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URANIUM AND THORIUM ANALYSIS IN GEOLOGICAL SAMPLES USING PLASTIC TRACK DETECTORS

N.P. Singh, Manwinder Singh, Surinder Singh
and H.S.Virk

Department of Physics, Guru Nanak Dev University,
Amritsar-143005, India

ABSTRACT

The relation given by Coppens (1977) between the concentrations of Uranium (U) and Thorium (Th) in geological samples and corresponding alpha track rate employing nuclear emulsions is:

$$10^6 N = (9.20U + 2.80Th)\ k$$

The modified formula for use in LR-115 type 2 plastic track detector is proposed as under:

$$10^6 N = (6.77U + 1.60Th)\ k$$

Uranium is estimated using fission track technique and Th is calculated by alpha autoradiography. The absorption coefficient (k) is determined from the composition of the sample under study. The proposed formula is applied for Th analysis in phosphorite samples from Mussourie Syncline, U.P.(India). Gamma ray spectrometric analysis of phosphorite samples establish the validity of the modified relation for U and Th estimation.

The quartizite samples collected from Kulu area of Himachal Pradesh (India) are analysed using modified relation. The value of absorption coefficient k is found to be 14.29 for quartzite rock. U and Th contents are found to vary from 2.63 to 18.73 ppm and 0.92 to 95.92 p-pm, respectively.

KEY WORDS

Uranium; Thorium; Geological Samples; Alpha-autoradiography.

THEORY

Uranium and Thorium are present in traces in geological samples since their time of solidification. These are natural alpha emitters and an emulsion detector when placed against the surface of a geological sample should record the alpha disintegrations. Coppens (1949) had given the Uranium (U) and Thorium (Th) content of a sample as a function of alpha track rate (N):

$$10^6 N = 8.58\ kU \quad \ldots \quad (1)$$

or $$10^6 N = 1.92\ kTh \quad \ldots \quad (2)$$

and $$10^6 N = (8.58\ U + 1.92\ Th)\ k \quad \ldots \quad (3)$$

if both U and Th are present. The constant k depends on the composition of the sample and is known as co-efficient of absorption.

Coppens (1977), further remarked that above expressions (Eqs 1-3) are not valid unless there is

a radioactive equilibrium. Secondly, the expressions are derived using a microscope with minimum detection limit of 3 μm. With the use of microscope which can identify trajectories of alpha particles upto 2 μm, Coppens (1977) improved the eqn(3) as:

$$10^6 N = (9.20U + 2.80Th)\, k \qquad \ldots \quad (4)$$

This relation can be modified for use with solid state nuclear track detectors which can record alpha particle tracks. In the present work we have used cellulose nitrate plastic (LR-115 type 2) as alpha track recorder. Under the changed circumstances e.g.

(a) taking the range of alpha particle emitted from RaC' (7.69MeV) as 54 μm in LR-115 (Fig.1) which was 38 μm in case of emulsions (Coppen, 1977),
(b) with the microscope having ability to distinguish tracks of 1 μm length, the eqn.(4) for LR-115 plastic is modified as:

$$10^6 N = (6.77\ U + 1.60\ Th)\, k \qquad \ldots \quad (5)$$

where $$k = \frac{0.85}{\sum \frac{CS}{A}} \qquad \ldots \quad (6)$$

C is the concentration of an element of atomic weight A and S is the stopping power of alpha particle in that element. The constant, k, can be found out from the composition of the sample under study and S/A values can be determined from the plot of S/A vs A (Fig. 2). Knowing the value of k and estimating U by homogenized fission track technique (Fisher, 1970), Th can be easily calculated from eqn.(5).

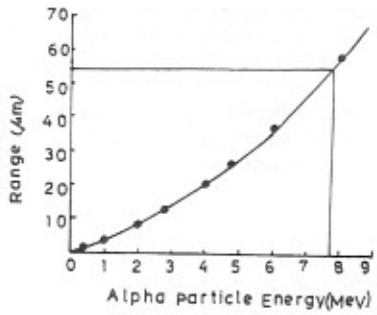

Fig.1. Plot of range Vs Energy for alpha particles (Enge, 1980)

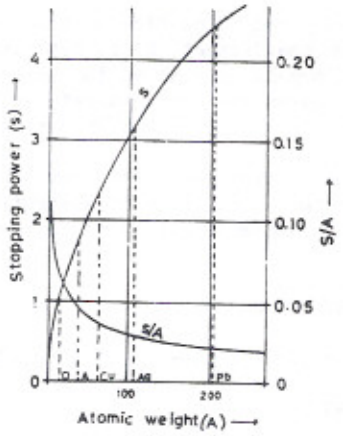

Fig.2. Variation of S/A Vs A (Coppens, 1949)

EXPERIMENTAL

Homogenized fission track technique is used for uranium estimation in geological samples. In this method the sample is powdered and pressed into a pellet (of 13 mm dia. and 1 mm thickness). The pellet sandwiched between lexan plastic discs is irradiated with a known dose of thermal neutrons from a Reactor alongwith a suitable U rich standard glass dosimeter pellet. The lexan plastic is then etched and scanned. A comparison of induced fission track densities recorded in the lexan covering unknown and standard pellets gives the U content in the sample:

$$U_X = U_S \frac{T_X}{T_S} \quad \ldots \quad (7)$$

where X and S stands for unknown and standard respectively, and T, the induced fission track density.

A sheet of LR-115 plastic is then placed against the polished surface of the sample and is kept undisturbed for a period depending upon the alpha activity, to allow the alpha tracks to accumulate. After accumulation period the plastic detector is etched for 3 hrs in 2.5N NaOH at 50°C. The tracks are counted using Olympus binocular microscope at a magnification of 600X. Since in this method U is estimated using fission track technique and Th is calculated by alpha-autoradiography, so this technique is termed as F/α technique (Fisher, 1977).

The details of gamma ray spectrometric technique for U, Th and K analysis are described elsewhere (Rao, 1974). This study is based on analysis of 1.46, 1.76 and 2.62 MeV peaks of K^{40}, Bi^{214} and Tl^{208} respectively of gamma ray spectrum of the sample. The detector assembly used consists of well type 3" x 3" NaI(Tl) crystal coupled to a multichannel analyser.

RESULT AND DISCUSSION

The proposed formula (Eqn.5) is applied for Th analysis in phosphorite samples collected from Maldeota area of Mussourie Syncline. U content in the samples as determined by fission track technique has been found to vary from 27.58 to 44.08 ppm. Using eqn.(5) with k value of 14.6 as reported by Coppens(1977), the Th content is determined to vary from 5.52 to 7.54 ppm. These values are found to agree with those determined by gamma ray spectrometry (Table 1). The Proposed formula can thus successfully be applied for Thorium analysis in geological samples provided the radioactive equilibrium exists in the radioactive series.

Table 1 - U, Th analysis of Phosphorite samples

Sample Number	Plastic detector (LR 115 type 2)			Gamma ray spectrometry	
	10^6 N/cm^2	U (ppm)	Th (ppm)	U(ppm)	Th(ppm)
P_1	2888	27.58	6.93	20.05	8.08
P_2	4299	42.19	5.52	18.41	5.50
P_3	4533	44.08	7.54	49.50	5.38

Value of k used = 14.6 (Coppen, 1977)

The Quartzite samples collected from three different locations from Kulu area of Himachal Pradesh (India) are analysed using modified relation. The value of absorption coefficient k is found to be 14.29 for quartzite rock (taking composition as SiO_2). U and Th contents are found to vary from 2.63 to 18.73 ppm and 0.92 to 95.92 ppm, respectively (Table 2).

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Table 2 - U, Th analysis of Quartzite samples of Kulu area (Himachal Pradesh).

Sample Location	Sr. No.	10^6 N/cm^2	U content (ppm)	Th content (ppm)
	Q1	1083	2.88± 0.07*	35.20 ± 0.63*
	Q2	2276	18.73± 0.19	18.18 ± 0.22
Shat	Q3	368	3.59± 0.09	0.92 ± 0.03
	Q4	738	2.63± 0.06	21.15 ± 0.44
	Q5	702	5.06± 0.08	9.28 ± 0.21
	Q6	3019	8.54± 0.11	95.92 ± 1.00
Rohtang pass	Q7	743	3.85± 0.07	16.19 ± 0.34
	Q8	350	3.25± 0.07	1.54 ± 0.05
Bunter	Q9	537	3.31± 0.07	9.50 ± 0.23
	Q10	2137	7.85± 0.10	60.24 ± 0.77

Value of k for quartzite samples = 14.29

*Statistical counting error $(1\sigma) = \frac{1}{\sqrt{N}}$

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