RADIOACTIVE CONTENTS OF ROCKS AND MINERALS

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Abstract

The distribution of radioactivity in some rock and mineral samples has been determined by alpha-activity measurements. A scintillation counter has been used for estimating the radioactivity. The method of measurement is discussed.

1. Introduction

The radioactive contents of rocks and minerals can be determined by different methods. The measurement of the alpha-activity of a rock sample is the best known method for the determination of the concentration of U, Th and their decay products. This type of measurement is very useful from many points of view. For determining the geologic time of a specimen using either "Alpha-Helium" method or Larsen's (1952) "Lead-Alpha" method, a knowledge of the correct value of the rate of emission of alpha-particles is required. Th-U concentration ratios of rock samples can be determined by alpha-activity measurements.

2. Method of Measurement

There are a number of detectors by which alpha-activities of rocks and minerals can be accurately determined. As far as the alpha-activity measurement was concerned, the properties of a scintillation counter are the same as those of a proportional counter. In the present case, a scintillation counter, using E.M.I. VX 5045 photomultiplier tube was used for activity measurements. The instrument was quite sturdy and quick measurements could be made by using a suitable phosphor. Specimen mounting was quite easy and could be interchanged within a short interval of time.

Application of the scintillation counter for the measurement of alpha-activities of rocks and minerals has been given by Kulp *et al.* (1952). Some of the properties of the photomultiplier tube VX 5045 have been described by Owen, R. B. and Sayle, E. A. (1951). Operating conditions and the characteristics have already been indicated in an earlier publication (Aithal, 1955). Zinc sulphide activated by silver supplied by Messrs. Isotope Developments Ltd., London, E.C. 2, was used as the phosphor. A thin coating of ZnS-Ag was given directly to the photocathode. The alpha-particles emitted by the radioactive elements present in the

rock samples, on striking the ZnS-Ag coating, will produce scintillations which are detected by the photomultiplier tube.

There are two ways by which alpha-activity of a rock specimen can be measured namely, by using (*a*) a "thick" source and (*b*) a "thin" source. Evans and Finney (1935) have worked out the relationship for the counting rate, when the sample is used in these two ways. In the first case, the counting rate is proportional to the area of the sample and the absorption factor μd, where μ is the absorption coefficient for alpha-particles in the sample and d is the density of the sample. It is clear that the absorption factor is different for different specimens and this has to be calculated for each type of rock or mineral. This is avoided by using a "thin" source whose thickness is of the order of 1 mg./sq. cm. According to Nogami and Hurley (1948) thin-source alpha-counting is probably still the most suitable method for measuring the total alpha-activity of acid igneous rocks. Correction to be applied due to the thickness of the sample is quite small and can be neglected. The counting can then be taken to be proportional to the weight of the sample.

The photomultiplier tube with its potential dividing system was kept in a light tight shielded box. Arrangements were such that the specimens could be interposed without exposing the photomultiplier tube to light. The E.H.T. was supplied by a power supply unit of type 1007. The output pulse was fed to a linear amplifier of type 1008 with a discriminator and counted by a scaling unit of type 200 A.

The samples were powdered to about 200–300 mesh. Thin samples were used in all the present measurements. 10–15 mg. of the sample from alcohol suspension were spread uniformly over 12 sq. cm. on a filter-paper. The weight of the specimen in each case was separately determined. The specimen was kept at a distance of about 2 mm. from the photocathode which had an area of about 18 sq. cm., to have a good geometry. The distance between the photocathode and the specimen was kept unchanged throughout the measurements. The alpha-activity of each specimen was measured for ½–1 hour so as to minimise the error due to statistical fluctuations. The background counts under identical conditions were of the order of 30–40 per hour. The efficiency of the detector was determined using a standard sample of samarskite under identical conditions.

3. RESULTS

The alpha-activities of 24 samples from different localities are given in Table I and expressed as alpha-counts per mg. per hour. Taking 1 gm. of U in secular equilibrium with its decay products to emit $6{\cdot}18 \times 10^6$ alpha-particles per minute, the percentage of U equivalent of each sample has been calculated and the values are given in Table I.

TABLE I

Alpha-activities of some of the rock samples measured by using a scintillation counter

	Name of Specimen	Locality	Alpha-activity counts/ mg./hr.	Percentage of U equivalent
1.	Allanite ..	Karithimmanahalli, Bangalore	2150	0·58
2.	,, ..	,,	187·5	0·05
3.	,, ..	Yediur, Bangalore	104·5	0·03
4.	,, ..	Seshadripura, Bangalore	381·6	0·10
5.	,, ..	Nellore	2316	0·62
6.	Ilmenite ..	Bangalore	69·2	0·02
7.	Magnetite ..	Bangalore	427·3	0·12
8.	Columbite Tantalite	Department of Atomic Energy	210	0·06
9.	Columbite ..	Bihar	11400	3·08
10.	Magnetite ..	Singhbum District, Bihar	57	0·015
11.	,, ..	,,	1854	0·50
12.	,, ..	,,	2406	0·65
13.	Zircon ..	T.C. State	1563	0·42
14.	,, ..	,,	350	0·09
15.	,, ..	Philadalphia	408·3	0·12
16.	Monazite ..	T.C. State	10760	2·90
17.	,, ..	Department of Atomic Energy	13710	3·70
18.	,, ..	Philadalphia	4155	1·12
19.	Magnetite Apatite ..	Bihar (Dhalbhumagarh)	935	0·25
20.	,, ..	,,	511·3	0·14
21.	,, ..	,,	231	0·06
22.	Samarskite ..	Nellore	23810	6·42
23.	,, ..	Chickbanavar, Bangalore	6944	1·87
24.	Pitchblende ..	Bagalpur, Bihar	207400	55·93

4. DISCUSSION

During the course of the investigation it has been found that certain samples from the same locality and of same nature exhibit considerable spread in the alpha-activity. In general, activities are found to vary over a wide range. Specimens, truly representative of the regions under study, were not available to us. As such, the activities of some of the samples that are given show the nature of distribution of the radioactive elements in the samples on hand. These observations can only be taken to mean that the suite of rocks from which the specimens were collected is considerably inhomogeneous or perhaps intruded by veins, rich in radioactive accessory minerals. In view of this, the relationship of the measured helium ratios to the actual geological age can also be expected to be of a varied and complicated nature due to the escape of helium or leaching of U. A similar approach can be made as regards lead ratios wherein the leaching of U or Pb is a possible explanation. However, a study of acid leaching of these samples will be very useful and throw light on whether radioactive elements are present in the acid "insoluble or soluble" portions of the rocks and whether radioactive elements are distributed homogeneously or not in the specimen. Hurley (1950) has observed that the low ratio of helium compared to the concentration of radio-elements in the rock as a whole may be either due to the loss of helium from highly radioactive areas in the rock that are easily affected by acid or due to superficial contamination of radioactive elements late in the geological history of the rock. Acid treatment removes just the surficial portion of the total activity from which the generated helium has been lost. He has further shown that the loss of alpha-activity by dilute acid treatment appears to have been related to the degree of retentivity of helium in the rock sample.

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REFERENCES

1. Larsen, E. S. (Jr.), *et al.* .. *Bull. Geol. Soc. Am.*, 1952, **63**, 1045.
2. Kulp, J. L., *et al.* .. *Trans. Am. Geophy. Union*, 1952, **33**, 101.
3. Owen, R. B. and Sayle, E. A. *Proc. Inst. Elc. Eng.*, 1951, **98**, 245.
4. Seetharam Aithal, V. .. *J. Sci. Inst. Research*, 1955, **14 B**, 519.
5. Evans and Finney .. *Phy. Rev.*, 1935, **48**, 503.
6. Nogami, H. H. and Hurley, P. M. *Trans. Am. Geophy. Union*, 1948, **29**, 335.
7. Hurley, P. M. .. *Bull. Geol. Soc. Am.*, 1950, **61**, 1.