Indian Journal of Pure & Applied Physics
Vol. 25, December 1987, pp. 499-500

Influence of Crystallographic Structure on the Activation Energy of Fission Track Annealing in Apatite

A S SANDHU, SURINDER SINGH & H S VIRK
Department of Physics, Guru Nanak Dev University, Amritsar
Received 24 November 1986; revised received 27 August 1987

The effect of crystallographic structure on the activation energy of fission track annealing in apatite is reported. The activation energy is found to vary with the crystallographic orientation, being maximum (0.71 eV) for 1010 plane and minimum (0.57 eV) for 0001 plane of the crystal. The plane parallel to c-axis (1010) is found to be the most resistant to track annealing.

Recently, it has been shown [1-5] that the crystalline minerals have very complicated fission track etching and annealing behaviour. Since the atomic spacing is variable along different crystallographic orientations in the anisotropic mineral, fission fragments travelling in different directions encounter different densities of matrix atoms[6]. Further, since the diffusion process in apatite is markedly anisotropic[7], different orientations may be characterized by different activation energies. The effect of crystallographic structure on the activation energy of track annealing, using the track etch technique, has not been reported so far. Only Ritter and Mark[8], on the basis of ultraviolet studies on latent damage trails in apatite, have reported different values of activation energy for two different planes. The present work reports the values of activation energy determined on different planes of apatite, derived on the basis of the annealing model proposed by Modgil and Virk[9].

Three different planes of apatite (viz. 0001, 1101 and 1010) crystal were selected for the present study. The annealing experiments were carried out to study the effect of temperature on the track annealing rate (V_a) for different planes. The samples from each plane were exposed to ^{252}Cf fission fragments at 15±2° angle of incidence and the samples were heated at 300, 325, 350, 375, 400 and 425°C for 10 min in each case. These samples were etched simultaneously with 2% HNO_3 for 3 min at 25°C. The track length (L) was measured at each temperature using Olympus binocular microscope at a magnification of 1500× (+ oil immersion). A reference sample prepared from each plane was etched under identical conditions to determine the mean length(L_0) of unannealed tracks. The mean track length as a function of annealing temperature is plotted for each plane (Fig. 1).

The following empirical relation[9]

$$V_a = a\, t^{-n} \exp(-E_a/kT) \quad \ldots(1)$$

is used to determine the activation energy (E_a) for different planes of apatite. The annealing rate (V_a) is defined as the rate of change of track length and can be measured as

$$V_a = (L_0 - L)/t \quad \ldots(2)$$

where t is the annealing time. To determine E_a, Eq. (1) can be written in the form:

$$\ln V_a = \ln A - n \ln t - E_a/kT \quad \ldots(3)$$

The slope of plot of ln V_a versus $1/T$ (Fig. 2) gives a unique value of activation energy for each plane.

It is observed (Fig. 1) that the annealing of fission tracks occurs faster for samples cut perpendicular (0001 plane) to the optical axis than for ones cut

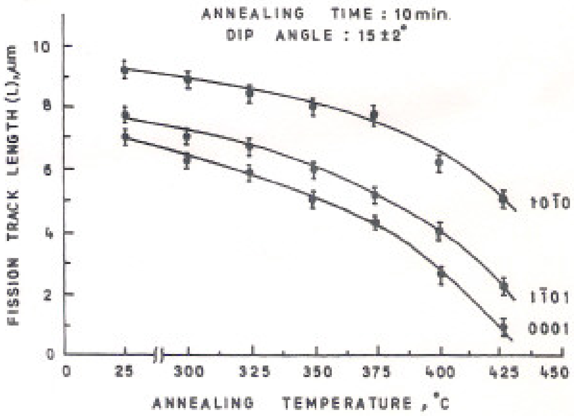

Fig. 1 — Fission track length versus annealing temperature for different planes in apatite

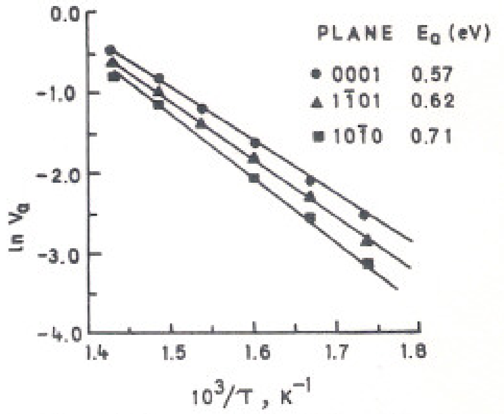

Fig. 2—Plot of ln V_a versus $1/T$ for different planes in apatite

parallel (1010 plane). Since the annealing is a diffusion of interstitial atoms and atomic vacancies, it must be a function of interatomic spacing between different planes. The value of E_a for fission track annealing in 1010 plane (Fig. 2) is higher (0.71 eV) than in 0001 plane (0.57 eV). This indicates that the interstitial atoms require less amount of energy to start the process of annealing in a plane perpendicular to c-axis. The difference in E_a may also be due to different total point-defect concentrations in different orientations.

One of the authors (A S Sandhu) thanks CSIR, New Delhi, for the award of a senior research fellowship.

References

1 Durrani S A, Khan H A, Bull R K, Dorling G W and Fremlin J H, *Proc Fifth Lunar Sci Conf, Geochim & Cosmochim Acta (USA)*, **5** (Suppl) (1974) 2543.

2 Green P F & Durrani S A, *Nucl Track Detect (GB)*,**1** (1977) 33.

3 Khan H A,*Radiat Eff (GB)*,**32** (1977) 49.

4 Watt S, Green P F & Durrani S A, *Nucl Tracks & Radiat Meas (GB)*,**8** (1984) 371.

5 Sing S, Sing D, Sandhu A S & Virk H S, *Mineral J (Japan)*, **13** (1986) 75.

6 Laslett G M, Kendall W S, Gleadow A J W & Duddy I R, *Nucl Tracks & Radiat Meas (GB)*, **6** (1982) 79.

7 Laslett G M ,Gleadow A J W & Duddy I R, *Nucl Tracks & Radiat Meas (GB)*, **9** (1984) 29.

8 Ritter W & Mark T D,*Nucl Instrum & Methods Phys Res Sect B (Netherlands)*,**14** (1986) 314.

9 Modgil S K & Virk H S, *Nucl Instrum Methods Phys Res Sect B (Neitherlands)*, **12** (1985) 212.