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The role of active margins in generating continental crust: a revision

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Active margins are central to Earth's tectonic system and have traditionally been viewed as primary sites of continental crust generation through arc magmatism. However, subduction zones also enable efficient crustal recycling and destruction, raising a fundamental and unresolved question: do active margins act as net generators, maintainers, or sinks of continental crust over geological timescales?

Arc magmatism is driven by slab dehydration and melting within the mantle wedge, generating magmas that display major-element compositions comparable to those of average continental crust. However, arc magmas reflect variable contributions from mantle-derived melts, recycled continental crust and slab-derived components. As a result, magmatic fluxes and juvenile isotopic signatures alone do not provide a direct measure of net continental crust growth.

Evidence from long-lived continental and intra-oceanic arcs demonstrates that active margins are intrinsically dynamic systems. Individual margins commonly alternate between periods dominated by crustal recycling and intervals characterised by enhanced mantle input, driven by changes in slab geometry, convergence rates, lithospheric structure and crustal thickness. Case studies from the Andes, Antarctic Peninsula, Tibet, western North America and the Izu–Bonin–Mariana arc illustrate that net juvenile crustal addition is neither spatially uniform nor temporally continuous, even within the same margin.

At the global scale, present-day estimates indicate that rates of arc magmatism are of similar order of magnitude to rates of continental crust loss through erosion, subduction erosion and lower-crustal delamination. This comparison has been interpreted as consistent with a near steady-state continental crust volume at present. However, such first-order balances remain insufficient to resolve long-term continental crust evolution, as they do not explicitly distinguish juvenile additions from recycled material, nor adequately account for temporal variability and preservation bias.

Here, we present a statistical assessment using a Bayesian modelling approach to estimate the proportion of mantle-derived material incorporated through arc magmatism based on Hf isotopes in zircon. This helps to evaluate whether the magnitude of mantle input required is consistent with the growth patterns proposed by existing models. This framework provides a means of testing the internal consistency of these models and assessing the overall role of active margins in the global continental crustal budget.