SOIL DIVERSITY AT MARS: COMPARISON OF DATASET FROM GALE AND JEZERO CRATERS

A. Cousin[1], P.Y Meslin[1], E. M. Hausrath[2], E. Cardarelli[3], J. Lasue[1], O. Forni[1], O. Beyssac[4], L. C. Kah[5], L. Mandon[6], O. Gasnault[1], E. Dehouck[7], F. Poulet[8], C. Quantin-Nataf[7], P. Pilleri[1], P. Gasda[9], S. Schröder[10], R. Wiens[9], S. Maurice[1] and the SuperCam science team. [1]IRAP, Toulouse, France (acousin@irap.omp.eu), [2]Dept. of Geoscience, UNLV, NV, USA, [3]NASA JPL, CA, USA,[5]Dept of Earth and Planetary Sciences, UTK, TN, USA. [4]IMPMC, Paris, France. [6]LESIA, Meudon, France. [7]LGL-TPE, Lyon, France. [8]IAS, Orsay, France. [9]LANL, NM, USA.[10]DLR, Berlin, Germany.

Introduction: Soils correspond to loose, unconsolidated materials resulting from the physical and chemical alteration of rocks by several processes [1-3]. Soils are interesting because they can be used to estimate the bulk composition of the crust by looking at their primary constituents[2], but they also bring important clues concerning the past environmental conditions on Mars as they are known to contain some secondary phases. Orbital data have shown that dust and soils are hydrated (4 ±1 wt%) and relatively homogeneous all over the planet [4]. Soil analyses performed with Viking, Pathfinder and the MER rovers have confirmed this [5]. The Mars Science Laboratory mission with the Curiosity rover showed that fine-grained soils at Gale crater contain up to 3 wt % H2O [6,7], and that this hydration is carried mainly by the X-ray amorphous component [8]. ChemCam observations showed that fine-grained soils are more hydrated than the coarser ones [1, 9], probably due to the amorphous component [10,11], that seems to contain some hydrated Mg sulfates [10]. The Perseverance rover landed at a new location, Jezero crater, in February 2021. Onboard Perseverance, the SuperCam instrument uses the same LIBS technique as ChemCam, which allows direct comparison between soils from Gale and Jezero.

Objectives: This study aims at comparing soils encountered at Jezero crater with those from Gale, analyzed with the LIBS technique, first to investigate the hypothesis of a local component in the coarser grains, and to investigate the homogeneity of the fine-grained soils over the planet.

Methodology: This study uses data from the ChemCam and SuperCam instruments. Only soil targets have been considered, but no distinction has been made between loose soils and soil crusts [12]. The ChemCam soil targets come from [13], where targets were classified up to sol 3007. The same visual classification has been performed using the SuperCam data. At Gale crater it was shown that there were no major differences in composition between fine (125-250 µm) and medium-grained (250-500 µm) sizes [12]. Therefore, soils from Jezero have been classified using only three categories: fines and medium-grained size (<500 µm), coarse-grained (0.5-1mm) and very coarse-grained size (1-2mm).

Results: As of sol 236, only 128 points (over 1130 points) have sampled a soil target with SuperCam/LIBS in Cf-fr and South Seitah. From the visual classification, 54 % of them correspond to fine/medium -grained soils, 5 % correspond to coarse-grained soils, 39 % correspond to very coarse-grained, and only 2 % to granules (> 2mm).

As there are only a few points on granules and coarse-grained soils, the study will mainly use the fine/medium and the very coarse-grained soils.

Fig. 1 shows the distribution of major elements between the fine/medium- and very coarse-grained soils. Some differences can be observed: fine/medium-sized soils have more points enriched in Al2O3, CaO and alkali, whereas very coarse-grained soils have more points enriched in FeO and MgO, and some low values in SiO2. There is a bimodal distribution for MgO that is observed in soils for all grain sizes, but there are more very coarse-grained soils enriched in MgO: this is probably due to the fact that larger grains are enriched in olivine [14,15]. This is also consistent with MnO content as shown in [16]. IR spectroscopy of soils has also revealed that the coarser ones are enriched in olivine and pyroxenes sometimes associated with alteration phases such as Mg-rich phyllosilicates, while the fine-grained soils are more mafic with a low abundance of olivine, as seen from orbit. Overall, very-coarse-grained soils show a wide dispersion in MgO content, as well as in alkali, Al_2O_3, CaO and SiO_2. This could reflect the presence of other phases, such as feldspars and non-silicates (some points enriched in MgO are lower in SiO2, but shot-to-shot data need to be investigated).

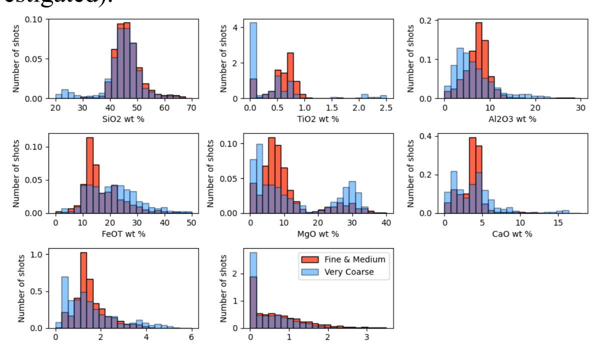

Fig.1: Distribution of elemental compositions for the fine/medium (orange) and very coarse-grained (blue) soils observed at Jezero with SuperCam.

Fig. 2 presents the distribution of H, Cl and S in the soil targets sampled by SuperCam. Fine/medium-grained soils are more enriched in H, S and Cl, as also observed at Gale [1,9,17]. Moreover, S and H seem to be correlated, which does not seem to be the case for Cl. However, more analyses need to be done, mainly to compare the shot-to-shot trends that are important for soil analyses.

One of the main objectives of this study is to compare fine-grained soils from Jezero to those from Gale crater.

Major elemental compositions and average spectra from both landing sides show that fine-grained soils from Gale and Jezero seem to be overall similar, except maybe concerning their Ca content that needs to be investigated further using several techniques, such as Independent Component Analysis [18,19]. The MgO shot to shot distribution however shows some differences, as at Jezero some are enriched in MgO compared to Gale (Fig. 3). Qualitative comparison shows that the H and S signal seems to be similar in both sites as well (Fig. 4). However, besides a different baseline in the spectra, Jezero fine-grained soils seem to be more enriched in Cl compared to those from Gale crater (Fig. 4).

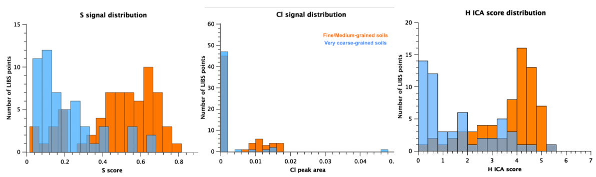

Fig. 2: Distribution of S signal, Cl signal and H ICA score in fine/medium (orange) and very coarse-grained (blue) soils observed at Jezero with SuperCam.

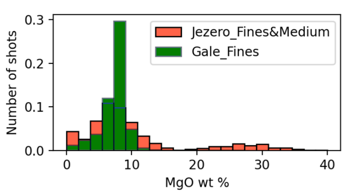

Fig. 3: Distribution of MgO content in Gale and Jezero fine-grained soils (containing medium-grained soils at Jezero).

Discussion: During this first year of Jezero exploration, we have found that the soils contain a higher proportion of very coarse grains (>1mm) compared to those analyzed at Gale crater. Chemistry and mineralogy of these very coarse-grained soils from Jezero show the influence of local/regional olivine-rich rocks, which is also consistent with [20]. However it seems that the fine/medium-grained soils at Jezero also have some influences from the local/regional rocks, which was not observed at Gale crater. For now it is difficult to know if this is due to some buried coarser-grains not visible from the images that could bias the average composition of this category of soils, or if this is related to chemistry/mineralogy of the medium-sized grains (250-500 µm), as those have not been distinguished in this study yet.

In such case that would mean that local inputs are not limited to very coarse grains and bigger particles, contrary to Gale crater. Indeed mafic minerals are more resistant to physical erosion, in contrast to feldspars [21], which were observed as local inputs at Gale crater [1,9].

Fine-grained soils at Jezero seem to be similar, from this preliminary study, to those from Gale crater. They also are enriched in S, Cl and H compared to coarser-grained soils. However, data from Jezero seem to have less S and more Cl than those from Gale.

If that is the case, this would mean that even in fine-grained soils there are some local inputs, as some perchlorates have been observed in Cf-Fr rocks [22,23]. [24] has shown that the dust observed at Jezero is overall similar to what was observed at Gale, even though some differences can be observed, possibly from local contributions as well (such as less S, more Cl, and slightly more Ca, Fe and Mg). This will be investigated further by removing the medium-grained soils from the finest fraction, but despite their apparent homogeneity at large-scale, fine-grained soils seem to suffer from local/regional contributions.

Future work: In this study the chemistry of the amorphous component in fine-grained soils at Jezero has not been investigated yet. H and S are correlated to each other but more investigations need to be done to infer the presence of hydrated Mg sulfates, such as in fine-grained soils at Gale [10]. This will be performed by looking at the shot-to-shot data. This work is a first step to investigate the processes of soils formation as well as the similarities or differences in fine-grained soils.

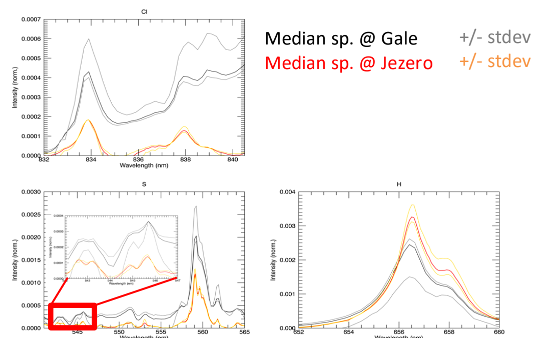

Fig. 4: Median spectrum of fine-grained soils at Gale (in black) +/- standard deviation and median spectrum of fine/medium-grained soils at Jezero (red) +/- standard deviation. Close-up at Cl, S and H signals.

References: [1]Meslin et al., Science, 2013;[2]Taylor & McLennan, 2009;[3]Certini et al., PSS, 2020;[4]Audouard et al., JGR 2014 ;[5] Yen et al., Nature, 2005;[6]Blake et al., Science, 2013;[7]Leshin et al., Science, 2013; [8]Bish et al., Science, 2012;[9]Cousin et al., Icarus, 2015;[10]David et al., Icarus, 2021;[11]David et al. 2022;[12]Hausrath et al., this meeting;[13]Cousin et al, this meeting;[14]Beyssac et al., this meeting;[15]Murphy et al., this meeting;[16]Gasda et al., this meeting;[17]Ehlmann et al., JGR, 2017;[18]Comon et al. Higher-Order Statistics, 1992; [19]Forni et al., Spec. Chem. Acta, 2013;[20]Cardarelli et al., this meeting;[21]Cornwall et al., Icarus, 2015; [22]Meslin et al., this meeting; [23] Schmidt et al., this meeting; [24]Lasue et al., this meeting.

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