A "LIMITED FIRST SAMPLE" APPROACH TO MARS SAMPLE RETURN – LESSONS FROM THE APOLLO PROGRAM Eppler, D. B., Draper, D., Gruener, J., Astromaterials Directorate, Mail Code KA, NASA- Johnson Space Center, Houston, TX 77058.

Apollo 17, with the other Apollo J-missions, represents a benchmark in scientific exploration of the planets. However, a mission as complex as the Apollo 17 mission would have never happened if it had been planned as the first lunar landing mission: the area explored, the size and configuration of the landing ellipse, the number of EVAs planned and executed, the assets brought to and deployed on the the lunar surface (ALSEP, LRV), and the total time the crew spent on the lunar surface were such that no reasonable space agency would have agreed to tackle them as the first and possibly only lunar landing mission. The previous fourteen Apollo missions, both crewed and uncrewed, as well as the twenty-one Ranger, Surveyor and Lunar Orbiter robotic missions, developed a depth of capability that Apollo 17 built on, and gave the mission planners and operations managers the confidence that such a mission would be successful. Mars sample return needs to be re-cast along similar lines of progressive development of capability.

Although the 104 recovered martian meteorites [1] have established a baseline of compositions and age ranges for a variety of putative locations on Mars, we still lack a set of samples with the minimum geological context to relate sample composition, position on the Martian surface, radiometric age range and sample. As with Apollo 11, the first sample from Mars with appropriate geologic context, whatever the size, will provide a hard framework that will be used to tie together martian meteorites. As argued by Draper, et. al., [2], any successful first sample return mission will also provide the necessary technical, operational, scientific and programmatic confidence to follow on with sample return missions from more difficult and scientifically interesting locations. In addition, the relative simplicity of such a mission should lead to lower cost and less complexity, avoiding the multi-mission designs that have hampered Mars sample return planning since the aborted Mars Return Sample Rover studies in the late 1980s.

The Apollo Program built an initial operational base on the Ranger, Surveyor and Lunar Orbiter missions. As delineated in Eppler [3], these missions provided both scientific data and basic engineering data that were used in design and verification of Apollo landed vehicle components. These data became critical in the design of both Lunar Module sub-systems as well as ancillary mission systems such as the EVA suit and life support system. The highly successful Mars exploration missions of the last 10-15 years have provided us with a similar data set.

When it came to designing the first Apollo landed mission, a very conservative approach was taken. In 1966, a three-day symposium was held to define each phase of the mission [4]. This symposium dissected each phase of the mission, in detail, to understand all the requirements, constraints and open questions for the successful completion of each phase and the overall mission. In a subsequent document, the single primary objective for the Apollo 11 mission was defined as, "Perform a manned lunar landing and return [5]." The sample return task on Apollo 11 was designed, in that regard, to return a simple documented sample set from a limited area while imposing minimal impact on mission operations. This approach allowed the science mission planners to enable significant science return within the primary mission objective. Draper et. al. [2] argued that the basic understanding of lunar evolution extant today had its initial formulation based on the data derived from the comparatively small sample set returned from Apollo 11. In fact, there were fragments of lunar anorthosite, whose existence led to the magma-ocean paradigm for lunar differentiation, contained in Neil Armstrong's "contingency sample", collected minutes after he first set foot on the lunar surface. Thus, had Apollo 11 ended prematurely and no other missions returned lunar samples, scientists might well have been able to arrive at this significant understanding from this simple "locality" sample.

As stated in [2], a major issue with all Mars sample return missions studied so far is the "…prohibitive cost of maximizing sample diversity." In particular, the missions studied so far have, as their baseline, used rovers to collect significantly diverse samples and to conduct preliminary chemical data to down-select samples for return. The complexity of the rover has ultimately driven up the landed mass of the spacecraft, making it impossible to land both the rover and the return sample vehicle within present technology. This hindrance, in turn, drives the mission to multiple launches over multiple opportunities, running up launch costs and increasing required program duration and funding as well as overall campaign complexity. Although the reasoning behind such a complex mission has merits, the fact remains that this mission set has twice failed to gain the necessary support for a new start since 1985. We advocate a simpler approach that is based on the historical record of lunar science exploration.

A locality sample, as defined by Draper et. al. [2], would be a sample that would be derived within mechanical reach of the landed spacecraft, similar to both the Luna 16, 20, and 24 missions and the Mars-Phoenix mission. Such a sample would not require in-situ characterization, and could be sized, as appropriate, for the sample return spacecraft. Sample return mass, while generally assumed to be low for such a mission, is likely to be only limited by delta-v considerations, not technology – for instance, the Luna 24 mission returned (*in 1976!*) 170 g of samples in a 1.6-m long core from Mare Crisium [6]. The value of any such sample is maximized by taking great care in choosing the landing site. We argue that the flotilla of orbital and landed spacecraft that have studied Mars since the Pathfinder mission have provided ample information from which to make this kind of careful site selection.

The locality sample could be collected using a basic spacecraft design that builds on Mars Phoenix heritage. A simple arm with a scoop would collect a sample within the proximity of the spacecraft to be delivered to a sample return capsule mounted on the lander base. Once full, the return capsule would be launched off the surface to return to Earth.

We recognize that this will still be a complex mission. A significant trade study would be needed to define delta-v requirements, and to choose between direct Earth return of the sample return vehicle and Mars orbital transfer operations of the sample return capsule. The delta-v requirements to get to Mars, land, and safely return will, of necessity, still dictate that the initial mass to Low Earth Orbit will be large. In particular, we recognize that both the Mars landed spacecraft and the return vehicle will be larger than the Luna spacecraft. However, we also believe strongly that the failure of the previous Mars sample return missions to be selected for new starts in the last 2 decades argues that a simpler approach needs to be considered if we are to expect geologically-documented Mars samples to be returned in the foreseeable future.

References: [1] Meteorite Bulletin Database *(2012)* *http://www.lpi.usra.edu/meteor/index/php*. [2] Draper, D., et al. *(2002) Amer Geophys Union Spring Mtg*, Abstract #P51A-04. [3] Eppler, D.B. *(1992) EXPO-T2-920001-EXPO*. [4] NASA *(1966) TM X-58006*. [5] NASA (1969) *Mission Op. Rpt. M-932-69-11*. [6] Heiken, et al. *(1991) The Lunar Sourcebook*.