THE GEOLOGY OF LOW ISLAND, SOUTH SHETLAND ISLANDS, AND AUSTIN ROCKS

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ABSTRACT. Low Island is formed of poorly fossiliferous Upper Jurassic sedimentary and volcanic strata, metamorphosed to a very low grade and intruded by acidic plutons. Fissure-controlled Ca-metasomatism is also evident. It is postulated that the sedimentary (largely volcaniclastic) strata are mainly turbidity-current deposits laid down in a fore-arc basin and that penecontemporaneous volcanic activity was located both on the Antarctic Peninsula and in local extrusive centres. Austin Rocks are formed by intrusions of adamellite and tonalite.

THE South Shetland Islands extend in a south-west or north-east direction parallel to the northernmost part of the Antarctic Peninsula, from which they are separated by Bransfield Strait (Fig. 1). The geology of the islands is dominated by discontinuous volcanism which may have begun as early as the (?) Upper Palaeozoic, but Smith Island and the Elephant and Clarence Islands group, forming the western and eastern terminations of the island chain, respectively, are known to be formed of metamorphic rocks of pre-Jurassic age (Smellie and Clarkson, 1975; Rivano and Cortes, 1976). Low Island is situated about 22 km south-east of Smith Island. Although Austin Rocks do not form part of the South Shetland Islands group, they are situated only about 36 km south-east of Low Island.

Until now, all that was known of the geology of Low Island was the description by Araya and Hervé (1966) of a fine-grained granodiorite intruded by basic dykes which crop out on a promontory on the east side of the island.

During January 1975, landings were made by a party of British Antarctic Survey geologists at Cape Wallace, Cape Hooker and several rocky promontories near Cape Hooker (Figs 1 and 2). The rocks were found to be mainly volcanic, metamorphosed to a very low grade and metasomatized along fissures, with intrusions varying from granodiorite to basalt. Poorly preserved fossils discovered *in situ* and in Recent moraines on Cape Wallace indicate an Upper Jurassic age for the strata (personal communication from M. R. A. Thomson) which have also suffered minor deformation.

Two specimens from Austin Rocks are described for the first time.

LOW ISLAND

Sedimentary and volcanic rocks

Two lithological groups form bedded sequences on Low Island:

i. A lava group.
ii. A sedimentary (volcaniclastic and epiclastic) group.

The two rock groups occur separately and stratigraphical relationships between them are obscure. At Cape Wallace, a lava unconformably overlies sedimentary rocks, whereas at station P.406 a (?) lava is intercalated within sedimentary strata. All the lithologies are indurated, well-jointed and pale to dark grey in colour. Epidote and, less commonly, pyrite are conspicuous on the joint surfaces.

Lavas

The lavas are aphyric and feldspar-phyric augite-andesites, hornblende-andesites and rare basalts. Gross textural variation is small within any outcrop and bedding can rarely be distinguished.

Br. Antarct. Surv. Bull., No. 49, 1979, p. 239–257.

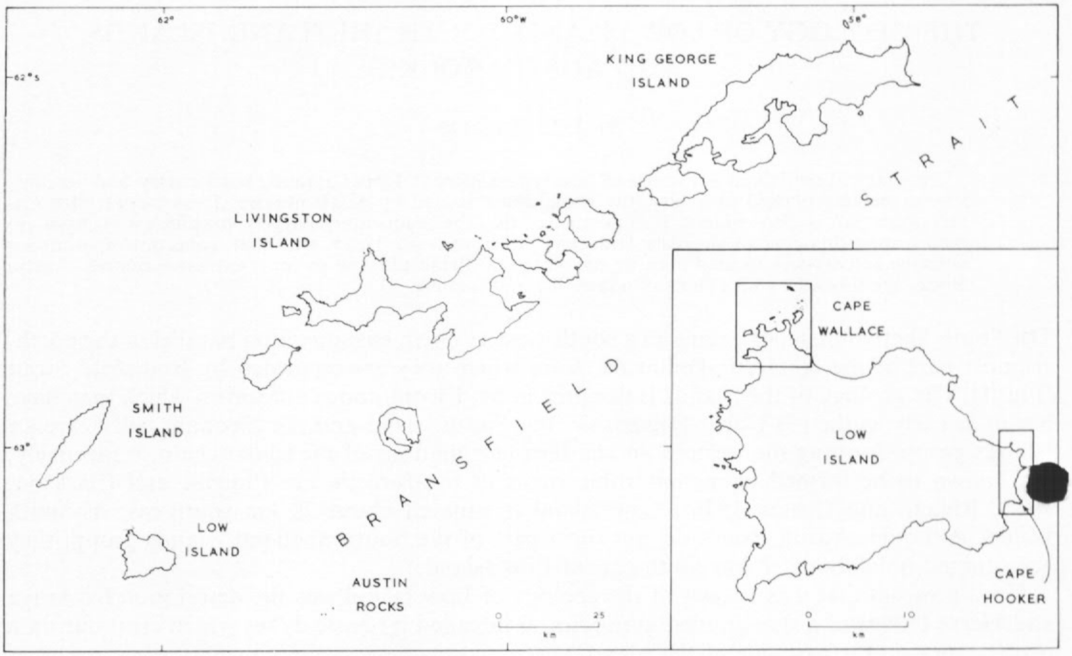

Fig. 1. Sketch map of the South Shetland Islands, showing the geographical location of Low Island (inset) and the areas studied.

The andesites contain euhedral to anhedral phenocrysts of andesine (An_{35-49}) and rare labradorite (An_{50-55}). The phenocrysts are rarely glomeroporphyritic and up to 3 mm in length, with rounded and embayed outlines, multiple twinning and normal zoning. Subhedral (six-sided) and anhedral hornblende, up to 0.8 mm in diameter, is the commonest ferromagnesian phenocryst but markedly embayed neutral or pale green augite phenocrysts, 0.1–1.4 mm across, occur in one of the lavas examined. The groundmass feldspars, ~0.04–0.14 mm in length, are oligoclase-andesine (An_{25-47}), though usually altered and recrystallized. Opaque ore (? titanomagnetite) varies in abundance between lavas and is commonly fringed by sphene. Secondary quartz is common in the groundmass. The augite-andesite (P.407.24) has been hornfelsed and contains labradorite-andesine phenocrysts (An_{38-67}) recrystallized around their margins set in a groundmass of small augite prisms (~0.01 mm long) and recrystallized feldspars (An_{38-47}). An original pilotaxitic texture is suggested by the stro[illegible] optical parallelism and parallel twin orientations of the groundmass feldspars.

Only one basalt (P.405.6) was examined petrographically. It is porphyritic, with phenocrysts of labradorite-bytownite (An_{52-82}) up to 1.7 mm in length, and augite, up to 0.9 mm, rimmed by secondary amphibole. The original composition of the groundmass feldspar is indeterminable. Anhedral opaque ore is common and accessories include much granular sphene and rare tiny apatite euhedra. Secondary quartz, actinolite and other alteration minerals are common.

With the exception of specimen P.407.16, all of the lavas show similar alteration. The feldspar phenocrysts have been partially replaced by untwinned albite. Anhedral poikilitic plates of epidote (*s.s.*) and, more rarely, calcite also replace feldspar and are often accompanied by ragged prisms of actinolite ranging in size from 0.05 to 0.17 mm. Biotite occurs in the feldspars of specimen P.407.24, tiny scattered flakes of sericite are ubiquitous and there are occasional pools of penninitic chlorite. Granules of opaque ore, occurring either as rare inclusions or in

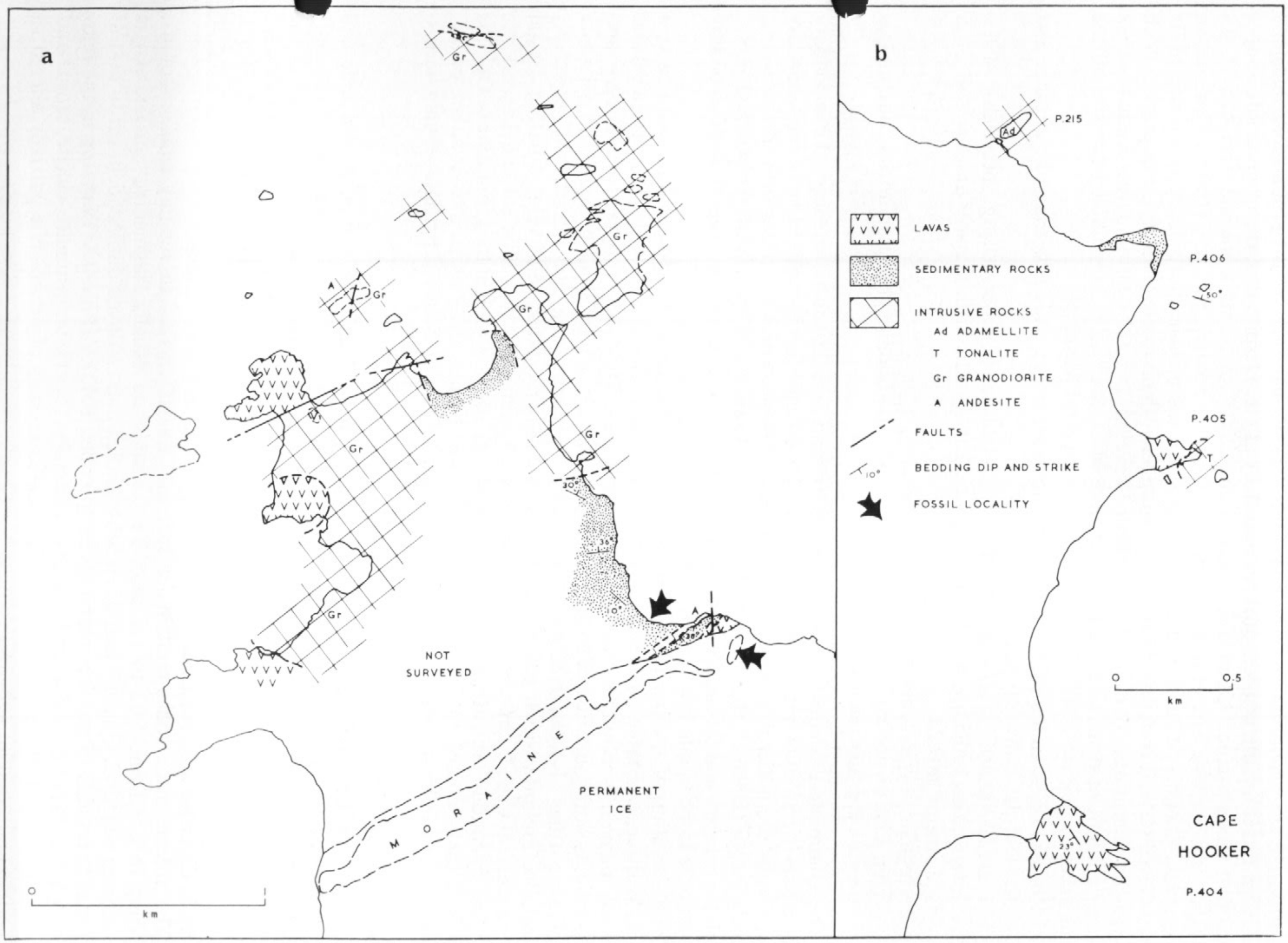

Fig. 2. Geological sketch maps of Cape Wallace (a) and the Cape Hooker area (b), Low Island.

the groundmass, often have narrow selvages of sphene. Alteration of the groundmass feldspars is similar but it mainly consists of replacement by albite. Despite this, the original lath shapes are often recognizable. Albite also occurs interstitially or forms a mosaic with quartz. K-feldspar is a variable but generally minor constituent, occurring in tiny scattered patches in plagioclase phenocrysts and in the groundmass. All the primary hornblende is altered. In its least-altered state, it contains minute grains of sphene which create a "dusty" appearance. With increasing alteration, coarser sphene anhedra develop and are commonly associated with a greater amount of penninite and minor epidote (*s.s.*). Secondary amphibole occurs in all the lavas except specimen P.407.16. It has formed in several ways:

i. Small ragged-ended prisms in the groundmass; the crystals penetrate one another and the feldspar laths, e.g. specimen P.406.3.
ii. Plate-like anhedra and ragged prisms within feldspar phenocrysts, e.g. specimen P.404.3.
iii. Interlocking anhedra, prisms and rare acicular crystals in thin discontinuous veins, e.g. specimen P.407.24.
iv. Irregular porphyroblasts, specimen P.407.20.
v. Thin bladed crystals in penninite aggregates (pseudomorphs after hornblende and/or augite), e.g. specimen P.405.6.

The commonest occurrences are those of (i) and (ii). In most instances, the secondary amphibole is actinolite but in specimen P.404.6 hornblende has formed. Most of the secondary amphiboles are noticeably free of micro-granular sphene, which contrasts with the invariable "dusty" appearance of the primary hornblende. However, in specimens P.404.3 and 405.6, both the primary and secondary amphiboles have a similar appearance. Alteration of secondary amphibole to penninite has occurred rarely.

The alteration of specimen P.407.16, an amygdaloidal aphyric andesite from south-eastern Cape Wallace, is notable. The feldspar laths are unusually elongate (0.1–0.7 mm in length) and crudely aligned, especially around the ovoid amygdales. They show progressive extinction and rare relict twinning because of widespread replacement by albite. Some prehnite and penninite replacement has also occurred but these minerals are more common interstitially, especially penninite. Prehnite forms barrel-shaped and columnar crystals, and rare radiating crystal aggregates up to 0.3 mm across. The amygdales are rimmed by penninite and filled by calcite; they rarely contain prehnite. Ragged calcite plates are also common in the groundmass. Opaque ore is virtually absent but it is probably represented by unusually abundant granular sphene. Bright yellow epidote is also present and there are a few tiny cubes of pyrite 0.03 mm across.

Sedimentary rocks

The sedimentary rocks are well-bedded, fine-grained volcanic claystones, crystal tuffs and lapillistones (terminology after Pettijohn and others (1972)). Individual beds are commonly 4–30 cm thick, laterally uniform and continuous. Graded bedding was not observed in the field but several specimens show normal grading in thin section. At Cape Wallace, small-scale cross laminations (correct way up), wash-outs and disrupted beds were observed (Fig. 3) but, in general, primary sedimentary structures are uncommon. Depressed ovoid nodules up to 3 cm in diameter are present on some bedding planes at Cape Wallace.

The volcaniclastic rocks contain feldspar and quartz crystals in roughly equal amounts, ranging in size from 0.02 to 1.0 mm. The crystals are usually fragmented but feldspar is sometimes euhedral. Quartz often has a sub-rounded and embayed outline identical to that of the quartz crystals of pumice fragments in specimen P.407.6 (Fig. 4a). Twinning in the feldspars (An_{25-45}) is often indistinct because of alteration to sericite, penninite, calcite, biotite and albite. Specimen P.406.6 contains rare fragmented crystals of hornblende partially altered to penninite and granular sphene.

Angular to sub-rounded lithic fragments, ranging up to 18 mm in diameter, are greatly

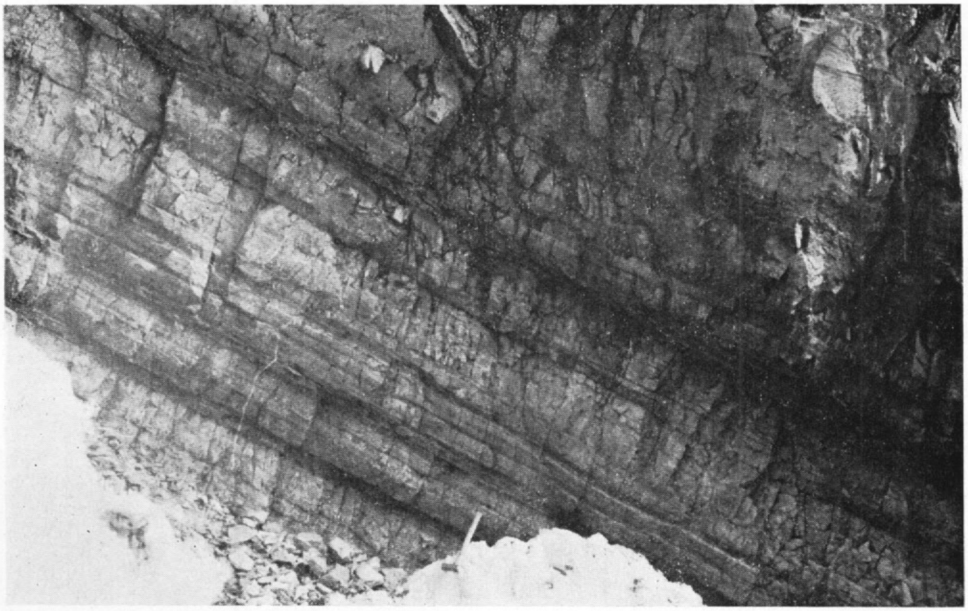

Fig. 3. Bedded tuffs at Cape Wallace. Individual beds are graded and show small-scale sedimentary structures (cross laminations, wash-outs and disrupted beds). The hammer shaft is 34 cm in length.

subordinate to crystals and are absent from many rocks. Fragments of juvenile lava are commonest. They are generally less than 1 mm across and usually feldspar-phyric (An_{27-57}) with a finely crystalline, sometimes pilotaxitic, groundmass of altered feldspar laths, opaque ore, penninite, epidote and actinolite. Aphyric fragments are less common and hornblende-phyric types are rare (P.404.6). Specimen P.406.6 contains clasts of juvenile scoria with quartz- and penninite-filled amygdales. Some fragments show great textural variation and are probably accessory, with an average size range of 1–5 mm. In a few, the introduction of silica has resulted in a quartz-mosaic groundmass with relict feldspar phenocrysts and/or laths; the feldspars of other clasts are recrystallized and untwinned but retain a relict pilotaxitic texture and sometimes include phenocrysts that are only slightly altered; actinolite may vary markedly in abundance relative to the enclosing matrix and adjacent fragments (Fig. 4b).

Fragments of tuff are represented by clasts composed of finely crystalline mosaic quartz. A few are composed of chalcedony and include rare crystal fragments. There is a textural grada[illegible]on between the tuff fragments and those of accessory andesite due to alteration.

Vitric fragments are recognizable in specimens P.407.6 (a pumice-lapillistone) and 407.11c (a lithic lapillistone) but they were probably present in most of the rocks originally. In specimen P.407.6, depressed pumice fragments measure up to 4 mm by 30 mm. Although completely altered, they are recognizable by their texture and contain quartz and feldspar crystals (Fig. 4a). The quartz crystals are sub-angular to sub-rounded, rarely subhedral, with pronounced marginal embayments and internal resorbed spots. The feldspars are altered to a chlorite–sericite–(?) smectite–chalcedony mineral assemblage similar to that of the matrix, and the vesicles are filled by an indeterminable colourless mineral with higher relief than the enclosing minerals.

The amount of matrix varies between rocks. It is sometimes difficult to distinguish because the outlines of many fragments, especially the lithic ones, are often indistinct. The most abundant constituents appear to be quartz and feldspar which form a closely interlocking micro-crystalline aggregate. Much of this may have formed by the alteration and textural

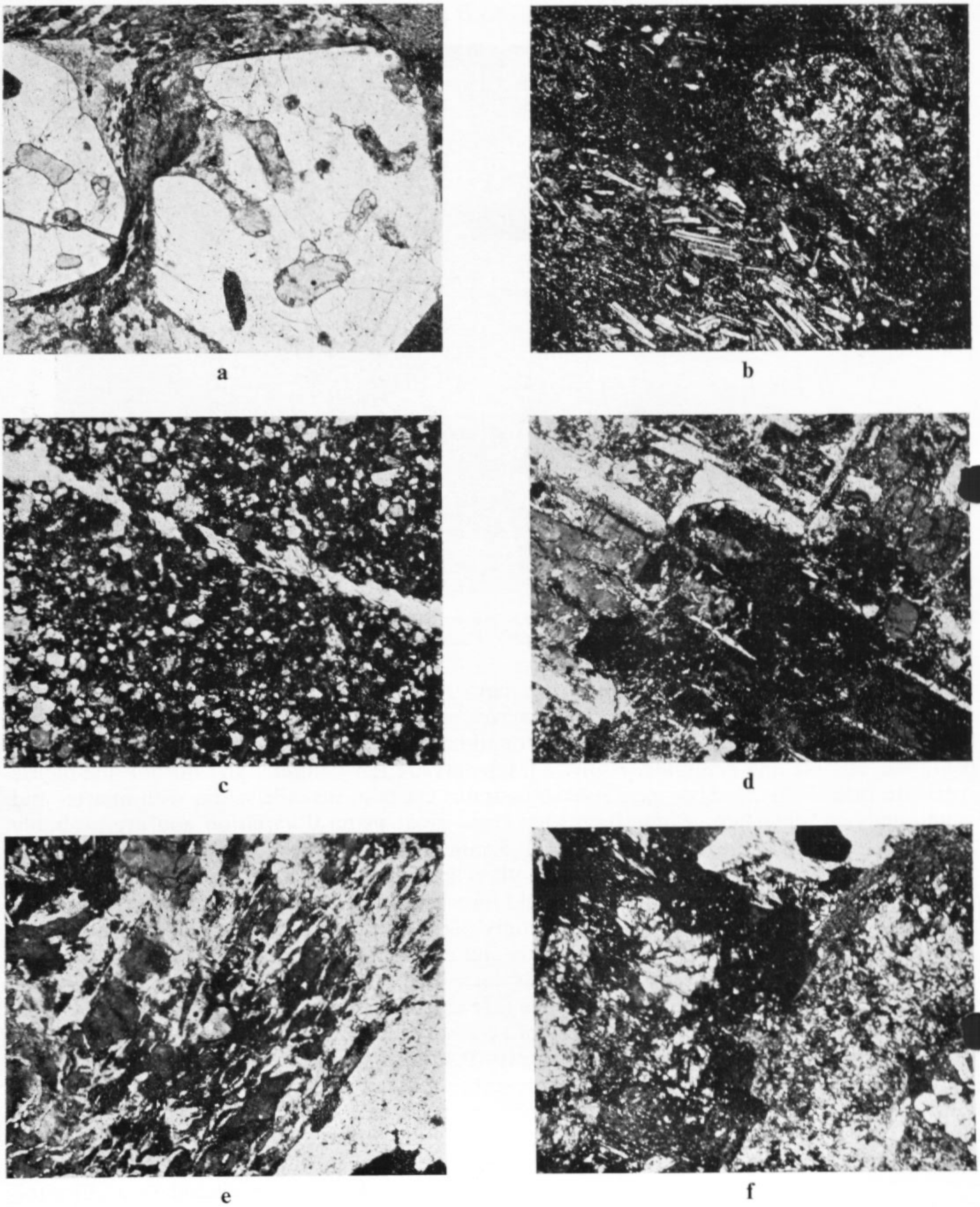

Fig. 4. a. Fragment of dacitic pumice altered to chlorite, sericite and chalcedony, with embayed quartz crystals (P.407.6; ordinary light; ×25).

b. Fragments of accessory andesite in lapilli-tuff, showing marked textural and mineralogical contrasts (P.406,6; X-nicols; ×25).

c. Vein of laumontite with radiating prehnite crystals in laumontitized tuff (P.406.2; X-nicols; ×100).

d. Plagioclase phenocrysts in a basalt. The phenocrysts are entirely replaced by laumontite except for narrow, sodic marginal zones. (?) Smectite occurs along cleavage planes and is abundant in the groundmass (P.405.10; X-nicols; ×100).

e. "Braided" textures in plagioclase caused by the development of albite along fractures (P.215.3; X-nicols; ×100).

f. Prehnite replacing plagioclase in an adamellite (AR.2; X-nicols; ×25).

destruction of glass shards (Fiske, 1969). Penninite and tiny opaque grains (largely altered to micro-granular sphene) are less common. At Cape Wallace, many of the rocks contain prominent sericite and calcite, and in specimen P.407.7 pale brown chalcedony has replaced most of the rock. Epidote is uncommon and generally forms grains less than 0.01 mm across but coarsely crystalline patches up to 0.9 mm across occur in specimen P.406.2 and biotite and/or amphibole are rarely present (P.406.2 and 7). Specimen P.406.2 has been laumontitized and contains in addition thin veins of laumontite–prehnite–epidote, epidote–chlorite and calcite (Fig. 4c).

Only one epiclastic rock (P.407.11c), a volcanic claystone, was examined petrographically. It includes a 1.6 cm layer of fine-grained lithic lapillistone with penninite-altered vitric clasts. The claystone is composed of an indeterminable fine-grained brown material interspersed with tiny feldspar laths and anhedra, some chlorite (pseudomorphing scattered glass shards) and many small plates of calcite. The rock is notable for an abundance of poorly preserved *Radiolaria*.

Intrusions

Intrusions are common on all the headlands examined. They are less altered than the volcanic rocks. Intrusive breccias are associated with the lavas at Cape Hooker and Cape Wallace and invade a hornblende-andesite intrusion at station P.406.

Basalt

Basalt intrusions are uncommon. Specimen P.405.10 contains a small number of feldspar phenocrysts, up to 1.5 mm in length, in a finer-grained groundmass (0.15–0.7 mm) of andesine and labradorite laths (An_{31-54}), abundant pale green, intergranular anhedral augite and opaque ore which is frequently crudely skeletal (? ilmenite). Undulose extinction is a conspicuous feature of the augite crystals. In sections showing {110} cleavage, extinction proceeds from the margins to the cores of crystals, travelling in a plane perpendicular to the cleavage, with a minor component parallel to the cleavage. Extinction angles in these sections vary by up to 14°. The extinction pattern often shows a sub-central "pinching" effect which resembles hour-glass structure in some instances. There is no complementary colour zoning in plane-polarized light.

The alteration of this rock is distinctive and consists of flaky aggregates of olive-green (?) smectite which is largely interstitial but also partially replaces feldspar. Laumontite (leonhardite in part) is abundant and forms interstitial and blasto-ophitic plates and finely radiating crystal groups. Much of the feldspar has been replaced by laumontite (Fig. 4d).

Andesite

Thin sheets of andesite are the commonest minor intrusions and invade all other lithologies. Feldspar phenocrysts (up to 2.5 mm in length) are invariably present, sometimes as the sole phenocryst phase, but more often accompanied by augite, hornblende or hypersthene. The feldspars (An_{22-41} but commonly zoned in the range An_{23-61}) are subhedral and anhedral, sometimes with corroded outlines but also rarely euhedral. Oscillatory zoning and multiple twinning are common, though often partially masked by fracturing (e.g. P.406.4). Augite is abundant in specimen P.216.1 but phenocrysts of this mineral, ranging from 0.3 to 1.1 mm in diameter, are generally rare. In specimen P.406.4, subhedral augite crystals are rimmed and replaced by hornblende, a relationship which may be primary. The hornblende phenocrysts (up to 1.9 mm in length) are subhedral to anhedral, rarely euhedral and corroded margins are often seen; many show parts of eight-sided sections and may have replaced pyroxene. Non-pleochroic hypersthene is abundant in the groundmass of specimen P.219.1. In this rock, hornblende has grown along cleavages and partings in rare hypersthene phenocrysts and it is closely associated with biotite. The rock has been hornfelsed by the Cape Wallace granodiorite and is similar in most respects to specimen P.407.24; one difference is the scattering of secondary quartz anhedra in the groundmass of specimen P.219.1; in specimen P.407.24, quartz is restricted to a few veinlets. Also in the thin section of specimen P.219.1, an opaque ore phenocryst, 0.8 mm in diameter, with bevelled outline and internal resorbed spots, is included in a hypersthene-augite phenocryst clot (largely replaced by hornblende and feldspar). Less obvious phenocrysts of opaque ore probably occur in other rocks (e.g. specimen P.406.8 and the angular opaque ore inclusions in some of the ferromagnesian phenocrysts).

The major groundmass minerals, ranging in size from 0.01 to 0.6 mm, are primary feldspar (An_{22-49} and possibly sodic labradorite, zoned and twinned), opaque ore and secondary albite, quartz and actinolite.

Alteration is very similar to that shown by the lavas but it differs in the following respects. (?) Clinozoisite is abundant in veins and scattered anhedra in the groundmass of specimen P.406.5. On Cape Wallace, andesite dykes, which intrude the granodiorite pluton near its eastern margin, have been altered marginally to a (?) ferrostilpnomelane–calcite assemblage. Scattered crystals of these minerals, up to 0.15 mm in length, have also grown in diffuse zones up to 1 m from each dyke, causing noticeable darkening in the granodiorite. In specimen P.407.12, irregular patches (0.1–0.2 mm in diameter) of secondary quartz and feldspar form a coarse mosaic in poikiloblastic relationship to the primary feldspar laths; (?) ferrostilpnomelane has grown along the intercrystalline boundaries in this mosaic.

Microtonalite

A fine-grained granodiorite intruded by many basic dykes has been described from Cape Hooker (Araya and Hervé, 1966). The locality was incorrectly named and is identified in this report as station P.215, situated about 2 km north of Cape Hooker (Fig. 2b). The "basic dykes" are sinuous cross-cutting sheets of dark grey microtonalite. They are sub-vertically to sub-horizontally orientated, 1–1.5 m thick and often pinch out. Elsewhere, a small microtonalite pluton intrudes lavas at station P.405. It is pale grey and contains darker grey, fine-grained sub-angular enclaves.

The main constituents of the microtonalities are feldspar (mainly sodic labradorite and andesine, with strong normal zoning (An_{8-54}), rarely oscillatory), hornblende (containing relict augite in specimen P.215.3), quartz, opaque ore and sphene. The grain-size varies from 0.1 to 1.8 mm, rarely ranging to 2.5 mm. Zoning of hornblende from a brown core to a pale green or blue-green rim is not uncommon but it is often asymmetrical relative to the crystal outline. Secondary feldspar (albite and oligoclase) has formed in the primary feldspars (with patchy or "braided" textures; p. 252) but most of the alteration consists of replacement of hornblende by actinolite, penninite, epidote and rare sphene. Other alteration minerals include sericite and rare calcite. Quartz does not form more than 12% of the rock (Table I).

Granodiorite

The largest plutonic body known on Low Island is a granodiorite which crops out over most of the northern half of Cape Wallace. This rock is greyish white and pale pink and is of uniform crystal size (~2 mm for the feldspars) except near the eastern margin where the crystal size decreases to 0.1 mm, with scattered plagioclase phenocrysts up to 1.5 mm in length. Medium to dark grey enclaves of augite-andesite and hornblende-augite-andesite are abundant, though relative concentrations vary irregularly over the outcrop. Most of the enclaves are probably derived from the surrounding lavas, against which the pluton shows steep intrusive contacts.

Specimen P.407.23 is from the western side of the outcrop. It is pale pink with large, subhedral to anhedral, twinned and zoned (normal and oscillatory) feldspars (An_{27-46}), much anhedral quartz with lobate margins rimmed with orthoclase, some subhedral augite (sometimes included in feldspar), hornblende and opaque ore. Faint colour zoning is present in some

Table I. Modal analyses of plutonic rocks from Low Island and Austin Rocks

	P.215.3	AR.2	P.407.23	P.215.2	P.407.3
Quartz	11.9	11.8	24.2	17.4	34.0
Plagioclase	58.6	54.4	46.9	31.0	23.0
Orthoclase	(?) tr	6.2	15.8	29.8	41.2
Biotite	–	–	–	0.2	0.2
Hornblende	25.8	21.0	9.7	18.6	1.0
Augite	–	–	1.0	–	–
Opaque ore	3.1	5.4	2.3	1.8	0.6
Sphene	0.6	–	0.1	1.2	–
Zircon	–	0.8	–	–	–
Apatite	–	0.4	–	tr	–
Allanite	–	tr	–	–	tr

tr Trace.
P.215.3 Microtonalite, Low Island.
AR.2 Tonalite, Austin Rocks.
P.407.23 Granodiorite, Low Island.
P.215.2 Micro-adamellite, Low Island.
P.407.3 Micro-adamellite, Low Island.

hornblendes with brownish cores and paler slightly greenish rims. Bright yellow epidote is prominent. Otherwise, alteration is as described for the microtonalites but not as well developed. Similar remarks apply to specimen P.407.4, a greyish coloured example from the eastern side of the outcrop. However, in the thin section of this specimen, pyroxene is restricted to a single prism, 0.2 mm long, included in plagioclase, whereas hornblende, often subhedral and unaltered, is relatively more common.

Metasomatism is a rare feature within the granodiorite. Specimen P.407.21 contains large relict feldspars (0.4–2.6 mm in length) surrounded by a recrystallized fine mosaic of quartz and polygonal K-feldspar (average grain-size 0.05–0.1 mm), with veins and small ovoid structures up to 0.4 mm across of more coarsely crystalline quartz (0.1–0.4 mm in diameter) with or without opaque ore, amphibole, traces of biotite and pools of sericite. Hornblende is common and forms ragged patchworks of small anhedra (0.01–0.2 mm in diameter) mixed with feldspar. Augite forms loose clusters of small crystals in the "matrix" and within feldspars. All the relict feldspars have ragged outlines where recrystallization has been halted and most show "braided" textures (Fig. 4e). Biotite occurs in flaky aggregates and fine films along cleavages and fractures in the feldspars, and scattered flakes in the "matrix"; the brown coloration of parts of some amphiboles is due to growth of biotite.

Micro-adamellite

Pink micro-adamellite veins and stringers up to 0.5 m thick, with rare double enclaves, intrude the Cape Wallace granodiorite and the adjacent country rocks. Against the latter, red chilled margins 1 cm thick have formed. The veins are formed of quartz, albitic plagioclase and orthoclase with minor hornblende, sphene, opaque ore and allanite. The feldspars are largely altered to indeterminable clay but minor sericite and calcite also occur. The hornblende is often partially altered to chlorite and epidote.

Dark grey enclaves of hornblende-andesite are common in the micro-adamellite intrusion which comprises station P.215. The lithology is similar to that of the Cape Wallace granodiorite but it differs in containing (?) oligoclase phenocrysts and large patches of quartz 1–4 mm across with lobate margins. Rare prehnite lenticles occur along cleavages in penninite, suggesting the former presence of biotite (Moore, 1975).

Intrusive breccia

The intrusive breccias are petrographically similar to the volcaniclastic rocks. However, they are clearly intrusive into the rocks in which they occur.

The breccias are largely composed of unsorted angular crystal and lithic fragments ranging up to a few centimetres in diameter but usually 1 mm or less. In contrast, specimen P.407.19 is composed predominantly of matrix with few clasts. The fragments, presumably derived from the rocks through which the breccias have passed, are andesites (feldspar-phyric, hornblende-feldspar-phyric and aphyric) and recrystallized tuffs (with quartz and feldspar crystal clasts). Fragments of pumice, both depressed and undistorted, are uncommon constituents in specimen P.404.4; the vesicles are rimmed with opaque ore and filled by quartz, and the vitric parts ar[illegible] crystallized to patchy and acicular feldspar crystals up to 0.17 mm in length. Quartz is the commonest crystal fragment but feldspar and hornblende also occur.

In specimen P.407.19, the matrix is mostly crystalline, whereas in specimen P.406.9 lithic and crystal fragments are volumetrically important. The crystalline constituents are feldspar and quartz with anhedral epidote up to 0.01 mm in diameter and opaque ore. Minute decussate actinolite crystals are abundant in the matrix and some lithic fragments of specimen P.404.4, whereas hornblende is common in specimen P.407.19 and forms discrete anhedra and dense clusters of crystals 0.05–0.6 mm in length. The abundance of penninite, calcite and epidote in specimen P.406.9 makes definition of the matrix difficult. Sphene is a common accessory. Ovoid and irregular crystalline structures 0.1–1.8 mm across, similar to those in the metasomatized granodiorite (P.407.21), are prominent in specimen P.407.19. They are composed of quartz and hornblende with or without opaque ore (? pyrite) and bright yellow epidote.

The Cape Wallace moraine

The sinuous moraine which forms the southern margin of Cape Wallace was examined for its erratic content in order to gain some knowledge of the geology of the island beneath the cover of permanent snow and ice. Clasts in the moraine consist mainly of highly altered and epidotized volcanic rocks (lavas, including occasional pillow lavas, breccias and coarse tuffs) but also include significant quantities of sedimentary rocks—fissile black silty shales with iron staining on joint faces, dark grey micaceous flaggy sandstones, sometimes with layers of mud-flake conglomerate and convolute laminations, and rare limestone nodules. An ammonite fragment was found in a piece of calcareous tuff and two belemnites in a small block of black feldspathic tuff. With the exception of pillow lavas and micaceous sandstones, all these lithologies are exposed around the coast of Low Island. No plutonic rocks were noticed in the moraine.

AUSTIN ROCKS

Austin Rocks are a group of small and jagged islets situated about 36 km south-east of Low Island. Their geology is unknown but two specimens, a tonalite and an adamellite, have been collected and it is possible that the islets are formed entirely of plutonic igneous rocks.

Specimen AR.1 is an adamellite. It contains subhedral plagioclase (An_{25-37}; seldom twinned) up to 3 mm in length in a finer-grained groundmass (0.3–0.4 mm) of patchy and vermicular quartz, orthoclase, plagioclase and loose crystalline aggregates, up to 1.5 mm across, of biotite and hornblende. The hornblende (? Mg-rich; estimated $2V = 80–90°$) is partly replaced by biotite. Sphene, opaque ore and apatite are minor constituents. Alteration is slight and consists of flecks of sericite, rare epidote and rare prehnite within plagioclase. The orthoclase contains much indeterminate clay.

Specimen AR.2 is a tonalite. Plagioclase (An$_{27-55}$) and hornblende, up to 4 mm in length, are the major constituents. Quartz, orthoclase and opaque ore are also present. Apatite, zircon and rare allanite are accessories. One euhedral zircon, an inclusion in orthoclase, shows marked resorption. The plagioclase shows both normal and oscillatory zoning and has rims (sometimes broad) zoned outwards to albite. Alteration is similar to that of specimen AR.1 but it is more advanced with relatively more sericite, prominent prehnite (within plagioclase (Fig. 4f)) and penninite–sphene–actinolite partial replacement of hornblende.

ALTERATION

The volcanic and sedimentary rocks of Low Island are indurated but otherwise they display little macroscopic evidence of alteration. However, thin-section examination reveals that considerable mineralogical reconstitution has occurred, particularly in the volcanic rocks, but it is not sufficiently advanced to destroy the primary igneous and sedimentary structures.

Metasomatism

Minerals such as plagioclase altered to prehnite and albite, and augite altered to actinolite, chlorite and epidote, clearly involve movements and segregation of Na, Ca, Mg, Al, Si and OH on the millimetre scale. Veining by epidote, pyrite, quartz, laumontite, calcite and prehnite is evidence for longer-range migration of material but, with the exception of epidote, there is little to suggest that major bulk transfer has occurred.

Epidotization is the main feature of low-temperature Ca-metasomatism. It is often restricted to joints and fractures (e.g. Firman, 1957). Epidote is conspicuous as a joint-coating on the rocks of Low Island. Away from joints, fractures and veins, the abundance of epidote relative to other alteration minerals is insufficient to suggest that its formation is due to Ca-metasomatism. Before alteration, the lavas of Low Island were composed of plagioclase, hornblende, ortho- and clinopyroxene, and opaque ore. Relics of these minerals are still preserved and petrographic examination of the less-altered Mesozoic lavas of Byers Peninsula, Livingston Island, confirms this as a common mineral assemblage (minus hornblende). Under low-grade metamorphic conditions, the alteration of ortho- and clinopyroxene by reaction with the anorthite component of plagioclase would produce actinolite, chlorite, epidote and quartz by the reactions:

i. $5\ \text{Opx} + 4\ \text{An} + 5\ \text{H}_2\text{O} \rightarrow 2\ \text{Clinozoisite} + 4\ \text{Qtz} + 1\ \text{Chlor}$.

ii. $10\ \text{Cpx} + 1\ \text{An} + 5\ \text{H}_2\text{O} \rightarrow 1\ \text{Act} + 1\ \text{Chlor} + 9\ \text{CaO} + 11\ \text{Qtz}$ (Deer and others, 1962, 1963).

On Low Island, epidote (*s.s.*) rather than clinozoisite is typical but it is probable that epidote can form through the oxidation of some of the ferrous iron of the reactants by reaction with magnetite or through the introduction of ferric iron (Strens, 1964). In addition, textural criteria indicate that the decomposition of actinolite has contributed to the volume of epidote and chlorite.

If reactions such as these have been important in the alteration of rocks on Low Island, this should be reflected in the relative proportions of the alteration minerals present. Comparisons between the theoretical and actual volumetric proportions of epidote, chlorite, actinolite and quartz are given in Table III using the data in Table II. The observed values for the epidote: chlorite ratio in specimens P.406.3 and 405.6 are very close to the theoretical value calculated using reaction (i), which suggests that orthopyroxene was an important constituent of these rocks before alteration. For the same specimens, there are obvious differences between the theoretical and actual values for the actinolite:chlorite ratio. The 7% difference between

TABLE II. MODAL ANALYSES OF THE ALTERATION MINERALS IN THREE LAVAS FROM LOW ISLAND

	P.405.5	P.406.3	P.405.6
Quartz	10.4	23.6	12.4
Albite	37.6	52.8	47.0
Epidote	5.8	9.8	7.6
Actinolite	24.8	4.2	22.8
Chlorite	13.2	7.6	6.8
Sphene	8.2	1.8	3.0
Calcite	tr	0.2	0.4

tr	Trace.
P.405.5	Andesite.
P.406.3	Andesite.
P.405.6	Basalt.

theoretical and actual values for specimen P.405.5 is probably within the combined errors involved in the modal analysis and the empirical calculations used; it may also indicate a contribution to the volume of actinolite (in excess relative to the amounts predicted by reaction (ii)) from sources other than the break-down of clinopyroxene. In the reaction involving orthopyroxene, all the Ca released during the alteration of plagioclase is incorporated in clinozoisite. The extraction of Ca from plagioclase will also cause albite to form and the amounts of albite and clinozoisite (epidote) in the altered rock should be directly proportional. This relationship is shown by the data in Table II. Therefore, it seems reasonable to suppose that these features are the result of local migration and equilibrium as opposed to introduction of new material (i.e. Ca) to the system.

The volume of secondary quartz is difficult to estimate. Its abundance relative to other alteration minerals varies irregularly within and between rocks and does not conform to the amounts predicted by either of the equations used in Table III. Quartz can be produced by a great number of reactions under low-grade metamorphic conditions and it is considered to have been a mobile constituent in these rocks; in general, it has probably not suffered large-scale migration, as is evidenced by the lack of macroscopic veins.

Myrmekitic textures are a common feature of plutonic intrusions, particularly granites, and are caused by the action of Na- or K-rich residual solutions on plagioclase or K-feldspar. Felsic plutons are common on Low Island but myrmekitic textures were observed only in part of the Cape Wallace granodiorite (P.407.4). In addition, the growth of sericite in plagioclase would be promoted by K-rich solutions but sericite is a minor constituent of these rocks. The volume of primary K-feldspar (orthoclase) in the plutonic intrusions, which is a measure of their relative alkalinity, reaches a maximum (30%) in the micro-adamellite at station P.215 (Table I). However, the majority of the plutons are characterized by small amounts of orthoclase and the largest pluton studied, the Cape Wallace granodiorite, contains only 16%. Residual solutions are commonly injected along fractures as pegmatite and aplite veins but these were only rarely observed on Low Island. K-metasomatism has been invoked to explain the growth of prehnite in biotite (Hall, 1965). The relationship has also been explained in terms of deuteric alteration (Moore, 1975). It is not proposed here to attempt to distinguish between either of these hypotheses but merely to bring attention to the occurrence on Low Island (in P.215.3) and to remark that it is extremely uncommon. The intrusive breccias are clearly of

TABLE III. THEORETICAL AND ACTUAL VOLUMETRIC PROPORTIONS OF EPIDOTE, CHLORITE, ACTINOLITE AND QUARTZ IN LAVAS FROM LOW ISLAND

Reaction: $5\ \text{Opx} + 4\ \text{An} + 5\ H_2O \rightarrow 2\ \text{Clinozoisite} + 4\ \text{Qtz} + 1\ \text{Chlor}^*$

	Theoretical volumetric proportions	*Actual volumetric proportions*		
		P.405.5	P.406.3	P.405.6
Epidote	42	20	24	45
Chlorite	19	45	18	40
Quartz	39	35	58	15
Epidote	56†	30	56	53
Chlorite	44†	70	44	47

Reaction: $10\ \text{Cpx} + 1\ \text{An} + 5\ H_2O \rightarrow 1\ \text{Act} + 1\ \text{Chlor} + 9\ \text{CaO} + 11\ \text{Qtz}‡$

	Theoretical volumetric proportions	*Actual volumetric proportions*		
		P.405.5	P.406.3	P.405.6
Actinolite	35	52	12	55
Chlorite	26	27	21	16
Quartz	39	21	67	29
Actinolite	58	65	36	77
Chlorite	42	35	64	23

The Fe:Mg ratio in actinolite and chlorite is assumed to be 2:3.
* Deer and others, 1962, p. 199.
† Strens, 1964.
‡ Deer and others, 1963, p. 259.
P.405.5 Andesite.
P.406.3 Andesite.
P.405.6 Basalt.

hydrothermal origin and are probably related to the plutonic intrusions. At Cape Wallace, Fe-rich hornblende (estimated $2V = 30–55°$) occurs in an intrusive breccia (P.407.19), whereas actinolite occurs in the enclosing lavas, indicating that the breccia was intruded at temperatures greater than those of the lavas. There is some evidence that pyrite formed during the injection of some of the intrusive breccias. In specimen P.407.19 (and P.407.21), pyrite and quartz have crystallized together in ovoid (amygdale-like) structures, and in specimen P.404.4 pyrite is conspicuous in the fine-grained matrix and rimming the angular clasts. K-feldspar occurs in the fine-grained matrices of some of the intrusive breccias and it comprises 29% of the specimen of metasomatized granodiorite from Cape Wallace (P.407.21) which shows textural features similar to those of the breccias (p. 248). The occurrence of K-feldspar in the lavas has already been mentioned (p. 242).

The (?) ferrostilpnomelane–calcite assemblage developed in and around andesite dykes, which intrude the eastern margin of the Cape Wallace granodiorite, can probably be attributed to hydrothermal alteration. Similarly, the asymmetrical colour zoning of some hornblende crystals in the plutonic intrusions (e.g. P.215.3) may be related to the migration of water-rich fluids along selective intercrystalline boundaries.

In summary, the bulk of the evidence suggests that fissure-controlled Ca-metasomatism (epidotization), not infrequently associated with pyrite, is the major metasomatic process to have occurred on Low Island. K-metasomatism has also occurred but to a much lesser extent and there is some evidence for the limited mobility of silica.

Metamorphism

Burial metamorphism takes place in the lowest temperature part of regional metamorphic terrains and is characterized by the zeolite and prehnite–pumpellyite facies. The commonest alteration mineral assemblage on Low Island is: albite–quartz–actinolite–chlorite–epidote–sphene–(sericite–calcite). This is characteristic of low- and very low-grade metamorphism (Winkler, 1974). Rarer specimens containing laumontite, prehnite and (?) smectite in association with some, or rarely all, of these minerals are *diagnostic* of very low-grade metamorphism. In addition, assemblages with biotite and/or hornblende are developed locally and indicate low-grade metamorphism at higher temperatures than are recorded in the rocks over most of Low Island; these invariably crop out close to the margins of igneous intrusions.

Zeolites, prehnite and pumpellyite are diagnostic minerals in very low-grade metamorphism but they are uncommon or (in the case of pumpellyite) absent on Low Island. Zen (1961) has shown that at high values of μCO_2 relative to μH_2O, calcite-bearing assemblages are favoured relative to the Ca-zeolites, prehnite and pumpellyite. Calcite is a common and volumetrically abundant constituent of rocks on Cape Wallace and in this area it may be inferred that μCO_2 was sufficiently high to suppress the formation of these minerals. The reasons for the unusual occurrence on Cape Wallace of the paragenesis: prehnite–calcite–chlorite–(sphene) are n[illegible] known but prehnite–calcite parageneses have also been recorded from New Zealand (Coombs, 1961) and Alexander Island (Taylor, 1967); Nicholls (1959) has described spilites from Wales which show textural and mineralogical features identical to those shown by specimen P.407.16. Nitsch (1971) considered that this assemblage (± pumpellyite) forms at temperatures between 300° and 400° C.

Ca-zeolites, prehnite and pumpellyite are stable only if the CO_2 content of the fluid is less than 1% (Winkler, 1974). Therefore, the presence of calcite in trace amounts in most of the rocks from Low Island may indicate that this concentration level has been exceeded. It is also likely that the temperatures which occurred during the metamorphic event were close to or exceeded the upper thermal stability limit of zeolites which, in the presence of quartz, is about 320° C (Coombs and others, 1959).

Laumontite occurs in specimens P.405.10 and 406.2. In specimen P.405.10 the paragenesis laumontite–(?) smectite–albite is present and this is diagnostic of very low-grade metamorphism. In specimen P.406.2, laumontite and prehnite occur together in veins and patches (Fig. 4c). It is well documented that, with increasing temperature, laumontite is commonly replaced by prehnite (and/or pumpellyite) under low-pressure conditions. Thus, a laumontite zone is succeeded by a prehnite–pumpellyite zone without laumontite and the occurrence on Low Island of a laumontite–prehnite paragenesis seems to be anomalous. However, laumontite–chlorite–prehnite parageneses are known from New Zealand (Coombs, 1961), Central America (Jolly, 1970) and Alexander Island (Taylor, 1967), and Liou (1971) has shown that the stability fields of the two minerals may overlap appreciably if the prehnite is iron-rich. This explanatio[illegible] may apply to the occurrence on Low Island.

In the presence of quartz, laumontite forms at temperatures around 200° C at pressures less than 3 kbar (Winkler, 1974; Laux and Nativel, 1975) and Coombs and others (1970) suggested that it probably disappears at temperatures above 300° C at 2 kbar. The upper thermal stability limit of prehnite is approximately 400° C and this limit is changed only slightly with increasing pressure. In natural environments where CO_2 is present and decreases the activity of H_2O (by dilution), the break-down of prehnite (to form zoisite + grossular + quartz + fluid) would take place at lower temperatures and assemblages such as prehnite–calcite–chlorite (specimen P.407.16) would be stable only at temperatures considerably less than 400° C at $P = 3$ kbar (Liou, 1971).

One of the most obvious signs of alteration is the partial albitization of plagioclase, which produces "braid-like" textures within the phenocrysts (Fig. 4e). In these, the growth of albite proceeds initially along irregular, or rarely sub-parallel, fractures and then laterally away from them. A *progressive* compositional change from the site of the original fracture to the margins of relict primary feldspar is suggested by the extinction of the phenocryst (within any twin). This begins with the relict patches of primary feldspar which extinguish fractionally before the closest rims of secondary feldspar (compositionally very similar to the altering feldspar at this point); the secondary feldspar then extinguishes progressively until the site of the original fracture is reached, where its composition is probably very close to that of albite; extinction is approximately symmetrical around the fractures.

Byerly and Vogel (1973) have described the processes involved in the re-adjustment of plagioclase to more stable compositions with increasing temperature during metamorphism. The fractures within the plagioclase crystals represent sites of high energy which would supply the activation energy required by albite to form from more calcic plagioclase. Reaction proceeds with the expulsion of excess Ca until a more stable composition is reached, consistent with the prevailing pressure-temperature regime and/or the supply of energy available.

Plagioclase crystals altered in this manner commonly show either diffuse inherited twinning or none at all, and progressive or patchy extinction. They are invariably "clouded" with minute indeterminate particles. Secondary albite, which formed interstitially in the groundmass, is not is noticeably cloudy as the albitized plagioclase; it shows fine polysynthetic twinning in the recrystallized matrix of specimen P.406.7. Eskola and others (1937) and Coombs and others (1959) have shown that albitization is retarded at temperatures below about 250–280° C. In view of the frequent presence of relict andesine and more calcic plagioclase in the rocks of Low Island, temperatures of a similar range, or probably somewhat greater, may be postulated.

Other indicators for the presence of low prevailing pressures and temperatures during the metamorphic event include:

i. The virtual absence of clinozoisite and the abundance of epidote (*s.s.*), often strongly yellow (Fe-rich). Clinozoisite is unstable at temperatures below those of the greenschist facies (i.e. in very low-grade metamorphism) and its place is taken by a stable Fe-epidote.
ii. Actinolite does not form in the zeolite facies and the lower part of the prehnite–pumpellyite facies (Miyashiro, 1973) but it is a common constituent of the rocks on Low Island which suggests that metamorphic conditions corresponding at least to upper prehnite–pumpellyite facies were prevalent (i.e. temperatures about 300° C).

The calcite in specimens P.407.12 and 16 is *biaxial*. It shows unmistakable rhombic cleavage and this, together with a variable 2V estimated to be 15° or less, serves to distinguish it from aragonite (2V = 18°). It has been proposed that biaxial calcite may form at high temperatures (in excess of 970° C; Walker and Parsons (1925)), by inversion from aragonite (Boettcher and Wyllie, 1967) or due to deformation (Gillson, 1927). However, high temperatures are not recorded on Low Island. Likewise, there is no evidence for the former presence of high pressures, which aragonite requires in order to form, and deformation is typically slight. At present, this problem remains unsolved.

Thus, consideration of the mineral assemblages observed on Low Island suggests that they formed during a low-pressure, very low-grade regional metamorphic event corresponding to burial metamorphism at depths less than 10 km and maximum temperatures around 300–350° C. Plutonic intrusion occurred subsequent to or during the metamorphism and caused contact metamorphic mineral assemblages to form within ill-defined thermal aureoles. It is possible that the plutons raised the temperatures in the volcanic pile sufficiently to destroy earlier-formed metamorphic parageneses over wide areas, and the albite–quartz–actinolite–chlorite–epidote mineral assemblages typical of Low Island rocks may have formed as a result of this. However, these minerals are found in both low-grade (greenschist facies) and very low-grade (prehnite–pumpellyite facies) rocks and the absence of minerals diagnostic of very low grade can be explained satisfactorily by the presence of small amounts of CO_2 during metamorphism. At present, it is not possible to decide whether the dominant metamorphic event was very low-grade regional metamorphism or large-scale, low-grade contact metamorphism related to plutonic intrusion. Kuniyoshi and Liou (1976) have described an area in British Columbia which shows many similarities to the situation on Low Island. They have convincingly demonstrated that plutonic intrusion was responsible for most of the effects which they described.

STRATIGRAPHICAL AND REGIONAL IMPLICATIONS

Contemporaneous volcanism

Within the sedimentary strata on Low Island, angular ash-sized crystal fragments of plagioclase, rare hornblende, embayed unstrained quartz and probably a considerable volume of delicate glass shards (now completely altered and texturally destroyed) form the bulk of the rocks. Dacite pumice-lapilli are locally conspicuous. The majority of the lithic clasts are angular, dense fragments and tiny vesicular scoria of juvenile andesite with which are mixed more altered accessory andesite fragments; no fragments of accidental material were observed. The crystals and scoria have no adhering groundmass or matrix to suggest that they were derived from previously consolidated rocks by weathering. The textures and structures of the sediments are very similar to those of rocks produced by terrestrial phreatic eruptions (Parsons, 1969), and eruptions from volcanoes producing andesite and dacite debris are typically highly explosive.

Pumiceous clasts in sedimentary rocks are commonly regarded as important evidence for contemporaneous volcanism and this is often corroborated by the occurrence of lavas within the pumice-bearing strata (Fiske, 1969); this clearly applies in the case of Low Island. Thus, the sedimentary rocks of Low Island are volcaniclastic deposits composed of primary volcanic tephra and formed as a result of active contemporaneous volcanism.

Contemporaneous plutonic activity and metamorphism

It is likely that the intrusive breccias are genetically related to the felsic plutons (p. 251). They contain broken crystals and rare scoriaceous clasts free of adhering matrix, which suggests that the sediments through which the breccias passed were poorly consolidated and that the intrusion of at least some felsic plutons occurred relatively soon after the sediments were deposited. Lithic fragments occur within the breccias which are similar to those regarded as accessory within the volcaniclastic rocks. The textures and alteration of these fragments are regarded as largely metamorphic in origin. Hence, metamorphism of some volcanic rocks occurred prior to plutonic intrusion (as recorded in the intrusive breccias) and during the period of volcanic activity; metamorphism probably continued after igneous activity in the area had ceased.

Environment and mechanisms of deposition

Thick sequences of marine terrigenous sediments (mainly sandstones and shales, rich in matrix) characterized by uniform, laterally continuous bedding and abundant primary sedimentary structures (graded bedding, sole marks, convoluted beds and minor large- and small-scale cross laminations), are considered to have formed principally by deposition from density flows (Pettijohn and others, 1972). Analogous sequences formed largely of volcaniclastic strata have been described by Fiske (1963) and Fiske and Matsuda (1964).

There are many similarities between these sequences and the volcaniclastic strata of Low Island. Most of the beds are formed of poorly sorted crystal-rich material without pumice but with a variable amount of fine (?) originally glassy matrix. Their primary sedimentary structures are described on p. 242. These are considered to be analogous to turbidity-current deposits (Fiske, 1963), which accumulated initially on the flanks of the vents by rapid ash-fall soon after eruption, then sloughed into the sedimentary basins as water-charged muddy slurries. The difficulty of detecting graded bedding in the field and the absence of sole marks (notable in rocks considered to have formed from turbidity currents) have been noted by Fiske and Matsuda (1964) in strata analogous to those of Low Island.

The turbidity-current deposits could have formed during or some time following eruptions, because the upper flanks of volcanoes are notoriously unstable. This is particularly true during eruptions, when thick piles of tephra are rapidly deposited, and the episodic sloughing of such large volumes of debris could increase the distances travelled by the flows.

The pumice-lapillistone (P.407.6) clearly formed as a pyroclastic flow and, since it crops out within a marine sequence, it must have been deposited subaqueously. It forms a thicker deposit than the surrounding strata but shows no evidence of heat retention, such as welding or columnar jointing, features typical of terrestrial pyroclastic flows; the pumice-lapilli were probably flattened by compaction under later-formed strata. Terrestrial pyroclastic flows are considered to form by the highly explosive eruption of vesiculating acidic magma from a fissure or vent, resulting in ash flows of incandescent, *nuée ardente* type; most subaqueous pyroclastic flows are probably erupted from submarine vents (Fiske, 1963) and it is likely that quenching by the surrounding sea-water is sufficient to cool the flow to a temperature at or near that of the sea-water and prevent welding in the resultant deposit; sudden quenching by sea-water was also probably responsible for the fragmentation of the crystals in the volcaniclastic deposits. Pyroclastic flows erupted and deposited under water can travel great distances and be deposited over huge areas; Niem (1977) has described a 20–40 m thick flow unit which crops out over 8 000 km^2 from which the nearest source vents are 100 km distant. Thus, although subaqueous pyroclastic flows clearly indicate contemporaneous volcanic activity, they do not provide evidence for the relative proximity of the volcanic source area.

Coarse volcaniclastic material is conspicuously absent from Low Island. This could suggest a relatively distant volcanic source but the presence of lavas on the island indicates that volcanic centres were located nearby, at least during part of the history of the area. In the underwater environment, it is unlikely that large rock fragments will be carried far from their source and Fiske (1963) has described coarse vent-facies agglomerates and lavas which wedge out gradually into thin-bedded tuffs and lapillistones over distances less than 2 km.

Although it is likely that the majority of the thin-bedded deposits on Low Island were laid down by turbidity currents, ash-fall tuffs are probably also present. One of the specimens examined (P.406.7) shows moderate sorting and contains relatively little matrix. These differences may be sufficient to distinguish it as an ash-fall deposit. Good sorting is expected in submarine ash-fall deposits, because sea-water has a great sorting effect on debris settling within a submarine eruption column. The finest ash carried up into suspension would settle much more slowly and form the featureless fine tuff units which commonly crop out between the turbidity-current and (?) ash-fall deposits on Low Island.

During long periods between eruptions, when no fresh pyroclastic debris was being produced and most of the debris produced by previous eruptions had settled, normal pelagic sedimentation would re-commence and the thick, dark grey, poorly fossiliferous claystone (or mudstone) beds were formed.

SUMMARY AND CONCLUSIONS

Low Island is formed of volcanic and sedimentary strata intruded by felsic plutons. It is likely that volcanism, plutonism and metamorphism were penecontemporaneous and the intrusion of the plutons caused metamorphism to occur at high levels within the volcanic pile. Some of the plutons may have acted as magma reservoirs which fed the andesite–dacite volcanism from local vents. The volcanic activity included occasional eruptions of *nuée ardente* type.

The main volcanic source area is unknown but, during the Upper Mesozoic, the Antarctic

Peninsula was the site of a partly submarine magmatic arc (Suárez, 1976). This could have been the source for much of the detritus in the volcaniclastic strata of Low Island. However, the presence of lavas on Low Island indicates that some volcanic centres were located nearby and their unbrecciated state indicates that they were erupted subaerially, probably when the volcanoes built up into small islands.

Dickinson (1974) has described the characteristics of sedimentary deposits associated with magmatic arcs. The volcaniclastic rocks of Low Island most closely resemble sediments which accumulated either within intra-arc basins or on the flanks of the arc. In view of the occurrence of pre-Jurassic glaucophane-schists to the west (Smellie and Clarkson, 1975), representing a subduction complex, and an Upper Mesozoic magmatic arc to the east, the strata on Low Island may have been deposited in a position corresponding to a fore-arc basin. This is similar to the palaeogeographical reconstruction proposed by Suárez (1976) for Alexander Island and Palmer Land but the analogous fore-arc basin strata, the Fossil Bluff Formation, were laid down in shallower water as evidenced by an abundance of shallow-water sedimentary structures and a varied fossil fauna (Elliott, 1974).

Felsic plutons form Austin Rocks. Their age is uncertain but West (1974) has described an early phase of (?) Jurassic plutonism from the Danco Coast, Graham Land, based on stratigraphical and chemical (especially trace-element) criteria. These are petrographically similar to the plutons of Austin Rocks. In particular, they show prehnite alteration, a feature absent from the younger plutons but clearly no age correlations can be inferred at present.

ACKNOWLEDGEMENTS

I should like to thank Dr M. R. A. Thomson for assistance both in the field and during the preparation of this paper, and Dr P. W. G. Tanner for further helpful criticism. I am also grateful to Captain E. M. S. Phelps, the Officers and crew of RRS *John Biscoe* for field support during January 1975 when the field work for this paper was carried out.

MS received 1 July 1977

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