# Investigating the chemical signatures of cold-climate alteration on Mars at a glaciated volcanic complex in the Oregon Cascades

Liquid water was abundant on early Mars, but whether the climate was warm and wet or cold and icy with punctuated periods of melting is poorly understood. Any model for the early climate on Mars must be reconciled with the chemical record; however, we currently do not understand how weathering mineralogy under snow and ice-dominated conditions compares to warmer climates. To resolve this knowledge gap, we conducted two years of field work on the glaciated and mafic Three Sisters volcanic complex, in the Oregon Cascades. We collected rocks, sediments, and water samples from throughout the two major glacial valleys in order to characterize weathering reactions and products in this analog for a cold and icy Mars. We analyzed water samples for major ions and determined the chemistry and mineralogy of rocks and sediments with field VNIR spectroscopy, as well as lab-based X-ray diffraction (XRD), microscopy (SEM, TEM, EDS), and thermal-IR spectroscopy.

The predominant form of chemical weathering in these periglacial mafic systems is dissolution of feldspar and volcanic glass by carbonic acid, which releases relatively large quantities of silica into solution compared to other ions. Where this occurs due to ice melt under the glacier, silica is precipitated at the ice-rock contact, leaving behind extensive hydrated silica coatings on glacially scoured bedrock. Where weathering occurs due to snow melt in the proglacial terrain, the silica is precipitated on glacial sediments in the form of poorly crystalline phases, which are typically enriched in silica. TEM-EDS analyses of individual amorphous phases in the sediments confirm that secondary phases are present and that they exhibit variable Fe-Al-Si compositions.

The dominant chemical signature of cold climate weathering by ice and snow in Mars analog environments is concentrated silica in both rock coatings and as a component of glacial sediments. Silica signatures have been identified from orbit on Mars in association with Amazonian periglacial terrains, and the Curiosity rover has identified significant amounts of X-ray amorphous materials in Hesperian fluviolacustrine sediments in Gale crater. We suggest that these amorphous phases on Mars could have formed in similarly cold and icy environments during punctuated melt events.

## Authors

- **Briony H. N. Horgan**
  - *Purdue University*
- Elizabeth B Rampe
  - *Aerodyne Technologies at NASA Johnson Space Center*
- Alicia M Rutledge
  - *Purdue University*
- Noel Scudder
  - *Purdue University*
- Rebecca Smith
  - *Purdue University*