Curiosity rover's sand-dune studies yield surprise

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Two sizes of ripples are evident in this Dec. 13, 2015, view of a top of a Martian sand dune, from NASA's Curiosity Mars rover. Sand dunes and the smaller type of ripples also exist on Earth. Credit: NASA/JPL-Caltech/MSSS

Some of the wind-sculpted sand ripples on Mars are a type not seen on Earth, and their relationship to the thin Martian atmosphere today provides new clues about the atmosphere's history.

The determination that these mid-size ripples are a distinct type resulted from observations by NASA's Curiosity Mars rover. Six months ago, Curiosity made the first up-close study of active sand dunes anywhere other than Earth, at the "Bagnold Dunes" on the northwestern flank of Mars' Mount Sharp.

"Earth and Mars both have big sand dunes and small sand ripples, but on Mars, there's something in between that we don't have on Earth," said Mathieu Lapotre, a graduate student at Caltech in Pasadena, California, and science team collaborator for the Curiosity mission. He is the lead author of a report about these mid-size ripples published in the July 1 issue of the journal *Science*.

Both planets have true dunes—typically larger than a football field—with downwind faces shaped by sand avalanches, making them steeper than the upwind faces.

Earth also has smaller ripples—appearing in rows typically less than a foot (less than 30 centimeters) apart—that are formed by wind-carried sand grains colliding with other sand grains along the ground. Some of these "impact ripples" corrugate the surfaces of sand dunes and beaches.

Images of Martian sand dunes taken from orbit have, for years, shown ripples about 10 feet (3 meters) apart on dunes' surfaces. Until Curiosity studied the Bagnold Dunes, the interpretation was that impact ripples on Mars could be several times larger than impact ripples on Earth. Features the scale of Earth's impact ripples would go unseen at the resolution of images taken from orbit imaging and would not be expected to be present if the meter-scale ripples were impact ripples.

"As Curiosity was approaching the Bagnold Dunes, we started seeing that the crest lines of the meter-scale ripples are sinuous," Lapotre said. "That is not like impact ripples, but it is just like sand ripples that form under moving water on Earth. And we saw that superimposed on the surfaces of these larger ripples were ripples the same size and shape as impact ripples on Earth."

Besides the sinuous crests, another similarity between the mid-size ripples on Mars and underwater ripples on Earth is that, in each case, one face of each ripple is steeper than the face on the other side and has sand flows, as in a dune. Researchers conclude that the meter-scale ripples are built by Martian wind dragging sand particles the way flowing water drags sand particles on Earth—a different mechanism than how either dunes or impact ripples form. Lapotre and co-authors call them "wind-drag ripples."

"The size of these ripples is related to the density of the fluid moving the grains, and that fluid is the Martian atmosphere," he said. "We think Mars had a thicker atmosphere in the past that might have formed smaller wind-drag ripples or even have prevented their formation altogether. Thus, the size of preserved wind-drag ripples, where found in Martian sandstones, may have recorded the thinning of the atmosphere."

The researchers checked ripple textures preserved in sandstone more than 3 billion years old at sites investigated by Curiosity and by NASA's Opportunity Mars rover. They found wind-drag ripples about the same size as modern ones on active dunes. That fits with other lines of evidence that Mars lost most of its original atmosphere early in the planet's history.

Other findings from Curiosity's work at the Bagnold Dunes point to similarities between how dunes behave on Mars and Earth.

"During our visit to the active Bagnold Dunes, you might almost forget you're on Mars, given how similar the sand behaves in spite of the different gravity and atmosphere. But these mid-sized ripples are a reminder that those differences can surprise us," said Curiosity Project Scientist Ashwin Vasavada, of NASA's Jet Propulsion Laboratory in Pasadena.

After examining the dune field, Curiosity resumed climbing the lower portion of Mount Sharp. The mission is investigating evidence about how and when ancient environmental conditions in the area evolved from freshwater settings favorable for microbial life, if Mars has ever hosted life, into conditions drier and less habitable.

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