Gypsum, basanite and anhydrite at Gale crater, Mars
DT Vaniman et al., 2018.

Summary
This article tackles data collected using the CheMin instrument on the Mars Science Laboratory rover (Curiosity). In particular, the authors examine the sulfate minerals present in different layers of rock and sands found in Gale Crater. It explores the implications of different sulfates on Mars and how they can change as a result of exposure on the Martian surface and during the analysis in CheMin's XRF system.

Key Terms
CheMin: X-ray diffraction (XRD) and x-ray fluorescence (XRF) instrument on the Mars Science Laboratory (Curiosity). Analyses samples collected via drill or scoop for a variety of elements.
Bassanite: Hydrated calcium sulfate – $CaSO_4 \bullet (\sim 0.5) H_2O$
Gypsum: Hydrated calcium sulfate – $CaSO_4 \bullet 2H_2O$
Anhydrite: Anhydrous calcium sulfate – $CaSO_4$
XRF (x-ray fluorescence): Material analysis technique that uses the fluoresced photons produced when x-ray beam strikes the material.
XRD (x-ray diffraction): Material analysis technique that uses x-ray to map the crystallographic pattern of the mineral.

Questions/Activities for Discussion

- How can the dehydration of sulfate minerals be useful in understanding climate change on Mars?
  The assumption is that gypsum is the primary mineral deposited during the desiccation of former Martian surface waters. As the climate dried, the gypsum would convert to bassanite, then to anhydrite under the right conditions. The relative stratigraphy and concentration of these minerals in the rock record at Gale Crater could be used to reconstruct wet and dry periods, along with the relative duration of drying after water was present.
- Describe what happens during the process of analysis for these sands and rocks. Why is it both good and bad for understanding them?
  Samples are collected via scoop or drill, sieved and then placed in CheMin chambers on the rover. The samples are "shaken" using piezoelectricity and then analyzed, typically overnight (on Mars). In the process, the sample is heated (due to being enclosed in metal on the Martian surface) and continues to desiccate, converting hydrous minerals to anhydrous minerals. Samples are typically run repeatedly, but in doing so, the analysis will overestimate the less hydrous minerals over time (see Tables 2a-2e; Figure 3). This is problematic for quantifying the original composition of the samples hydrated sulfates but allows for experiments that can be used to understand how long it might take to desiccate these minerals under normal Martian surface conditions.
- What would we need to be concerned with during a Mars sample return mission? How could this be solved or mitigated?

This question is speculative. The main problem is the sample must endure being transported from the Martian surface, travel through the vacuum of space, and then the re-entry on Earth.

- What might be some ways to get at the age of exposure for other materials on the surface of Mars (constrained by what we can analyze off Earth)?
  Again, somewhat speculative, but the dehydration of the sulfates, using the experiments run on Curiosity, could be used to determine an average exposure again based on the relative sulfate concentrations.
- What are places that these minerals form on Earth? How are they analogs (and not analogs) to Martian environments, past and present?
  Earth analogs include Death Valley, Clayton Playa in Nevada, Big Bend NP in Texas. The second part is more speculative but should include thoughts on the relative liquid budgets on both planets across their history, humidity, water composition, seasonality and more.