RADIOMETRIC DETERMINATION OF URANIUM, THORIUM AND POTASSIUM IN SOME ROCKS OF THE GUANAJUATO MINERAL DISTRICT, MEXICO

SURENDRA PAL* DAVID JORGE TERRELL*
and EMILIO HERRERO BERVERA*

RESUMEN

Se midieron los contenidos de Uranio, Torio y Potasio en algunas rocas ígneas y sedimentarias del Distrito Minero de Guanajuato, por espectrometría de rayos γ. Mediciones preliminares demuestran que el área estudiada no es una zona de altos contenidos radiactivos. Los datos obtenidos para diferentes tipos de rocas son, en general, concordantes a los encontrados en otras regiones. La razón promedio de K/U está cercana a 1×10^4 y la razón K/Th 3.9×10^3 en concordancia con los valores establecidos en la literatura.

ABSTRACT

Uranium, Thorium and Potassium contents of some igneous and sedimentary rocks of the Guanajuato Mineral District have been measured by γ-ray scintillation spectrometry. Preliminary measurements show that the area studied is not a province of high radioactive contents. The data obtained for different rocks types is, in general, consistent with what has been found in other areas. The average K/U ratio is close to 1×10^4 and K/Th ratio 3.9×10^3 in agreement with the figures established in the literature.

* *Instituto de Geofísica, UNAM.*

INTRODUCTION

The problem of estimation of natural radioactive elements is of great importance in basic as well as applied research. In reality, ever since the discovery of natural radioactivity, uranium and then thorium and potassium have been of increasing geologic and geochemical interest. A particularly interesting geophysical aspect of their geochemistry is the heat produced in the Earth and other planets by radioactive desintegration of these elements and their daughters. On the other hand, the geochemistry of these elements is intimately related to rock-dating and economic development.

Thus for several reasons, installation of an adequate laboratory was undertaken at the Institute of Geophysics, in order to carry out sistematic research in this important branch on different Mexican provinces.

EXPERIMENTAL DETAILS

The instrument used to carry out the present work consists of:

a) a scintillation detector of 4" dia. x 4" height thallium activated sodium iodide crystal (Bicron) with a 4" dia. x 2" height pure sodium iodide crystal in order to reduce the background originating in the photomultiplier tube to which this detector is hermetically sealed.

b) an Ortec model 456 high voltage source

c) an Ortec model 113 pre-amplifier

d) an Ortec model 452 spectroscopy amplifier

e) an Ortec model pulse generator

f) a Hewlett-Packard model 5401B of 1024 channels pulse-height analyzer

g) a Teletype Corporation ASR-33 teletype modified to adapt the multi-channel analyzer.

h) a lead shield and several sample-holders.

A block diagrams of this instrument set-up is given in Fig. 1. The system resolution measured with a 137Cs source is of 6.9% for 662 kev γ –rays.

The instrument is located in an underground laboratory at a depth of about 20 meters, which helps to reduce considerably the cosmic-ray contribution to the background.

The uranium and thorium standards were those obtained from the New Brunswick Laboratory of the U. S. Atomic Research and Development Administration, while the potassium standard was Merck's Laboratory grade KCN.

The aluminium sample-holders were filled with powdered samples to the same degree of compactness, a certain amount of variation in results has been observed with different degrees of packing (e.g., Heier and Rogers, 1963). The sample-weight for the same amount of compactness varied from about 400 to 550 gms. depending upon the rock density. The results were recalculated to a standard weight of 500 gms.

The background of the system was measured with an empty sample-holder placed around the detector and was found to be quite low even with a relatively small lead-shield (2 1/2 inch thick only). Thus, with the detector surrounded by the lead-shield and the system located underground, a sample containing 1 ppm U, 3 ppm Th and 1% K, gave in the uranium (1.76 Mev), Thorium (2.62 Mev) and Potassium (1.47 Mev) channels contributions of about 45, 40 and 20% respectively of the background in the respective channels. This means statistical errors of 5-10% in these determinations with exposure-times of the order of 500 minutes.

The results are calculated using a method similar to that given in Hurley (1956).

Inter-laboratory calibrations of a number of samples measured in this work as compared to those obtained by Rice University, Texas (J. A. S. Adams, 1974) have been quite satisfactory and some of them are presented in Table 1.

Further, the radiometric determinations of Th and K are, in general, consistent with Instrumental Neutron Activation Analysis (INAA) of Th and Flame-photometric measurements of K. The INAA and Flame-photometric measurements on a number of samples from this area are given in Pal (1972). It is worth pointing out that the

radiometric method used in this work assumes that both uranium and thorium are in equilibrium with their decay series, wich is fortunately the case with most of the rock and mineral occurrences.

TABLE 1.
Inter-laboratory Measurements on some Mexican Rocks

		This work			Rice University, Texas		
Sample No.	Rock-type	U ppm	Th ppm	K %	U ppm	Th ppm	K %
7240	El Cedro Andesite	1.85	6.05	2.21	1.87	6.42	2.43
7229	Locero Rhyolitic Tuff	0.80	1.26	1.08	0.73	1.51	1.20
7236	do	2.28	9.37	2.97	2.40	10.06	3.17
7217	Dyke-rock	4.98	3.25	2.04	4.69	3.74	2.46
7223	Limestone	1.73	1.00	0.04	1.54	0.75	0.01

RESULTS AND DISCUSSION

The geology of this area has been described in Guiza *et al.* (1949) CRNNR (1963) and Echegoyen *et al.* (1970), while a brief summary and sample location is given in Pal (1972).

The results of these preliminary measurements are given in Table 2, while a tentative interpretation is given below.

The rocks of the area studied do not contain high contents of these radioactive elements, although relatively small number of analysis does not permit us to evaluate them statistically.

The igneous rocks (andesites, rhyolites, etc.) of this area have normal uranium and potassium contents (Peterman, 1963: unpublished refered to in Rogers and Adams, 1969a; Heier and Billings, 1970). Further the average Th/U ratio is in the normal range, indicating normal Th values.

Particularly low U, Th and K values observed in one mineral vein sample is of particular interest, as economically important gold and silver mineralization is observed in this area.

Shales have, as expected, greater radioactive contents than limestones from this area, as has been observed by Rogers and Adams (1969a,b) in other areas. The Th/U ratio for Shales (2.1 - 3.6) are towards the lower side of the normal range (Th/U: 2 - 6; Adams and Weaver, 1958).

The K/U ratio of most of these rock-types and in particular, the average K/U ratio is very close to 10^4, in agreement with Heier and Rogers (1963) who deduce that the K/U ratio is about 10^4 in all crustal material. On the other hand, the average K/Th ratio of about 3.9×10^3 (eliminating rather high value for the sample No. 7208 from the mean), is somewhat greater than the value of approximately 3×10^3 obtained by the same authors. This constancy of K/Th ratio has also been observed in sediments as well as igneous rocks by Pliler and Adams (1962), and the observation that K/Th ratio is, in general, more constant than the K/U ratio in surface materials.

Though interesting results are obtained in this study, much more data is needed to establish validity of certain variation trends.

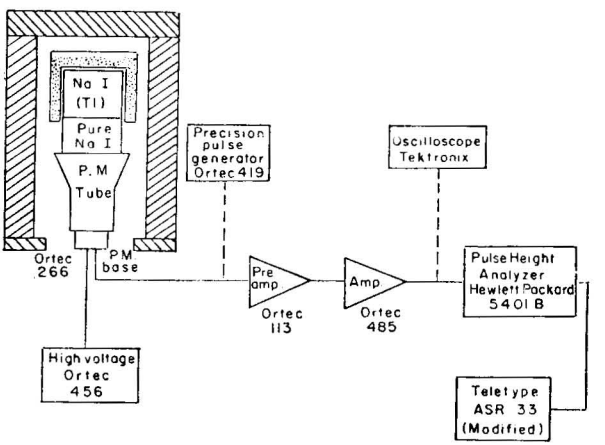

Fig 1 BLOCK DIAGRAM OF THE γ-RAY SCINTILLATION SPECTROMETER

TABLE 2.
Radioactive Elements in Guanajuato Mineral District

Sample No.	Rock-type	U ppm	Th ppm	K %	Th/U	(K/U) x 10^{-4}	(K/Th) x 10^{-3}
7240	El Cedro Andesite	1.85	6.05	2.21	3.3	1.2	3.7
7211	Calderon Andesite	0.92	0.98	0.53	1.1	0.6	5.4
7214	–do–	2.32	5.56	0.32	2.4	0.1	0.6
7231	–do–	1.65	6.12	2.36	3.7	1.4	3.9
7208	La Bufa Rhyolite	2.88	2.44	3.50	0.8	1.2	14.3
7244	–do–	2.11	7.75	3.59	3.6	1.7	4.6
7229	Locero Rhyolitic Tuff	0.80	1.26	1.08	1.6	1.4	8.6
7236	–do–	2.28	9.37	2.97	4.1	1.3	3.2
7203	Dyke-rock	3.12	11.44	4.40	3.7	1.4	3.8
7217	–do–	4.98	3.25	2.04	0.7	0.4	6.3
7233	Granite-diorite Intrusive	1.76	7.23	2.04	4.1	1.2	2.8
7238	Mineral Vein	< 0.1	<0.2	< 0.05	–	–	–
7223	Limestone	1.73	1.00	0.04	0.6	0.02	0.4
7226	–do–	0.50	1.73	0.29	3.5	0.6	1.7
7234	–do–	< 0.5	< 0.2	< 0.1	–	–	–
7220	Shale	2.51	5.24	2.41	2.1	1.0	4.6
7224	–do–	2.67	9.54	2.32	3.6	0.9	2.4
7232	–do–	0.92	2.91	2.69	3.2	2.9	9.2
7222	Red Conglomerate	0.80	1.68	0.24	2.1	0.3	1.4

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