Apatite fission track dating of the post-magmatic apatite + hematite + carbonate assemblage from the Jumilla lamproites (SE Spain)

Datación mediante huellas de fisión en apatito de la paragénesis post-magmática apatito + hematites + carbonato de las lamproitas de Jumilla (SE español)

Barbero, L., Martínez Monasterio, E. and Domínguez Bella, S.

Dpto. de Geología, Facultad de Ciencias del Mar, Universidad de Cádiz, 11510 Puerto Real, Cádiz, Spain

RESUMEN

En este trabajo se presentan los resultados de la datación mediante la técnica de huellas de fisión en apatito de las venas incluidas dentro de las lamproitas de la localidad de Jumilla (Murcia). Los resultados obtenidos están de acuerdo con las edades K-Ar obtenidas en sanidinas y K-richteritas de la roca lamproítica. Estudios de inclusiones fluidas han revelado que la temperatura de cristalización de las venas debió ser de unos 630-700°C y que por lo tanto éstas son de carácter tardi-magmático. Por lo tanto, la edad obtenida en los apatitos de las venas corresponde a una edad de cristalización y no refleja ningún tipo de borrado térmico posterior como consecuencia de enterramientos importantes post-extrusión.

Key words: *apatite fission track dating, lamproites, Jumilla*

Geogaceta, 28 (2000), 15-17
ISSN: 0213683X

Introduction

Fission track analysis is a powerful approach to low temperature thermal history evaluation in a variety of geological settings. Despite this potentiality, minor attention has been paid to the study of late-magmatic to hydrothermal products where the apatite fission-track technique may be used to place important constraints on the timing and the thermal setting of mineral deposits. The standard approach in the case of igneous-related deposits is to study the fission-track age reduction at the time of intrusion in the nearby country rocks. This fission-track age reduction is the consequence of the partial or total annealing of fission tracks near the intrusion. The case of the Jumilla apatite+hematite+carbonate assemblage, which occurs as veins included in the lamproites, is different because the late-magmatic assemblage contains apatite itself. Therefore, the timing of formation of these veins could be directly determined using apatite fission-track techniques.

Geological setting

The lamproitic rocks from Jumilla are located in the external part of the Betic Cordillera in the province of Murcia and belong to the Neogene magmatic province of southeastern Spain (López Ruiz & Rodríguez Badiola, 1980). This magmatic province consists primarily of calc-alkaline and shoshonitic rocks, the lamproitic rocks being volumetrically scarce.

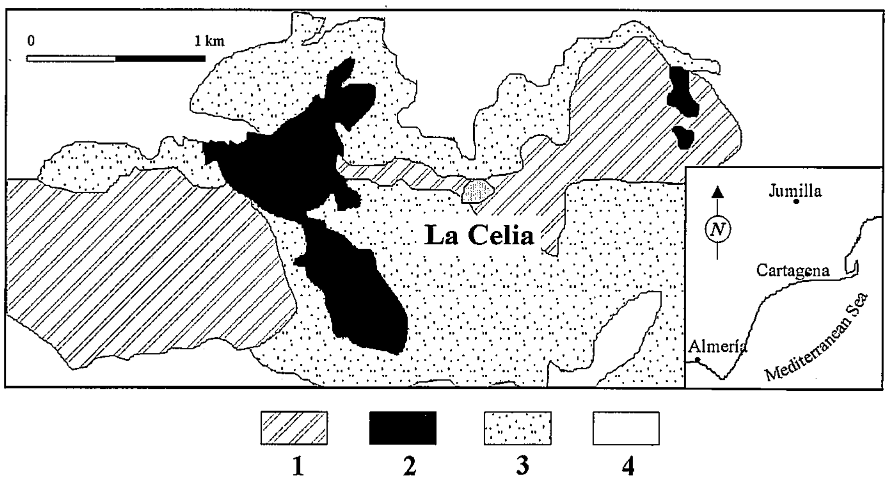

Fig. 1.- Geological sketch map of the Jumilla lamproites outcrops simplified after MAGNA, sheet 869. 1.-Triassic evaporates; 2.- Lamproites; 3.- Miocene sediments; 4.- Quaternary deposits.

Fig. 1.- Esquema geológico de los afloramientos de lamproitas de Jumilla (simplificado de la hoja MAGNA 869).

The Jumilla lamproites crop out in two separated locations near La Celia (Fig. 1). They were emplaced into Miocene continental deposits and Triassic evaporites and consist of massive and autobrecciated lavas. Mineralogically, the Jumilla lamproites are composed of Mg-olivine,

Analyst	No. of Crystals	Spontaneous ρ_s	(N_s)	Induced ρ_i	(N_i)	Dosimeter ρ_d	(N_d)	Age Dispersion $(P\chi^2)$	Apatite FT Central Age ± 1σ (Ma)
LB	17	5.49	(163)	121.7	(3612)	116.5	(5399)	87.75 %	**8.87 ± 0.75**
EMM	20	5.82	(94)	131.7	(2125)	105.9	(4911)	91.22 %	**7.95 ± 0.85**

Notes: (i) Analysis by external detector method using 0.5 for the 4π/2π geometry correction factor; (ii) Ages calculated using dosimeter glasses CN5 with ξCN5 = 337.81 ± 8.09 for LB analyst and 339.43 ± 5.32 for EMM analyst; (iii) $P\chi^2$ *is the probability of obtaining a χ^2 value for* n *degrees of freedom where* n *= number of crystals - 1; (iv) Spontaneous, Induced and Dosimeter Track Densities are measured as 10^{+4} tracks/cm^2.*

Table 1. **Apatite fission-track data from the post-magmatic Apatite+Hematite+Carbonate assemblage from the Jumilla Lamproites.**

Talba 1. Datos de huellas de fisión en apatito de la paragénesis post-magmática apatito +hematites + carbonato de las lamproitas de Jumilla

phlogopite, clinopyroxene, F-apatite, sanidine, analcime, Cr-rich spinel, K-rich amphibole, Ti-magnetite, ilmenite and calcite. In places, the Jumilla lamproites are permeated by thin veins that are mainly composed apatite, hematite and carbonates. Based on fluid inclusion data performed in apatites from these veins, Venturelli *et al.* (1993) considered that they crystallized at very low pressure under highly oxidizing conditions, and temperatures from 630 to 700ºC which are comparable to the temperatures of final crystallization of the Jumilla lamproitic magma. The veins are then considered to be late-magmatic. Geochronological data from the Jumilla lamproites are scarce. The lamproitic rocks from southern Spain are upper Miocene in age (8.5 – 6.0 Ma, Venturelli *et al.*, 1984). The only geochronological data available from the Jumilla rocks are K-Ar ages on sanidine and K-richterite that range from 7.2 to 7.6 Ma (Noble *et al.*, 1981). However, no geochronological data are available from the veins. The Jumilla apatites are clear yellow varieties of F-apatite (F is up to 3.1 %), several millimetres long, and rich in REE (Venturelli *et al.*, 1993). The purpose of this work is to present preliminary results of the apatite fission track age of the veins that can either support its post-magmatic character or/and elucidate the posterior evolution in terms of exhumation of this part of the external Betic Cordillera.

Analytical methods

Apatite fission track dating has been performed in the Fission-track Laboratory of the University of Cádiz. Samples have been recovered from La Celia outcrop (Fig. 1). Due to the coarse grain size of the apatite crystals in the veins, no mineral separation procedure has been necessary. Handpicked 3-4 millimetre-sized apatite crystals were crashed with a hand mortar and mounted in clear epoxy resin on a 3 x 1 inches glass slide. Polishing was performed using standard grinding paper and 3 and 1 microns diamond slurries wtih an automated polishing machine (Struers Rotopol 35). Etching for revealing the fission tracks was made using 5M HNO_3 during 20 seconds at 20 ± 1°C. The external detector method has been used, the detector being ruby clear mica with no U. The apatite samples and the mica detectors were packed into Delrin® plastic capsules together with two CN-5 glass dosimeters placed at the top and the bottom of the capsule in order to monitor the neutron flux and possible flux gradients in the nuclear reactor. Irradiation was performed at Ris National Laboratory at Roskilde (Denmark) in the reactor DR3 using a neutron flux of 9 x 10^{15} n cm^{-2}. Ages were determined using the zeta (ξ) calibration method following Hurford & Green (1983) with ξ(CN5)LB = 338 ± 8 and ξ(CN5)EMM = 339 ± 5 obtained using Fish Canyon, Durango and Mt Dromedary apatite age standards. Spontaneous and induced fission track densities were determined using a Zeiss Axioskop microscope at x1250 magnification with an automated Kinetek stage.

Results and discussion

In Table 1, the apatite fission-track results of 17-20 crystal fragments from the Jumilla apatite+hematite+carbonate assemblage made by two different analysts (LB and EMM) are summarised. These results are also represented in a radial plot (Fig. 2) in which it is possible to observe that for both analysts all the crystals plot in a narrow band. This kind of ploting, together with the low value obtained in the chi-squared test (see Table 1) indicates that all the crystals form a single population, which is generally the case in apatites from igneous rocks. The age obtained is 7.9-8.8 Ma (see Table 1) and the average U content is 12.7-15.1 ppm. This age is slightly older than the one obtained by Nobel *et al.* (1981) using K-Ar in sanidines and K-richterite (7.2-7.6 Ma) but overlaps the K-Ar ages within error. Although discrepancy between both ages is very low it could be argued that apatite fission track ages do not seem to be affected by any important annealing process as the age is slightly

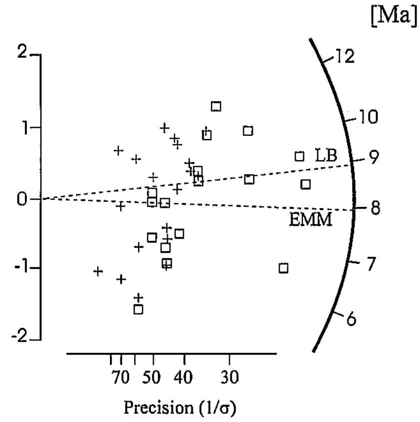

Fig. 2.- Radial plot of the with the apatite fission track dating results after two different researchers. Squares: LB; Crosses: EMM. The age which correspond to each point can be read off this scale by drawing a straight line through *y = 0* and the point that is considered. Points which fall within the 2 sigma vertical scale are age determinations which agree with the reference age within error and thus correspond to a single population. Dotted lines represent central ages for both analysts.

Fig. 2.- Proyección radial de los resultados de la datación mediante huellas de fisión en apatito de dos analistas diferentes. Cuadrados: LB; Cruces: EMM. La edad de cada punto se lee trazando una recta que una el origen de coordenadas y = 0 y el punto en cuestión. Los puntos que se proyectan dentro del rango 2 sigma de la escala vertical corresponden a datos que se adecuan a la edad central y por lo tanto pertenecen a una única población. Las líneas de puntos representan la edad central obtenida por ambos analistas.

older than the K-Ar age. Moreover, it seems that the possibility of Ar loss in ether sanidine or K-richterite must be consider for explaining this slight discrepancy.

The apatite fission track age obtained in this work corresponds to the crystallization age and confirms the results from the fluid inclusions (Venturelli *et al.*, 1993), which ascribes the apatite + hematite + carbonate assemblage as late-magmatic. An important post-extrusion burial episode would led to reduction in the track lengths due to annealing, and as a consequence spontaneous track densities would be lowered. The result of this spontaneous track density reduction would be a reduction in the apatite fission track age, which is not observed in this case. This absence of important post-extrusion burial (temperature has not reach 60° C) could be confirmed by the absence of horizontal confined tracks with lengths less than 15 microns. However, track length measurements (TINTS, Tracks IN Tracks) in the apatites have not been possible because of the very low spontaneous track density. A future development for solving this problem of the absence of horizontal confined tracks would involve the irradiation of the sample with a ^{252}Cf source to produce an areal density of Cf tracks of around $5x10^6$ tracks/cm^2 that after re-etching would reveal a measurable amount of horizontal confined tracks.

Acknowledgments

This work has been funded by a co-financed FEDER project 1FD97-0732 "Aplicación de las técnicas de termocronología mediante huellas de fisión en apatite a la exploración de hidrocarburos: desarrollo de la metodología y una aplicación al estudio de la evolución T-t de una parte de la cuenca Prebética Mesozoica (Zonas Externas de las Cordilleras Béticas, Sierras de Segura y del Pozo)".

References

Hurford, A. J. and Green, P. F. (1983): *Chem. Geol. (Isotope Geoscience)*, 1, 285-317.

López-Ruiz, J. and Rodríguez-Badiola, E. (1980): *Estudios Geológicos*, 36: 5-63.

M. A. G. N. A. Hoja 869, E: 1:50.000.

Nobel, F. A., Andriessen, P. A. M., Hebeda, E. H., Priem, H. N. A.and Rondeel, H. E. (1981): *Geol. Mijnbouw*, 60: 209-214.

Venturelli, G., Salvioli-Mariani, L., Toscani, L., Barbieri, M, and Gorgoni, C. (1993): *Lithos*, 30: 139-150.