An Investigation into Fluorine within Gale Crater and its Implications for Martian Geology

Conference or Workshop Item

An Investigation into Fluorine within Gale Crater and its Implications for Martian Geology.

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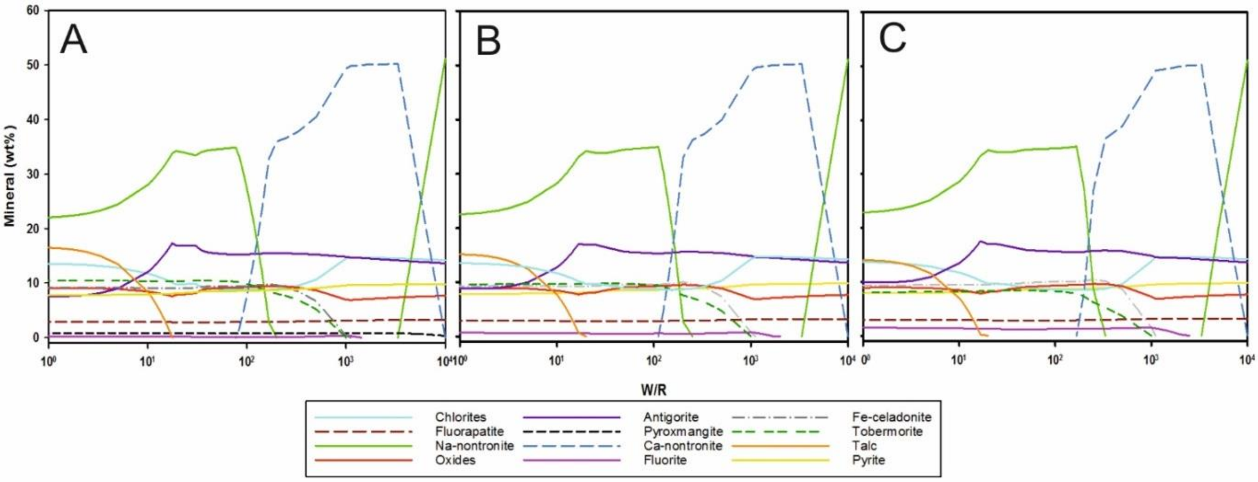
Since the Mars Science Laboratory's (MSL), Curiosity Rover began its exploration of Yellowknife Bay in Gale Crater, it has discovered an array of basaltic and secondary mineral assemblages representative of deposition in environments ranging from aeolian sand dunes to habitable lacustrine settings[1]. Recently, the molecular analysis of ChemCam data[2] has shown that fluorine has been detected in multiple locations along the rover's traverse. Building on the equilibrium thermochemical modelling of the Sheepbed mudstones by Bridges *et al* (2015)[3], this study simulates which mineral phases fluorine is likely to precipitate as in an open system to determine whether it is related to an evolved magma composition in the Martian crust, secondary mineral alteration in Gale Crater or biological activity[3].

Gale Crater lies on the crustal dichotomy straddling the densely cratered uplands and the less cratered lowlands[1]. It formed roughly 3.7 Ga ago at the Noachian-Hesperian boundary and the uppermost limit of what has been deemed by several authors to be Mars' "wet period"[3]. Approximately 450 m from its landing site, Curiosity found its first mudstones in the Sheepbed Mudstone Unit indicative of a fluviolacustrine, neutral pH environment potentially habitable to chemolithoautotrophic organisms[1]. Previous models of these mudstones aimed to constrain the nature of alteration of this lithology[2], but did not include halogens which are important indicators of paleoenvironment, alteration and biogenic activity in sediments. Earlier Martian rovers were not able to detect fluorine on the Martian surface within an acceptable limit of detection (LoD)[2]. However, the new method of using a molecular analysis approach of CaF_2 and $CaCl_2$ with data collected from Curiosity Rover's LIBS (Laser-Induced Breakdown Spectroscopy)[4] on the ChemCam instrument has permitted the detection of halogens to a degree acceptable for geological analysis.

A starting mixture of 70% Portage amorphous component, 20% olivine and 10% whole rock[3] was modeled and shown to be consistent with a source composition for diagenetic clays observed using the Curiosity CheMin instrument[5]. Here we have modelled the same starting composition, using CHIM-XPT, a FORTRAN program[6] which calculates a series of titrations based on a specified starting fluid and rock composition. Compared to the previous models[3] we modified Gale Portage Water (GPW) starting aqueous solution to have varying NaF concentrations. Fig. 1 shows that fluorine present in the Sheepbed mudstone and soils exists as fluorite and fluorapatite. Fluorite is more abundant at low water rock ratios (W/R) in mineral assemblages where Ca is not incorporated into other mineral phases such as Ca-Nontronite. Its relative abundance is also greater at higher NaF concentrations in the starting aqueous solution and can exist at greater W/R than when F is depleted in the starting conditions. Fluorapatite has a consistent presence throughout the different models. These results mirror those found previously to be the result of secondary alteration systems within Gusev Crater's Home Plate[7] and matches current observations on the surface which strongly suggests that the fluorine-bearing minerals are likely a product of diagenesis and not the result of igneous input.

Now that a working model has been established, this can be used to determine the fluorine-bearing phases of other rocks of interest to see whether it is the result of secondary mineral alteration and/or other processes. With the recent discovery of high SiO_2-bearing rocks along Curiosity's traverse up Aeolis Mons[8] this could aid in identifying the sources and pathways of important species responsible for Martian diagenetic and hydrous alteration, which in turn could provide further scope on determining the habitability and paleoenvironment of ancient Mars.

Figure .1: Mineral abundance in weight % is plotted alongside the water-rock ratio (W/R), which represents the ratio of fluid interacting with the host rock for an adapted Gale Portage Water (GPW) with NaF at (a) 0.5 wt %, (b) 1.0 wt % and (c) 2.0 wt %.



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