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Ups and downs of zircon-bearing magmas and the onset of global plate tectonics

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It is arguably impossible to demonstrate a globally fragmented network of lithospheric plates delineated by weak boundaries at any time before the Archaean-Palaeoproterozoic transition. The overall consensus is that plate tectonics was operational at least since the early Proterozoic, but extending this minimum age towards the deep geological past remains difficult, primarily because of the lack of well preserved ancient continental crust.

The convergent interaction across weak lithospheric boundaries generates collisional orogens and the assembly of supercontinents. Magmas are trapped within the deeper crust, and crustal reworking is intensified. During the break up of supercontinents, divergence allows magmas to migrate to shallower levels, and the process usually involves lesser crustal reworking. Supercontinents are thus a hallmark of plate tectonics activity and disclose characteristic intense reworking and deep crustal magma entrapment.

U-Pb, Lu-Hf and Oxygen analyses of magmatic and detrital zircons have been exhaustively used to probe the ancient geological record and to derive crustal evolution models. We explore the variations of measured radiogenic and stable isotopes in zircon and highlight periods of inverse correlations between them in the global zircon database. Specifically, peaks of Oxygen isotopes associated with Lu-Hf isotopes troughs are taken to depict an increase in reworking rates during continental collision and amalgamation.

We observe that the crystallisation of zircon-bearing magmas took place over a range of depths and underwent cyclic variation over time. Interestingly, similar variations are less pronounced and not paired with reworking indexes in the Palaeo and Eoarchaean. These observations provide new evidence that plate tectonics and the supercontinent cycles have been globally operational since ~3.0 billion years ago when cycles in the crystallisation depths of zircon-bearing magmas appeared in the geological record.