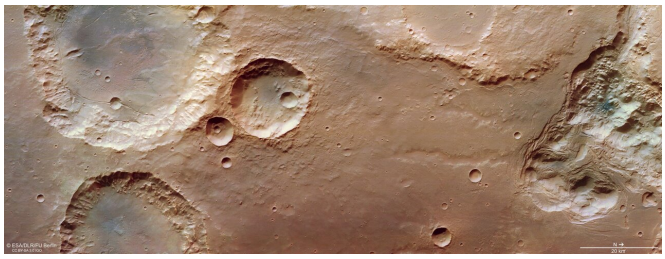
Creating chaos: Craters and collapse on Mars

19 November 2020



Chaotic terrain in Mars' Pyrrhae Regio. Credit: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO

Elevation can be deceiving in satellite imagery of Mars, even when differences are extreme—as demonstrated by this image of Pyrrhae Regio from ESA's Mars Express. A chunk of terrain has collapsed and dropped more than four kilometers below its surroundings, illustrating the incredible contrast and dynamism seen across the martian surface.

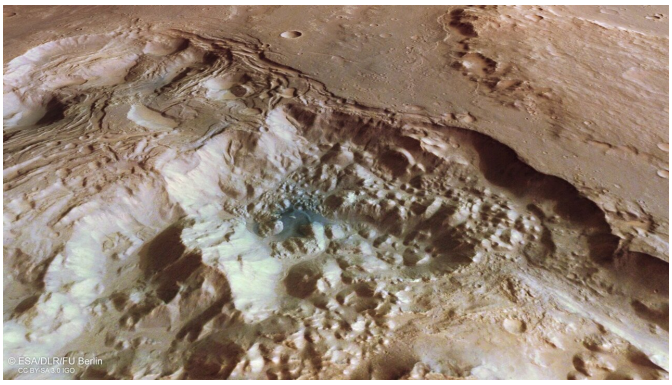
This slice of Mars, seen here as imaged by Mars Express' High Resolution Stereo Camera (HRSC), shows signs of various intriguing processes.

A scattering of impact craters, formed as incoming bodies from space collided with Mars' surface, can be seen to the left of the frame; the floor of the largest and uppermost basin spans about 40 kilometers, and contains some fractures and markings that formed just after the crater itself. Hot, molten rock is thought to have been thrown up during the crater-forming collision, after which it cooled and settled to form the scar-like features visible here.

Toward the middle of the frame, the surface is relatively smooth and featureless—however, two broad channels have worked their way through the landscape, and can be seen as meandering, branching indentations in the surrounding terrain.

These channels are reminiscent of so-called 'sapping valleys' on Earth, which form as water consistently seeps and flows through sediment to carve out a natural drainage network.

The valleys are attached at their rightward end to the real star of this image: a sunken, uneven, scarred patch of ground known as chaotic terrain.



Perspective view of chaotic terrain in Mars' Pyrrhae Regio. Credit: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO

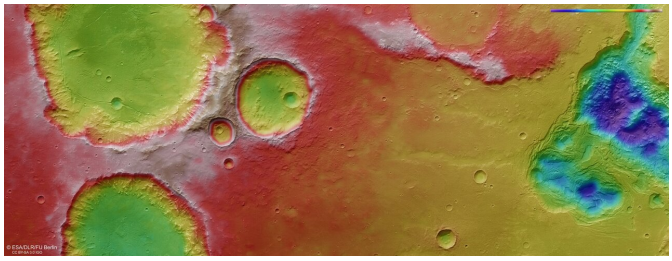
Chaotic terrain, as the name suggests, looks irregular and jumbled, and is thought to form as sub-surface ice and sediment begins to melt and shift. This shifting layer causes the surface above to collapse—a collapse that can happen quickly and catastrophically as water drains away rapidly through the regolith (the near-surface layer of rocky planets). Ice can be triggered to melt by heating events such as volcanic lava flows, subsurface magmatism, impacts by large meteorites, or changes in climate.

In the chaotic terrain seen here, ice has melted, the resulting water drained away, and a number of disparate broken 'blocks' have been left standing in now-empty cavities (which once hosted ice).

Remarkably, the floors of these cavities lie some four kilometers below the flatter ground near the craters to the left, as seen clearly in the associated topographic view—a colossal difference in height (for reference, the highest mountain peaks of the Pyrenees and the Alps top out at just over 3.4 km and 4.8 km, respectively).

Considering the broader landscape containing and surrounding Pyrrhae Regio, the chaotic nature of this area is unsurprising. To the west of this patch of ground lies one of the most extreme features in the Solar System: a colossal canyon system named Valles Marineris.

Valles Marineris is roughly ten times longer and five times deeper than the Grand Canyon on Earth, and comprises myriad smaller rifts, channels, outflows, fractures and signs of flowing material (such as water, ice, lava or debris). It is home to many substantial chaotic terrains, including Aurorae Chaos and Erythraeum Chaos.



Topographic view of Mars' Pyrrhae Regio. Credit: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO

Valles Marineris is an unmissable scar on the face of Mars, and thought to have formed as the planet's crust was stretched by nearby volcanic activity, causing it to rip and crack open before collapsing into the deep troughs we see today. These troughs have been further shaped and eroded by water flows, landslides, and other erosive processes, with spacecraft including Mars Express spying signs that water existed in parts of Valles Marineris in the relatively recent past ('mere' hundreds of millions of years ago).

As well as characterizing the complex processes at play in standout features such as Valles Marineris, Mars Express—in orbit around the Red Planet since December of 2003—has spent years imaging Mars' surface, mapping its minerals, identifying the composition and circulation of its tenuous atmosphere, probing beneath its crust, and exploring how phenomena such as the solar wind, a stream of charged particles emanating from the Sun, interacts in the martian environment.

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