Evidence of Ancient Water on an Asteroid

May help lead to new information on the formation of Earth

Working in part at the National Synchrotron Light Source (NSLS), scientists have discovered evidence of ancient water on a large asteroid previously thought to lack water. The findings indicate that water was most likely deposited *onto* the asteroid, suggesting it came from an outside source, such as a collision with an icy comet. The discovery may give scientists new insight into the rules governing the mobility and availability of water in the solar system at the time Earth was formed.

The results appear in the March 15, 2004 issue of *Earth and Planetary Science Letters*.

The scientists learned about the asteroid, named 4 Vesta, which orbits the Sun in our solar system, by studying a meteorite that is believed to have once been part of it, due to the two bodies' very similar chemical compositions. The meteorite, called Serra de Magé, fell to Earth in 1923. When analyzing Serra de Magé, the researchers discovered a sign that water had once been present: threads, or "veinlets," of quartz, a mineral that is often deposited onto rocks by liquid water solutions. The appearance and condition of the veinlets suggested that water existed on the meteorite long ago, and could only have been deposited before Serra de Magé broke away from 4 Vesta.

Allan Treiman, a geologist from the Lunar and Planetary Institute and the study's lead scientist, explained, "The veinlets are quite old – 4.5 billion years – so they formed when the solar system was quite young. Because Vesta is now so dry, our best guess is that the veinlets' water came from an outside source, such as comets or water-rich meteorites that hit Vesta."

According to Treiman, this hypothesis has some important potential implications. "Scientists have theorized water delivery by comets for the early solar system, especially for how the Earth got enough water to make our oceans. However, gathering evidence for or against this theory has been difficult, because few Earth rocks (or Moon rocks) are old enough. But this ancient meteorite from Vesta appears to show that it received water somehow, which suggests that water could have been delivered to Earth in a similar way."

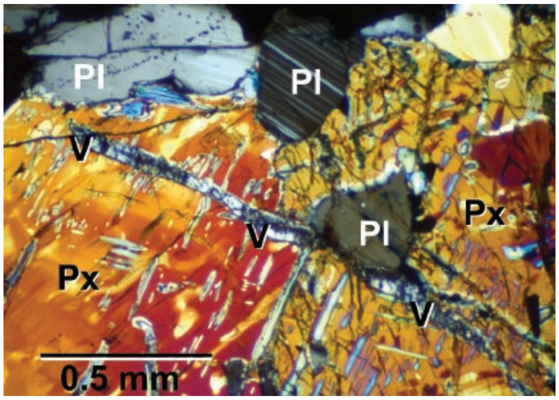
To analyze Serra de Magé, the researchers bombarded it with x-rays at NSLS beamline X26A. In this method, called x-ray micro-diffraction, the x-rays entered the sample, scattered off its molecules, and emerged from the sample in a distinct pattern. A camera created an image of the diffracted x-rays, and, from this, the scientists were able to determine what materials make up the sample based on known diffraction patterns of many different substances. This is how they identified the quartz veinlets.

4 Vesta is the third-largest asteroid in the Main Asteroid Belt – the ring of cosmic debris that orbits the Sun outside Mars' orbit and inside Jupiter's. The asteroid is 320 miles in diameter, or about as wide as the state of Iowa, and is roughly spherical in shape. Its chemical composition is unique: Unlike other large asteroids, Vesta appears to have once contained a hot molten center, as Earth does. This finding contradicts conventional ideas that asteroids are cold, rocky remnants of the early days of planet formation. Studying Vesta may help scientists learn how Earth formed, as the asteroid has other characteristics similar to terrestrial planets, such as evidence of ancient lava eruptions. Its surface is pocked with impact craters – which is most likely how Serra de Magé was knocked loose.

Allan Treiman

In the future, Treiman and his colleagues plan to study other meteorites from 4 Vesta and look for similar quartz veinlets. They will also study them for more definitive signs of water on the asteroid, such as actual water – very small droplets trapped in the quartz – or water-bearing minerals. Another approach is to look for excess hydrogen in Serra de Magé as compared to meteorites without quartz veinlets, which would indicate that water, a hydrogen-oxygen compound, may have been present. This could be done using the infrared rays produced at the NSLS vacuum ultra-violet (VUV) ring.

The collaboration that performed this research also includes Antonio Lanzirotti,



The largest quartz veinlet in the meteorite (V), surrounded by the minerals pyroxene (Px) and plagioclase (Pl).

of the University of Chicago's Consortium for Advanced Radiation Sources at Brookhaven National Laboratory and Dimitrios Xirouchakis, of the National Aeronautic and Space Administration's (NASA) Johnson Space Center.

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—Laura Mgrdichian