Closer look at Mars reveals new type of impact crater

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This is an example of a low-aspect-ratio layered ejecta crater (LARLE). Credit: Nadine Barlow

Lessons from underground nuclear tests and explosive volcanoes may hold the answer to how a category of unusual impact craters formed on Mars.

The craters feature a thin outer deposit that extends many times beyond the typical range of ejecta, said Nadine Barlow, professor of physics and astronomy at Northern Arizona University. She has called these craters Low-Aspect-Ratio Layered Ejecta (LARLE) craters since the ratio of the thickness to the length of the deposit (the aspect ratio) is so small. Barlow presented the findings of her LARLE crater study at the American Astronomical Society's Division for Planetary Sciences meeting in Denver this week.

Barlow found the LARLE craters while poring over high-resolution images to update her highly popular catalog of Martian craters. These craters stood out since they displayed this extensive outer deposit beyond the normal ejecta blanket of the crater. "I had to ask, 'What is going on here?' " Barlow said.

Unlike the normal fluidized ejecta patterns seen around fresh Martian impact craters, the LARLE deposit is thin, uniform in thickness, displays dune-like features and hollows, and terminates in a sinuous flame-like pattern. The long run-out distances of these outer deposits (up to 20 crater radii from the rim) indicate that the material is emplaced by a much more fluid process than the normal ejecta blankets.

Delving into "explosion literature," Barlow and her collaborators Joseph Boyce of the University of Hawaii and Lionel Wilson of Lancaster University learned more about a phenomenon known as base surge. Expanding gas from the impact picks up fine-grained material from the surface and moves it outward. The density of this dust cloud is much greater than that of the atmosphere, causing the cloud to flow outward as a ground-hugging current. This current can travel up and over preexisting topography and drops its load of fine-grained material into a thin, extensive deposit.

By adjusting equations from volcano research for Martian conditions, Barlow and her colleagues could accurately replicate the thin, sinuous, almost flame-like deposits characteristic of the LARLE layers.

A global survey using data from the Mars Odyssey and Mars Reconnaissance Orbiter spacecraft revealed 140 LARLE craters ?1-km-diameter. The craters are found primarily at higher latitudes, a location that correlates with thick, fine-grained ice-rich mantles emplaced during periods when Mars' rotation axis was tilted more than today. "The combination of fine-grained and ice-rich materials produces the perfect condition to create a base surge," Barlow said.

Barlow and her colleagues believe that the majority of impacts on Mars produce a base surge, but the fine-grained deposits are quickly removed by the planet's winds. The LARLE deposits remain because they are armored against erosion. Water moving upward through the LARLE deposit shortly after its formation will carry dissolved salts. These salts will form a sticky surface layer at the top of the LARLE deposit called duricrust, which has been observed at several landing sites across Mars.

LARLE craters are seen in the same size range and same areas of the planet as pedestal craters, which are craters which sit on a plateau elevated above the surroundings. Pedestal craters are proposed to form when ice sublimates from the surrounding materials, lowering the surroundings and leaving the crater, ejecta blanket, and outer pedestal elevated. "Based on our research, we believe that pedestal craters are simply eroded forms of LARLE craters", said Barlow.

Thus the base surge model can explain two enigmatic crater forms seen on Mars and answers the long-standing question of how the pedestal crater plateau is armored against erosion.

Provided by Northern Arizona University