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Evaluating a link between eruption of the Siberian Traps and the End-Permian Mass Extinction with high-precsion geochronology

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Linking the eruption of a continental large igneous province (LIP) with the onset of a global mass extinction event is critically dependent on knowing precisely when each event took place and its duration. Many studies invoke the Siberian Traps LIP as a cause for the end-Permian mass extinction event, however none demonstrated with highest-precision geochronology ($\pm$ <0.1 %) whether the LIP was erupted just prior to, during, or after the main pulse of the mass extinction. The main pulse of extinction, as defined by U-Pb CA-TIMS geochronology from bed 25 in the marine section at Meishan, China, occurred at 252.25 $\pm$ 0.04 Ma. The oldest published U/Pb date for the Siberian Traps is 251.7 $\pm$ 0.4 Ma (Kamo et al., 2003), which is an ID-TIMS perovskite date from a flow near the base of the entire lava sequence. A recent Ar-Ar date on plagioclase (Reichow et al. 2008) from a basaltic flow near the base of the sequence is 251.8 $\pm$ 1.5 Ma. The range of precision for these three dates highlights the difficulty in evaluating the coincidence of the onset of eruption and the extinction. These dates also demonstrate the necessity for achieving the highest possible precision. Even if corrected for the discrepancy between U-Pb and Ar-Ar dates, uncertainty in the Ar-Ar data is too large to test coincidence. Although precision on currently published U-Pb data from Siberia are typically $\leq$ 400,000 years, in some cases it should be possible to reduce uncertainties by almost an order of magnitude.

Obtaining the highest precision U-Pb dates for the Siberian Traps is limited by two factors. First, a lack of zircon-bearing rocks in the dominantly silica-undersaturated LIP necessitates using other uranium-bearing silicates and/or oxides such as perovskite and baddeleyite, respectively. Unlike zircon, these minerals may contain common Pb, which introduces significant uncertainty in the final calculated date. Secondly, most zircon dates from the Siberian lavas, including the date from the oldest erupted basalt, were published prior to routine adoption of CA-TIMS to eliminate effects of Pb-loss and have typical uncertainties of $\pm$ 0.4 Ma. Overcoming the first factor requires sampling rare, silicic, usually tuffaceous units interlayered with the dominantly basaltic sequence. We have sampled two zircon-bearing silicic tuffs near the stratigraphic base of the approximately 900 m thick Delkansky unit (Fedorenko and Czamanske, 1997). The Delkansky is thought to be the youngest group of basaltic flows in the stratigraphy, which in the Maymecha-Kotuy area is $\sim$2.5 Km thick.

Weighted mean 206Pb/238U dates from both samples overlap within analytical error and are roughly 1 Ma younger than U-Pb data on zircons published by Kamo et al. (2003) from what is interpreted as a higher stratigraphic interval. This discrepancy in dates is not yet understood but may reflect a previously unrecognized stratigraphic complication. Assuming the U/Pb on perovskite date of 251.7 $\pm$ 0.4 Ma from Kamo et al. (2003) is the best estimate for the onset of trap volcanism, then our new data from the upper part of the same stratigraphic column indicate that volcanism persisted for at least 1 Ma.

A protracted eruptive history bears directly on volatile load per unit time and therefore the efficacy of the volcanism to drive environmental change. High-precision U-Pb geochronology is the key to defining when the eruption began and for how long it persisted. At the present time there are no U/Pb dates that are equal to or overlap the date for the end-Permian extinction in China and our new data suggest that magmatism occurred over more than 1 million years.