NEW K–Ar AGE DETERMINATIONS ON THE JAMES ROSS ISLAND VOLCANIC GROUP, NORTH-EAST GRAHAM LAND, ANTARCTICA

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ABSTRACT. Nineteen new whole-rock K–Ar age determinations are presented for the James Ross Island Volcanic Group (JRIVG) of north-east Graham Land, Antarctica. The overall age range of the samples is 7.13 ± 0.49 to 1.27 ± 0.08 Ma (upper Miocene–Pliocene). However, the samples show a strong geographical correlation with age. Lavas from islands in north-east Prince Gustav Channel are relatively young, (*c.* 2.5–1.2 Ma), whereas petrographically identical lavas from James Ross Island are usually older, (*c.* 5.7–4.4 Ma). Intrusive rocks dated from James Ross Island include laccolithic bodies and dykes but, although they are consanguineous with the lavas of the JRIVG, they show more extended age range, from about 6.5 to 3.0 Ma. The range of ages determined compares well with data of previous workers and corroborates their conclusion that the focus of volcanic activity migrated north-eastward from James Ross Island about 2 Ma ago, an event which possibly relates to the opening of the Bransfield Strait to the north-west at this time. A JRIVG clast from the tillites beneath the JRIVG extends the period of volcanism back to about 7.1 Ma.

INTRODUCTION

James Ross Island (Fig. 1) lies off the eastern coast of Trinity Peninsula, northern Graham Land. The purpose of this study was to clarify the age and migration of eruptive events in the James Ross Island Volcanic Group (JRIVG; Nelson, 1975) – a series of mildly alkaline basaltic and hyaloclastic rocks erupted in a subglacial-to-periglacial environment. All the dated samples were collected in the 1985/86 field season from northern James Ross Island, Vega Island and smaller islands in Prince Gustav Channel, and were selected for dating in order to represent all magmatic lithologies and a range of stratigraphic levels.

The JRIVG consists of a sequence of interstratified hyaloclastic breccias and subaerial olivine-basalt lava flows. It forms part of a more extensive alkaline volcanic belt from north-east Graham Land, through James Ross Island, Seal Nunataks, Alexander Island, Jones Mountains, Marie Byrd Land to Victoria Land. There is a general trend for the composition of the volcanic rocks of this belt to become more alkaline, more undersaturated and hence more nepheline-normative westward (Baker and others, 1977).

Geochronology of samples from other areas has shown them to be broadly coeval with the JRIVG. Rex (1976) dated some samples from James Ross Island itself at between 6 and 2 Ma, with younger basalts occurring farther north on islands in the Prince Gustav Channel and on Tabarin Peninsula. This trend continues north-east as far as Paulet Island, dated at 0.3 ± 0.1 Ma (Baker and others, 1977). The other provinces, with the exception of Marie Byrd Land, give dates generally between 10.0 and 0.2 Ma (Smellie and others, this volume). Marie Byrd Land shows a much longer history of alkaline volcanism stretching back to the Oligocene, with hyaloclastites from the USAS Escarpment dated at 27 ± 1 Ma and a still older date of 44 ± 2 Ma from a supposedly related pluton (LeMasurier and Rex, 1982).

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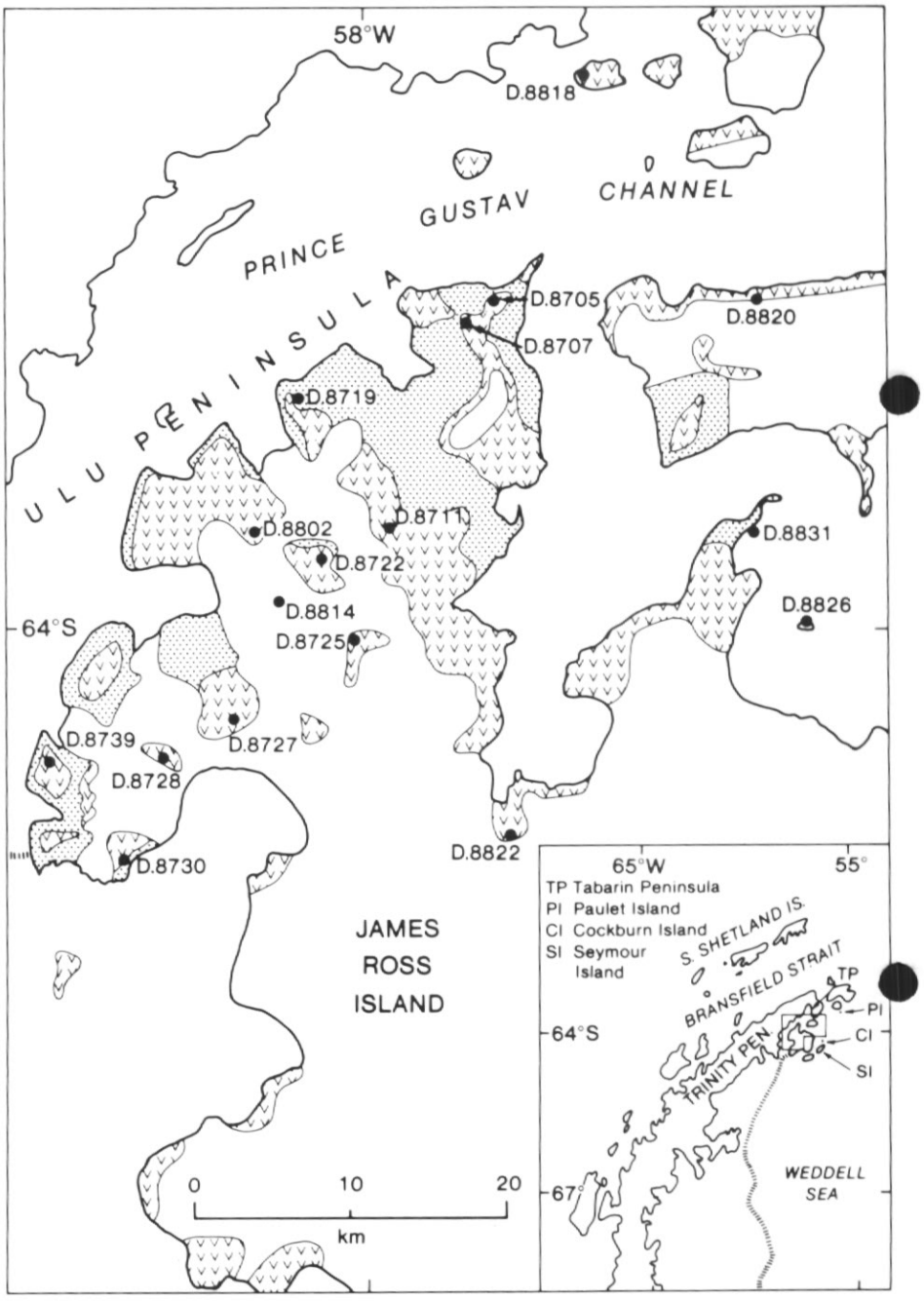

Fig. 1. Map of sample localities for new K–Ar age determinations. The inset shows the location of James Ross Island in relation to the Antarctic Peninsula. v, volcanic rocks; stipple, Cretaceous sedimentary rocks; blank, snow and ice.

Field relationships suggest that the JRIVG is younger than Oligocene but older than Pleistocene. Throughout most of James Ross Island it is underlain by Cretaceous sediments as young as Campanian–Maastrichtian in age (Ineson and others, 1986), but on Cockburn Island, 12 km east of James Ross Island, it unconformably overlies Oligocene sands and silts similar to those cropping out on nearby Seymour Island (Zinsmeister, 1982). On Cockburn Island it is overlain in places by the Pecten Conglomerate which Andersson (1906) correlated with a similar deposit of Pliocene age at Cape Fairweather in Patagonia; Hennig (1911) and Zinsmeister and Webb (1982) considered the Pecten Conglomerate to be Pleistocene in age. However, Cockburn Island is the only known exposure of this conglomerate in the whole of the James Ross Island area, and it is possibly unreasonable to conclude that the entire JRIVG is older than the Pecten Conglomerate on the basis of a single instance. Other areas may have remained volcanically active after the Pecten Conglomerate was laid down on Cockburn Island (below). It is also clear from the highly irregular erosion surface underneath the volcanics, and from the range of established dates, that there was a considerable hiatus between the deposition of the underlying sedimentary rocks and the onset of volcanism.

The data of Rex (1976) indicate that the volcanic centre of the James Ross Island region migrated north-eastward after 2 Ma ago (Baker and others, 1977; Fig. 2) with no dates older than 2 Ma recorded from the islands in Prince Gustav Channel and Tabarin Peninsula, and the only known manifestation of more recent activity on James Ross Island itself being the poorly known, partially eroded 'Coley Cone' in the north-east of the island, discovered by air photography in 1979 (González-Ferrán, 1983).

Analytical methods

Age determinations were performed by whole-rock ^{40}K–^{40}Ar methods using the MM 1200 mass spectrometer at the NERC Isotope Geology Centre, Grays Inn Road, London. Fresh, non-vesicular samples of magmatic rocks were crushed, cone-milled and sieved to obtain a 0.125–0.250 mm grainsize fraction. This separate was thoroughly washed to clean off any fine dust adhering to the sandy particles and 3 g of this sample were fused under vacuum to release the radiogenic ^{40}Ar. After removal of active gases by means of a liquid nitrogen cold trap and a Ti furnace, the Ar sample was fed into the mass spectrometer, where analysis was performed over 20 independent scans. The concentration of K in the samples was determined on powdered rock by flame photometry, following dissolution in HF and HCl.

Results

Nineteen new K–Ar whole-rock age determinations for the JRIVG are presented in Table I and shown graphically in Fig. 2. There is a crude geographical pattern to the data, with rocks from any one area tending to have similar ages. The overall range of ages determined is 7.13 ± 0.49 Ma to 1.27 ± 0.08 Ma, which constrains the JRIVG in this area to between upper Miocene and Pleistocene ages. However, within this range are two clearly defined sets of data; an older group of lavas ranging from 5.7 to 4.4 Ma from James Ross Island itself, and a small group of younger lavas, two from the northern Prince Gustav Channel area and one from Dobson Dome, James Ross Island, ranging from 1.2 to 2.5 Ma. The young sample from James Ross Island occurs at an altitude of about 700 m and is thought to be one of the most recent basaltic rocks on the island.

Table I. New whole-rock K-Ar age determinations on the James Ross Island Volcanic Group

Station	*Rock type*	*K* (%)	*Radiogenic* ^{40}Ar (*nl/g*)	*Atmospheric* ^{40}Ar (%)	*Age* (*Ma*)
D.8705.1	Basalt lava	0.9545	0.1833	62.2	4.93 ± 0.27
D.8707.2	Basaltic clast from tillite	0.5420	0.1504	68.5	7.13 ± 0.49
D.8707.4	Basalt lava	1.1350	0.2045	84.0	4.63 ± 0.57
D.8707.8	Dolerite sill	0.7595	0.1547	83.4	5.23 ± 0.57
D.8711.1	Basalt lava	1.0670	0.1843	64.5	4.44 ± 0.25
D.8719.3	Dolerite plug	1.0020	0.2390	78.1	6.13 ± 0.56
D.8722.2	Basalt dyke	1.2690	0.1818	88.0	3.68 ± 0.82
D.8725.4	Basalt lava	0.6825	0.0406	82.2	1.53 ± 0.18
D.8727.1	Basalt lava	0.9745	0.1776	60.1	4.68 ± 0.20
D.8728.1	Dolerite laccolith	1.6800	0.3508	73.2	5.36 ± 0.5
D.8730.1	Basalt lava	1.2270	0.2563	66.8	5.37 ± 0.35
D.8739.5	Basalt pillow	0.6910	0.1466	58.3	5.45 ± 0.32
D.8802.7	Basalt lava	0.9480	0.2095	63.8	5.68 ± 0.31
D.8814.1	Dolerite laccolith	1.6670	0.2828	53.6	4.36 ± 0.21
D.8818.1	Basalt lava	1.3695	0.1318	85.6	2.47 ± 0.38
D.8820.5	Basalt lava	1.9980	0.0987	71.8	1.27 ± 0.08
D.8822.1	Basalt lava	0.8675	0.1737	49.4	5.15 ± 0.33
D.8826.1	Dolerite plug	0.5785	0.1453	79.7	6.45 ± 0.60
D.8831.2	Dolerite laccolith	1.1240	0.1563	79.6	3.57 ± 0.34

The intrusive rocks show a greater scatter, with ages ranging from 3.6 to 6.5 Ma and no apparent break in the data similar to that observed in the lavas. The relative youth of the two samples dated from the Prince Gustav Channel area appears to confirm the hypothesis of Baker and others (1977) that a north-eastward migration of the volcanic activity occurred after about 2 Ma ago. Furthermore, the general range of ages for James Ross Island itself determined by Rex (1976) are mirrored, with an overall range of 6.5 and 3.0 Ma. However, there is no clear reason why virtually all of the James Ross Island lavas are older than about 4 Ma, which was followed by a break of nearly 2 Ma before the inception of volcanism in the Prince Gustav Channel region. Intrusions were apparently emplaced periodically between 6.5 and 3.0 Ma ago.

Nelson (1975) divided the JRIVG into five phases of volcanic activity on the basis of altitude above sea level and correlation between adjacent exposures, with phase 1 being the oldest and lowest and phase 5 being the youngest and highest. Phase 1 rocks were restricted primarily to the area of Prince Gustav Channel, but have since been found to be the youngest volcanic rocks in the area. Although local correlations on James Ross Island are valid, the new K–Ar geochronology, which was carried out on samples selected to test the stratigraphical model, does not confirm the existence of the five discrete phases of volcanism. Indeed it is demonstrable that volcanic rocks at a low altitude in one place are younger than those higher up in another, and hence correlation between exposures based solely on altitude can be misleading.

The oldest age determined in this group of samples was on sample D.8707.2, a volcanic clast in a diamictite beneath the JRIVG at Crame Col, which yielded an age of 7.13 ± 0.49 Ma. Abundant volcanic clasts within tillites at several localities on Ulu Peninsula indicate that the tillites were deposited after the onset of volcanism. These clasts are clearly consanguineous with the JRIVG since they have identical mineralogy and petrography. This result shows that the maximum age of the JRIVG is older than

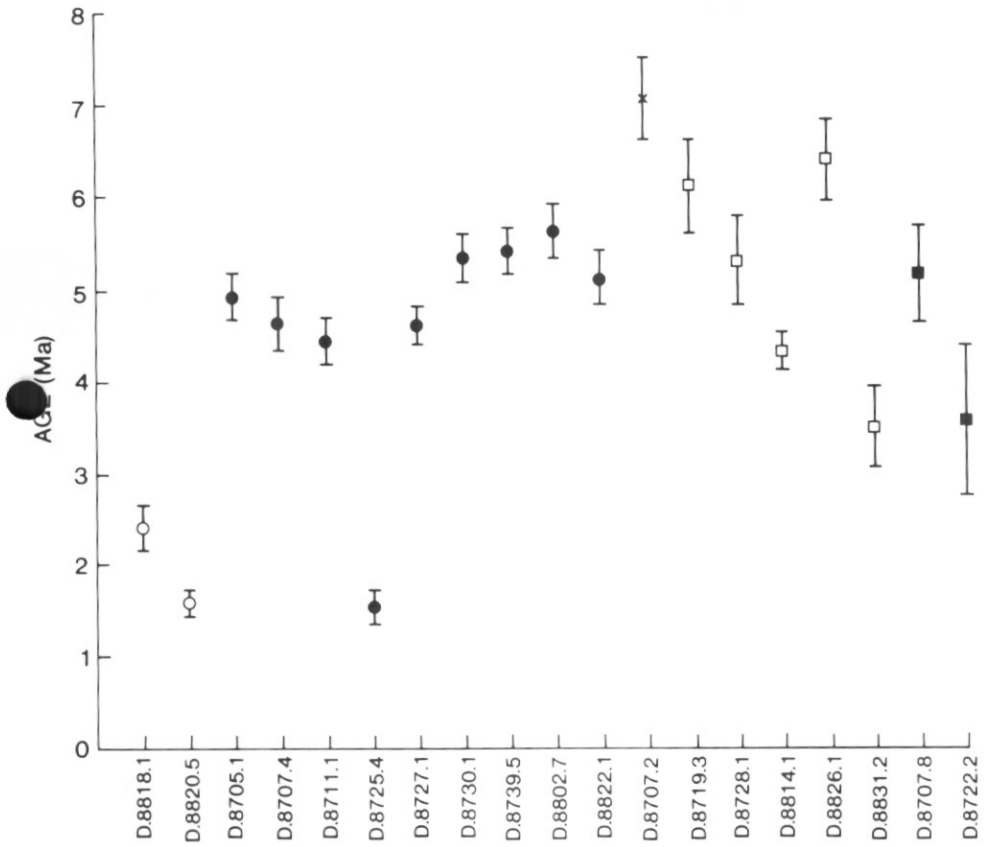

Fig. 2. Geographical distribution of new K–Ar age determinations. Prince Gustav Channel islands lavas, ○; James Ross Island lavas, ●; JRIVG clast from diamictite, ×; Laccolithic intrusions, □; Dykes, ■.

oldest date recorded for *in situ* volcanic rocks. It is suggested that the best method of ascertaining the onset of alkaline volcanism would be to collect an extensive suite of unequivocal JRIVG clasts from the diamictites underlying the JRIVG and determine their maximum age.

Conclusions

(1) The age range of the JRIVG in northern James Ross Island is about 6.5–3.0 Ma. However, with the exception of very young lavas of comparable age to those from islands in Prince Gustav Channel, lavas mostly give dates between about 5.75 and 4.5 Ma.

(2) Two basaltic samples obtained from the Prince Gustav Channel area are considerably younger than similar lavas from James Ross Island: 1.27 ± 0.08 Ma and 2.47 ± 0.38 Ma. This appears to agree with the hypothesis of Baker and others (1977) that the volcanic activity migrated north-eastward from about 2 Ma ago. The cause of this shift is not known, but it may be significant that this age corresponds to the initial rifting of the Bransfield Strait marginal basin between Graham Land and

the South Shetland Islands now 120 km north-west of the James Ross Island area (Thomson and others 1982).

(3) A JRIVG-type clast from a diamictite underlying the volcanic rocks yielded an age of 7.13 ± 0.49 Ma. This is considerably older than the oldest date recorded from JRIVG rocks *in situ*, indicating an earlier onset of alkaline volcanism in the area. It is probable that prior to the great effusions of magma starting about 6 Ma ago, the JRIVG was of low volume and limited extent.

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