POTASSIUM-ARGON DATING OF GHANAIAN ROCKS

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Summary

A K-Ar Geochronology Laboratory has been set up under the joint sponsorship of the University of Ghana, Ghana Atomic Energy Commission (GAEC) and the Geological Survey Department of Ghana as the beginning of radiometric dating research in the region. The argon extraction line in both conventional K-Ar and Ar^{40}/Ar^{39} methods is usually divided into several sections by valves but only one unpartitioned line is used in this laboratory. Consequently analysis time is considerably reduced. Comparison of the analytical results obtained for six inter-laboratory standards and four Ghanaian rocks with reported values indicate that there is no loss of either precision or accuracy for the samples and ages that are likely to be dealt with.

Introduction

Radiometric dates of rocks in the West African region, especially Ghana and the other Anglophone countries are scanty. To understand the geochronology of the region, there is, therefore, the need to undertake more age determinations. The few dates available indicate that the rocks may be as old as about 2,000 Ma (Precambrian), overlain by geological formations as young as about 600 Ma. All the age determinations have so far been undertaken in laboratories outside the region and in fact outside Africa. A K-Ar Geochronology Laboratory has, accordingly, been set up at the National Nuclear Research Centre of the Ghana Atomic Energy Commission (GAEC) to begin this work in Ghana.

Special local problems like lack of spare parts, intermittent electrical power failure and other limitations are considered, and attempts are made to simplify the experimental procedure as much as possible and make it less sophisticated. However, great care is taken not to impair accuracy and precision unduly.

This paper outlines the techniques used in this laboratory in analysing some Ghanaian magmatites and granites collected from the Cape Coast area and also publishes the results of a number of inter-laboratory standards.

Experimental

Analytical techniques

The extraction and purification of argon are performed in a single unpartitioned volume consisting of three pyrex furnaces, a liquid nitrogen cold finger, an activated charcoal finger and a titanium furnace. This procedure deletes two or more of the metal bakable valves, one of the Ti and the Cu/CuO furnaces which are used in the usual multi-compartment argon lines.

The argon line is usually pumped down to a pressure better than 10^{-6} torr. The samples are heated in molybdenum crucibles supported on quartz inserts inside the three furnaces. Argon is released by fusing the samples through radio frequency heating and cleaned twice by gradually cooling the titanium which has been heated to dull red. Condensables are removed by the liquid nitrogen could finger and after the first cleaning non-condensables are pumped out while heating the titanium above dull red temperature. The absence of peaks at masses 35, 37, 39 and 41 on the most sensitive setting of the MS10 indicates that cleaning was effectively done.

The amount of Ar released is determined by isotope dilution, adding the Ar^{38} spike after the first cleaning. The spike volume is determined after each tenth or so sample using a biotite standard Bi 133 of accurately known radiogenic Ar-

gon 40 content of 0.413 mm^3/g.

The relative isotopic currents of argon are measured statically on an AEI MS10 mass spectrometer fitted with the 4.1 kg magnetic for better resolution (Rex & Dodson, 1970). The use of a 25 litre per sec ion pump always easily produces a pressure of less than 10^{-8} torr in the mass spectrometer. The sample sizes are so chosen that it is possible to equilibrate the argon released into the spectrometer with that in the argon line (Baksi, 1973); there was thus no need for oriffice correction as has been suggested (Baksi & Ferrar, 1973; Gale & Bekinsale, 1974) and has also been in practice in some laboratories (Rex & Dudson, 1970).

The potassium content is determined by conventional flame photometry using the EEL photometer; sample solutions being bracketted by standard potassium solutions. Both standard and sample solutions are buffered by 100 p.p.m. Na/Li.

All the standards received were not further processed before both Ar and K analyses. For the Ghanaian rocks, the K-analysis was done on a pulverized sample, while Ar-analysis was done on 60-100 mesh samples in order to avoid any possible loss.

Ages recorded are calculated using decay constants and branching ratio recommended by the IUGS subcommission on geochronology.

As a check on the analytical procedure, a number of international standards and mineral separates from migmatites collected from four different Birimian locations in Ghana are analysed. Also comparison is made of the reproducibility of the first few spike volumes of the present argon line with those of other conventional argon lines investigated in this study, viz. a two-section argon line using one titanium furnace and a three-section line using two titanium furnaces. The quantity of spike in the reservoir is different for each system of argon line. The calculated depletion constant for the pipette system used in all variations of the argon line is about 5×10^{-4}.

Results

Table 1 shows the first few spike volumes of various argon lines while Table 2 shows the results of the K_2O and the radiogenic Argon 40 content measurements together with the reported values. Results of age determinations of mineral separates from four Ghanaian rocks are shown in Table 3. All errors indicated in the Tables are one standard deviation of the mean and numbers in brackets are number of analyses.

Discussion

The technique of performing the extraction and purification of argon in the same space does not in any way seriously affect the results (Table 1). This is further supported by the results of international standards which are reproducible and agree with the reported values within experimental errors. The procedure reduces the usual extraction and purification time to about two-thirds. With the exception of the standard A89, the K_2O values are also in agreement with reported values. No explanation has been found for this yet.

The results of the analyses of the Ghanaian rocks agree reasonably well with the published

TABLE 1

Reproducibility of spike volumes using different argon lines

	Spike volume/$mm^3 \times 10^{-2}$		
Spike no.	*Ar line a*	*Ar line b*	*Ar line c*
1	0.7184	-	-
2	-	0.2190	-
4	0.7198	0.2230	1.332
5	0.7193	-	-
6	0.7158	0.2171	1.328
8	-	-	1.303
11	-	-	1.304
12	-	0.2223	-

* Line a - Single unpartitioned line with one Ti furnace
Line b - Two-section line with one Ti furnace
Line c - Three-section line with two Ti furnaces

Biotite standard Bi 133 was received from J. G. Mitchell, University of Newcastle-Upon -Tyne.

TABLE 2

Potassium and radiogenic Ar^{40} of standards

Standard	*Supplier*	*K_2O%*		*Radiogenic Ar/mm³/g*	
		Published	*This work*	*Published*	*This work*
A89	a	9.64	7.47 ± 0.03 (5)	0.02376	0.0231 ± 0.0005 (3)
CRD24WR	b	0.12	0.13 ± 0.04 (5)	0.00459	0.00462 ± 0.00004 (3)
IGSCCR3	c	9.28	9.11 + 0.03 (7)	0.1318	0.1290 ± 0.0010 (3)
LP-6B10	d	10.03	10.17 + 0.03 (10)	0.043	0.04292 ± 0.00069 (3)
ANRT-GL-O	e	7.94	7.92 ± 0.04 (6)	0.0248	0.02413 ± 0.00069 (3)
AUON SLATE	f	4.05	4.09 ± 0.05 (3)	0.04242	0.04142 ± 0.00031 (3)

a. D.C. Rex, Department of Earth Sciences, University of Leeds
b. D.C. Rex, Department of Earth Sciences, University of Leeds
c. C. Rundel, Institute of Geological Sciences, London
d. U.S. Geological Survey, Menlo Park, California, U.S.
e. Centre de Recherches Petrographiques et Geochimique (C.N.R.S.), France
f. D.C. Rex, Department of Earth Sciences, University of Leeds

TABLE 3

The result of analysis of four Ghanaian rocks

Sample no.	*K_2O%*	*Radiogenic $Ar^{40}/mm^3/g$*	*Age/m.a.**
AT25 hornblende	0.46 ± 0.01 (5)	0.01132 ± 0.00065 (3)	645 ± 46
AT37-100 hornblende	0.36 ± 0.01 (5)	0.04006 ± 0.00070 (3)	1926 ± 57
AT 35 hornblende	0.51 ± 0.01 (6)	0.01174 ± 0.00026 (3)	610 ± 24
BN5 biotite	8.66 ± 0.05 (7)	0.9391 ± 0.0063 (3)	1897 ± 15

Samples AT25, AT37-100, AT 35 were received from Mr A. O. Adjei and sample BMS from Dr J. E. J. M. van Landewijk, both of the Department of Geology, University of Ghana, Legon.

* Constants used = 4.962×10^{-10} year^{-1}; e = 0.58×10^{-10} year^{-1};
$^{40}K/K = 0.0001167$ (Steiger & Jager, 1977).

ages of rocks in the same region (Sarcia, 1971). In view of these promising results, it is felt that provided the study has not dealt with very young samples of the order of tens of million years old or less and where atmospheric contamination may be very high, K-Ar dating can be reliably undertaken in the GAEC laboratory. This exercise is continuing.

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