OXIA PLANUM, THE LANDING SITE FOR EXOMARS 2018

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Introduction: The ExoMars 2018 mission (ESA) has for scientific objectives to search for signs of past and present life on Mars, to investigate the water/geochemical environment as a function of depth in the shallow subsurface, to study to Martian atmospheric trace gases and to characterize the surface environment [1]. The Exomars rover will carry a suite of instruments dedicated to geology and exobiology and will be able to travel a few kilometers searching for past and present traces of life. Its landing ellipse is 19 km by 104 km. The Rover will collect and analyze samples from outcrops and from subsurface drills down to 2 m depth to look for well preserved organic molecules [1]. The landing site has to be relevant with regard to these objectives while fitting the restrictive engineering constrains. From the scientific point of view, the site must be ancient, from the Early Mars period, for which many scientific evidences favor the existence of a water-related cycle. The site must bear abundant morphological and mineralogical evidence of long-lived aqueous activity, the site must expose sedimentary rocks that are good candidates for organic matter preservation and more importantly, the relevant outcrops must be distributed over the landing ellipse to ensure that the rover will have access to one of them within its traverse range, which is restricted to a few (~4) kilometers [1]. In this paper, we present the unique location called Oxia Planum, a wide clay bearing plain located between 16° and 19° North and -23° to -28° East, which has been chosen by ESA as the prime landing site for Exomars 2018 (Fig. 1). We will discuss the geological context of these clay-bearing deposits, and the fluvio-lacustrine system observed on the site. We will ultimately discuss the results in term of implications for ancient Mars history and for ExoMars mission.

Geological context: Oxia Planum is located between Ares Vallis and Marwth Vallis in a wide basin just at the outlet of Cogoon Vallis System, with elevations ranging from -2800 m down to -3100 m. The regional compositional mapping of Oxia planum has been achieved based on near-infrared, nadir-pointed OMEGA data at a 2.5 km pixel scale as well as CRISM multispectral data at 200 m/pix. Mg/Fe phyllosilicates are identified and mapped based on their diagnostic absorptions at ~1.4, ~1.9 and ~2.3 µm [2]. Phyllosilicates are exposed over about 80% of the ellipse surface, based on a conservative mapping at low resolution.

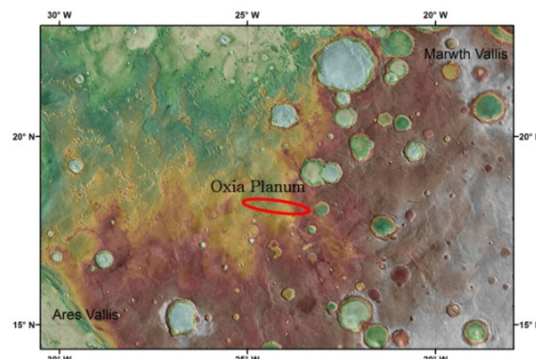

*Figure 1: Regional context of Oxia Planum and landing ellipse for ExoMars 2018 (red ellipse is 19*104 km). Background is MOLA topography.*

Several hyperspectral targeted CRISM cubes at full (~20 m/pixel) and half (~40 m/pixel) resolution are also available over Oxia Planum and confirm widespread occurrence of Mg/Fe phyllosilicates [2] in association with a layered light-toned unit. The entire unit with phyllosilicates signatures corresponds to a light-toned layered unit that is observed over a large range of elevations (from -2600 m to -3100m). Layering is visible over a thickness of at least 50 m anywhere in this unit. This may suggest that like in Marwth Vallis region, the layered and altered formation overlaps a pre-existing topography [3]. The age returned from crater count on the clay rich formation is 3.9 Ga. At the top or embedded within the layered formation, several fluvial morphologies such as former valleys or inverted channels are observed (cf fig. 2). At the top of the layered clay-rich formation, a deltaic deposit is observed suggesting sub-aqueous episodes postdating the altered layered formation. On top of the stratigraphy, a deposit about 20 meters thick fills the lowest points, covering both the layered formation and the fluvial morphologies. This latter unit shows several morphologies suggesting effusive volcanism and crater counting yields an age of 2.6 Ga. This unit has no hydration signature. The entire area is undergoing erosion, which is attested by anomalies in crater density. The youngest exposures of the underlying phyllosilicate rich unit is about 100 My old, based on crater retention age assessment. There could thus be a fair chance that putative biosignatures have been preserved from the cosmic ray exposure during the past 4 Gy, and only exhumed recently.

Fluvio-deltaic morphologies: The landing ellipse is located in a basin into which several valley systems converge (cf. Figure 2). It is the case of the Cogoon valley system. At the outlet of Cogoon Valles, a fan is observed. This fan has a relatively flat surface, is more than 10 km long and about 80 m thick (Fig. 3). On THEMIS night-time infrared images, the fan behaves as a low thermal inertia material suggesting fine grain material (Fig. 3). Detailed morphological analysis of the fan reveals overlapping flow directions. This particularity, the fact that the fan is relatively flat and that the material seems fine grains suggest that this fan may be a delta fan. Looking at the waterline elevation required to immerse this fan, we can observe that the other valley systems converge to low thermal inertia fan at exactly the same elevation as the major fan. This fact re-enforces the hypothesis of a standing body of water postdating the history of the layered clay rich formation. In terms of mineralogy, the putative delta fan shows layers enriched in hydrated silica [2]. This delta fan implies a second and distinct period of alteration in Oxia Planum. In term of age, the delta has a too small surface to allow a confident age assignment from crater count. We can only say that the delta-fan is older than 3.5 Ga. However, if we look at the global geological map from [4], the outlet of Oxia Planum basin is capped by the volcanic formation filling the northern plains mapped as early Hesperian. The hydrological activity in Oxia Planum would be Early Hesperian or older.

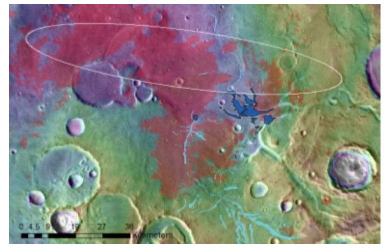

*Figure 2: Fluvio-deltaic deposits in the catchment area around the landing ellipse. Light Blue denotes the valleys and Blue denotes the deltaic deposits. The landing ellipse for Exomars appears in white and is 19*104 km. Red color map the hydrated mineral from OMEGA and CRISM multispectral data. The background is MOLA in transparency on THEMIS day time mosaic.*

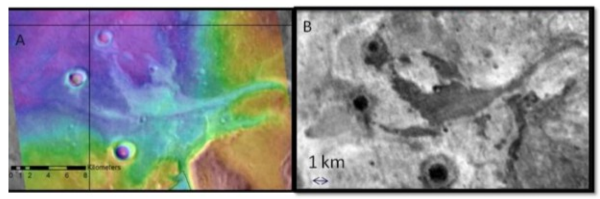

Figure 3: The deltaic system at the outlet of Cogoon Vallis. A] Mola topography and B) THEMIS night time infrared mosaic.

Conclusion : Oxia Planum exhibits outcrops of Noachian phyllosilicates over hundreds of kilometers of terrain. The site also hosted a standing body of water leading to the formation of a delta fan enriched in hydrated silicates. Hence, this site recorded at least two clearly distinct alteration environments and contexts: 1) the alteration of the Noachian layers and 2) the fluvio-deltaic system post-dating the Noachian clay rich unit. Deciphering the formation environments for such diverse altered rocks would fulfill the goals of the ExoMars Rover.

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References: :[1] ESA, 2013. ExoMars Science Management Plan, Doc. No: EXM-MS-PL-ESA-00002, Issue: 6, Rev. 0, 20 September 2013, 66 p. [2] Carter et al., (this conference); [3] Loizeau et al., JGR, E08S08, 2007. [4] Tanaka et al., 2014.