

**EXPERIMENTAL ROCKS ALTERATION UNDER VENUS-LIKE CONDITIONS.** G. Berger<sup>1</sup> and T. Aigouy<sup>2</sup>, <sup>1</sup>IRAP, CNRS-Université Toulouse (14 av. E. Belin, Obs. Midi-Pyrénées, 31400 Toulouse, France, berger@imtg.obs-mip.fr), <sup>2</sup>GET, CNRS-IRD-Université Toulouse (14 av. E. Belin, 31400 Toulouse, France).

**Introduction:** Venus is a very warm and dry planet with a dense carbon dioxide atmosphere. Although water should have been abundant on early Venus, it is scarcely present today at the level of few ppm in the low atmosphere (below the clouds). Numerous measurements fixed the deuterium:hydrogen ratio in Venus atmosphere at high values, suggesting that a large part of water escaped to space and raising question on the geochemical cycle of H<sub>2</sub>O on Venus [1].

The presence of few centimeters thick slabs observed at the Venera landing sites suggested that the surface of Venus could be chemically altered. Chemical weathering has never been directly measured given the lack of mineralogical and chemical data at microscopic scale. Scenarios have however been modeled and experimented [2-5], focusing on the effect of a dry atmosphere and assuming the hypothesis of chemical equilibrium between the atmosphere and the rocks: anhydrite formation, oxidation of pyrite, ...

In this study we explored the alternative scenario, that of an ephemeral aqueous alteration process during wet volcanic events. We experimentally reproduced the current Venus surface conditions and made react volcanic materials for few days with CO<sub>2</sub> + various amount of water. The question is the nature and extent of mineral transformation versus H<sub>2</sub>O fugacity, and the possible reversibility of the process leading, or not [6], to the complete remove of the secondary paragenesis previously produced.

**Experimental:** The experiments were conducted at 470°C during one to seven days in a 300 ml hydrothermal cell made of Hastelloy and heated by an electric furnace. The reactor is equipped with several connections allowing the control of the pressure and the addition of several gases by separate ways. Three rock samples were used: an hydrothermally altered basalt from *Piton des Neiges* (Ile de la Réunion, France), a fresh picritic basalt from a recent lava flow of *Piton de la Fournaise* (Ile de la Réunion, France) and an obsidian from *Vulcano* island (Italia). Centimetric samples were reacted under 95 bars CO<sub>2</sub> (modeling the low atmosphere) + various H<sub>2</sub>O pressure (modeling a volcanic contribution) up to 140 bars. In the last case, the total pressure was 235 bars and the H<sub>2</sub>O:CO<sub>2</sub> molar ratio approached 2:1.

The samples were examined at the end of the experiments under scanning electron microscopy (SEM) and by X-ray diffraction (XRD).

**Results:** Without water, or at low H<sub>2</sub>O partial pressure, the rock forming minerals of the volcanic

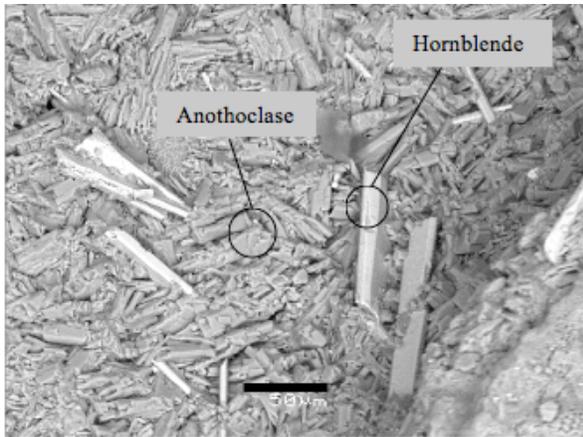
samples did not show any sign of alteration even after one week of reaction. Especially, no secondary carbonate phases were detected. The predicted thermodynamic reaction converting diopside or olivine into calcite or other carbonates did not occur at this time scale without of water. The only observation is the expected change in the interlayer distance of the phyllosilicates in the altered basalt sample.

In water dominant atmosphere (Figure 1), the mineralogical change is more spectacular: the surface of the obsidian sample is transformed into a 10-50 microns thick anorthoclase-hornblende assemblage, the millimetric olivine crystals of the picritic basalt, as well as plagioclase, are covered by micrometric phyllosilicates but pyroxene does not display visible signs of alteration. From these preliminary results, the reactivity of the rock forming minerals can be ranked as follows: glass >> olivine, plagioclase > pyroxene. The absence of secondary carbonates is still noticeable again. We should also mention the precipitation of silica in the colder part of the reactor, suggesting an efficient mass transport in the supercritical wet fluid in response to a thermal-induced chemical gradient. Si,Al,Fe,Mg coating of plagioclase also suggests mass transfer at lower scale.

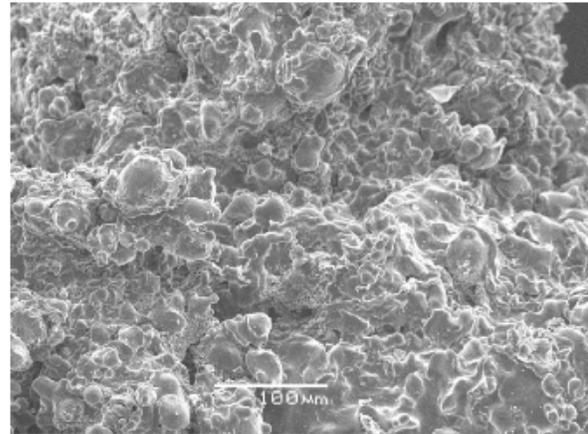
These preliminary results suggest that secondary hydrated minerals, even metastable, can easily form and may persist at the surface of Venus as previously proposed for tremolite [6]. Further experiments will include SO<sub>2</sub> as a component of the gas, and LIBS/Raman microanalyses of the altered surfaces will provide information on the capacity of determining the micro-mineralogy of the Venus surface on possible future spacecraft missions.

#### References:

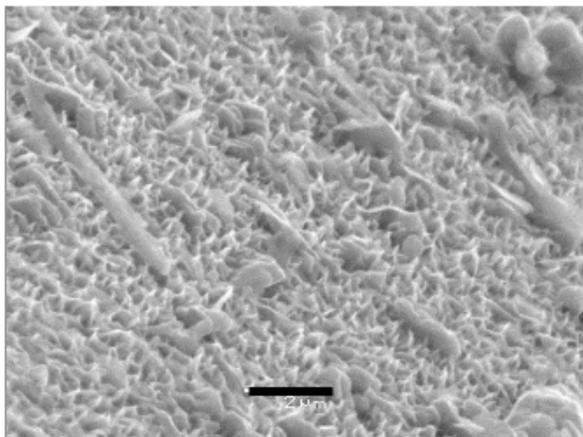
- [1] Lammer H. et al. (2006) *Planet. & Space Sci.*, 54, 1445-1456. [2] Zolotov M.Y. et al. (1997) *Icarus*, 130, 475-494. [3] Fegley B. Jr. et al. (1997) *Icarus*, 125, 416-439. [4] Fegley B. Jr. et al. (1995) *Icarus*, 115, 159-180. [5] Fegley B. Jr. et al. (1995) *Icarus*, 118, 373-383. [6] Johnson N.M. and Fegley B. (2000) *Icarus*, 146, 301-306.



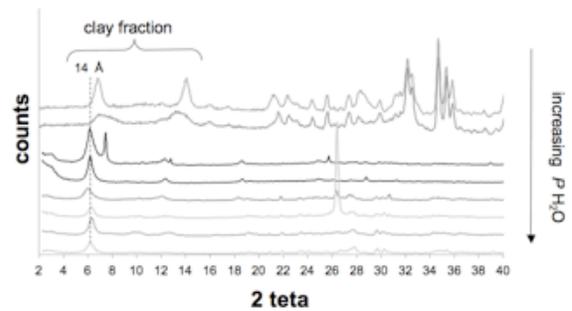
A) Obsidian sample. Scale bar is for 50 μm.



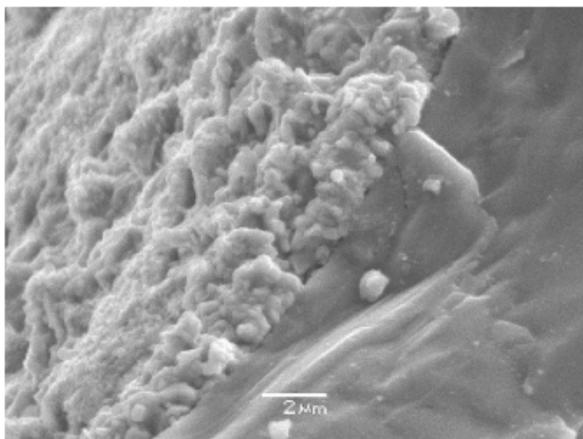
D) Silica deposit in the colder part of the reactor.



B) Olivine from the picritic basalt sample. Scale bar is for 2 μm.



E) DRX pattern of an altered basalt reacted at various water content.



C) Plagioclase covered by a Si,Al,Fe,Mg rich coating.

Figure 1. Altered samples under CO<sub>2</sub>-H<sub>2</sub>O gas mixtures. A to D: SEM observation. E: XRD patterns of the clay fraction of an hydrothermalized basalt