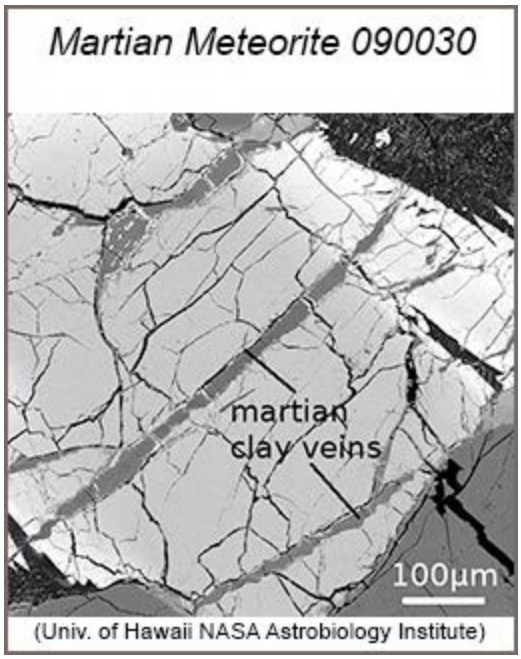
PLANETARY SCIENCE RESEARCH DISCOVERIES
CosmoSparks

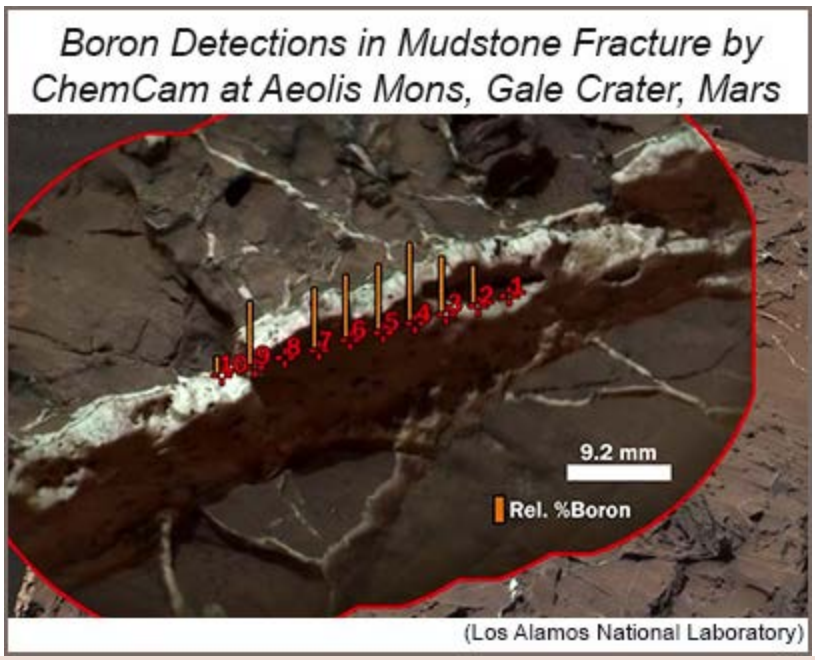
Quick Views of Big Advances

Boron Found in Martian Meteorites and in situ in Gale Crater

The element boron is a bio-geo-cosmo chemical superstar for scientists studying the role of water and habitability on Mars. Why? This water-soluble element is typically found on Earth in evaporite deposits after large bodies of water have evaporated or it is found adsorbed (soaked in) to clays derived from weathered rocks. An even more tantalizing aspect is that borates (formed when boron dissolves in water) are known to stabilize ribose, a key sugar in RNA, thus scientists think borates may have played an important role in the prebiotic chemistry of early Earth. These terrestrial links between boron and water and prebiotic reactions may extend to Mars. So in both geological and astrobiological terms, the finding of boron on Mars has exciting implications for understanding the history of aqueous activity, habitability, and the likelihood that conditions could have supported prebiotic chemical reactions. If you are interested in the question of whether environments on Mars were ever favorable for supporting life, then boron is a valuable asset to have.

Boron was detected in clay in Martian meteorite MIL 090030 [***Data link*** from the Meteoritical Database] in 2013 by evolutionary biologist James Stephenson and cosmochemist Lydia Hallis (at that time both were Postdoctoral Fellows at the University of Hawai‘i NASA Astrobiology Institute) and colleagues. The boron abundance (~160 ppm) identified in the Martian clay was attributed to secondary alteration processes on Mars (contamination after the meteorite fell in Antarctica was ruled out) and it exceeded boron concentrations previously reported from *any* extraterrestrial body. In 2015 another team headed by Kathie Thomas-Keprta (Johnson Space Center) found boron in association with halite and carbonaceous material in Martian meteorite Nakhla [***Data link*** from the Meteoritical Database].





[TOP] Electron microscope image of Martian Meteorite 090030 showing the clay veins analyzed for boron using a Cameca ims 1280 ion-microprobe. [BOTTOM] Ten ChemCam point observations (numbered spots) in a calcium-sulfate-filled fracture in mudstone, with relative percent of boron shown by orange vertical bars. The ChemCam instrument suite consists of a laser-induced breakdown spectroscopy (LIBS) instrument and a remote microimager (RMI).

In 2017 an international group of scientists lead by Patrick Gasda (Los Alamos National Lab) reported the first in situ detection of boron on Mars using the ChemCam instrument suite onboard NASA's Curiosity rover. The team identified boron (up to ~500 ppm) in fractures (filled with calcium sulfate) within five different layers of mudstones and sandstones on Aeolis Mons, the 5.5-km-high mountain of layered sedimentary bedrock within Gale crater that Curiosity rover is ascending. The new data support models of a late-stage, warm, boron-bearing groundwater system below Gale crater that developed after the disappearance of the crater-filling lake, thus extending the habitability of the crater environment well past the loss of water on its surface. The researchers contend the groundwater that circulated under Gale crater in ancient times could have had all the right conditions (temperature, alkalinity, dissolved mineral content) to support pre-biotic chemical reactions between borates and organics, if organics were present.

There are many details yet to learn from the mudstones and sandstones in Gale crater. More data are being gathered by Curiosity as it moves up Aeolis Mons, and with it researchers gain more chemical evidence to build a better understanding of the history of Martian aqueous activity, habitability, and the potential for life to have developed in this crater environment.

Coauthors Ethan Haldeman and Veronica Sanford (both from Ursinus College, PA) were undergraduate students on the project.

See Reference:

· Gasda, P. J., Haldeman, E. B., Wiens, R. C., Rapin, W., Bristow, T. F., Bridges, J. C., Schwenzer, S. P., Clark, B., Herkenhoff, K., Frydenvang, J., Lanza, N. L., Maurice, S., Clegg, S., Delapp, D. M., Sanford, V. L., Bodine, M. R., and McInroy, R. (2017) In Situ Detection of Boron by ChemCam on Mars, *Geophysical Research Letters,* v. 44, p. 8739-8748, doi: 10.1002/2017GL074480. [***open access article***]

See also:

· ***Boron Discovered in Ancient Habitable Mars Groundwater***, Video from Los Alamos National Laboratory.

· ***Discovery of Boron on Mars Adds to Evidence for Habitability***, News Release from Los Alamos National Laboratory.
· Martel, L. M. V. (October 2006) LIBS: Remote Analysis of Elemental Compositions, *Planetary Science Research Discoveries, **http://www.psrd.hawaii.edu/Oct06/libs.html***.
· ***PSRD articles related to Gale Crater, Mars***.
· Stephenson, J. D., Hallis, L. J., Nagashima, K., and Freeland, S. J. (2013) Boron Enrichment in Martian Clay, *PLoS ONE*, v. 8(6): e64624. [***view research article***]
· Thomas-Keprta K. L., Clemett, S. J., D. S., Gibson E. K., and Wentworth, S. J. (2015) Indigenous Carbonaceous Matter and Boron Associated with Halite Crystals in Nakhla, presented at *46th Lunar and Planetary Science Conference,* The Woodlands, Texas, ***abstract 2770***.

Written by Linda Martel, Hawai'i Institute of Geophysics and Planetology, for ***PSRD***.

January 2018
http://www.psrd.hawaii.edu

psrd@higp.hawaii.edu