Curiosity rover finds possible evidence of ancient explosive volcanoes on Mars

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This low-angle self-portrait of NASA's Curiosity Mars rover shows the vehicle at the site from which it reached down to drill into a rock target called "Buckskin." Bright powder from that July 30, 2015, drilling is visible in the foreground. Credit: NASA/JPL-Caltech/MSSS

(Phys.org)—A large team of researchers from across the U.S. studying data sent back from Mars by the Curiosity rover has found evidence of tridymite, a type of mineral associated with explosive volcanoes here on Earth. In their paper published in *Proceedings of the National Academy of Sciences*, the team describes how the rover found the sample, the testing it underwent, and why it might lead to rethinking the early history of the Red planet.

To date, planetary scientists believe that the geological history of Mars has been very tame compared to our own home planet—this is, they believe, because Mars does not have shifting plates that lead to big earthquakes and explosive volcanoes. Evidence of volcanoes on that planet to date has shown them to be of the steady flowing type such as those that led to the creation of the Hawaiian Islands—they form due to melting hot mantel plumes just below the surface. But now, a mineral find might mean scientists will have to rethink the ancient history of Mars.

The Curiosity rover has been rolling around in Gale crater since 2014, and last year it began digging and studying samples from an area known as Marias Pass. The research team noted that the makeup of the rocks there appeared to suggest silica, so they subjected them to X-ray analysis. That showed the samples to have a very high level of tridymite, which was both surprising and thought provoking because it conflicted so sharply with the history that has been written for the planet—they suggest it appears likely that the mineral was created somewhere else on the planet and was carried to the crater basin. This is because prior research has suggested parts of the basin were once filled with water—that Martian lake would have been filled by streams and rivers coming from distant places bringing with them and depositing sediments, some of which could have been material ejected or formed by explosive volcanoes. But if Mars did have such volcanoes, the team wonders, how did they form in the absence of plate tectonics?

The findings by the team and their theories are likely just the first stage of what will be many projects aimed at reevaluating Mars' history, or looking for ways that tridymite might be created without the intense heat of a violent volcanic eruption.

More information: Richard V. Morris et al. Silicic volcanism on Mars evidenced by tridymite in high-SiOsedimentary rock at Gale crater, *Proceedings of the National Academy of Sciences* (2016). DOI: 10.1073/pnas.1607098113

Abstract
Tridymite, a low-pressure, high-temperature (>870 °C) SiO2 polymorph, was detected in a drill sample of laminated mudstone (Buckskin) at Marias Pass in Gale crater, Mars, by the Chemistry and Mineralogy X-ray diffraction instrument onboard the Mars Science Laboratory rover Curiosity. The tridymitic mudstone has ~40 wt.% crystalline and ~60 wt.% X-ray amorphous material and a bulk composition with ~74 wt.% SiO2 (Alpha Particle X-Ray Spectrometer analysis). Plagioclase (~17 wt.% of bulk sample), tridymite (~14 wt.%), sanidine (~3 wt.%), cation-deficient magnetite (~3 wt.%), cristobalite (~2 wt.%), and anhydrite (~1 wt.%) are the mudstone crystalline minerals. Amorphous material is silica-rich (~39 wt.% opal-A and/or high-SiO2 glass and opal-CT), volatile-bearing (16 wt.% mixed cation sulfates, phosphates, and chlorides−perchlorates−chlorates), and has minor TiO2 and Fe2O3T oxides (~5 wt.%). Rietveld refinement yielded a monoclinic structural model for a well-crystalline tridymite, consistent with high formation temperatures. Terrestrial tridymite is commonly associated with silicic volcanism, and detritus from such volcanism in a "Lake Gale" catchment environment can account for Buckskin's tridymite, cristobalite, feldspar, and any residual high-SiO2 glass. These cogenetic detrital phases are possibly sourced from the Gale crater wall/rim/central peak. Opaline silica could form during diagenesis from high-SiO2 glass, as amorphous precipitated silica, or as a residue of acidic leaching in the sediment source region or at Marias Pass. The amorphous mixed-cation salts and

oxides and possibly the crystalline magnetite (otherwise detrital) are primary precipitates and/or their diagenesis products derived from multiple infiltrations of aqueous solutions having variable compositions, temperatures, and acidities. Anhydrite is post lithification fracture/vein fill.