Exploring Salty Worlds: Brines, Ice, and Weathering Products

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Dust, sediments, and rocks observed by orbiters and landed spacecraft indicate that Mars hosts geographically widespread salt deposits. Salty water is likely present in the outer Solar System as well as within ice crusts on Europa, Enceladus, Titan, and perhaps other icy bodies including Ganymede and Pluto. Preliminary evidence of salts and hydrated mineral phases on Ceres and similar phases in altered chondritic meteorites suggest brines may also affect the near-surface mineralogy of some asteroidsere we investigate brines at low temperatures and analyse basalt-brine and siderite-brine alteration products using Raman spectroscopy to understand spectral signals of ice and brines and brine-rock interactions in planetary systems.

Our experiments demonstrate solutes can be detected and quantified in high salinity brines using Raman spectroscopy, providing a unique method for identification of solids and (semi)quantitative chemical analysis of brine solutes that does not require direct contact with the liquid, thus preventing potential contamination of habitable environments. Brine freezing experiments conducted using near-saturated chloride, sulphate, and perchlorate solutions produced systematic changes in the spectra due to brine chemistry, temperature, and cooling rate. Mixed brines and their solid products formed via freezing often produce unique spectra, with peak positions that are intermediary between the peaks observed in the separate endmember brines. Freezing rates also appear to influence the hydration state of magnesium sulfate salts that form as the brine solidifies, based on shifts in the sulfate peak position.

Iron oxides were observed on basalt chips reacted with near-saturated chloride, sulfate, perchlorate, and mixed brines for 3, 6, and 12 months. Basalt-brine reactions also produced corn flake-like textures indicative of clay formation in scanning electron microscope (SEM) images. Siderite-brine alteration experiments also formed secondary Fe-oxide phases observed with both Raman and SEM, and evidence of possible chukanovite precipitation. These rock-brine-ice experiments will aid interpretations of future Raman spectra collected by the Mars 2020 and ExoMars rovers.