ISOTOPE COMPOSITION OF STRONTIUM IN MESOZOIC BASALT AND DOLERITE FROM DRONNING MAUD LAND

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ABSTRACT. Initial $^{87}Sr/^{86}Sr$ ratios of basalt and dolerite from Dronning Maud Land have a bi-modal distribution with mean values of $0 \cdot 7037 \pm 0 \cdot 0004$ (σ) and $0 \cdot 7072 \pm 0 \cdot 0003$ (σ), assuming that all samples crystallized 170 m. yr. ago. The low group has an average rubidium content of $6 \cdot 5 \pm 1 \cdot 4$ p.p.m., while the high group contains $16 \cdot 9 \pm 4 \cdot 7$ p.p.m. Strontium concentrations range from about 145 to 380 p.p.m. and do not correlate with initial $^{87}Sr/^{86}Sr$ ratios. The initial $^{87}Sr/^{86}Sr$ ratios of the basaltic rocks from Dronning Maud Land are lower than those of the Ferrar Group in the Transantarctic Mountains. The former also have lower rubidium concentrations and higher strontium concentrations than the latter.

THE isotope composition of strontium and concentrations of rubidium and strontium have been determined for 12 specimens of basalt and dolerite from Dronning Maud Land. The samples were collected by members of the British Antarctic Survey, who also provided information about sample locations and descriptions.

All of the specimens analysed by us originated from Heimefrontfjella, Vestfjella and Mannefallknausane, Dronning Maud Land. Rex (1967) dated two specimens of dolerite from Vestfjella by the whole-rock K-Ar method and obtained dates of 168 ± 6 and 172 ± 6 m. yr. These dates are in satisfactory agreement with a K-Ar date of 174 ± 7 m. yr. for sample Z.372.1 which is a coarse-grained basalt from western Bjørnnutane (personal communication from R. J. Adie). There appears to be little doubt therefore that the basalts and dolerites of this part of Dronning Maud Land date from the Jurassic period. The petrology and geochemistry of dolerite sills and dykes of Mannefallknausane and Vestfjella have been described by Juckes (1968).

ANALYTICAL METHODS

The $^{87}Sr/^{86}Sr$ ratios of the basalts and dolerites were measured on a 60°-sector 6 in. [15 cm.] radius of curvature solid-source mass spectrometer (Nuclide Corporation, Model 6-60-S). The measured $^{87}Sr/^{86}Sr$ ratios were corrected for isotope fractionation to a standard value of the $^{86}Sr/^{88}Sr$ ratio of $0 \cdot 1194$. The Eimer and Amend strontium isotope standard was analysed repeatedly and has an average $^{87}Sr/^{86}Sr$ ratio of $0 \cdot 7083 \pm 0 \cdot 00044$ (σ).

Concentrations of rubidium and strontium were measured by X-ray fluorescence using the rock standards of the U.S. Geological Survey (G-2, AGV-1, BCR-1 and W-1) to construct calibration curves. Major- and trace-element compositions of these rocks were recently published by Fleischer (1969) and Flanagan (1969). Matrix corrections were made by a method developed by Reynolds (1963) and described by Powell and others (1969) which makes use of the relationship between the mass-absorption coefficient and the intensity of the Compton-scattered $K\alpha$ X-radiation of the primary X-rays. The reproducibility for strontium determinations at concentration levels in excess of 100 p.p.m. is ± 2 per cent at the 95 per cent confidence limit. Because of the low concentrations, the reproducibility of the rubidium analyses is estimated to be ± 20 per cent.

The analytical data are compiled in Table I. Initial $^{87}Sr/^{86}Sr$ ratios were calculated for each sample using the observed Rb/Sr ratios and by assuming a common age of 170 m. yr. and a value of $1 \cdot 39 \times 10^{-11}$ yr.$^{-1}$ for the decay constant of ^{87}Rb. These corrections for decay of ^{87}Rb lower the observed $^{87}Sr/^{86}Sr$ ratios by less than $0 \cdot 1$ per cent in all cases.

DISCUSSION OF THE RESULTS

The initial $^{87}Sr/^{86}Sr$ ratios of the basalts and dolerites from Dronning Maud Land range from $0 \cdot 7018$ to $0 \cdot 7076$. The histogram of these ratios in Fig. 1 reveals a distinct bi-modal

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TABLE I. CONCENTRATIONS OF Rb AND Sr AND THE ISOTOPE COMPOSITION OF Sr FOR BASALT AND DOLERITE FROM DRONNING MAUD LAND

Specimen number	*Description*	Rb (p.p.m.)	*Total* Sr (p.p.m.)	$(^{87}Sr/^{86}Sr)m$	*Initial* $^{87}Sr/^{86}Sr$
	Basalts				
Z.308.4	Lat. 74°37′S., long. 10°00′W. From the centre of a 16 m. thick flow near the base of the succession; eastern Bjørnnutane	13·4	310·0	0·7076	0·7073
Z.310.2	Lat. 74°37′S., long. 10°00′W. From the centre of a 6 m. thick flow near the base of the succession; eastern Bjørnnutane	3·3	337·0	0·7057	0·7056
Z.349.1	Lat. 74°29′S., long. 8°13′W. Specimen showing flow banding, from the base of the exposed succession at Sembberget	10·0	187·5	0·7045	0·7041
Z.350.1	Lat. 74°29′S., long. 8°13′W. Coarse basalt from a thick flow (at least 16 m.) near the middle of the section at Sembberget	19·2	169·7	0·7083	0·7075
Z.350.2	Lat. 74°29′S., long. 8°13′W. Lighter-coloured basalt with trachytic texture from near the middle of the section at Sembberget	10·8	144·7	0·7080	0·7075
Z.370.1	Lat. 74°36′S., long. 10°04′W. Coarse basalt from western Bjørnnutane	4·5	350·3	0·7038	0·7037
Z.371.7	Lat. 74°36′S., long. 10°06′W. Uppermost exposed part of the basal flow (at least 10 m. thick); collected from a small nunatak about 2 km. west of Bjørnnutane	18·2	325·1	0·7083	0·7079
Z.372.1	Lat. 74°36′S., long. 10°04′W. Coarse basalt from western Bjørnnutane; dated by the whole-rock K-Ar method as 174±7 m. yr.	5·0	378·9	0·7040	0·7039
	Dolerites				
Z.353.7	Lat. 74°19′S., long. 9°49′W. Fine-grained dolerite from 2 m. below the upper contact of a 10 m. thick sill intruding (?) Lower Permian sediments; north-east Heimefrontfjella	14·5	184·9	0·7055	0·7050
Z.388.1	Lat. 74°36′S., long. 14°21′W. Basaltic dyke 0·6 m. wide, intruding Basement Complex gneisses, Mannefallknausane	23·0	247·0	0·7082	0·7076
Z.391.5	Lat. 74°35′S., long. 14°18′W. Chilled margin of a differentiated 5 m. thick sill of olivine-dolerite intruding Basement Complex gneisses; Mannefallknausane	8·9	201·5	0·7021	0·7018
Z.395.1	Approximate position: lat. 73°48′S., long. 14°30′W. Dolerite, presumably from a sill; Vestfjella	4·3	269·4	0·7038	0·7037

Concentrations of Rb and Sr were determined by X-ray fluorescence spectrometry as described in the text. The measured $^{87}Sr/^{86}Sr$ ratios were corrected for decay of ^{87}Rb assuming an age of 170 m. yr. and a value of $1 \cdot 39 \times 10^{-11}$ yr.$^{-1}$ for the decay constant of ^{87}Rb. The $^{87}Sr/^{86}Sr$ ratio of the Eimer and Amend isotope standard (lot 492327) is $0 \cdot 7083 \pm 0 \cdot 00044$ (σ). All measured $^{87}Sr/^{86}Sr$ ratios have been corrected for fractionation to $^{86}Sr/^{88}Sr = 0 \cdot 1194$.

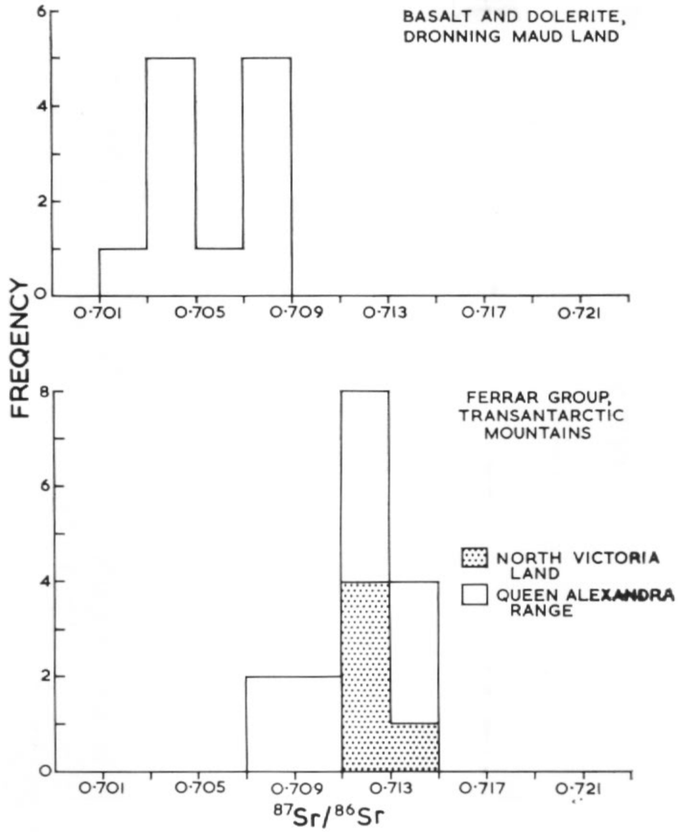

Fig. 1. Histograms of initial $^{87}Sr/^{86}Sr$ ratios of basalt and dolerite from Dronning Maud Land and from the Ferrar Group of the Transantarctic Mountains (Hill, 1969).

distribution, with means of $0 \cdot 7037 \pm 0 \cdot 0004$ and $0 \cdot 7072 \pm 0 \cdot 0003$. The errors are one standard deviation of the mean. It is interesting to note that both high and low values may occur in the same section of basalt flows. This is shown by samples Z.349.1, 350.1 and 2, which originated from Sembberget at lat. 74°29′S., long 8°13′W. Sample Z.349.1 is from the base of the exposed section and has a low $^{87}Sr/^{86}Sr$ ratio (0·7041), while the other two are from flows near the middle of the section and have high $^{87}Sr/^{86}Sr$ ratios (0·7075). There is at least the suggestion of a stratigraphical variation of the $^{87}Sr/^{86}Sr$ ratios of the basalt flows at this nunatak.

Anomalously high initial $^{87}Sr/^{86}Sr$ ratios in Mesozoic dolerites of Tasmania and Antarctica were first reported by Heier and others (1965) and Compston and others (1968), respectively. Recently, Hill (1969) analysed suites of basalt belonging to the Ferrar Group from Scarab Peak (Rennick Glacier) in northern Victoria Land and from the Queen Alexandra Range (Beardmore Glacier). Both suites were found to have high initial $^{87}Sr/^{86}Sr$ ratios with an average of about 0·712. Hill's data are shown as a histogram in Fig. 1 for comparison with the basalts and dolerites from Dronning Maud Land. It is evident by inspection that the basaltic rocks of the Ferrar Group differ significantly from those of Dronning Maud Land by their higher $^{87}Sr/^{86}Sr$ ratios. A few samples of basalt from the Queen Alexandra Range have somewhat lower $^{87}Sr/^{86}Sr$ ratios, comparable to the high group in Dronning Maud Land. The significance of these data is still under investigation.

The concentrations of rubidium and strontium of the basaltic rocks from Dronning Maud Land are plotted in Fig. 2 and are compared there to Hill's data for the Ferrar Group. It is

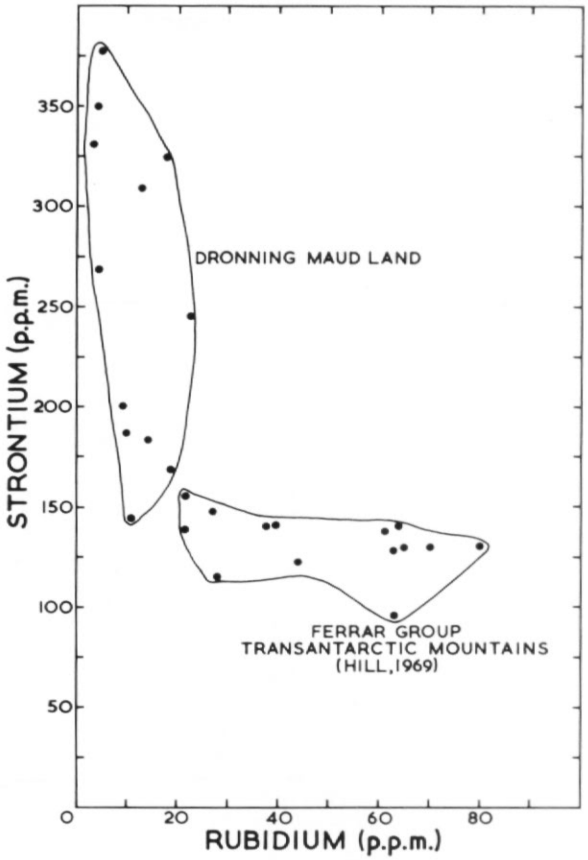

Fig. 2. Variation of rubidium and strontium concentrations of basaltic rocks from Dronning Maud Land and from the Ferrar Group of the Transantarctic Mountains.

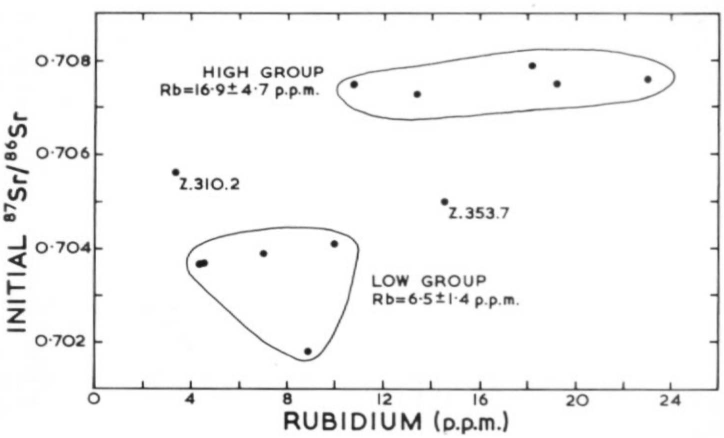

Fig. 3. Apparent correlation of low rubidium content with low initial $^{87}Sr/^{86}Sr$ ratios in the basaltic rocks of Dronning Maud Land.

apparent that the basaltic rocks from Dronning Maud Land have significantly *lower* rubidium concentrations, but *higher* strontium concentrations than the rocks of the Ferrar Group. The low rubidium content of the basaltic rocks from Dronning Maud Land is consistent with the observation by Juckes (1968) that the dolerites from Dronning Maud Land and Coats Land have lower potassium concentrations than the basaltic rocks of Victoria Land.

In Fig. 3 the rubidium concentrations of the basaltic rocks from Dronning Maud Land have been plotted against their initial $^{87}Sr/^{86}Sr$ ratios. The data form two clusters, suggesting that the rocks having low initial $^{87}Sr/^{86}Sr$ ratios also have lower rubidium concentrations than do rocks with high initial $^{87}Sr/^{86}Sr$ ratios. The average rubidium content of five specimens in the low group is $6 \cdot 5 \pm 1 \cdot 4$ p.p.m., while that of the high group is $16 \cdot 9 \pm 4 \cdot 7$ p.p.m. Two of the samples (Z.310.2 and 353.7) appear to occupy an intermediate position between the two groups. The association of high $^{87}Sr/^{86}Sr$ ratios with high rubidium content may be an important clue to the petrogenesis of these rocks. In contrast to rubidium, the strontium content of the two groups appears to be identical.

ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of Dr. R. J. Adie, who provided the samples for analysis. R. P. Rao, René Eastin and Dr. Lois M. Jones assisted with the analysis. This research was supported by the National Science Foundation through grant GA-898X.

MS. received 9 February 1970

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Note added in proof

After this study had been completed, D. C. Rex (SCAR/IUGS Symposium on Antarctic Geology and Solid Earth Geophysics, Oslo, 6–14 August 1970) reported K-Ar age determinations which confirm a Jurassic age for five of the basalts and dolerites from Milorgfjella (Z.349.1, 353.7, 371.7, 372.1 and 380.4). However, the two specimens from Mannefallknausane (Z.388.1 and 391.5) appear to be significantly older and may be of early Palaeozoic age. Because of the low Rb/Sr ratios of these rocks, their calculated initial $^{87}Sr/^{86}Sr$ ratios given in Table I are not appreciably changed. Their inadvertent inclusion in the suite of Mesozoic basalts and dolerites therefore does not alter the conclusions of this paper.