THE PROPOSED MARS ASTROBIOLOGY EXPLORER - CACHER [MAX-C] ROVER: FIRST STEP IN A POTENTIAL SAMPLE RETURN CAMPAIGN.

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Introduction: Sample return from Mars has been advocated by numerous scientific advisory panels for over 30 years, most prominently beginning with the National Research Council's [1] strategy for the exploration of the inner solar system, and most recently by the Mars Exploration Program Analysis Group (MEPAG's) Next Decade Science Analysis Group [2]. Analysis of samples here on Earth would have enormous advantages over *in situ* analyses in producing the data quality needed to address many of the complex scientific questions the community has posed about Mars. Instead of a small, predetermined set of analytical techniques, state of the art preparative and instrumental resources of the entire scientific community could be applied to the samples. The analytical emphasis could shift as the meaning of each result becomes better appreciated. These arguments apply both to igneous rocks and to layered sedimentary materials, either of which could contain water and other volatile constituents.

In 2009 MEPAG formed the Mid-Range Rover Science Analysis Group (MRR-SAG) to formulate a mission concept that would address two general objectives: (1) **conduct high-priority *in situ* science** and (2) **make concrete steps towards the potential return of samples to Earth.** This analysis resulted in a mission concept named the Mars Astrobiology Explorer-Cacher (MAX-C), which was envisioned for launch in the 2018 opportunity. After extensive discussion, this group concluded that by far the most definitive contribution to sample return by this mission would be to collect and cache, in an accessible location, a suite of compelling samples that could potentially be recovered and returned by a subsequent mission. This would have the effect of separating two of the essential functions of MSR, the acquisition of the sample collection and its delivery to martian orbit, into two missions.

The strategy of collecting and caching geological samples on Mars for possible return to Earth by a later mission has been discussed as far back as at least the mid-1990s. However, the first detailed discussion of caching was presented in 2005 by MacPherson *et al.* [3]. They pointed out some of the major advantages of caching, including reducing time on the surface for the potential Mars Ascent Vehicle (MAV), improving sample documentation by a prior mission that has better instrumentation, and the engineering advantages of sending the potential Mars Sample Return (MSR) lander into known terrain. Sample caching was also recognized as a strategy to increase the scientific value of a potential future sample return by Mars architecture planning teams [e.g. 4]. Caching would improve the quality of the sample collection returned by a potential MSR by allowing more information to go into sample selection decisions. These discussions were followed up by seriously considering in 2007-08 adding a cache to Mars Science Laboratory (although the specific implementation proposed raised significant scientific concerns), and by the NRC [5] who recommended "sample caching on all surface missions that follow MSL, in a way that would prepare for a relatively early return of samples to Earth."

MAX-C Mission Concept: The study assumed that a single solar-powered rover would be landed using the MSL sky-crane landing system, would have a targeting accuracy of ~ 7 km (semi-major axis landing ellipse), would have a mobility range of at least 10 km, and would have a lifetime on the martian surface of at least one Earth year.

The proposed MAX-C mission would be launched in May of 2018 and arrive at Mars in January of 2019 at L_s=325° (northern mid-winter). Given the favorable atmospheric pressure at this season, performance of the MSL delivery system might allow altitudes up to +1 km, but given the need for a subsequent MSR mission to rendezvous with this one, altitude would be constrained by the attributes of subsequent opportunities in the 2020s, all of which are lower performing. MSL-like performance of -1 km might be the resulting limit. Latitude access for a solar powered rover with a minimum of a one Earth year primary mission lifetime would be restricted to between 25°N and 15°S.

MAX-C Science Capabilities: Two key conclusions of the MRR-SAG team are that: 1). In order for a returned sample collection to be of maximum scientific usefulness, the samples would need to be carefully selected and their geologic context would need to be documented, and 2). The capabilities needed to achieve #1 above and to carry out compelling, breakthrough science at the martian surface are the same. This leads to a rover concept with the following attributes:

- **Mast- or body-mounted instruments capable of establishing local geologic context and identifying targets for close-up investigation**

- **A tool to produce a flat abraded surface on rock samples**

- **A set of arm-mounted instruments capable of interrogating the abraded surfaces by creating co-registered 2-D maps of visual texture, major element geochemistry, mineralogy, and organic geochemistry to the sub-cm scale**

- **A rock core acquisition, encapsulation, and caching system; this cache would be left in a position (either on the ground or on the rover) where it could be recovered by a future potential sample return mission**

Potential Sample Return Campaign

It is widely accepted that the return of samples from Mars cannot be done with less than two flight missions, and it is now recognized that there are potential advantages to using three missions [6,7]. In both cases we refer to this approach as the MSR campaign. The proposed MAX-C mission would be intended to be the first step of a potential 3-element campaign, followed by another potential lander mission (MSR-L) carrying a small rover that would fetch the proposed MAX-C cache (i.e., surface rendezvous) and also carrying a MAV. The MAV would be capable of launching a container holding the proposed cache into orbit for rendezvous with an orbiter (MSR-O) capable of carrying the sample to Earth.

Exploring a site prior to sending the potential sample return system (i.e., lander and MAV) would reduce both engineering and scientific risk for the overall potential sample return campaign. Many scientists and engineers have previously concluded that it would be too risky to send the mission that would land the MAV to a site other than one that has been previously visited [3].

Successful site exploration, *in situ* analysis at the outcrop scale, and coring/caching would assure that the samples exist, are retrievable, and are of sufficient scientific interest before committing to sending the potential lander mission with the MAV. Moreover, the rover would have completed exploration and documentation of the samples' geological context with a payload optimized for science.

For the potential 3-element approach, the MAV would not be put "at risk" until after the cache has been prepared, thus making it more likely that the proposed MAX-C rover would be allowed visit a site that has not been previously ground-truthed. Allowing a broader range of landing sites to be considered is a significant scientific benefit of a potential 3-element campaign. The amount of time available for the proposed MAX-C rover to collect a thoughtfully selected, thoroughly documented, diverse suite of samples from a well-characterized geologic setting would depend on considerations related to managing the risks during Mars surface operations.

Summary: As the next lander mission in the Mars Exploration Program, the proposed MAX-C mission would be a logical step in addressing MEPAG's goals, especially those related to astrobiology and geology. It could be sent to a previously visited site or to a new more-compelling site selected from orbital data, with sample return objectives included in the site selection criteria. It would be capable of yielding exciting *in situ* mission results in its own right, as well as making a significant feed-forward contribution to sample return, likely becoming the first step in a potential sample return campaign.

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