IDENTIFICATION AND IMPLICATIONS OF IRON DETECTION WITHIN CALCIUM SULFATE MINERALIZED VEINS BY CHEMCAM AT GALE CRATER, MARS

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OBSERVATIONS OF DIAGENETIC FEATURES BY CHEMCAM

The Mars Science Laboratory instrument ChemCam [1] LIBS and the associated RMI camera) has observed diagenetic mineralized veins [2,3,4] at Gale Crater Mars, along the Curiosity rover traverse, starting at Yellowknife Bay shortly after landing (Figure 1). Among these features, light-toned veins – primarily composed of Ca-sulfate (anhydrite [5] and bassanite [6]) – are pervasive to all units and cross-cut other diagenetic features [7]; thus hinting at a regional late-stage episode of fluid circulation.

Recent observations show the presence of iron and magnesium within the bulk of the veins, seemingly unrelated to the host rock silicate components as revealed by shot-to-shot analysis of the LIBS spectra. This chemistry appears to differ from mixed composition observed at the interface between distinct lithologies, which are not uncommon with ChemCam because the LIBS laser spot is up to 500 μm in size.

The chemical composition deviating from the host rock – Ca-sulfate mixing line seen so far may thus hint at chemical heterogeneity within the light-toned vein facies.

IRON DETECTION IN LIGHT-TONED VEINS

A thorough investigation of the LIBS spectra of every light-toned vein observed so far by ChemCam has been conducted in order to distinguish Fe-enhanced vein chemistry from host rock contributions. This selection was made based on the ratio of maximum intensity between Fe (260.017 and 404.695 nm) and Si (288.242 nm) peaks deviating significantly from typical host rock ratios. A Fe-rich subset of light-toned veins has thus been identified (Figure 2), mainly in the last ~ 500 sills of the mission.

In addition, ChemCam recently observed darker-toned material, often associated with light-toned veins as inclusions, which display very high FeO, and MgO abundances associated with high MnO and P detection [8]. A potential genetic link between these features and the iron enrichment in light-toned veins is considered, especially in the more recent iron detections.

TEXTURE AND STRATIGRAPHIC DISTRIBUTION

Fe-rich light-toned veins are often associated with a branched texture and spotted aspect (i.e. displaying darker areas within the vein, Figure 3), as opposed to the massive texture and pristine aspect of the pure Ca-sulfate veins [1,2].

These detections are also heterogeneous within the light-toned veins, with several LIBS points displaying a Fe-rich chemistry amidst an otherwise pure calcium sulfate phase (e.g. in the Khababun target).

INTERPRETATION FOR MINERAL PHASE

Ternary diagrams (Figure 4) of ChemCam major elements quantified contents (MOC quantification [9]) illustrating a similar FeO enrichment in light-toned veins and in dark-toned features in the vicinity. A genetic link between these features is considered and may provide constraints on the chemistry of the iron phase detected, potentially indicating a Fe sulfite and/or phosphite component.

In addition, Fe appears to be weakly correlated with higher Al2O3 and MgO (separately) potentially indicating two distinct chemical trends toward Fe-Al and Fe-Mg mineral phases. It is for the most part not correlated with Fe in these features, likely indicating a non detrital origin for the Fe-rich phases.

STRATIGRAPHIC CONTEXT

The distribution of the Fe-bearing calcium sulfate vein targets in the Gale stratigraphy (Figure 5) show that they are mostly encountered in the Murray formation (lake mudstones), especially near the Naukluft Plateau and Precipice localities. The dark-toned features were also found near Precipice, supporting the case for a co-genetic deposition alongside calcium sulfate, potentially as Fe-Mg phosphate.

Naukluft Plateau on the other hand is located near the stratigraphic unconformity with the overlying Stimson formation (sodic sandstones), where a Girish composition was identified in fracture related holes [11] (Lucubago (GB) and Greenhorn (GH) drill holes). This chemistry may result from the acid leaching of the host rock [12] containing iron and aluminum in the fluids, that would have later re-precipitated in the vicinity either as Fe-Al sulfates (coquiibuns) or as Fe & Al oxides.

CONCLUSION

Observations of iron-rich chemistry within calcium sulfate veins attest for evolving fluid chemistry. Two deposition mechanisms are proposed to account for these observations:

1. Related to Fe-Mg (Cr/Mn) rich dark-toned features near Precipice, and a potential co-genetic precipitation as a phosphate phase.

2. Acid leaching in the overlying Stimson unit near Naukluft Plateau with subsequent concentration of Fe & Al in fluids, and later re-precipitation as either sulfates or oxides.

As for mineral phases implications, an Fe-sulfate phase would indicate a more acidic diagenetic fluid composition while Fe-oxides and phosphates could point toward both oxidizing and acidic conditions.

In addition, light-toned vein chemistry may be influenced by the proximity to the hematite ridge [13] and the sulfate layers observed from orbit [14] farther up the slopes of Mount Sharp, as the rover continues its ascent.

REFERENCES