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High precision U-Pb dating of Large Igneous Provinces (LIPs): recent advances and future challenges.

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High-precision U–Pb geochronology, particularly using CA-ID-TIMS analysis of zircon, has transformed our understanding of the timing and tempo of large igneous province (LIP) emplacement. For several Phanerozoic LIPs, these datasets now allow direct comparison between magmatic activity and major disturbances of the global environment and the biosphere. The strength of these correlations depends critically on both the LIP and the associated stratigraphic record being temporally constrained at comparable precision, ideally using the same radio-isotope system.

Despite the growing number of high-precision ages, for example, nearly 30 CA-ID-TIMS dates from the Central Atlantic Magmatic Province, spatial coverage remains sparse relative to the vast extent of most LIPs. Also, emplacement rates and magmatic flux are often poorly constrained. These limitations stem largely from the undersaturation of zircon in mafic LIP magmas, such that zircon typically crystallizes in late-stage evolved melt pockets that may partly represent assimilated host sediments. Importantly, basaltic lava flows typically cool too quickly to crystalize zircon or baddeleyite meaning they cant be dated at high precision. Consequently, U–Pb ages are concentrated on intrusive events and record the waning stages of magma flowing through these systems rather than their initiation. Even so, several LIPs appear to have been emplaced over geologically brief intervals (<1 Ma), reinforcing the potential for rapid and severe environmental perturbation.

Here we present high-precision U–Pb datasets from two LIP systems: i) the Paraná–Etendeka province of Brazil and Namibia, recently proposed to be temporally linked with the Equatorial Atlantic Magmatic Province, and ii) the Wrangellia flood basalts of western Canada and Alaska. The timing of these events in the Lower Cretaceous and Upper Triassic is becoming increasingly well resolved. However, their climatic and biotic consequences remain uncertain due to insufficient temporal constraints on coeval stratigraphic successions. Future progress in resolving the influence of LIPs on the climate and biosphere requires improved constraints on eruptive tempo, magma and volatile flux, combined with tighter chronological control in synchronous sedimentary sections.