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FISSION TRACK AGES AND URANIUM CONTENTS OF SOME INDIAN MUSCOVITES

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ABSTRACT

Fission track ages of muscovite samples from Bihar (984 m.y., 1062 m.y.), Rajasthan (631 m.y., 825 m.y.), Andhra Pradesh (564 m.y.), Nilgiri (810 m.y,) and Delhi (915 m.y.), have been measured and their uranium concentrations have been determined. Samples from Bihar have the lowest uranium content ($0{\cdot}5 \times 10^{-11}$ atom/atom) and those from Andhra Pradesh have the highest uranium content ($16{\cdot}9 \times 10^{-11}$ atom/atom). Average measured ages are found to be in good agreement with ages determined by other workers using similar and other radiometric methods and are related to the metamorphic orogenic cycles of the regions.

INTRODUCTION

AGE of muscovite micas has been determined by many workers using the fission track dating technique[1–4]. In many cases the reported fission, track ages are lower than those determined by other radiometric methods. This is known to be due to the loss of "fossil" tracks resulting from the high temperatures encountered during the geological history of the specimen. The fission track age, in fact, gives an idea about the time of crystallisation of the mineral or the time of occurrence of the last overheating event in the history of the specimen since when the tracks have been preserved in it, whichever is later.

In their earlier experiments Fleischer *et al.*[2] had expressed a doubt that precambrian muscovites older than a few hundred million years, could not be dated by this technique, because of very large fading effects on the "fossil" tracks over the geological times. However by carefully counting the over-etched "fossil" tracks Mehta and Nagpaul[5] reported the fission track ages of several precambrian muscovites of India and have obtained meaningful age data by applying the fission track density correction as suggested by Mehta and Rama[6].

Using a similar method, we have also determined the fission track ages and uranium concentrations of several muscovite samples from the three important mica belts of India, *viz.*, Bihar, Rajasthan and Andhra Pradesh and other precambrian muscovites namely from Nilgiri and Delhi (Masoodpur area). The samples at Sl. No. 1, 2, 5 and 6 (Table I), are from the muscovite books already dated by Mehta and Nagpaul[5] while the other samples are from undated muscovite books obtained from other sources. An inter-laboratory comparison of the results for the common samples dated by the Kurukshetra group has been made and the results have been compared with the known radiometric ages of other pegmetites from the same region. The measured ages are found to correspond to the metamorphic orogenic cycles of the regions.

EXPERIMENTAL DETAILS

The method of sample preparation and other experimental procedures were basically the same as used by Mehta and Nagpaul[5] and have been described in detail elsewhere[7].

The fossil track length distribution measurements were carried out after 30 minute etching of the samples in 48% HF at 25° C. These were compared with the track length distribution for the induced fission tracks in the samples after reactor irradiation and similar etching for the purpose of finding the track fading correction. Our separate laboratory track annealing experiments[7] using the reactor irradiated muscovites have also revealed that practically there is a negligible reduction ($\leqslant 5\%$) in the track density corresponding to a track length reduction of about 25%. A larger track length reduction requires a track density fading correction to be applied. A normalised track length versus normalised track density curve was plotted to assess the track fading correction. However, in none of our samples, was there a track length reduction of more then 20%. The mean track length of neutron induced fission tracks in muscovite was found to be 10·5 microns and has been used for calculating the uranium contents.

The fossil and induced fission track densities ρ_s and ρ_i respectively, in the muscovite samples were determined after over etching them for three hours in 48% HF at 25° C. The standard glass dosimeters of Fleischer *et al.*[8], were used to measure the thermal neutron dose. For these dosimeters under standard conditions of etching (5 sec, 48% HF, 22° C), the integrated neutron dose, ϕ, is related to the track density ρ_d, by the formula $\phi = 2{\cdot}26 \times 10^{11}\ \rho_d$. The following equations were used for age, A, and uranium content, C (U), calculations :

$$A = 6{\cdot}57 \times 10^9 \ln \left\{1 + 2{\cdot}1 \times 10^{-4} \frac{\rho_s \rho_0}{\rho_i}\right\} \text{ years}$$

$$C(U) = 3{\cdot}18 \times 10^4 (\rho_i/\phi) \text{ gm/gm} = 2{\cdot}534 \times 10^4 (\rho_i/\phi) \text{ atom/atom},$$

TABLE I

Fission Track ages and uranium concentrations of Indian muscovites

Sl. No.	Sample Location	Lab. No.	Total Neutron Dose ($\times 10^{17}$ nvt)	ρ_s (cm^{-2})	ρ_i (cm^{-2})	$\rho_s \rho_D / \rho_i$ (cm^{-2})	U-Concentration ($\times 10^{-11}$ atom/atom)	U-Concentration ($\times 10^{-10}$ gm/gm)	F.T. Age: Individual Ages (my)	F.T. Age: Mean (my)	Ages (my) by other methods
1.	*Mohanbaria mica mines, Kodarma Zone, Hazaribagh, Bihar	MMB I	8·7	99	5142	74237	1·5	1·88	951·8 ± 141	984·4 ± 38	850–1100
		MMB II		96	4775	76986	1·4	1·75	986·6 ± 150		Ref. (9, 10)
		MMB III		129	6979	70908	2·0	2·55	912 ± 119·3		
		MMB IV		107	4775	85869	1·4	1·75	1089·2 ± 158		
2.	*Paharia mica mines, Dhorakola Divn. Kodarma Zone, Hazaribagh, Bihar	MPD I	9·29	39	1837	86312	0·5	0·63	1094·4 ± 185·3	1062·2 ± 50·8	850–1100
		MPD II		63	3232	79633	0·88	1·12	1015·9 ± 134·1		Ref. (9, 10)
		MPD III		60	3306	74210	0·90	1·13	951·5 ± 128·5		
		MPD IV		72	3122	94290	0·85	0·17	1186·9 ± 148·3		
3.	**Debari, Udaipur, Rajasthan	MDU I	7·99	551	45913	42445	14·6	18·3	561 ± 49·2	630·5 ± 41·7	700–1150 Ref. (9, 10, 11)
		MDU II		661	41505	56343	13·2	16·5	734·7 ± 59·7		
		MDU III		738	51789	50422	16·4	20·6	661·3 ± 50·7		
		MDU IV		511	42240	42753	13·4	16·8	564·9 ± 49·3		

4.	***Ajmer Area, Rajasthan	MAJ	I	9·29	202	15427	53867	4·2	5·28	704·1 ± 71·1	824·8 ± 33·3	700–1150 Ref. (9, 10, 11)
		MAJ	II		222	14692	62222	4·0	5·03	806·8 ± 78·8		
		MAJ	III		228	13590	68934	3·7	4·65	888·2 ± 86·3		
		MAJ	IV		246	15426	65627	4·2	5·28	848·3 ± 79		
		MAJ	V		219	13223	67991	3·6	4·53	876·9 ± 86·7		
5.	*Utukur mica mines, Raipur Taluqua, Nellore, Andhra Pradesh	MUR	I	8·26	606	55095	40201	16·9	21·2	532·5 ± 44·2	563·7 ± 40·6	~ 500 Ref. (9, 10)
		MUR	II		496	47749	37952	14·6	18·4	503·8 ± 46·1		
		MUR	III		386	34894	40393	10·7	13·4	534·9 ± 55·5		
		MUR	IV		367	25711	52209	7·9	9·9	683·6 ± 76		
6.	*Nilgiri, Ruby Mica	MNG	I	8·88	461	29751	60892	8·49	10·65	790·6 ± 60·2	809·8 ± 11·7	
		MNG	II		483	29568	64200	8·44	10·59	830·9 ± 60·2		
		MNG	III		512	32322	62301	9·21	10·57	807·8 ± 58·7		
7.	****Masoodpur Area Delhi,	MDL	I	3·92	184	4371	72979	2·82	3·55	936·8 ± 67·7	915·3 ± 20·9	750–860 Ref. (10)
		MDL	II		165	4224	67721	2·73	3·43	873·6 ± 65·6		
		MDL	III		193	4591	72881	2·96	3·72	935·6 ± 64·8		

* Sample provided by Prof. K. K. Nagpaul of Kurukshetra University.

** Sample collected by authors.

*** Sample provided by Prof. S. H. Rasul of Geology Department, A.M.U., Aligarh.

**** Sample provided by Dr. Roonwal of Geology Department, Delhi University.

Results and Discussion

The fossil track ages of seven muscovite samples and their uranium concentrations measured by us are given in Table I. The errors given in the individual age data correspond to the statistical error in track density measurements of the fossil tracks and induced fission tracks in muscovite samples and the induced fission tracks in the glass dosimeter. The error in the average age of the samples from the same site is the overall standard deviation error

$$\sigma_A = \sqrt{\frac{1}{n(n-1)} \Sigma (A - \bar{A})^2}.$$

The fission track ages of muscovite samples from the same site or duplicates from the same tight book are found to agree with each other within 20%. The youngest samples are from Nellore, Andhra Pradesh ($563 \cdot 7 \pm 40 \cdot 6$ m.y.) and the oldest are from Bihar ($1062 \cdot 2 \pm 50 \cdot 8$ m.y.).

Our results on fission track ages of the muscovite samples received from Prof. K. K. Nagpaul agree very closely (within 10%) with those obtained by Mehta and Nagpaul[5]. These and our other results also compare very well with the radiometric ages of other pegmatites of the same region[9–11]. These fission track ages are in conformity with the last metamorphic orogenic cycles of the regions[9]. The above comparisons reaffirm the successful applicability of the fission track dating technique even to the cases of precambrian muscovites and places the technique on a firm footing.

The uranium concentration in our samples varied from $0 \cdot 5 \times 10^{-11}$ atom/atom to $16 \cdot 9 \times 10^{-11}$ atom/atom. This is very small concentration to be commercially exploitable. This concentration, in fact, is the concentration of the syngenetic U-atoms which are fitted in the crystal lattice of muscovite during crystallisation of the mineral. The actual concentration of the uranium present as epigenetic deposits between the loose cleavages of muscovite, however, is much larger. Although the concentration of uranium in muscovite samples from the duplicates of the same book is found to vary, the fission track ages agree within very close limits.

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