THE GEOLOGY OF CARSE POINT, PALMER LAND

By N. G. CULSHAW

ABSTRACT. 400 m. of tuffs, agglomerates and andesites directly overlie an undetermined thickness of marine mudstones, shales and conglomerates at the southern end of Carse Point, Palmer Land. Fossils found in these rocks define their age as late Jurassic, and the minimum extent of a mid–late Jurassic sea is delineated locally.

IN the course of the geological survey of western Palmer Land, Carse Point (lat. 70°14′ S., long. 68°12′ W.; Fig. 1) was visited by C. G. Smith and A. C. Skinner, who found sedimentary rocks similar to those described here and also some trace fossils. While on a sledge journey to Fossil Bluff, the author accidentally discovered the fossil-bearing sediments intercalated with volcanic tuffs, agglomerates and andesites, and several days were spent collecting material and making a sketch map of the area. The thicknesses of a limited number of sedimentary beds were measured, but accessibility to much of the rock was difficult because of the steepness of the cliffs. It was also difficult to make accurate dip measurements because of the fractured nature of the rocks.

The marine origin of this sedimentary sequence was first recognized when vermicular structures (Taylor, 1967) were noticed in specimens collected by C. G. Smith from almost equivalent beds 1·5 km. north of this locality. These structures are extremely common in the Upper Jurassic and Lower Cretaceous marine siltstones of south-eastern Alexander Island.

The fauna collected at the Carse Point locality includes a variety of bivalves, ammonites, belemnites (Willey, 1973; Thomson, 1975) and a possible gastropod. Carbonized plant stems and rarer fronds occur sporadically. A late Jurassic age is suggested for these sediments by the molluscan fauna (Thomson, 1975).

GEOLOGICAL SETTING

Carse Point is a compact snow and rock massif, 6 km. by 4 km. in size, and indented on the west by an extensive snowfield which gives it a bulbous horseshoe shape. The highest point is over 1,000 m. but it is flat-topped and ice-capped, suggesting that it is a down-faulted remnant of the Tertiary peneplain which is believed to form the plateau of the Antarctic Peninsula (Linton, 1964).

Both C. G. Smith and A. C. Skinner (personal communications) have reported from this area over 1,000 m. of basaltic andesites, andesites and basalts intruded by small quartz-porphyry and diorite bodies, and overlying a marine mudstone-conglomerate sequence.

These rocks are part of a volcanic group forming in western Palmer Land a sequence over 2,000 m. thick, and long considered to be Upper Jurassic in age. Mudstones similar to those described here but unfossiliferous have been reported from various localities in north-western Palmer Land (Skinner, 1973), where they are exposed at the base of similar volcanic sequences. In the same area, high-grade *ortho-* and *para*gneisses have been found and these presumably form the basement to the later stratified rocks. The whole succession is intruded by rocks of the Andean Intrusive Suite (Adie, 1955).

In Palmer Land most of these features are similar to those of Graham Land, but they contrast strongly with the east coast of Alexander Island which is only 25 km. west of Carse Point. The coastal sequence of south-eastern Alexander Island youngs southward and, as far as is known, it is composed predominantly of marine clastic sediments. The Aptian sedimentary rocks of south-eastern Alexander Island were considered by Horne and Taylor (1969) to have been deposited in a neritic environment. The provenance of the material is believed to have been an elevated, predominantly crystalline landmass to the east, where andesitic volcanoes were active during the Upper Jurassic. The fossiliferous sediments of Belemnite Point and Ablation Point range in age from late Jurassic to early Cretaceous and include marine sandstones, conglomerates, minor agglomerates and lavas.

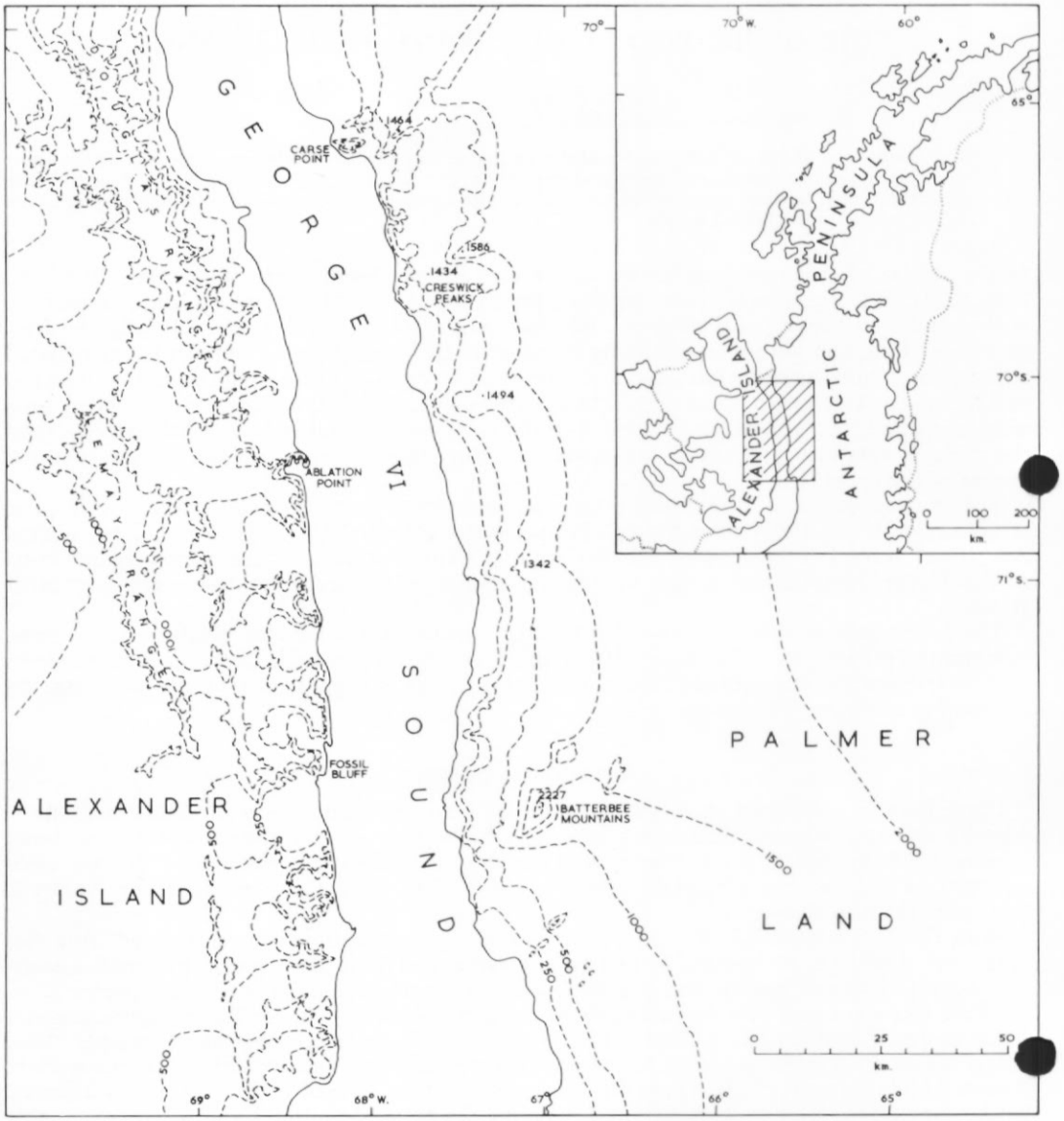

Fig. 1. Sketch map showing the location of Carse Point in relation to the west coast of Palmer Land and the east coast of Alexander Island. The form lines are in metres. The inset shows the position of the sketch map in relation to the Antarctic Peninsula.

General Geology

The cliffs of Carse Point are split into two by a gently rising snowfield, 2 km. deep and 1 km. wide. The area described here comprises the bluffs backing this snowfield and the cliffs continuing eastward as far as the unnamed north–south-trending glacier forming the eastern boundary of the massif and which is a distributary of Riley Glacier. Although the Carse Point massif itself attains a height of over 1,000 m., the cliffs above the outcrop described here are only about 400 m. high (Fig. 2). Access to the foot of the cliffs is over gentle snow slopes broken occasionally by ice falls but steepening at buttress edges and gullies. The lowest

outcrops occur in four buttresses which are also stratigraphically the lowest points. These buttresses are referred to as buttresses 1, 2, 3 and 4 from south-east to north-west (Fig. 3).

Stratigraphy

The whole sequence at this small locality is conformable and not folded. Andesitic volcanic rocks have been erupted on to marine sediments; in the early stages the volcanic rocks were water-laid but most of the subsequent material was deposited subaerially. The main volcanic sequence is more than 850 m. thick (Skinner, 1973), but the sequence at Carse Point is as follows:

	Thickness (m.)
Andesites and basaltic andesites	~400
Green tuff and agglomerate bands	~20
Black crystal tuff	16
Shales, mudstones and conglomerates with a bivalve, ammonite and belemnite fauna	15
Blocky pyritic mudstones with a sparse marine fauna	>60

Sedimentary Rocks

At buttress 4, about 60 m. of black pyritic mudstones (KG.1258.16A and 17) are exposed and they dip gently to the north-east. They are characterized by a brown weathered surface and a grey-black fresh surface, vertical jointing, and ill-defined bedding which is here and there picked out by light-coloured silty bands with convolute bedding (KG.1258.40) and varying between 4 and 6 cm. in thickness. Ammonites, bivalves and belemnites occur sparsely.

At buttress 2, there is a distinct transition between mudstones and shales, the upper surface of the former forming a discontinuous platform at the foot of the cliff where the shales (KG.1258.76) and the volcanic rocks are exposed (cf. Fig. 4). In the cliffs on the eastern side of the snowfield the outcrop of the mudstones is only about 20 m. because much of it is cut by a quartz-diorite intrusion (KG.1258.16 and 17).

Above these mudstones are about 15 m. of mudstones and shales with conglomeratic lenses which are pyritic and often purple and yellow-stained. There is a regular joint system perpendicular to the bedding. The thickness of each shale sequence varies from a few centimetres to over 1 m.; the associated less fissile mudstones are generally thinner. These two rock types resemble each other except in their fissility, and they appear to grade into one another. Subordinate light-coloured silty beds (KG.1258.6) are rarely more than 20 cm. thick and are common in the lowest few metres of the shale beds.

At buttress 2, lenses of coarser material (KG.1258.48) attain a maximum thickness of 90 cm. They wedge out evenly and vary in length from 7 to 17 m. There seems to be no relation between the length and thickness of the lenses, since the one referred to above has a maximum thickness of 55 cm. The lenses consist mainly of a poorly sorted pebble fraction set in a carbonate and limonitic matrix forming <15 per cent of the rock. The largest clasts, up to 12 cm. in diameter, are well rounded and occur in only one lens where they form 10 per cent of the rock. The bulk of this lens and all of the others is composed of angular and elongate lava and quartz fragments between 2 and 5 cm. in maximum length. Belemnites are very common especially in the lower parts of the bed; they show no preferred orientation. The lower contact of these lenses with the shales is marked by a band of calcareous concretions which are 5 cm. thick and cut by gypsum veins up to 2 cm. wide (KG.1258.3). Belemnites and ammonites were also found in these bands.

Petrography. The typical mudstone (KG.1258.76) from buttress 2 is the darkest of all the sedimentary rocks examined. Its black colour is due to the predominance in the matrix of carbonaceous streaks and lenses defining the bedding. The rest of the matrix is probably composed of minute quartz and feldspar grains and indeterminate white laths. 40 per cent of the rock consists of ill-sorted quartz and feldspar fragments. Anhedral authigenic iron pyrites, forming at least 10 per cent of the rock is also present in the matrix as disseminated

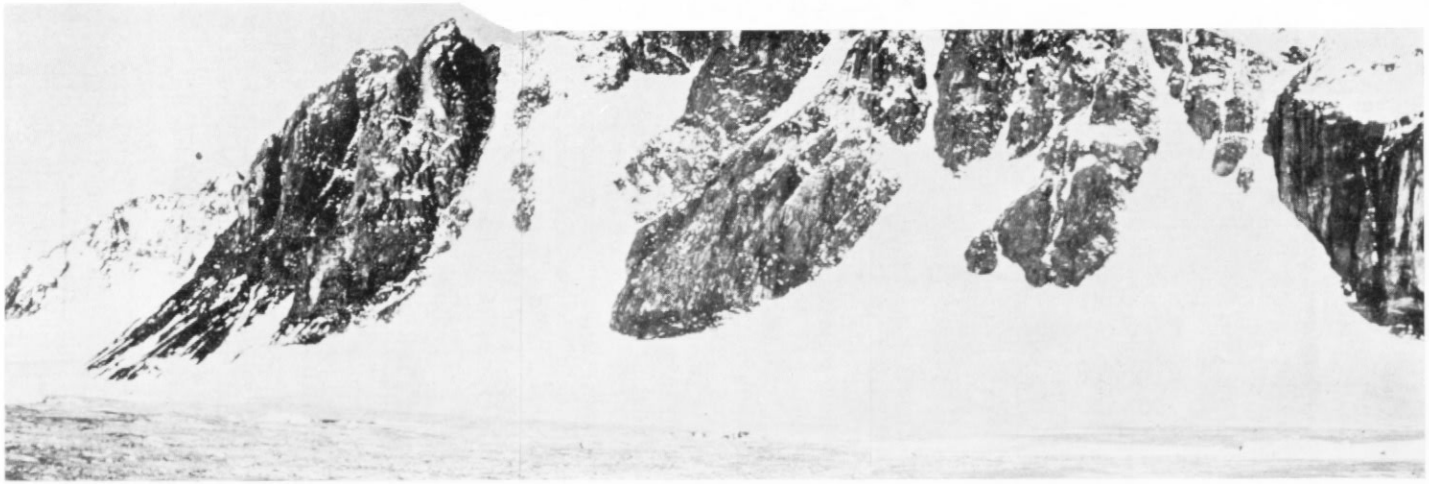

Fig. 2. Panorama of the south-facing cliffs of Carse Point, showing the four buttresses where the sedimentary rocks were discovered below the volcanic sequence forming the cliffs.

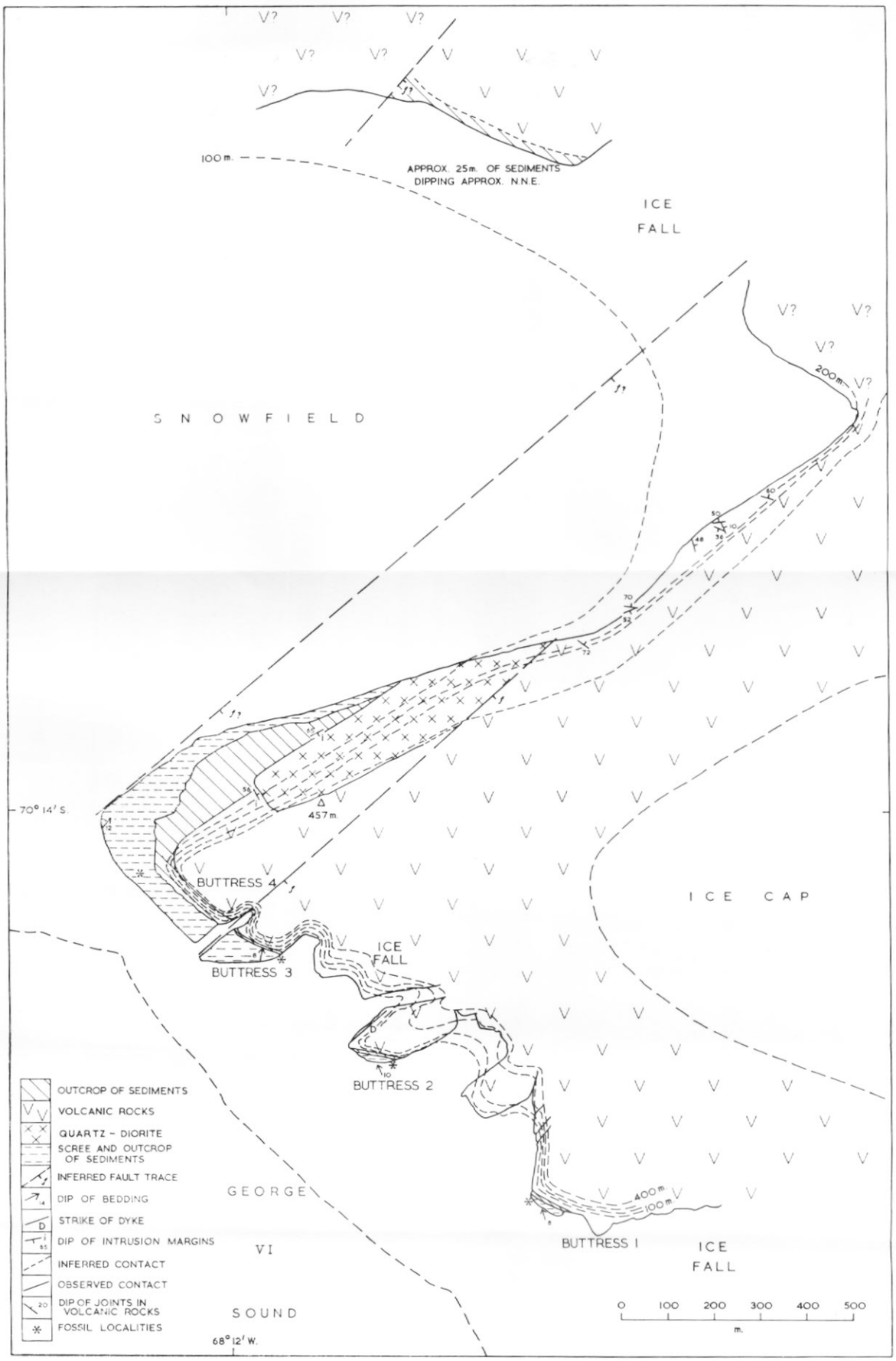

Fig. 3. Geological sketch map of Carse Point.

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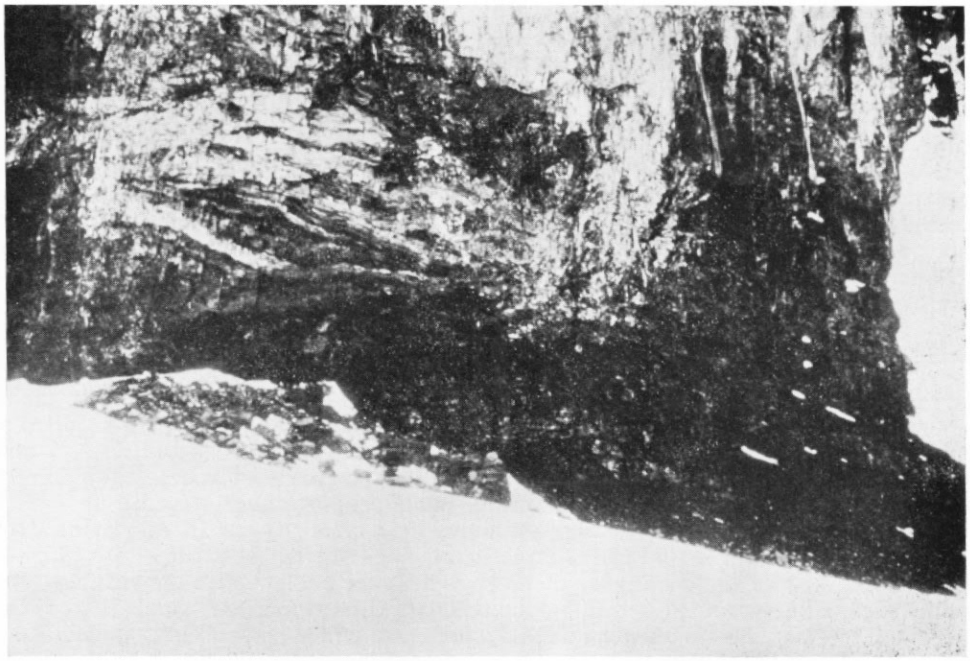

Fig. 4. Buttress 1, showing the exposure of the mudstone-shale sequence and the contact with the volcanic tuffs above.

specks. Quartz is in excess of feldspar, the smaller fragments being relatively elongate and angular, whereas the larger grains range from sub-spherical to elongate and form only 20 per cent of the total quartz fraction. The feldspar grains are all silt size and have an albitic composition. The sediments adjacent to the quartz-diorite intrusion (KG.1258.16 and 17) have been slightly hornfelsed; this is shown by the sub-microscopic recrystallization of the groundmass which contains a criss-cross of white laths and an interlocking mosaic of quartz and other indeterminate low-birefringent mineral grains. Within a few centimetres of the contact with the intrusion margin there is similar recrystallization of the groundmass, together with the widespread formation of biotite (KG.1258.17), and the appearance of secondary quartz aggregates.

At the lower margin of the (?) sill on the south side of buttress 4, the rock is again a metamorphosed mudstone with a felsic fraction containing poorly sorted quartz grains ranging in size from silt to clay, a few sand-size quartz grains, altered plagioclase and lava fragments. The remaining 60 per cent of the rock is formed of the recrystallized groundmass, ragged clots of calcite, minor epidote and specks of iron pyrites and leucoxene. Normal to the bedding are minute veinlets which contain anhedral sphene and radiating (?) penninite.

Other features recognized in the thin section include bioturbation, scattered vermicular structures similar to those recognized in C. G. Smith's specimens from north of Carse Point, and one *Spreitenbaute*.

A specimen was collected from a conglomerate lens (KG.1258.48) at buttress 2. In this rock the matrix, forming 25 per cent of the rock, is composed of limonite, iron pyrites and a coarse mosaic of calcite plates possibly derived from bivalve or belemnite fragments. 35 per cent of the clastic material is composed of quartz grains, well rounded and ranging in size from 0·5 to 1 mm. The remainder are lithic fragments, most of which are within the size range 1·5–2 mm., but a small percentage are up to 10 mm. long, elongated and angular. Most of the lithic fragments are of either trachytic or quartz-latite lavas. These have a felted trachytic texture of oligoclase laths, twinned oligoclase phenocrysts, clots of chlorite replacing mafic

minerals and subordinate corroded quartz with zircon inclusions. There are also a few micrographitic fragments containing anhedral strained quartz, sericitized perthite, and chlorite and iron ore pseudomorphing biotite.

The silty bands low in the mudstone-shale sequence (KG.1258.5) of the same buttress are composed of alternating bands of fine and coarse silt-size quartz grains. The fine bands are 2–3 mm. thick and the coarse ones are up to 10 mm. thick, but each band has a constant grain-size. There are a few plagioclase and lithic fragments but 80 per cent of the rock is composed of quartz grains set in a matrix of secondary iron pyrites, calcite and limonite.

The light-coloured "silty" partings (KG.1258.40) in the mudstones of buttress 4 which display convolute lamination in fact contain little quartz. Silt-size quartz grains comprise only 15 per cent of the rock, the majority of the clasts being altered tabular feldspar crystals set in a clay and carbonaceous matrix.

Volcanic Rocks

The sedimentary rocks are overlain by more than 400 m. of volcanic material. In the rock wall east of the snowfield a sequence of coarse- and fine-grained andesites (KG.1258.15) rests on the more acid tuffs and agglomerates which overlie the sediments of buttresses 1 and 2. At buttress 2, a green tuff (KG.1258.22, 35 and 38) overlies 16 m. of andesitic, agglomeratic (KG.1258.27), black crystal tuffs containing a small proportion of rounded pebble- and cobble-size clasts of intrusive rock. Discontinuous light-coloured bands, displaying current bedding, and the rounded nature of the larger clasts suggest that these tuffs were water-laid. This is corroborated by the occurrence of bivalves near the contact with the sediments.

At buttress 1, a fine-grained green tuff is interbedded with agglomerate bands (Fig. 5) about 50 cm. thick. Again, the fragments in the agglomerate include ill-sorted rounded igneous pebbles and cobbles. At the western end of this exposure a lace-work of white, highly feldspathic tuff "veins" (KG.1258.34) occurs within the green tuffs. These "veins", approximately 0·5 m.

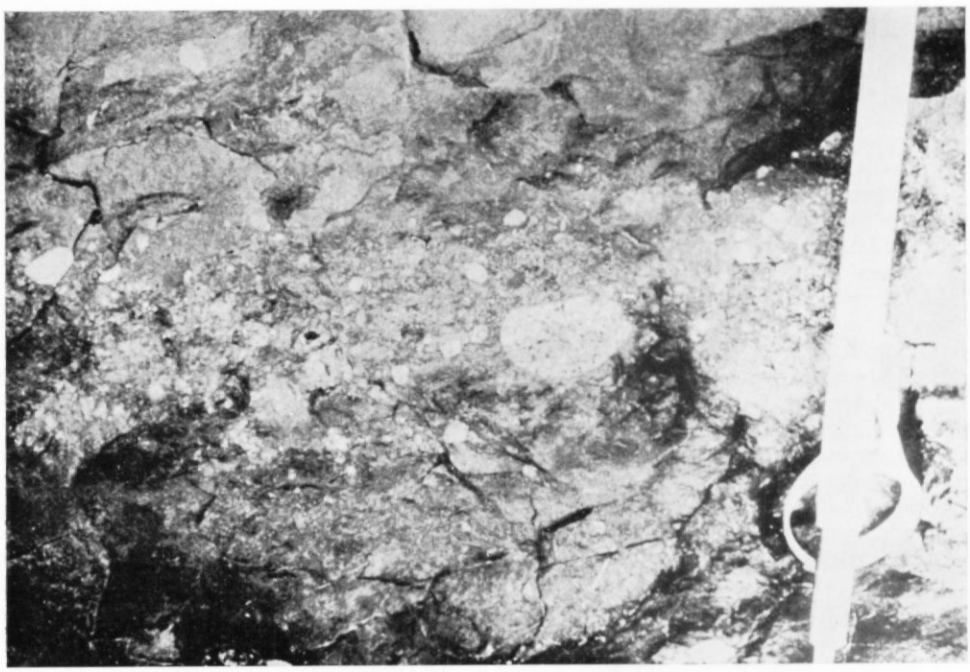

Fig. 5. A water-laid volcanic agglomerate band in tuffaceous rocks; in a fallen block from immediately above the contact between the volcanic and the sedimentary rocks.

wide, trend sub-parallel to the contact between the sediments and the volcanic rocks, having a lateral extent of 15 m. before coalescing and disappearing in an easterly direction. The western end of this exposure is formed by a thick knot of the rock which subdivides to form the anastomosing veins.

A tuffaceous dyke-like body, 2·2 m. wide, crops out at the western end of buttress 1 (KG.1258.36). It is vertical and strikes in a direction parallel to the local faults. Its composition suggests that it could be some form of feeder to the overlying volcanic rocks.

Petrography. The lowest black tuffs, which are best exposed in buttresses 1 and 2, are mixed crystal tuffs (KG.1258.27). Mineral fragments form 50 per cent of the rock and most of these are ill-sorted oligoclase and albite grains ranging from coarse euhedral crystals to fine crystal fragments. Subordinate quartz comprises the crystal fraction, while chloritized lava fragments, secondary chlorite and calcite, very fine crystal fragments, iron ore and an indeterminate matrix form the remainder of the rock.

The tuffs and lithic tuff-agglomerates (KG.1258.27, 35 and 38) overlying the rock described above are green in colour. Rounded quartz grains are subordinate to rounded lava fragments, which are either highly chloritized or are unaltered and have a typical trachytic texture. Many of the clasts are of interlocking quartz, anhedral calcite and epidote, probably representing altered fragments of intrusive rocks. The clast size ranges from about 6 to <1 mm.

The associated white "vein" rock from buttress 1 (KG.1258.34) is a highly feldspathic crystal tuff composed of altered plagioclase, subordinate quartz and lithic fragments. There is a small percentage of unidentifiable matrix and some interstitial chlorite.

The andesites exposed higher in the sequence in the rock wall east of the snowfield are grey-black, fine-grained and non-porphyritic (KG.1258.15). In thin section they display a pilotaxitic texture of plagioclase laths and sparse quartz. Andesine (An_{40}) phenocrysts predominate over the corroded quartz phenocrysts. The mafic mineral, an unidentified amphibole, is associated with a brown, fine-grained, micaceous alteration product which has crystallized interstitially throughout the rock.

The dyke in buttress 2 is a crystal tuff (KG.1258.36) composed predominantly of coarse angular quartz grains set in an indeterminate ash matrix, which is highly altered to chlorite forming 70 per cent of the rock. The calcite aggregates are up to 2 mm. across with deeply embayed margins and some are intergrown with the quartz margins.

Intrusive Rocks

The sediments and volcanic rocks forming the rock wall west of the snowfield are intruded by a small quartz-diorite body (KG.1258.16). It is elongated, 200 m. wide and extends 600 m. to the north-east before it is faulted out. The shape of this intrusion is unknown but its dip of 60° to the east at the north-western margin and its dip of 56° to the north at the south-western margin suggest an eastward-dipping sheet. The central part of this intrusion is more leucocratic than the marginal zone (KG.1258.71), where it is contaminated by reaction with the sediments.

A minor sill (KG.1258.19) crops out on the eastern side of buttress 4, where only its upper and lower contacts are visible through the snow cover over a short distance. Its contacts are horizontal and the underlying sediments are intruded by vertical chlorite veinlets a few centimetres long. In the hand specimen, these appear as light-coloured filaments projecting downward from a horizontal turbid green and white zone (KG.1258.18), 3 cm. wide, composed mainly of calcite and zeolites.

Petrography. The quartz-diorite of the main intrusion is a light-coloured medium-grained holocrystalline rock (KG.1258.16). Microscopically, the texture is granitic with subhedral feldspars set in an anhedral quartz mosaic. The quartz, forming about 30 per cent of the rock, has an undulose extinction and contains a few inclusions. The plagioclase, with an oligoclase to low andesine composition, is often heavily saussuritized and shows extensive oscillatory zoning. The well-formed plagioclase crystals contrast with the finer-grained anhedral potash feldspars which comprise 35 per cent of the total feldspar content.

The mafic minerals include a small amount of biotite but a larger proportion of biotite pseudomorphed by penninite and iron ore parallel to the biotite cleavages. The accessory minerals are epidote, sphene and apatite.

Within 20 cm. of the contact with the mudstones (KG.1258.17), the quartz-diorite shows little change in grain-size, but the feldspars are almost unrecognizable because of their severe alteration; chlorite pseudomorphs biotite perfectly and the quartz assumes a coarse graphic intergrowth with the original mosaic being highly embayed and rimmed by the feldspar alteration products.

The (?) sill at buttress 4 is an altered microdiorite (KG.1258.19). Glomeroporphyritic aggregates of altered andesine are set in a felted matrix of plagioclase laths. The aggregates are associated with accessory quartz, subordinate iron ore, chlorite flakes and irregular calcite masses, presumably the alteration products of the mafic minerals.

Structure

The western extremity of the south-facing cliffs is a fault block, on the northern side of which the fault line is marked by a breccia and the disappearance of the quartz-diorite; on the southern side there is a deep gully and the sediments are warped. The inferred fault block is roughly delineated by buttress 4. It is likely that its eastern boundary is formed by a fault beneath the snowfield, thus explaining the mudstone exposures in the rock wall north of the snowfield. Alternative explanations for the appearance of these mudstones, such as the undetected presence of further sediments higher in the volcanic sequence, or some form of synclinal structure, cannot be excluded at this stage.

Conclusions

In later Jurassic times marine depositional conditions spread eastward from the Alexander Island area at least as far as the present coastline in the Carse Point area of western Palmer Land. Immediately following this stage there was extensive volcanicity and the crystalline clasts found in a volcanic agglomerate at Carse Point tend to support the concept of an adjacent landmass composed of crystalline rocks. Post-volcanic plutonic and hypabyssal intrusive activity was followed by block faulting.

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