Geochemical Evolution of Piceance Basin Groundwater During Heating

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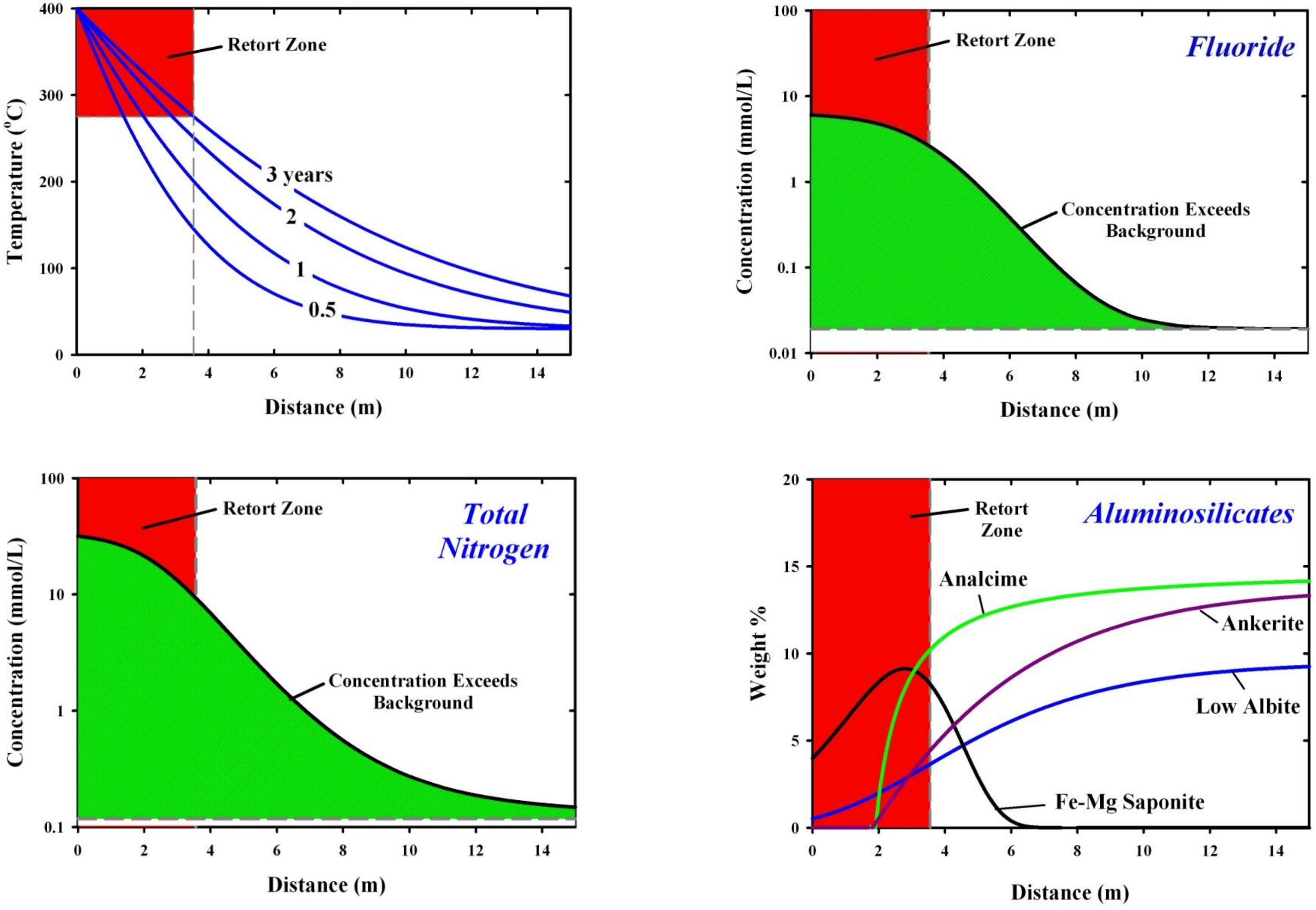
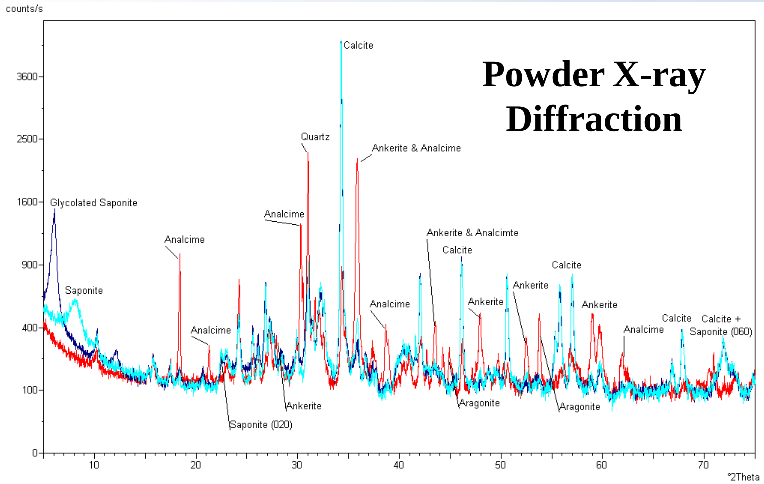
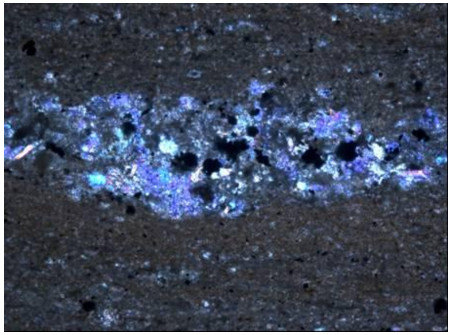
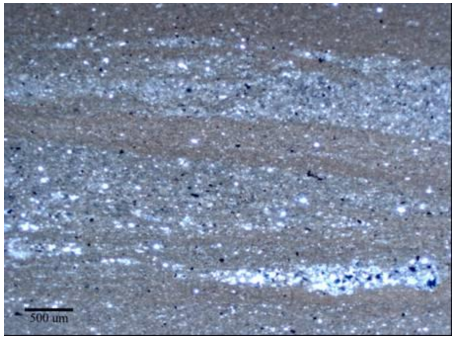
Geochemical Modeling Results

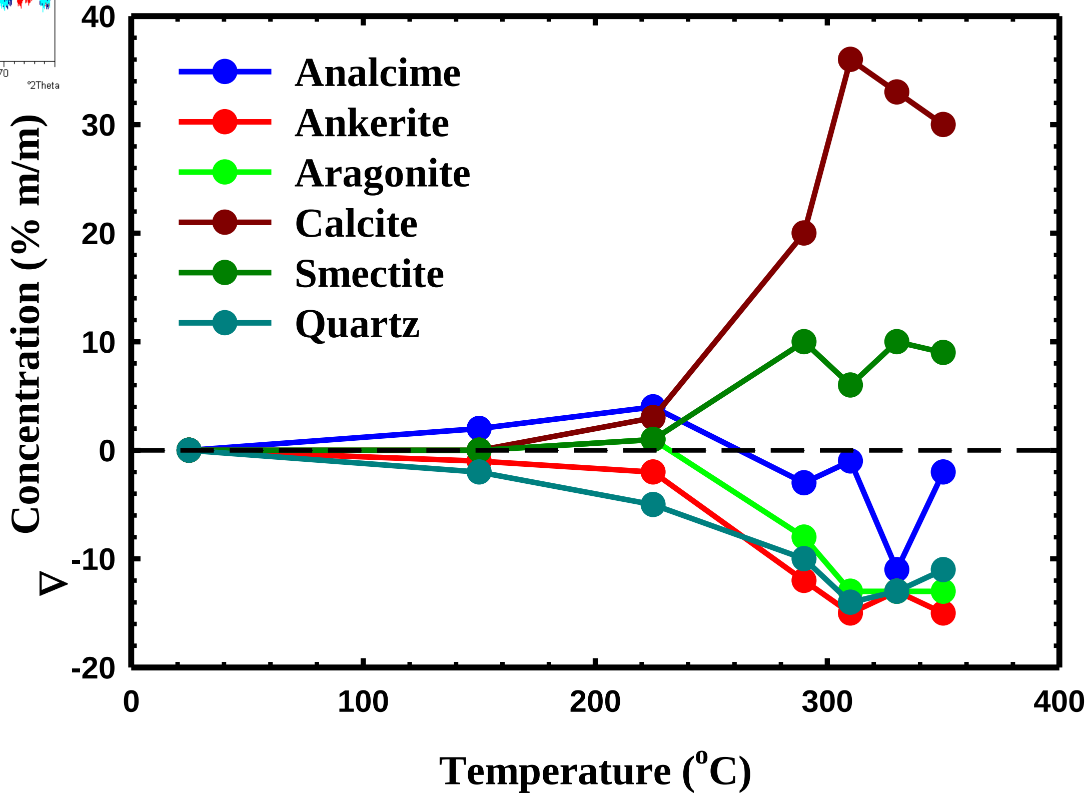


Mineralogical Changes in Retorted Oil Shale









Objective:

To develop models of the geochemical evolution of groundwaters from the Piceance Basin during heating

Approach:

- Determine the natural groundwater composition and thermodynamic status using Phreeqc-Interactive,
- Simulate chemical evolutions during evaporation,
- Estimate the type and amounts of precipitates that may be formed.

Data Sources

- CSM database,
- Kimball (1984),
- USGS and other reports

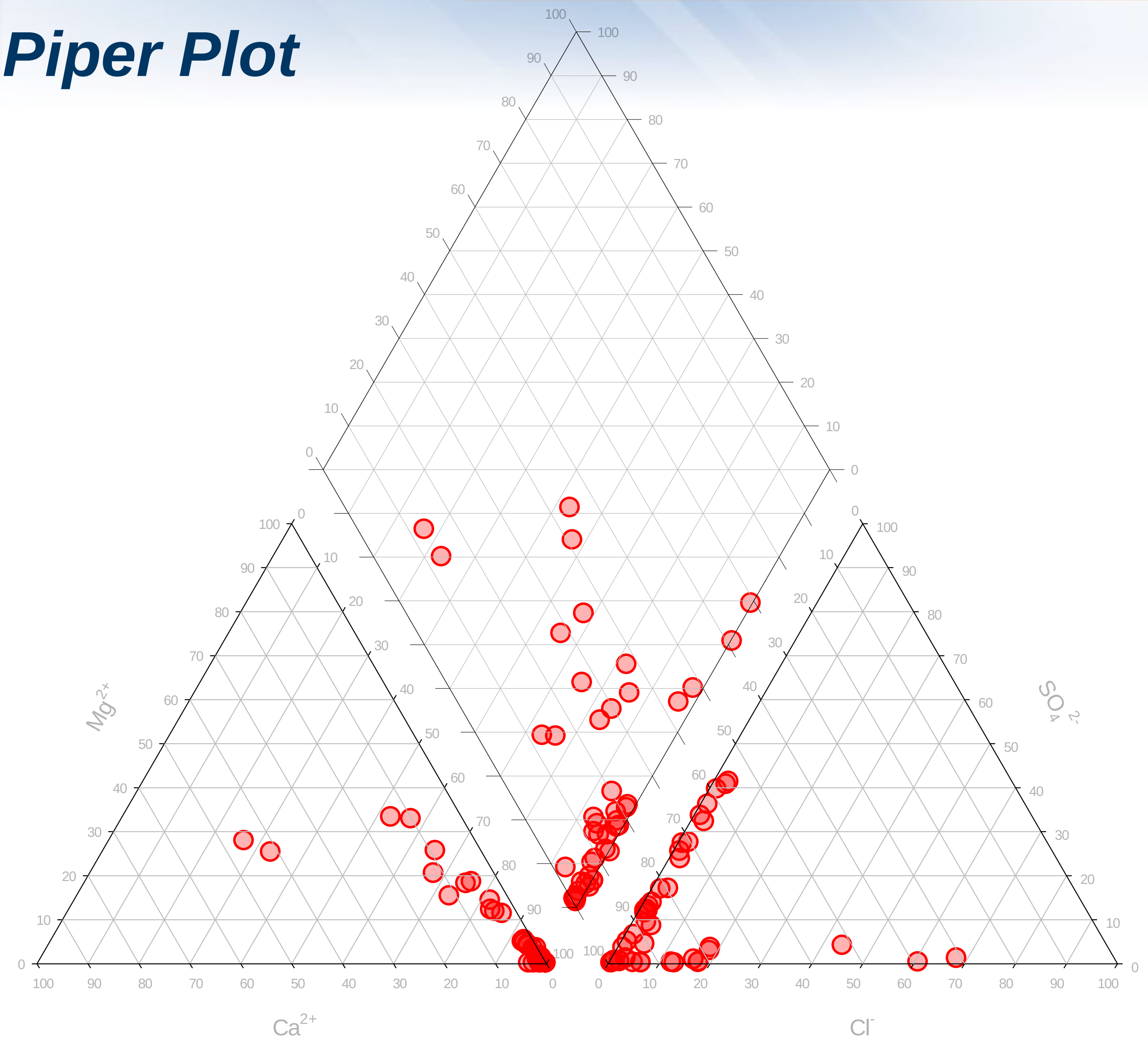
Issues

- **Many reported pH values are not reliable,**
- **Aluminum values are often missing or unreliable,**

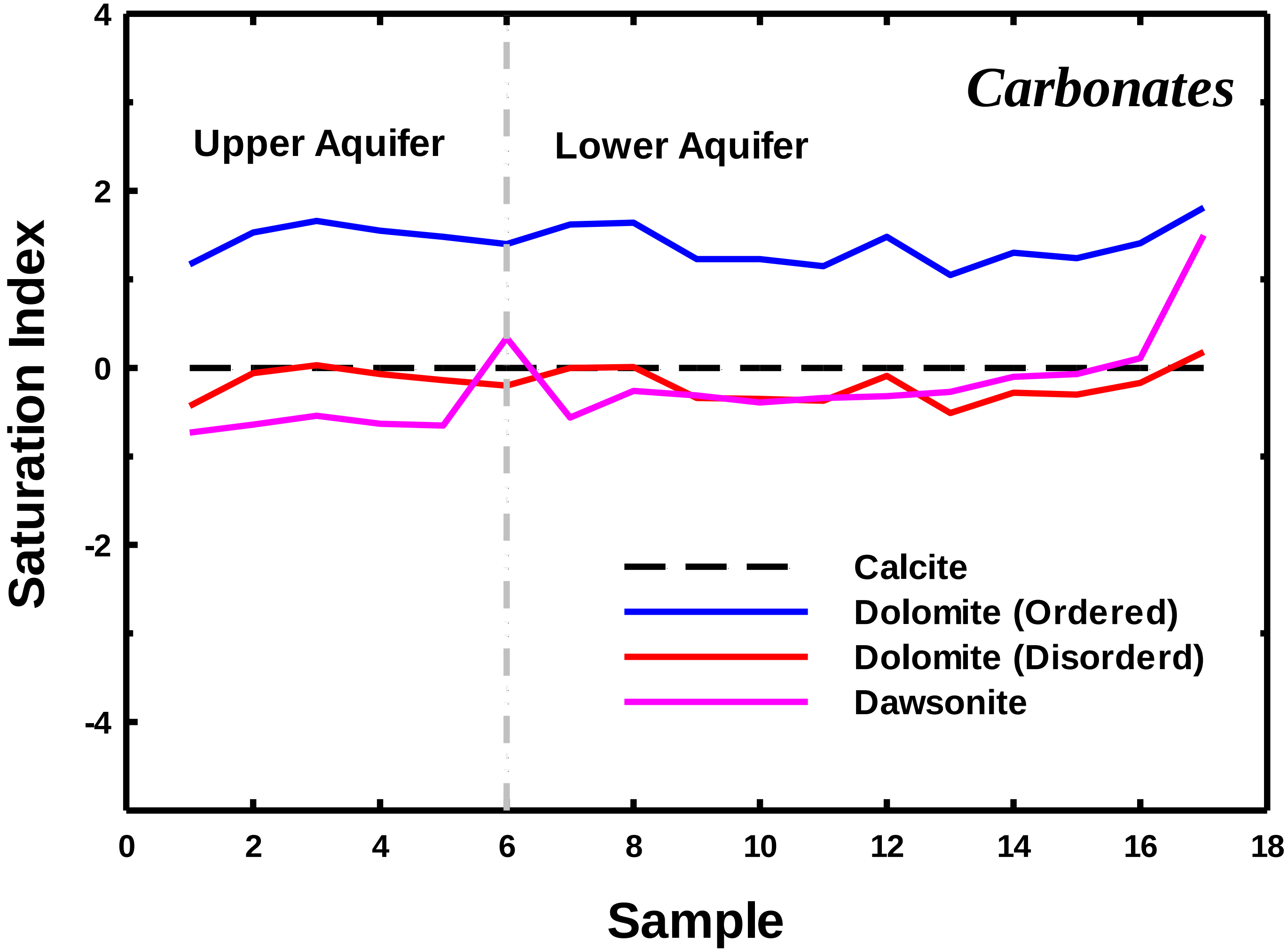
Potential Solutions

- **Calculate pH on the assumption of calcite equilibrium,**
- **Calculate Al activity on assumption of gibbsite equilibrium,**

Piper Plot

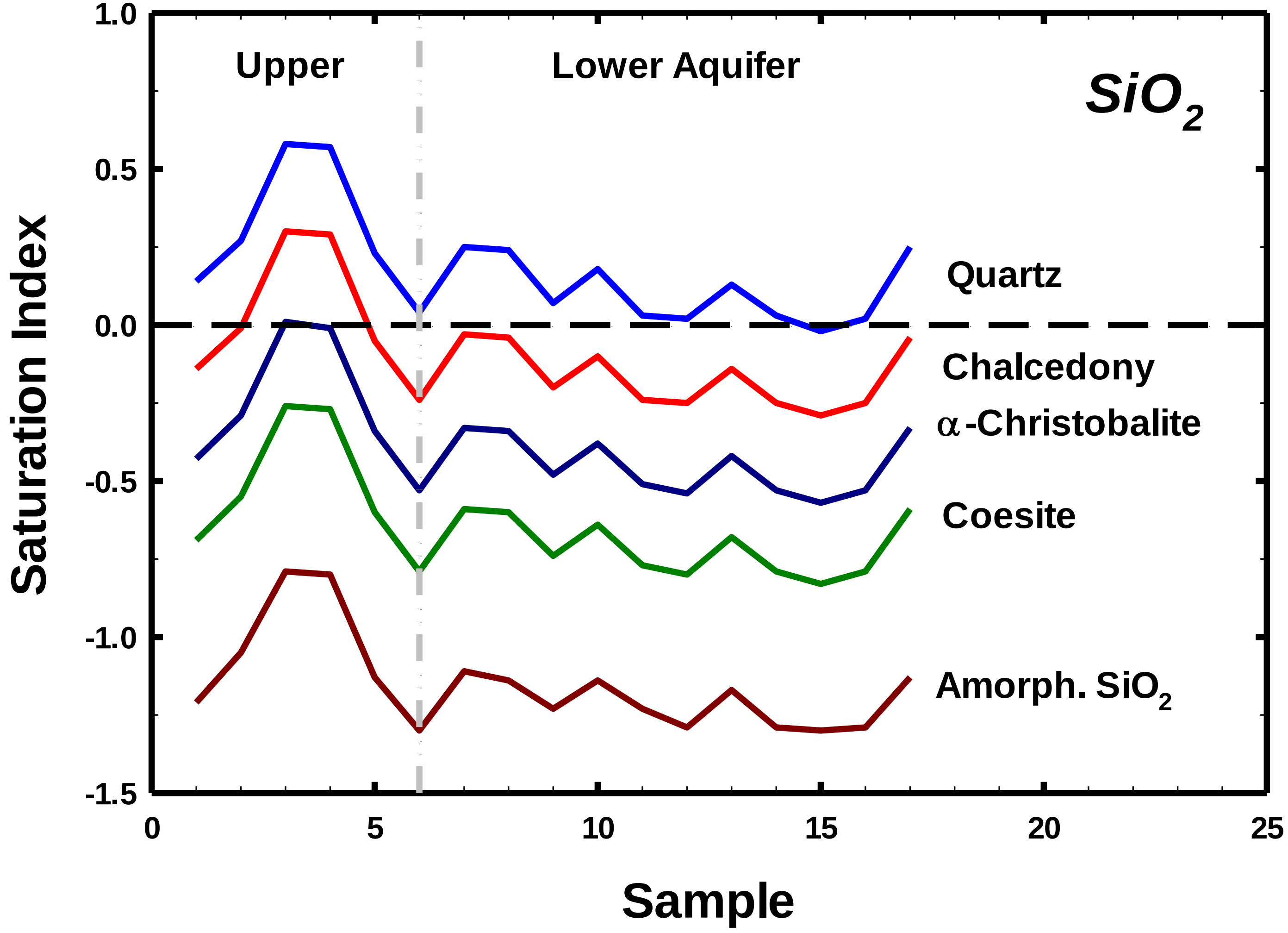


Mineral Saturation Indices



Based on data from Kimball (1984)

Mineral Saturation Indices



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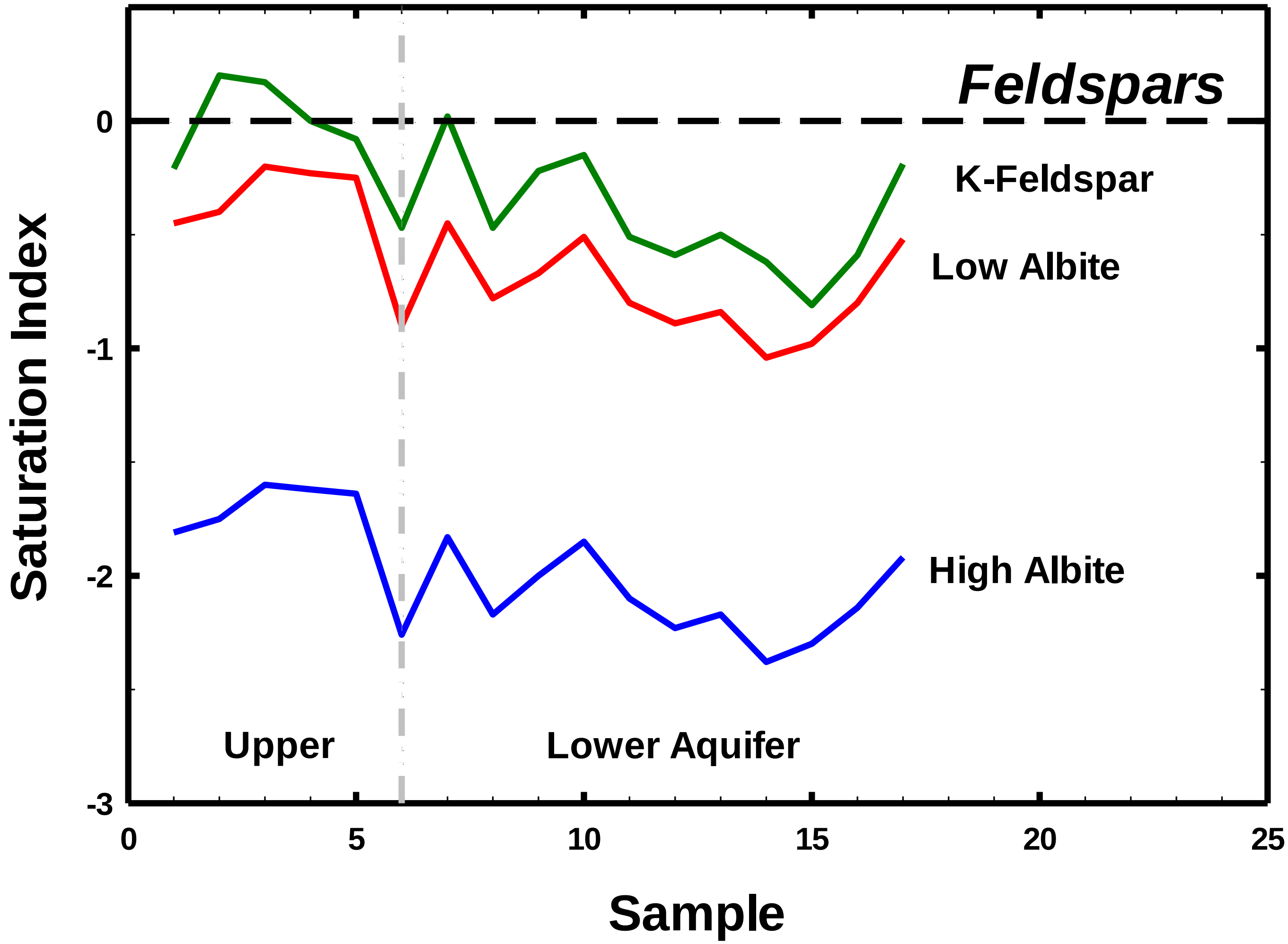

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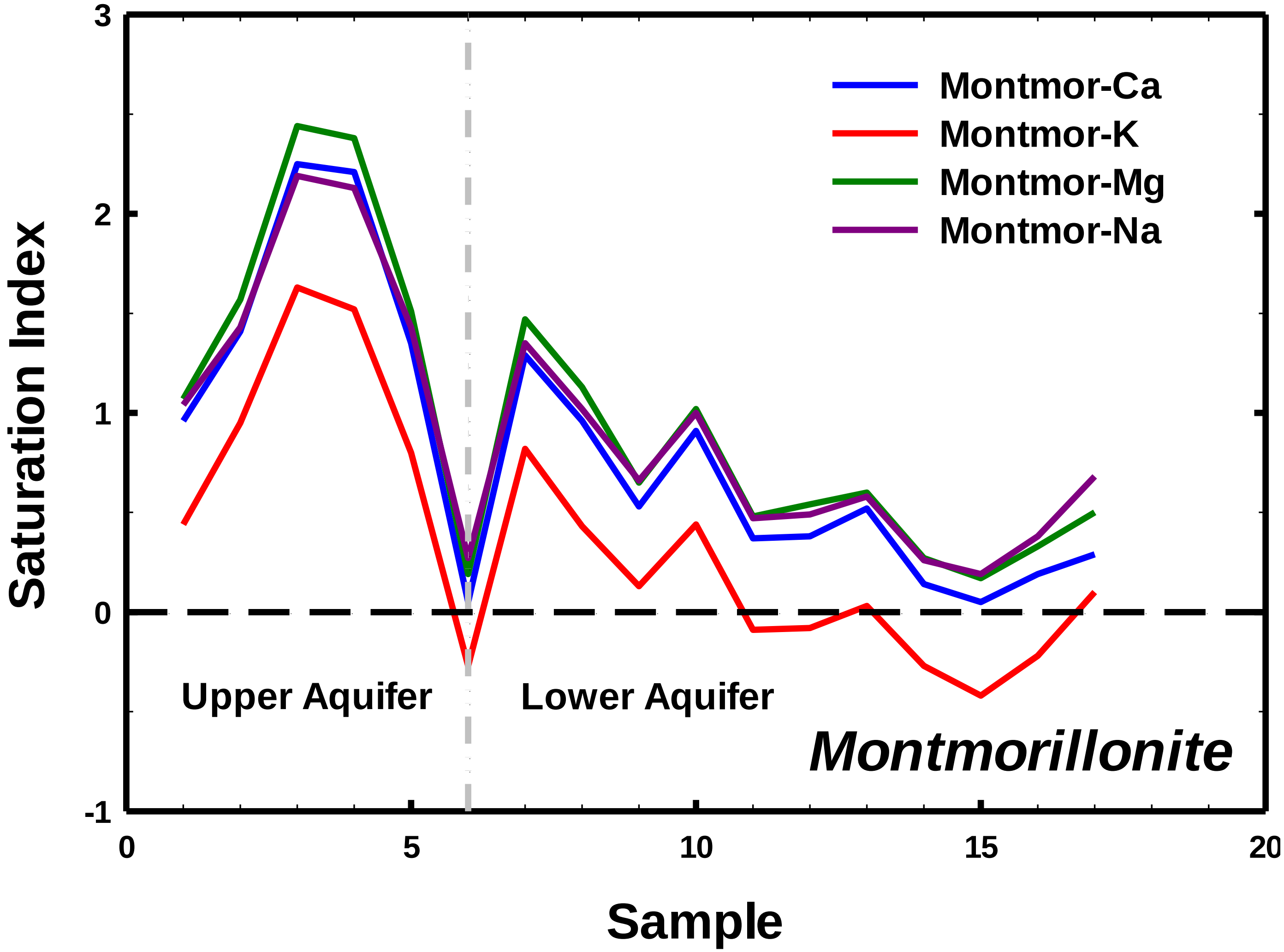

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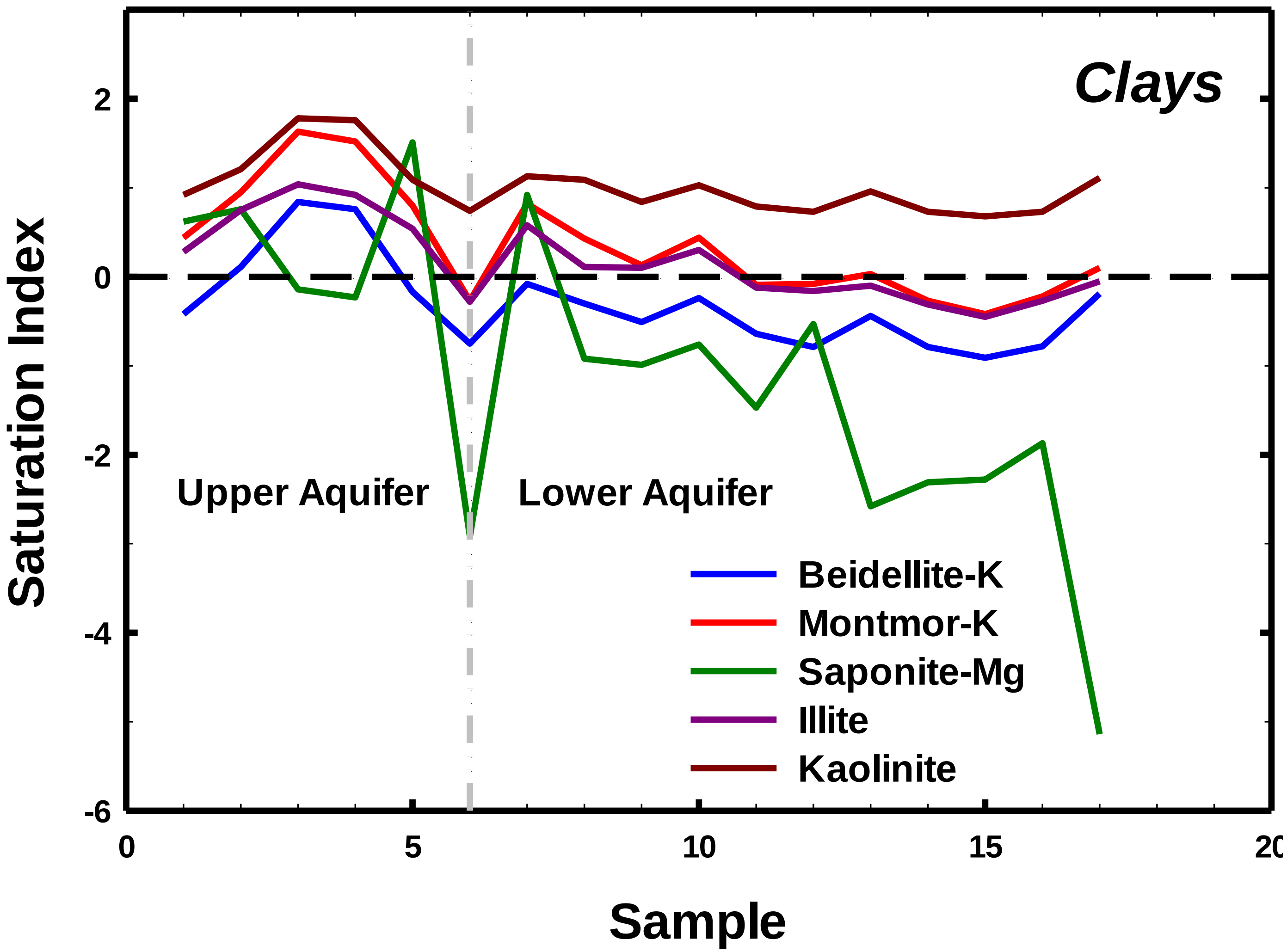
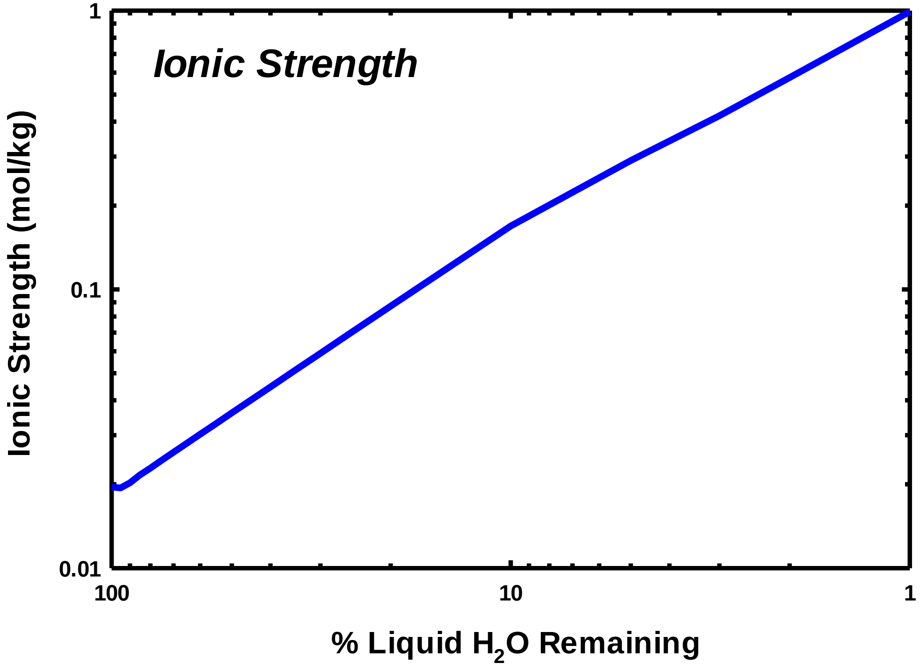
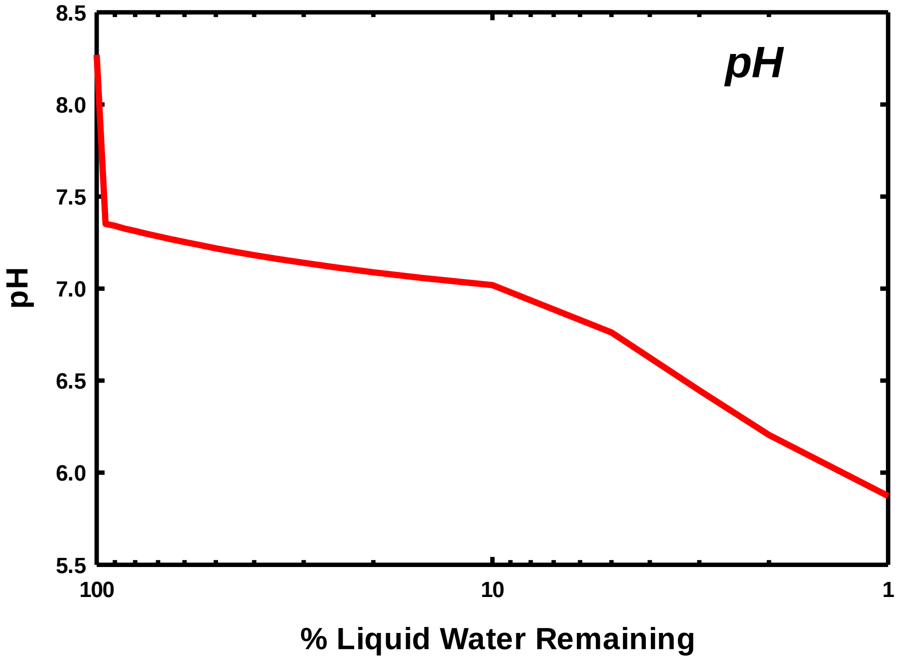


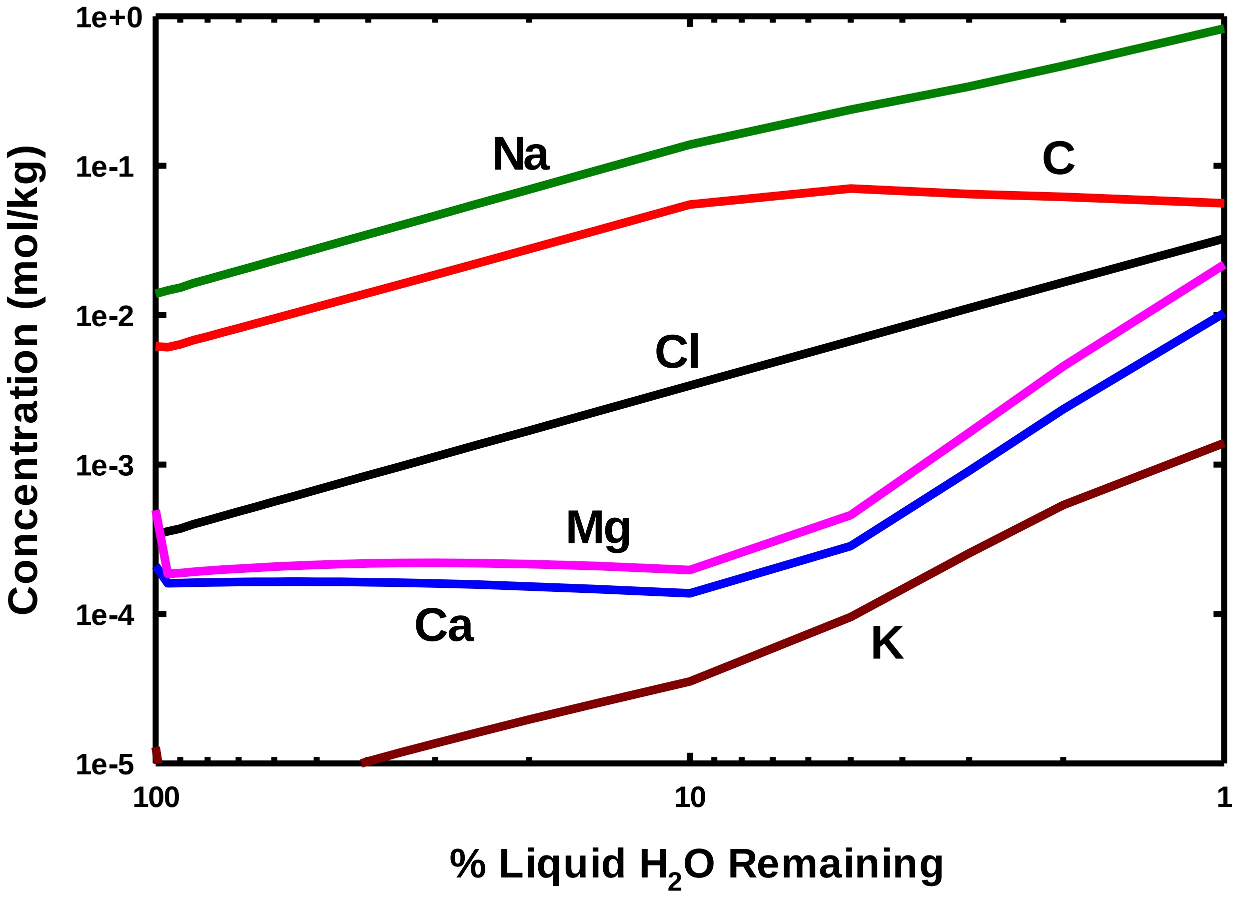
Based on data from Kimball (1984)

Evaporation within Mineral Matrix – Upper Aquifer





Evaporation (Upper Aquifer)



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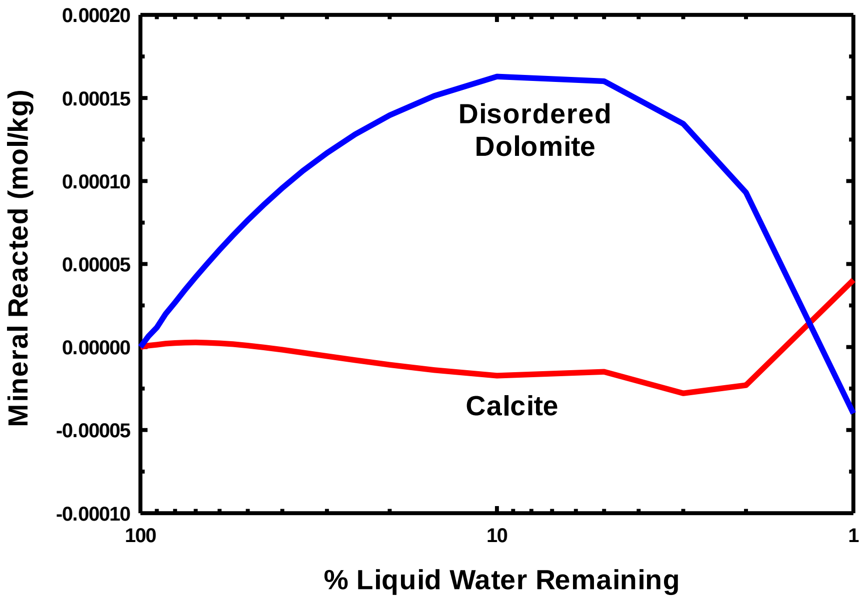
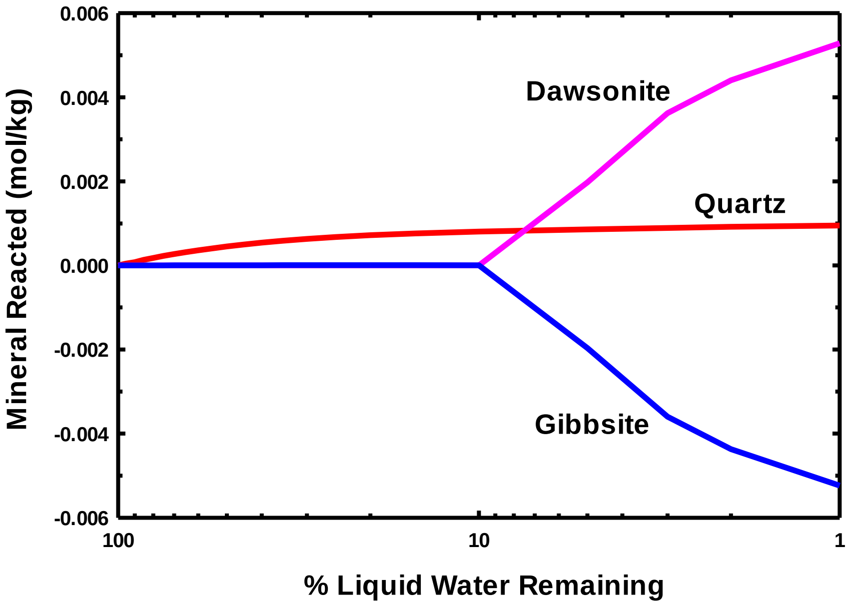
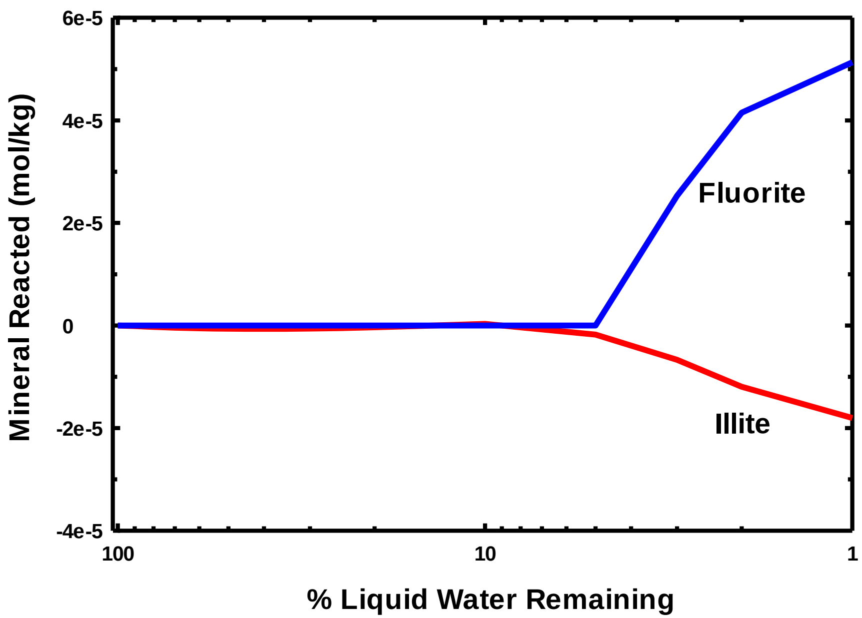
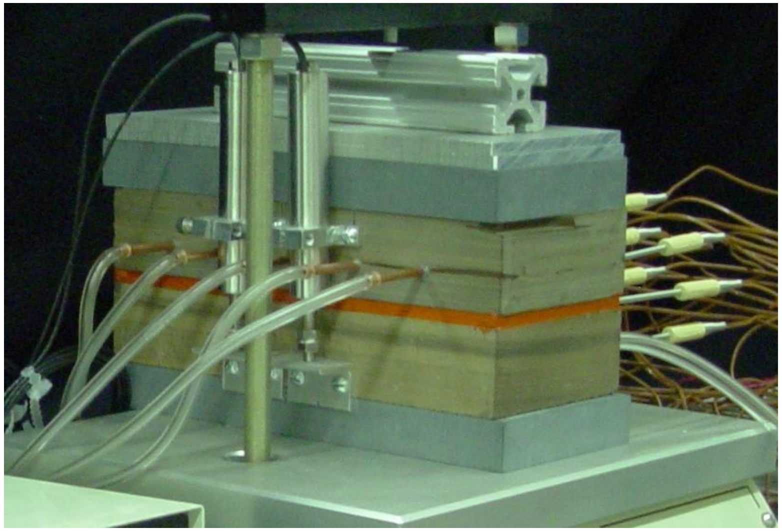






Experiments



An experimental apparatus has been designed and built to study the evolution of fracture permeability as precipitates form from boiling solutions

Summary

- We have initiated a modeling study of the groundwater geochemistry in the Piceance basin to determine the thermodynamic state of those waters,
- We have simulated the evolution of Piceance Basin groundwaters undergoing evaporation,
- These simulations will improve our understanding of potential groundwater impacts and permeability evolution,
- Next Steps are to:
  - Simulate the evaporation of other groundwaters in the basin,
  - Determine the effects of temperature on groundwater composition
  - Experimentally investigate evolution of oil shale fracture permeability as waters boil and precipitates form.