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Carbonation and Serpentinization of the Martian Crust inputs from by Geochemical Modelling

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Abstract

The investigation of the CRISM data indicates that the serpentinization and the carbonation have to be considered as significant processes of alteration of the early Mars. We report here a tentative of characterization of these processes by geochemical modelling with EQ3/6 programs.

1. Introduction

Carbonates are described in Martian meteorites as minor phases [1]. In situ analysis of the Martian dust also reveals carbonates as a minor component [2]. Only orbital detections allow the analysis of the geological context of the formation of the Martian carbonates. Crustal outcrops have revealed carbonates and serpentine: in an olivine rich layers linked with the ejectas of Isidis basin, or in crustal outcrops such as deep canyon or central peak of large impact crater that may have exhumed crust from depth [3], [4], [5], [6] and [7]. A systematic analysis of the alteration minerals in these central peaks of impact craters on the Noachian crust has been conducted by [4]. They demonstrate that the typical mineralogical assemblage observed in central peak of impact crater between Isidis and Hellas Basins are chlorites, Fe-Mg smectites, serpentine and carbonates. The most abundant phases in term of detection are chlorite and smectite while serpentine and carbonate are rarer. A geological analysis of these detections suggests that these minerals are exhumed from depth rather than being formed at time of the impact.

2. Geochemical Model

Our model use the software code EQ3/6, version 8.0 [8] and [9] and a customized database for 0-400°C and 50MPa [10].

We use different pCO2 from 6mbar to 1 bar in a closed system and heat the fluid at different temperature (400°C and 200°C). Then, the system is studied during a cooling from 400° (or 200°) to 25°C with two endmember of W/R (1 and 10) to simulate rock- vs fluid-dominated environments. We used three different rock compositions (mafic, basaltic and anorthositic). We used different fluids from pure water to typical terrestrial seawater enriched in sodium and potassium and a typical water of serpentinization systems describe by [11] and also used in [12].

3. Results

Our results show that the hydration and carbonation of the martian crust lead to minor presence of serpentine and carbonates along with Mg-smectite, chlorite and talc under certain conditions. This study shows that it should be a fluid dominated system, with a partial pressure of CO2 (pCO2) of 1 bar and high amount of olivine should be present in the protolith (~30%) [13]. Moreover, we show that the serpentinization is favoured by a fluid influenced by an ultramafic system and that the carbonation is favoured by a fluid influenced by a mafic system [14].

4. Discussion

Our modelling success to reproduce most of the Martian minerals association found with serpentine and carbonates. We will present the possible scenarios for the formation of these mineral associations.

Our results demonstrate that the hydration and carbonation can lead to a production of H_2 and CH_4 what are key parameter for the construction of more complex organics matters and therefor the emergence of life. We will detail which mineral associations should or should not be seen as life friendly. These results will help to determine the potential of habitability of future landing sites.

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