The Geochemistry of Huaynaputina Volcano, Southern Peru

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INTRODUCTION

The Central Volcanic Zone (CVZ) of the Peruvian and Chilean Andes is an active, convergent margin, continental arc, but with a highly thickened crust (up to 75 km) which is thicker than any other subduction zone. This gives rise to volcanic suites which are chemically and isotopically distinct from those erupted in other parts of the Andean arc, where the continental crust is of normal thickness (Thorpe et al., 1984; Harmon et al., 1984; Wörner et al., 1992). A quantity of data exists for young volcanic rocks south of 17°S (Wörner et al., 1992) but data from volcanic centres above this latitude are scarce. We detail here some data from the volcanic centre of Huayanaputina in Southern Peru.

The Volcano Huaynaputina is situated at 16°35'03" S: 70°52'00"W in the province of Moquegua, Southern Peru at approximately 80 km east of the town of Arequipa. The last recorded eruption from this volcano was in 1600 when a series of large plinean type eruptions took place lasting for approximately one month. From contemporaneous accounts, the ash and pumice fall out from this series of eruptions was extremely heavy, and resulted in a large loss of life over a fairly wide area. At the same time records also show that large pyroclastic flows descended the valley of the Rio Tambo (Figure 1.) reaching the coast some 130 km from the source.
In this paper we detail the geochemistry of the products from this last eruption together with rocks from earlier eruptions and attempt to show the geochemical evolution of this typical CVZ calc-alkaline volcano.

GEOLOGICAL SETTING:

The Volcano rises to a maximum elevation of 4800 metres but the actual volcanic edifice is much smaller than this having an approximate elevation of less than 1000m. The volcano is situated on a plateau with an average elevation of 4200 meters which has been deeply incised by the Rio Tambo and the eastern side of the volcano falls away into the gorge (Figure 2). The volcano is built on volcanics and sediments of the Barroso formation, which lie unconformably over, to the west gneisses and granites of the Precambrian basement, which have been faulted to the surface, these have been intruded by basic and acidic dykes but it is not known if this was a contemporaneous episode. To the south the rocks are formed of sediments of the Yura (Upper Jurrassic-Lower Cretaceous) formation whilst to the east the rocks are of the Toquepala (Cretaceous) formation which have been intruded by tonalites and granodiorites which have been Rb/Sr dated to 22.8 +/- 2Ma (Oliver et al. 1993).

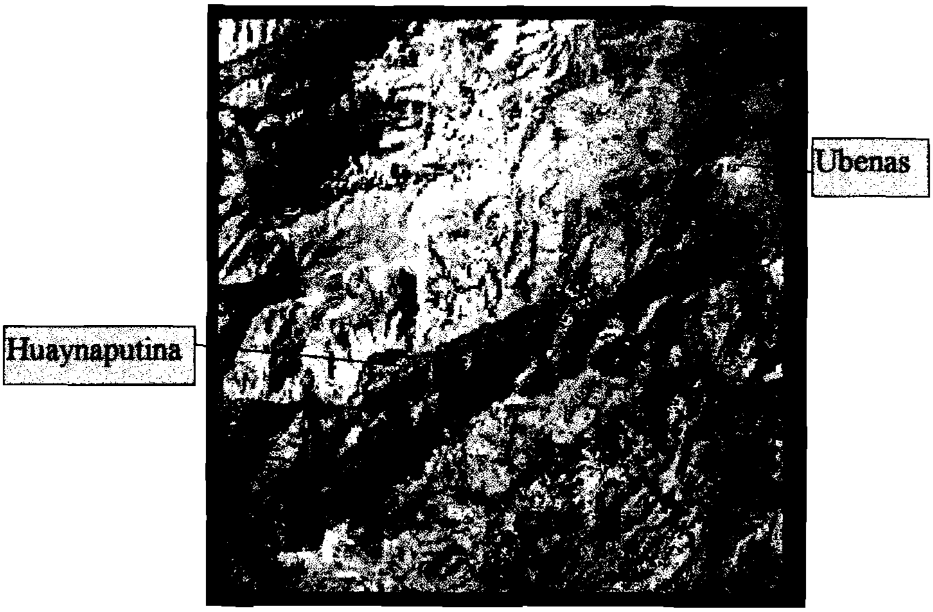

Figure 2. Landsat photo of Huaynaputina volcano (centre left) with Ubenas volcano (top right).

GEOCHEMISTRY

Rock types from the Huaynaputina volcano range from andesites to dacitic pumices (SiO_2 wt% from 57-67.8), Fig 3 and as with other examples from the northern part of the CVZ fall into the high-K field of volcanic rocks. Relative to high-K calk-alkaline rocks the Huaynaputina lavas are indistinguishable from andesites from Solimana, (Vatin Perignon et al., 1992) and Coropuna, (Venturelli et al., 1978). Multi-element discriminant diagram patterns are almost identical to other centres from this region (Figure 4.), although some samples show a distinct negative anomaly for Ta. This possibly indicates an increasing contamination by crustal components (Davidson et al., 1988).

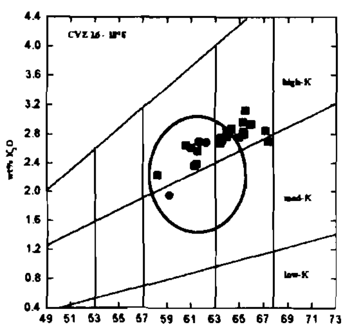

Figure 3. Plot of wt% K_2O versus wt% SiO_2 for rocks from the Huaynaputina volcano, S. Peru
(circle is field for other CVZ rocks (Wilson,1989)

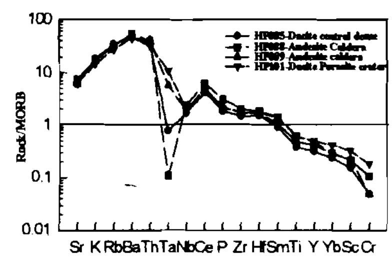

Figure 4. Multi-element discriminant diagram for representative samples from Huaynaputina volcano

This is born out by a plot of Th versus Ta (Figure 5) where samples from Huaynaputina lie both in the field of subduction zone magmatism and Orogenic related magmatism indicating the crustal contamination of these volcanics. However it is also evident that some crystal fractionation has taken place which is shown by a plot of Zr versus Hf (Figure 6.) where the lavas follow a trend away from mantle values.

The variation of Sr isotopes with SiO_2 For Huaynaputina volcano is compared with other data from the CVZ. The variation of $^{87}Sr/^{86}Sr$ ratios is fairly small varying from 0.70637 to 0.70692

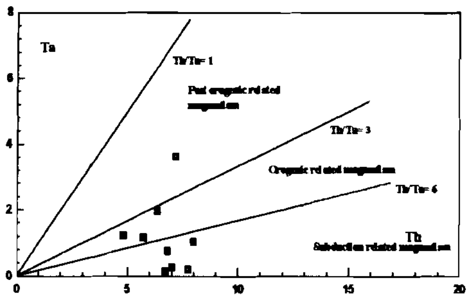

Figure 5. Plot of Th versus Ta for Huaynaputina volcanics.
(fields are from Cabanis et al., 1990)

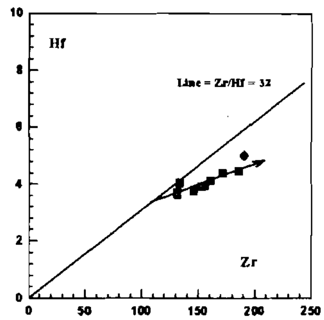

Figure 6. Plot of Zr versus Hf for Huaynaputina volcanics.

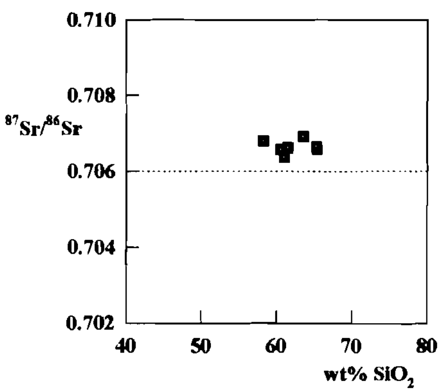

Figure 7. Plot of Sr isotope ratios versus SiO_2 for andesites and dacites from the Huaynaputina volcano compared to data from (A) San Pedro-San Pablo. N. Chile (Thorpe et al., 1976), (B) Solimana, S. Peru, (Goemans, 1986).

These values fall within the fields described for the San Pedro-San Pablo complex, N. Chile, field A on Figure 7., and Solimana volcano, S. Peru, field B. This indicates similar source types as for other volcanic centres within the region with similar amounts of crustal contamination. This is born out by a slightly negative correlation for ε_{Sr} with increasing Sr content.

CONCLUSIONS

The geochemistry of the Huaynaputina volcano is shown to be typical for the CVZ, with andesitic to dacitic magmas showing evidence for both crystal fractionation and crustal contamination.

REFERENCES

Cabanis B., Cocheme J.J., Vellutini P.J., Joron J.L and Treuil M., 1990, Post collisional Permien volcanism in northwestern Corsica: an asessment based on mineralogy and trace-element geochemistry. *J. Volc. Geotherm. Res.*, 44, 51-67.

Davidson J.P., Ferguson K.M., Colucci M.T. and Dungan M.A., 1988. The origin and evolution of magmas from the San Pedro Pellado volcanic complex, S. Chile: multicomponent sources and open system evolution. *Contrib. Mineral. Petrol.*, 100, 429-445.

Goemans P., 1986, Pétrogéochimie du volcan Solimana, Sud Pérou. (Géochimie comparée de quelques édifices des Andes centrales et septentrionales). *Mem. DGUG, UJF de Grenoble*, 114p, (unpublished)

Harmon R.S., Barreriro B.A., Moorbath S., Hoefs J., Francis P.W., Thorpe R.S., Deruelle B., McHugh J. and Viglino J.A., 1984, Regional O-, Sr and Pb isotope relationships in late Cenozoic calc-alkaline lavas of the Andean Cordillera., *J. Geol. Soc., London*, 141, 803-822.

Oliver R.A., Vatin Perignon N., Keller F. and Salas G., 1993, Geochemical constraints on the evolution of the Southern peruvian Coastal Batholith: Toquepala segment. (abst). *Proceedings of 2nd ISAG, Oxford, England.*

Thorpe R.S, Potts P.J. and Francis P.W., 1976, Rare earth data and petrogenisis of andesites from the North Chilian Andes., *Contrib. Mineral. Petrol.* 54, 66-75.

Thorpe R.S., Francis P.W. and O'Callaghan L.et al., 1984, relative roles of source composition, fractional crystallisation and crustal contamination in the petrogenisis of Andean volcanic rocks., *Phil. Trans. R. Soc. Lond.*, A310, 675-692.

Vatin Perignon N., Oliver R.A., Goemans P., Keller F, Briqueu L. and Salas G., 1992, Geodynamic interpretaions of plate subduction in the northernmost part of the Central Volcanic Zone from the geochemical evolution and quantification of the crustal contamination of the Nevado Solimana volcano, Southern Peru., *Tectonophysics*, 205, 329-355.

Venturelli M., Frangipane M, Weibel M. and Antiga D., 1978, Trace element distribution in the Cenozoic lavas of the Nevado Coropuna and Andagua valley, central Andes of Southern peru. *Bull. Volcanol.*, 41, 213-228.

Wilson M.,1989, Igneous Petrogenesis, Unwin Hyman, London.

Wörner G., Moorbath S. and Harmon R.,1992, Andean Cenozoic volcanic centers reflect basement isotopic domains. *Geology*, 20, 1103-1106.