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Transient subducting slab superflux and enhanced mantle activity – a general feature of supercontinent dispersal?

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Subduction is a fundamental mechanism of material exchange between the planetary interior and the surface, and is closely tided to both mantle dynamics and plate tectonics. Our temporal understanding of slab flux has currently been limited to proxy estimates, despite its significance. Here we present a new quantification of subduction zone parameters from the Late Triassic to present day (230 – 0 Ma). We use a community plate motion model with evolving plate boundaries to extract trench-normal convergence rates through time and compute subducting plate areas. Slab flux (volume) is then derived by using seafloor paleo-age grids to estimate the thickness of subducting lithosphere. Our results imply that slab flux doubled to values greater than 500 km^3/yr from 180 Ma in the Jurassic to 130 Ma in the mid-Cretaceous, largely driven by circum-Pacific subduction zones. The peak at 130 Ma can be attributed to a two-fold increase in mid-ocean ridge lengths following the break-up of Pangea, and a coincident increase in convergence rates, with average speeds exceeding 10 cm/yr. With one third of the total subducted volume (230 – 0 Ma) entering the mantle during this ~50 Myr period, we propose that this slab superflux drove a surge in slab penetration into the lower mantle and an associated increase in the vigour of mantle return flow. With a delay of at least 10 Myr, this mantle response was observed at the surface as a pulse in plume activity and dynamically elevated topography above large hot upwellings known as superswells. Features such as the Darwin Rise, the volcanic and erosional history of the South African Plateau, and Pacific plateaus including the Ontong-Java-Hikurangi-Manihiki complex, record this mid-cretaceous mantle activity. The models presented here contribute to an improved understanding of the time-evolving flux of material consumed by subduction, and suggest that slab superflux may be a general feature of continental dispersal following supercontinent breakup. These insights may be useful for better understanding how supercontinent cycles are related to transient episodes of large igneous province and superswell formation, and the associated deep cycling of minerals and volatiles, as well as leading to a better understanding of tectonic drivers of long-term climate and icehouse-to-greenhouse transitions. An accelerated slab flux event of this scale would have had the potential to significantly affect surface environments (terrestrial, marine and atmospheric), initially via increased arc volcanism, and ultimately the triggering of large igneous provinces, which are known to be linked to mass extinction events. Validation of this ‘break-up – superflux – upwelling’ model will require a wider search for patterns of global mantle activity following both the most recent and earlier supercontinent cycles.