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Fission track blocking temperatures in rock minerals : a re-evaluation

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The concept of the closure or blocking temperature was first introduced in geochronology to model the post-metamorphic thermal history of geological samples. The blocking temperature can be considered as the "effective temperature" at which the radiometric clock starts. The apparent radiometric age thus corresponds to the time at which the system cools down to the blocking temperature. The first analytical attempt to introduce the concept of blocking temperature in the field of fission track geochronology was made by Haack (1977). A prerequisite in estimating the blocking temperature for tracks in rock mineral is to know the manner in which the etchable track length is foreshortened for any prescribed thermal history of the mineral. Haack could only partially consider this aspect in his treatment. Bertagnolli *et al* (1983) made the first atempt to realistically estimate the continuous change in the length distribution of tracks, upto any given point of a specified thermal history by considering an empirical relation for rate of annealing of tracks proposed by Mark *et al* (1973). James and Durrani (1986) subsequently extended this approach to estimate fission track blocking temperatures in different rock minerals and found that they are systematically higher than those obtained earlier by Haack. We have shown in an earlier publication (Goswami *et al* 1984) that the problem of annealing of tracks for any given thermal history and track production rate can in fact be treated quantitatively. The equation describing the track annealing process was primarily based on the assumption of the validity of the Arrhenious equation for annealing of tracks. The validity of the four parameter semi-empirical relation derived by us was demonstrated by carrying out laboratory annealing studies of mineral grains subjected to complex temperature history. We have now used this formalism to calculate the foreshortening of tracks in rock minerals for any prescribed thermal history and used these data to obtain their fission track blocking temperatures. In Table 1, we show the results for blocking temperature of apatites for several linear cooling history all of which terminate at 300°K. Comparison of these values with those obtained by others indicate significant differences. Of course the blocking temperature obtained by both James

Table I. Fission track blocking temperatures for apatite.

Source of F.T. data	Blocking temperatures (°C) for cooling rates of			50% Annealing temp. (°C) (t=1 m.y.)
	0.1°/m.y.	1°/m.y	10°/m.y.	
Naeser and	62	78	94 (Haack)	110
Foul (1969)	95	107	119 (This work)	
Wagner and	71	83	95 (Haack)	140
Reimer (1972)	125	137	149 (This work)	
Watt and	64	74	84 (Haack)	
Durrani (1985)	73	86	99 (James and Durrani)	123
	113	125	137 (This work)	

and Durrani (1986) and us are higher than those of Haack, which is to be expected considering the oversimplication in the approach used by Haack. Blocking temperatures for other common rock forming minerals used in fission track studies (e. g. Sphene, epidote, garnet etc) as well as illustrative examples of track length distributions during various stages of prescribed thermal history have also been studied. We believe that our approach is more appropriate, and the blocking temperature estimated here should be a proper guide for the geochronological/geophysical interpretation of fission track data.

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