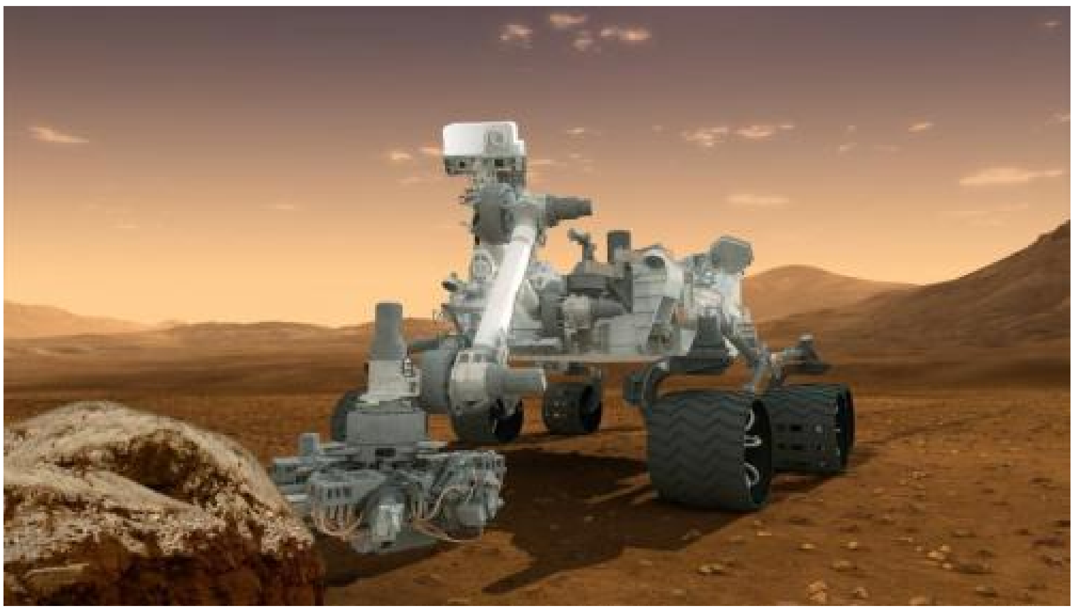
PHYS.ORG

Curiosity rover shakes, bakes, and tastes Mars with SAM (w/ video)

December 3 2012



This artist's concept features NASA's Mars Science Laboratory Curiosity rover, a mobile robot for investigating Mars' past or present ability to sustain microbial life. Credit: Credit: NASA/JPL-Caltech

NASA's Curiosity rover analyzed its first solid sample of Mars in Nov. with a variety of instruments, including the Sample Analysis at Mars (SAM) instrument suite. Developed at NASA's Goddard Space Flight Center in Greenbelt, Md., SAM is a portable chemistry lab tucked inside the Curiosity rover. SAM examines the chemistry of samples it ingests, checking particularly for chemistry relevant to whether an environment can support or could have supported life.

The sample of Martian soil came from the patch of windblown material called "Rocknest," which had provided a sample previously for mineralogical analysis by Curiosity's Chemistry and Mineralogy (CheMin) instrument. CheMin also received a new sample from the same Rocknest scoop that fed SAM. SAM has previously analyzed samples of the Martian atmosphere.

SAM can get a solid sample of Mars from either a drill or a scoop attached to the end of Curiosity's robotic arm. Since Rocknest is essentially a pile of loose soil, the scoop was used this time.

"This is the first time we've analyzed a solid sample using all three instruments that comprise SAM," said Paul Mahaffy, SAM Principal Investigator at NASA Goddard. "We also cleaned Curiosity's sample manipulation system and successfully tested our ability to move the sample from the manipulation system through the instrument suite."

A complex choreography was required to get the sample inside SAM for analysis, according to Mahaffy. First, since the scoop might still have had contamination from Earth, the first three scoops were shaken, run through a sieve, then dumped right back on the surface with the idea that they would carry away any contaminants with them. A sieved portion of the fourth scoop – just a few thousandths of a gram – was then delivered to SAM. A cover that protects SAM from accidentally ingesting windblown material was opened, and Curiosity's arm positioned the sample over SAM's inlet funnels. Before the sample was dropped, SAM turned on its inlet funnel vibrators, which move the sample into a tiny quartz cup. After the sample dropped, the vibrator was turned off, the cover was closed, and the cup, which is on a carousel holding 74 sample cups, was lowered and moved to one of two ovens.

After the sample was baked to release its gases, SAM's three instruments "digested" them and gave Curiosity its first "taste" of Mars. A basic three-step process will be used to analyze future samples as well:

Separate the molecules:

Gas from the sample first travels to the Gas Chromatograph (GC) instrument. The purpose of this instrument is to sort out all the different molecules in the sample, and tell how much of each kind there is. It accomplishes this by using a stream of helium gas to push the sample down a long, narrow tube (which is wound into a coil to save space). Helium is used because it is inert, meaning it won't react with and change any of the sample molecules. The inside of the tube is coated with a thin film. As molecules travel through the tube, they stick for a bit on the film, and the heavier the molecule, the longer it sticks. Thus, the lighter molecules emerge from the tube first, followed by the middleweight molecules, with the heaviest molecules bringing up the rear.

Identify the molecules:

Since molecules of different weights emerge from the tube of the gas chromatograph at different times, the GC can send groups of different weights, one at a time, to SAM's next instrument, which will determine exactly what kind of molecule makes up each of the groups. This is the Quadrupole Mass Spectrometer (QMS) instrument. It fires high-speed electrons at the molecules, breaking them up into fragments and giving the molecules and their fragments an electric charge. These molecules and their fragments with an electric charge can be moved by electric fields. The QMS uses both direct current and alternating current fields to sort the electrically charged molecules and fragments based on their weight (mass). Molecules and fragments of different mass are counted by a detector at different times to generate a mass spectrum, which is a pattern that uniquely identifies molecules.

Identify the volatiles and determine the isotopes:

After the QMS identifies the molecules, the sample is directed into the Tunable Laser Spectrometer (TLS), which can identify and analyze certain volatile molecules, like methane and carbon dioxide. The sample enters a chamber with precisely positioned mirrors at both ends. A laser is fired through a tiny hole in one of the mirrors. As the laser light bounces between the mirrors, it illuminates the sample. Different molecules will absorb certain colors (frequencies) of light, so the TLS identifies the molecules by which colors of the laser are blocked (since the laser is tunable, it can be adjusted to shine in a range of colors).

The TLS can also identify isotopes the same way. Isotopes are versions of an element that are a little bit heavier because their nucleus contains more neutrons. For example, carbon 13 is an atom of carbon with an extra neutron, so it is a heavier version of the more common carbon 12. Occasionally, a carbon 13 will take the place of a carbon 12 in an organic molecule. This is important since life prefers to use the lighter isotopes, because chemical reactions with them require less energy. So if we measure the isotopes of carbon in a material and discover that there is more light carbon relative to heavy carbon than would be found randomly, we might guess that we are seeing the effects of life.

Finally, since volatile molecules are found in the atmosphere as well as in soil and rock, samples of the Martian air can be sent directly to the TLS without going through SAM's other instruments.

SAM was developed at NASA Goddard, but with significant elements provided by industry, university, and NASA partners. NASA's Jet Propulsion Laboratory, a division of the California Institute of Technology, Pasadena, manages the Curiosity/Mars Science Laboratory Project for NASA's Science Mission Directorate, Washington. JPL designed and built the rover.

Provided by NASA's Goddard Space Flight Center