

DISRUPTIONS IN THE HYDROTHERMAL WATER GEOCHEMISTRY INSIDE MISTI VOLCANO IN COINCIDENCE WITH THE 8.4 Mw EARTHQUAKE OF JUNE 23rd, 2001, IN SOUTHERN PERU.



Instituto Geofísico del Perú
Sector Educación

Vicentina Cruz(1), Anthony Finizola(2), Orlando Macedo(1), Francesco Sortino (2)

(1) Instituto Geofísico del Perú, Urb. La Marina B-19 Cayma-Arequipa, Peru. E-mail : vcruz@axil.igp.gob.pe

(2) Istituto Nazionale di Geofisica e Vulcanologia, sezione Palermo, Via Ugo La Malfa 153,90146 Palermo, Italy. E-mail: a.finizola@pa.ingv.it



Palermo

Misti Volcano (16°18'S, 71°24'W and 5822 in elevation) is located 17 Km from Arequipa (~800000 inhabitants). It is characterized by two concentric summit craters. The youngest one hold lava dome, 130m wide, with fumarolic activity and temperature higher than 200°C.

Geochemical techniques turn out to be very effective for the monitoring of active volcanoes. The ascent of a magmatic gases and their interaction with aquifers induce changes in the chemical composition and physical properties of the waters that can be sampled at the surface.

The geochemical monitoring of the Misti volcano began in 1998 with a systematic sampling of the hot spring of "Charcani V", located to 6 Km of the active crater at 2960 meters in elevation.

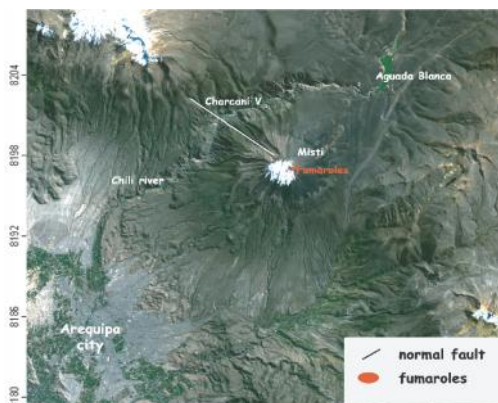


Fig. 2. Map of localization of the Misti Volcano

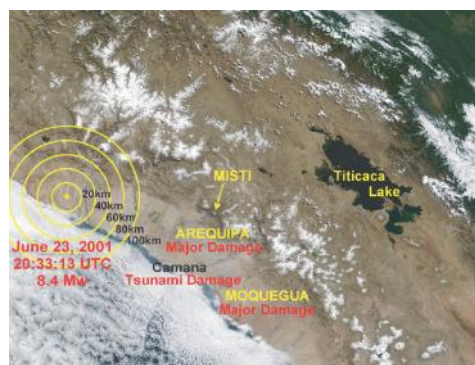


Fig. 3. Epicenter location of the earthquake occurred June 23, 2001 in southern Peru



Fig. 4. Peruvian newspaper showing the damages in southern Peru caused by earthquake of June 23, 2001

A major earthquake occurred near the coast of southern Peru (16.15S 73.70W 33Km depth), at 175 km west of Arequipa on June 23, 2001, at 3:33 pm local time.

A revised magnitude of 8.4 Mw was computed for this earthquake (USGS source). At least 75 people killed, 1368 injured and extensive damage in Arequipa-Moquegua-Tacna areas.

This earthquake was the highest one in magnitude in the world since more than 30 years !!

Thermal source	: Charcani V
Sampling date	: 17/09/98
Temp.	: 36.5 °C
pH	: 6.9
Conduct. (mS)	: 2770
Chemical Composition	
Element	concentration
SiO ₂ (in the field)	90
SiO ₂ (laboratory)	74.151
B (meq/l)	0.121818182
H ⁺	0.000446684
NH ₄	0
Li (meq/l)	0.135
Na (meq/l)	6.6
K (meq/l)	0.166
Mg (meq/l)	4.778
Ca (meq/l)	5
F (meq/l)	0.11
Cl (meq/l)	1.36
Br (meq/l)	0.024
NO ₃ (meq/l)	0.122
SO ₄ (meq/l)	1.739
HCO ₃ (meq/l)	13.725
sum of cations	16.67944668
sum of Anions	16.981
%error	-1.791736867

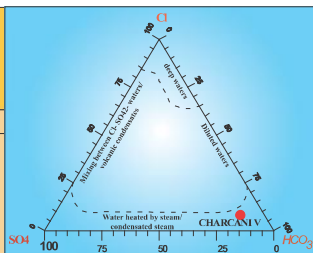


Fig. 6. (Cl-SO₄-HCO₃) ternary diagram.

The Cl-SO₄-HCO₃ ternary diagram displays that the "Charcani V" "water spring is located inside the area of water heated by steam". This suggests that Charcani V water spring results from a mixing between a meteoric water and volcanic fluids as supported by the warm temperature of the water spring and the high concentration in magmatic species such as SO₄²⁻ and Cl⁻.



Fig. 1 Misti volcano (5822 m) and Arequipa (2300 m) second largest city of Peru. The "Charcani V" hot spring gush out through ignimbrite and volcaniclastic deposits of dacitic and rhyolitic composition. It is located at the base of a protrusion at about 2960 m of elevation on the NW flank of Misti volcano, in coincidence with a N127° trending regional fault crossing the entire edifice (Thouret, et al., 2001).

This hot spring is located outside a huge hydrothermal system, 6 kilometer in diameter, centred on the present-day active crater and evidenced by Self - Potential measurements (Finizola et al., 2004).

RESULTS AND DISCUSSION

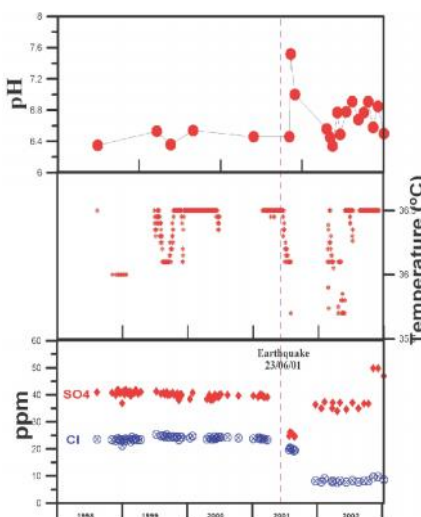


Fig. 5. Temporal variation of pH, temperature, sulphates and chlorides of the Charcani V hot spring.

Temperature, pH, chlorides (Cl⁻) and sulphates (SO₄²⁻) concentrations have been measured from 1998 until 2002 (Fig. 5). The results display some variations during the monitoring period:

The concentration of Cl⁻ and SO₄²⁻ shows a sharp decrease after the June 30, 2001 earthquake (Fig. 5). We can also note a slight decrease in temperature with lower values than those measured previously and slight increase in pH with higher values than those measured previously. At the same time, 1) The water flow of Charcani V hot spring increased significantly and 2) huge variations occurred in the fumarolic activity: (2a) This later increased his steam output since August, 2001 making visible the steam emission from Arequipa city of several hundred meters above the active crater, and (2b) also the highest dome temperature increased from a maximum of 221°C at December 1, 1997 to 430°C at September 11, 2001.

The occurrence of the June 23, 2001 earthquake in coincidence with the disruption of the fluid inside Misti volcano suggests a close relationship between these two events.

One possible hypothesis is to consider a reactivation of the fault system crossing the Misti edifice, inducing in this way an increasing of permeability and making easier the introduction of fresh meteoric water coming from the surrounding aquifers, inside the Misti's hydrothermal system.

This could explain: 1) the increase of the water flow of the Charcani V water spring, 2) the slight temperature decrease of the hot spring due to the entrance of cold water in the hydrothermal system, 3) the decrease in the concentrations of ions of magmatic origin (Cl⁻ and SO₄²⁻) due to their dilution with fresh waters and 4) the increase in the fumarolic activity inside the summit crater.

According to these results, it appears that the June 23, 2001 earthquake located 175 Km of the Misti has influenced of important way in the circulation of the fluid flow inside Misti volcano.

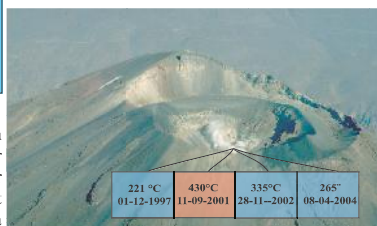


Fig. 7. Highest temperatures measured on the fumarolic dome of Misti volcano.



Fig. 8. Fumaroles visible from Arequipa city

REFERENCES:

- THOURET J.-C., Finizola A., Fornari M., Legeley-Padovani A., Suni J., Frechen M., (2001).- Geology and volcanic hazards of El Misti volcano near the city of Arequipa, Peru. Geological Society of America Bulletin, 2001, 113, n°12, 1593-1610.
- Finizola A. & Macedo O. (2001).- Rapport sur l'activité du Volcán Misti.- Revue L.A.V.E. Association Volcanologique Européenne, n°93, Septembre 2001, pp. 12-13.
- Finizola A., Lénot J. F., Macedo O., Ramos D., Thouret J.-C., Sortino F., (2004).- Fluid Circulation and structural discontinuities inside Misti volcano (Peru) inferred from self-potential measurements, Journal of volcanology and geothermal research, 135 343-360.