NASA/JPL-Caltech

What meteorites can tell us about Mars

Hundreds of millions of years ago, something crashed into the planet Mars with enough force to eject pieces of Martian rock into space. Some of these pieces of rock made their way to Earth where they entered our atmosphere as meteors. A precious few landed on the surface of our planet as meteorites. Thanks to scientists like Geoffrey Howarth, a geologist based at the University of Cape Town (UCT), these Martian meteorites are now being studied to better understand the structure and geological history of the red planet. Here's what we know so far.

Howarth, who grew up on a farm in the Eastern Cape, first came across the field of igneous petrology (the study of how volcanic rocks form) as an undergraduate. Little did he know then that he would one day specialise in two very different types of igneous rocks: one that formed in the heart of our planet and others that came from the surface of a planet 137 million kilometres away.

"As a child I liked to collect rocks because I found them mysterious, but it was only later when I first began studying geology that I became fascinated with what rocks can tell us about the history of a planet through time. I still remember the first time I came across a Martian meteorite, holding a little piece of a different planet in my hand definitely made an impression."

Today, Howarth's research focuses on kimberlite, the type of rock in which most diamonds are found, and which forms deep in the Earth's crust, as well as meteorites from Mars.

Messengers from the mantle

To date, Howarth and a global team of geologists have studied 252 individual Martian meteorites from 11 distinct ejection sites on Mars. Some of these samples are on loan from NASA, while many more have been sourced more recently in North West Africa by local Bedouin experts and commercial meteorite hunters.

"Studying these meteorites gives us insights into the composition, differentiation and evolution of the Martian mantle. The meteorites also offer clues into secondary geological processes such as the role that water has played in the formation of these rocks," explains Howarth.

To understand the chemical composition of the meteorites, Howarth and his team use an electron probe to analyse very fine sections of the rock. The data collected so far shows that Mars has a heterogeneous mantle, meaning it is made up of a variety of different kinds of rocks.

"These various mantle sources have not mixed very much because unlike Earth, Mars does not have any plate tectonics. The recent discovery of new Martian meteorites has revealed a diversity of sources and magmatic history, and that the Martian interior is more varied than previously thought."

A recent paper published in *Journal of Geophysical Research: Planets*, by Howarth and other geologists from around the world, also explains that the study of these Martian meteorites supports the idea that early Martian history involved fast accretion and core formation compared to Earth. But Howarth cautions that the majority of Martian meteorites studied to date are quite young by geological time standards, and combined with the fact that many come from the same ejection sites on Mars, they cannot give us a complete understanding of Martian geology.

Libby Young

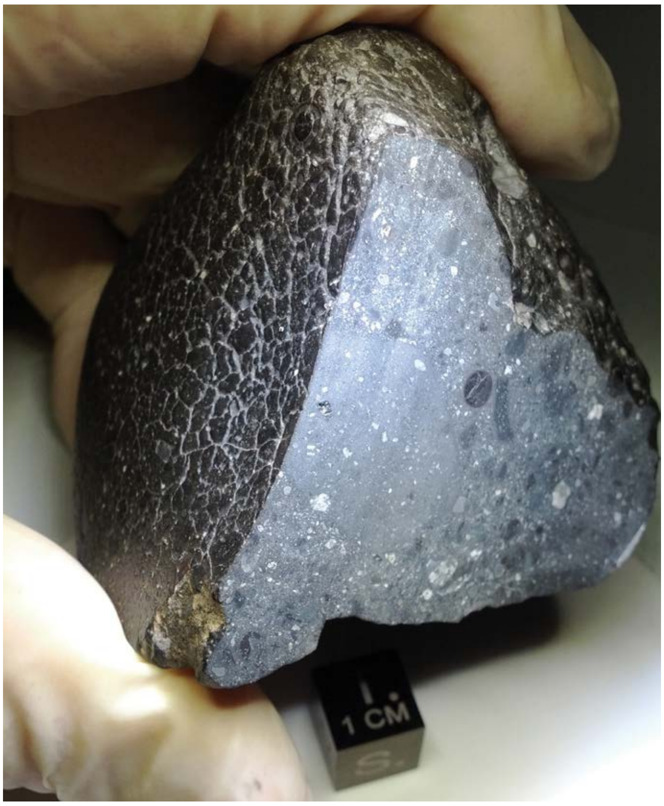
UCT geologist Dr Geoffrey Howarth.

Time capsules from outer space

"Most of the meteorites studied so far are younger than 600 million years old. Three quarters of the meteorites are shergottites (named for the first location where they were found in Sherghati in India), which are almost identical to the rock basalt we find here on Earth. The rest are mostly made up of Nakhlites, named for the Nakhla meteorite found in Egypt in 1911. These are also igneous (volcanic) rocks composed largely of augite and olivine crystals."

Over the last two decades the number of recovered Martian meteorites has almost doubled, which has allowed scientists to study suites of meteorites for the first time. But according to Howarth, this still represents a biased sample with many coming from unknown ejection sites on Mars' surface.

"To really be able to look back in time and understand how the surface and interior of Mars was formed, we need samples from Mars itself. Lucky for us, the Mars 2020 Perseverance rover is aiming to collect over 30 diverse surface samples from the Jezero Crater on Mars. These rock samples may be returned to Earth as soon as 2031."



University of New Mexico

The Martian meteorite officially named North West Africa (NWA) 7034, but nicknamed 'Black Beauty', was found in Morocco in 2011.

These samples will allow scientists such as Howarth to analyse a greater variety of Martian rocks with known origins.

"Studying these rocks alongside the meteorites will help us to narrow our hypotheses of how the Martian interior and surface evolved," says Howarth.

Water on Mars

Howarth has a particular interest in the history of water on Mars and its role in atmospheric dynamics and volcanic activity. Previous missions to Mars have shown strong evidence for the past presence of water on its surface, as well as the current-day presence of ice at the polar caps and in the subsurface of the planet.

Howarth explains that by studying how and when minerals in Martian meteorites interacted with water, we can better understand the hydrologic history of Mars itself.

"While some of these minerals were formed from crystallised magma directly, others were formed through interaction with water occurring on the Martian surface or subsurface. So, we know that early on in the planet's history there must have been substantial water present. What we don't know is how much water cycling took place on Mars or how similar it might have been to our own planet."

Not over the moon yet

Howarth is hopeful that the discovery of new Martian meteorites here on Earth, or the return of samples from the next mission to Mars, will help to answer some of the many questions that remain about the planet's geology.

"Once we have access to older Martian rocks we can start to answer questions about the role of water in Martian magmatism (magma activity), such as how the magma ocean on Mars crystallised, how volcanic rocks came to be found at the surface of the planet, and how volcanic activity on Mars evolved over time."

But Martian meteorites are not the only bits of interstellar rock that Howarth is interested in.

"In the future I hope to apply such techniques to other meteorites, such as lunar meteorites from the moon. I think in many important ways Mars is really a jumping-off point. Although the current COVID-19 crisis has meant that I have had to put my plans for an outreach project on hold, I hope that I can soon share this work with students so that they too can get excited about its possibilities, just as I did the first time I held a little piece of Mars in my hand when I was a student."

Photo of Dr Howarth by Libby Young. Captions and additional images sourced by the Editor.