'Magma P.I.' unearths clues to how crust was sculpted

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About a decade ago, Johns Hopkins University geologist Bruce Marsh challenged the century-old concept that the Earth's outer layer formed when crystal-free molten rock called magma oozed to the surface from giant subterranean chambers hidden beneath volcanoes.

Marsh's theory – that the deep-seated plumbing underneath volcanoes is actually made up of an extensive system of smaller sheet-like chambers vertically interconnected with each other and transporting a crystal-laden "magmatic mush" to the surface – has become far more widely accepted. This sort of system, known as a "magmatic mush column," is thought to exist beneath all of the world's major volcanic centers.

Now, Marsh – using the windswept McMurdo Dry Valleys of Antarctica as his "walk in" laboratory -- posits that these channels did more than simply transport or supply magma and crystals to form the Earth's surface: As the magma pushed up through the earth, the pressure fractured the crust in such a way that it provided a sort of "template," guiding later erosion in sculpting a series of valleys and mountain ranges there.

Marsh described his latest findings to fellow scientists at a recent meeting of the American Geological Society.

"As the magma made its way to the surface, the pressure broke the crust up into pieces," Marsh says. "That fracturing reflected a pattern of stress in the same way that a windshield put under pressure will eventually

fracture and the pattern of the broken glass would reflect where the stress was originally applied.

“Magma then seeped in," he says, "and ‘welded’ the fractures, sealing them temporarily until erosion – in the form of snow, rain, ice and wind – went to work on these weaknesses, carving out valleys, mountains and other landforms that we see there today and marking where the solidified magma originally was.”

Marsh said that, in Antarctica, both of these functions date back at least 180 million years to the time when the continents split apart. He points out that this observation brings together the usually disparate study of deep-seated magmatic processes and land-surface evolution.

“It’s one of those situations where, usually, never the twain shall meet, but they do in this case,” the earth scientist said. “Having recognized evidence in this critical process in the McMurdo Dry Valleys is important because it may allow us to recognize it in other areas where the geologic record is scantier and less complete.”

The Dry Valleys makes an ideal place to study these systems because it was eroded into its present form millions of years ago and has, unlike the rest of Earth’s surface, undergone very little subsequent erosion. His colleagues George Denton of the University of Maine and David Marchant of Boston University call this region “a relic landscape,” because it is the only known place on Earth that looks almost exactly as it did millions of years ago.

“The delicacy of the landscape in the Dry Valleys has preserved for us an unusually rich collection of geologic evidence of the processes that formed this terrain,” Marsh said.

For more than a quarter of a century, Marsh -- who could be thought of

by fans of 1980s detective television shows as sort of a "Magma P.I." -- has been working to understand the deep underground systems that bring magma to the Earth's surface. In 1993, he found the Dry Valleys, a walk-in "museum" that he calls "the one place on earth where the plumbing system is exposed in this way."

"You can stand on shelves of solidified lava that were deposited by magmatic activity 180 million years ago," he said. "It's awe inspiring."

Source: Johns Hopkins University