SAMPLE COLLECTION FOR INVESTIGATION OF MARS (SCIM): AN EARLY MARS SAMPLE RETURN MISSION THROUGH THE MARS SCOUT PROGRAM. L. A. Leshin[1,2], A. Yen[3], J. Bomba[4], B. Clark[4], C. Epp[5], L. Forney[6], T. Gamber[4], C. Graves[5], J. Hupp[4], S. Jones[3], A. J. G. Jurewicz[3], K. Oakman[4], J. Rea[5], M. Richardson[7], K. Romeo[4], T. Sharp[1], B. Sutter[4], M. Thiemens[8], J. Thornton[4], D. Vicker[5], W. Willcockson[4], M. Zolensky[5]; [1]Dept. of Geological Sciences, [2]Center for Meteorite Studies, ASU, Tempe, AZ 85287-1404; [3]JPL, 4800 Oak Grove Dr., Pasadena, CA 91109, [4]Lockheed Martin Astronautics, P.O. Box 179, MS S-8000, Denver, CO 80201, [5]NASA JSC, Houston, Texas 77058; [6]Dept. of Chemical Engineering, Georgia Tech., Atlanta, GA 30340, [7]Div. of Geological and Planetary Science, Caltech, Pasadena, CA 91125, [8]Dept. of Chemistry, UCSD, San Diego, CA 92093. (laurie.leshin@asu.edu)

In this abstract we describe a Mars Scout mission concept competitively selected for a 6-month concept study through NASA.

Background: The Mars Scout Program intends to fly competitively-selected, PI-led science missions that complement the core missions in the Mars Exploration Program. Mars Scout missions will be similar in scope and cost to NASA Discovery Missions. The first Scout launch is anticipated in the 2007 opportunity.

The **S**ample **C**ollection for **I**nvestigation of **M**ars (SCIM) mission is designed to (1) make a ~40 km pass through the Martian atmosphere, (2) collect dust and atmospheric gas, and (3) return the samples to Earth for analysis. This Mars Scout mission concept is compelling because it will return a Martian sample to Earth within this decade without assuming the substantial risk, complexity, and cost of landing on and launching from the surface.

SCIM Science Goals:

- Determine the extent of aqueous processing (weathering) of Martian crustal materials
- Quantitatively establish the chemical, isotopic and mineralogical composition of Martian dust
- Quantify the size- and compositional-distribution of dust in the Martian atmosphere
- Provide ground truth for past and future remote sensing observations of martian surface materials
- Unambiguously demonstrate whether Martian (SNC) meteorites are indeed samples of Mars
- Discover evidence relevant to Mars' original volatile inventory and its subsequent evolution
- Investigate current atmospheric chemical phenomena such as escape to space

To meet the science goals outlined above, return of samples to Earth for analysis is necessary. Remote sensing data will continue to suffer from lack of "ground truth," and remote geochemical methods are inflexible and imprecise relative to Earth-based laboratories. The return of even a small amount of Martian material to Earth will provide an enormous advance in our scientific understanding of Mars.

The Scientific Value of Martian Dust: Fine dust is ubiquitous on the Martian surface, being especially abundant in “bright regions.” This dust is thought to represent the relatively globally homogenous product of material processing on Mars, and its µm-grain size makes it an extremely sensitive indicator of environmental processes. Because of its global nature, it provides a representative “grab” sample of Martian crustal materials, likely including primary igneous and secondary weathered materials (e.g. silicates, Fe oxides, possibly carbonates, and clays). Telescopic observations suggest that the fine dust in the Martian atmosphere is essentially indistinguishable from the dust-mantled bright regions on the surface.

The Martian fines, although representative of the planet's origin and evolution, are difficult to characterize with remote observations for precisely the reasons that they are scientifically interesting: (1) the dust is an intimate mixture of materials diverse on the µm-scale, and (2) it is very fine grained. Several models for chemical weathering on Mars [1,2] have been proposed to account for the bulk composition and spectral properties of Martian fines as determined from Earth-based telescopes, orbital missions, and landed chemical and spectroscopic analysis [e.g., 3-5]. However, the fundamental conclusions of remote studies lack the support of detailed, high-precision chemical, isotopic, and mineralogical characterization of Martian dust.

Accordingly, SCIM mission samples will address first order questions regarding:

- *Major geologic provinces/crustal evolution:* Because terrestrial fine sediments sample large areas, detailed chemical and mineralogical studies of these materials on Earth have been used to identify source terrain types and processes, and to estimate bulk crustal composition [e.g., 6,7]. Similar information has been extracted from lunar regolith fines [e.g., 8]. Trace elements and isotopic ratios are particularly valuable in this endeavor. We currently have no data on the trace element and isotopic composition of Martian fines.
- *Weathering/volatile history:* Mineralogy and stable isotopes are critical to unraveling Martian environmental conditions, volatile cycles, and the origin and weathering of Martian regolith.
- *Origin of Martian Meteorites:* Because of several unique chemical characteristics of Martian meteorites, high-precision analyses of O isotopes or K/La ratios (for example) will confirm that these rocks are Martian samples.
- *Interpretation of remote sensing data:* Quantitative characterization of the chemical and physical properties of Martian dust will provide ground truth for past and future remote sensing observations.

The Scientific Value of Martian Atmosphere: The chemical and isotopic makeup of the Martian atmosphere contains evidence of Mars' primordial volatile inventory, large-scale volatile evolution, and transient events or disequilibrium chemistry. Viking and telescopic observations have provided bulk atmospheric composition and ratios of a few isotopic species, but at relatively low precision [e.g., 9]. Science gained by high-precision analyses of an atmospheric sample includes:

- Volatiles lost or sequestered through time and the degree of surface-atmosphere interaction (H, C, and O isotope measurements)
- The degree of exchange of atmospheric CO_2 with the polar caps and regolith reservoirs (^{14}C analyses)
- Transient outgassing events, volatile loss processes, and conclusive proof that Martian meteorites come from Mars (Analyses of noble gases; He – Xe)
- Mass-independent isotope effects in the Martian atmosphere (O isotope analyses)

SCIM Mission Parameters: Calculations indicate that an equatorial atmospheric pass at 40 km altitude near summer solstice, (Ls ~270±40) will allow a significant amount of dust to be collected during a non-stormy year, and a higher pass will suffice if a large dust storm is present. Mission calculations "flying" a 100 cm^2 collector through a model martian atmosphere shows that ~11 million particles >2µm in diameter would be encountered. The size distribution of these particles is skewed towards the smallest sizes, but thousands of particles with diameters ≥10µm should be encountered. Calculations show that the particles should reach the SCIM dust collector (an aerogel design broadly similar to Stardust) intact, and with relatively little heating. Unlike the Stardust encounter, the SCIM aeropass will impart significant heating on the spacecraft and sample collector, requiring special attention to its design. Detailed thermal modeling and testing of collector materials under realistic thermal loads suggest the collector can be engineered to survive the aeropass intact. Results of these tests are described in [10].

The SCIM flight system, designed by Lockheed Martin Astronautics in cooperation with JPL and JSC, is capable of launch aboard a Delta 2925 in the 2007 opportunity. The atmospheric pass would take place in mid–2009, and the samples returned to Earth in 2010.

Planetary protection concerns for the returned samples would be significantly less than for a Mars surface sample, because the SCIM samples have been exposed to extreme UV conditions in the martian atmosphere and heated to sterilization temperatures during collection. The data analysis plan will ideally involve samples being handled in a similar way to Stardust, with curation at JSC (probably after some short preliminary examination period). Dust and gas aliquots would be made available to many individual investigators from around the world selected through a proposal process, with CAPTEM overseeing curation and sample allocation.

References: [1] Banin A. et al. (1997) *JGR*, *103*, 13341. [2] Burns R.G. (1993) *GCA*, *57*, 4555. [3] McSween H.Y. and Keil K. (2000) *GCA*, *64*, 2155. [4] Clark B.C. et al. (1982) *JGR*, *87*, 10059. [5] Bell J.F.I. et al. (2000) *JGR*, *105*, 1721. [6] McClennan S.M. and Taylor S.R. (1984) in *Archean Geochem.,* Springer-Verlag: 47. [7] McClennan S.M. et al. (1990) *GCA*, *54*, 2015. [8] Taylor S.R. (1975) in *Lunar Science: A post-Apollo View,* Pergamon: 55. [9] Nier A.O. and McElroy M.B. (1977) *JGR*, *82*, 4341. [10] Jurewicz, A.J.G., LPSC XXXIII, *this volume* (2002).