CARBONATE-BEARING CRUSTAL EXPOSURE IN AN IMPACT CRATER ASSOCIATED WITH AN OUTFLOW CHANNEL CONTEXT.

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Introduction: The proposed landing site is located in an unnamed crater at the south-east boundary of Eos Mensa and an outflow channel. This eastern part of Valles Marineris has not been intensively studied up to now. However, a recent study on impact craters central peaks in the vicinity of Valles Marineris has shown that this unnamed crater, so called "J", exhibits some rocks enriched in low-calcium pyroxenes and carbonates [1].

As the proposed site is located in Noachian terrains, it gives access to old primitive crust and its alteration products. Presence of carbonates in the central peak could indicate a hydrothermal activity associated with the emplacement of the mafic unit [2,3] or with the impact process [4]. Hydrothermal deposits are of primary importance when considering past habitability as they could preserve the physical and chemical signs of life and organic matter [e.g., 5, 6].

The landing ellipse proposed here is directly inside the crater and include the central peak. Site characteristics are reported in Table 1 and Figure 1. Requested images focus on the main part of the central peak and additional outcrops going up to the rim of the crater.

Site stratigraphy and mineralogy: The unnamed crater "J" has been observed two times with HiRISE.

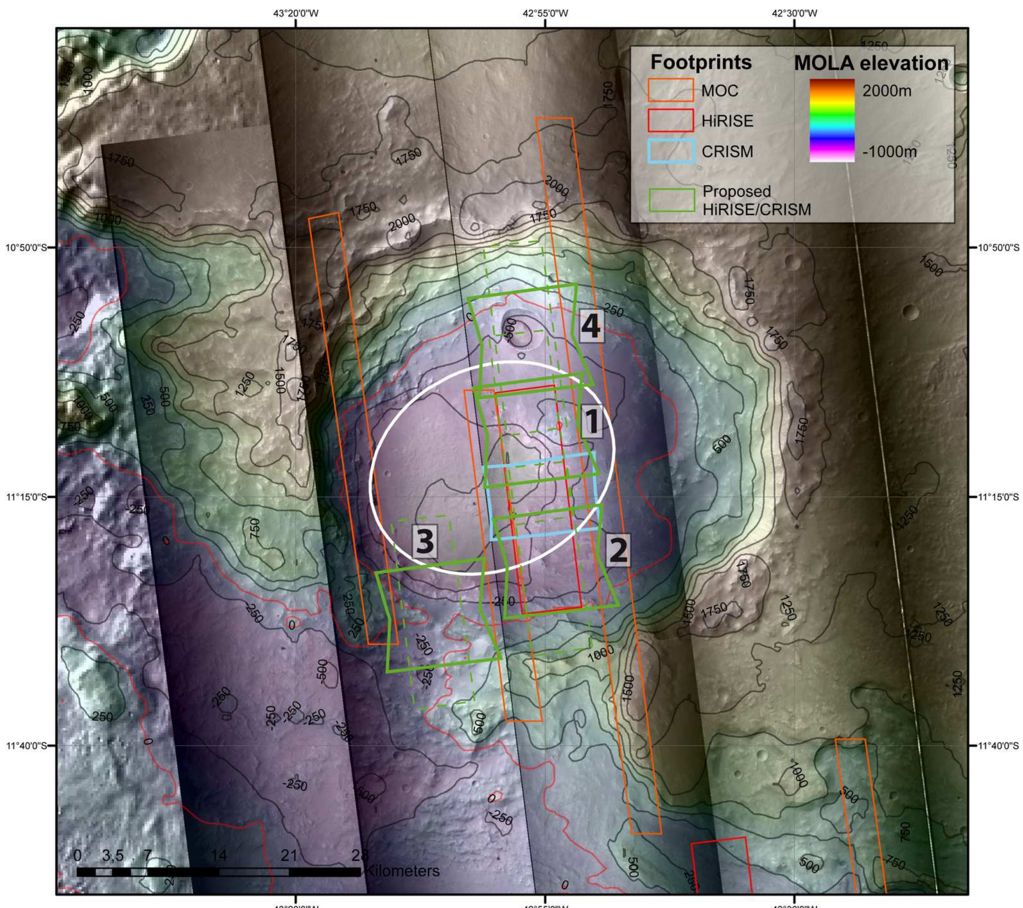

Figure 1: The 25 km by 20 km ellipse is centered at 11.20°S, 43.00°W at a MOLA elevation of -800 m (CTX background). The prime science targets are alteration products and igneous rocks in the central peak in the eastern part of the ellipse. The footprints of existing HiRISE, CRISM (low resolution product), and MOC images are shown. In green are the requested HiRISE and CRISM images, with priority ranging from 1 to 4 (respectively centered at 11.14°S, 42.94°W; 11.36°S, 42.90°W; 11.44°S, 43.10°W; 10.99°S, 42.94°W).

Table 1: Site characteristics

Site Name	Unnamed crater "J"
Ellipse center Science target center	• 11.20°S, 43.00°W • 11.14°S, 42.94°W
Elevation	-0.80 km
Prime Science and/or Sampling Targets	1) carbonates 2) mafic rocks (LCP)
Distance of Science and/or Sampling Targets from Ellipse Center	• 1-2) ~5 km to NE • Potentially other places in the crater peak and in crater south rim (<15km)

Images focus on the central peak which shows massive bright rocks (Figure 2). Those terrains look similar to other old Noachian rocks exposed around Valles Marineris [1,7]. There is here no apparent layering visible in the high resolution imagery. Deposits extend towards S, SE and N, up to the bottom of crater rim.

The only low resolution CRISM image which has been targeted on the central peak is localized just south to the main mound. The most interesting mineralogic signatures are located north of the image (cf. Figure 2). Spectral features clearly indicate two types of units, without obvious morphological distinction. The first spectrum shows the two pyroxenes absorption bands (black spectrum in Fig. 2). Band centers positions are typical of an enstatite-like composition with low Ca and Fe content. This could indicate a primitive mafic unit, potentially representative of the old Martian crust. The second unit shows three main absorptions (red spectrum in Fig. 2). The 3.86µm absorption indicates carbonate rather than serpentine. Band centers positions indicate here a magnesium carbonate [e.g., 2,8].

Carbonates have probably formed in a hydrothermal system, either during the emplacement of the mafic unit or in relation with the impact process. This implies relatively high temperature fluids percolating through fractures. Nevertheless, a second hypothesis could also explain their formation. Indeed, surface alteration dur-

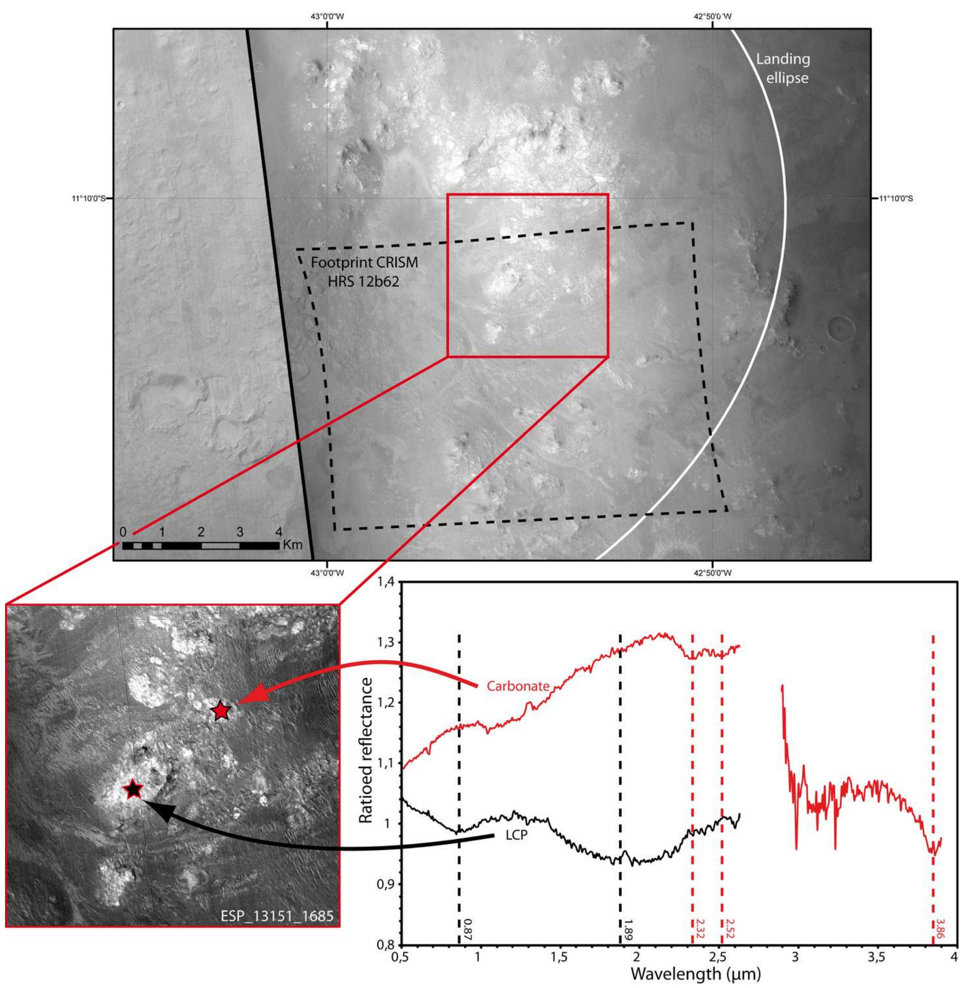

Figure 2: Spectra from the CRISM low resolution product HRS12b62 on high resolution imagery background (CTX and HiRISE) of the central peak at an unnamed crater on Eos Mensa. Two units can be found north of CRISM image. Spectral features indicate the presence of low-calcium pyroxenes and carbonates.

ing later Hesperian aqueous activity, in relation with the outflow channel SW of the crater, could also lead to the carbonate formation. Hydrothermal system or paleolake induced deposits are two different geologic settings and consequently the biological processes that may be recorded would differ.

Rationale for Images: More data are needed to distinguish between the two carbonates formation hypothesis and show that this place is particularly suitable for searching evidence of early life habitability. The characteristics of each requested CRISM/HiRISE is reported in Figure 1 and associated caption.

The highest priority ranked image (#1) is a detailed view of the central mound, just north to HRS12b62 (cf. Fig. 2). It seems obvious that high resolution spectroscopy is required to constrain previous detection of each unit. A CRISM image covering the entire bright outcrop will give information on i) what is the spatial extent of LCP and carbonates units? ii) is there a stratigraphic relationship between them? All these information will lead to a better comprehension of the hydrothermal cycle that may have affected the primitive crust. The CRISM image #2 is located south to the main bright outcrop. This image will allow the analysis of rocks coming from shallower depth. This is important to see what could have been the duration of the hydrothermal system. Moreover, it will give us information on a potential evolution of the minerals chemical compositions, indicative of a change in igneous chemistry and/or hydrothermal fluids characteristics. This could also help discriminate between an hydrothermal system related to emplacement of mafic unit or to the impact process itself. This could have strong implications for geological units habitability.

Next image, priority ranked #3, is localized southwest to the landing ellipse. With a distance of ~15km from ellipse center, this is the further science target. Goal is here to target outcrops in a place where surface water could have flow into the crater during the outflow event. If the rocks compositions are similar to the one on the crater floor, this could mean that the carbonates formation is apparently not related to hydrothermal activity. Habitability would have then been favored later in Martian history and for a shorter time.

Finally, the last image (CRISM #4) is requested to use a small impact crater in the northern part of the floor to sample deeper layer than in image #2. It could be used to make a global cross-section of units present in this area.

Engineering Constraints: The site is within 30° of the equator (11.20°S) and thus meets the latitude constraint. Surface has a thermal inertia of ~300 $J.m^{-2}.s^{-0.5}.K^{-1}$ which is above the 100 $J.m^{-2}.s^{-0.5}.K^{-1}$ threshold. The global altitude of the ellipse is below the 0 km MOLA elevation (-1000 to -200m), except for a circular mound (diameter ~2km) which have a summit at +27m (Fig. 1). This mound is also located close to a stronger slope (up to 20°) compared to the rest of the ellipse (<7°). However, even if this slope is high, it is below the limit of 25°-30° slopes at length scales of 2-5m and there are opportunity for the rover to go around the outcrop. Finally, as the proposed landing site is in a crater, the main difficulty could be the proximity of the crater rim where the slope are between 20 and 28° within the limit of 2-10km. Nevertheless, this criterion is not satisfied only if the rover is going to land in a west-east direction.

CTX coverage of the region is already complete. At this resolution, and except for the outcrop itself, terrains in the ellipse look like relatively smooth, with locally small sand ripples. Little impact depressions, sometimes partially filled, can also be found. Acquisition of the requested CRISM and HiRISE images will allow more complete assessment of both safety and in-ellipse science. The proposers would work with the landing site selection engineering team to ensure best targeting of MRO resources.

References: [1] Quantin et al., *Composition and structures of the subsurface in the vicinity of Valles Marineris as revealed by central uplifts of impact craters*, submitted to Icarus; [2] Ehlmann et al., *Orbital identification of carbonate-bearing rocks on Mars*, Science 322, 2008; [3] Ehlmann et al., *Identification of hydrated silicate minerals on Mars using MRO-CRISM: geologic context near Nili Fossae and implications for aqueous alteration*, JGR 114, 2009; [4] Rathbun and Squyres, *Hydrothermal systems associated with Martian impact craters*, Icarus 157, 2002; [5] Farmer and Des Marais, *Exploring for a record of ancient Martian life*, JGR 104, 1999; [6] Farmer, *Subsurface hydrothermal systems as Havens for Martian life*, Goldsmith Conference, 2006; [7] Flahaut et al., *Pristine crust and key geologic transitions in the deep walls of Valles Marineris: insights into the early igneous processes on Mars*, submitted to Icarus., [8] Cloutis et al., *Spectral reflectance properties of carbonates from terrestrial analogue environments: Implications for Mars*, PSS 58, 2010;