5.2.14

Modelling long term climatic and geochemical consequences of the Karoo-Ferrar Traps eruption (183 Ma)

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The onset and subsequent chemical weathering of large magmatic provinces appears to be a major component of the Earth's climatic evolution. At time scales of 10^5 to 10^6 yrs, the release of large amounts of CO_2 during the eruptive phase and the subsequent rapid weathering of fresh basaltic surfaces strongly perturb global biogeochemical cycles, and particularly the carbon cycle.

Recent studies have modelled this long-term impact through the use of simple 0-D models of the geological carbon cycle [1]. Here we present a study of long-term perturbations linked to the onset and weathering of a magmatic province with a powerful new tool: the GEOCLIM model [2]. This numerical model couples a climatic 2-D EMIC model (Climber 2) with a model of the global geochemical cycles of carbon, alkalinity, oxygen and phosphorus (the COMBINE model, a 6-box ocean-atmosphere numerical model). This approach allows us to quantify the change in regional climate (with a coarse resolution of 50° long. × 10° lat.), together with the change in regional chemical weathering, oceanic carbonate deposition and atmospheric CO_2 in the long-term aftermath of trap eruptions.

We focus on the eruption of the Karoo-Ferrar Traps at 183 Ma. The GEOCLIM model is used to track geochemical and climatic evolution of the Earth's surface for 5 Myr after the beginning of eruptions. We suggest a link between the Karoo-Ferrar and the Toarcian carbonate crisis, following the acidification of surface waters due to the accumulation of CO_2 into the atmosphere. We explore with GEOCLIM plausible links between the eruptive onset and the OAE of the lower Toarcian through perturbations of the delivery of nutrients to the ocean through continental weathering.

References

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5.2.21

New age constraints on the Karoo Large Igneous Province: Triple junction and brevity questioned

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The early Jurassic Karoo-Ferrar large igneous province is related to Gondwana break-up. It is represented by huge volumes of basalts (lavas and sills) and giant apparently radiating dyke swarms that are supposed to represent a triple junction. The Karoo magmatism (Southern Africa) is generally interpreted as a short magmatic event (1-2 Ma) based on few Ar-Ar and U/Pb datings almost restricted to the south (~183-184 Ma, e.g. [1]). However, some crucial areas have received little attention. Here we present new $^{40}Ar/^{39}Ar$ age data on the northern prominent lava flows of Botswana and the four apparently radiating dyke swarms.

The Karoo "triple junction" questioned

Recent dating on the giant Okavango dyke swarm (ODS) by "speedy step-heating" experiments, (SSH=2-3 heating steps on few plagioclases [2]) reveals that this dyke swarm includes ~12% Proterozoïc dykes and thus was emplaced using a N110° pre-existing structure. Similar SSH dating on the NNE oriented Olifants River dyke swarm (ORDS) shows that it mostly consists of old dykes (poorly defined ages ranging from around 850 to 2870 Ma) although field relationships show few ORDS dykes cross-cutting the Karoo formation. One SSH dating on a N-S dyke yielded also a pre-Karoo apparent age around 1460 Ma. SSH dating are in progress on the N70° swarm as well. These data highlight the inheritance of the so-called triple junction and question the mantle plume-head impact model.

The timing and duration of the Karoo LIP revisited

Lava flows and sills from northern Karoo yield plateau ages mostly ranging from 178.0 ± 1.6 to 182.1 ± 0.4 Ma (±2σ), slightly but significantly younger than the southern lava-flows and bracketing the brief emplacement of the ODS and Sabie-Limpopo (N70°) major dyke swarms (~179 ± 2 Ma). The N-S Lebombo and associated MORB-like Rooi Rand dyke swarms (173.9 ± 0.6 and 173.9 ± 3.8 Ma respectively) may represent the final stage of the Karoo province (before oceanisation). Together, these ages show a clear north-south diachronism and a total emplacement duration of ~10 My longer than previously estimated.

References

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