 060°.

The pale green *talc-schists* (L.2.3; Table I), which are extremely friable, are composed of parallel flakes of talc, often slightly bent and compressed into micro-folds with a wave-length of 2 mm. and an amplitude of 4–8 mm. Larger prismatic crystals of tremolite-actinolite (1·0 by 0·03 mm.) occur singly, in thin bands or as knots at the apices of the micro-folds. Occasional aggregates of quartz and albite, or of calcite with minor tremolite-actinolite, form lenses up to 4 mm. long. These may be boudinaged, and chlorite often fills the tension gap between the micro-boudins and partially surrounds them. Iron pyrites is rarely present, although hypidioblastic crystals of sphene (0·04 mm.) are abundant. Graphite forms irregular bands up to 3 mm. thick.

The *impure quartzites* (L.2.1; Table I) are similar to the more quartzitic rocks at station *L.1'* but the muscovite generally has a pale greenish colour and is pleochroic, and a little chlorite is present. Muscovite, iron pyrites and graphite form contorted segregations (Fig. 4d) and in places a weak schistosity has developed.

In the *quartz veins* the crystals are strained and the minor crush zones are characterized by sutured finer-grained quartz and by the presence of well-twinned calcite.

The groundmass of the grey-green *doleritic dyke rock* (L.2.2; Fig. 4e), though largely obscured by alteration products, consists of plagioclase, granules of pale green tremolite-actinolite and small patches of sphene/leucoxene (0·05 mm.). Some titaniferous magnetite is also present. The random laths or anhedra of plagioclase ($Ab_{50}An_{50}$) are often zoned, especially near their margins, and in a few instances both simple and multiple twinning are present. Slightly pleochroic and occasionally twinned tremolite-actinolite is an alteration product of the augite, some of which still remains in the cores of the crystals.

The altered plagioclase phenocrysts (average 2 mm., maximum 4 mm.) have a yellowish or greenish colour and are now almost entirely sericitized, with further alteration to turbid leucoxene and clay minerals. The pseudomorphs retain the subhedral to euhedral shape of the feldspars and sometimes the remnants of multiple twinning can be detected. From one such example the approximate composition of the plagioclase is $Ab_{40}An_{60}$. Colourless or very pale yellow phenocrysts of pigeonitic augite (black in the hand specimen), with $\gamma{:}c = 44°$, occur singly or in clusters of three or four. These well-formed crystals average 1 mm. in size and the majority of them are either polysynthetically twinned on (001) or have simple twinning on (100). There are occasional interpenetrant twins and one crystal exhibits a peripheral series of fine black striations parallel to the basal plane (salite structure). The pseudomorphs are possibly after orthopyroxene, since all of the clinopyroxene crystals are remarkably fresh in contrast to the generally altered state of the rock. They consist mainly of pale green smectite-chlorite but some are of actinolite, chlorite, antigorite and calcite. In addition, there are central patches pleochroic between dark red-brown and dark green (possibly a mixture of iddingsite and chlorite). The length-slow fibres are arranged radially and may show a black extinction cross.

The landing point on the north-east coast of the northernmost island at station *L.4* is backed by a large scree slope about 200 ft. (61 m.) across at the base, and with a 100–200 ft. (30·5–61 m.) rock face at the summit. Marked banding in the rocks appears to be dependent on the amount and distribution of quartz and mica. The cleavage is well developed but uneven, and two sets of vertical joints trend in directions 060° and 120°.

The light green-grey rocks collected from this locality are either *muscovite-chlorite-schists* or *impure quartzites*. Mineralogically, the two rock types are identical and the distinction between them is based on the cleavage development. They resemble the quartzitic rocks of station *L.1'*, apart from the frequent occurrence of irregular patches and dendritic streaks of limonite and calcite, and the absence of graphite. In the quartzites (L.4.2; Fig. 4f), muscovite, chlorite, calcite and some plagioclase ($Ab_{70}An_{30}$) are concentrated in narrow crush zones.

CONCLUSIONS

The most widespread rock type in the Inaccessible Islands is hornblende-plagioclase-epidote-(biotite)-schist. Locally, the rocks are garnetiferous with a higher proportion of felsic minerals.

These schists could possibly be correlated with the Amphibolite Series of Signy Island (Matthews and Maling, 1967; Thomson, 1968), since they represent a series of regionally metamorphosed magnesia, iron oxide and lime-rich sediments (possibly greywackes, tuffaceous sediments or marls) with some impure sandstones. The metamorphic grade lies in the zone between the albite-epidote-amphibolite and amphibolite facies (Fyfe and Turner, 1966); the diopsidic rocks belong to the latter facies. Similar rocks of the albite-epidote-amphibolite facies have been recorded at Signy Island and in southern Elephant Island (Tilley, 1930, 1935). Tilley (1935) has also mentioned the presence of "quartzose muscovite biotite schists" in south Coronation Island.

The rocks collected from the Larsen Islands and Monroe Island belong to the greenschist facies and they are probably a lateral extension of identical rocks which occur on the west coast of Coronation Island (Tilley, 1935).

The close petrographic relationship between the South Orkney Islands and the easternmost of the South Shetland Islands, 300 miles (480 km.) to the west, is further emphasized by the occurrence of muscovite-chlorite-(graphite)-schists on the north-east and west coasts of Elephant Island and on Gibbs Island (Tilley, 1930; Tyrrell, 1945). Greenschists have also been recorded at Clarence Island (Holtedahl, 1929; Barth and Holmsen, 1939) and at Shag Rocks just to the west of South Georgia (Tyrrell, 1945).

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