# URANIUM ESTIMATION IN PEGMATITIES USING SOLID STATE TRACK DETECTOR

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Homogenised fission track analysis has been used to determine the uranium abundances in common minerals and rocks of Pegmatite deposits. Lexan Polycarbonate detector has been used to register fission tracks from the thermal neutron induced fission of uranium. The purpose of the work is to illustrate the usefulness of the solid state track detector method and to present preliminary data on uranium contents in mineralizations of possible future economic importance. Most of the minerals have uranium concentration less than 1 PPM, but some minerals contain as much as 30 PPM uranium.

## INTRODUCTION

An extensive use of Lexan Solid State Track detectors has been used for the determination of trace amounts of uranium in geological and biological materials. The fact that the solid state track detectors can withstand large neutron doses without deterioration makes them uniquely suitable for the registration of fission fragments from uranium and plutonium. The technique is especially attractive in that it offers a variety of methods for trace analysis which are fast, simple and have good sensitivity.

The present experiments are aimed to determine the uranium concentration of pegmatitic minerals of India and Nepal by the newly developed fission track technique. Since its introduction by Price and Walker [1], the etching technique has been used to reveal tracks formed due to thermal neutron induced fission of $U^{235}$ atoms in many uranium bearing materials [2–7] of both terrestrial and extra terrestrial origin. To measure the uranium concentration in a material, neutron induced tracks may be etched and counted either on a surface of the material 'itself' or an 'overlay' placed against the material during the irradiation. 'Overlay' placed against the material during the irradiation is usually either mica or lexan polycarbonate. The authors have used the latter as an overlay detector as its uranium content is negligible. Also, it has capability to discriminate against low energy charged particles and light mass recoiling nuclei. By exposing the samples to thermal neutron flux, we eliminate interference by thorium which undergoes only fast neutron fission. Therefore it is necessary to note the material in which tracks can be formed, quantitative measurements should be made to establish whether particular particles produce tracks or not and consequently to decide relative sensitivities of different detectors.

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## EXPERIMENTAL DETAILS

The mineral and rock samples collected from different geological regions of India and Nepal, namely zircon, carbonaceous phylite, garneti-ferrous mica, actinolite and pegmatite-bearing-corrundum were used for uranium measurements. All the samples were powdered up to 100 mesh size. Instead of keeping pure sample powder as was done by Fisher [8], an homogeneous mixture of rock powder and methyl cellulose powder was made.

Table I

Estimation of uranium in various mineral & rock samples.

| S. No. | Sample Location | Lab. Symbol | Uranium in Upper Surface | Uranium in Lower Surface | Total Uranium (p. p. m.) |
|---|---|---|---|---|---|
| 1. | Zircon Manavalakurichi, Madras | ZMM-I | 12·3 | 20·0 | 32·3 |
| | | ZMM-II | 13·0 | 17·6 | 30·6 |
| | | ZMM-III | 13·2 | 18·4 | 31·6 |
| 2. | Zircon Kanya Kumari, Madras | ZKM-I | 7·5 | 15 | 22·5 |
| | | ZKM-II | 6·8 | 11 | 17·8 |
| | | ZKM-III | 5·7 | 10 | 15·7 |
| 3. | Carbonaceous Phyllite Paddar Valley, Kishtwar (J. & K. State) | CPL-I | 0·169 | 0·25 | 0·419 |
| | | CPL-II | 0·092 | 0·146 | 0·238 |
| | | CPL-III | 0·176 | 0·470 | 0·646 |
| 4. | Tourmaline Paddar Valley Kishtwar (J. & K.) | TLP-I | 0·584 | 0·615 | 1·199 |
| | | TLP-II | 0·584 | 0·595 | 1·180 |
| | | TLP-III | 0·092 | 0·515 | 0·607 |
| 5. | Pegmatite bearing corrundum Paddar Valley Kishtwar (J. & K.) | PBR-I | 2·3 | 5·0 | 7·3 |
| | | PBR-II | 1·6 | 2·7 | 4·3 |
| | | PBR-III | 1·7 | 2·6 | 4·3 |
| 6. | Garneti-Ferrous mica, Sangrah, Leh Ladakh (J. & K.) | GRF-I | 0·20 | 0·215 | 0·415 |
| | | GRF-II | 0·169 | 0·223 | 0·392 |
| | | GRF-III | 0·138 | 0·246 | 0·384 |
| 7. | Actinolite Sangrah, Leh, Ladakh (J. & K.) | ACT-I | 0·161 | 0·40 | 0·561 |
| | | ACT-II | 0·146 | 0·36 | 0·506 |
| 8. | Tourmaline Sundrijal Area Kathmandu Valley Nepal | TLJI-I | 0·107 | 0·24 | 0·347 |
| | | TLJI-II | 0·115 | 0·25 | 0·365 |
| | | TLJI-III | 0·16 | 0·33 | 0·47 |

Total Thermal Neutron Dose = $10^{15}$ nvt.

For uranium measurements 50 mgm rock samples mixed with 100 mgm of methyl cellulose were pressed into 1·3 cm diameter pellets in a hand processing machine designed for that purpose. Lexan polycarbonate discs of the same diameter were cut out with a steel punch, washed with alcohol, triply distilled water and dried in dust free atmosphere to avoid contamination. Each sample pellet was placed between two lexan polycarbonate detector discs and all samples were stacked as a cylindrical unit, along with a standard glass dosimeter in an aluminium irradiation capsule. The capsule was sent to Isotope Division of B.A.R.C. Trombay, Bombay for the irradiation in CIRUS reactor with a thermal neutron dose of $10^{15}$ (nvt). After the irradiation the detectors were removed from the rock and dosimeter glass pellets and labelled according to their location. The irradiated plastic detector discs were etched in 6 N. NaoH in a constant temperature bath at 70 °C for 30–40 minutes. Fission fragments entering the detector whose apparent length depends upon the entry angle of the fragment and its starting position in the sample were dark cylindrical lines with a typical range of 15 microns.

Fission fragment track counting in the optical microscope matched against measurements for standard glass dosimeter, yielded the uranium concentration listed in Table 1. The total track density registered on the detector for each pellet of the rock pellets were measured in surface with uniform and nonuniform distribution of uranium (Figs. 1, 2, Plate I, p. 832a). The total track densities in all the samples were compared with that of standard dosimeter glass pellets. The detailed experimental procedure is described elsewhere [6, 9].

## DISCUSSION

The main purpose here is to present these data as an illustration of the usefulness of the fission track method and to develop interest so that such studies are continued. The technique of track counting has been described in many papers but it is yet difficult to evaluate its advantage in uranium estimation of minerals and rocks. The measurement in an 'overlay' detector could have the following advantages:

i. The overlay can be chosen so that the tracks in it are easily recognised and counted which are readily distinguished from scratches and surface dislocations.

ii. The solid state track detector method has the distinct advantage over autoradiographic methods in that, as demonstrated here, it allows a determination to be made of exceedingly small concentrations of uranium. It is only necessary to increase the thermal neutron dose.

iii. Etch tracks have sometimes been counted on replicas of the etched surface rather than the surface itself. Only experience with the particular situation would show whether this technique has any advantage. Such replicas are easily prepared [10, 11].

iv. Overlay method is inexpensive, precise, sensitive and requires only a very small amount of the sample.

The results of the analysis for uranium contents in different rock and mineral samples, e.g. zircon, pegmatite bearing corrundum, carbonaceous phyllite, tourmaline and actinolite, are presented in Table I. Uranium concentrations measured for upper and lower surfaces are different. However, the average uranium content is the same for all the individual samples. Present analysis shows that the precision of the technique mainly depends on the error in counting tracks in the samples, an error due to fluctuations of thermal neutron dose and the non-uniform distribution of uranium in various samples which is about three percent in this experiment. After taking all the above parameters into consideration, a nearly constant ratio between measured values on the both sides of the pellets has been observed. In addition the constancy in the measured values may be due to the fact that all the detector discs and the samples were stacked as a cylindrical unit in the thermal column of the reactor and all the samples were exposed to the same thermal neutron dose. Uranium concentration within particles which are smaller than a hundred microns will pass undisturbed into powdered rock surface and will show up in the detectors as clusters of tracks. Samples which were having such clustering effect were rejected for the investigation.

Like almost all the geochemical techniques, the fission track method is most valuable when its results are combined with chemical data obtained by other methods. The accuracy of the method was checked by using the gamma-ray spectroscopy method for the determination of uranium content. The samples showed almost identical results as determined by the overlay detector method [12].

The amount of uranium in each sample was determined by comparing the total fission tracks from the sample to those from glass dosimeter of known uranium content. Zircons from Kanyakumari and Manavalakurichi (Madras) show higher concentration of uranium (15 - 32 PPM) as compared to other mineral and rock samples. Uranium concentration in carbonaceous phyllite, pegmatite bearing corrundum and tourmaline from Paddar valley Kishtwar (J & K State) range between 0·5 – 7 PPM. Among all these pegmatite bearing corrundum is having maximum uranium concentration. Garneti-ferrous mica, actinolite from Sangrah (Ladakh) and tourmaline from Sundrijal area (Nepal) have the lowest concentration of uranium (Fig. 3, Plate I, p. 832b) ranging between 0·3 – 0·5 PPM. But in actinolite the lexan detectors were having sun bursts like events (Fig. 4, Plate I, p. 832b) which may be due to the presence of grains rich in uranium.

The results of uranium concentrations of various minerals and rock samples studied were not high enough for the purpose of obtaining uranium. But the experiments are in progress in finding the possible samples with high uranium concentrations from the same orogenies which may be useful for the development purposes.

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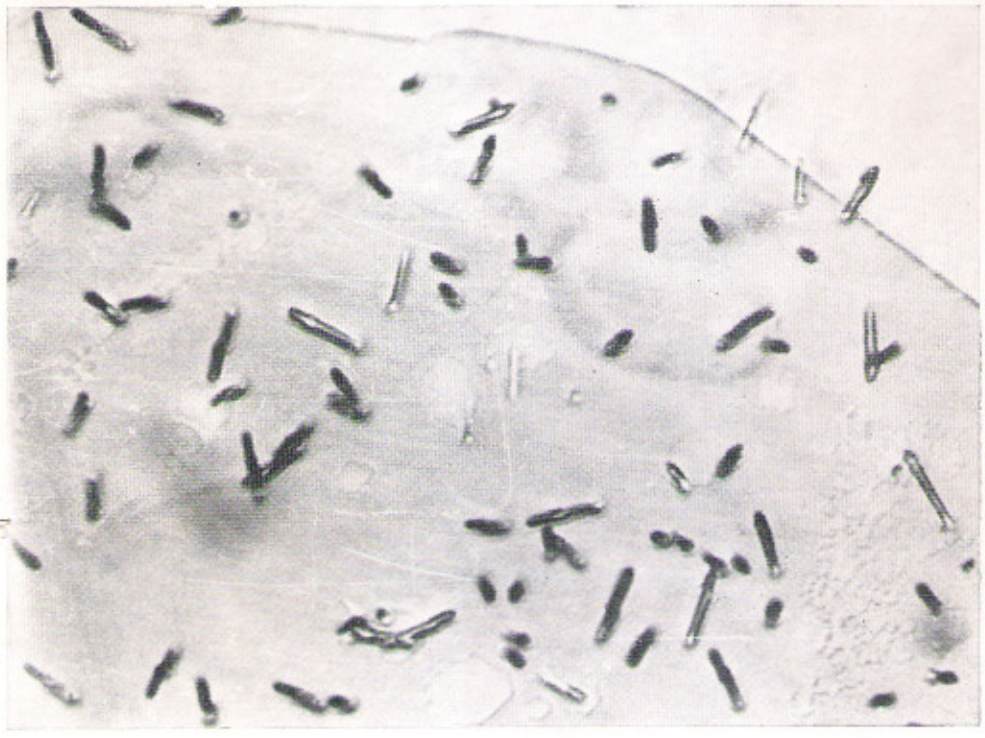

Fig. 1. Uniform distribution of Uranium in Zircon from Kanya Kumari (Madras) detectors etched in 6N NaOH for 35 minutes.

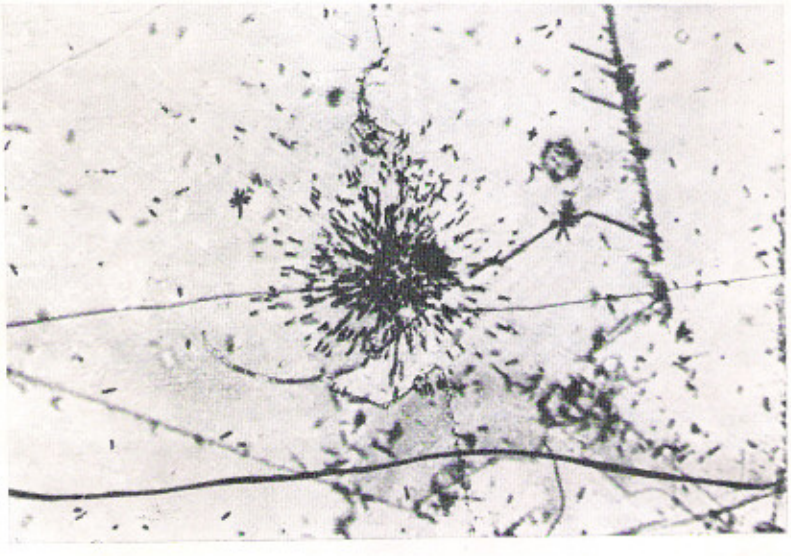

Fig. 2. Zircon sample showing non-uniform distribution of uranium from Kanya Kumari (Madras).

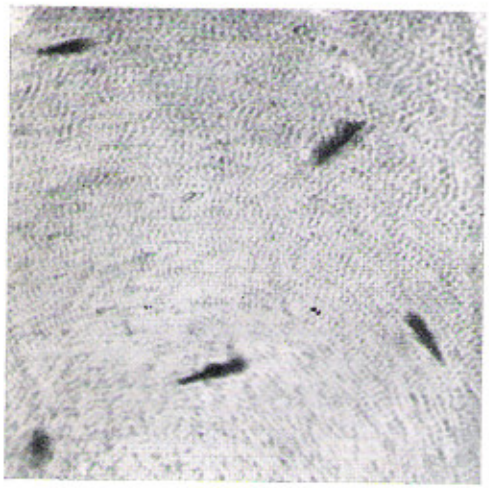

Fig. 3. Tourmaline, from Nepal showing lowest concentration of uranium, using lexan as solid state track detector etched in 6N NaOH for 30 minutes.

Fig. 4. Actinolite from Sangrah (Ladakh) showing sunburst like events, due to non-uniform distribution of uranium irradiated with a total thermal neutron dose of $10^{15}$ (nvt).