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PRESS RELEASE

Tokyo Institute of Technology research: Meteorite samples provide definitive evidence of water and rock types on Mars

Tokyo, 19 November 2012: Researchers at the Tokyo Institute of Technology, NASA's Johnson Space Center, Lunar Planetary Institute, and Carnegie Institute of Washington report on geochemical studies that help towards settling the controversy that surrounds the origin, abundance, and history of water on Mars.

The abundance and origin of water on Mars underpins a number of planetary science hypotheses including crust and mantle dynamics, and even the existence of life. Researchers at Tokyo Institute of Technology, NASA, the Lunar Planetary Institute, and the Carnegie Institute of Washington analyse the geochemical and isotopic composition of two different meteorites and conclude definitively that the mantle is dry and provide the first evidence of assimilation of old Martian crust into the mantle [1].

Despite its crucial role in biological and geological processes information about water on Mars is still controversial. In addition previous geochemical studies of Martian basalts (shergottites) have raised unsettled questions over the sources of the parental magmas.

The researchers studied two meteorites that provide different samples from the Martian mantle and crust. "There are several competing theories that account for the diverse isotopic and geochemical compositions of Martian meteorites," said Tomohiro Usui, a former NASA/ LPI postdoctoral fellow who led the research. "Until this investigation there was no direct evidence that primitive Martian lavas contained material from the surface of Mars".

The researchers also report direct evidence that the dry Martian mantle retains a primordial ratio of hydrogen and its heavier isotope deuterium that is similar to the ratio in water on Earth. This further implies that terrestrial planets including Earth have similar water sources, which are chondritic meteorites, and not comets.

Background

The search for water elsewhere in the solar system is a strong driving factor behind planetary science. Its presence may suggest the existence of life as well as a number of other geological processes [2,3].

The sculpted channels of the Martian southern hemisphere speak loudly of flowing water, but this terrain is ancient. Consequently, planetary scientists often describe early Mars as 'warm and wet' and current Mars as 'cold and dry'.

The composition of volatile elements such as hydrogen and nitrogen can differ from that of the nebular gas from which the solar system formed [4,5]. Volatile gases are released from Martian interiors by volcanic activity and have a critical influence on the climate in Mars. Hydrogen (H), in particular, is an important indicator of atmospheric loss and whether climate change may result turning Mars from wet and warm to cold and dry.

As on Earth hydrogen also exists in the form of its isotope heavy hydrogen or deuterium (D), which has a neutron as well as proton at the nucleus. The ratio H/D changes as a result of lighter hydrogen being lost more readily from the Martian atmosphere. Consequently D/H ratios can provide important information on the origin of water and rocks on Mars.

Much of our information about the martian interior comes from studies of the basaltic martian meteorites (shergottites) [2]. However conclusions as to the water content range from relatively dry (1-36 ppm) to relatively wet, such as 73–290 ppm [2]. In addition previous geochemical studies of martian meteorites indicate two sources of parental magma, one that has an enriched elemental composition and one that has a depleted elemental composition.

The researchers studied samples of shergottite –martian basalt - from two meteorites. One of the meteorites, Yamato (Y) 980459, appears to be a basalt that underwent minimal modification as it was transported to the surface of Mars from the deep martian mantle. In contrast, another meteorite, LAR06319, appears to have sampled a martian crust that had been in contact with the martian atmosphere.

As the authors also point out it can be difficult to estimate the D/H ratio of the Martian mantle from meteorite samples due to terrestrial contamination. Air left in the vacuum system during analysis, oils (and/or water) used as lubricants during polishing, and epoxy (or acrylic) resin used as amounting agent can all contribute to contaminants. Resins can be the most challenging and unavoidable sources of contaminants for Martian meteorites as they penetrate the many microfractures of the shergottite and cannot be removed. The researchers used a sample preparation method using indium metal instead of resin and thus avoided this primary source of contamination in their samples.

“Tomo was able to demonstrate that the initial hydrogen isotopic composition of Mars was Earth-like, but not from Earth because he designed and conducted an experiment that greatly reduced laboratory contamination to the meteorite sample here on Earth,” said Justin Simon, a NASA cosmochemist on the team.

They analysed the isotopic composition of volatile elements in the two meteorite samples and provide direct evidence of a mantle that is dry and has a depleted elemental composition. They report definitive evidence that the Martian mantle has retained a primordial D/H ratio similar to water on Earth. They also demonstrate that that the enriched shergottite source does not represent an enriched mantle domain in the deep interior but, rather, assimilation of old Martian crust. The result is the first indication of such crust mantle interaction.

References

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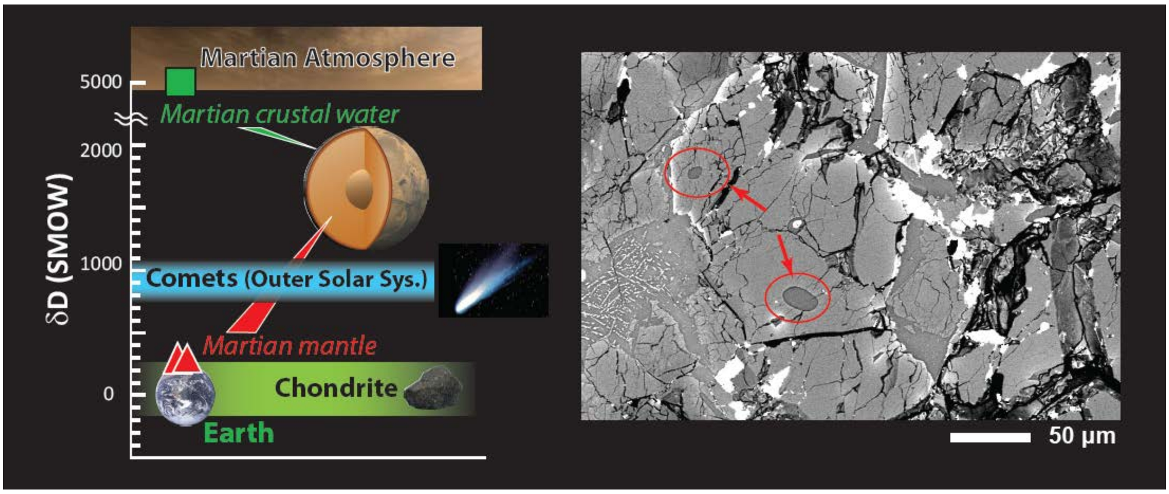

Figure caption

Hydrogen isotopic compositions of Martian volatile reservoirs (left diagram): near-surface crustal water (green square) and primordial water in the mantle (red triangle). These hydrogen isotopic compositions were obtained from tiny (<20 µm) melt inclusions (pointed by red arrows) hosted by olivines in martian basaltic meteorites, and expressed as permillage difference (δD) relative to the reference Earth's ocean water; $\delta D = [(D/H)_{sample}/(D/H)_{reference} - 1] \times 1000$. Most terrestrial water has relatively limited δD values, which overlap with the martian primordial water and bulk-chondrites but are distinct from comets and the martian atmosphere and crustal water.

The right figure is an electron microprobe image (called back-scattered electron or compositional image); brighter areas indicate denser (i.e., richer in heavy elements such as iron) than darker areas.