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A global census of continental rift activity since 250 Ma reveals a missing element of the deep carbon cycle

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The deep carbon cycle connects CO_2 concentrations within the atmosphere to the vast carbon reservoir in Earth's mantle: subducted lithosphere carries carbon into the mantle, while extensional plate boundaries and arc volcanoes release it back to Earth's surface. The length of plate boundaries thereby exerts first-order control on global CO_2 fluxes on geological time scales.

Here we provide a global census of rift length from the Triassic to present day, combining a new plate reconstruction analysis technique with data from the geological rift record. We find that the most extensive rift phase during the fragmentation of Pangea occurred in the Jurassic/Early Cretaceous with extension along the South Atlantic (9700 km) and North Atlantic rifts (9100 km), within East Gondwana (8500 km), the failed African rift systems (4900 km), and between Australia and Antarctica (3700 km). The combined extent of these and other rift systems amounts to more than 50.000 km of simultaneously active continental rifts. During the Late Cretaceous, in the aftermath of this massive rift episode, the global rift length dropped by 60% to 20.000 km. We further show that a second pronounced rift episode starts in the Eocene with global rift lengths of up to 30.000 km.

It is well-accepted that volcanoes at plate boundaries release large amounts of CO_2 from the Earth's interior. Recent work, however, highlights the importance of deep-cutting faults and diffuse degassing on CO_2 emissions in the East African Rift, which appear to be comparable to CO_2 release rates at mid-ocean ridges worldwide. Upscaling measured CO_2 fluxes from East Africa to all concurrently active global rift zones with due caution, we compute the first-order history of cumulative rift-related CO_2 degassing rates for the last 250 Myr. We demonstrate that rift-related CO_2 release in the Early Cretaceous may have reached 400% of present-day rates. In first-order agreement with paleo-atmospheric CO_2 concentrations from proxy indicators, our degassing rates correlate with the two distinct periods of elevated atmospheric CO_2 in the Mesozoic and Cenozoic. Compiling the length of other plate boundaries through time (mid-ocean ridges, subduction zones, continental arcs), we do not find such a correlation with the paleo-CO_2 record, which leads us to suggest that rift-related degassing constitutes an important element of the deep carbon cycle.