THE FIRST GY OF MARTIAN HISTORY AND ITS DIVERSE ENVIRONNEMENTS EXPOSED IN COPRATES CHASMA, VALLES MARINERIS

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Introduction: Analysis of MRO data inside Valles Marineris and in the vicinity of the canyon have revealed a major crustal boundary separating volatile-rich pre-Noachian Martian primitive crust in the eastern parts of Valles Marineris and a Noachian volcanic accumulation due to Tharsis activity in the western parts [1,2]. The crustal transition is exposed in Coprates Chasma and would occur in the vicinity of Coprates rise. We propose a potential landing site for future missions of the joint program of NASA-ESA on the flat floor of Coprates Chasma, Valles Marineris at the level of the major crustal dichotomy (center latitude -12.59°N, center longitude -64.13°E, elevation -5000 m, Figure 1). The landing site on the floor of one of the canyons of Valles Marineris offers also the opportunity to study sulfates bearing Interior layered Deposits (ILD) [3, 4] and water flow morphologies.

The walls of Coprates Chasma northward and southward of the ellipse expose both the pre-noachian primitive Low Calcium Pyroxene rich crust (Figure 2) and the Noachian Tharsis lava stack [2]. The canyon entailed this complex crust presumably at the begin-

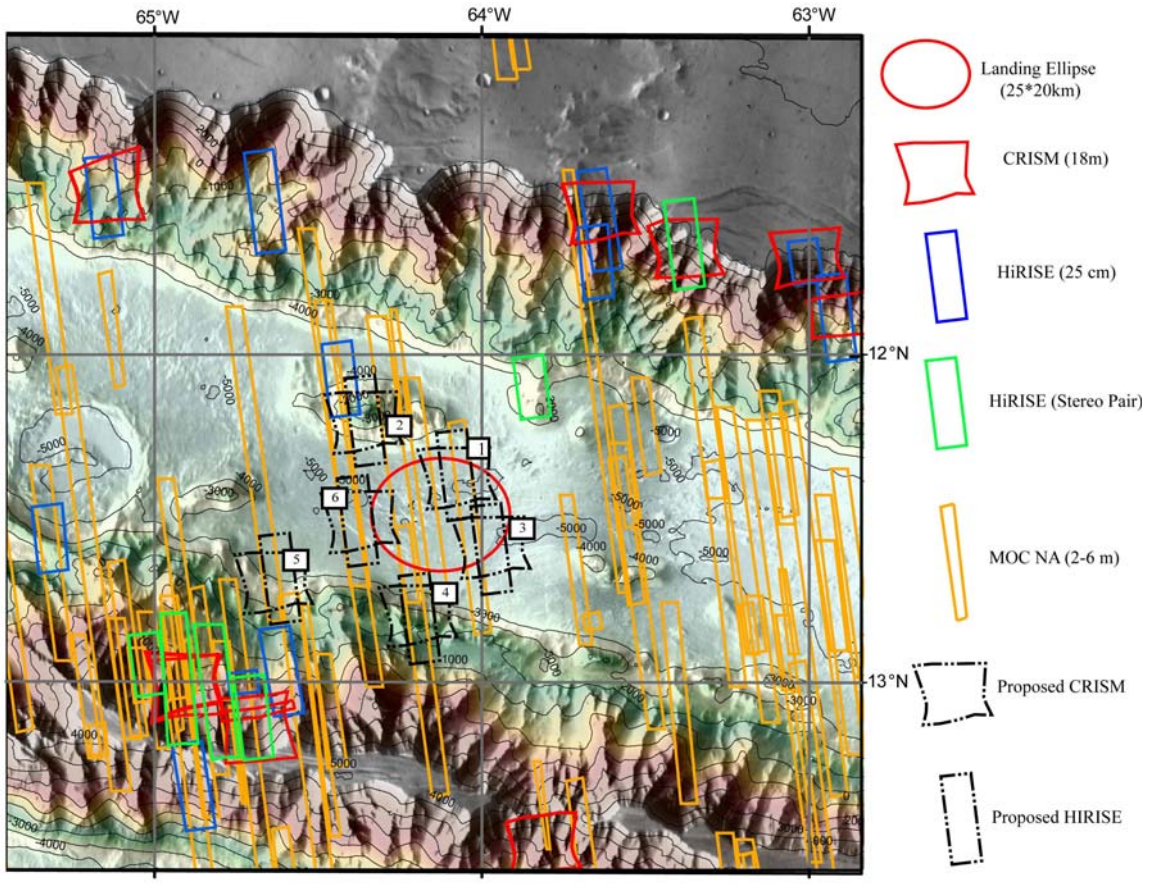

Figure 1: Location of the suggested landing site in Coprates Chasma centerd at -64.13°E and -12.59°N. The footprints of existing HiRISE, CRISM and MOC images are shown as well as requested HiRISE image and CRISM image ranked from 1 to 6 by priority order.

ning of the Hesprian period. Coprates Chasman hosts a sulfate-rich ILD [4] perched in the walls just south of the landing ellipse. CTX images provide evidences that water flooded on the floor of Coprates Chasma and that the floor of the canyon is covered by a thin layered light toned formation (Figure 2B). The geological surrounding of the proposed landing site has recorded major phases of the first Gy of Martian geological evolution: 1) formation of the primitive crust possibly from a magma ocean, 2) the volcanic accumulation due to Tharsis activity, 3) Opening of Valles Marineris, 4) Hesperian water discharges, 5) Hesperian sulfates rich deposit formation. Each phase represents potential environment for life development as attested by the presence of large diversity of hydrated minerals [1, 2, 4, 5, 6]. Consequently, Coprates is a unique site for testing life emergence in distinct periods of early mars history in a single landing site.

Engineering Constraints: Coprates landing site (Figure 1) meets most of the current engineering criteria defined by the future Mars exploration. As the landing ellipse is located inside the floor of the canyon, the area is almost flat with slopes < 3°, except for small areas. The wallslope of the canyon with highest slopes (<20°) are present at a distance of 5 to 10 km to the ellipse. The mean elevation of the canyon floor of Coprates chasma is -5000 m. The thermal inertia from TES [7] is around ~600 $J.m^{-2}.s^{-0.5}.K^{-1}$ which is above the 100 $J.m^{-2}.s^{-0.5}.K^{-1}$ threshold. The roughness at CTX scale seems not to be concerning. However, as the ellipse is not yet imaged by HIRISE, the probability that a rock taller than 0.55 m high cannot yet be assessed. The winds inside the canyon could be a major concern that needs to be studied in more detail.

Science Merit Related to Mission Objectives:

Coprates Chasma is a unique place for exposing rocks from distinct periods of early mars history:

-**Formation of the primitive crust** possibly under a magma ocean: Valles Marineris is a unique place where the primitive martian crust enriched in Low Calcium pyroxene is exposed [2]. Various hydrated minerals have been detected in the context of these crustal exposures [2, 5, 6]

- **Tharsis related volcanic activity**. The volcanic layers exposed in the walls of the eastern canyons of Valles Marineris are more than 10 km thick at certain location. The assessment of their total thickness suggests a volcanic pile of more than 15 km [1]. These layers observed upfilted in central peak of the surrounding plain of Valles marineris are enriched in phyllosilicates, such as smectites [1]. These layers are supposed to be exposed in the walls of Coprates Chasma just south of the ellipse [2].

- **Valles Marineris formation:** the canyon would have been formed by tectonic extension in response to Tharsis emplacement [7]. Many faults are observed in Coprates Chasma including around the ellipse.

- **Hesperian water discharges:** The floor of Coprates Chasma exposes morphologies related to water discharges [8]. These figures are presents inside the ellipse.

- **Hepserian sulfate-rich deposits**: Coprates Chasma has a perched ILD enriched in sulfates interpreted as Hesperian deposits [3,4]. The landing ellipse is located at the outlet of this perched basin.

Each of these periods of early Mars history had favorable conditions for putative life emergence.

Table 1: Summary of the proposed landing site

Site Name	Coprates
Center Coordinates Latitude, longitude	-12.59°N , -64.13°E
Elevation	-5 km (MOLA)
Prime Science and/or Sampling Targets	Crustal exposures [Highest Priority], Phyllosilicates and sulfates [Highest Priority], Layered materials[Lowest Priority]
Distance of Science and/or Sampling Targets from Ellipse Center	Crustal exposures (Mafic+ hydrated minerals) 22 km to N Sulfates – 33 km to SE Layers – 0 km Channels – 0 km

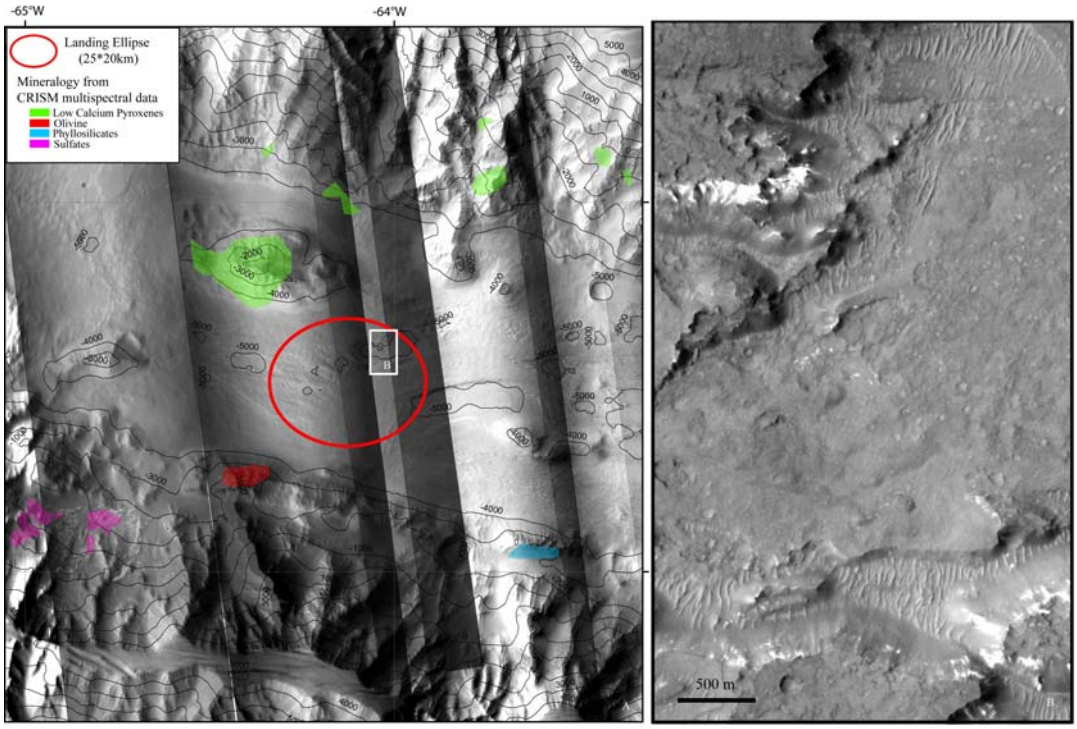

Figure 2: A) Mineralogy suggested by CRISM mulitpsectral survey around the ellipse. All these detections need to be checked by high resolution (spatial and spectral) data. The geological context of the landing site is enriched in mafic minerals as well as in hydrated minerals (both phyllosilicates and sulfates). B) Enlargement of the MOC image M0401534 covering a part of the ellipse. This image illustrates the light toned floor layered formation.

Rationale for Images:

Currently, the floor of the canyon is not covered by high resolution instrument from MRO and only few images cover the walls. New data as proposed in the figure 1 would provide crucial inputs about the diverse environments exposed in Coprates Chasma:

Requested image ranked 1 is located inside the ellipse and has for goal to image at high resolution the landing ellipse. Exposures of the light toned layered floor formation are present in this location.

Requested imaged ranked 2 is located on a central Mons of the canyon exposing crustal bedrock enriched in Low Calcium Pyroxenes and possibly in phyllosilicates. This image is located 2 kilometers north to the landing ellipse.

Requested image 3 would images the south part of the landing ellipse. The scientific goals of this image are the same as requested image 1.

Requested image 4 would image the base of the southern wall of Coprates Chasma 5 kilometers south of the ellipse. This part of the walls should not expose the crust enriched in Low Calcium pyroxene but volcanic layers instead. High resolution Image would test this hypothesis.

Requested image 5 is located at the outlet of the perched basin hosting the sulfate-rich ILD of Coprates Chasma. The presence of sulfates in this area has to be checked.

Finally, the requested image 6 would image the western part of the ellipse on the floor of Coprates Chasma with the same scientific goal as requested image 1 and 3.

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] 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., [3] Gendrin et al., Science 2005, Sulfates in martian layered terrains: The OMEGA/Mars Express view [4] Fueten et al., JGR 2010, Interior layered deposits within a perched basin, southern Coprates Chasma, Mars: Evidence for their formation, alteration, and erosion [5] Ehlmann et al., Science 2011, subsurface water and clay minerals formation during early mars history [6] Murchie et al., JGR 2009, Compact Reconnaissance Imaging Spectrometer for Mars investigation and data set from the Mars Reconnaissance Orbiter's primary science phase; [7] Carr and Head, EPSL 2010, Geologic history of Mars, [8] Harrison and Chapman, Icarus 2008, Evidence for ponding and catastrophic floors in central Valles Marineris, Mars