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POTASSIUM - ARGON RADIOMETRIC DATES OF THE MID-ATLANTIC OCEAN FLOOR

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Summary

The basalt and six trachyte rock samples from the King's Trough in the mid-Atlantic ocean floor have been dated by the conventional potassium-argon method. The basalts give two different ages, 155 ± 6 Ma (late Jurassic) and 53 ± 6 Ma (lower Eocone), while the trachytes give a range of ages from 31.6 ± 0.6 Ma to 35.2 ± 0.2 Ma and an average of 33.0 ± 0.4 Ma (lower Oligocene). The Lower Eocene age of the *in-situ* basalt matches the age of the original volcanic activity of the region while the lower Oligocene age is associated with the subsequent faulting event. The late Jurassic age of the erratic basalt is interesting because of the scarcity of extrusive igneous rocks of that age along the margins of the North Atlantic and, therefore, needs to be investigated further.

Introduction

The area under study is some 450 km long chain of parrellel basin and ridges situated 700 km northeast of the Azores, in the mid Atlantic Ocean. It is popularly known as the King's Trough. There have been several attempts to solve the chronological mode of formation of this portion of the ocean sea floor. Recent seismic and gravity investigation indicates that the flanking ridges result from volcanic activity which began about 55 Ma ago, while the trough could have been produced by a later faulting or shearing. This paper describes the K-Ar dating of some trachyte and basalt samples obtained from one of the ridges along the troughs. It is hoped that these dates will make a useful contribution to unravel the tectonic history of this part of the King's Trough.

Experimental

Analytical procedure

Samples investigated were dredge samples gathered by RRS "Discovery" Cruise 84 in 1977 and kindly supplied by J. G. Mitchell of School of Physics, The University, Newcastle Upon-Tyne.

Two groups of samples were provided, namely:

(a) *D9562 series.* Taken from the location latitude 43⁰ 54.75' N to 43⁰ 53.90' N and longitude 21⁰ 56.47' W to 21⁰ 55.22' W within seafloor depth range of 3350 m and 3187 m. The six separate samples of trachytes supplied for this work were selected from 35 assorted rocks from this dredge. The trachytes were jointed and grey-green in colour. There were two types, one fresh showing little alteration, the other evidence of potassium enrichment which may have been caused by metamorphism. It is believed that these samples were associated with one of the step faults in the area.

(b) *D9564 series.* Taken from the location latitude 43⁰ 59.09' N to 44⁰ 00.11' N and longitude 21⁰ 54.08' W to 21⁰ 52.34' W within sea floor range of 2645 m to 2446 m All the basalts recovered in this dredge were typical oceanic tholeiites. There were two troups; one was of glacial origin and the other was *in-situ.* All the basalts were severely weathered; only two of them being sufficiently unweathered to provide meaningful K-Ar radiometric dates. One of these two basalts samples made available, D9565-105 was from the group of proven erratics while the other D9564-105 was *in-situ* basalt. Fresh samples of each hand specimen was cut, degreased, washed with distilled water and dried at temperatures less than 100 °C. Each sample was then crushed in a jaw crusher to about 60-100 mesh and divided into two, one portion being used for

Argon determination and the other being further pulverized in a ball mill for potassium determination.

Argon extraction

The argon line comprised three sections. The fusion section was made up of a cold finger, an activated charcoal finger, a molybdenum crucible inside a pyrex furnace with a 'christmas tree' arrangement for multiple sample loading. The second section, the cleaning section was made up of another molybdenum crucible loaded with titanium and placed inside a pyrex furnace. The third section, the cleanest section consisted of one activated charcoal where the cleaned argon was usually stored ready for leakage into the mass spectrometer.

One metal bakeable valve separated two adjacent sections and another one connected the argon line to the vacuum system made up of a rotary pump backed by an oil diffusion pump capable of producing, in the argon line a vacuum of 10^{-6} torr or better. Another valve connected the third section to the mass spectrometer. All the connecting tubes of the argon line were stainless steel. The spike system which was of the bulb type also used metal bakeable valves and a pyrex glass bulb arrangement.

The mass spectrometer used was an AEI MS10 fitted with the 4.1 kg permanent magnet for higher resolution (Rex & Dodson, 1970). The pressure in the mass spectrometer was easily maintained at 10^{-8} torr or better by the use of a 25-litre per second ion pump.

Ten samples in glass phials were loaded in the 'christmas tree' at a time, the last one to be analysed being the standard biotite sample Bi 133 of accurately known argon content of 0.413 $mm^3 g^{-1}$. The whole set-up was then baked overnight at temperature of about 150 °C. Liquid nitrogen was placed on the cold finger in the first (fusion) section for about 15 min. The phials were dropped into the crucible by a magnet and soft iron pieces arrangement. The pressure in the extraction line was then checked and if found to be better than 10^{-6} torr still all the valves were closed and liquid nitrogen placed on the activated charcoal finger in the first section. The samples were then fused by radio frequency heating for at least 20 min at minimum temperature of about 1300 °C.

The titanium was then heated to dull red while the liquid nitrogen was removed from the activated charcoal and the released argon let into the second section by opening the valve between this section and the fusion section. The first cleaning was thus achieved by cooling the titanium. The valve between the second and the third sections was opened and the cleaned argon collected on the activated charcoal in the third section for 15 min, together with a pipetted ^{38}Ar spike.

Next, the spike valve, the valve between the the second and the third sections were closed and the valve between the first and the second sections and that between the first section and vacuum pumps opened while the titanium was heated above red hot to drive out all the adsorbed impurities which were pumped away simultaneously. The liquid nitrogen was removed from the activated charcoal in the third section, the valve between first and second sections closed, that between the second and third sections opened and the titanium, still hot above dull red, cooled slowly to effect the second cleaning.

The doubly cleaned argon could then be admitted into the mass spectrometer for analysis. However, if it was not enough to give reasonable response it was concentrated first into the third section by absorbing it on the activated charcoal in the third section before releasing it into the mass spectrometer, with the valve between the second and third sections closed. The valve admitting the argon into the mass spectrometer was of such dimensions that flow was non-molecular and therefore no orifice correction was needed (Baksi & Ferrar, 1973). The pressure inside the mass spectrometer as the argon was admitted was monitored by an ion gauge on that section and was not permitted to exceed

10^{-6} torr.

From the measurements of peaks corresponding to the ion currents of ^{40}Ar, ^{38}Ar, ^{36}Ar and the amount of the ^{38}Ar spike, determined at intervals, usually every tenth analysis, the radiogenic ^{40}Ar released from the rock sample could be calculated. The sample sizes for fusion were usually between 0.25 g and 1.0 g. The argon determinations performed at least in duplicates.

Potassium analysis

For the potassium content determination, up to about 0.2 g of the pulverized rock sample was dissolved in about 10 ml of 40% HF and three drops of concentrated H_2SO_4 and evaporated to dryness overnight. It was then dissolved in ion exchange water which had been distilled and dilute nitric acid, made up to a known volume, usually 250 ml with ion exchanged/distilled water. The potassium content in the sample solution thus prepared was determined by comparing the flame photometric response of the solution with that of a standard potassium solution. An ELL 450 flame photometer was used. Both the sample and standard solutions were buffered to contain 100 p.p.m Na/Li. The potassium analyses on the pulverized samples were at least in triplicates.

Results and discussion

Detailed results of the potassium, argon and the age determinations are all shown in Tables 1 and 2. The ages are calculated using constants recommended by the IUGS Subcommission on Geochronology Constants (Steiger & Jager, 1977):

λ_β = 4.962×10^{-10} Year $^{-1}$
λ_e = 0.581×10^{-10} Year $^{-1}$
$^{40}K/K$ = 0.001167 atoms %

The errors indicated are all one standard deviation of the mean.

The atmospheric argon contamination indi-

TABLE 1

Potassium-argon ages of whole rocks from Cape Verde Islands

Sample No.	*K_2o(%)*	*Radiogenic argon content*	*Atmospheric argon contamination*	*Age (Ma)*
HI/7885	2.34±0.04	0.65±0.03	93.1±0.3	8.6±0.4
		0.73±0.01	74.4±0.4	9.6±0.2
		0.71±0.01	74.1±0.2	9.3+0.5
H2/7886	2.33±0.02	0.70±0.02	87.6±0.3	9.3±0.3
		0.70±0.01	74.6±0.3	9.2±0.2
H3/7887	2.10±0.31	0.51±0.01	70.5±0.5	7.6±0.2
		0.54±0.01	73.1±0.5	8.0±0.2
		0.60±0.01	73.3±0.5	8.8±0.2
H4/7888	2.45±0.01	0.80±0.01	73.9±0.4	10.2±0.1
		0.77±0.02	75.9±0.4	9.7±0.2
H6/7889	4.08±0.02	1.28±0.06	89.3±0.5	9.7±0.5
		1.46±0.04	85.2±0.3	11.1±0.3
		1.56±0.03	84.5±0.3	11.8±0.2
H7/7890	4.63±0.02	1.60±0.03	79.3±0.3	10.7±0.2
		1.69±0.03	76.8±0.4	11.3±0.2
H8/7891	3.24±0.01	1.44±0.03	74.8±0.4	13.7±0.2
		1.45±0.02	75.9±0.3	13.8±0.2
H9/7892	3.34±0.01	1.59±0.03	74.1±0.3	14.7±0.2
		1.49±0.02	73.9±0.3	13.7±0.2
		1.59±0.02	73.2±0.3	14.8±0.2

$\lambda_\beta = 4.962 \times 10^{-10} yr^{-1}$; $\lambda_e = 0.581 \times 10^{-10} yr^{-1}$; $^{40}K/K = 1.1167 \times 10^{-2}$ atoms %

TABLE 2

Mean K-Ar ages at the different sites

Site	*Sample*	*Age (Ma)*
A	H1/7885	9.2 ± 0.3
	H2/7886	9.3 ± 0.1
	H3/7887	8.1 ± 0.4
B	H4/7888	10.0 ± 0.3
C	H6/7889	10.1 ± 0.6
	H7/7890	11.0 ± 0.3
D	H8/7891	13.8 ± 0.1
	H9/7892	14.4 ± 0.4

cated includes the background contamination from the argon line itself. This is of the order of 10-4mm^{3}.

The age of the basalt from the group of erratics is 155±6 Ma. (late Jurassic). This date is interesting in that there are scarcely any late Jurassic extrusive igneous rocks along the margins of North Atlantic. This age may, therefore, represent that of the source materials, if further work on the erratic proves beyond all doubt that they have not gained or lost either argon or potassium in moving down to its present location. ^{40}Ar/^{39}Ar and step heating investigation may throw some light on this. The *in-situ* basalt dates back to 53±6 Ma (lower Eocene) and agrees with recent findings of Searle &Whitmarch (1978).

The trachytes all belong to the same age group ranging from 31.6±0.6 Ma to 35.2±0.2 Ma with an average of 33.0±0.4 Ma (lower Oligocene). This disagrees with the results of the recent studies but may be the date associated with the faulting after the initial volcanism. .

It will be necessary to investigate more basaltic rocks from this area of the King's Trough.

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References

BAKSI, A. K. & FERRAR, E. (1973) Orifice correction for K-Ar dating. *Can. J. Earth Sci.* **10,** 1419-1414.

REX, D. C. & DODSON, M. H. (1970) Improved resolution and precision of argon analysis using an MS10 Mass Spectrometer. *Eclogae Geol. Helv.* **63** (1), 275-280.

SEARLE, R. C. & WHITMARSH, R. B. (1978) The Structure of King's Trough, Northeast Atlantic from bathymetric, seismic and gravity studies. *Geophys. J. R. Astron. Soc.* **53,** 259-287.

STEIGER, R. H. & JAGER, E. (1977) Subcommission on Geochronogy: Convention on the use of decay constants in geo- and cosmochronology. *Earth Plant. Sci. Lett.* **36,** 359-362.

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