PS Field Observations and Geochemical Analysis of Laterally Continuous Aragonite Veins: Insight into Ancient Fluid Travel*

Elizabeth A. Horne[1], James P. Evans[1], Dennis Newell[1], Niko Kampman[2], Steven Nelson[3], and Elizabeth S. Petrie[1]

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[1]Utah State University, Logan, UT (elizabeth.horne@aggiemail.usu.edu)
[2]Cambridge University, Cambridge, UK
[3]Brigham Young University, Salt Lake City UT

Abstract

The capability to store CO_2 in subsurface geologic reservoirs is a proposed technique that will reduce the amount of human-generated CO_2, a greenhouse gas, from accumulating in the atmosphere. By examining bedrock sites where evidence for ancient carbonate deposition, and where we see natural CO_2 leaks, we can understand how fluid flow in the subsurface behaves in relation to faults and fractures. Understanding fluid flow in a natural system improves our understanding of risks involved in the storage of CO_2 in subsurface reservoirs. We focus on two different outcrops of Mesozoic rocks associated with active CO_2 leaks. The field locality for this work is in the Salt Wash Graben SE Utah, adjacent to the Ten-Mile fault, a normal fault with hundreds of meters of offset. Field observations at this location allow an understanding of crosscutting relationships of laterally extensive carbonate veins and travertine deposits associated with the Salt Wash fault zone. Maps of crosscutting relationships in outcrop are used to understand timing of mineralization along with petrographic analysis of host rock and vein mineralization of calcite veins to understand relationships between host rock and mineralization. Both stable carbon and oxygen isotope analysis are used to understand changes in the fluid reservoir composition. Preliminary stable carbon isotope analyses give $\delta^{13}C$ values between 3.9-6.0 per mil; variations may indicate change in fluid source, relative timing of mineralization, and depth of mineralization. Stable carbon isotope analysis is important because they serve as geochemical markers related to source fluids.

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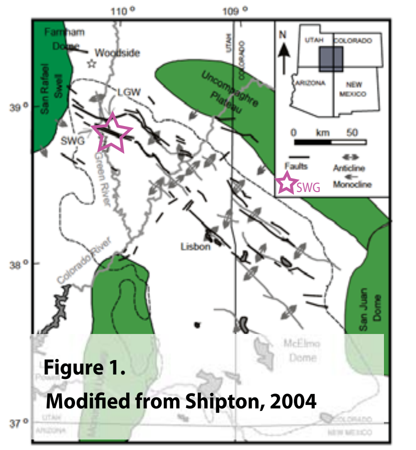
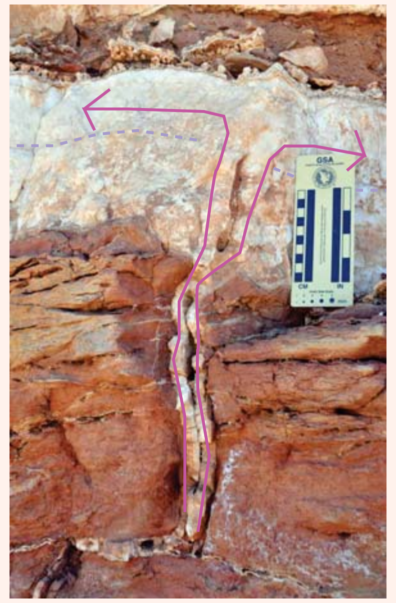
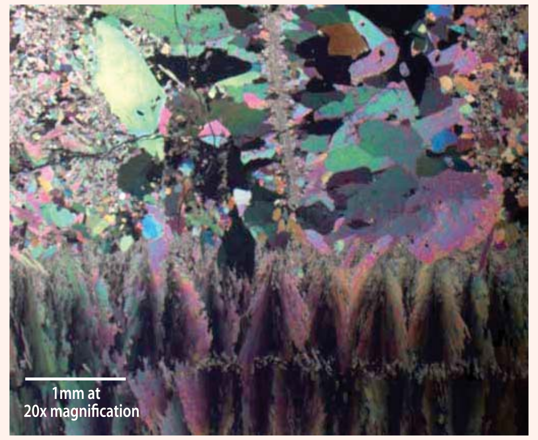
Introduction

There are several exposed vein systems within Salt Wash Graben that are created by CO_2 charged groundwater leaking from deeper subsurface reservoirs. These vein systems are up to hundreds of thousands of years old and record changes in fluid chemistry (Burnside, 2010).

We evaluate the geochemistry and mineralogy of aragonite and calcite veins associated with this natural system of CO_2 to understand the potential risks involved in the storage of CO_2 in subsurface reservoirs.







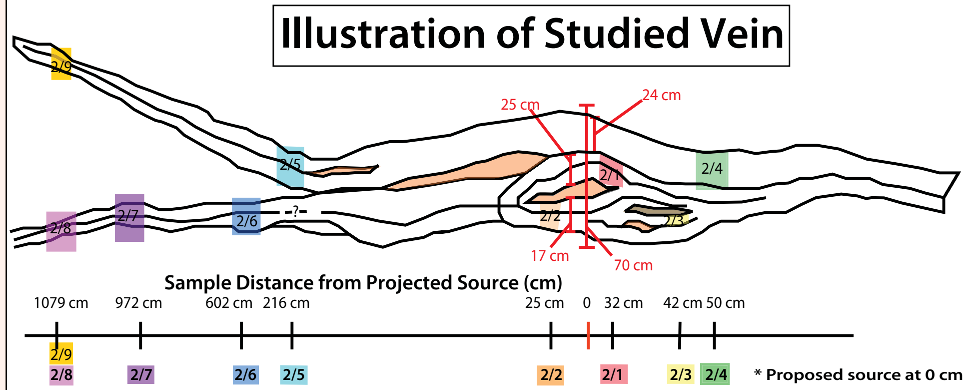
Photomicrograph
Horizontal vein intersects vertical, viewed in thin section. These veins also have different textures which could be linked to rate of crystalization or changes in fluid chemistry.

Methods

- Field mapping and hand sample collection of a laterally continuous aragonite vein
- Geochemical Analyses
  - Stable carbon and oxygen isotopes
  - Elemental analysis
  - X-Ray Diffraction
  - Petrography

Ten Mile Geyser, Salt Wash Graben.

Illustration of Studied Vein



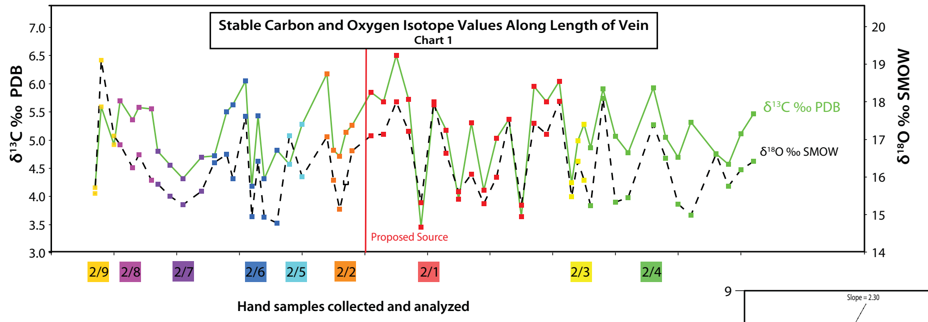
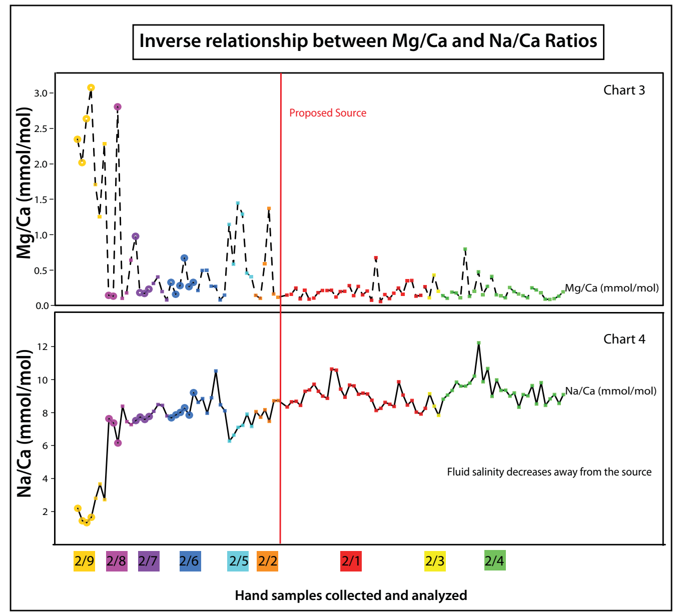


Chart 1: Carbon and oxygen isotope values along the length of vein. The fluctuations seen within each sample grouping record changes in fluid chemistry along the veins thickness.



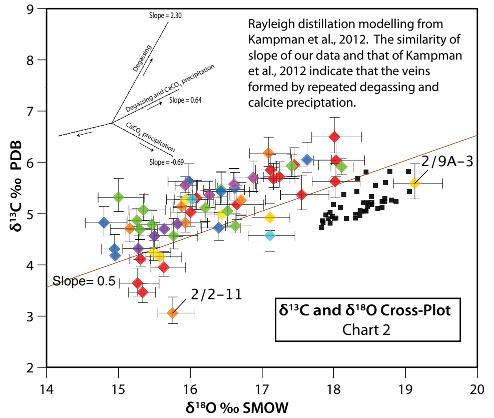
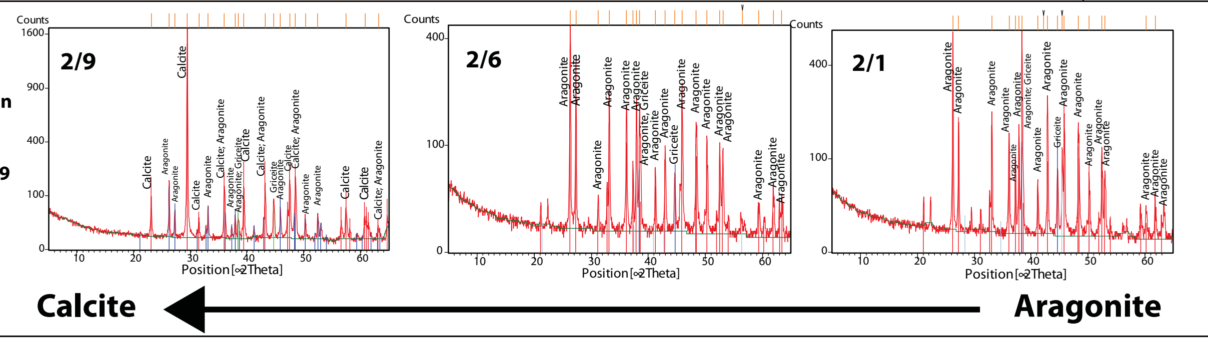


Chart 2: Linear covariation between carbon and oxygen isotope values. These values are affected by the same processes, and are interpreted to come from the same reservoir.

Samples Analyzed (Chart 2)
- 2/1
- 2/2
- 2/3
- 2/4
- 2/5
- 2/6
- 2/7
- 2/8
- 2/9
- Aragonite compositions of veins tested in Kampman et al., 2012
- Slope= 0.5

Chart 3 & 4: Inverse relationship between Na/Ca and Mg/Ca, fluid evolving away from source.

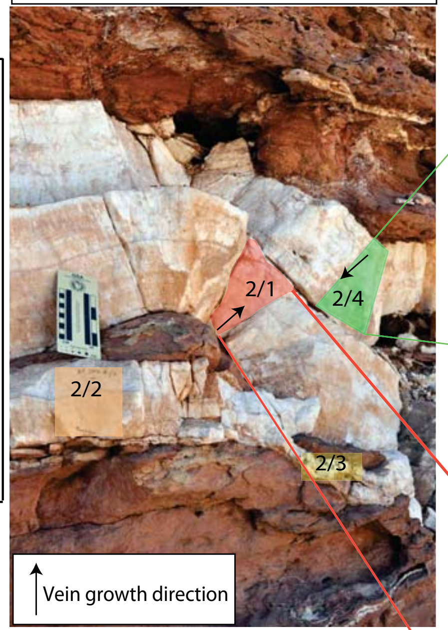
X-Ray Diffraction Results for Samples 2/1, 2/6, and 2/9



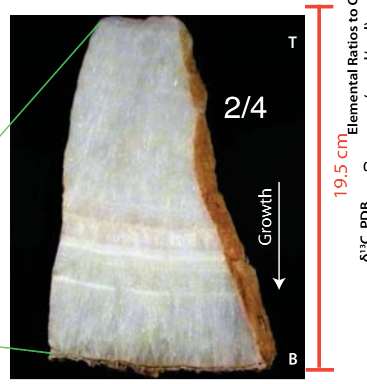
Outcrop view of vein sampled in this geochemical investigation

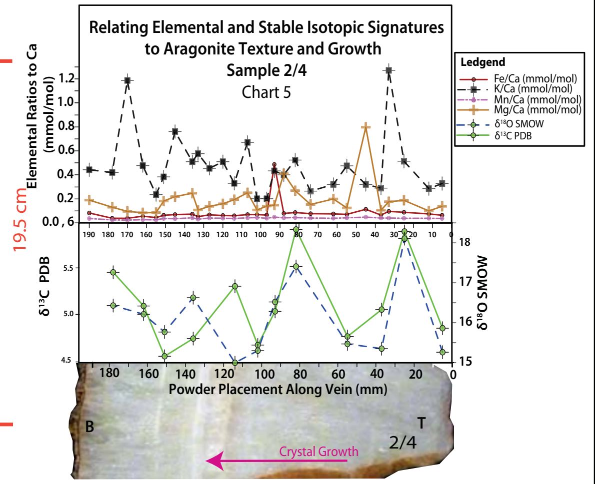
Region of analysis

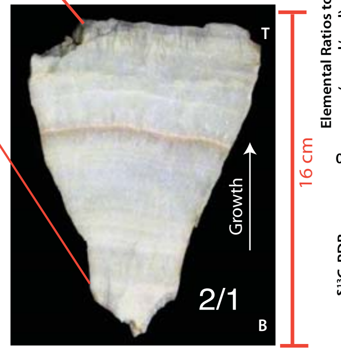
Outcrop photo of vein, sample 2/1, 2/2, & 2/3's location.

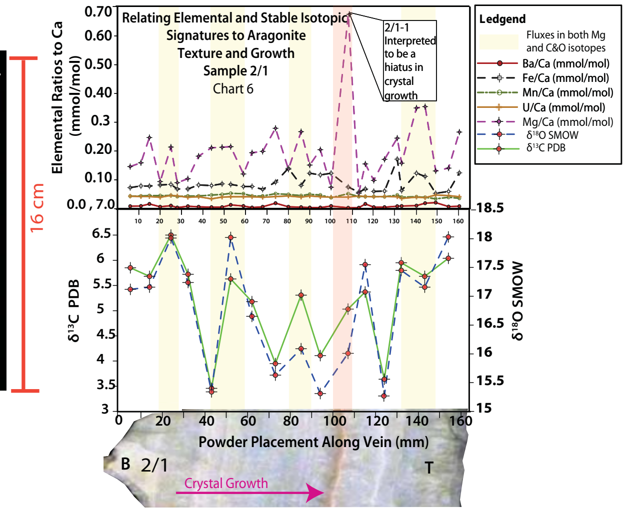


Samples 2/1 and 2/4 were analyzed on a mm scale to understand if there is a correlation between texture and geochemical composition.









Key Results:

Stable Oxygen and Carbon Isotopes

- Covariation in isotopic spikes and depressions, suggests that they are affected by the same processes within reservoir.
- Correlation between elemental signatures, vein textures and isotopic amounts (Charts 5&6)
- Carbonate veins formed by repeated degassing and calcite precipitation

Trace Element Geochemistry

Mg/Ca:
- Increase in Mg/Ca ratio away from source
  - Aragonite does not take much Mg into its crystal lattice.
  - Enrichment in Mg due to aragonite precipitation may account for the partial calcification shown in XRD results for sample 2/9

Na/Ca:
- Decrease in Na/Ca away from the source.
- Salts precipitating out of solution, causing a freshening of water away from source.
- Inverse relationship to Mg/Ca (Charts 3&4)

Future Work

Petrophysical Analysis:
- Analyze samples which have undergone geochemical analysis, to understand if geochemical signatures are represented in mineral textures.

Preliminary Conclusions:

Geochemical results support the hypothesis of fluid emanating from a point, and flowed laterally outward from that site. This vein appears to record at least one large flow of fluid into the host rock. The geochemical data preserves a record rapid fluid chemistry changes as the flows occur.

Implications:

These results suggest that in a CCS system, if there is a rapid change in pressure there will be a change in fluid chemistry, deposition may occur, and lateral flow might be fast with large volumes. This rapid change in chemistry and stable isotope composition will complicate 'leak detection' strategies and monitoring plans in overlying aquifers, in addition to any flow and transport modeling aimed at predicting impacts to water quality.

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