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Timing of Emeishan magmatic activity and implications for the end-Middle Permian biotic crisis

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Evidence from high-resolution geochronology combined with fossil records and proxies for changes in the paleoenvironment suggest that there is a link between large-scale (but short-term) volcanic events and mass extinctions. Synchroneity has been shown between large-scale volcanic events and three of the five most severe mass extinctions: the end-Permian extinction (P-T) coincides with Siberian Traps LIP; the end-Triassic extinction (Tr-J) with Central Atlantic Magmatic Province; and the end-Cretaceous (K-P) with the Deccan Traps LIP. Recent studies also show that the magnitude of the extinction is not a simple function of the size (volume) of the igneous event; rather, the eruption rate and nature of the host rock that is intruded exert important controls on the rate and magnitude of the release of gases that affect climate and ocean chemistry. Consequently, high-resolution geochronological constraints on LIP volcanism, biotic extinctions, and climatic change are essential to understanding the role of magmatism in these evolutionary catastrophes.

The end-Guadalupian (latest Middle Permian) extinction event shows a selectivity pattern similar to the better-studied end-Permian extinction. Single zircon U-Pb ages from intrusions related to the late Middle Permian ca 260 Ma Emeishan LIP (central and southwest China) have recently been shown to have intruded within a very narrow time interval between 260 and 257 Ma, broadly overlapping the timing of end-Guadalupian biotic change. New zircon U-Pb ages from felsic volcanic rocks overlying the youngest Emeishan related basalts show that effusive volcanism was terminated between 258 and 259 Ma, suggesting that the main stage of volcanism was very short. Unfortunately, $^{40}Ar/^{39}Ar$ analyses applied to minerals extracted from basalts have proven notoriously difficult because of thermal overprint in the studied area. Whereas the timing of Emeishan related magmatic activity is now better constrained by our new U-Pb zircon analyses, there are so far only few robust geochronologic data from biostratigraphically constrained sedimentary sequences across the Middle to Late Permian boundary.

The volume of intrusive and effusive rocks related to the Emeishan LIP is difficult to reconstruct, but is thought to be significantly smaller than the three LIPs mentioned above. Consequently, the volume of gas release and its effects on the atmosphere and hydrosphere may have been not as devastating as during the following three major extinctions (P-T, Tr-J, K-P). Initial results from stable calcium isotope records in marine carbonates and conodont microfossils across the Middle to Late Permian boundary indicate the magnitude of changes in ocean carbonate and redox chemistry was much smaller than those associated with the subsequent end-Permian mass extinction. Ongoing research is aimed at corroborating this finding but compromised by the scarcity of marine sedimentary archives of this age. In addition, our current efforts concentrate on constructing a robust chronostratigraphic framework for this time interval.