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ON THE REPRODUCIBILITY OF APATITE FISSION-TRACK PLATEAU-AGE DATING

by

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ABSTRACT

Duplicate measurements as well as published data show that plateau-age measurements on apatites have a reproducibility - when made in optical microscopy - generally better than ± 5%, which may be accounted for by statistical errors on track density measurement.

Key-words: FT dating; Plateau-ages reproducibility.

INTRODUCTION

In recent years, much attention was given to the problem of the evaluation of random errors in Fission-Track (FT) dating. The relative merits of the various FT dating procedures and error calculation models proposed thus far were tested by Bigazzi et al. (1983), and from computer experiments by McGee et al. (1984). It was concluded in both studies that, for the "population" method of dating, the most realistic estimate of the relative error on a FT age was that computed as the square root of the sum of the quadratic error on the fossil track density (D_f), the induced track density (D_i), where the uncertainties σ_f and σ_i are the standard errors of the mean on D_f and D_i, and on the neutron dose. Other sources of error in track density measurements which may be associated to crystal selection, track identification criteria, etc., are thus not included in this calculation. Their effect can only be evaluated from repeated measurements made by several observers on the same set of etched crystals.

In plateau-age dating (Storzer and Poupeau 1973) of apatites, we usually measure with the population method, for each sample, at least 4 individual ages, from which a plateau-age and its precision are computed as weighed means (Poupeau 1982). We show here, from duplicate measurements, that this way of calculating plateau ages and their associated errors is a realistic approach of their experimental reproducibility.

EXPERIMENTAL PROCEDURES

All samples were prepared as follows: after conventional mineral separation, apatite concentrates in the ≃ 80 - 200μm grain size were split into two parts. Crystals from one of these parts were then annealed (500°C for 2 hours) and irradiated in the thermal column of a nuclear reactor together with metal foils for neutron dosimetry. Afterwards aliquotes of respectively irradiated and non-irradiated apatites were submitted to various thermal treatments for the determination of isochronal and isothermal plateau-ages (Poupeau 1982). Crystals from each aliquote pair were then mounted in an epoxy disc, polished and etched in HNO_3 5% for 45 seconds at room temperature. For each track density measurement, from ≈ 60 to 100 crystals were available. Each observer was let free of crystal selection for track counts (only basal sections were systematically rejected), number of crystal counted and surface area and its location in individual crystals for counting. Seven samples from french and brazilian metamorphic rocks were counted by at least 2 and up to 9 observers.

RESULTS AND COMMENTS

Our results are presented in Table 1. Apatite 2520, the most thoroughly studied sample, was measured by 9 observers. Up to 61 individual FT ages were measured from 17 epoxy mounts. Each epoxy mount was observed at least by 2 and up to 6 observers.

The arithmetic average of 61 population ages is of 241 ± 24 m.yr. (± 2 standard deviations), 2 age determinations being outside of this interval (Fig. 1). For each sample, plateau-ages and their statistical uncertainties were calculated using the usual weighing relationships:

$$t_{pl} = \frac{\sum(t_i/\sigma_i^2)}{\sum(1/\sigma_i^2)} \qquad \sigma_{pl}^{-2} = \frac{1}{\sum(1/\sigma_i^2)} \qquad (1)$$

Over the 10 plateau ages determined for apatites 2520, (the two determinations by observer 5 were made 1 year apart), seven are within ± 1 standard deviation of the arithmetic average of plateau values (Fig. 2).

Other samples were stùdied with less detail. Apatites M44 and 70242 were respectively studied by 4 and 5 observers on respectively 6 and 24 epoxy discs, producing 25 and 44 single FT ages. In samples RS 03 to RS 08, duplicate measurements were made by 2 observers on four epoxy discs. For all these samples the overall results are similar to those obtained for 2520.

Noteworthy, for the above samples, any particular plateau-age value is within ± 5% of the average of plateau determinations.

We found in the litterature 20 plateau-age determinations on apatites from metamorphic and plutonic rocks covering an age range extending from 40 to 290 m.yr. (Poupeau 1982, Poupeau et al. 1978, 1985, Fonseca and Poupeau 1984, Carpena 1980, 1985, Mailhe 1985). Where FT counts were performed with an optical microscope, the precision (± 2σ) of FT plateau-ages as calculated from relations (1) above is compatible with the dispersion of individual FT ages. Where due to the high fossil FT density, track counts were performed with a Scanning Electron Microscope (Poupeau et al. 1978, Carpena 1980), the dispersion of FT ages is significantly larger than expressed by formulas (1). This is due to the fact that track identification criteria are more uncertain in SEM than optical microscope observations.

CONCLUSION

Duplicate determinations as well as data compiled from the literature show that the reproducibility of FT plateau-ages is within that range predicted by statistical errors on track density measurements, when optical microscopy is used. This means that other potential causes of dispersion as track identification criteria, introduce minimal, although not necessarily negligible effects, as some systematic differences between observers may appear (see Fig. 1). The existence of such systematic differences had been already pointed out by Hutford and Green (1983).

The source of the larger than in this work dispersion of FT ages which is observed when same samples are dated in different laboratories (see f.i. Naeser et al. 1981) is therefore due to additional factors, such as track etching conditions, neutron dosimetry uncertainties associated to the age calibration factor, etc...

The use of Scanning Electron Microscopy, if useful when fossil track densities are large, introduces however a significant additional factor of dispersion in track density counts, due to more evasive track identification criteria. In that case, equations (1) above will generally underestimate the uncertainties in plateau-ages.

TABLE AND FIGURES CAPTIONS

Table 1 - Comparison between repeats of plateau-age determinations on 7 apatite samples

Fig. 1 - Distribution of individual FT ages determined on apatites 2520 with the population method. Each symbol refers to one observer.

Fig. 2 - Dispersion of plateau-age value for apatites 2520, around the average of all determinations. Numbers on the right refer to observers in table 1.

TABLE 1

1	2	3
	2520	
1	5	242±10
2	5	249±35
3	5	246± 7
4	5	235±12
5	5	234±12
5	6	232± 7
6	5	242± 7
7	10[§]	244± 9
8	8[§]	244±15
9	7[§]	231±11

1	2	3
	70 242	
1	5	283±11
2	5	280±44
2	19[§]	282 n.d.
3	5	287± 9
5		279±22
6		263±19
	M 44	
1	5	275±15
2	5	296±35
3	5	289±10
3	5	277±11
5	5	291±10

1	2	3
	RS 03	
5	4	273±14
6	4	267±19
	RS 04	
5	[illegible]	285±13
6	4	259±19
	RS 05	
5	4	285±13
6	4	267±19
	RS 08	
5	4	260±10
6	4	285±12

1, observer; 2, number of plateau steps; 3, plateau age ± 2σ; all measurements are isochronal plateau-ages, except those marked §, which are isothermal plateau-ages. Errors on neutron dose were not considered here; n.d. = not determined.

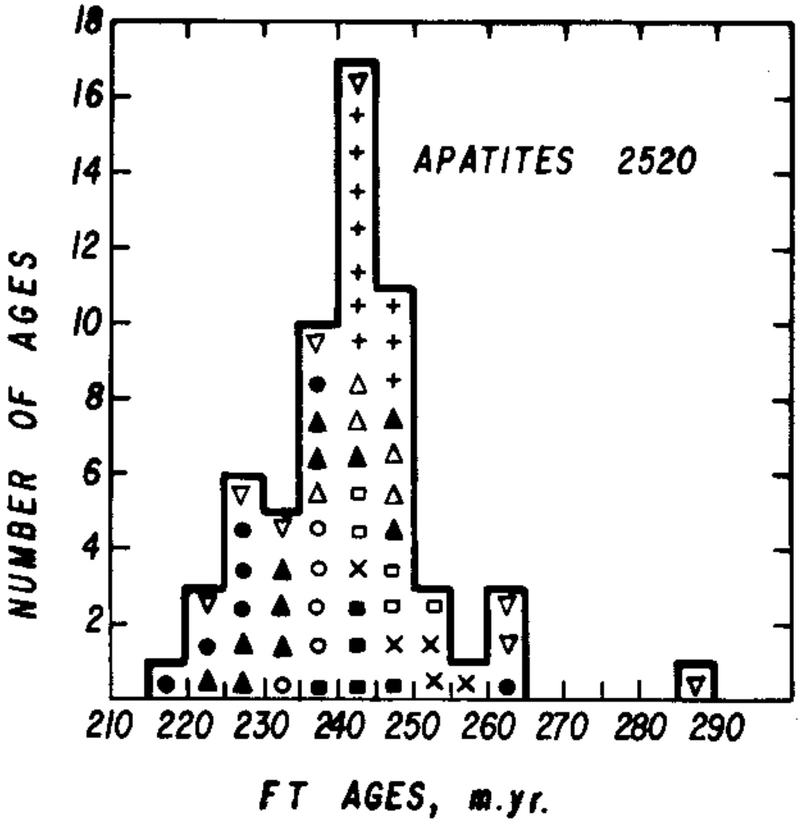
18
16
14
12
10
8
6
4
2
NUMBER OF AGES
APATITES 2520
210 220 230 240 250 260 270 280 290
FT AGES, m.yr.

Fig. 1

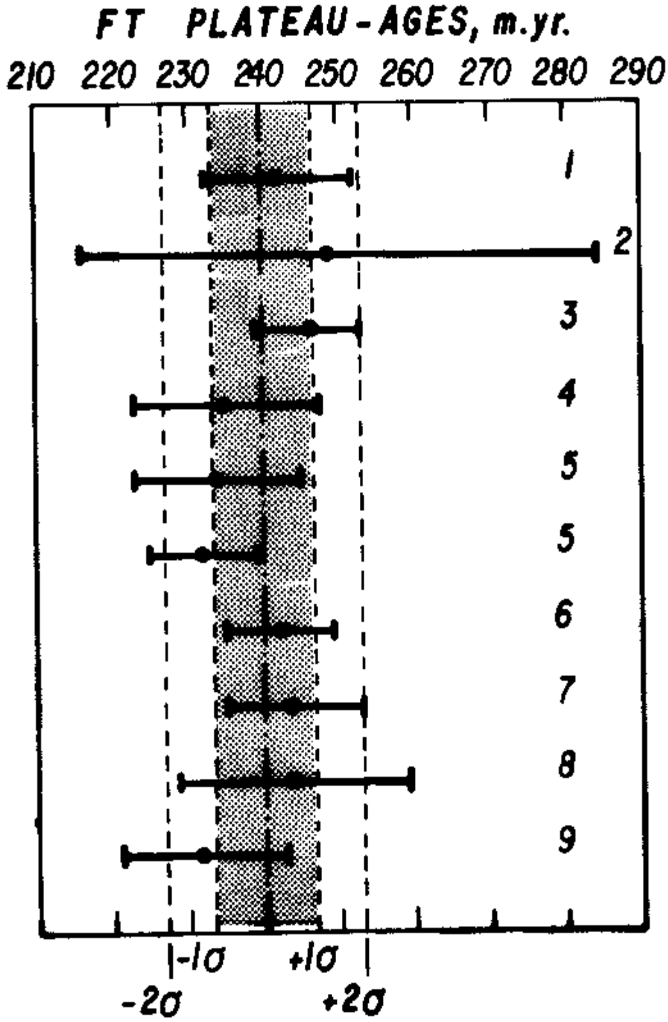
FT PLATEAU-AGES, m.yr.
210
220
230
240
250
260
270
280
290
1
2
3
4
5
5
6
7
8
9
-1σ
+1σ
-2σ
+2σ

Fig. 2

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