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ExoMars 2018 Rover Candidate Landing Sites: Aram Dorsum and the Hypanis Vallis Delta

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1. Introduction

The search for life on Mars is a cornerstone of international solar system exploration. In 2018, the European Space Agency will launch the ExoMars Rover to further this goal. The ExoMars Rover's key science objectives are to: 1) search for signs of past and present life on Mars; 2) investigate the water/geochemical environment as a function of depth in the subsurface; and 3) characterize the surface environment. ExoMars will drill into the sub-surface to look for indicators of past life using a variety of techniques, including assessment of morphology (potential fossil organisms), mineralogy (past environments) and a search for organic molecules and their chirality (biomarkers).

The choice of landing site is vital if the objectives are to be met. The landing site must: (i) be ancient (≥3.6 Ga); (ii) show abundant morphological and mineral evidence for long-term, or frequently recurring, aqueous activity; (iii) include numerous sedimentary outcrops that (iv) are distributed over the landing region (the typical Rover traverse range is a few km, but ellipse size is ~104 by 19 km). Various engineering constraints also apply, including: (i) latitude limited to 5º S to 25º N; (ii) maximum altitude of the landing site 2 km below Mars's datum; and (iii) few steep slopes within the ellipse.

In 2014, two international workshops were held to discuss potential landing sites. The outcome of these workshops was a shortlist of four possible sites: Aram Dorsum, Hypanis Delta, Mawrth Vallis, and Oxia Planum. We proposed the Hypanis and Aram Dorsum sites and led the scientific presentations for these sites at the Workshops. Here, we present the science cases for Aram Dorsum and Hypanis Vallis.

2. Aram Dorsum

The Aram Dorsum site in western Arabia Terra (Fig. 1) is situated about half way between Meridiani Planum and the dichotomy boundary, where Arabia Terra meets the northern lowlands. Aram Dorsum itself is a flat-topped, branching, sinuous ridge-like feature that is surrounded by smoother marginal materials. We interpret Aram Dorsum to be a former fluvial channel system that has been preserved in positive relief by differential erosion. Such features are fairly common on Mars [1], and are also well-studied on Earth [2]. Aram Dorsum is interesting in that it is overlain by overburden materials including both ejecta from nearby 10-50 km diameter craters, and regionally-extensive, sedimentary layers [3]. These materials are Noachian, so Aram Dorsum itself must be at least this old.

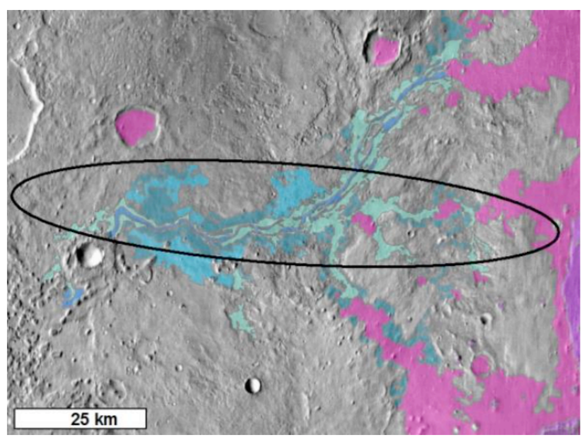

Figure 1: Aram Dorsum site and 2018 landing ellipse. Blue/green areas are Aram Dorsum or its marginal units. Flow is inferred to be East-to-West. Purple areas are regionally extensive, Noachian-aged superposing sedimentary units.

The presence of channels at different stratigraphic positions indicates long-lived fluvial activity, not catastrophic flow. This is reinforced by the overall sinuous, branching morphology of the channel, consistent with a river-like fluvial system. Aram Dorsum is a Noachian-era, aggradational, multithread/sinuous river-system, including small tributaries and extensive flood plain-like marginal deposits. It displays clear evidence for the long-lived action of water in the Noachian. Although the inverted channel likely contains mainly coarse-grained sedimentary outcrops, the channel marginal unit is probably fined-grained sediments, or could contain lenses and/or 'islands' of fine-grained material suitable for preserving biosignatures. Importantly, the system has been exposed from beneath >100s of metres of overburden materials; outliers of such overburden are still present. Such burial/exhumation greatly benefits preservation of biosignatures. Science targets comprising channel marginal units and inliers within the overburden cover a significant proportion of study area and are distributed throughout the ellipse.

3. Hypanis Vallis

The Hypanis landing site in northern Xanthe Terra is situated on the dichotomy boundary. Our study area includes fluvio-deltaic deposits at the termini of Sabrina Vallis and Hypanis Vallis (Fig. 2). Mapped Sabrina terminal deposits are constrained to within the buried crater, Magong. The Hypanis deltaic system is more extensive, with multiple depositional lobes extending to the north and east.

Significant aeolian modification has occurred since delta formation, with crater counts on both Sabrina [6] and Hypanis [8] delta units revealing crater-retention ages of < 100 Ma, supported by the presence of ubiquitous aeolian features and suggesting recent exhumation from overburden. The large crater population classifies the study area as mid to late Noachian terrain [6, 8].

CRISM observation FRS0003157E ('Y' in Fig. 2) shows a 1.9 μm hydration signature that spatially aligns with exposed strata in eroded deltaic sediments, indicating putative hydrated minerals in discrete layers. A spectral unit in FRS0003134F ('X' in Fig. 2) is defined by the combined presence of the 1.9 μm absorption plus a strong 2.3 μm dropoff in reflectance, indicative of the presence of Fe/Mg-phyllosilicates [4,5]. Both spectral signatures are located between, but not immediately adjacent to, the Sabrina or Hypanis deltas, perhaps indicating that extensive ancient fluvial activity has influenced mineralogy throughout the landing ellipse. The Sabrina Vallis delta deposits in Magong crater also indicate a weak Fe/Mg-phyllosilicate signature that is consistent with the presence of nontronite, verminculite or saponite in delta sediments [6].

The Hypanis site displays clear evidence for the long-lived action of water in the Noachian. The total northward flow, including that through a now degraded channel connecting Nanedi Vallis to Hypanis Vallis, removed and deposited ~850 km^3 of material, of which the Hypanis deposits are estimated to comprise ~150 km^3 [7]. The most rewarding science target may lie in the Sm, Em and Le units, which are pervasive throughout the ellipse. Sm and Le exhibit fine-scale layering and the presence of phyllosilicates. Low-energy depositional environments that formed or influenced delta-proximal exposures of these units may have concentrated any potential biosignatures transported from the upstream Hypanis-Nanedi fluvial system.

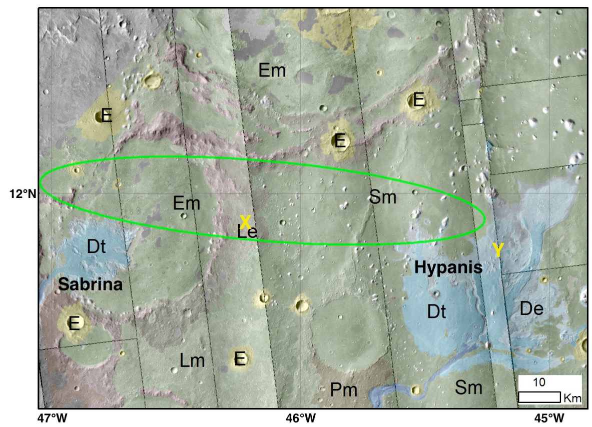

Figure 2: Geologic map of Hypanis study area overlaid on CTX. Deltaic units are blue. The nominal 104 x 19 km 2018 landing ellipse is bright green. CRISM observations are the yellow 'X' and 'Y'.

Recent exhumation of this formation could imply its protection from the surface environment for much of Mars' history, resulting in a high preservation potential for any biomarkers emplaced in the Hypanis-Sabrina delta system.

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