Happy 10th anniversary Opportunity

January 23 2014

NASA’s Opportunity rover captured this panoramic mosaic on Dec. 10, 2013 (Sol 3512) near the summit of “Solander Point” on the western rim of vast Endeavour Crater where she starts Decade 2 on the Red Planet. She is currently investigating summit outcrops of potential clay minerals formed in liquid water on her 1st mountain climbing adventure. See wheel tracks at center and dust devil at right. Assembled from Sol 3512 navcam raw images. Credit: NASA/JPL/Cornell/Marco Di Lorenzo/Ken Kremer-kenkremer.com

Ten years ago, on Jan. 24, 2004, the Opportunity rover landed on a flat plain in the southern highlands of the planet Mars and rolled into an impact crater scientists didn't even know existed. The mission team, understandable giddy that it hadn't crashed or mysteriously gone silent during the descent (as other Mars missions have done) called it "a hole in one."

In honor of the rover's 10th anniversary, Ray Arvidson, PhD, deputy principal investigator of the dual-rover mission, recently took an audience at Washington University in St. Louis on a whirlwind tour of the past decade's exploration of Mars, cheered on by students holding signs reading "Boffins." ("Boffin" is British slang for "scientist.")

Introducing Arvidson, Bill McKinnon, PhD, a fellow WUSTL planetary scientist, said Arvidson had done graduate work under Tim Mutch of Brown University, who led the Lander Imaging Team for the Viking mission to Mars. When Mutch stepped down as team leader in 1977, Arvidson took over for him. Arvidson, the James S. McDonnelll Distinguished University Professor in Arts & Sciences, has been involved in every significant U.S. interplanetary mission to Mars and Venus since then, McKinnon said.

Arvidson had a good story to tell. The 10-year-old rover, dirty and arthritic though it may be, just found evidence of conditions that would support the chemistry of life in the planet's past, work that earned it a spot in the Jan. 24 issue of *Science* magazine, just in time for Opportunity's anniversary.

Why are we on Mars?

"We're exploring Mars to better understand Earth," Arvidson said. "On Mars, we can learn about geological processes and environmental processes—maybe habitability, maybe life, that remains to be seen—for a period of time that's lost on Earth.

"Mars preserves the whole geologic record," he said, "because there's so little erosion there. We have the whole stratigraphic section; minerals are well preserved. So by touring and exploring Mars, we can travel back into early geologic time.

"The punch line is that the farther back we look in the rock record, the more we find evidence of the interaction of relatively mild waters with the Martian crust. And the farther back we look, the better the chemical conditions for life.

"Today, Mars is dry and cold. But in the past, there were exploding volcanoes with hydrothermal vents, there were fumaroles (steam-charged vents), there were rivers, there were dendritic streams, there were lakes.

"The older you look, the better it gets in terms of warm and wet," Arvidson said.

The MER rovers

"The rovers are really field geologists," Arvidson said. "They're robotically driven, but they're doing what we would be doing if we had boots on Mars with rock hammers, collection bags, microscopes and little huts where we could do some chemical analyses.

"What people don't realize is that on any given day, in the afternoon Mars time, when the data come down through the Deep Space Net, we get just 100 to 200 megabits. That's a soda straw, not a fire hose. So we have to be really careful about what we command and prioritize what we acquire.

"But operating at 100 to 200 megabits per sol, we've attempted to reconstruct the past environment from the geologic record just as a field geologist would do. (Sols, or Martian days, are 39 minutes longer than Earth days.)

"We lost Spirit, Opportunity's twin, back in 2010," Arvidson said. Stuck in the sand, it was unable to point its solar arrays in the correct direction to survive winter, and it went quiet March 22, 2010, or sol 2,210.

But Arvidson is not complaining; the rovers were expected to survive only about 90 to 180 sols. "They were supposed to last three or six months and it's been 10 years," he said. "They were supposed to drive maybe a thousand meters, and Opportunity is now about to break 40,000 meters."

Crater-hopping on Mars

Early in its mission although already past its expiry date (on sol 134), Opportunity drove into a 430-foot-wide crater named Endurance. It spent the next half-year exploring sedimentary layers exposed in the crater wall.

They were named the Burns formation for Roger Burns, a geologist who predicted the importance of sulfate mineralogy on Mars based on results obtained by the Viking missions and his laboratory analyses. "The formation consists of many thin layers of sulfate sandstone that formed in ancient lakebeds, were reworked into sand dunes by the wind, and then recemented into rock by rising groundwater," Arvidson said.

Looking at the chemistry of the rocks, the mission scientists inferred that they had formed under acidic and oxidizing conditions. The rover, they quipped, had discovered evidence not of water but of acid on Mars.

Nothing daunted, Opportunity struggled out of Endurance and trundled off toward Argo, the next-nearest crater. It was to crater-hop for the next nine years, checking out Argo, Vostok, Erebus, Victoria, Conception and Santa Maria, but encountering the Burns Formation everywhere it went.

And then, finally, it drove to Endeavour, a monster crater, measuring a full 14 miles across. Formed by the impact of an asteroid or a comet, perhaps 4 billion years ago, the crater has been filled in by Burns Formation sandstones, but a few islands of rock still stand exposed on the rim.

"They're ancient rocks that predate the Endeavour impact," Arvidson said. Rather than enter the crater, Opportunity stayed on its rim to look at those rocks.

"We drove to a spot on the rim called Cape York because the CRISM instrument on the Mars Reconnaissance Orbiter had identified the spectral signature of clay materials on its eastern side," Arvidson explained.

At Cape York, the rover ground into a rock called Espérance. The deeper it ground, the more the rock's composition resembled that of an aluminum-rich clay called montmorillonite.

"To make an aluminum-rich clay," Arvidson explained, "you have to leach many other elements out of the rock, such as iron and magnesium. So this is a place a lot of water flowed through, probably because fracturing made the rock very permeable.

"If you go through the chemistry and infer characteristics of the water, it was mildly acidic at best and reducing, not oxidizing, and those are habitable conditions. We think this kind of environment existed many places on Mars," he said.

What happened to Mars?

But if Mars was once warm and wet, what happened to turn it cold and dry?

"Early Mars was volcanically active," Arvidson said. "The volcanoes would have pumped greenhouse gases into the atmosphere that warmed the planet. It also had an internal magnetic field that deflected the solar wind, preventing it from stripping away the atmosphere. But as the core of the planet froze, its magnetic field diminished, the solar wind scoured away the atmosphere, and without a dense atmosphere, it became the cold, dry planet we know today.

"That's what the geologists think," he said. "So we're convincing the atmosphere modelers to give us enough greenhouse oomph, with whatever gas they want, in order to get up to temperature where there would be liquid water on the surface. Because the geological evidence says, 'That's a fact, Jack.'"

The Boffins-in-training all stood up and cheered.

Provided by Washington University in St. Louis

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