Application of allanite (U-Th)/He dating and mineral magnetism to correlating tephras in Quaternary terrestrial climate records

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Quaternary sediment records in arid lakes are extremely sensitive indicators of past climate, but creating high precision timescales to accompany them is challenging. Materials that are routinely dated using the U-Pb and $^{40}Ar/^{39}Ar$ systems in older rocks and sediments are often difficult or impossible to date using these systems in very young deposits. In the absence of easily dated macrofossils, the radiocarbon system—typically the most precise system available for the recent past—encounters complications that can significantly reduce precision.

Two general approaches can be used to overcome these obstacles. The most direct approach is the development of new mineralogical dating systems such as the allanite (U-Th)/He system that are characterized by abundant parent isotopes and low resetting thresholds suitable for recording recent volcanic eruptions. The other approach is the development of techniques that allow volcanic ashes lacking a precise timescale to be correlated to others that exist within a well-established radiocarbon timescale, allowing both ashes to be tied to that timescale.

To the first end, we plan to develop the allanite (U-Th)/He in collaboration with Ken Farley at Caltech. Allanite is an abundant accessory mineral in many volcanic deposits, including some of the deposits at Mono Lake. The allanite phase hosts abundant thorium and is therefore expected to produce a significant amount of helium daughter product even on the short timescales of Quaternary climate science. The allanite in the ash that bisects the Mono Lake Excursion will be dated in order to better characterize the age of this globally significant paleomagnetic event.

For the purpose of ash correlations, we plan to apply a new mineral magnetic technique developed by Josh Feinberg at the Institute for Rock Magnetism at the University of Minnesota to the Mono Lake ashes. His initial analyses of some of these ashes were promising, but others displayed variable results, much like the variable age results that often result from bulk samples of the same ashes. We hope that our improved sampling of individual layers within the compound ashes will mitigate this problem as it has done for the multiple age populations and will allow high value ashes like the Mono Lake Excursion ash to be correlated to well-dated ashes outside the basin.

Both of these techniques will serve as checks on one another and will contribute to the general arsenal of geochemical tools available for creating Quaternary timescales. The exciting new collaborations that will grow out of this work will lead to collaboration on larger federal grants and other projects in the future.