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End-to-End Mars Sample Return Science Analysis Group: From Objectives to Reference Landing Sites

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1. Aim of the analysis

The End-to-End Mars Sample Return analysis group goals are to (1) define objectives, (2) define criteria for sampling and landing site definition (3) identify reference landing sites and (4) propose technological inputs for the overall sample return campaign (from the first mission to the analysis of samples on Earth), and not just one segment of this program. Here, a focus is on the definition of landing site criteria to provide reference sites for the proposed MSR campaign. The purpose of the reference sites will be to help the engineers design the mission elements in a way that at least some sites of interest could be accessed. These reference sites will not carry any formal status; there is to be an independent landing site competition.

2. Landing site criteria

To assist in planning the engineering of the landed elements of the proposed MSR campaign, we identified several reference landing sites of interest that contain the proposed attributes. The search for reference landing sites for the proposed 2018 caching mission began with a review of the ~60 landing sites proposed for the MSL mission [1] and ~25 landing sites proposed for possible future missions and possessing varying objectives. Although the overall proposed objectives for the 2018 mission differ from those for these other missions, they were viewed as a good starting point because of some overlap in science objectives and because many of the sites considered for other missions are partially to nearly completely covered by high resolution spatial and spectral resolution data (e.g., from MRO, MEx, and Odyssey).

A sub group focused on four threshold criteria listed in Table 1. These threshold criteria relate primarily to the inferred depositional setting and age of the rocks considered to be of highest priority for sample return and included the strong desire for the presence of igneous rocks, a major objective for the proposed MSR campaign, as defined from the E2E group. Additional qualifying criteria ranging from morphologic evidence of setting to the age of volcanic units to be accessed were not included in identification of reference sites because there was concern that too many criteria would overly constrain the number of viable sites. This was not viewed as a problem because the reference sites are not intended to serve as a short list for where sample return would occur, but rather are intended to define reasonable science and engineering criteria for the mission.

3. Reference sites

The region of Nili Fossae spans a diversity of hydrated minerals rarely obtained on Mars. Three sites are proposed in this broad region with a different context and the presence of igneous rocks at each of them. **Nili Fossae Trough** is located on the floor of the Nili graben on Hesperian volcanic flows. Locations favorable to exobiology contain phyllosilicates in both layered and massive units, and impact breccia [2]. About 200 km east of Nili trough, **Jezero crater** is a paleolake identified by two delta fans [3]. The fans contain hydrated minerals and possibly carbonates and would have collected material from the altered highlands [4]. The crater floor contains mafic minerals showing rough textures consistent with Hesperian age volcanic flows. Landing on plains at the **NE Syrtis Major** site would enable a sampling of a well-defined volcanic unit with a go-to exobiological objective inside the layered material beneath the lava flows and in the altered highlands [4]. The **Mawrth Vallis** region is another region with strong aqueous alteration, mainly present as phyllosilicates [e.g. 5], which is considered of high interest for early Mars environment and exobiology [6]. **Eastern Margaritifer Terra** is located in the channeled highlands of Noachian age, south of Meridiani Planum. The small basin where the ellipse is located contains phyllosilicates, and possibly chlorides, with basaltic unit at the top [7].

Although **Gusev crater** was not the expected holy grail of the Martian paleolakes, the Spirit rover found that the Columbia hills in the center of Gusev were a paradise for hydrothermal alteration [e.g. 8]. Gusev provides both the well-defined igneous units and the diversity of mineralogy and rocks formed under an environment that should be of exobiological interest. **Ismenius Cavus** is a 60 by 90 km elliptical trough located in Ismenius Lacus region. It is the most challenging site proposed here, because it is at high latitudes (34°N). The interest of this site is that it shares the presence of a paleolake, phyllosilicates and mafic signatures in spectral data and mid-latitude glaciers on its side [9]. Thus, in addition to containing reachable igneous rocks, the seven reference sites proposed have been chosen to be complementary and representative of different geological context (paleolakes, ancient basin, hydrothermal sites, altered crust) containing a variety of alteration minerals (phyllosilicates, sulfates, chlorides, carbonates).

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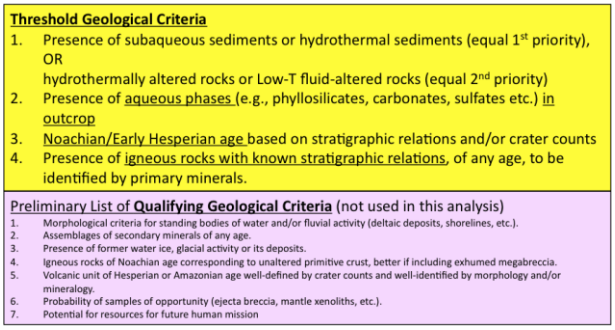

Figure 1: Threshold and qualifying criteria