GEOCHEMICAL CHARACTERIZATION AND FISSION TRACK AGES OF HISTORICAL IGNIMBRITE FLOWS: THE SILLAR OF AREQUIPA (WESTERN CORDILLERA, SOUTHERN PERU)

Nicole VATIN-PERIGNON[1], Gérard POUPEAU[1], Richard A. OLIVER[2], Ludovic BELLOT-GURLET[1,2], Erika LABRIN[1], Francine KELLER[1] & Guido SALAS A[3].

(1) Laboratoire de Géologie, UA 69 CNRS, Université Joseph-Fourier, 15, rue Maurice Gignoux, 38031 Grenoble Cedex, France
(2) Institut Laüe-Langevin, B.P.156X, Avenue des Martyrs, 38042 Grenoble Cedex, France
(3) Universidad Nacional San Agustín, Casilla 1203, Arequipa, Perú

RESUMEN
El SA tufo corresponde a una única venida volcánica de enfriamiento con dos unidades. Las REE de sus obsidianas dan espectros característicos de alto-K riolitas y se distinguen de los demás tufos por su alto contenído en MREE. Su edad de 2.41 Ma (huellas de fisíon) es compatible con un período de alta convergencia y de espesamiento de la cortesa.

KEY WORDS: pyroclastic flow - volcanic glass - sillar of Arequipa - macusanites - fission track dating - rare earth elements

INTRODUCTION

The reputation of the tuff, the so-called Sillar of Arequipa (SA) as the best building stone in the Arequipa Province, is well-established in southern Peru.
The SA tuff is a white, welded, crystal-poor and pumice-rich rhyolitic tuff. It is extremely well exposed near the airport of Arequipa where it has infilled a pre-existing canyon, the Quebrada Añas Huayco (71°35'13"W - 16°20'14"S - 2525 m), and across which passes the main road to Yura and the railway to Puno.
This paper presents new petrological, major and trace element data on glass clasts and pumices from the SA tuff as well as FT ages on obsidian clasts from the SA tuff and the Macusani field (Eastern Cordillera). It examines the correlations between these two centres of ignimbritic volcanism and the timing of Pliocene to Recent deformations in southern Peru.

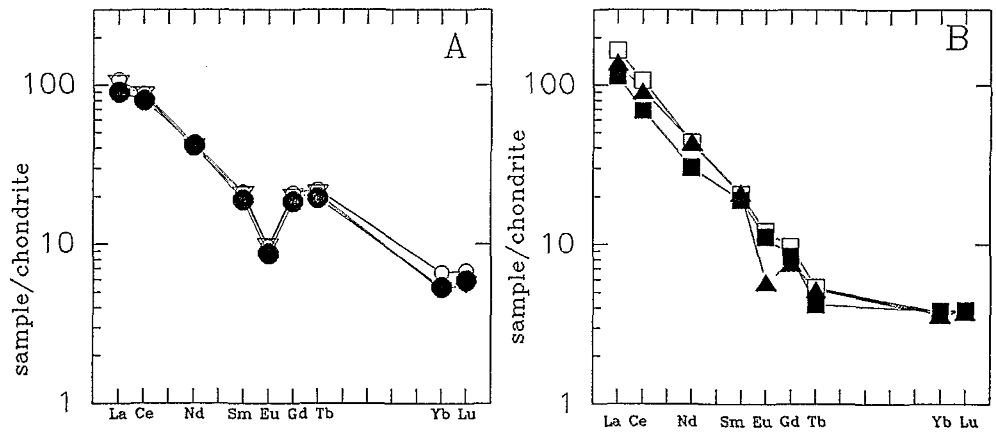
GEOLOGICAL SETTING

Previous reconnaissance studies and details of stratigraphy of the SA tuff are summarized by Salas et al. (1990). The SA tuff forms a single cooling sheet which consists of two distinct flow units. The base of the tuff has not been observed and although the overall thickness of the tuff is not known, it probably exceeds 25m (information from the quarriers) with 10m visible in the quarry situated to the south of the airport. The top of the SA tuff is separated from an overlying salmon-pink ash flow tuff by an irregular erosion surface. This tuff in turn is overlain by glacial conglomerates, coarse fluvial gravels and lahars which cap the mesa in the Arequipa area.
The outcrop within the quarry consists of 1) *a lower flow unit* (3-4m thick). This is a lithic-rich and well indurated tuff. At the base both white and oxidized fibreous and vesicular glassy pumices and glass shards tend to be small, rarely exceeding 1-2cm. Towards the top of this unit the pumices increase in size (~10-15cm) and relative abundance. It also contains about 30-35% of plagioclase, biotite, quartz and magnetite crystals, indicating a concentration by elutriation of ashes, and that up to 30% of the SA tuff may have been dispersed. Lithic clasts (up to 25%) are concentrated particularly at the base of the unit and consist mainly of subrounded oxidized andesite fragments (~5 cm). Isolated crystals are abundant in the fine- to medium-grained matrix of pumice shards and ashes. This lower unit shows facies variations from its base to the top. 2) *The upper flow unit* is a welded, homogeneous, pumice-rich (30%) rhyolitic tuff which shows large columnar joints indicating emplacement at a high temperature. Its exposure within the quarry is about 6m. The matrix is fine-grained, crystal-poor (~10%), with a mineralogy identical to the underlying unit. Lithic clasts are rare and small (0.5-3cm) and typical of the basement rocks (andesites). Grey to yellow glassy pumices are fragile, highly vesiculated and their phenocryst content is low (~5%). Coarse pumices occur at the top of this unit. Continuous layers or lenses several meters long are observed with coarse pumices (>5cm). The dense component concentrations and fines-depleted nature suggests a nearby source for the SA tuff.
Further to the west the Vitor tuffs which are crossed by the Panamerican South highway, has been dated by K/Ar spectrometry at 2.76±0.1 Ma (Vatin-Pérignon et al., 1982) and show some differences with the SA tuffs notably the nature of the clastic material which is made up of plutonic and metamorphic rocks as well as volcanic rocks.

PETROGRAPHY AND GEOCHEMISTRY

Dense obsidian glass clasts of the SA tuff are black and exhibit a pale brown color in thin section. Plagioclase microlites and cristallites have compositions ranging from

$Ab_{68}An_{17}Or_{15}$ to $Ab_{74}An_{20}Or_6$ which are close to albitic compositions. Biotite phenocrysts are similar in composition and size to those in the groundmass of the SA tuff. Accessory minerals of magnetite, containing 0.5 to 4% TiO_2, and apatite are present within the glasses. Several crystals of feldspar show out of equilibrium textures with the coexisting glass. Observations show that the alkali content is important, especially K and Na in glass clasts, biotite and plagioclase crystals.



Chondrite–normalised REE profiles for (A) obsidian glasses from the SA tuff (2.4 Ma) and (B) pumices and glass shards from the Vitor tuff (2.76 Ma, Arequipa Province, Peru, filled triangle) and the Perez tuff (2.5 Ma, hollow square) and the Toba 76 (5.4 Ma, filled square), Bolivia.

The REE patterns of the 3 obsidian glass clasts analysed are all remarkably similar but the patterns are quite singular in apparence, having fairly high LREE values (La/Yb from 24 to 29) and a marked negative Eu anomaly; the HREE being depleted with respect to the LREE or MREE. In comparison with REE patterns from other similar types from the CVZ, the SA tuffis less enriched in LREE but more enriched for the MREE.

FISSION TRACK DATING

Three glass spherules from the SA tuff have been dated by fission-tracks. As the fossil tracks were, on the average, shorter than the nuclear reactor-induced fission-tracks, the samples were treated by the plateau method of Storzer & Poupeau (1973). Unannealed glass fragments from each sample were irradiated in the Orphée reactor and the neutron fluences monitored with NIST glass standards 962. The analytical procedures were the same as described in Poupeau et al. (1992) for the dating of macusanites. Fission-track ages were determined by the "difference" technique (Gleadow, 1981), without thermal treatment and after a heating step at 205°C for 2 hours and the size of tracks measured. It appears that the mean fossil track diameters are about 20% smaller that induced tracks. Therefore, the apparent ages of the samples, in the range from 1.19±0.10 Ma (SA2-90) to 1.42±0.11 Ma (SA3-90), are only lower estimates of their formation ages. After thermal treatment at 205°C, the fossil and induced track diameter distribution have similar shapand mean values. The three samples analysed, SA1-90, SA2-90 and SA3-90 present then concordant formation ages, at respectively 2.32±0.21 Ma, 2.43±0.24 Ma and 2.48±0.17 Ma (1σ).

CONCLUSIONS

Because tuff ages have such important implications for regional geotectonic interpretation, we have determined TF ages of ignimbritic glasses from two different contexts in southern Peru. Macusanites from the ignimbritic field of the Puno district, present plateau ages distributed between 7.9 and 4.8 Ma in good agreement with ages reported independently by Cheilletz et al. (1992) on mineral separates. The 3 separate FT analyses of the SA tuff obsidian glass clasts yield an average age of 2.41±0.08 Ma which is significantly younger and must be related to a more recent compressional phase. The Macusani ignimbrite field may be related to an important phase of magmatism in the Eastern Cordillera arc system and belongs to the same volcanic cycle as the Bolivian Soledad tuffs (Redwood & Macintyre, 1989). Data on the SA tuff place the establishment and the evolution of the ignimbritic magma system in the Arequipa area within a precise temporal framework beginning with the eruption of the Vitor tuff at 2.76 Ma. The timing of the SA tuff correlates well with the F6 phase of deformation (Sébrier et al., 1988), contemporaneous with the early Quaternary period of high convergence rate during which the crust was thickned.

REFERENCES

CHEILLETZ, A., CLARK, A.H., FARRAR, E., ARROYO PAUCA, G., PICHAVANT, M. & SANDEMAN, H.A., 1992. **Tectonophysics** 205, 307-327.

GLEADOW, A.J.W., 1981. **Nuclear Tracks** 5, 3-14.

POUPEAU, G., LABRIN, E., SABIL, N., BIGAZZI, G., VATIN-PERIGNON, N. & ARROYO, G., **Nucl. Tr. Rad. Meas.**, submitted.

POUPEAU, G., SABIL, N., VILLA, I.M., BIGAZZI, G., VATIN-PERIGNON, N., FLORES, P., PEREYRA, P., SALAS, G. & ARROYO, G. 1992. **Tectonophysics** 205, 295-305.

SALAS ALVAREZ, G., VATIN-PERIGNON, N. & POUPEAU, G., 1990 *in* Géodynamique Andine, ORSTOM, Paris, 333-335.

REDWOOD, S.D.& MACINTYRE, R.M., 1989. **Economic Geology**, 54, 648-630.

SEBRIER, M., LAVENU, A., FORNARI, M. & SOULAS, J.-P., 1988. **Géodynamique** 3 (1-2), 85-106.

STORZER, D. & POUPEAU, G., 1973. **C. R. Acad. Sci. Paris**, 276D, 137-139.

VATIN-PERIGNON, N., VIVIER, G., SEBRIER, M. & FORNARI, M., 1982. **Bull. Soc. géol. France** 7, 24 (3), 649-650.