MAGMATIC GAS-INDUCED ALTERATION OF THE MARTIAN BASALTIC CRUST: INSIGHTS FROM EXPERIMENTS. M. Safari[1], N. Zimmermann[1], H. Nekvasil[1] Department of Geosciences, Stony Brook University, Stony Brook, NY 11794-2100, (morteza.safari@stonybrook.edu)

Introduction: Mars has experienced episodes of violent to quiescent igneous activity throughout its history. Its basaltic crust, clusters of enormous volcanoes, and presence of globally distributed pyroclastic deposits are indicative of such activity. These features have been dated from the water-rich Noachian era to the more tranquil and drier Amazonian. Magmatic degassing is an inseparable part of igneous activity and Mars as an igneous planet has revealed many degassing-related features.

The widespread occurrence of secondary minerals and non-crystalline alteration products associated with the basaltic crust of Mars has been confirmed by rover and orbital observations [1]. Numerous experiments to constrain the physicochemical conditions of alteration of basalt to form Mars-relevant alteration assemblages have been performed [2], [3]. Almost all of the experiments and resulting proposed alteration mechanisms require the presence of long-standing surficial liquid water. Here, we propose that magmatic gas can produce Mars-relevant alteration minerals or the precursors of such mineral phases without the presence of free-standing surface water.

Method and Materials: Gas-rock reactions in evacuated silica glass tubes and gas flow-through furnaces have already been explored by several research laboratories and the results show a diversity of phases produced. We have conducted a set of evacuated silica tube experiments built upon the method developed by [4], but using the composition of Wishstone class rocks [5] doped with 1 mol % of S, Cl, Br, H_2O volatiles (for details see Zimmermann et al., this conference). This volatile-doped Wishstone glass serves as the source for the magmatic gas. These experiments in conjunction with those from [4] have elucidated the nature of vapor deposits from diverse igneous lithologies on Mars. With the understanding of the nature of the vapor-deposited material, alteration was investigated by placing common basaltic target minerals in the gas stream. In our first alteration experiments, the target was placed at 600 ˚C. At this temperature, most of the alteration products are stable and there is less directly precipitated salt so the gas has better access to the target.

A 150 mg aliquot of Wishstone composition glass synthesized at 1300 ˚C and 1 GPa with piston cylinder apparatus was placed in $Au_{80}Pd_{20}$ capsule at the bottom of the tube. Target minerals (olivine, augite, albite, anorthite and the basaltic glass itself) were suspended in the evacuated and sealed silica tube for each experiment. The tube was placed in a furnace with a well-calibrated thermal gradient. All experiments ran for 48 hours in order to ensure complete degassing of the source glass and enough time to achieve gas-rock equilibrium.

Results: The targets showed evidence of alteration and crack filling to the naked eye. All the phases were analyzed in detail by SEM.

Olivine: This mineral is known to be easily altered in presence of liquid water; however, it seems to be similarly vulnerable and penetrable by magmatic gases which results in the release, transport and formation of Fe and Mg halides (Fig. 1). In addition to that, both iron oxides and oxychlorides have formed on the olivine surface as what appears to be primary alteration products (Fig. 2).

Augite: Ca and Mg sulfates and halides are found on the surface (Fig. 3). Because of the extremely low transportability of Ca and Mg in the gas phase, the source of these elements in sulfates and salts is clearly the target mineral.

Anorthite: The alteration products include abundant Ca-sulfate (Fig. 4).

Albite: Showed no alteration.

Wishstone glass: Abundant chlorapatite formed during alteration which is likely a reflection of the high Ca and P content of the glass target (fig. 5). A variety of crystalline halides were also produced.

Conclusion: The halides of Na, K, Fe and Mg and the $FeSO_4$ and $CaSO_4$ sulfates are the most commonly produced alteration phases in all experiments. The contribution of these salts to Martian soils and fines or reworking and concentration in the evaporitic remnants of lake deposits could lead to significant concentrations [6].

Gas-rock alteration produces small crystals that do not strongly adhere to the host mineral; we observed crystals on the surface that were generally less than 100 microns, compatible with Martian fines. This size is very reactive with atmospheric agents. Most of the phases are H_2O-soluble and can be dissolved by available surface water.

Basaltic glass is widespread on Mars; the Fe and Mg salts produced by its alteration can contribute to the Martian chloride deposits upon dissolution, transportation and deposition along rivers and lake beds. chlorapatite can also be the source of phosphor-rich soils analyzed by rovers in the Gusev crater and Meridiani Planum [7]. Furthermore, [8] introduces chlorapatite as the source for chloride deposits on Mars.

In general, primary alteration products and the residue of altered minerals are the two main products of gas-rock reaction and both of them may gradually convert to other minerals or amorphous components [9], [10] that are frequently observed by rovers [11].

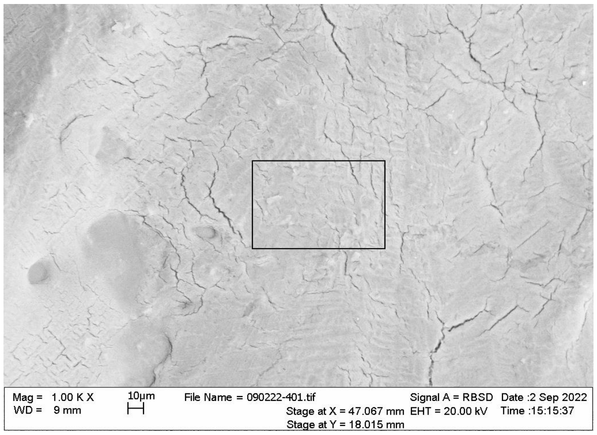

Figure 1 Fe and Mg halides coating the olivine.

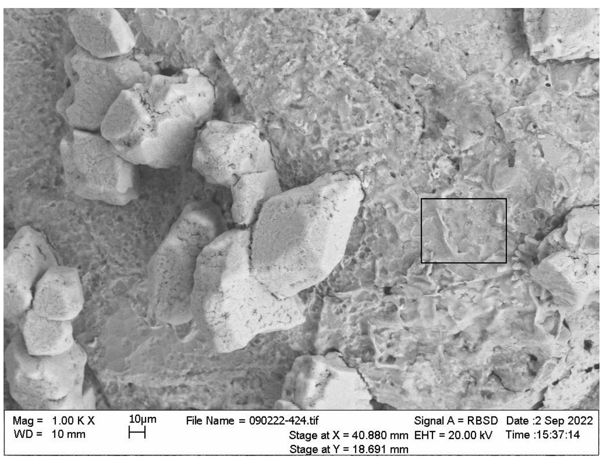

Figure 2 FeOCl (boxed region) encrusting olivine; large crystals are iron oxides.

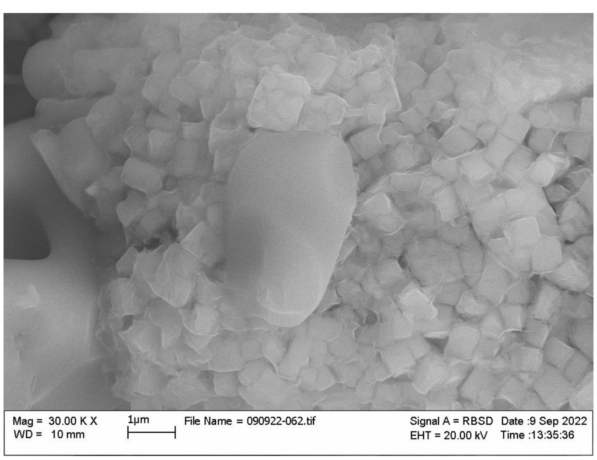

Figure 3 A Ca sulfate grain on top of chloride cubes resulted from the alteration of augite.

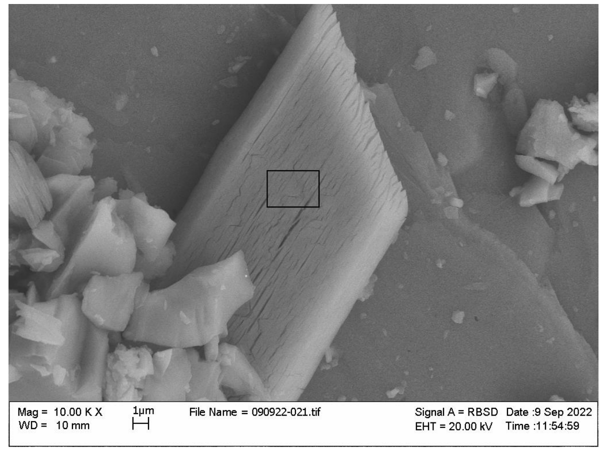

Figure 4 Ca sulfate on anorthite.

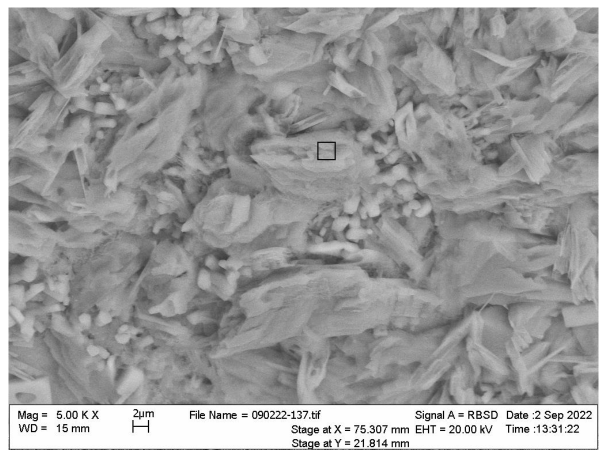

Figure 5 Chlorapatite blanketing the surface of synthetic Wishstone glass.

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