Autonomous rover drills underground in the Atacama

July 4 2013, by Leslie Mullen

Zoë being checked out at start of the traverse. In the background are the two 4x4 trucks that we will use to follow the robot. The engineers stay within communication range to monitor the robot, but try to say out of view as much as possible. Credit: CMU Field Robotics Center

A rover named Zoë recently traveled the Atacama Desert in Chile, the driest place on Earth and a landscape that has much in common with the harsh terrain of Mars. From the unrelenting UV radiation, to the thin, cold air at high altitudes, to the desiccated sand and lava flows, the Atacama is not especially "life-friendly," but it is a great place to test instruments for future Mars missions.

Equipped with a drill, cameras, spectrometers and other sensors, for a little over two weeks Zoë analyzed soil samples from above and below the surface. The surface of Mars is considered uninhabitable because of the harsh UV, thin atmosphere, extreme cold and acidic soil, and so many believe the best place to find evidence of past or present life on Mars is deep underground.

This recent excursion with Zoë ended on Saturday, June 29, and it is part of a longer three-year campaign, led by David Wettergreen of Carnegie Mellon University, to test the rover's instruments and drilling capability. The project is supported through NASA's ASTEP program to advance the technology and techniques used in planetary exploration.

Thanks to Zoë's onboard autonomy software, the science team in the United States was able to explore the Atacama remotely, just as NASA mission control would operate a rover on Mars.

The engineering team was in the field with the rover, on hand just in case anything went wrong. Also, "we had a couple people collecting ground truth," says Wettergreen, "digging pits to make sure what the rover was sampling autonomously was the same as what we'd get on our own."

Zoë sets out bravely in the Atacama. Like the Spirit and Opportunity rovers, which landed on Mars in 2004, Zoë is powered by solar panels. Because dust on the panels sometimes shuts down the rovers, the Curiosity rover, which reached Mars in 2012, is nuclear powered. In the Atacama, however, Zoë's panels can be cleaned if they should become dusty. Credit: A. Wang

After Zoë's meter-long drill dug up a sample, the rover deposited them into sample cups and analyzed them with instruments such as a laser Raman spectrometer (the MMRS or Mars Microbeam Raman Spectrometer). The MMRS shines a laser on the sample and measures the energy of the photons scattered back, providing a clear spectrum of each mineral phase and organic molecule.

"The Raman spectrometer instrument was remarkably robust," says Wettergreen. Not only was it exposed to a broad range of temperatures, "which is a lot for a laser and detector to take," he says, "but it got quite a beating over some pretty rocky terrain. Some of the areas we crossed were fairly rugged, so it had to put up with a lot of vibration and shock."

The rover also has a Bio-UltraViolet Fluorescent instrument (BUF) composed of light-field cameras that can focus at multiple depths. "The UV causes organics to fluoresce, telling us the abundance of organic materials in the samples," he says.

Zoë made 11 sample drill holes, with samples taken at different depths, resulting in about 40 samples. "Ultimately the science team settled on taking samples from 10 centimeters, then 30 centimeters, and then 80," says Wettergreen. "The depths were determined on where salt layers formed in the soil, which is a function of how far moisture penetrated."

Zoë’s planned path through the Atacama included visits to salt flats, volcanic slopes and alluvial fans of material eroded off of mountains. Credit: Google Earth

Nathalie Cabrol of the SETI Institute, the Science PI for the project, sees the field campaign as a big success—the rover was highly mobile, traveling up to 10 kilometers per day, and the drill and other instruments worked as they should to gather samples and analyze them. And importantly, all of this was performed autonomously for the first time.

"This is huge," says Cabrol. "We can now provide astrobiology with a highly mobile drill-mounted rover that is able to test for the possibility of life on Mars."

She says that by "punching holes down to 80 centimeters, Zoë can get better access of the record of life on Mars than the MER Opportunity or the MSL Curiosity rovers that are now on Mars." She says they collected good quality data, and now scientists need time to analyze it all.

The laser Raman spectrometer (silver box) aboard Zoë. The peaks in a Raman spectra immediately identify the chemical compounds in the sample, without further processing. None of the instruments aboard the rovers currently on Mars can match its diagnostic ability. Credit: A. Wang

One problem that can arise with drilling is contamination of the samples. Wettergreen says this issue was studied intensively in the lab by Honeybee Robotics, the company who made the drill (and also made the drills for MER Opportunity and MSL Curiosity). He says there are two ways to contaminate a drill hole: by moving material at different depths (either up or down the drill column), and transferring material from one drill site to another.

The Honeybee lab tests found that only a small fraction of material moves in the drill column—instead the force of the drilling process essentially cleans the drill. Although they did not practice this in the field due to the limitations of time, on Mars, a rover would minimize any contamination between sites by drilling a few "waste" holes just to clean off the drill.

After this year's field campaign, the engineers now have a list of improvements and refinements they need to make on the rover and its instruments. Next year they plan to take Zoë even farther afield, following a east-west transect across Chile into different elevations and environmental conditions, and hopefully generating even larger science returns.

Source: Astrobio.net

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