Mars-surface minerals in the hyper-acid lake of Poás volcano, Costa Rica

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1. INTRODUCTION

Orbital and landed missions have provided evidence for the widespread occurrence of sulfate-rich mineral associations across the Martian landscape (Swayse *et al.*, 2008; Ehlmann *et al.*, 2011; among others). They must have formed under acidic and oxidizing conditions in the presence of water (Xu *et al.*, 2010). Active volcanoes with crater lakes on Earth are SO_4^- and Cl^- dominated systems in which sulfate-forming processes can be studied *in situ*. For this purpose, we are exploring the active crater of Poás volcano (Costa Rica) that hosts Laguna Caliente, a hot (T>45°C) and hyperacid (pH<2.0) sulfate-chloride lake (Figs. 1 and 2).

Fig. 1. Location map and aerial view of Laguna Caliente

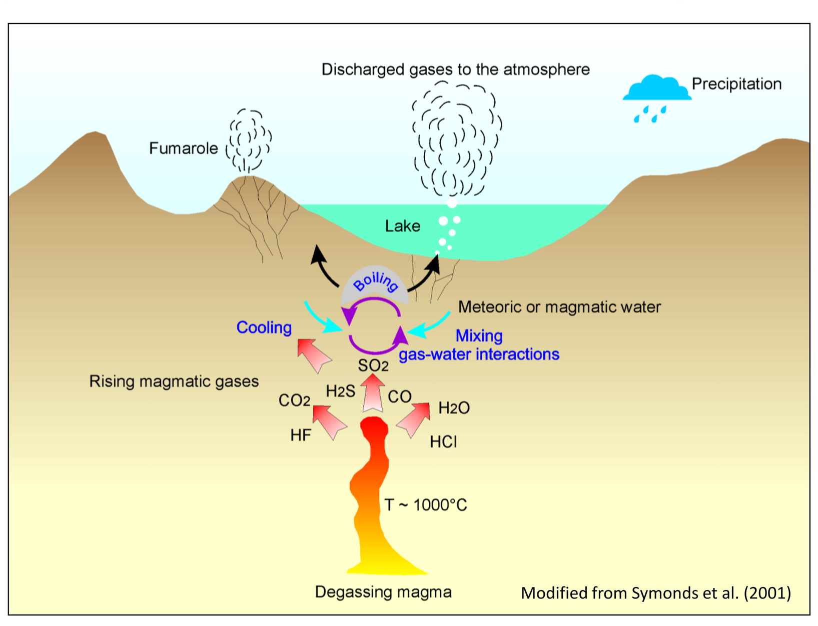

Fig. 2. Conceptual model of a volcanic lake

2. SECONDARY MINERALOGY

SEM, EPMA and XRD techniques revealed the presence of alunite ($KAl_3(SO_4)_2(OH)_6$) in a clastic sedimentary rock found in the lake shore. It presumably originated in the bottom of Laguna Caliente and must has been expelled during a recent explosive phreatic event. Additionally, anhydrite, amorphous silica, cristobalite, rhomboclase ($(H_5O_2)Fe(SO_4)_2 \bullet 2H_2O$) and bilinite ($Fe^{2+}Fe^{3+}_2(SO_4)_2 \bullet 22H_2O$) were identified by powder XRD in a bottom sediment from Laguna Caliente (Figs. 3 and 4).

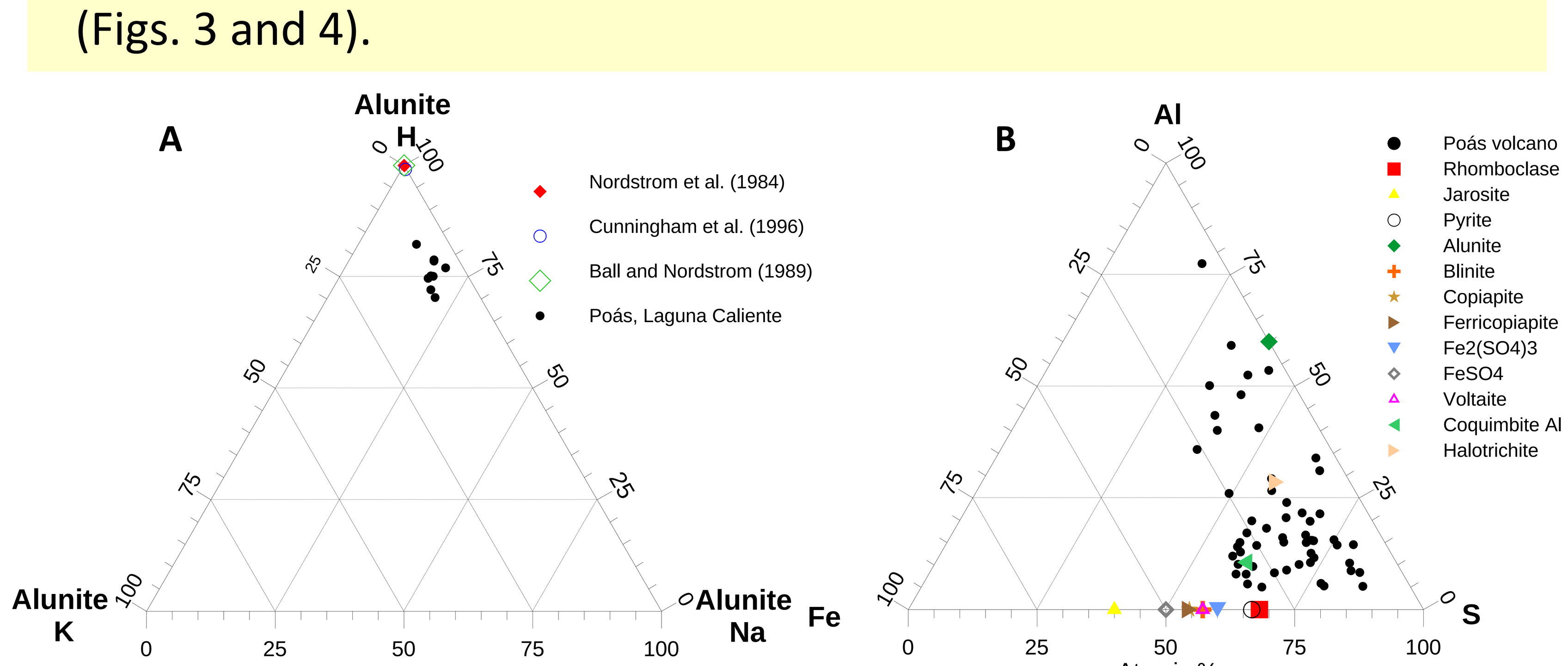

Fig. 3. EPMA analyses of a clastic sedimentary rock (A) and bottom lake sediment (B)

6. REFERENCES

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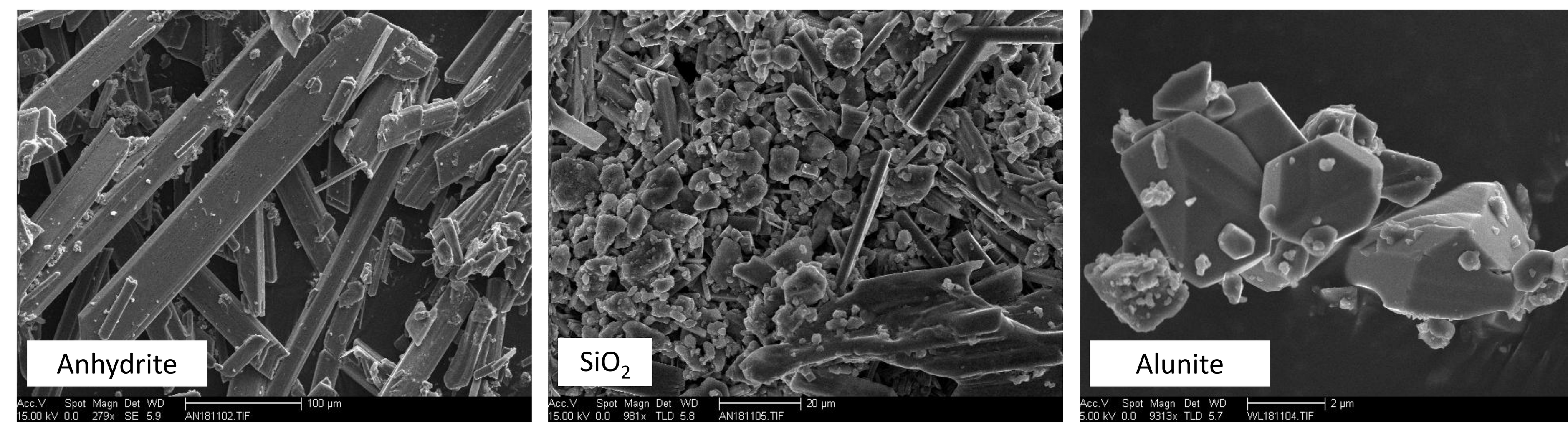

Fig. 4. SEM images of some secondary minerals

3. SATURATION INDICES

Speciation calculations carried out with PHREEQC (Parkhurst and Appelo, 1999) on data from Laguna Caliente (Martínez, 2008) show that lake waters are in equilibrium with amorphous silica, anhydrite, cristobalite, sulfur, pyrite and are undersaturated in alunite, jarosite, fluorite and epsomite. Increasing temperatures lead to kaolinite, AlF_3, and eventually alunite supersaturation whereas pyrite and sulfur become undersatuted (Fig. 5).

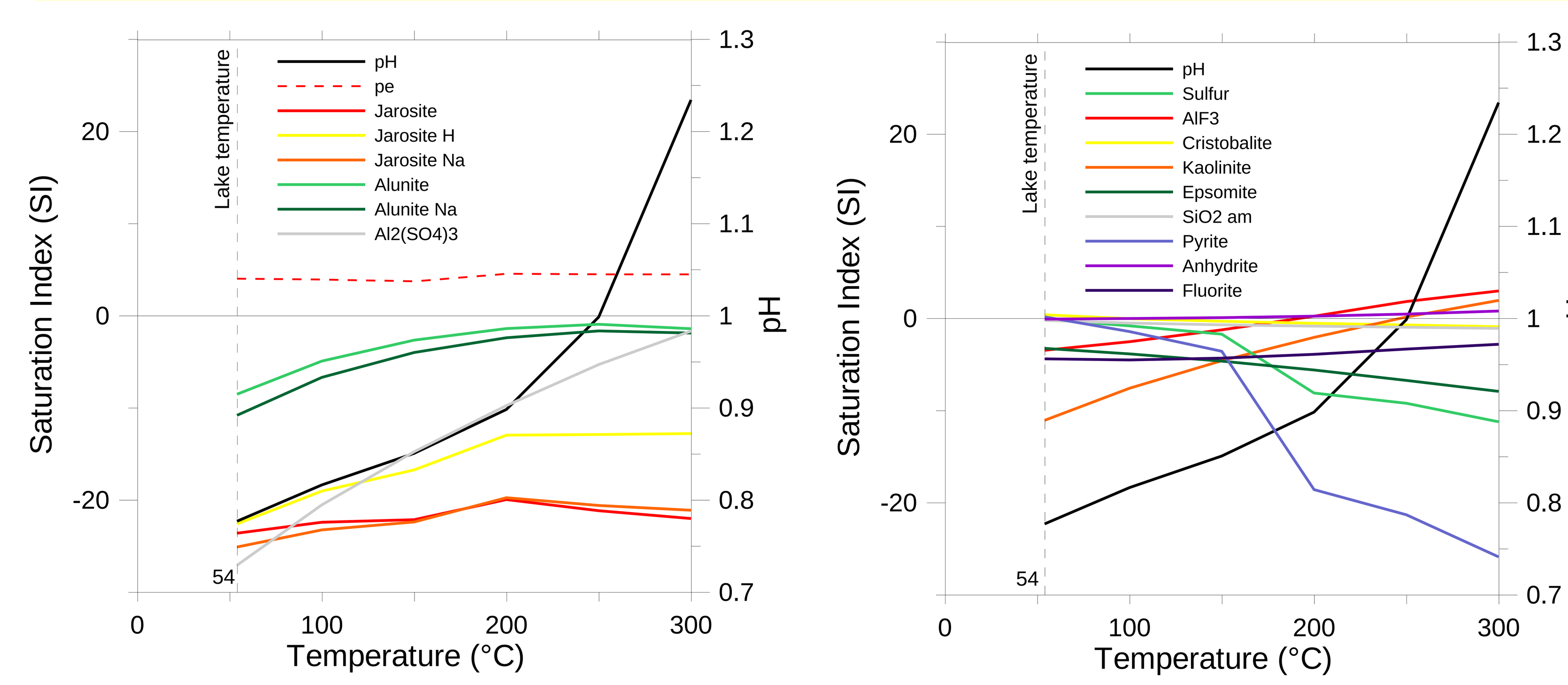

Fig. 5. Variation of mineral saturation indices with temperature for a sample taken on November 30th, 2005 in Laguna Caliente

4. REACTION PATH MODELING

Reaction path modeling was carried out in PHREEQC (Parkhurst and Appelo, 1999). Anatase, amorphous silica, nontronite-H and anhydrite form at low reaction progress whereas alunite, kaolinite, and eventually pyrite and fluorite appear with increased rock dissolution (Fig. 6).

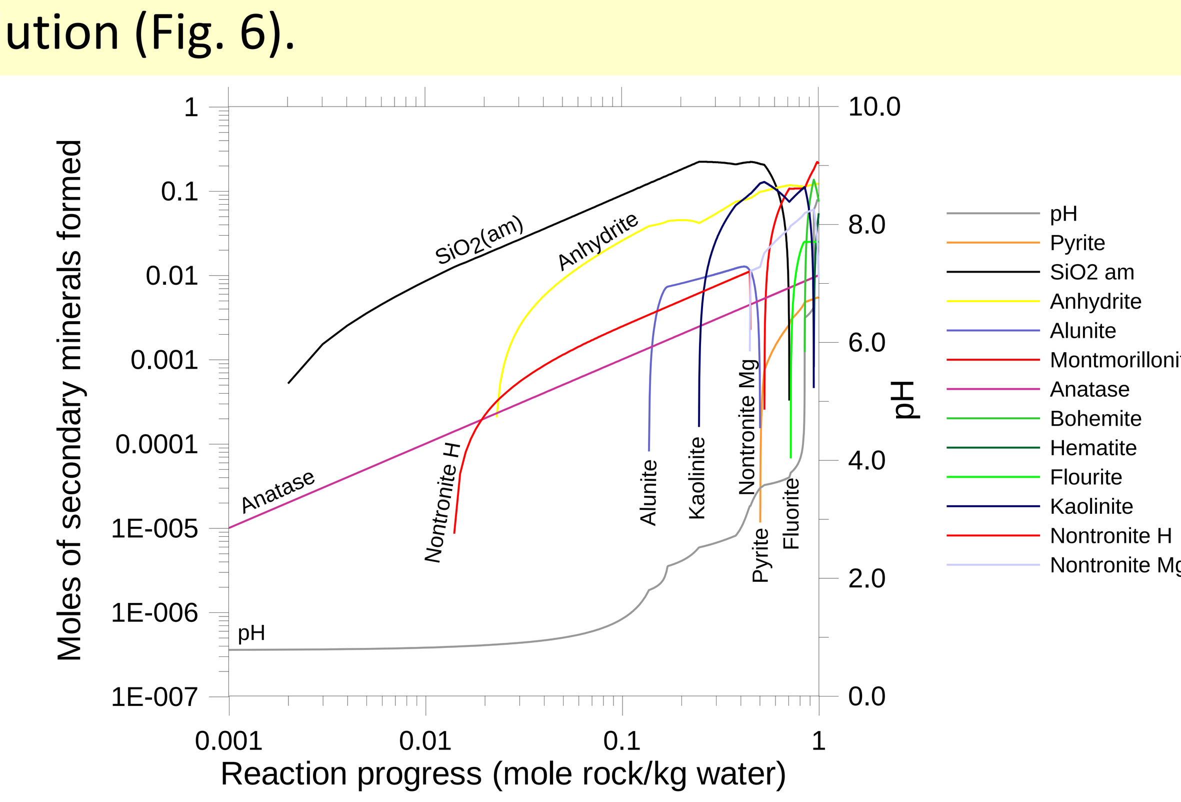

Fig. 6. Reaction path modeling of 110 g of a basaltic andesite from Poás volcano. Rock analysis reported by Cigolini et al. (1991)

5. ONGOING WORK

Field work will be carried out during April 2012 in order to collect water and gas samples from Laguna Caliente. Additionally, the distribution of alteration minerals around the crater will be studied. Sulfur, chlorine and bromine will receive special attention as their concentrations and isotopes will provide valuable information on pathways and formation mechanisms of sulfates and halides.

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