NECESSITY OF RETURNING A SAMPLE OF THE MARTIAN ATMOSPHERE. B. M. Jakosky[1], R. W. Zurek[2], S. K. Atreya[3], P. R. Mahaffy[4], K. Zahnle[5], O. B. Toon[1], M. Tolbert[1], M. J. Mumma[4], D. J. DesMarais[5], C. R. Webster[2], and M. Amato[4]. [1] University of Colorado at Boulder, [2]Jet Propulsion Laboratory, California Institute of Technology, [3] University of Michigan, [4] NASA/Goddard Space Flight Center, [5] NASA/Ames Research Center. (Corresponding author, bruce.jakosky@lasp.colorado.edu)

Introduction: A returned sample of unaltered Martian atmosphere would have considerable scientific value for understanding the evolution of Mars, its climate, and the potential for past or present life. Collecting a scientifically adequate sample is not currently incorporated into the Mars 2020 rover mission. Such a capability could easily be incorporated into an anticipated "fetch" rover that would collect the samples and package them for return to Earth.

In light of recent measurements from *Mars Science Laboratory* and *MAVEN*, and results from the ongoing *Trace Gas Orbiter* mission, we want to revisit the scientific value of returning a sample of atmosphere. The *MSL Sample Analysis at Mars* (*SAM*) instrument suite has obtained high-precision measurements of the composition of the present-day Mars atmosphere. These include isotopic measurements of key gases and abundances of certain trace gases. *MAVEN* observations of the composition and structure of the upper atmosphere provide fundamental information on how to interpret some of the results relative to atmospheric loss through time.

Scientific objectives: Measurements of the present-day atmosphere that would be made on a returned sample would provide information that allows us to understand key aspects of climate evolution and habitability of Mars:

(i) Isotope ratios of the noble gases tell us about the sources of gas in formation of the atmosphere and its subsequent evolution. Of particular interest, and requiring more-precise measurements than currently available, are the isotopes of Xe (that may be indicative of ongoing processes within the regolith and surface-atmosphere exchange) and Kr (that relate to supply and loss of gas to the atmosphere through time).

(ii) Trace gas abundances tell us about ongoing geological and potential biological processes in the Martian regolith or deeper subsurface.

(iii) Isotopic ratios in trace gases (such as $^{13}C/^{12}C$ and D/H in methane, CH_4, and D/H in H_2O for comparison) and high precision measurements of $^{18}O/^{17}O/^{16}O$ in CO_2 can tell us about their chemical formation processes, possibly including biology.

(iv) Airborne dust that could be included in an atmospheric sample would allow us to understand factors controlling the present-day climate and atmospheric cycles and their chemical evolution. The current sample-collection schemes will not obtain airborne dust, and it is by no means certain that surface dust would be present everywhere that is being sampled or that it would resemble dust in the atmosphere.

(v) A sample of the atmosphere provides important boundary conditions on exchange of gas between the surface and atmosphere and on related chemical processes. Of particular importance are regolith compounds such as perchlorates and hydrogen peroxide that can reflect surface-atmosphere interactions; understanding the implications of such compounds in the regolith requires knowledge of the composition of the atmosphere.

(vi) An unaltered sample of atmospheric gas would be necessary for evaluating possible contamination of the geological samples. Samples from the interior of rocks may never have been in contact with the atmosphere, and might be altered by drilling and sample collection. Measurement of atmospheric gases would help us to understand changes that might have occurred.

(vii) An atmospheric sample can serve as "ground truth" in situ verification of atmospheric abundances derived from the *Trace Gas Orbiter* or, if key *TGO* measurements are not available, can provide key measurements.

Sample collection: Enrichment and gas compression methods could enable sufficient Martian gas to be collected for precision analysis on the returned sample. An atmospheric sample for multiple noble gas analyses could be obtained from a simple, passive collector. A scrubber/getter system to remove the active gases (CO_2, O_2, N_2, and H_2O) would allow gases enriched in the inert noble gases to fill a previously evacuated container. Both the scrubber and the gas container would be returned to Earth. The technology for this type of system is well developed and the required components have been flight qualified and utilized on Mars for in situ noble gas measurements with the SAM experiment on the Curiosity rover. Collection of sufficient methane to determine the ^{13}C isotope abundance to several per mil could be implements using a miniature compressor to bring the pressure in a small (~100 cc) capture volume to ~50 times above its ambient value for return to Earth.

Conclusions: The return of Mars samples would enable investigations of all aspects of a complex and interconnected Mars environment. Given the role of the atmosphere in driving our understanding of climate and the potential for life, it is imperative that we obtain an atmospheric sample as part of any returned collection. As sample collection would be done on a not-yet-designed fetch rover or its associated lander platform, now is the appropriate time to begin development of the concept for incorporation into rover planning.