

**INITIAL RESULTS FROM THE MER ATHENA SCIENCE INVESTIGATION AT GUSEV CRATER AND MERIDIANI PLANUM.** S.W. Squyres<sup>1</sup> and the Athena Science Team, <sup>1</sup>Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853 (squyres@astro.cornell.edu).

**Introduction:** The Mars Exploration Rover *Spirit* landed in Gusev Crater on January 4 (UTC), 2004. It was followed 21 days later by the rover *Opportunity*, which landed on Meridiani Planum.

Each rover carries a copy of the Athena science payload. The topography, morphology, and mineralogy of the scene around each rover are revealed by two remote sensing instruments called Pancam and Mini-TES. Pancam is a stereo camera whose filters provide 14 color spectral bandpasses over the spectral region from 0.4 to 1.1  $\mu\text{m}$ . Pancam's angular resolution is 0.28 mrad/pixel. Mini-TES produces high spectral resolution ( $10\text{ cm}^{-1}$ ) infrared image cubes with a wavelength range of 5-29  $\mu\text{m}$  and angular resolution modes of 20 and 8 mrad.

Once promising targets have been identified using Pancam and Mini-TES, they are studied in more detail using two in-situ compositional sensors mounted on a 5-degree-of-freedom robotic arm. These are an Alpha Particle-X-Ray Spectrometer (APXS) and a Mössbauer Spectrometer. Radioactive alpha sources and two detection modes (alpha and x-ray) in the APXS provide elemental abundances of rocks and soils. The Mössbauer Spectrometer measures the resonant absorption of gamma rays produced by a  $^{57}\text{Co}$  source to determine splitting of nuclear energy levels in Fe atoms, revealing the mineralogy and oxidation state of Fe-bearing phases.

The instrument arm also carries a Microscopic Imager that is used to obtain high-resolution images of the same materials for which compositional data are obtained. Its spatial resolution is 30 mm/pixel over a 6-mm depth of field.

The payload also includes a Rock Abrasion Tool (RAT). When placed against a rock, it uses a mechanical grinding wheel to remove 5 mm of material over a circular area 47 mm in diameter. The resultant exposed region is large enough to be investigated in detail using all of the instruments on the payload.

These payload elements have been used along with the rovers' mobility capabilities to conduct missions of scientific exploration at the Gusev and Meridiani sites. The initial results reported here are those obtained as of February 9, 2004.

**Gusev Crater:** The landing site at Gusev crater lies on a flat, rock-strewn plain. The rocks at the site are mostly angular, and some clearly appear to contain vesicles.

The rock at Gusev that has been studied best to date has been named "Adirondack". In its surface texture,

Adirondack appears to be dense, fine-grained and sand-blasted. Pancam images of Adirondack show evidence for a surface coating of some sort, perhaps dominated by dust. Three sets of measurements have been made on Adirondack with the full set of payload instruments: one of the natural rock surface, one of the same location after being brushed by the RAT, and one of the same location after removal of 2-3 mm of rock by the RAT. The concentration of presumably dust-borne elements like sulfur and chlorine diminished significantly with brushing, and diminished dramatically with grinding. All of the observations of Adirondack are consistent with it being an essentially unweathered olivine and magnetite-bearing, low-silica basalt.

The only soil at Gusev that has been investigated in detail so far is one dominated by fairly coarse (100-300 micron) grains that have the appearance and behavior of well-cemented agglomerates. APXS spectra of this soil are similar to those of soils found at the Viking and Pathfinder sites. Mössbauer spectra show two ferrous doublets and a ferric doublet, with the stronger ferrous doublet assigned to olivine. Mini-TES spectra have been acquired for soils surrounding the the *Spirit* landing site, and show spectra nearly identical to globally averaged soil viewed by the TES instrument on Mars Global Surveyor. This includes identification of a small amount (a few percent) of carbonate.

The dominant rocks in the vicinity of the *Spirit* landing site at Gusev are clearly volcanic. Upcoming rover activities include a traverse to a nearby crater that is about 200 m in diameter and whose ejecta may include other non-volcanic geologic materials.

**Meridiani Planum:** The landing site at Meridiani Planum lies inside an impact crater that is roughly 20 meters in diameter. The lander came to rest on soil that fills most of the crater. An outcrop of layered bedrock is exposed on the crater wall. The landing site was selected partly because coarse gray hematite was expected to be present on the basis of orbital data. Mini-TES data have confirmed the presence of this hematite in the soil.

The soil within the crater has several components. Microscopic images of undisturbed surface soil show that one component is fine (~100 micron) sand. Mössbauer spectra of the sand show two ferrous doublets (one of them due to olivine), a ferric doublet, and a weak magnetic sextet. APXS and Mini-TES data on

this sand are consistent with a composition dominated by basalt.

Another component of the soil consists of coarse (several mm) granules. These range in shape from subangular to rounded to remarkably spherical. In some locations, granules have been pressed down into the soil by the impact of the lander's airbags. At those locations the concentration of hematite as determined by Mini-TES is sharply reduced, suggesting that at least some of the granules are hematite-bearing.

The bedrock outcrop is roughly 12 meters long and up to half a meter in height. It is finely laminated, with typical layer thicknesses of only a few mm. The texture of the outcrop as viewed in microscopic images suggests that it is fine-grained, with well-expressed structure that is revealed by varying degrees of mechanical abrasion of layers of varying induration. Initial APXS results on this fine-grained matrix suggest an unusual composition, including sulfur concentrations significantly higher than any observed elsewhere on Mars.

Embedded within the outcrop and weathering out of it are highly spherical granules with diameters of several mm. The visible to near-IR spectral properties of these embedded spherical granules, as determined by Pancam, are distinctly different from those of the matrix in which they are embedded.

The highest Mini-TES-derived concentrations of hematite are found in soil and possible rock units above the bedrock outcrop that have not been visited by the rover as of this writing. Future activities include climbing out of the crater and investigating this hematite-rich material.

**Atmospheric Science:** Upward-looking observations with the remote sensing elements of the Athena payload have been used to characterize the martian atmosphere. Direct observations of the sun by Pancam have been used to make daily determinations of atmospheric dust opacity. Mini-TES data have been used to perform temperature retrievals in the martian boundary layer. These retrievals have elucidated the daytime thermal structure of the boundary layer, and have revealed short-duration thermal excursions apparently related to convection.