NEOGENE IGNIMBRITES IN THE AREA OF AREQUIPA, SOUTHERN PERU: CORRELATIONS BASED ON FIELD OBSERVATIONS, GEOCHEMISTRY AND GEOCHRONOLOGY

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INTRODUCTION

In the area of Arequipa, the ignimbrites termed "sillars" (Fenner, 1948; Jenks and Goldich, 1956) are indurated, generally nonwelded pyroclastic-flow deposits of dacitic and rhyolitic composition and middle Miocene to late Pliocene in age (this study). They encompass incipiently welded or sintered vitric tuffs, indurated by vapor-phase crystallisation, and previously welded but devitrified tuffs. They mantle an area of roughly 600 km² around the quaternary stratovolcanoes of Chachani and Misti and they fill the depression of Arequipa with a thickness of 100 m to as much as 200 m in the Rio Chili canyon (Fig.1). Similar ignimbrites

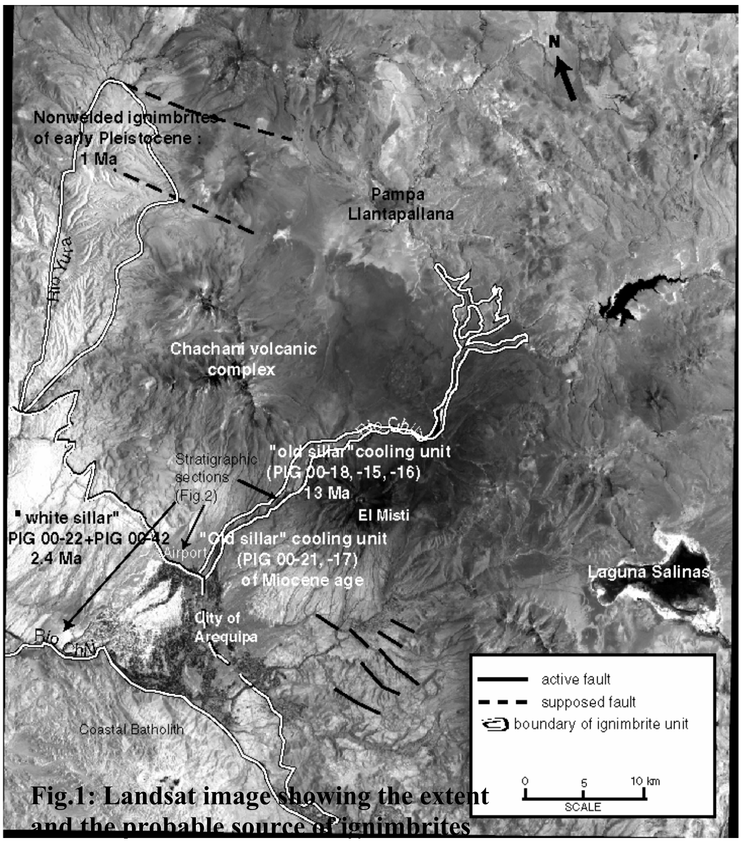

Fig.1: Landsat image showing the extent and the probable source of ignimbrites

have flowed downvalley the Rio Chili and Rio Yura at least 30 km south and southwest of Arequipa beyond the confluence of the three rivers into the Rio Vitor canyon.

Figure 2 shows two stratigraphic sections in the valley of Rio Chili that cuts the flank of the Western Cordillera. They encompass two ignimbrite cooling units above the Jurassic basement: the devitrified, welded ‘old sillar’ comprises at least two flow units, the lowermost is strongly welded bearing fiammes. The ‘old sillar’ yielded Ar-Ar Ages of 13.8±0.1 and 13.12±0.05 Ma (on biotite single grain). This Miocene ignimbrite is overlain by a ‘orange’ nonwelded unit of pumice-rich flows. In the Rio Chili valley, the ignimbrites are overlain by volcaniclastic sediments of Plio-Quaternary age and in turn by the lava flows of the base of El Misti stratovolcano (0.833 ± 0.06 Ma whole rock; Thouret et al., 2001).

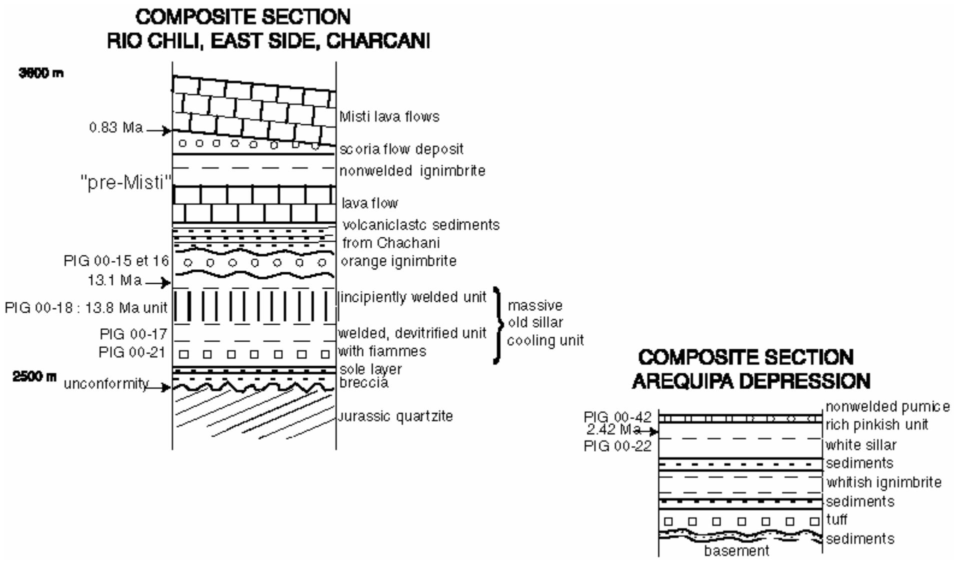

Figure 2: Composite stratigraphic sections in the Rio Chili valley (location in Fig.1)

At least three ignimbrites intercalated with sediments fill the depression of Arequipa. Two ‘white sillars’, i.e. indurated, nonwelded, crystal-rich vitric tuffs, form the piedmont of Chachani volcanic massif and fill the depression of Arequipa. Towards the WSW of the depression, thick ignimbrites fill paleovalleys and part of the Rio Vitor canyon. The upper whitish ignimbrite (Airport quarry, 2.42 ± 0.11 Ma fission-track Age on glass, *in* Vatin-Perignon et al., 1996) apparently flowed from a NE direction (Fig. 2). One similar whitish ignimbrite (La Joya, Ar-Ar Age of 4.87±0.02 Ma on sanidine) flowed down the Rio Chili valley and ran up the 350-m-high scarp of the coastal batholith south of Arequipa. Finally, on the western side of the Chachani volcanic complex, several nonwelded pumice-flow deposits have filled the Yura valley and flowed downvalley towards the confluence of Rio Vitor. One of these pumice-flow deposits has been dated at 1.02±0.09 Ma (Ar-Ar on biotite).

The goal of our study is to correlate the neogene ignimbrites and to point to their geographic source(s), such as calderas. We have thus used petrological, mineralogical, geochemical analysis, as well as paleomagnetic measurements (Paquereau et al., this volume), for correlating the ignimbrites over widespread areal extents.

GEOCHEMICAL AND MINERALOGICAL CORRELATIONS

1- Petrologic characteristics

The vitric tuffs are pumice and glass rich (50% to 70%), including obsidian. They also contain free crystals (15% to 30%), and accidental fragments, Jurassic sediments and andesite (5% to 10%). Pumice and rocks fragments are surrounded with matrix which contains glass shards and plagioclase microlites. Crystal content ranges between 15% and 40%, and crystals consist of feldspar (plagioclase and sanidine), quartz, biotite, amphibole, and iron-titanium oxyde.

Correlations are based on components proportions (glass and pumice, free crystals, accidental fragments), and percentages of mineral phases. For example, the ignimbrite unit PIG 00-18 is unique in being porphyric and rich in amphiboles, which are absent in the majority of samples. Samples PIG 00-16, -42, -20 rocks are aphyric, with 5% of crystals only. The size of phenocrysts, being highly variable, does not provide a discriminant feature.

2- Mineralogical correlations

Mineral analyses were made using the JEOL JXA 8900R microprobe of the University of Göttingen, on minerals sections and glass shards.

Oxides are present in all samples and the MgO/FeO ratio for titano-magnetites provides discriminative values (Fig. 3). Point analyses on glass shards in matrix or pumice glass, provide good discriminant results.(CaO versus Al_2O_3.diagram : Fig. 4). Figures 3 and 4 show five groups of sillars: group I = most mafic ignimbrite (PIG 00-18) ; group IIa = quite evolved compositions ignimbrites (PIG 00-17) ; group IIb = evolved compositions with large range in degree of differenciation (PIG 00-15, -16, -42, -22) ; group IIc =.PIG 00-20 ; group III (PIG 00-19 and –21).

The feldspars and biotites show a wide range in composition in each ignimbrite unit, therefore adding little discriminative value. Amphiboles which are present in three samples (PIG 00-18, PIG 00-19, and PIG 00-21), are more discriminant. These calcic amphiboles (11% in wt%) show magnesio-hornblende and actinolitic-hornblende composition. The MnO versus Al_2O_3 plot for hornblende is the best discriminant, enabling us to distinguish two compositional groups: PIG 00-18 with high AL_2O_3 (8-9%) and low MnO (0.4-0.6%) and PIG 00-19 and –21, with high Mno (1-1.20%) and low Al_2O_3 (4-5%).

3- Correlations with stratigraphy

These geochemical and mineralogical groups coincide roughly with the pre-established stratigraphy. Group I (PIG 00-18) is dated at 13.8-13.1 Ma using the Ar-Ar method and is termed “old sillar”. Group I underlies rocks PIG 00-15, -16 ("orange cooling unit"), wich belong to the younger ignimbrite type (“white sillar” ignimbrite sequence), is located in compositional group IIb. Ignimbrite unit PIG 00-22, which is locally termed "white sillar", is mineralogically similar to the “orange cooling unit”, and so was linked to it in group IIb. The “pink unit” (PIG 00-42), overlying the “white sillar” and similar in mineralogy, represents the top of the entire ignimbrite sequence. The group IIb present a fractionation trend. The PIG 00-17 ignimbrite unit is stratigraphically beneath PIG 00-18, thus slightly older than 13.8 Ma. The distinct composition of PIG 00-17 points to the group IIa. The group III (PIG 00-19 and -21) comprises two units which belong to the 'old sillar' probably Miocene in age. The whitish, devitrified facies with quartz and sanidine of these two units show similar petrologic and mineralogic characteristics.

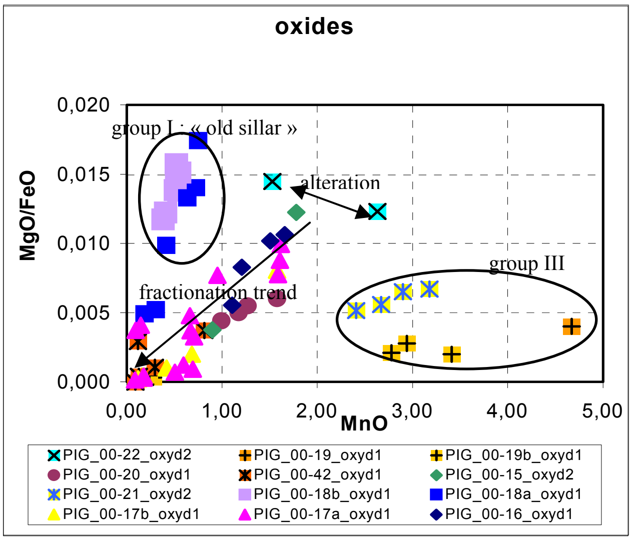

Figure 3: MgO/FeO v. MnO diagram for titano-magnetites

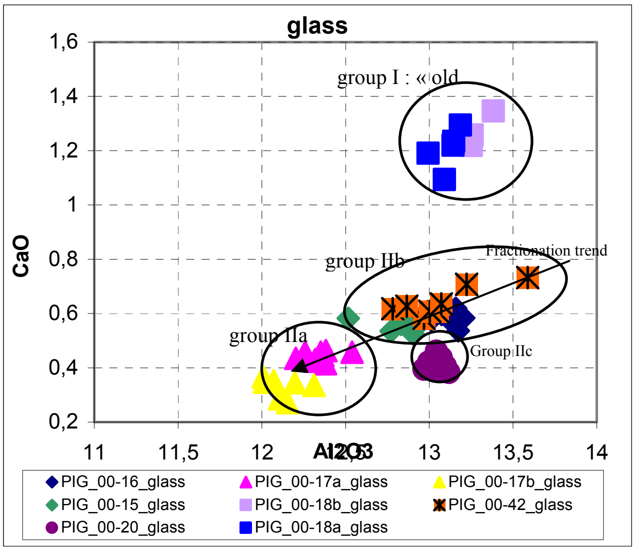

Figure 4: CaO v. Al_2O_3 diagram for glass

CONCLUSION

In order to fingerprint ignimbrites, correlation must depend on a combination of criteria, as suggested by Hildreth and Mahood (1985): careful mapping, field characteristics and geochronology, combined with mineral chemistry or whole-rock chemistry of the juvenile component, glass chemistry of the ignimbrites, and paleomagnetic caracteristics of the ignimbrites (Paquereau et al., this volume). Finally, we aim to localize the geographic source(s), i.e neogene calderas, of the ignimbrites. Our investigation is based on the structural interpretation of one DEM (30m*30m) based on digitized topographic maps and on radar interferometry, as well as Landsat and SPOT satellite images. We also use new ASM data (Paquereau et al., this volume) to attempt to localize the source area. The source of the "white sillar" ignimbrite of Pliocene age is thought to be located NE of the Arequipa depression. At this stage, the study is too preliminary to identify clearly a source for the ignimbrites.

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