STROMIUTR ISOPTIC ANALYSIS OF TEPHRA: A CASE STUDY FROM THE WESTERN INTERIOR SEAWAY

Jeffrey Hannan and Warren Huff

*University of Cincinnati, Department of Geology, Cincinnati, OH, 45221

Introduction

The Western Interior Seaway (WIS), the epicontinental sea stretching across North America during the Late Cretaceous, is home to a myriad of bentonite layers found amid typical marine stratigraphic sequences. Apart from being a highly economic resource, bentonites are renowned for their cumulative utility, providing geologists with a powerful stratigraphic tool. During the Late Cretaceous, active volcanism was responsible for the ubiquitous bentonites found within the WIS.

Bentonites are a claystone, authigenically formed from devitrified volcanic glass. Even though bentonites consist almost entirely of authigenic smectite clay, primary volcanic minerals (zircon, apatite, Feldspar, etc.) are commonly preserved, revealing the clay’s explosive volcanic glass. Even though bentonites consist almost entirely of diagenetic nature of bentonite clay, the nature of strontium isotopes from such event horizons would be a highly precise and reliable.

Results

Strontium Isotopes

Every strontium bearing rock and mineral on the planet has a preserved isotopic signature that can be analyzed using separations and isochron-based radiometric dating. Rubidium 87 decays to strontium 87 with a half-life of 48.8 Ga. Therefore, rock systems with higher rubidium concentrations have, overall, produced more radiogenic strontium 87. This leads to higher ratios of 87Sr/86Sr and because rubidium is an incompatible element with respect to most mafic mineral phases, felsic rocks tend to have higher 87Sr/86Sr ratios. For example, mid-ocean ridge basalt have an average 87Sr/86Sr=0.703 (depleted), while average continental crust 87Sr/86Sr=0.710 (enriched). Most rocks fall in between these values, due to assimilation of various rock types.

Geochemical Discrimination Diagrams


Methods

- Strontium isotopic ratios of altered tephra deposits (bentonites) are representative of the original magmatic source from which the ash originated. Magmatic trends can be tracked through time in regions where abundant bentonites are preserved, and may be used to reconstruct magmatic regimes in ancient subduction zones. Stratigraphic applications will be tested in future work.

- Strontium isotopic ratios (87Sr/86Sr) of altered tephra deposits (bentonites) is a reflection of the magmatic nature of the isotopic composition.

- Geochemical discrimination plots indicate a distinct calc-alkaline influence on all bentonites tested. All samples fall primarily within dacite/phonolite geochemical boundaries with respect to Zr/SiO2 and Nb/Y vs SiO2.

- Rare earth element and trace element trends closely follow igneous counterparts, including data plotted from the Idaho batholith. Most incompatible elements are enriched in the liquids, which is translated to the preserved ash.

Discussion

Several discrete datasets have been compiled in an effort to understand the geochemical affinities of bentonites with respect to their igneous and secondary origins. When volcanism is deposited into a sedimentary basin, it undergoes rapid chemical alteration, a chemical dissolution of glasses into a stable clay phase. This diagenetic alteration of glass to clay could mean significant changes in the geochemical makeup of the preserved ash layer, but evidence appears to prove otherwise.

The initial hypothesis for bentonite 87Sr/86Sr speculated that the interlayer cations of the diagenetic smectite reveal seawater through isotopic replacement of calcium with strontium. Because the interlayer cations are a significant substitution for calcium, the hypothesis was determined to be false approximately 0.7074. Throughout the geochemical analysis, Sr values maintained very close to Cenomanian global strontium levels, whereas bentonites had values significantly higher than this, ranging from 0.70786 to 0.70792. Campanian fossil samples have not been tested, but the bentonite strontium values range from 0.7064 to 0.7077 weighing lower than whisked Campanian seawater values (0.7070).

Conclusions & Future Directions

This study has provided evidence that whole rock bentonites may be used, under conditions of minimal diagenetic alteration, as a geochemical proxy for the magmatic source of which the ash originated. Magmatic trends can be tracked through time in regions where abundant bentonites are preserved, and may be used to reconstruct magmatic regimes in ancient subduction zones. Stratigraphic applications will be tested in future work.

- Strontium isotopic ratios (87Sr/86Sr) of altered tephra deposits (bentonites) is representative of the original magmatic source from which the ash was ejected.

- Cenomanian volcanism had a higher strontium ratio than seawater, a reflection of the magmatic nature of the isotopic composition.

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One of the most common uses for strontium isotopes is strontium stratigraphy. The strontium signature of seawater, which is consistent world-wide at approximately 0.708, significantly higher than all bentonites tested. A series of trace elements, normalized to MORB values, for the A model of bentonite formation. Volcanic ash is deposited in adjacent basins from active continental margins as the subduction of the Farallon Plate incorporated ancient continental crust into the liquidus, the strontium ratio became more radiogenic from the calc-alkaline series of dacite/rhyodacite, with and Nb/Y shows a clear felsic igneous affinity to the calc-alkaline series of dacite/rhyodacite, with

Various discrimination diagrams can be utilized to determine rock type within the diagenetic smectite matrix. Isochron in (a) shows a correlation of 87Sr/86Sr values, data from the Cenomanian isopleth runs through the ACM, while the data falls through the ACM/Ensialic data more closely, though peaks and troughs are normal for this trend. The bentonite strontium values uphold a process that occurred due to the mixing of the isopleth seawater magnitudes as the subduction of the Farallon Plate incorporated ancient continental crust into the liquidus, the strontium ratio became more radiogenic from the calc-alkaline series of dacite/rhyodacite, with

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ICP-MS/OE

- Element abundance quantification was calculated for each bulk bentonite sample. Data is normalized to mid-ocean ridge basalt and compared to existing datasets for magmatic comparisons. (Analysis performed by Actlabs Ltd.)

X-Ray Diffraction

- Mineralogical data was quantified for bulk bentonite and isolated clay speciation. Variations in smectite structure was determined to provide evidence of post-burial diagenesis or thermal maturation. (Analysis performed at the University of Cincinnati)

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