FISSION TRACK AGES AND URANIUM CONCENTRATION OF APATITES OF DIFFERENT ROCKS OF SOUTH INDIA

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ABSTRACT

The uranium concentration and ages of apatite grains of various rocks of South India have been measured by fission track technique. The ages range from 100 m.y. to 730 m.y. whereas uranium concentrations vary from 0·5 to 23·8 atom/million atoms of the apatite mineral. The ages agree well with the Deccan volcanic and Indian Ocean Cycle activities.

INTRODUCTION

THE fission track technique of dating the minerals is a promising tool for geochronological studies. Since the discovery of track etch technique by Fleischer and Price[1], Nagpaul *et al.*[2], and Nand Lal *et al.*[3] dated some of the Himalayan granites, Bundelkhand granites[4] and alkaline rocks of India[5] by *'in situ'* apatite measurements. The present report on South India is in continuation of the same. The results have been discussed in the light of other isotopic age data available for the region.

EXPERIMENTAL PROCEDURE AND RESULTS

Transparent sections of about 1 to 2 cm^2 area and 100–200 micron thick rock specimen were prepared by polishing successively with 800, 1200, 1500 mesh of aluminium oxide abrasive and finally with 8 micron diamond paste. They were etched with 5% HNO_3 at about 25° C for 30–50 seconds to reveal the fission tracks in apatite grains. Measurements of fossil and induced densities were carried out by usual procedures described elsewhere[2]. No observations were made (*i*) when grain size was very small (< 50 microns), (*ii*) there was non-uniformity of track density in the grain, (*iii*) near the grain boundary. The thermal neutron flux ϕ was measured by counting $\sim 10^4$ tracks in the uranium loaded glass sample irradiated simultaneously with the rock sections. The age T and uranium concentration C_w calculated with the following relations are given in columns 6 and 9 respectively in Table I.

TABLE I

Fission track ages and uranium concentration in apatites

S. No.	Name and Location of Rock	No. of analysis made	Fossil track density (ρ_s) $\times 10^6/cm^2$	ρ_s/ρ_i	Observed fission track age (million years)	Track length reduction % (corresponding density reduction)	Corrected f.t.age (million years)	U-conc. atom/10^6 atom	Total neutron dose $\times 10^{16}$
1	2	3	4	5	6	7	8	9	10
1.	Granite from Tharumarakuppan hill near Puttur (A.P.)	3	2·6	·473	600±60	*a*	600±60*	(0·5-1·7)	2·2
2.	Granite from Khamam Dist. (A.P.)	4	5·5	·293	580±60	*a*	580±60*	(1·5-3·5)	3·5
3.	Biotite granite gneisses from Kottavalasa, Vishakhapatnam Dist. (A.P.)	4	8·2	·257	470±5	*a*	470±5*	(3·6 6 0)	3·0

TABLE I—*Contd.*

1	2	3	4	5	6	7	8	9	10
4.	Hornblende granodiorite from Gudur-Nellore schist belt.	3	3·4	·660	460±60	7 (3)	480±60	(1·7)	1·2
5.	Hornblende pyroxene granulite from Kottavalasa Vishakhapatnam Dist. (A.P.)	8	6·5	·480	370±40	32 (32)	490±70	(2·2–12·5)	1·3
6.	Coarse biotite hypersthene gneisses from Pre-cambrian terrain of Kottavalasa, Vishakhapatnam Dist. (A.P.)	6	6·8	·691	480±70	9 (3)	500±75	(2·2–3·5)	1·2
7.	Granite from Krishan Samudram Tunvola near Chitoor (A.P.)	3	2·2	·271	340±30	20 (16)	410±40	(1·0–2·0)	2·2
8.	Nirth Granite (A.P.)	3	3·5	·230	300±20	21 (18)	360±30	(1·4–4·0)	2·2
9.	Nepheline Syenite from Kundulura (17° 40′; 81° 24′) (A.P.)	5	2·9	·245	250±30	36 (38)	400±50	(0 8–4·4)	1·7
10.	Hornblende Syenite from Phanai Mata Hill, Chhota Udaipur (Gujarat)	4	·4	·095	100±10	*a*	100±10*	(0 8–1·4)	1·7
11.	Granite from Attur, South Arcot Dist. (T.N.)	3	4·5	·378	670±30	*a*	670±30*	(4·4–23·8)	3·0
12.	Biotite granite, 5–6 km from Arsikere (Karnataka)	3	20	·332	730±80	*a*	730±80*	(4·2–9 4)	3·8
13.	Charnockite rock from Kabbal South of Bangalore (Karnataka)	5	7·5	·749	730±115	11 (4)	760±120	(1·7–3·9)	1·7

a Annealing correction to these ages was not possible.
* Uncorrected ages.

$$T = 6{\cdot}57 \times 10^{9}\ ln\ (1 + 9{\cdot}25 \times 10^{-18}\ \rho_s/\rho_i\ \phi)\ \text{yrs.}$$

$$C_w = 4{\cdot}0 \times 10^{3} \rho_s/\phi\ \text{atom/atom}$$

where ρ_s = fossil track density
ρ_i = induced track density
ϕ = integrated thermal neutron dose.

In order to assess the geological annealing, *in situ* length measurements of fossil tracks were made[6] and compared with the length of induced fission tracks. The method for applying the corrections has already been discussed in the literature[7]. The corrected ages are given in column 8 of Table I. The corrections to some of the ages could not be made because (*i*) fossil track density $< 10^6/cm^2$, does not satisfy TINT formation conditions[6] as in sample No. 10. (*ii*) Number or size of apatite grains, though enough for age determinations, was not sufficient to give statistically significant number of TINTS. The errors given with the individual values are only the statistical counting errors com-

puted from fossil and induced track densities. The mean values are given with one standard deviation. Measurements of fossil and induced track densities on the same grain, no doubt eliminates the error due to the non-uniformity of uranium on the surface, but the variation of the uranium in the volume may give rise to some errors in the age. This factor along with the uncertainty in the neutron dose measurement constant, have not been quoted with the ages. The uranium content in apatite shows large dispersion. Even in the same section it varies from grain to grain.

Discussion

In general, the ages of Andhra Pradesh witnessed the influence of Eastern Ghat belt which runs from Cuttack to Bezwada, attaining the maximum width in Cuttack-Ganjam region[8]. The dominant trend of the belt in Andhra Pradesh is NE–SW, with local variation due to cross folding[9-11]. It is mainly composed of sub-parallel alternating layer of khondalites and their variants, granite gneisses and charnockites[8] (pyroxene granulite). On the basis of available geological and geochronological data, the following probable sequence of events can be assigned to this belt[8,12,13,14].

(*i*) Deposition of pelitic sediments in an extensive geosyncline.

(*ii*) Folding and metamorphism of the sedimentary rocks to form khondalites (~ 1600 m.y.).

(*iii*) Emplacement of charnockites and granites (~ 1300–1500 m.y.).

(*iv*) Metamorphism, folding and uplift of the Eastern Ghats (~ 700–450 m.y.) known as Indian Ocean cycle.

The fission track ages of different apatites (Andhra Pradesh) range from 360 to 600 m.y. (sample Nos. 1 to 9). These ages which generally respond to last metamorphic activity due to high sensitivity of fission tracks against thermal variations support the last, *i.e.,* Indian Ocean cycle episode (~ 700–450 m.y.)[13]. The mineral under investigation is apatite which is most temperature sensitive (as far as fission tracks are concerned), further strengthen the susceptibility of these fission track ages to the last thermal event. These fission track ages of apatites of Andhra Pradesh, also fall in the range of fission track ages of minerals muscovite, biotite and apatite of Nellore mica belt[15].

The age (580 ± 60 m.y.) of Khamam Dist. is comparable with the isotope age of Galena (650–770 m.y.)[12]. It is also consistent with the other fission track ages made on zircon (518 ± 17 m.y.) and apatite (571 ± 37 m.y.) minerals of pegmatitic origin[16] from the nearby regions.

The age 100 ± 10 m.y. of hornblende synetite of Phanai Mata Hill indicates that it lies within Deccan Volcanic province. On the basis of this result, it should be placed well within Mesozoic.

The fission track age 670 ± 30 m.y. of granite from Tamil Nadu (sample No. 11) is corroboratable with 700 m.y. event, *i.e.,* Indian Ocean cycle.

Karnataka region has undergone quite a number of orogenic metamorphic cycles, the effect of which is found to be increasing towards the south, accompanied by some igneous activity (pegmatisation, granitisation, and alkaline gabro syenite complex)[8]. The fission track ages 730 ± 80 and 760 ± 120 m.y. of sample Nos. 12 and 13 are probably due to latest thermal event during Indian Ocean cycle or due to some later igneous activity. Due to the low annealing temperature, the age 730 ± 80 of apatite is lower than the corresponding fission track age of hornblende (840 ± 33 m.y.) from the same region[17].

Conclusion

From the above data it may be concluded that : most of the fission track ages of apatite grains from different rocks of South India corroborate the Deccan Volcanic and Indian Ocean cycle.

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