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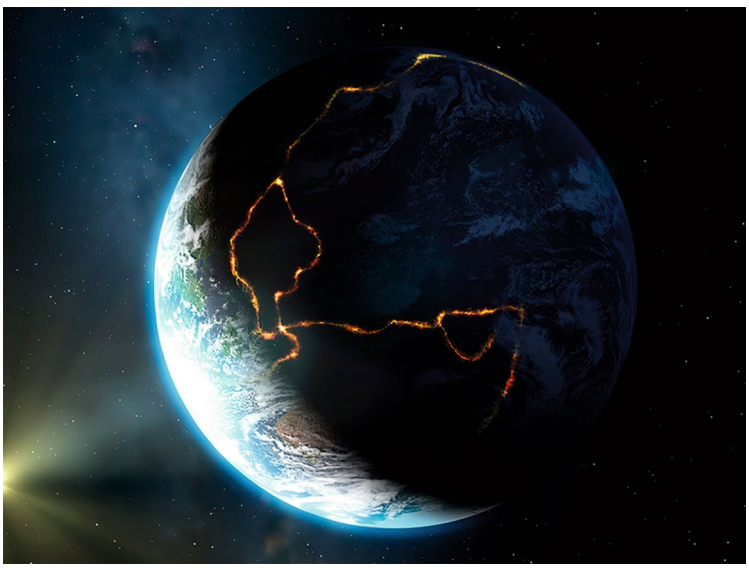
TECTONICS

Plume-induced subduction

Plate tectonics represents one of the key factors that separate the Earth from other planetary bodies in the Solar System. Formation of new crust at mid-ocean ridges, and recycling of this crust into the Earth's mantle at subduction zones, are important tectonic processes that control vital geochemical cycles, thus maintaining the Earth's climate and habitability over geological timescales. However, whilst the importance of plate tectonics is widely appreciated, the mechanism that initiates subduction of the Earth's rigid outer shell (the lithosphere) remains poorly constrained.

Marzieh Baes from GFZ German Research Center for Geosciences, Germany, and colleagues, used 3-dimensional thermo-mechanical models to investigate the origin of subduction on present-day Earth. They found that a high-temperature mantle plume impinging on the base of relatively young (<50 Myr) oceanic lithosphere may cause it to fracture and subduct due to magmatic weakening and plume-induced density variations. Plume-driven subduction can even occur in cases where no prior lithospheric weaknesses are present. However, further numerical simulations demonstrate that pre-existing extensional stresses, and/or the presence of a high-temperature plume 'tail' beneath the plume head, increase the likelihood of plate subduction regardless of lithospheric age or crustal thickness. Simulations run with higher mantle temperatures and thicker crust also indicate that plume-driven subduction might be feasible in the Archean (>2.5 Ga).



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Verifying that plume presence may initiate subduction could explain the formation of several modern-day subduction zones (such as the Caribbean) and, importantly, how the Earth transitioned from a stagnant-lid regime to a plate-tectonic regime during the Archean. Further modelling is required to assess the precise conditions that can lead to plume-induced subduction on the early Earth, and identify why plate-tectonics dominates on Earth yet is absent on Mars and Venus where mantle plumes are expected to be present.

Matthew Gleeson

ORIGINAL ARTICLE Baes, M. et al. Plume-induced subduction initiation: single- or multi-slab subduction? *Geochem. Geophys. Geosyst.* https://doi.org/10.1029/2019GC008663 (2020)