Introduction: Mineral assemblages produced by evaporation or freezing can only be predicted by chemical modeling if appropriate processes are taken into account. This paper describes several processes that can lead to more complex assemblages than those expected from simple fractional crystallization.

Dilute Inflow Additions to Brine

The well-known Hardie-Eugster diagram, shown below, illustrates how the development of distinct terrestrial brine chemical types is determined both by initial inflow water composition and the subsequent precipitation and fractionation of key mineral phases (chemical divides). On Earth, the final, highly "evolved", brine compositions always include a NaCl component; other chemical components differ between brine types and lead to a variety of characteristic mineral phases in efflorescent crusts developed from each brine type.

Hydrothermal or Other Unusual Chemical Additions to Brine

Unusual chemical components, such as boron derived from deep-circulating hydrothermal waters, can impose additional chemical divides on the development of brines. Although relatively rare, such chemical processes can produce large mineral deposits, as seen in the case of borate mineral deposits on Earth.

Conclusions: Mixing and re-solution processes can have important effects on terrestrial evaporite mineralogy. New spectral information from CRISM and follow-on missions may afford insights into the operation of such processes on Mars.

References:

Efflorescent Crust Recycling/Zone Refining

\[ \text{MgCl}_2 \geq \text{MgSO}_4 \geq \text{NaCl} \geq \text{Na}_2\text{SO}_4 \geq \text{Borates} \]

\[ \text{CaCl}_2 \quad \text{NaF} \quad \text{Na}_2\text{CO}_3 \]

\[ \text{KCl} \quad \text{K}_2\text{SO}_4 \]

Dilute inflow in the form of precipitation or other intermittent water sources can partially dissolve pre-existing evaporite deposits and crusts. On Earth the presence of abundant highly soluble halite in many evaporites, quickly increases the inflow source concentrations, lowering the activity of water. This tends to stabilize certain chemical components in solid phases, notably, Na-carbonates, Na-sulfates, and various borates, while leaching other components into the brine. In the recycling order shown above, components to the right of NaCl are mainly preserved in solid phases, whereas those to the left are leached into the 'bitters'. Nearly pure crusts of Na-(Ca)-borates and/or trona are produced by this process in some terrestrial playa settings. The bitters are composed of components that are very soluble and in some cases extremely hygroscopic.

Chemical modeling based on Mars-like inflow water chemistry suggests some ways in which this process might operate on Martian evaporites: