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Elemental sulphur deposit and its related enrichments as viewed by Chemcam.

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Here we characterize the first detections by ChemCam of native sulphur found in float rocks in the Gediz Vallis channel in Gale Crater, Mars, and we document sub-millimetre heterogeneities within the deposit and associated rocks. ChemCam is an active remote sensing instrument suite that has operated successfully on the Curiosity rover since landing on Aug. 6th, 2012 [1,2]. It uses laser pulses to remove dust and to profile through weathering coatings of rocks up to 7 m away. Laser-induced breakdown spectroscopy (LIBS) obtains emission spectra of materials ablated from the samples in electronically excited states. Gediz Vallis (GV) is a narrow canyon on the flank of Aeolis Mons that drains a catchment of about 127 km² and leads to a 900 m wide, 120 m deep canyon that curves and terminates abruptly [3]. It cuts a stepped surface, and broad, shallow flat-floored canyons that terminate in a deeply etched yardang unit [4]. In GV, a triangular area, probably resulting from the exhumation of channel fill deposits, show the presence of numerous allochthonous light-toned blocks forming a talus. The overlying material just above those blocks and at the bases of large bedrock blocks is a light-toned nodular strata. Further south above the deposit, at the edges of these large blocks, light-toned halos have also been observed. Among all these light-toned blocks, thirteen have been analysed by ChemCam. They are generally characterized by a cottony and fluffy texture, and their average LIBS spectra of these targets exhibit all the theoretical lines of sulphur up to the fourth excitation state, indicating an almost pure phase [5]. This is confirmed by the fact that in shot-to-shot spectra, no other element shows emission lines, except in the first five shots that sample the dust cover. However, some contamination can be observed in some points that are generally located on holes or small fractures. But in these rare cases, the sulphur signal is always anti-correlated with the signal of those other elements, supporting that sulphur is a distinct and pure phase. This applies also to minor and traces elements like Li, Ba, Sr or Rb. On Earth, sulphur is commonly associated with chalcophile elements (As, Cu, Ni, Cs, Co, Zn, Ga, ...) that concentrate in sulphides during partial melting of the mantle by sulphur immiscibility [6]. None of the main chalcophile elements were identified in our LIBS spectra, at least at the ChemCam sensitivity. Indeed, all the emission lines can be explained by a sulphur line up to SIV. Finally, the sulphur spectra are characterized by the complete absence of hydrogen, chlorine or fluorine. The oxygen signal is also low and decreases with the sulphur signal in the shot-to-shot data. All these observations mean that the pure sulphur is highly reduced. The composition of these blocks is compatible with pure native sulphur. No other elements are correlated with sulphur and notably no chalcophile elements are detected, which indicates that the sulphur unlikely originated by the fusion of a deep mantle source. A regional metamorphic process leading to the deposition of sulfosalts formed in a closed system, like in the Alps [7], seems also unlikely. An impact derived molten sulphur lava flow that fills a pool is envisaged. The overlying strata and especially the bright halos exhibit also sulphur enrichments.

Keywords: Mars; ChemCam; Sulphur

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