PAULET ISLAND AND THE JAMES ROSS ISLAND VOLCANIC GROUP

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ABSTRACT. The late Tertiary James Ross Island Volcanic Group is exposed on several small islands and peninsulas along Prince Gustav Channel and Antarctic Sound. Ranging from submarine to subaerial deposits, their present elevation suggests uplift of at least 400 m. since the late Pliocene. Although pyroclastic rocks are dominant on the other islands, the younger Paulet Island is composed almost entirely of lava flows. Throughout this area, the rocks are largely of alkali-basalt composition comparable with those of James Ross Island itself. On three islets east of Dundee Island there is a limited occurrence of conspicuously different lavas, which are calc-alkaline hypersthene-andesites, probably Jurassic in age.

A COMPREHENSIVE account of the volcanic rocks of James Ross Island has been given by Nelson (1966), and both he and Bibby (1965) described the northerly extension of the James Ross Island Volcanic Group into the smaller islands and peninsulas along Prince Gustav Channel and the southern end of Antarctic Sound. The object of a Chilean expedition to this area in early 1972 was to make a geological study of Paulet Island and to evaluate its status with respect to the James Ross Island Volcanic Group. At the same time, new collections were made for comparative purposes from several of the other small islands and from Tabarin Peninsula (Fig. 1). This latter aspect of the project was in part supplementary to the previous studies of British Antarctic Survey geologists.

VOLCANISM IN THE NORTHERN PART OF THE ANTARCTIC PENINSULA

Volcanic activity appears to have been remarkably persistent in the northern part of the Antarctic Peninsula and the offlying islands from Mesozoic times to the present day. Quantitatively, the most important are the Upper Jurassic calc-alkaline volcanic rocks which reach a maximum thickness of about 3,000 m. on the east coast of Graham Land (Adie, 1971). Geochemically, the Upper Jurassic volcanic rocks are closely allied to the plutonic intrusions of the Andean Intrusive Suite. Metasomatism and contact metamorphism around the intrusive bodies has made it difficult to obtain reliable radiometric ages on the Upper Jurassic volcanics forming the country rocks, but Rex (1971) has reported a K-Ar age of 186 m. yr. for an andesite from Jason Peninsula.

In the present investigation, landings were made on three small unnamed islets (lat. 63°30′S., long. 55°40′W.) which are aligned in a south-easterly direction within 5 km. of the east coast of Dundee Island. Although from their general appearance and location it was originally thought that they might belong to the James Ross Island Volcanic Group, petrographically their lavas proved to be quite distinct. They are typical calc-alkaline two pyroxene-andesites, in complete contrast to the alkali-basalts which occur on the chain of islands to the south. Their composition precludes the possibility of any affinity with the James Ross Island volcanic rocks and it seems likely that they belong to an earlier phase of volcanism, possibly Upper Jurassic.

To the west of the Antarctic Peninsula, an Eocene age has been recorded on two basic lavas from Tower Island and an Oligocene age on a similar lava from Two Hummock Island, near the south-western end of Bransfield Strait (Rex, 1971). Volcanic rocks of a Tertiary age are well known from the South Shetland Islands (Hawkes, 1961; González-Ferrán and Katsui, 1970), and at Deception Island volcanism persists to the present time (Baker and McReath, 1971; González-Ferrán and others, 1971).

To the east of Trinity Peninsula a 1,500 m. sequence of lavas and palagonite-breccias overlies the Cretaceous and Lower Miocene sediments on James Ross Island (Nelson, 1966). A Middle to Upper Miocene age has long been inferred for the James Ross Island Volcanic Group, since it rests on Lower Miocene sediments and is overlain, on Cockburn Island, by a Pliocene Pecten Conglomerate. However, K-Ar age determinations by Rex (1971) now place the James Ross Island Volcanic Group entirely within the Upper Pliocene (1–5 m. yr.). Of particular interest

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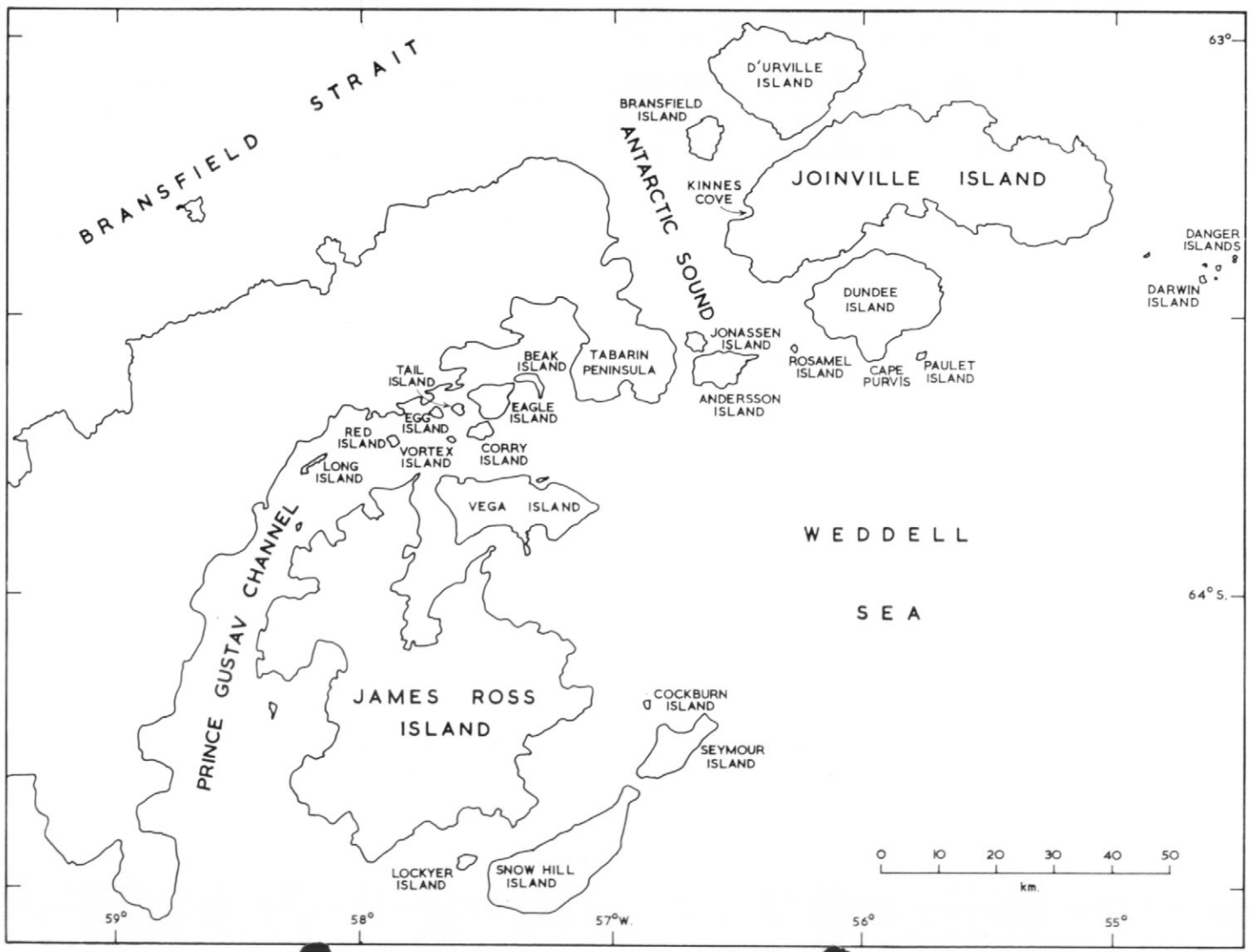

Fig. 1. Location map of the islands in Prince Gustav Channel and those in the vicinity of Antarctic Sound.

has been the additional discovery by Rex that olivine-basalt lavas from the Seal Nunataks, hitherto correlated with the James Ross Island Volcanic Group (Nelson, 1966), are of Pleistocene to Recent age (less than 1 m. yr.). Although Nelson (1966) did not investigate Paulet Island in detail, he considered it to be part of the James Ross Island Volcanic Group.

Nelson (1966) and Bibby (1965) recognized that several of the small islands in Prince Gustav Channel belong to the James Ross Island Volcanic Group which is also represented on Tabarin Peninsula, Andersson Island, Jonassen Island and Rosamel Island at the south-eastern end of Antarctic Sound, and on Dundee Island (Fig. 1). According to Elliott (1967), basic rocks south-east of Kinnes Cove, Joinville Island, are also probably related to the James Ross Island Volcanic Group but he found that the Danger Islands are composed of a gabbro, ascribed to the Andean Intrusive Suite, overlain by a microdiorite thought to be of Tertiary to Recent age.

The present scattered outcrops of the James Ross Island Volcanic Group probably represent the eroded remnants of an extensive basaltic plateau which was essentially confined to the south-eastern side of Trinity Peninsula and the offlying islands. Although it occurs on Tabarin Peninsula and at Cain and Abel Nunataks, there is no evidence that it extended farther across Trinity Peninsula, and there does not appear to be any correlation with the Tertiary volcanic rocks of the South Shetland Islands. The absence of the James Ross Island Volcanic Group from the greater part of the mainland is indicative of major structural control over the distribution of the late Tertiary volcanism. It is likely that an arcuate fault extends from the vicinity of Joinville Island across the isthmus of Tabarin Peninsula and down the east coast of Trinity Peninsula into Prince Gustav Channel (Adie, 1953).

Paulet Island

Paulet Island (lat. 63°34′S., long. 55°48′W.) is a small pear-shaped island measuring about 3·5 km. north–south by 2·5 km. east–west and lying about 5 km. south-east of Dundee Island (Fig. 2). The northern part of the island is formed by small lava hills linked together by a broad spit of low ground which encloses a frozen lagoon and tapers southward to join the beaches of the east and west coasts. Beaches extend all around the island but they become narrower in the south. Apart from the low ground in the north, Paulet Island is composed of a pile of lava flows eroded around the periphery to steep cliffs (Fig. 3). The lavas are surmounted by a steep cone which forms the south-central part of the island and on its south-western flank in another but less conspicuous eruptive centre. A small snow-filled crater is set in the summit of the main cone and red scoriaceous deposits bearing a growth of lichen crop out around the southern rim. A preliminary petrographical study of lavas from the northern (P1) and western sides of the island (P3) shows that both are porphyritic basalts with abundant phenocrysts of olivine, less abundant clinopyroxene and microphenocrysts of plagioclase and opaque oxides. The pale brown colour of the clinopyroxene suggests a titanaugite composition which with the other modal features suggest that the basalt has alkalic affinities. The basalts appear to be very similar to those described by Nelson (1966) from the James Ross Island Volcanic Group.

The James Ross Island Volcanic Group on the Smaller Islands and Peninsulas

On James Ross Island, Nelson (1966) distinguished five separate volcanic phases, each one represented by alternating palagonite-breccias and olivine-basalt lavas. He considered that only the first of these phases was present on the islands of Prince Gustav Channel and only the second on the islands in the vicinity of Antarctic Sound.

No single island shows a complete succession through the volcanic stratigraphy but taken together the composite sequence appears to represent a progression from relatively deep-water volcanism through to shallow water and then subaerial volcanism (Table I). Some of the islands, such as Rosamel, Tail and Vortex Islands, are composed exclusively of various types of yellow tuff. These include primary pyroclastic material with palagonite, some also containing dark subaerial bombs and scoria, and a variety of re-distributed facies showing current bedding and wash-out structures. On Egg Island, subaerial deposits of red scoria cap the succession of yellow tuffs, and on Red Island there are numerous thin flows of basaltic lava, associated with red scoria, overlying the yellow tuffs.

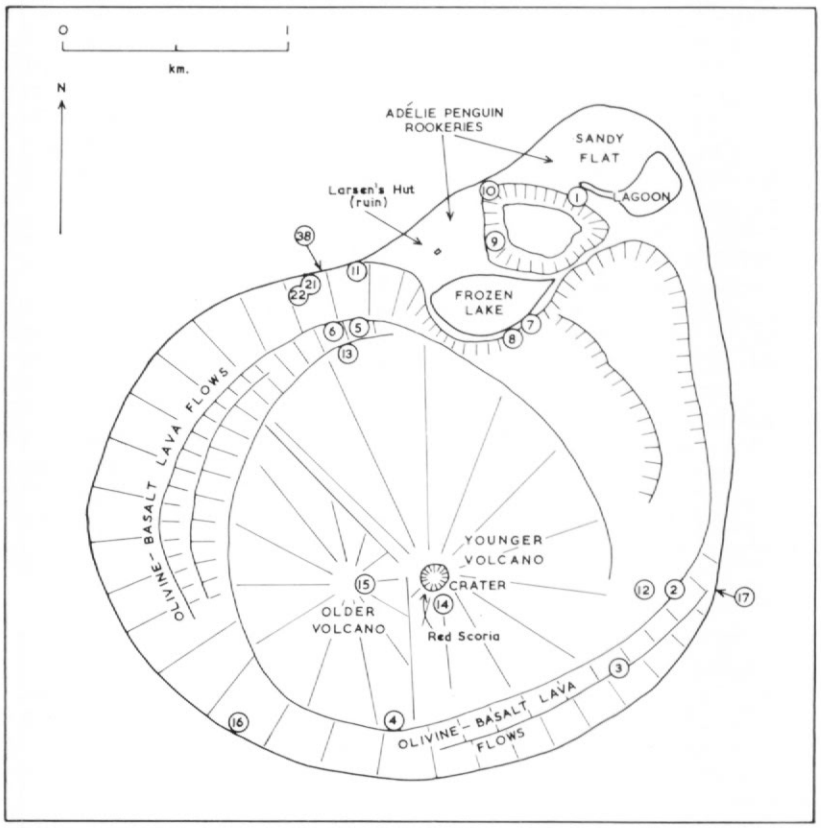

Fig. 2. Sketch map of Paulet Island, showing features of the volcanic physiography and locations where samples were collected (circled numbers).

Around Tabarin Peninsula there is a succession from yellow tuffs up into darker grey tuffs and agglomerates, and finally into basaltic lava flows. At Cape Purvis, Dundee Island, a different type of agglomeratic material is exposed in the high cliffs; the agglomerate is composed of glassy basaltic fragments together with some pillows in a sparse yellow matrix. Nelson (1966) mapped the lowermost part of Tabarin Peninsula as palagonite-breccia but he did not refer to the Dundee Island section.

There appears to be a general relationship between the type of volcanic rock and height above sea-level. Hyaloclastites and palagonite-tuffs form the lower parts of the succession and red scoria and lava flows tend to be restricted to higher elevations. This vertical sequence, though complicated by subsequent uplift, which was probably not constant across the entire area, reflects the different environment in which the various types of volcanic rock originally accumulated. The decisive factor is likely to have been the depth of water, since this will effectively control the rate and amount of outgassing from a magma and the degree of fragmentation. The deepest-water facies is probably represented by the hyaloclastites with pillows occurring at Cape Purvis, Dundee Island. The coarse hyaloclastite-agglomerates of Tabarin Peninsula probably form the next, less deep facies. This interpretation differs from that of Nelson (1966), who attributed the formation of the palagonite-breccias to aqueous brecciation of olivine-basalt flows as they passed from a subaerial vent into the sea, building outwards in delta fashion.

In shallower-water facies, the reduction in hydrostatic pressure would allow a more complete disintegration of the magma to give the commonest rock type of this area which is a yellow

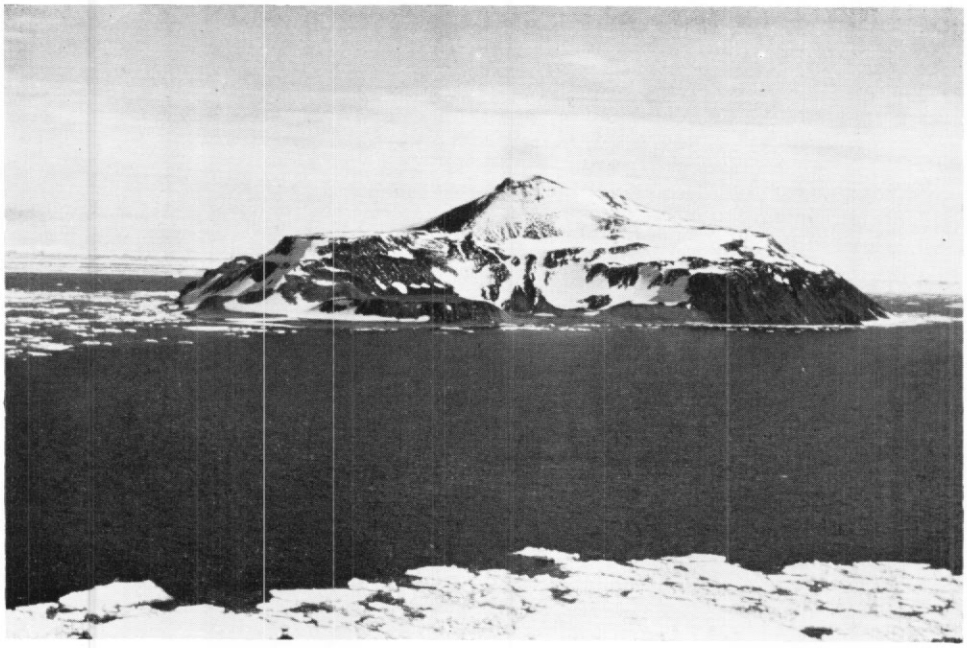

Fig. 3. Paulet Island viewed from the north-north-west.

TABLE 1. GENERALIZED SUCCESSION OF THE JAMES ROSS ISLAND VOLCANIC GROUP IN THE ISLANDS OF PRINCE GUSTAV CHANNEL AND ANTARCTIC SOUND

Rock type	*Depositional environment*	*Example*
6. Red scoria and bombs	Subaerial	Egg Island
5. Basaltic lava flows	Subaerial	Red and Paulet Islands
4. Re-worked yellow tuffs	Shallow water	Tail Island
3. Primary yellow tuffs with some dark volcanic bombs and scoria	Essentially shallow water with some subaerial components	Rosamel and Tail Islands
2. Primary yellow tuffs and hyaloclastites	Moderately shallow water	Corry Island and Tabarin Peninsula
1. Hyaloclastites with pillows	Deeper water	Cape Purvis, Dundee Island

tuff (e.g. Rosamel Island). The transition to subaerial deposits is seen on Tail Island, where dark subaerial bombs are associated with yellowish shallow-water tuffs, which frequently show evidence of current action and re-distribution. The appearance of red scoria and lava flows at the top of the sequence of yellow tuffs and agglomerates is a clear indication of a change to subaerial volcanic activity and is well illustrated by the uppermost parts of Red and Egg Islands.

Most of the James Ross Island Volcanic Group, as represented on these smaller islands, appears to have been erupted in a subaqueous environment as indicated by the sedimentary structures and advanced palagonitization. Although a subglacial environment might have had

a comparable influence on the deposits, a submarine situation is thought to be more likely (Nelson, 1966, p. 36). If this is so, then the present altitude of the submarine pyroclastic rocks on the small islands requires emergence of at least 400 m. since the late Pliocene. The alternating palagonite-breccia–olivine-basalt phases of James Ross Island indicate repeated submergence throughout the time of the volcanic rocks, and Nelson (1966, p. 60) referred to subsequent uplift which is possibly of the order of 1,200 m., whilst Bibby (1965) described the raised beaches and wave-cut platforms which resulted from smaller-scale recent uplift (e.g. 24 m. a.s.l.). The enormous emergence since late Pliocene times is probably largely an expression of the regional tectonic and thermal environment together with lesser eustatic changes.

On most of the islands of the James Ross Island and Joinville Island groups, present sea-level is at the height of the yellow tuffs, hyaloclastites and pillows, originally formed in relatively deep water. In sharp contrast to all of the others is Paulet Island, where no yellow tuffs appear and where the cliffs are composed entirely of subaerial lava flows. This is regarded as further evidence that Paulet Island is significantly younger than the remainder, having formed entirely within recent times with sea-level essentially the same as it is today.

Conclusions

The James Ross Island Volcanic Group, as represented on the small islands in Prince Gustav Channel and Antarctic Sound, is thought to indicate a progressive change from deeper-water volcanism, through to shallow water and then subaerial activity. Uplift of at least 400 m. since the Pliocene is probably a tectonic or thermal updoming rather than a general eustatic event.

Paulet Island appears to be a younger volcanic structure and in this respect is perhaps comparable with the Seal Nunataks farther south. However, petrographically the Paulet Island lavas are alkalic basalts, very similar to those of James Ross Island. The evidence that the James Ross Island Volcanic Group is itself younger than previously supposed (i.e. 1–5 m. yr.) suggests that the volcanic rocks of Paulet Island and the Seal Nunataks, though younger, need not necessarily be regarded as constituting an entirely separate period of activity. They should probably be regarded as simply the latest manifestations of a volcanic province which was instituted about 5 m. yr. ago.

These mildly alkaline volcanic rocks belonging to the latest period of activity in this part of the Antarctic Peninsula contrast with the older (Upper Jurassic–(?) early Tertiary) volcanic rocks and probably reflect a major change in tectonic environment from an orogenic type to one of major faulting and crustal extension.

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