UA student finds 'Hawaiian beach' sand on Mars

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During one of her stints at NASA's Jet Propulsion Laboratory in Pasadena, Calif., Shaunna Morrison got to play with the "scarecrow," a replica of the Curiosity rover. The "scarecrow" lacks the instrumentation of Curiosity, but features identical wheels and base, and is exactly weighted and calibrated so it behaves as it would on Mars. "We can control it with a smartphone, and it was pretty neat to tell it to spin its wheels this way and move backwards and things like that." Credit: Thomas Bristow

(Phys.org) —The world's largest database of minerals, developed and housed at the UA, enables NASA to identify the minerals that make up the soil on Mars. As a member of the science team on NASA's Curiosity rover currently exploring Mars, graduate student Shaunna Morrison helps uncover the secrets of the Red Planet.

Most geology students are used to traveling far and wide to collect samples for their research, but University of Arizona Shaunna Morrison has everybody beat by a long shot: 140 million miles, on average, stand between her sampling sites and her lab.

As part of NASA's designated science team in charge of CheMin, one of 10 scientific instruments mounted on the Mars rover Curiosity, Morrison never gets her hands on the samples she collects, but that's a small price to pay for the opportunity to analyze soil scooped up by a robot on another planet.

Earlier this month, Morrison co-authored two scientific publications in the journal *Science*, reporting the first scientific results of Curiosity's digging into the soil near Mount Sharp in Gale Crater. Morrison provided the first detailed analyses of individual mineral compositions in the Martian surface.

"We knew from previous Mars missions what elements are present in the Martian soil, but we didn't know how they are arranged, in other words, what minerals they form," said Morrison, a first-year PhD student in the UA Department of Geosciences.

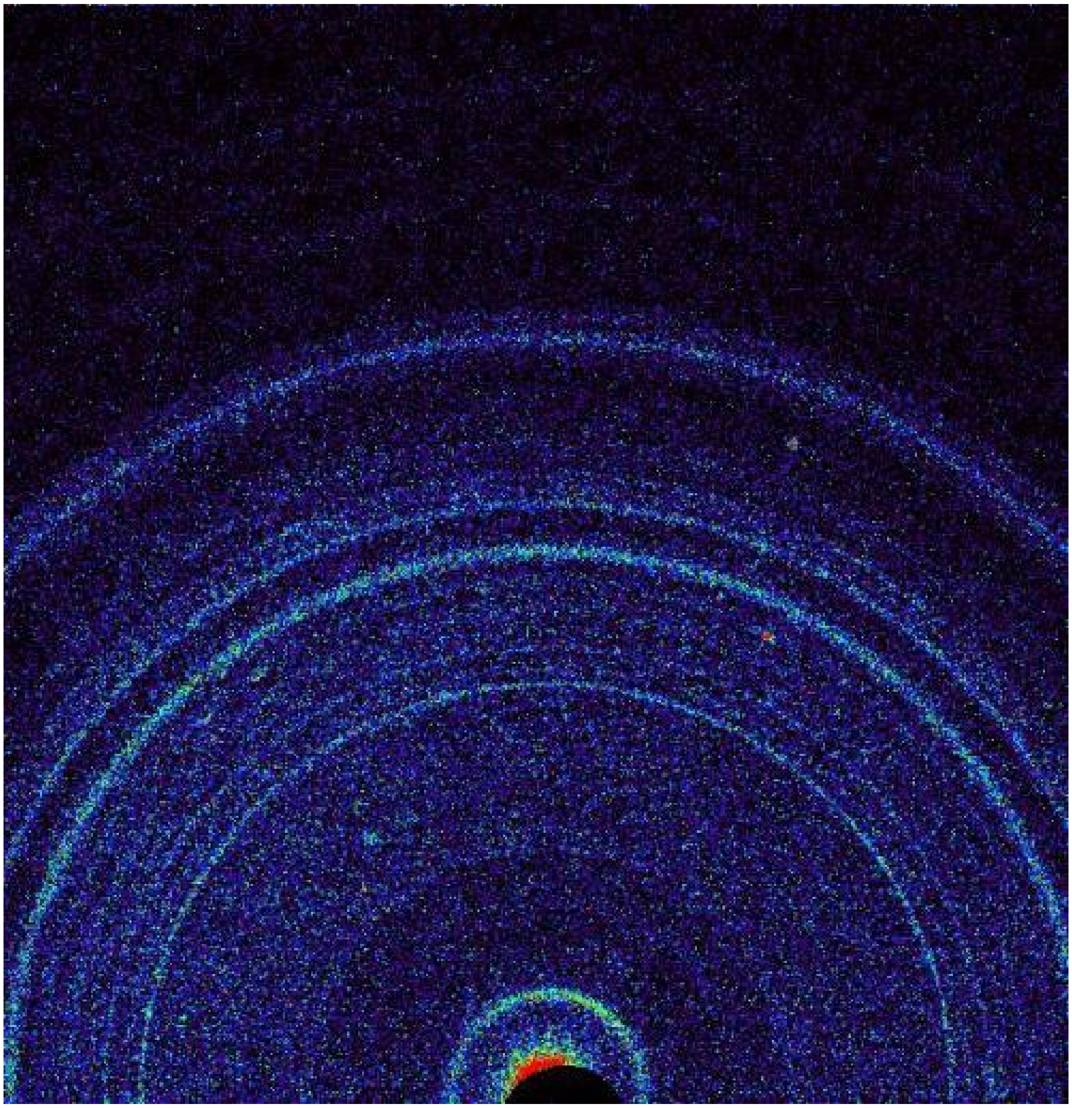
For scientists to better understand how planets form, they need to first determine and compare what they're made of.

"Earth, Mars, probably Venus, all have the same bulk chemistry of mainly iron, magnesium, silicon and oxygen," said Robert Downs, a professor in the Department of Geosciences and Morrison's PhD adviser. "Those four make up about 94 percent of Earth's elements."

"For the first time, we have been able to determine what minerals are on Mars, and we find it's same stuff you'd find on a beach in Hawaii," he added.

One of the minerals in the Mars samples that Morrison analyzed is olivine, a silicate mineral that is abundant on Earth, where it also comes in a gemstone variety known as peridot, which is mined in San Carlos, Ariz. from the Peridot Mesa.

"Peridot has a beautiful green color and is used as a gemstone around the world," Downs explained. "But the olivine you find on Mars would not be gemstone quality. We found that it has a lot of iron in it, which makes it much darker."



The x-ray diffraction pattern Curiosity sent down after analyzing scoop number 5. To a mineralogist, the concentric rings are like a fingerprint, revealing the structure and chemistry of a particular mineral. Credit: NASA/JPL-Caltech/Ames

Other minerals identified in the Martian sample are plagioclase, augite and pigeonite, with small amounts of K-feldspar, magnetite, quartz and others. Morrison performed the analyses that determined the amount of calcium, magnesium and iron in the augite found on Mars.

To identify minerals on Mars, the team relies on the same technology used on Earth for that purpose, called X-ray diffractometry. The CheMin instrument – short for chemistry and mineralogy – shoots X-rays at a rock sample, which interact with the electrons in the rock and sends back signals that are like fingerprints, revealing the three-dimensional structure of a given mineral. CheMin is the first X-ray diffractometer ever sent to space, Downs said.

As with any fingerprint, the pattern doesn't tell you much if you don't have anything to compare it to. Downs's research group has established the largest reference database of minerals that have been analyzed, and new ones are being added every day. About 5,000 small vials, neatly labeled and stored in a cabinet in his lab, represent about 2,200 species of the approximate 4,800 known minerals, more than any other lab in the world.

"Once the data come down from the rover, we analyze it with software and do search matching with our library," Morrison explained. "Using our resources here, we find correlations and work out the chemistry. Having this huge database at the UA allows us to really compare the Mars samples to enough minerals with known chemistry so we are able to narrow their structure down fairly accurately."

As one of NASA's designated primary uplink and downlink leaders – or a PUDL, affectionately referred to as "poodle" in NASA jargon – Morrison divides her time between Tucson and NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif.

"I create the commands for the CheMin instrument, telling it to turn on, perform the analysis and send the data back down," she said. "The instrument science teams put together their commands as a package, and after extensive testing, that package will be sent to 'Curiosity.'"

"We have another rover sitting at JPL," she said. "They feed the commands to that one first, and see what it does, before sending them to Mars."

Once Curiosity's robotic arm has scooped up a soil sample, it is divided into portions, which are then fed to the various analytic instruments, including CheMin, housed in the rover's body.

"We open CheMin's hatch, the sample is dropped onto a sieve and a funnel, and then slides down a chute into the analyzer," Morrison explained.

Once CheMin has finished analyzing a rock sample, which can take up to 10 hours, Curiosity sends the data to Earth.

"Recently, Curiosity went to a rock and drilled into what is called mudstone, and sure enough, it was filled with clay," Downs said. "That is a really big deal because it means there was water at some point. That was done with our instrument as well, and Shaunna was involved in those analyses."

Besides exploring what makes up the Red Planet, Morrison is pursuing another, more earthly, project for which she was awarded a graduate fellowship from the National Science Foundation: the study of rare Earth minerals.

Rare Earth minerals attract increasing interest from scientists and engineers because of their unique chemical properties. Some of them have strong magnetic properties, making them prime candidates for smaller electrical motors or tiny yet powerful speakers. As a key ingredient of LED screens, technology already strongly depends on those minerals.

Morrison is going to use the fellowship to study where rare Earth minerals come from and how they form, processes that are still poorly understood.

"There are around 314 rare Earth minerals known, but we don't know one third of them yet in any detail," Morrison said. "We know they exist, we have samples of them, but nobody has spent time yet to analyze them to figure out exactly what they're made of."

As Curiosity makes its way toward its main destination, Mount Sharp, more sites await to be sampled and no one knows what surprises they might hold.

Provided by University of Arizona

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