THERMAL ANNEALING OF NUCLEAR TRACKS IN MINERALS

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Recently extensive use has been made of solid state nuclear track detectors (SSNTDs) for the detection of nuclear radiations. The fact that a large number of crystalline minerals have been found in terrestrial and extra-terrastrial samples, the track registration, development and retention properties of crystals are of paramount importance. It has been shown[1] that of various environmental parameters which could possibly affect the long-term stability of fission tracks temperature is by far the dominant factor. Despite a large number of annealing studies in a variety of minerals, very little is known about the physical nature of annealing process. The only significant advance in this area is the model of single activation energy, proposed by Modgil and Virk[2], without taking recourse to Arrhenius plots. The purpose of this work is to find activation energy (E_a) of some crystalline minerals on the basis of single activation energy model.

The empirical formula based on single activation energy model[2] relating annealing rate, V_a, and activation energy, E_a is as follows:

$$V_a = At^{-n} \exp(-E_a/kT) \qquad (1)$$

where A is a proportionality constant, n the exponent of annealing time (t) and T the annealing temperature. The annealing rate is defined as the rate of change of track length and can be easily measured as $V_a=(Lo-L)/t$.
To determine the activation energy, eq.1 can be written in the form:

$$\ln V_a = \ln A - n \ln t - E_a/kT \qquad (2)$$

The slope of a plot of $\ln V_a$ versus 1/T will give us a unique value for the activation energy.
Different sets of samples prepared from Zircon (100 plane), Chlorite and Muscovite were exposed to Ca-40 (15.0 MeV/n), La-139 (14.6 MeV/n) and U-238 (16.53 MeV/n) ion beams, obtained from the UNILAC accelerator at GSI Darmstadt, West Germany, at 15^{o} angles of incidence. Irradiated samples were heated at temperatures varying from 350 to 900^{o}C using intervals of 50^{o}C and heating time 10 min for each sample. The samples were etched and the track lengths were measured and the activation energy, E_a, is calculated (Table 1).
It is interesting to note that all categories of heavy ions, even of different beam energies, yield almost identical values of activation energy of annealing in the crystalline minerals.

Table 1

Detector	Incident ion	E_a(eV)
Zircon	Ca-40	3.58
	La-139	3.51
	U -238	3.65
Chlorite	Ca-40	0.80
	La-139	0.78
	U -238	0.77
Muscovite	Ca-40	0.98
	La-139	0.98
	U -238	0.96

1. R.L. Fleischer, P.B. Price and R.M. Walker, J. Geophys. Res. 70(1965) 1497.
2. S.K. Modgil and H.S. Virk, Nucl. Instr. and Meth. B 12(1985) 212.