EPSC Abstracts
Vol. 12, EPSC2018-578, 2018
European Planetary Science Congress 2018

The Science Process for Selecting the Landing Site for the 2020 Mars Rover

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Abstract

Identifying the landing site for NASA's Mars 2020 rover began by: defining threshold mission science criteria related to seeking signs of ancient habitable conditions; searching for biosignatures of past microbial life; assembly of a returnable cache of samples for possible future Earth return; and collection of data for planning human missions to Mars. Mission engineering constraints helped identify candidate landing sites addressing mission science objectives. For the first time, however, these constraints did not have a major influence on candidate viability due to reductions in ellipse size and the ability to avoid hazards, Hence, sites were evaluated and down-selected based on science merit.

1. Introduction

The Mars 2020 rover will evaluate surface materials to achieve mission science objectives that include: exploration of an ancient astrobiologically relevant environment preserving information on the geological record, including past habitability and biosignature preservation potential; searching for potential biosignatures; and caching samples for possible future Earth return [1]. All landing site selection activities serve to maximize the probability of landing safely with access to high-priority science targets. Because the rover and entry, descent, and landing (EDL) system are evolved from the Mars Science Laboratory (MSL) rover [2], many engineering constraints are comparable. The higher atmospheric density expected on arrival at Mars in 2021 [3] and inclusion of Range Trigger and Terrain Relative Navigation (TRN) EDL capabilities on the 2020 rover [1, 3-5], however, enables a smaller landing ellipse at higher elevation and provides access to locales where surface relief precluded landing by MSL. All activities related to discussion of the candidate landing sites are available at: https://marsnext.jpl.nasa.gov.

2. Landing Site Workshops

Candidate sites with likely acceptable surface and atmospheric conditions were assessed at workshops in the years prior to launch (Fig. 1). During that period, iteration between engineering constraints and the evolving relative science potential of candidate sites led to identification of three final candidate sites.

2.1 The First Landing Site Workshop

Initial evaluation of ~30 sites (including landing sites and final candidate sites from prior missions) was made at the first landing site workshop in 2014 (Fig. 1). The focus was on identifying which sites were best suited to achieve mission science objectives within the constraints imposed by engineering and planetary protection requirements, and the necessity of ensuring a safe landing. Voting determined which sites: 1) had the highest overall science merit; 2) were most in need of additional imaging by orbital assets; and 3) included regions of interest likely accessible upon landing or located outside the landing ellipse. Proposed sites with a range of science regions of interest, encompassing a wide range of martian history, and relatable to important events in the Mars stratigraphic record were ranked highest. Nevertheless, all sites remained under consideration and were targeted for additional orbital data to better assess their science merit and ability to meet engineering or planetary protection constraints.

2.2 The Second Landing Site Workshop

The focus during the second landing site workshop in 2015 was to distill the list of candidate sites down to ~8 sites (Fig. 1). Five scientific criteria guided assessment and included: 1) confidence that the geologic setting and history of the landing site could be characterized and understood; 2) evidence that the site offers an ancient habitable environment; 3) rocks with high biosignature preservation potential are available and accessible for investigation of astrobiological potential; 4) the site offers an adequate abundance, diversity, and quality of samples suitable for addressing key astrobiological questions if returned to Earth; and 5) the landing site offers an adequate abundance, diversity, and quality of samples suitable for addressing key planetary evolution questions if returned to Earth. The rank ordering of the final eight sites became: Jezero crater (18.5ºN, 77.4 ºE), Columbia Hills (Gusev crater, 14.4 ºS, 175.6 ºE), Northeast (NE) Syrtis Major (17.8 ºN, 77.1ºE), Eberswalde crater (23.0ºS, 327.0ºE), Southwest (SW) Melas Basin (12.2ºS, 290.0ºE), Nili Fossae (21.0ºN, 74.5ºE), Mawrth Vallis (24.0ºN, 341.1ºE), and Holden crater (26.4ºS, 325.1ºE).

2.3 The Third Landing Site Workshop

With focus on science merit rather than engineering concerns as the driver for final landing site selection, discussion at the third workshop in 2017 provided community input into culling the candidate sites down to three (Fig. 1). The Jezero crater and NE Syrtis sites were consistently assessed higher for astrobiological relevance and potential of returned samples and were highly ranked relative to confidence of site interpretations and accessibility of targets in regions of interest. By contrast, the Holden crater and SW Melas basin sites were consistently assessed the lowest relative to astrobiological relevance and potential of returned samples and were ranked low relative to confidence of site interpretations and accessibility of targets in regions of interest. Columbia Hills, Eberswalde crater, Mawrth Vallis, and Nili Fossae sites received intermediate assessments

3. Three Final Candidate Sites

Following the third workshop, the Mars Landing Site Steering Committee, the Mars 2020 Project Science Group, representatives from the Returned Sample Science Board, and 2020 Project engineers down-selected the candidate sites. The NE Syrtis site was chosen because it includes lithologic diversity in an accessible and understood stratigraphic context that appears to span a broad interval of early Mars history. The Jezero crater site was selected because it offers a well-defined Noachian-aged delta environment including bottomset and lacustrine facies deemed to be fine-grained and most favorable for organic concentration and preservation. The Columbia Hills site includes a range of potentially attractive exploration targets including a silica-rich, putative hydro-thermal sinter deposit and the presence of a diverse suite of previously characterized volcanic rocks. The Columbia Hills site is relatively less favorable compared to the NE Syrtis and Jezero crater sites and its retention is contingent on further development and testing of its geologic setting and work to overcome potential engineering challenges involving sampling the putative sinter deposits. A fourth workshop in October 2018 will focus on assessing new results on site science potential, possible extended mission targets, and Project provided mission scenarios that includes discussion of potential exploration targets, observations, and sampling strategies relative to mission goals and important Mars science described in the 2013-2022 Planetary Science Decadal Survey.

References

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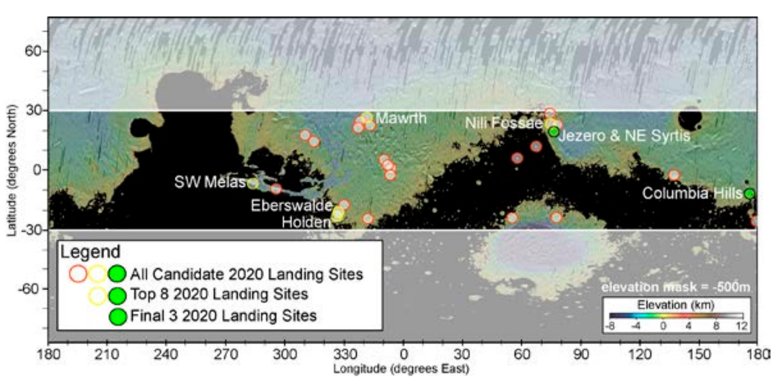

Figure 1. Map showing location of all 2020 candidate landing sites. Excluded elevations (above -500 m) are black and excluded latitudes (above 30^0 N and S) are shaded white. Actual ellipse size is smaller than dots. MOLA data over global THEMIS daytime IR data (irregular black areas indicate data gaps).