High-Precision U-Pb Geochronology and the Two Biggest Extinctions in Earth History.

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Introduction: The cause and killing mechanisms for the two largest known extinctions in earth history, the K/T and P/Tr, is the subject of much debate and controversy. Key to understanding the cause and effects of proposed mechanisms is a high-precision chronology. With high-precision U-Pb zircon geochronology it is now possible to constrain the age of volcanic ash layers interbedded with sedimentary rocks to <± 0.1-0.05% (or <± 250,000-125,000 years for P/Tr and < ± 66,000 to 33,000 years for K/T). This level of precision has required major methodological improvements and the elimination of interlaboratory biases. We will review state-of-the art U-Pb geochronological techniques, all sources of uncertainty, and the ultimate resolving power for sequencing earth history from the oldest rocks to the last million years.

Key to understanding the end-Permian extinction is the duration/tempo of extinction, the age, duration, and relationship of large perturbations to the carbon cycle to the extinction, and the time-scale of recovery. We show that in southern China a detailed sequence of events can be deconvolve at the ± < 50 Ka level. Two major hypotheses for the extinction are: the Siberian Traps Large Igneous Province played a major role by injecting large quantities of gases and particulates into the atmosphere; and that a stagnant ocean characterized by long-lived anoxic and hypoxic waters flooded shallow marine areas with CO_2 and H_2S. The first can be evaluated by comparing the age and duration of the Siberian Traps to the highly calibrated record of the marine extinction. The second requires detailed evaluation of the timing of chemostratigraphic proxy data (biomarkers, stable and radiogenic isotopes), and the paleontological record of extinction. However to distinguish between cause and coincidence a very highly calibrated record is necessary.

The K/T boundary has been associated with the Chicxulub impact for almost two decades although there is much debate about the role of the Deccan Traps Large Igneous Province. Again the key is to establish a detailed chronology of the extinction using calibrated chemostratigraphic, paleontological, and magnetostratigraphic records and to compare the age and duration of the Deccan with the age of the extinction. This is complicated by the fact that the Deccan has been dated using Ar-Ar geochronology and comparing geochronometers is plagued by small uncertainties in decay constants and a consistent ca 0.7-1.0 % bias between them. Integration of absolute chronology, magnetostratigraphy, and paleontology are key to resolving this issue.

High-precision U-Pb geochronology can now provide critical constraints for understanding the cause and effects of mass extinctions as well as other major events in earth history. We are building a well-calibrated record of life on earth that will allow us to interrogate the rock record at unprecedented levels of precision.