Oxychlorine detection in Gale Crater, Mars and implications for past environmental conditions

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The Sample Analysis at Mars (SAM) instrument on the Mars Science Laboratory (MSL) rover has detected oxychlorine compounds such as perchlorate or chlorate in Gale Crater samples. Two potential pathways for oxychlorine formation on Mars are UV-induced interaction between chlorine and metal oxides or atmospheric oxygen and radiolysis of Cl-containing surface materials by galactic cosmic rays, with the chlorine being volcanically derived in both cases. Oxychlorine compounds are identified by a diagnostic release of O_2 at temperatures <600 °C and an HCl release from ~350-850 °C during sample pyrolysis. Of the 16 samples analyzed by SAM as of July 2018, 12 have contained oxychlorine compounds, including all four scooped samples and 8 of the 12 drilled samples.

In the drilled samples, two observations in particular help constrain past environmental conditions. First, SAM analyzed two samples, John Klein (JK) and Cumberland (CB), a few meters laterally from each other in the same geologic unit. CB contained ~1.2 wt% Cl_2O_7 equivalent, the highest measured to date, and JK only had ~0.1 wt%. A higher abundance of fracture-filling veins in JK compared to CB implies that oxychlorine formation was occurring

during lithification in the ancient martian past and that removal (and redeposition) took place as later stage fluids moved through the rock.

Second, in the drilled samples, oxychlorines were detected in the first 8 samples but have not been detected in the last 4 samples. The disappearance of oxychlorines does not correlate with a decrease in elemental Cl abundance measured by the Alpha Particle X-Ray Spectrometer. A decrease in the oxychlorine:total chlorine ratio could have multiple causes: a thicker atmosphere with more ozone could decrease surface UV irradiation or cosmic rays; a wetter climate would wash Cl into basins, giving it less time as a solid at the surface to oxidize; increased sedimentation/lithification rates would also give less time for surface reactions necessary for Cl oxidation to take place; and the higher solubility of oxychlorines versus chlorides could result in the preferential removal of oxychlorine species.

These data suggest that oxychlorine formation in the ancient martian past was not uniform over time, giving potential insight into evolving environmental conditions on Mars.