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# F/α TRACK-ETCH METHOD FOR U, Th AND ISOTROPIC DISEQUILIBRIUM STUDY OF GEOLOGICAL SAMPLES

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**Abstract:** The relation connecting concentration of uranium (U) and thorium (Th) atoms in geological samples with alpha track production rate in plastic track detector, LR-115 type 2, is used for analysis of some rock and fossil bone samples. The alpha track measurements from the samples under secular equilibrium define the total U and Th contents, while fission track measurements yield U concentration alone, thus by combining the results of both these measurements, U, Th and Isotropic disequilibrium is determined. Uranium concentration determined by fission track analysis in radioactive fossil bones is found to vary form 93.8 to 418.0 ppm. The results of U concentration as determined by alpha autoradiography are pronouncedly lower than those determined by fission track analysis indicating the presence of radioactive disequilibrium. However, the quartzite and phosphorite samples analysed using this technique show the presence of radioactive equilibrium.

## 1. INTRODUCTION

Uranium and thorium are natural alpha emitters and an emulsion detector when placed against the surface of a geological sample should record the alpha disintegrations. Coppen[1] had given the uranium (U) and thorium (Th) content of a sample as a function of alpha track production rate (N):

$$10^6 N = 9.20kU \quad (1)$$

$$\text{or} \quad 10^6 N = 2.80kTh \quad (2)$$

$$\text{and} \quad 10^6 N = (9.20U+2.80Th)k \quad (3)$$

Eq (3) has been modified by Singh et al.[2] for use with solid state nuclear track detectors which can record alpha particle tracks more precisely. We used cellulose nitrate plastic (LR-115 type 2) and modified eq (3) for this plastic track recorder as follows:

$$10^6 N = (6.77U+1.60Th)k \quad (4)$$

$$\text{where} \quad k = \frac{0.85}{\Sigma \frac{CS}{A}} \quad (5)$$

In eq (5), C is the concentration of an element of atomic weight A and S is the stopping power of an alpha particle for that element. Knowing the value of k and estimating U by homogenized fission track technique, Th concentration can be easily determined from eq(4).

A comparison between the U concentrations determined by authoradiography and those by other methods (viz. fission track method, fluorimetry, etc.) allows the indication of existence of a radioactive equilibrium/disequilibrium.

In the present investigations the modified relation is used for U, Th and isotopic disequilibrium study of some radioactive Siwalik fossil bones and phosphorites and quartzites collected from Kullu area of Himachal Pradesh (India).

## 2. EXPERIMENTAL

The homogenized fission track technique[3] is used for uranium estimation in geological samples. In this method, the sample is powdered and pressed into a pellet (13 mm dia and 1 mm thickness). The pellet sand-wiched 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 the unknown and standard pellets gives the U content in the samples as follows[4]:

$$U_x = U_s T_x / T_s \qquad (6)$$

where x and s stand 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 kept udisturbed for a period depending upon the alpha activity, to allow the alpha tracks to accumulate. After the accumulation period, the plastic detector is etched for 3 h in 2.5N NaOH at 50°C. The tracks are counted using Olympus binocular microscope at a magnification of 600X. Since in this method the concentration of U is estimated using fission track technique and concentration of Th is calculated by alpha autoradiography, this technique is called F/$\alpha$ techniques. The mechanism of the technique is shown in Fig.

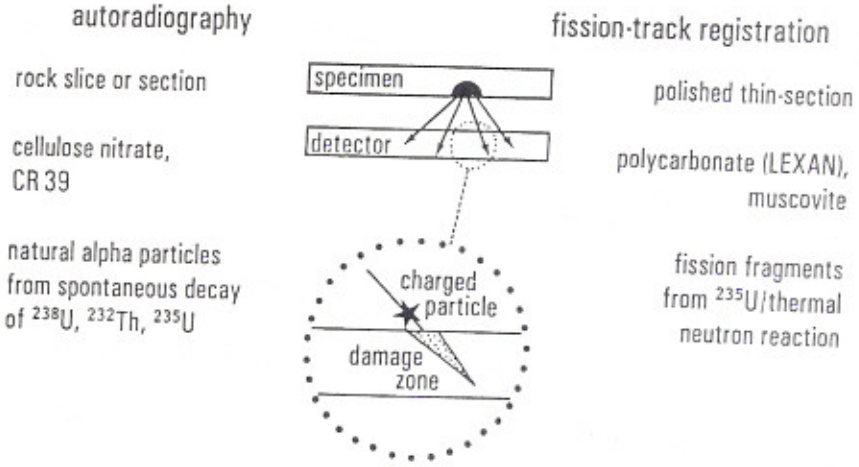


Fig. 1. Mechanism of F/$\alpha$ Technique

## 3. RESULTS AND DISCUSSION

Since Th is absent[6] is Siwalik fossil bones, the simplified relation

$$10^6 N = 6.77\ KU$$

is used for U estimation in these samples. The results of U measurements by alpha autoradiography and fission track analysis are reported in Table 1. U content values obtained using alpha-autoradiography are

**Table 1**

U concentration by Alpha-autoradiography and fission track analysis in radioactive fossil bones.

| Sample Number | Specimen | $10^6$N | $U_\alpha$ (ppm) | $U_f$ (ppm) |
|---|---|---|---|---|
| **SAHARANPUR*** | | | | |
| FS1 | Elephant tusk | 6100 | 58.3 | 118.6 |
| FS2 | Elephant tusk | 2951 | 28.2 | 93.8 |
| FS3 | Molar teeth | 4976 | 47.6 | 102.9 |
| FS4 | Unidenitified | 6620 | 63.3 | 159.7 |
| **NARAINGARH** | | | | |
| FS3 | Tortise bone | 7998 | 76.5 | 165.1 |
| FS4 | Unidentified | 5799 | 55.4 | 119.7 |
| **NALAGARH** | | | | |
| FV1 | Horn piece | 15961 | 152.6 | 418.0 |
| FV2 | Elephant tusk | 11180 | 106.9 | 292.8 |
| FV3 | Unidentified | 6377 | 61.0 | 131.7 |

$U_\alpha$ - U content determined by alpha autoradiography

$U_f$ - U content determined by fission track analysis

Value of k for fossil bone = 15.44

* Sample location

pronouncedly lower than those determined by fission track analysis, which reveals the presence of radioactive disequilibrium of U in radioactive fossil bones. These results thus confirms the hypthesis of secondary enrichment of U in Siwalik fissil bones reported earlier[7]. Our recent X-ray fluorescence spectrometric analysis[8] of these samples have detected Ti, V, Cu, Y and As (Table 2) only in some of the bone samples with enomalous U content (threshold value for U content in these samples is already reported[9] to be 56.2 ppm). These are pathfinder elements of U and their presence suggests that besides uranium, Ti, V, Cu, Y and As also got enriched in bone samples with anomalous U content. The uranium anomalies found in the samples from Saharanpur (U.P.), Naraingarh (Haryana) and Nalagarh (HP) are typical of those found in Siwalik Himalayas. Moreover, the U concentration in fossil bones is controlled by availability of uranium in contemporary environment in which the vertebrates lived and the nature of the mineralizing solution acting as the carrier of uranium.

Alpha-autoradiographic analysis predicted a linear relationship between U content and alpha track rate satisfied by the relation[9].

Comparison of results shows that U determined by both these methods is in good agreement. This indicates that the U present in these samples is in radioactive equilibrium. This fact is also confirmed from the results of gamma ray spectrometry.

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