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CO_2 Degassing at Continental Rifts and other Tectonic Settings: Towards Quantifying Plate Tectonic Control on Long-term Climate Change

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Solid Earth degassing exerts a major control on long-term atmospheric CO_2 variations and, via the greenhouse effect, on paleo-temperatures. Despite being a key quantity in driving long-term climate change, tectonic CO_2 degassing remains one of the least-constrained processes. Here we combine latest estimates of CO_2 release at present-day plate boundaries with reconstructions of past plate tectonic configurations in order to estimate CO_2 flux contributions of different tectonic settings during the last 200 million years.

The approach is exemplified for continental rifts by conducting a worldwide rift length census since the beginning of Pangea breakup. Using regional present-day estimates of rift-related CO_2 flux, we convert time-dependent rift length to a global CO_2 degassing time series. We find that along the extensive Mesozoic and Cenozoic rift systems, rift-related CO_2 degassing rates reached more than 300% of present-day values. Using a numerical carbon cycle model we show that two prominent periods of enhanced rifting 160 to 100 million years ago and after 55 million years ago coincided with greenhouse climate episodes, during which atmospheric CO_2 concentrations were more than three times higher than today.

We apply a similar workflow to mid-oceanic ridges, continental arcs and to large igneous provinces. Preliminary results show that the relative degassing contributions of these tectonic settings remained fairly similar during Cenozoic times with rifts, ridges, arcs, and plumes contributing about 50%, 20%, 20%, and 10%, to tectonic CO_2 degassing respectively. The Cretaceous however features pronounced variations where relative contributions of plumes and ridges each temporarily reach values of up to 40%.

These results come with large uncertainties that emerge from measuring local tectonic CO_2 fluxes, from scaling them to global plate boundary networks and from kinematically modelling the history of Earth's tectonic plates through time. Reducing these uncertainties by applying new measurements techniques, more detailed characterisation of tectonic CO_2 degassing rates and enhanced plate reconstructions remains a key challenge for assessing the solid Earth drivers of long-term climate change.