Investigating the link between LIP magma flux and topology of the carbon isotopic record

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Large amplitude fluctuations (± 3-5 ‰) punctuate the marine carbonate carbon isotopic record, and although they do not exclusively accompany global environmental perturbations, such as mass extinctions, sharp excursions are coincident with all major extinction events during the past 300 Ma. Large igneous province (LIP) magmatism is hypothesized to trigger extinctions and drive carbon cycle perturbations via liberation of carbon dioxide and methane during volcanic degassing and contact metamorphism of host sediments. This causal connection is supported by geochronology from coupled LIP and mass extinction records, which show magmatism preceded extinction onset, and was coincident with carbon cycle perturbations.

Although relative timing permits causal connections, the limit of analytical resolution on dates is in many cases larger than the duration over which LIP magmatism and carbon cycle perturbation occur, obscuring details of the relationship between them, and precluding investigation of questions such as: Is magma emplacement rate or style (e.g., intrusive vs. extrusive) linked to the magnitude of carbon cycle perturbation? What is the time lag, if any, between the start of high-flux magmatism and carbon isotope perturbation? Is magma flux related to carbon cycle recovery/rebound?

To explore these questions, we employ U/Pb chemical abrasion TIMS on zircon crystals isolated from silicic ash beds intercalated with lavas of the ~16 Ma Columbia River flood basalt province (CRB). Although not associated with a large carbon cycle perturbation, our dates on the Miocene CRB are precise to the ~10 ka level, allowing a more accurate estimation of magma flux than can be achieved on Paleozoic and Mesozoic LIPs. We assume analogous emplacement mechanisms for different flood basalt provinces, and use a magma flux value from the CRB Butler Canyon section (magnetozone N_2) to better estimate flux for the initial extrusive stage of the Permian-Triassic Siberian Traps LIP, on which dates are roughly an order of magnitude less precise. We further examine the links between this LIP flux estimate, the carbon cycle, and mass extinction at the end of the Permian period.