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MÖSSBAUER STUDIES IN VOLCANIC MATERIAL
OF THE PERUVIAN VOLCANO QUIMSACHATA*

by

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ABSTRACT

We report here Mössbauer studies of lava samples from the extinct volcano Quimsachata (Perú). The Mössbauer spectra of samples from the outer part of the crater show the presence of olivine, pyroxene and one of them exhibit superparamagnetic maghemite. A piece of extruded rock from the inner part shows the spectrum of magnetite that can be consequence of the dehydration of ferric hydroxides (αFeOOH) forming Fe_2O_3 and subsequent reduction to magnetite in the volcanic reducing atmosphere.

Key-words: Volcanic lavas; Maghemite; Superparamagnetism; Mössbauer spectroscopy.

1 INTRODUCTION

Mössbauer Spectroscopy studies have been performed on lava samples from the extinct volcano Quimsachata, located at 120Km south of Cuzco - Perú, collected by one of the authors (E.M.). The eruption of this volcano has already been referred in the Incaic legends. Archaeological rests deposited above the lava dated by ^{14}C , has indicated that eruption has occurred more than three thousand years ago.

2 RESULTS AND DISCUSSION

A set of five samples of volcanic material has been considered in this study: three designed by E-1, E-2 and E-3 collected outside the crater and two, designed by I-4 and I-5, collected inside the crater. The I-4 is a pyroclastic black fragment and the most dense of the samples. The I-5 is dark brownish and was cleaved from a piece of extruded rock, located in the inner wall of the crater. The E samples, collected outside the crater, are pyroclastic fragments ejected from the volcano: E-1 is gray, E-2 is black and E-3 is ochre. All three presents a spongeous aspect.

The Mössbauer spectra (M.S.) of the E-1 and E-2 samples, as well as the I-4, except a small fraction, reveal that the iron ions are essentially divalent; consequently, the M.S. measured at room temperature (Fig. 1) has been fitted with three doublets for the Fe^{2+} ions and one doublet of small intensity for the Fe^{3+} ions. The hyperfine parameters in Table 1 show that one of the Fe^{2+} doublets can be assigned to a mineral phase of the olivine type; while the other two can be assigned to pyroxene /1/. The three samples doesn't exhibit magnetic hyperfine interaction even at liquid Helium temperature.

The M.S. of the E-3 sample measured at room temperature show the Fe_2O_3 sextet, which confirm that the ochre colour is due to a oxidation process. A detailed analysis of the spectra measured at R.T. and 4.2 K (Fig. 2) indicate that the iron oxide are in the superparamagnetic state and that the mean dimension of the particles are in the range from 100 to 200 Å /2/.

Since the values of the measured spectra (Table 2) doesn't allowed a distinction between the two possible phases: $\alpha\text{Fe}_2\text{O}_3$ (hematite) and $\gamma\text{Fe}_2\text{O}_3$ (maghemite), a X-ray powder diffraction has been performed. The X-ray indicates the presence of $\gamma\text{Fe}_2\text{O}_3$ as the principal oxide phase (all the principal hkl reflection of the maghemite with relative intensity of about 100% has been identified). However it has also been detected the presence of small quantities of $\alpha\text{Fe}_2\text{O}_3$.

The most interesting sample, I-5, was collected in situ from the inner wall of the crater. It resemble fused and extruded pottery clay. The M.S. at room temperature and 4.2 K (Fig. 3 and Table 2)

indicate the presence of Fe_3O_4 (magnetite) as the principal phase, and a small paramagnetic component, that still remain in this state at 4.2 K.

This material seems to have been formed from the original sedimentary soil, melted in the crater's border. In this case, the formation of magnetite, can be consequence of the dehydration of ferric hydroxides (αFeOOH) forming Fe_2O_3 and subsequent reduction to magnetite in the volcanic reducing atmosphere.

FIGURE CAPTIONS

- Fig. 1 - Mössbauer transmission spectra of sample E-2 at room temperature.
- Fig. 2 - Mössbauer transmission spectra of the superparamagnetic samples E-3. a) room temperature; b) 4.2 K.
- Fig. 3 - Mössbauer transmission spectra of sample I-5 at room temperature.
- Table 1 - Hyperfine parameters of samples E-1, E-2 and I-4 at room temperature.
- Table 2 - Hyperfine parameters of samples E-3 and I-5.

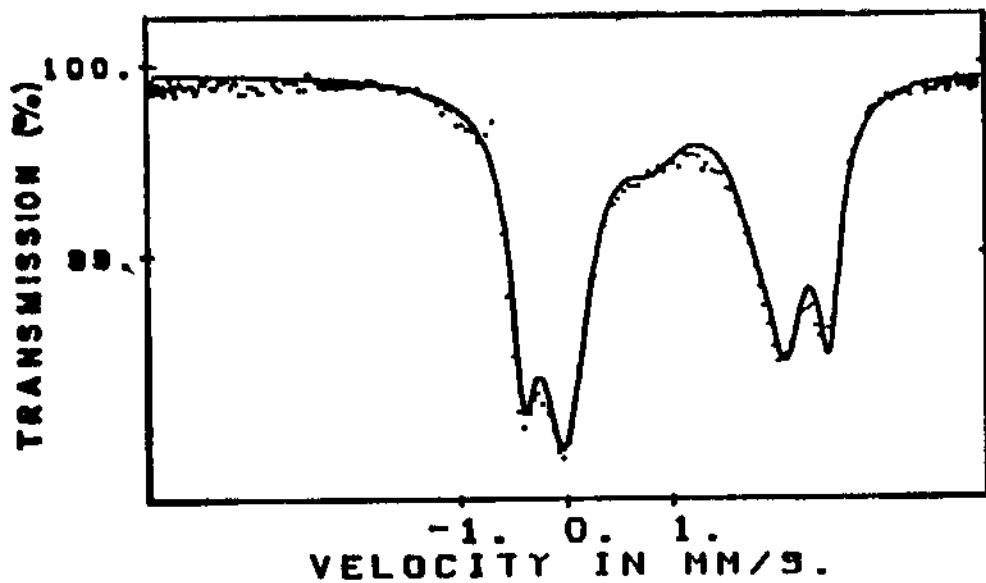


Fig. 1

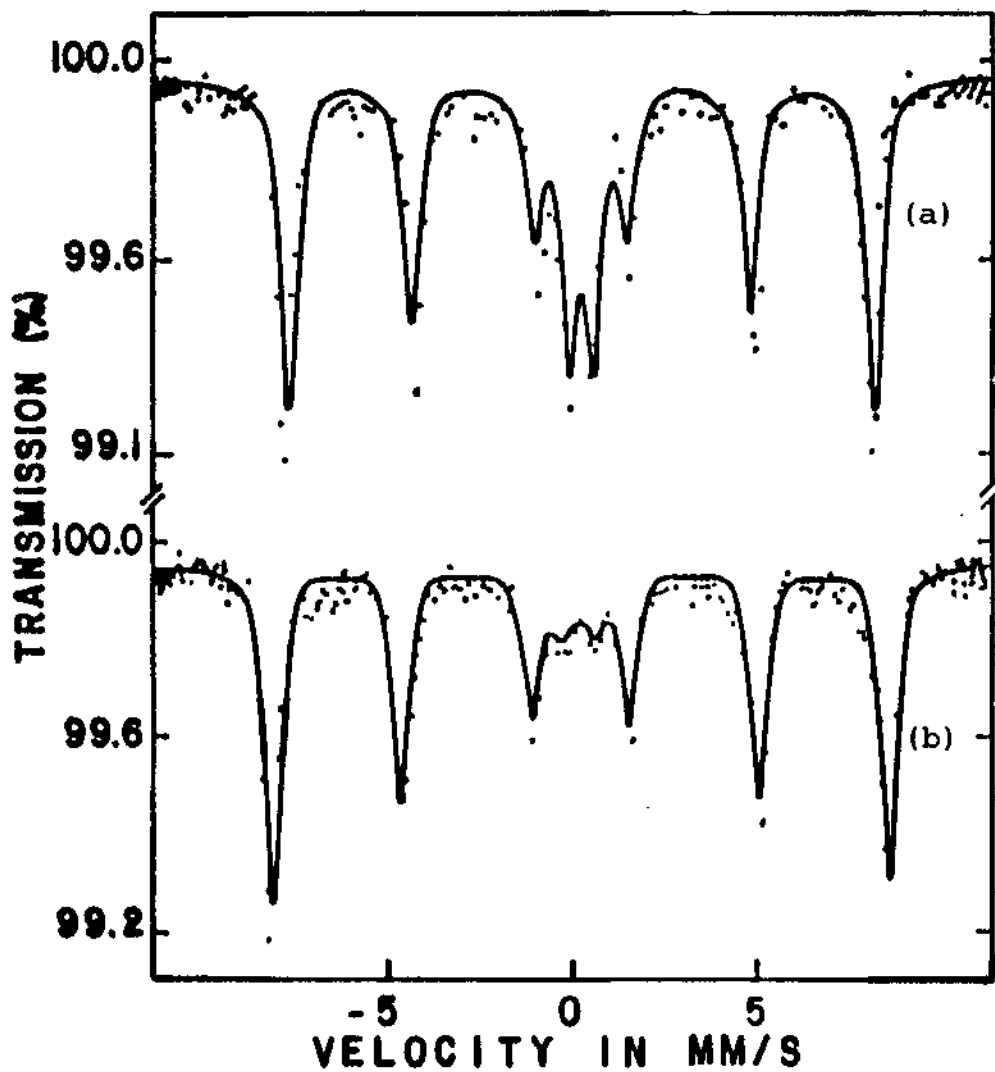


Fig. 2

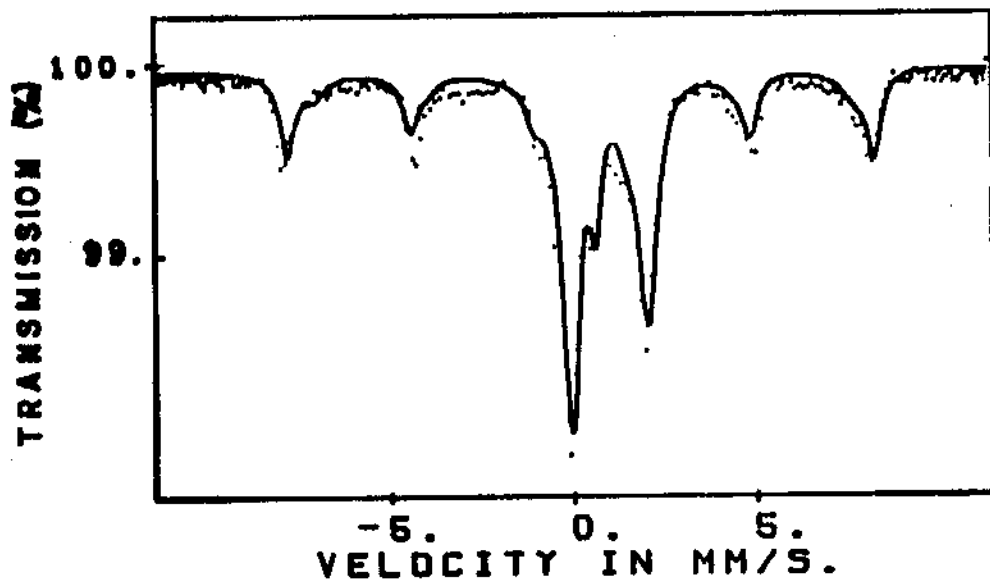


Fig. 3

TABLE 1

Sample	IS mms ⁻¹	ΔE_Q mms ⁻¹	Γ mms ⁻¹	A %	
E-1	Olivine (Fe ²⁺)	1.14	2.82	0.27	17.1
	Pyroxene (Fe ³⁺)	0.38	1.01	0.74	15.6
	Pyroxene (Fe ²⁺)M1	1.10	2.19	0.48	33.1
	Pyroxene (Fe ²⁺)M2	1.03	1.69	0.56	34.2
E-2	Olivine (Fe ²⁺)	1.15	2.90	0.28	37.6
	Pyroxene (Fe ³⁺)	0.45	0.98	0.76	27.8
	Pyroxene (Fe ²⁺)M1	1.13	2.12	0.47	9.9
	Pyroxene (Fe ²⁺)M2	1.05	1.68	0.52	24.8
I-4	Olivine (Fe ²⁺)	1.15	2.92	0.27	29.8
	Pyroxene (Fe ³⁺)	0.29	1.42	0.47	8.7
	Pyroxene (Fe ²⁺)M1	0.89	2.08	0.68	15.4
	Pyroxene (Fe ³⁺)M2	1.15	0.82	0.50	46.0

IS = Isomer Shift relative to iron foil; ΔE_Q = Quadrupolar splitting; Γ = Line width; A = Relative area.

TABLE 2

Sample	T °K	IS mms ⁻¹	ΔE_Q mms ⁻¹	Γ mms ⁻¹	H kOe	A %	
E-3	Magnetic Phase	300	0.36	—	0.54	503.5	74.2
	Superpa. Phase	300	0.38	0.64	0.53	—	25.9
	Magnetic Phase	4.2	0.35	—	0.48	527.6	88.2
	Superpa. Phase	4.2	0.26	0.89	0.87	—	11.8
I-5	Magnetic Phase (A)	300	0.33	—	0.50	505.2	24.4
	Magnetic Phase (B)	300	0.43	—	0.95	466.2	14.5
	Paramagnetic (Fe ²⁺)	300	1.11	2.16	0.65	—	47.3
	Paramagnetic (Fe ³⁺)	300	0.44	0.63	0.40	—	13.8
	Magnetic Phase (A)	4.2	0.35	—	0.44	528.8	25.2
	Magnetic Phase (B)	4.2	0.38	—	0.83	501.8	19.2
	Paramagnetic (Fe ²⁺)	4.2	1.12	2.21	0.87	—	22.6
	Paramagnetic (Fe ³⁺)	4.2	0.54	1.03	0.73	—	11.0

Superpa. = Superparamagnetic; H = Magnetic hyperfine field.

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