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The role of Large Igneous Provinces in controlling long-term Phanerozoic climate change

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Large Igneous Provinces (LIPs) are accumulations of igneous rocks representing periods of intense volcanism in Earth's history. The timing of the emplacement of many LIPs corresponds with global climatic perturbations and mass extinctions, leading to the hypothesis that their occurrence is implicated in these events. However, detailed investigations into these hypotheses are typically restricted to studies of individual events (e.g. the Siberian Traps emplacement at the Permian-Triassic boundary), and single forcing mechanisms (e.g. carbon emissions). As a result, it is often unclear what the overall impact of LIP emplacement was on climate in Earth's history.

In this work, we present the results of the first integration of LIP degassing and weathering to a long-term model of global carbon cycling. We use the SCION climate-chemical model, which allows for both the addition of LIP degassing as a CO_2 forcing mechanism, and the introduction of LIPs as highly weatherable terranes on the Earth surface. In this way, we can estimate both the warming impact LIPs may have had on climate change in the past, through carbon degassing, but also the cooling effect they would have had, through enhanced silicate weathering. Our work shows the importance of LIP location on weathering rates, with those which are emplaced in the mid-latitudes having the biggest cooling impact.

Comparison of our reconstruction with previous estimates of Phanerozoic climates show that the inclusion of LIPs enhances model-data comparability. This is particularly clear in the late Triassic, and Cretaceous periods, where previous model reconstructions overestimated atmospheric CO_2 and global temperature. Our findings suggest LIP weathering is an important factor mitigating global climate change through the Phanerozoic.