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Radiometric constraints on the timing, tempo, and effects of large igneous province emplacement

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There is an apparent temporal correlation between large igneous province (LIP) emplacement and global environmental crises, including mass extinctions. However, in order to assess whether or not LIPs play a causal role in these crises, it is necessary to first generate timelines of the highest accuracy and precision possible for both LIP magmatism and environmental change. In the past few decades, numerous advances in the accuracy and precision of radioisotopic ages have significantly improved estimates of the timing and duration of LIP emplacement, mass extinction events, and global climate perturbations, and in general have supported a temporal link between them. Ages resolved with uncertainty on the order of 10-100 ka – the timescales relevant to Earth system change – are required to better understand the role of LIPs in these perturbations.

Here, we share our findings from a recent review (Kasbohm et al., 2021) of 12 pairs of LIPs and extinction or climate events from the past 700 Ma of Earth history, comparing the relative timing of magmatism and global change, and assessing the chronologic support for LIPs playing a causal role in Earth's climatic and biotic crises. We find that (1) improved geochronology in the last decade has shown that nearly all well-dated LIPs erupted in < 1 Ma, irrespective of tectonic setting; (2) for well-dated LIPs with correspondingly well-dated mass extinctions, the LIPs began several hundred ka prior to a relatively short duration extinction event; and (3) for LIPs with a convincing temporal connection to mass extinctions, there seems to be no single characteristic that makes a LIP deadly. We present new ages from the Columbia River Basalt Group and the Miocene Climate Optimum that reinforce these conclusions and demonstrate that better-resolved age models can reveal more complex Earth system interactions. Despite much progress, higher precision geochronology of both eruptive and intrusive LIP events and better chronologies from extinction and climate proxy records will be required to further understand how these catastrophic volcanic events have changed the course of our planet's surface evolution.