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The obsidian from Quiron (Salta Province, Argentina): a new reference glass for fission-track dating

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Abstract

In the course of a geochronological study of the volcanic activity in the Andean Cordillera in northern Argentina, we have found in the El Quevar volcanic complex (24°19′S/66°43′W, 6180 m) a phenocryst poor obsidian (Quiron obsidian) showing an unusually high spontaneous track density. Defects which might produce "spurious" tracks are virtually absent. Application of fission-track dating using an absolute approach, based on the IRMM-540 standard glass for neutron fluence measurements, yielded an apparent age of 7.27 ± 0.29 Ma (1σ) and a plateau age of 8.99 ± 0.31 Ma (1σ).

A ^{40}Ar–^{39}Ar isochron age on biotite of 8.61 ± 0.04 Ma (1σ) was already available for the Quiron rhyolite. We determined further ^{40}Ar–^{39}Ar ages on several chips of the glass itself using two analytical approaches: total fusion with a focussed laser beam (LTFA) and a step-heating approach using a de-focussed laser beam (LSHA). We have obtained a weighted average of 8.77 ± 0.09 Ma, an isochron age of 8.71 ± 0.12 Ma and an integrated age of 8.77 ± 0.09 Ma for LTF analyses, and a w.a. of 8.75 ± 0.09 Ma, an iso.a. of 8.77 ± 0.09 Ma and an int.a. of 8.77 ± 0.09 Ma for LSH analyses (all age errors are 2σ).

The Quiron obsidian is very easy to analyse for its high spontaneous track density and because microlites which might produce spurious tracks are very rare. Independent reference ^{40}Ar–^{39}Ar ages determined in different laboratories are available. For these reasons we believe that this glass may be very useful for testing fission-track system calibrations and apparent age correction procedures.

Splits of obsidian Quiron will be distributed upon request to colleagues who intend to test it.

Keywords: Obsidian; Fission-track dating; ^{40}Ar–^{39}Ar dating; Reference glass

1. Introduction

Reference materials play an important part in fission-track dating whether the ζ calibration or an absolute approach is adopted. One can attain a reliable fission-track calibration system only through these materials. The only glass enclosed in the list of the age standards by the I.U.G.S. Subcommission on Geochronology is Moldavite, the central European tektite (Hurford, 1990).

Other glasses, namely: obsidian JAS-G1 (Japan), Macusanite (Peru) and the rhyolitic glass Roccastrada (Italy) have also been proposed as putative age standards and/or useful materials for standardization of analytical procedures (Balestrieri et al., 1998, and references therein).

Recently, Latin American obsidian that was being analysed using the fission-track dating method revealed an unusually high spontaneous track density (around $100,000\ cm^{-2}$) due to a relatively high U content

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(28.5 ppm). Natural glasses with similar track densities are very rare. Considering, for example, the glasses mentioned above, the spontaneous track density ratio between this obsidian and these glasses is >6, >30, >3 and >4, respectively. A relatively high track density makes track counting procedures easier and may be a useful requisite when a sample is used for testing experimental methodologies.

For these reasons we decided to share this glass with the fission-track community and to propose it as a useful reference material. For this purpose an independent ^{40}Ar–^{39}Ar age was also determined.

2. The Quiron obsidian

The El Quevar volcanic complex (24°19′S/66°43′W, 6180 m) rises on about 50 km southwest of San Antonio de los Cobres (Salta Province), in the Andean Cordillera of northern Argentina. Its volcanic activity developed during Late Miocene. The evolution and the volcanic stratigraphy of this complex have recently been studied in detail by Goddard et al. (1999).

One of the products of the El Quevar complex is a rhyolite lava dome (Quiron rhyolite), erupted from a source to the west of Cerro Azufre (about 5 km south–southwest of Cerro Quevar). This dome outcrops in Quebrada Quiron and Quebrada Incahuasi. The Quiron rhyolite consists of a 15–30 m body of fractured green perlite, bonded at the top and at the base by a rapidly cooled shell of <2 m phenocryst poor (5%) obsidian. This is the Quiron obsidian subject of this study.

3. Fission-track dating

The obsidian of Quiron was analysed using the techniques described in previous papers (Balestrieri et al., 1998, and references therein).

One split of glass was irradiated in the Lazy Susan facility (Cd ratio 6.4 for Au and 48 for Co) of the LENA Triga Mark II reactor of the University of Pavia, Italy. The neutron fluence was determined using the NRM IRMM-540 standard glass (De Corte et al., 1998).

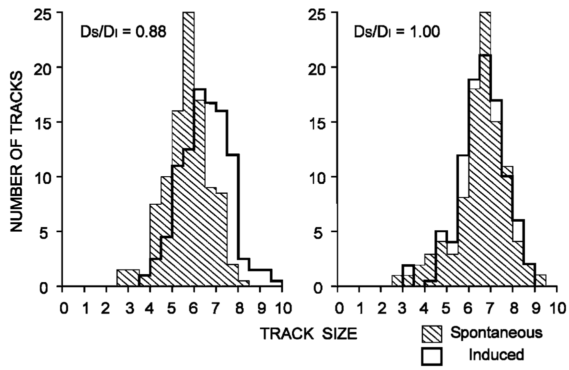

Fig. 1. The reduced spontaneous to induced track-size ratio ($D_S/D_I = 0.88$) indicates that the spontaneous tracks of the Quiron obsidian suffered a moderate degree of thermal annealing. After the thermal treatment imposed for the plateau age determination the D_S/D_I ratio is ~ 1, indicating that the plateau condition was attained.

After irradiation, two fractions of sample for spontaneous and induced (the irradiated one) track density determination, respectively, were mounted in epoxy resin, grounded and polished in order to expose an internal surface, and then etched for 120 s in 20% HF at 40 °C for track development. Tracks were counted in transmitted light under a Leica microscope at a magnification of 500×. Track sizes were measured using Leica Microvid equipment at a magnification of 1000×.

The results of the measurements are shown in Table 1. The thermal stability of fission tracks in natural glasses over geological times is relatively poor. A certain amount of annealing of spontaneous tracks occurs in many glasses even at room temperature. Partially annealed tracks are revealed with reduced efficiency compared to the "fresh" induced tracks produced by the irradiation. Therefore, a fission-track age on glass is commonly a reduced age ("apparent age").

Storzer and Wagner (1969) have shown that the annealing amount can be estimated in glass by track-size (the major axis of the etch pit) measurements. The obsidian Quiron shows a reduced (<1) spontaneous to induced track-size ratio (the induced tracks are assumed here as undisturbed reference tracks), $D_S/D_I = 0.88$ (Fig. 1), which corresponds

Table 1
Fission-track dating of the obsidian from Quiron, Salta Province (Argentina)

Sample	Φ ($\times 10^{15}$) (cm^{-2})	ρ_S (cm^{-2})	N_S	ρ_I (cm^{-2})	N_I	$p(\chi^2)$ (%)	D_S/D_I	Age $\pm 1\sigma$ (Ma)
App. age	3.15	93,400	1349	2,014,600	1217	98	0.88	7.27 ± 0.29
4 h 220 °C		75,900	2248	1,324,800	2102	53	1.00	8.99 ± 0.31

App. age: apparent age; 4 h 220 °C: thermal treatment imposed for the plateau age determination; Φ: neutron fluence; ρ_S (ρ_I): spontaneous (induced) track density; N_S (N_I): spontaneous (induced) tracks counted; $p(\chi^2)$: probability of obtaining χ^2 value testing induced track counts against a Poisson distribution; D_S/D_I: spontaneous to induced track-size ratio.

Parameters used for age calculation: $\lambda = 1.55125 \times 10^{-10}$ a^{-1}; $\lambda_F = 8.46 \times 10^{-17}$ a^{-1}; $\sigma = 5.802 \times 10^{-22}$ cm^2; $^{238}U/^{235}U$ isotopic ratio = 137.88.