VOL. 106 | NO. 2
FEBRUARY 2025

Eos

SCIENCE NEWS BY AGU

Gaining New Insights from Old Storms

South America Is Drying Up

Earth May Survive the Sun's Demise

HOW GREAT WAS the Great Oxidation Event?

Answers to existential questions are coming from a planetary perturbation billions of years in the past.

AGU
ADVANCING EARTH AND SPACE SCIENCES

Martian Meteorite Points to Ancient Hydrothermal Activity

In 2011, a striking black rock about the size of an apple was discovered in the Sahara desert. Its unusual appearance tipped off its finder, and it soon passed into the hands of a meteorite dealer in Morocco. An American collector ended up buying the stone, and pieces of it have since been parceled out to various scientists. And that meteorite, which has come to be known as NWA 7034, or "Black Beauty," is different from most other meteorites: It's a chunk of Mars.

Despite many orbiters and landers visiting Mars, none has returned a piece of the Red Planet to Earth. Scientists turn to meteorites such as Black Beauty to better understand the conditions on Mars just a few tens of millions of years after it formed.

Tiny grains of zircon from NWA 7034 have now revealed that hydrothermal activity likely persisted in Mars's crust 4.45 billion years ago. That's the earliest indirect evidence of water on the Red Planet.

"If you want to reach back to some of the oldest history of Mars, there's not too many ways to go about doing that."

Not Just Any Old Meteorite

The vast majority of the roughly 60,000 meteorites that have been collected to date are pieces of asteroids. But about 200 belong to a rarefied group of Martian meteorites. These rocks were dislodged from Mars's surface by asteroid impacts and imbued with sufficient kinetic energy to escape the planet's gravitational field. They then went on to intersect Earth's orbit and plunge through the atmosphere before ultimately being picked up by a person.

A Martian meteorite is something special, said Jack Gillespie, a geochemist at the University of Lausanne in Switzerland. "It represents something from the Martian surface that we have access to on Earth."

Gillespie and his colleagues recently analyzed a single grain of zircon from Black Beauty measuring about 20 × 30 micrometers. Roughly three such grains could be stacked widthwise across a human hair.

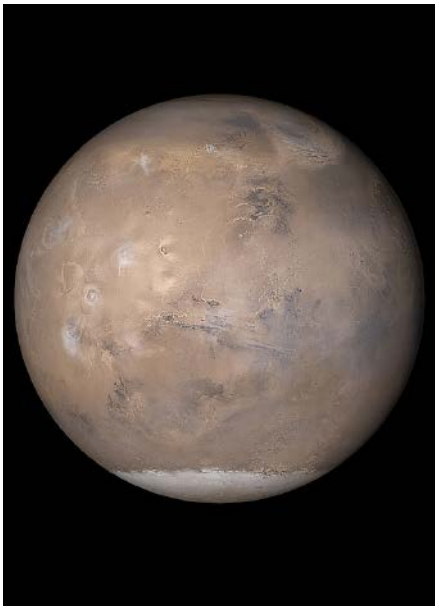
Zircon is a mineral that's extremely tough and can be readily dated, which makes it an ideal tracer of the distant past. "If you want to reach back to some of the oldest history of Mars, there's not too many ways to go about doing that," said Aaron Cavosie, a planetary scientist at the Space Science and Technology Centre at Curtin University in Perth, Australia, and a member of the research team.

In 2022, Cavosie and his colleagues published an analysis of 66 zircon grains from Black Beauty and two other Martian meteorites. The team showed that the crystal structure of one of the grains in Black Beauty had been distinctly rearranged, a feature that suggested the passage of an intense shock wave. Similar features have been noted in rocks unearthed from the site of the cataclysmic Chicxulub impact in the Yucatán Peninsula that spelled the demise of nonavian dinosaurs, the researchers reported.

Unexpected Elements

Gillespie, Cavosie, and their colleagues revisited that same zircon grain, which was previously shown to have an age of 4.45 billion years. The team used a variety of techniques, including one particularly powerful method known as time-of-flight secondary ion mass spectrometry, to probe the chemistry of the grain. They found trace amounts of iron, aluminum, and sodium.

Finding those elements in a zircon grain was a big surprise, said Carl Agee, director of the Institute of Meteoritics at the University of New Mexico who was not involved in the research. "They aren't normally there." And when they are, the mineral typically also exhibits signs of radiation damage. "Grains that have this level of trace elements are normally damaged goods," Cavosie said. (Radiation damage is far more destructive, structurally speaking, than shock wave–imparted changes.) A grain exposed to radiation damage would lose its structural integrity and be prone to incorporating such "nonformula elements" after it formed, said Cavosie. But the grain from Black Beauty showed no sign of this damage—its atoms were all neatly arranged. "They're like little oranges lined up at the grocery story," Cavosie said.



An amalgam of hot rock and water-based fluids likely persisted on ancient Mars. Credit: NASA/JPL/Malin Space Science Systems

Gillespie and his collaborators showed that atoms of iron, aluminum, and sodium persisted within growth zones of the zircon grain. That finding suggests that these unexpected elements were deposited as the grain crystallized rather than incorporated at a later date. One well-known way for delivering such elements is a hydrothermal event, in which a zircon crystallizes in an underground amalgam of hot rock and water-based fluids.

It's likely that this zircon grain was therefore bathed in hydrous fluids during its birth 4.45 billion years ago on Mars, the researchers concluded. That's the earliest evidence of water on the Red Planet, the team noted. These results were published in *Science Advances* (bit.ly/hydrothermal-Mars).

These findings make a lot of sense, Agee said. Mars was likely more geologically active in the past, and many of its features suggest that water coursed over its surface long ago. "It seems very plausible that there would be hydrothermal activity on Mars," he said.

By **Katherine Kornei** (@KatherineKornei), Science Writer