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INFLUENCE OF ANNEALING TEMPERATURE AND TIME PARAMETERS ON FISSION TRACKS IN SEDIMENTARY AUTHIGENIC GLAUCONITE

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Fission tracks in minerals are reduced in size and lost ultimately as a result of thermal heating in the geologic past. Therefore, a correction to fission track ages for the loss of tracks is essential and must be taken into account. Glauconite is one of the most common authigenic minerals of any sedimentary deposit and shows a high potential to directly date the sedimentary mineral deposits. For applying an age correction to the observed ages of glauconite, its track annealing characters have been investigated and are presented here. The results indicate that the glauconite is a low temperature mineral thermometer among the minerals studied so far in fission track geochronology. The colour of the analysed crystals changes on heating at 150 °C for one hour; from green or bluish green it becomes brown, or yellowish brown. Hence, the sedimentary formations where glauconite occurs as a green or bluish green colour might not have witnessed even a moderate thermal episode. Track annealing characteristics indicate that no age correction is necessary in such cases and hence the glauconite fission track ages would closely correspond to true age of sedimentation.

Key Words : Fission Tracks; Sedimentary Authigenic Glauconite

INTRODUCTION

THE effect of annealing temperature and time parameters on fission tracks in the minerals of volcanic origin is well established.[1-6] But no work has been done so far on the annealing characteristics of the sedimentary authigenic minerals. Fission track technique has been successfully applied to date glauconite which is one of the most abundant authigenic minerals in sedimentary rocks[7-9] to assign ages to their strata. But the track annealing studies in the mineral still remains untouched. Without annealing corrections the glauconite fission track ages carry no meaning. The ages for glauconite with annealing correction should closely correspond to the true age of the formation as compared to the results obtained by K–Ar method where no correction for Ar escape can easily be deduced. This indicates the essentiality of the study of annealing parameters for the sussessful application and interpretation of fission track dates.

The argon is easily released from glauconite even at moderate PT condition in geologic past and mechanical shocks in laboratory while grinding. The ages obtain-

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ed by K–Ar dating method on glauconite of older deposits are not always reliable and it has been observed that generally there exists under estimation of K–Ar ages by about 10 to 20 per cent compared to the true ages of the deposits.[10–13] Since argon is apparently lost so readily from glauconite, the stability of fission tracks in glauconite must be carefully considered. Therefore, the mineral needs a careful and systematic study on the effect of heating on fission tracks in it. The track annealing characteristics on a glauconite sample from Kutch area are presented in this report.

Experimental Procedure

Sample No. BSFT53 from Kutch sediments has been selected for the annealing Study. A piece of green sandstone of approximately 200 grams of the sample was crushed into powder. Excessive hammering and high mechanical shocks were avoided lest track may fade. It was washed in water and then dried at room temperature. The clear crystals of glauconite were separated from the fraction obtained after sieving through 300 400 mesh size. These glauconite crystals were irradiated in CIRUS reactor at Bhabha Atomic Research Centre, Bombay *vide* can No. F19S9407 to a thermal neutron fluence of 1.2×10^{16} n/cm.[2] A part of irradiated sample was embedded in araldite mounts.[8] Etching of the polished mounts was done at 25 °C in a mixture of H_2SO_4, HF and distilled water in the ratio 1:2:4. The other lots of crystals were heated in a small furnace at different temperatures for various annealing times. Heating time was varied from a few minutes at higher temperature to a few weeks at lower temperature. In beginning higher temperatures e.g. 400°, 350°, 300 °C etc. were tried for annealing but it was found that tracks anneal very fast and it was not practically possible to study degree of annealing in stages. These observations point to low annealing characteristics of glauconite. Then the annealing temperatures 180, 150, 120 and 90 °C were selected. At each heating step the change in colour of the crystals was noted in addition to track counts. Unannealed induced track density (ρ_0) was obtained from the track count data in 1000X magnification of BH2 Olympus microscope. Annealed induced track density density (ρ) was obtained for different annealing times at each temperature. The reduction in track density $\left(\frac{\rho_0-\rho}{\rho_0} \times 100\right)$ was thus calculated and plotted against annealing times (Fig. 1). The straight line was obtained for each temperature when the track density was plotted on Y–ordinate as linear scale versus annealing time on X–ordinate as 5 cycles logarithmic scale.

Formation of Glauconite and Kinds

Glauconite forms the deposits of almost every age from Cambrian to present day and lies as irregular rounded grains with quartz sands to form green sands. It is next to quartz in order of abundance and constitutes 10 to 25 per cent of the deposit by volume. It occurs in both colloidal and crystalline forms showing considerable variations in composition. Glauconite is a micaceous mineral and occurs almost exclusively in marine sediments particularly in green sandstone. It is

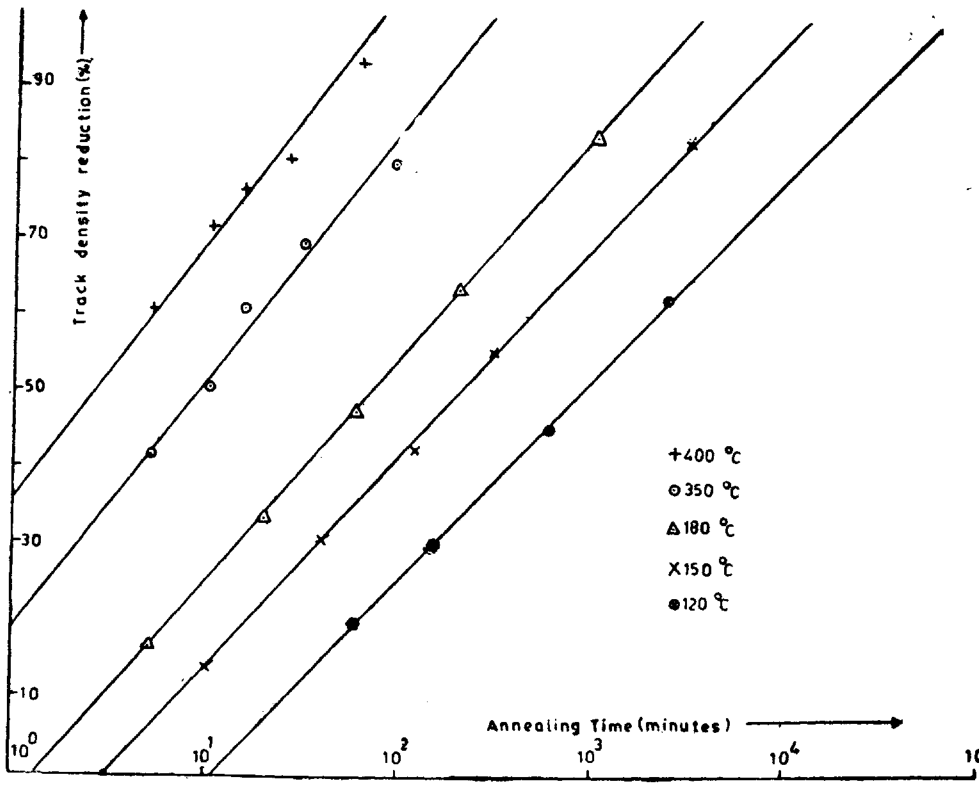

FIG 1 Laboratory experimental set up to investigate the combined effect of temporal and thermal heating parameters on fission tracks in glauconite mineral of sedimentary origin from Kutch (Sample No. BSFT53).

generally accepted that glauconites are formed from a variety of starting materials by main diagenesis in shallow water during periods of slow or negative sedimentation. They are found in impure limestones, sandstones and siltstones; green sands are so called because of large amount of glauconite which they contain from their content of both ferric and ferrous ion, it is deduced that glauconites are formed under moderately reducing conditions of the type which, may in some cases at least, occur through the action of sulphate reducing bacteria on decaying organisms. Some glauconites, may however, form by the coagulation of suspended colloidal particles.[14]

According to shapes and sizes of grains, glauconite is classified into three kinds.[15] First is known as pelletal glauconite and is rounded and oval to papillae in form with well defined boundaries. Interiors of these grains are formed of microcrystalline aggregate. They are transparent to translucent with green/olive green/bluish green colour. These grains are bigger in size than that of calcareous grains and are equal to quartz grains present in the deposits. The other kind of glauconite grains are found in clusters between quartz grains and differ from pelletal glauconite in their shape and internal structure and are known as flaky glauconite. Individually the flakes vary in size from a very small flake occurring between the two quartz grains to as big as detrital pelletal variety. The flaky glauconite is generally oxidised and usually looks yellowish brown in colour. The third type is interstitial glauconite. It is found from pelletal and flaky glauconites during the process of recrystallization and flowage in between the quartz grains.

Results and Discussions

Upon heating the interstitial atoms of the crystal matrix of minerals are energised and return to their original positions in the crystal lattice. As a result, tracks are erased depending on the degree of heating as well as the duration of annealing. As the geological heating lessens the original numbers of fossil track and hence results in lowering the age of the analysed sample. The natural geological annealine suffered by the sample can be assumed identical to the laboratory process performed.[16]

The track annealing characteristics (Fig. 1) indicate that the glauconite is a low temperature mineral similar to apatite[17] and Kyanite.[6] The colour of the glauconite changes from green or bluish green to brown or yellowish brown upon heating in the furnace at 150 °C for one hour. When it changes colour then it is no more a true glauconite mineral but converts into chlorite etc. The green colour of the sandstone is attributed to the presence of glauconite.[18] The green colour of the analysed glauconite samples indicates that there was no appreciable temperature rise in geologic past in the areas of sample locations. This is otherwise true also because the mineral is formed in marine conditions and slow or negative sedimentation. Hence, the glauconite fission track date directly relates to age of deposition and need not to be corrected for any track annealing loss which has been investigated to be negligibly small if any. As described in the preceeding section 3, the analysed crystals contained only the pelletal glauconitic grains except a few flaky grains. The interstitial grains which are formed as result of metamorphism were not found in this sample. This additionally supports that the pelletal glauconitic grains formed at low temperature conditions during the process of sedimentation have not been subjected to thermal episode in the entire course.

A survey of track annealing studies of igneous minerals[2–4] indicated that Kyanite was the low temperature recording mineral thermometer. But the present studies on sedimentary authigenic glauconite mineral give still more low track fading characteristics.

Conclusions

Since glauconite is formed in low temperature environments in sedimentary deposits and contains only its pelletal variety, it has perceived no geological activity severe in temperature where it is found in green colours. The track annealing characteristics of glauconite are extremely low and changes colour at 150 °C if heated for an hour thereby indicating that no age correction is required to its fission track age in such cases.

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References

1. R L Fleischer P B Price and R M Walker *Nuclear Track as in Solids* University of California Press Berkeley (1975) pp 605
2. H S Saini and K K Nagpaul *Int J appl Rad Isotop* 30 (1979) 213–231
3. H S Saini O P Sharma and K K Nagpaul *Nucl Tracks* **3** (1979) 139–141
4. H S Saini A P Srivastava and G Rajagopalan In : *2nd National Seminar cum Workshop on Geological Records and Contemporary Fluxes of Energetic Charged Particles, PRL Ahmedabad* (*Abstr*) (1981) 69–71
5. H S Saini O P Sharma and K K Nagpaul *Min J* **11** (1982) 21–31
6. H S Saini A P Srivastava and G Rajagopalan *Geol Mag* **120** (1983) (4) 341–348
7. A P Srivastava H S Saini and G Rajagopalan In : *3rd National Seminar cum Workshop on SSNTDS* Guru Nanak Dev University, Amritsar (*Abstr*) (1983) 1–3
8. A P Srivastava H S Saini and G Rajagopalan *Curr Sci* **52** (18) (1983) 866–867
9. A P Srivastava H S Saini and G Rajagopalan *Earth Planet Sci Lett* (1986) (*in press*)
10. D L Eicher *Geologic Time : Foundation of Earth Series* Prentice-Hall Inc Englewood Cliffs New Jersey (1968) pp 150
11. F J Fitch P J Hooker J A Miltor and N R Brereton *J geol Soc London* **135** (1978) 499–512
12. G S Odin D Curry and J C Hunziker *J geol Soc London* **135** (1978) 481–497
13. G S Odin *Numerical Dating in Stratigraphy* John Wiley London and New York (1982)
14. W A Deer R A Howie and J Zussman *An Introduction to the Rockforming Minerals* The English Language Book Society and Longman London (1979) pp 528
15. S Prasad and M R Kalsotra *Ind Min* **35**(1981) 43–46
16. C W Naeser and R B Forbes *Trans Am Geophys Union* **57** (1976) 353–358
17. K K Sharma H S Saini and K K Nagpaul *Him Geol* **8** (1978) 296–312
18. S K Chanda and A Bhattacharya *J geol Soc India* **7** (1966) 91–99