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Solar system

Ancient meteorite overturns our ideas of how Mars formed

Alex Wilkins

A METEORITE that landed on Earth more than 200 years ago is upending our ideas of how Mars formed. A new analysis of it reveals that the interior chemical make-up of the Red Planet largely came from meteorite collisions, rather than from a cloud of gases as was previously thought. This makes Mars's early formation similar to that of Earth.

Most of what we know about Mars's mantle, the section of rock outside the planet's core, comes from three Martian meteorites – Shergotty, Nakhla and Chassigny – that crashed to Earth after being blasted off Mars by impacts.

Previous analyses of Chassigny, which landed in France in 1815, looked at isotopes of xenon, a chemically inert gas that can survive unchanged for millions of years. These isotopes – atoms that differ by their number of neutrons – occur in specific ratios that can be tied to a place and time.

The isotope ratios from the meteorite seemed to match those of both Mars's atmosphere and the solar nebula, a large cloud of gas from which the primitive solar

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A piece of the Chassigny meteorite, which has now been reanalysed

system formed. This led to the hypothesis that the Red Planet's volatile elements, such as hydrogen, carbon and oxygen, came from the solar nebula and that additional elements came from meteorites later.

Now, Sandrine Péron at ETH Zurich in Switzerland and Sujoy Mukhopadhyay at the University of California, Davis, have analysed a sample from Chassigny to look at isotopes of krypton – another inert gas – by using a high-resolution mass spectrometer.

"With xenon isotopes, it's difficult to distinguish the precise source of volatiles, but that's not the case with krypton," says Péron. "With krypton, you can better see the difference between potential sources, like from solar or meteorites... but krypton isotopes are more difficult to measure than xenon isotopes, so that's why it had not been previously done."

The researchers found that the isotopes came from meteorites rather than from the solar nebula (*Science*, doi.org/gqcdw8).

This also implies that the Martian atmosphere, which contains mainly solar nebula isotopes, wasn't created by gases exuding from the mantle as we previously thought, says Péron. So where did those atmospheric gases come from? It could be that they were trapped in the ground closer to the surface, or in the cold polar caps if the young Mars grew quickly, and are being gradually released by impacts, says Péron.

The work could fundamentally change our picture of how Mars was formed, as well as shore up our understanding of planetary formation in our solar system, in which Mars seemed an outlier.

"It's a major change in our understanding of the origin of volatiles in Mars," says Chris Ballentine at the University of Oxford. "The end result is that Mars looks much closer to the way the Earth formed and the way that Earth acquired volatiles, which gives us a much more consistent view of how planets acquire their volatile elements."

1815

The year the Chassigny meteorite crash-landed in France

Finding out how volatile elements are acquired and distributed is also essential for understanding a planet's chemical make-up, says Ballentine. "The timing and source of the volatiles controls the oxidation state, which, in turn, controls the structure and distribution of elements in the planet, which for our own Earth is why we can live on it." ▮

Technology

Global satellite map will help hunt down illegal fishing vessels

ABOUT 20 per cent of the global seafood catch is harvested illegally, but it might be possible to clamp down on that now an online map using satellite radar can spot where boats are operating incognito.

Commercial-size vessels must usually have Automatic Identification System (AIS) transponders so they can be tracked. However, fishing boats can hide by simply turning off their AIS.

Satellite-based radar can be used to find ships without their AIS turned on, and in 2020 the Global Fishing Watch (GFW) non-profit group used satellite data to detect a "dark fleet" fishing in North Korean waters. But it was only possible to focus on small areas.

Now, more affordable processing makes global oversight possible, says David Kroodsma at GFW.

Instead of asking humans to spend hours looking through specific satellite images, "we can use computer-vision algorithms to look through every single satellite image we record in a matter of minutes", says Jared Dunnmon at the US Department of Defense's Defense Innovation Unit, which has been working with GFW.

GFW processed AIS data to get known ship locations, then sifted through petabytes of information from the European Union's two Sentinel-1 radar satellites to extract the signatures of vessels in coastal waters. Comparing the two data sets revealed where vessels are operating without AIS switched on.

"We can use computer-vision algorithms to look through every single satellite image in minutes"

"We have processed about six years' worth of data," says Kroodsma, and "are currently showing data from 2022."

The map allows viewers to zoom in to see activity by incognito vessels across the globe. A vessel not broadcasting its position isn't necessarily engaged in illegal activity, though, says Kroodsma.

The map could help coordinate efforts against illegal fishing and tell law enforcement where to patrol, says Steve Trent at the Environmental Justice Foundation. ▮

David Hambling