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Estimation of silica, carbonate and other clay mineral content by FTIR Spectroscopy in mud-rich sediments and its implications for sediment provenance analysis

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UNAVCO

Abstract

Fine-grained particles may yield crucial insights in reconstructing the depositional processes, history, provenance, and paleogeography of mud-rich settings. This study utilizes FTIR Spectroscopy to determine the relative abundance of quartz, carbonates, feldspar and other clay minerals in mud-rich conglomerates and sandstones from Cretaceous offshore, shallow marine and alluvial fan deposits in western USA. With this project, we aim to establish a methodology on fine-grained sediment identification and quantification using FTIR as well as establish its limitations on provenance and paleogeographic reconstructions.

Research Goals and Implications

- Combine previous (*Leva, 2014; Laskowski et al., 2013; Gehrels, 2014)* standard petrographic analyses with infrared spectroscopy analyses to offer further insights into the role of basement-involved uplift on sediment dispersal patterns, sediment composition, and provenance in the Cordilleran foreland basin.
- Test FTIR-ATR practicality for provenance analysis.
- Improve source-to-sink reconstructions.
- Determine if thick-skinned deformation was active and influencing late Campanian sedimentation north of the Uintas and Rock Spring segments of the Cordilleran foreland basin.

Geologic Background

- The Cordilleran orogenic system started ~160 Myr ago as a product of convergence and shortening during subduction of the Farallon Plate beneath the North American plate, resulting in volcanism, plutonism and retro-arc contractional deformation along the inherited cratonic hinge line in the western United States.
- Late-Cretaceous, the style of deformation shifted from thin- to thick-skinned tectonics likely in response to shallowing of the subducting slab, leading to basement-involved uplift known as the Laramide uplift and continental dynamic subsidence.
- In Wyoming, the deformation shift occurred sometime during the deposition of the Iles, Erickson, Almond, and Williams Fork Formations all parts of a similar fluvial-to-shallow marine depositional setting.

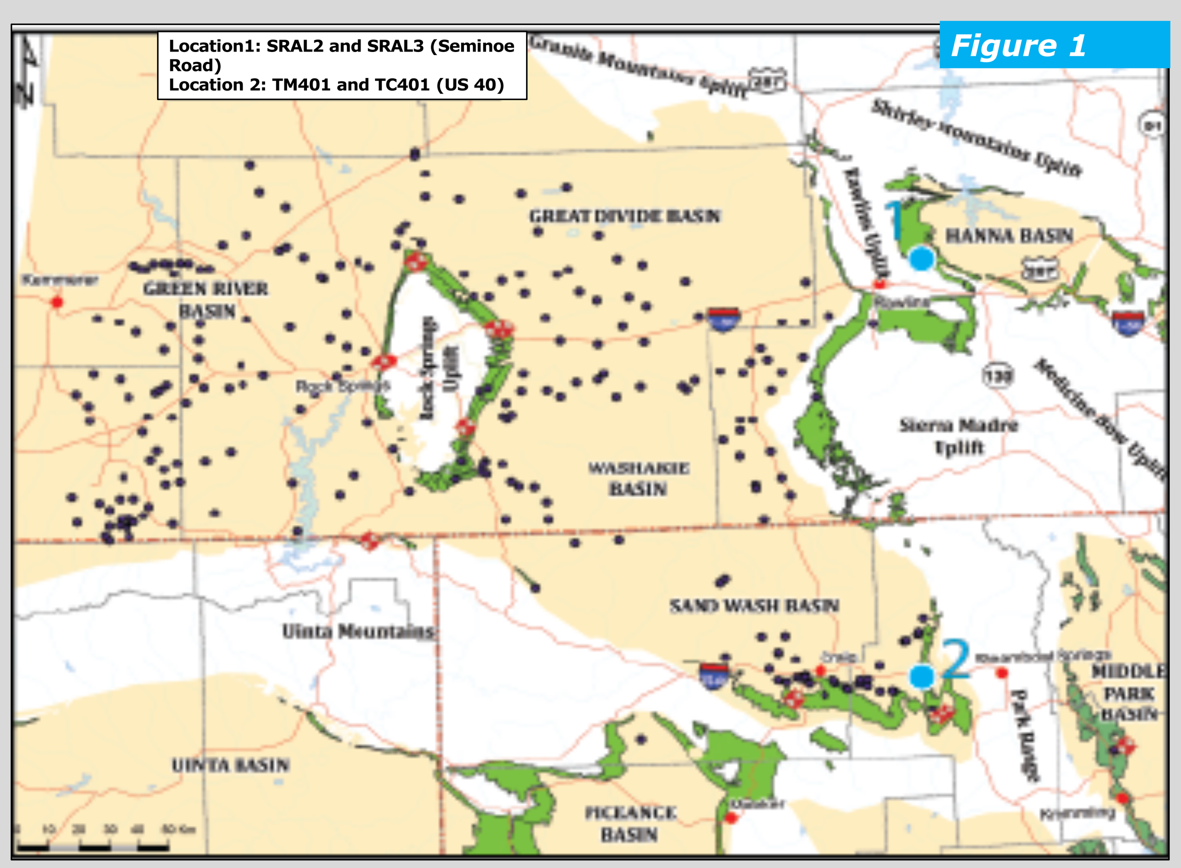


Figure 1

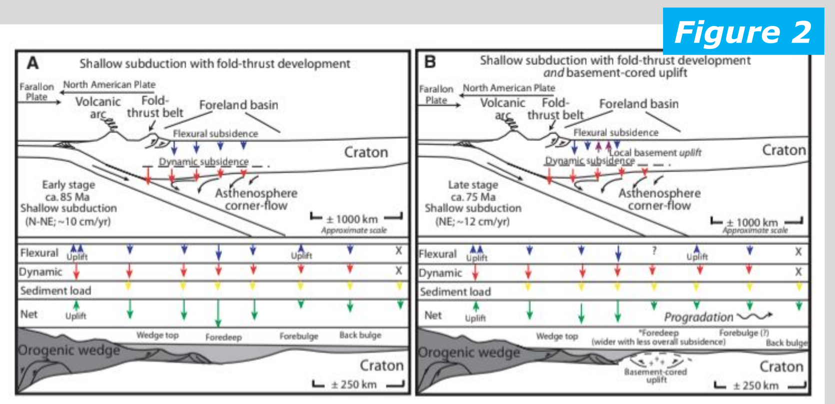


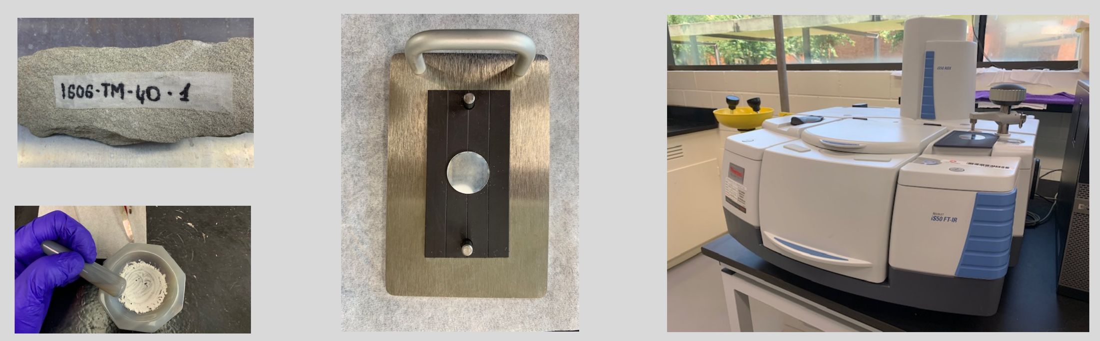
Figure 2

To the left Above: *Figure 1 (Leva, 2014)*shows the sample locations from Wyoming and Utah.
To the left Below: *Figure 2 (Whitmeyer, 2007)* is a representation of the shallowing subduction of the Farallon plate.

Methodology

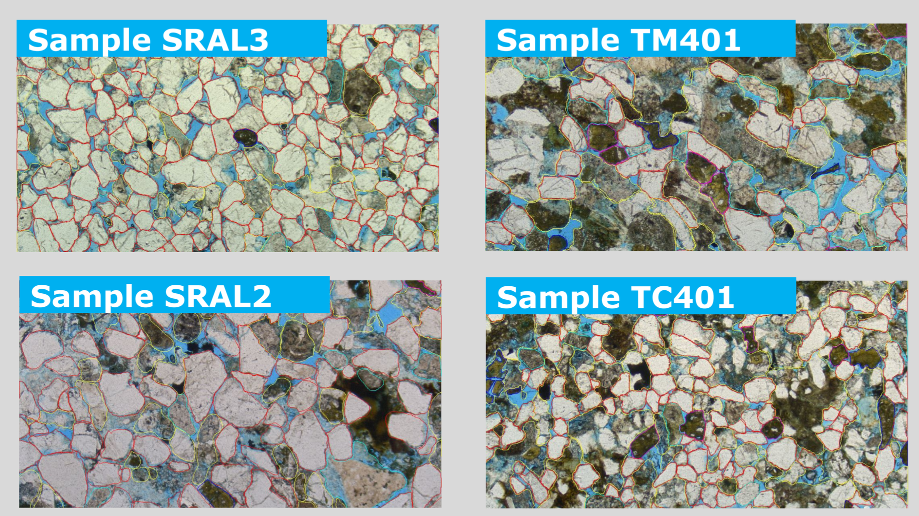
- For FTIR analysis each mineral was ground into powder to homogenize the mixture of the sample with KCl.
- We recorded the spectra in absorbance verses wavenumber, and ran each pellet at 4 cm-1 resolution, and 64 scans per minute.
- Rock thin-sections from the 4 samples were photographed and a petrographic analysis was performed using JMicrovision©, to collect the mean grain size, grain composition, and morphology data.

Pictured below from the top left: A sandstone sample used in this study;
KCl powder and sample being ground with a mortar and pestle;
KCl pellet with sample loaded onto accessory to be inserted in infrared spectrometer;
iS-50 Fourier Transform Infrared Spectrometer used in this study to obtain infrared spectra of samples.



Sandstone Petrographic Results

Standard petrographic analyses were performed on mud-rich sandstones to assess sorting, roundness, and composition. Quartz-Feldspar-Lithics (QFL) of the sandstones indicates provenance.



Above: Pictured are the samples SRAL2, SRAL3, TM401 and TC401 in the Jmicrovision© image analysis software.

Below: *Figure 3* is a Quartz-Feldspar-Lithic (QFL) chart of the provenance and composition of the samples

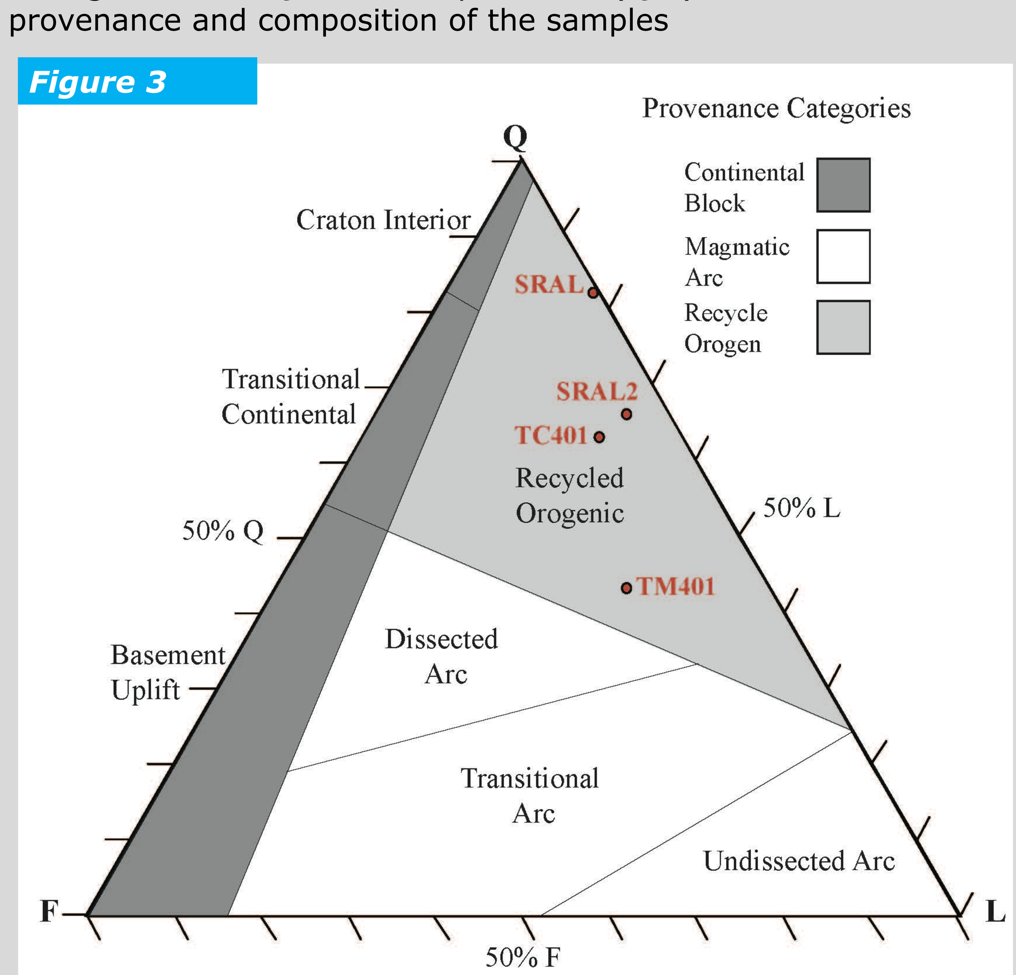
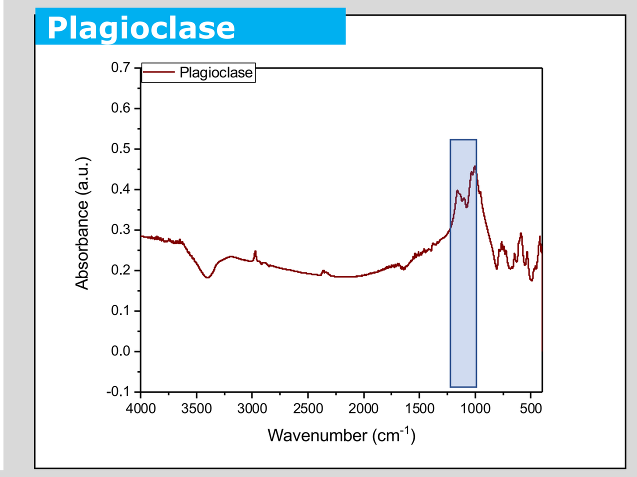


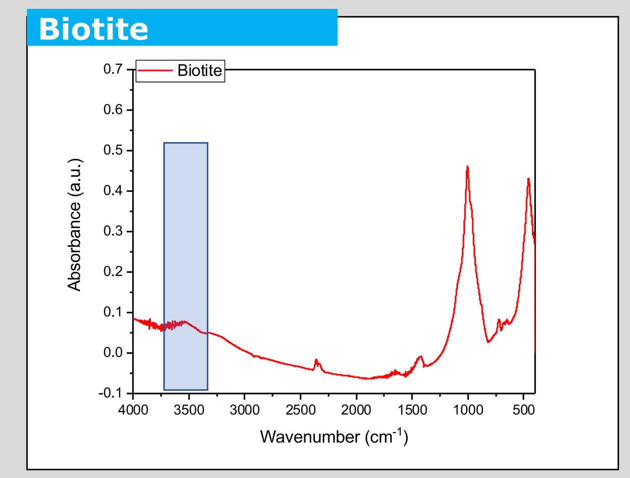
Figure 3

FTIR-ATR Results: Mineral Spectra

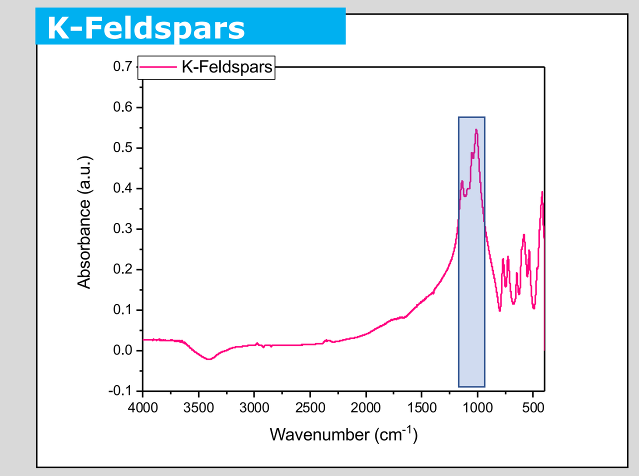
- To the right and below are the absorbance spectra of the five minerals analyzed by FTIR .
- These minerals were chosen based on the composition derived from the petrographic analyses of the rock samples and because they are rock-forming minerals.
- Created a mineral standard to compare the spectra of the minerals to the spectra of the samples as a means of identifying the specific chemical bonds indicative of the mineral.



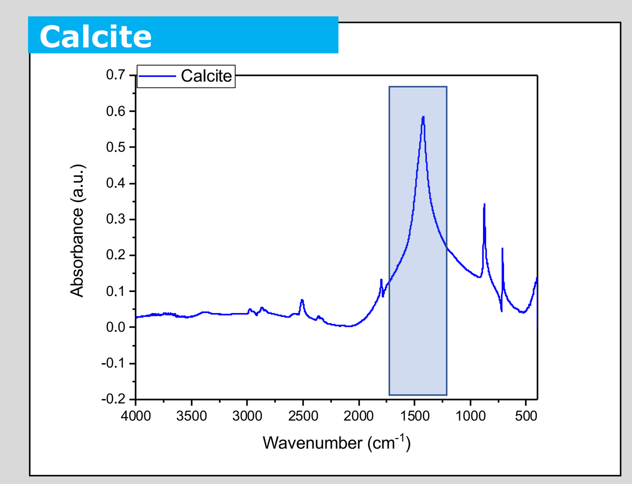
Plagioclase



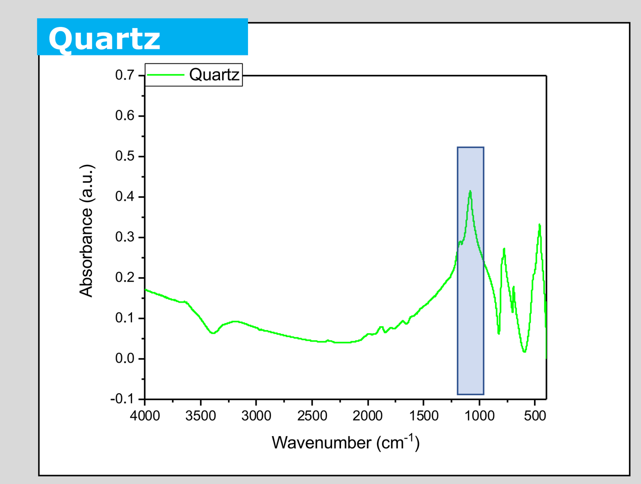
Biotite



K-Feldspars



Calcite



Quartz

FTIR-ATR Results: Sample Spectra

Figure 4 through *Figure 7* show the spectra of the rock samples analyzed. SRAL2 and SRAL3 are mud-rich sandstones from the Almond Formation, and TM401 and TC401 are deltaic sandstones from the Williams Fork Formation.

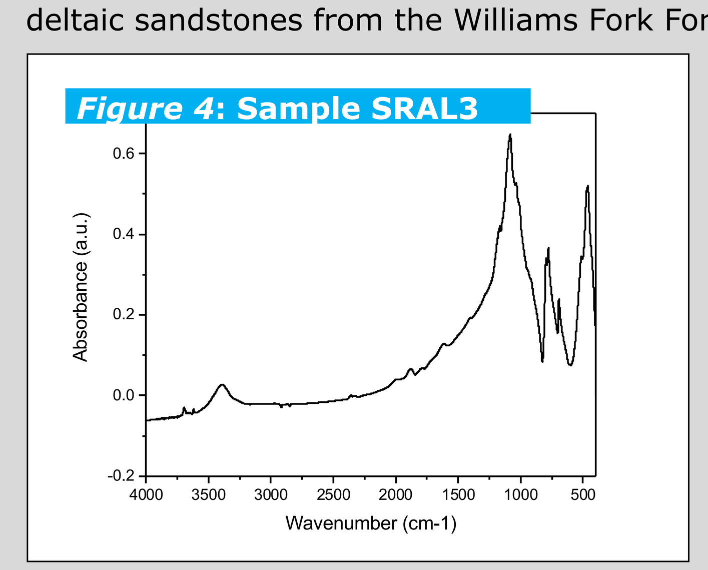


Figure 4: Sample SRAL3

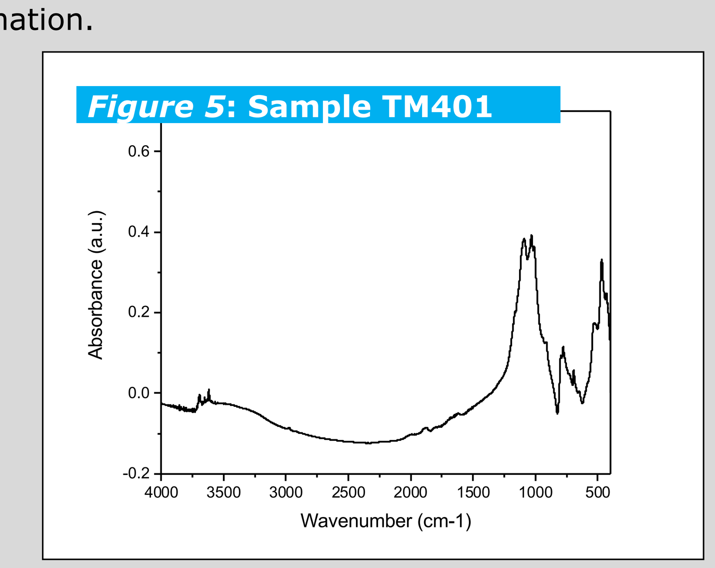


Figure 5: Sample TM401

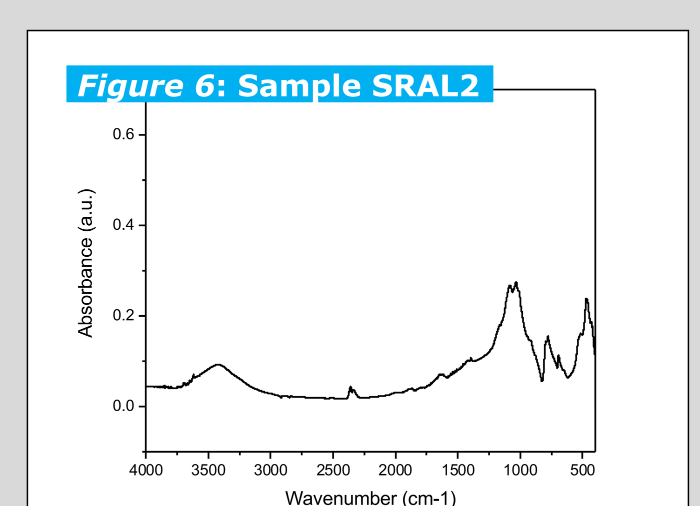


Figure 6: Sample SRAL2

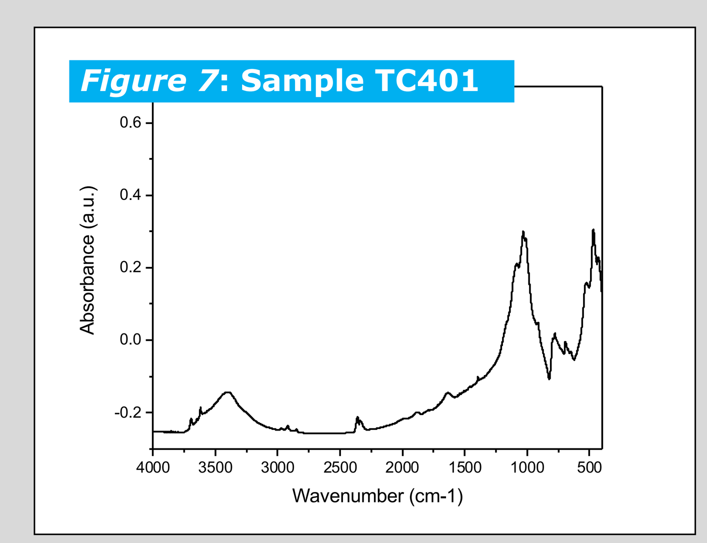


Figure 7: Sample TC401

Discussion and interpretation

- Sediment provenance results from the QFL plot showed that the samples from the Rock Springs vicinity were mainly recycled orogenic material (QFL Plot).
- FTIR qualitative analysis on the Almond and Williams Fork Formations showed similar mineral compositions.
- The Quartz and Feldspar spectra appear to dominate the sample's composition from the FTIR analysis consistent with the petrographic analysis. Plagioclase and the K-Feldspar group are nearly indistinguishable from one another.
- FTIR spectra (shown in Figure 4 –Figure 8) shows the presence of possible amphiboles and phyllosilicates (OH bond), both mineral groups common to felsic igneous rocks.
- The FTIR results reveal the presence of felsic minerals and arkosic sands, indicating sediment sourcing from the Uintas basement uplift and recycled orogenic sediments from the Sevier Fold and Thrust belt.
- Quantification results based on the calibration curves derived from differing concentrations of the standards is inconclusive; further work is needed to obtain accurate mineral percentages from the sandstone samples.

Below: *Table 1* shows is a list of the five minerals used, and the spectra used to identify the chemical bond as a means of minerals identification.
Below Right: *Figure 8* shows the spectra of the sample SRAL2 compared with the five mineral spectra.
Below Right: *Figure 9* is a calibration curve derived from the absorbance peak of Quartz at 1083-1090 (notice the Quartz spectra to the left).

Table 1

Mineral	Identifying Peaks (cm^{-1})	Chemical Bonds
Biotite	3419 452	OH Group
K-Feldspar	1139 1050 537	Si-O Si(Al)-O K-O
Plagioclase	1160 1033	Si-O Si-O and Si(Al)-O
Quartz	1082 797	Si-O
Calcite	1426 875	C=O

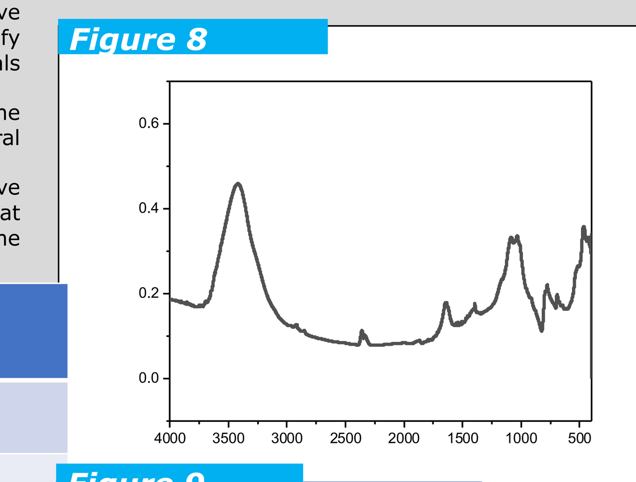


Figure 8

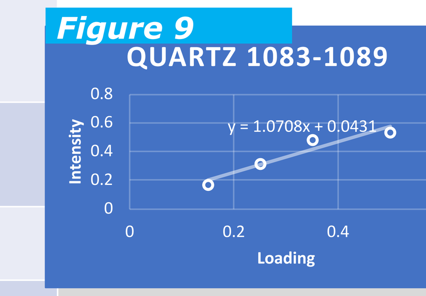


Figure 9

Future Work

- Characterize more rock-forming minerals using FTIR.
- Further refine method of homogenizing sample for FTIR-ATR analysis to ensure accurate representation of composition throughout the sample.

Acknowledgements

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