Refining the Geomagnetic Polarity Timescale: High-precision U-Pb geochronology from Late Cretaceous of US Western Interior and NE China

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An accurate and precise reconstruction of the Earth history is essential to resolving the mode and tempo of biotic evolution and its interrelationship to environmental change in deep time. However, this goal cannot be accomplished without high-fidelity intercalibrations of various geochronometers that are used to scale geologic time. Abrupt reversals in the Earth’ s magnetic polarity form the basis of the Geomagnetic Polarity Timescale (GPTS) and serve as ideal timelines for stratigraphic correlation, especially in depositional environments where diagnostic marine fossils are absent. The Neogene part of the GPTS has been calibrated using astrochronological models that are based on orbital forcing of climate manifested in cyclic sedimentary successions. The application of these approaches to the pre-Neogene timescale has nonetheless been complicated given the uncertainties of orbital models and the chaotic behavior of the solar system farther back in time. Absolute calibration of the GPTS can be achieved at high resolution by radioisotopic dating of volcanic ash deposits intercalated with stratigraphically complete successions with well-preserved magnetostratigraphic records.

The Late Cretaceous to Paleocene segment of the GPTS is of particular interest as it encompasses a critical period of Earth history marked by the Cretaceous greenhouse climate, the peak of dinosaur diversity, the end-Cretaceous mass extinction and its paleoecological aftermaths. Here we present a refined calibration of the GPTS based on high-precision U-Pb geochronology of ash beds within predominantly continental strata of the Western Interior Basin of North America and the Songliao Basin of Northeast China. Results from the Songliao Basin (end-C34), Bighorn Basin of Wyoming (end-C32) and Denver Basin of Colorado (C29 to C28) place tight constraints on the Late Cretaceous –Paleocene GPTS, by either directly constraining the chron boundaries and/or by testing their underpinning astrochronological age models. Our new GPTS calibration displays good consistency with those from the most recent astrochronology- and radioisotope-based studies of other coeval continental and marine records. Together, they demonstrate the power of a multi-chronometer approach to the calibration of the Earth history.

Keywords: U-Pb geochronology, Geomagnetic Polarity Timescale, Cretaceous, Western Interior Basin, Songliao Basin

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