MAVEN mission to investigate how sun steals Martian atmosphere

EurekAlert

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The Red Planet bleeds. Not blood, but its atmosphere, slowly trickling away to space. The culprit is our sun, which is using its own breath, the solar wind, and its radiation to rob Mars of its air. The crime may have condemned the planet's surface, once apparently promising for life, to a cold and sterile existence.

Features on Mars resembling dry riverbeds, and the discovery of minerals that form in the presence of water, indicate that Mars once had a thicker atmosphere and was warm enough for liquid water to flow on the surface. However, somehow that thick atmosphere got lost in space. It appears Mars has been cold and dry for billions of years, with an atmosphere so thin, any liquid water on the surface quickly boils away while the sun's ultraviolet radiation scours the ground.

Such harsh conditions are the end of the road for known forms of life. Although it's possible that martian life went underground, where liquid water may still exist and radiation can't reach.

The lead suspect for the theft is the sun, and its favorite M.O. may be the solar wind. All planets in our solar system are constantly blasted by the solar wind, a thin stream of electrically charged gas that continuously blows from the sun's surface into space. On Earth, our planet's global magnetic field shields our atmosphere by diverting most of the solar wind around it. The solar wind's electrically charged particles, ions and electrons, have difficulty crossing magnetic fields.

"Mars can't protect itself from the solar wind because it no longer has a shield, the planet's global magnetic field is dead," said Bruce Jakosky of the University of Colorado, Boulder. Jakosky is the Principal Investigator for NASA's MAVEN mission, which will investigate what is responsible for the loss of the martian atmosphere. NASA selected the MAVEN (Mars Atmosphere and Volatile Evolution Mission) on September 15, 2008.

Mars lost its global magnetic field in its youth billions of years ago. Once its planet-wide magnetic field disappeared, Mars' atmosphere was exposed to the solar wind and most of it could have been gradually stripped away. "Fossil" magnetic fields remaining in ancient surfaces and other local areas on Mars don't provide enough coverage to shield much of the atmosphere from the solar wind.

Although the solar wind might be the primary method, like an accomplished burglar, the sun's emissions can steal the martian atmosphere in many ways. However, most follow a basic M.O., the solar wind and the sun's ultraviolet radiation turns the uncharged atoms and molecules in Mars' upper atmosphere into electrically charged particles (ions). Once electrically charged, electric fields generated by the solar wind carry them away. The electric field is produced by the motion of the charged, electrically conducting solar wind across the interplanetary, solar-produced magnetic field, the same dynamic generators use to produce electrical power.

An exception to this dominant M.O. are atoms and molecules that have enough speed from solar heating to simply run away, they remain electrically neutral, but become hot enough to escape Mars' gravity. Also, solar extreme ultraviolet radiation can be absorbed by molecules, breaking them into their constituent atoms and giving each atom enough energy that it might be able to escape from the planet.

There are other suspects. Mars has more than 20 ancient craters larger than 600 miles across, scars from giant impacts by asteroids the size of small moons. This bombardment could have blasted large amounts of the martian atmosphere into space. However, huge martian volcanoes that erupted after the impacts, like Olympus Mons, could have replenished the martian atmosphere by venting massive amounts of gas from the planet's interior.

It's possible that the hijacked martian air was an organized crime, with both impacts and the solar wind contributing. Without the protection of its magnetic shield, any replacement martian atmosphere that may have issued from volcanic eruptions eventually would also have been stripped away by the solar wind.

Earlier Mars spacecraft missions have caught glimpses of the heist. For example, flows of ions from Mars' upper atmosphere have been seen by both NASA's Mars Global Surveyor and the European Space Agency's Mars Express spacecraft.

"Previous observations gave us 'proof of the crime' but only provided tantalizing hints at how the sun pulls it off — the various ways Mars can lose its atmosphere to solar activity," said Joseph Grebowsky of NASA's Goddard Space Flight Center in Greenbelt, Md. "MAVEN will examine all known ways the sun is currently swiping the Martian atmosphere, and may discover new ones as well. It will also watch how the loss changes as solar activity changes over a year. Linking different loss rates to changes in solar activity will let us go back in time to estimate how quickly solar activity eroded the Martian atmosphere as the sun evolved." Grebowsky is the Project Scientist for MAVEN.

As the martian atmosphere thinned, the planet got drier as well, because water vapor in the atmosphere was also lost to space, and because any remaining water froze out as the temperatures dropped when the atmosphere disappeared. MAVEN can discover how much water has been lost to space by measuring hydrogen isotope ratios.

Isotopes are heavier versions of an element. For example, deuterium is a heavy version of hydrogen. Normally, two atoms of hydrogen join to an oxygen atom to make a water molecule, but sometimes the heavy and rare, deuterium takes a hydrogen atom's place.

On Mars, hydrogen escapes faster because it is lighter than deuterium. Since the lighter version escapes more often, over time, the martian atmosphere has less and less hydrogen compared to the amount of deuterium remaining. The martian atmosphere therefore becomes richer and richer in deuterium.

The MAVEN team will measure the amount of hydrogen compared to the amount of deuterium in Mars' upper atmosphere, which is the planet's present-day hydrogen to deuterium (H/D) ratio. They will compare it to the ratio Mars had when it was young -- the original H/D ratio. The original ratio is estimated from observations of the H/D ratio in comets and asteroids, which are believed to be pristine, "fossil" remnants of our solar system's formation.

Comparing the present and original H/D ratios will allow the team to calculate how much hydrogen, and therefore water, has been lost over Mars' lifetime. For example, if the team discovers the martian atmosphere is ten times richer in deuterium today, the planet's original quantity of water must have been at least ten times greater than that seen today.

MAVEN will also help determine how much martian atmosphere has been lost over time by measuring the isotope ratios of other elements in the air, such as nitrogen, oxygen, and carbon.

MAVEN is scheduled for launch between November 18 and December 7, 2013. If it is launched November 18, it will arrive at Mars on September 16, 2014 for its year-long mission.

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