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Common minerals and common Pb isotopes:

Uncommon applications and new method development for detrital K-feldspar provenance analysis

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Our new work tests the use of detrital K-feldspar common-Pb isotopic ratios as a provenance indicator in sandstones from southern Utah. The well-studied Late Cretaceous Cordilleran foreland basin provides a robust detrital zircon U-Pb geochronology dataset, already integrated with stratigraphy, paleocurrent data, and sandstone petrography; however, some ambiguity regarding provenance interpretations remains, specifically the relative input of sediment from the more distal Mogollon Highlands and Cordilleran Magmatic Arc, versus the more proximal Sevier fold-thrust belt.

In order to progress both method development and contribute new provenance data to the existing Late Cretaceous foreland basin story, we are analyzing more grains from our pilot sample location, and developing multiple robust standards to apply to all new datasets. Four samples from the John Henry Member were mounted, imaged, and analyzed for Pb-Pb isotopic composition. These data were presented at GSA 2017 in Seattle. Our data demonstrate analytical viability of the common-Pb isotope method, indicating a dominant population of K-feldspars sourced from the Mogollon Highlands and the Sevier fold-thrust belt, but a weak Cretaceous arc signal. This method results in a different provenance record that does not align directly with the zircon provenance, which poses new questions about sediment routing systems and the basin's development through time.

Four additional samples, also from the John Henry Member, were mounted and are in the process of being imaged. This will increase our grain sample size significantly. These grains are being imaged by SEM at Utah Valley University under the direction of Dr. Mike Stearns. Mounts are expected to have ~100 good quality detrital grains each for isotopic analysis. This increased sample size will allow us to better characterize the detrital populations represented in these intervals as well as tighten analytical error. Additionally, our University of Utah lab is now well equipped to provide detrital feldspar LA-ICP-MS analysis for Pb-Pb isotopes to other workers who wish to begin using this technique.

We are developing standards for detrital grain Pb-Pb LA-ICP-MS analysis. We prepared a standard mount for LA-ICP-MS analysis as well as grain standards for dissolution. To do this, we tested dissolution of the standard grains for high-precision lead concentration values and found that Pb-concentration is in the hundreds of ppm per grain, easily within our analytical threshold. The following grains are being developed as standards: Mary's Vale (Utah), Little Cottonwood Stock (Utah), Shap Granite (Ireland), and Fish Canyon Tuff (Colorado). Each of these will be dissolved and analyzed for precise Pb concentrations and isotopic values, and will thus constrain our laser ablation data. Additionally, we have developed a sediment source K-feldspar Pb-Pb database for western North America from published literature, allowing us to understand isotopic ranges for most of the tectonic provinces recorded in the Cretaceous foreland basin and others. This database can be applied to new basins and increases efficiency in comparing detrital populations to possible sediment sources.

Current key in-progress tasks include modifying mass spectrometry cup configurations to decrease error, analyzing new detrital samples to increase grain analysis sizes to better characterize detrital distributions and compare to Pb-Pb domains of sediment sources, and comparisons between in situ thin-section and grain-separate analyses, which will allow us to compare our results to those of other workers using only thin-sections. This comparison will allow us to determine if large detrital grain samples are necessary to characterize provenance or if thin sections can accurately represent intricate sediment routing systems. Finally, a manuscript detailing the methodology and our Cretaceous provenance data is in progress with target submission by end of 2018.