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A MULTI-INSTRUMENT INVESTIGATION OF LOW-TEMPERATURE PRECIPITATED SILICA RELEVANT TO MARS AND ICY MOONS: MAFEKING QUARRY, MANITOBA

Abstract

The presence of silica on Mars is well established and may have formed via different processes. While hydrothermal and lacustrine formation processes are well known, less is known about low-temperature driven deposits, which may be more relevant for some silica deposits on Mars and icy moons. The Mafeking Quarry site is located 600 kilometers northwest of Winnipeg, MB, Canada. The quarry is a primary bedrock source of Swan River chert nodules showing various growth textures, including massive, layered nodules, intricate vugs, and saccharine and botryoidal structures. Silica is of interest for potential habitability and astrobiology for Mars and Icy moons due to its microbial preservation potential and ability to record past environmental conditions. Each sample was analyzed as a whole rock, including weathered exterior surfaces, broken fresh surfaces, and polished interior surfaces, using five different spectroscopic techniques. Reflectance spectroscopy was able to identify quartz as the dominant mineral in each sample collected from the site, as shown by the adsorption feature at 2200 nm. Chlorophyll, 675 nm, was also detected by reflectance in some samples in minor quantities, likely from current biological communities. XRD confirmed the presence of quartz as the dominant mineral with the presence of minor carbonate minerals such as calcite and dolomite in a few samples. Raman spectra indicated the presence of only quartz in most samples and did not detect trace minerals in most samples; however, the presence of chlorophyll was detected in two samples. Raman spectroscopy was able to distinguish different silica phases, specifically opal A, opal CT, and quartz. Multiple scans of Raman on the same sample showed different phases of silica suggesting that the sample is not transforming uniformly throughout. SEM was able to show microscale structures of silica, showing the transformation from opal A to opal CT and finally to quartz. XRF results identified major and selected minor elements in each sample, all of which were silica-rich. This study suggests that the most effective way to the different phases of silica is through reflectance and Raman spectroscopy. The SuperCam instrument on the Perseverance rover has relevant capabilities that should be able to identify various polymorphs of silica. Further analysis of the Mafeking Quarry samples is expected to reveal additional features that allow low-temperature driven silica precipitates to be distinguished from other types of silica deposits.