

**WHAT WE MIGHT KNOW ABOUT GUSEV CRATER IF THE MARS EXPLORATION ROVER SPIRIT MISSION WERE COUPLED WITH A MARS SAMPLE RETURN MISSION.** R. V. Morris, Astromaterials Research Office, NASA Johnson Space Center, Houston, TX 77058 (richard.v.morris@nasa.gov).

**Introduction:** The science instruments on the Mars Exploration Rover (MER) Spirit have provided an enormous amount of chemical and mineralogical data during more than 1450 sols of exploration at Gusev crater. The Mössbauer (MB) instrument identified 10 Fe-bearing phases at Gusev Crater: olivine, pyroxene, ilmenite, chromite, and magnetite as primary igneous phases and nanophase ferric oxide (npOx), goethite, hematite, a ferric sulfate, and pyrite/marcusite as secondary phases [e.g., 1,2,3]. The Miniature Thermal Emission Spectrometer (Mini-TES) identified some of these Fe-bearing phases (olivine and pyroxene), non-Fe-bearing phases (e.g., feldspar), and an amorphous high-SiO<sub>2</sub> phase near Home Plate. Chemical data from the Alpha Particle X-Ray Spectrometer (APXS) provided the framework for rock classification, chemical weathering/alteration, and mineralogical constraints. APXS-based mineralogical constraints include normative calculations (with Fe<sup>3+</sup>/Fe<sub>T</sub> from MB), elemental associations, and stoichiometry (e.g., 90% SiO<sub>2</sub> implicates opalline silica).

If Spirit had cached a set of representative samples and if those samples were returned to the Earth for laboratory analysis, what value is added by Mars Sample Return (MSR) over and above the mineralogical and chemical data provided by MER?

**In situ analysis on Mars versus MSR:** The sampling strategy employed by MER is to present the instrument to the sample. That is, samples are analyzed in situ with little or no sample preparation, except as provided by the Rock Abrasion Tool (RAT), the Magnetic Properties Experiment, and the churning action of the rover wheels. Some sample preparation was provided by natural processes on Mars, e.g., size sorting of soil particles by the wind. MSR opens two doors that are not possible with in situ analysis: (1) a wide variety of analytical techniques can be employed that are not possible or practical for in situ analysis (e.g., isotopic analysis, high-resolution scanning and transmission electron microscopy (SEM/TEM) with elemental analysis capability, electron microprobe analysis; high-resolution X-ray diffraction (XRD)); (2) pre-analysis sample preparation (e.g., thin sections, phase separation by density, magnetic properties and hand picking, and selective dissolution). In the next sections, we give a few examples of the value added by a MSR of a hypothetical cache made by the Spirit rover.

**Nanophase ferric oxide:** This Fe<sup>3+</sup>-bearing alteration product is ubiquitous in basaltic soils, and its molar abundance correlates with both S and Cl. Its composition is not well constrained by MER and could be any combination of the following Fe<sup>3+</sup> alteration products found in terrestrial environments: superparamagnetic hematite and goethite, ferrihydrite, schwertmannite, iddingsite, and the nano-scale particles found in palagonitic tephra. With MSR, the sample preparation and analytical techniques employed to identify these phases on Earth can be used (e.g., sedimentation and selective dissolution followed by XRD and SEM/TEM). We might learn that the form of npOx on Mars is not present on the Earth.

**Age dating:** MSR of Adirondack, Irvine, Barnhill, and other basaltic rock classes would permit age dating of igneous events by isotopic analysis of whole rocks and mineral separates. This type of analysis was not possible with the MER instruments and it is unlikely that a Mars robotic mission will house a high-precision stable isotope mass spectrometer.

**Thin Sections:** Thin sections of Gusev rocks (including alteration rinds) can be made and analyzed by standard optical and electron beam microscopy on samples returned to the Earth. For example, is the rind on the rock Mazatzal accretionary or derived from the rock. What is the elemental composition of the igneous minerals, and are they zoned and have exsolution? Is magnetite always present as a primary mineral? What is the thin-section evidence for the origin of the high-SiO<sub>2</sub> phase [4].

**Analysis of soil particles:** Selection and analysis of individual soils particles is possible with samples returned to Earth. Such particles, for example, may represent new igneous lithologies and may be concentrations of specific alteration phases (e.g., sulfates), permitting analysis of their mineralogical, chemical composition and isotopic.

**Summary:** Samples returned to the Earth will permit analyses that are not possible in situ because of instrumental and/or sample preparation constraints, thereby extending our knowledge of the martian surface composition and the processes the form and modify it

**References:** [1] Morris, R.V., *et al.* (2006) *JGR*, **111**, doi:10.1029/2005JE002584. [2] Ming, D.W., *et al.* (2006) *JGR*, **111**, doi:10.1029/2005JE002560. [3] Squyres, S.W., *et al.* (2007) *Science*, **316**, 738. [4] Squyres, S.W., *et al.* (2008) *Science*, submitted.