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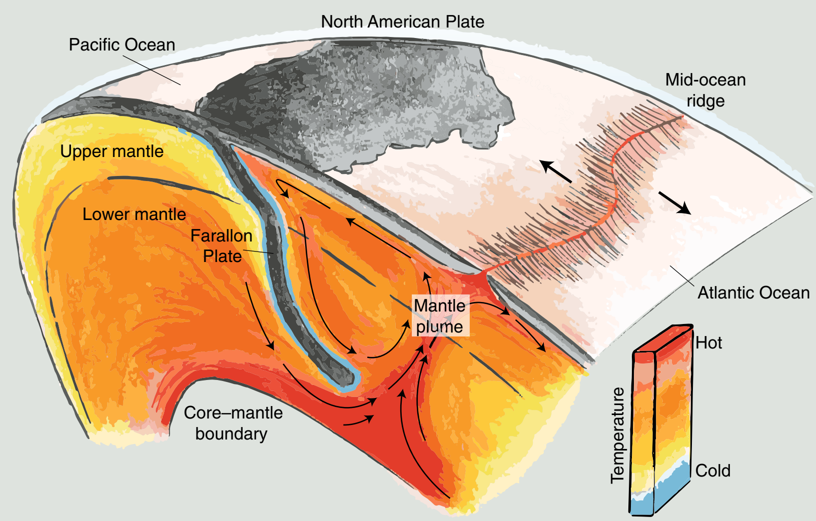
ANNIVERSARY RETROSPECTIVE

Subduction-driven Earth machine

In the 1960s, the concept of plate tectonics revolutionized the field of geoscience. This theory describes how Earth's surface is a jigsaw of seven large tectonic plates and a variety of smaller ones that move slowly over time. Some of the most spectacular consequences of this motion are out there, right in front of our eyes: magnificent mountain ranges and immense oceans.

Throughout much of Earth's history, tectonic plates have collided together, forming supercontinents, and broken apart several times. Earth's last major supercontinent — Pangaea — began to break apart about 180 million years ago, but it is unclear what drove this break-up. Mantle plumes are often invoked as the ultimate cause of significant episodes of continental dispersal. These upwelling plumes, thought to be a component of mantle convection, are probably the source of large lava outpourings, but unambiguous detection of mantle plumes has so far been challenging. On the other hand, subduction of cold lithosphere is widely recognized as an essential component of mantle convection. But whether and how subducting plates reach the lower mantle is under debate.

Writing in *Nature*, Saskia Goes and colleagues used plate reconstructions and numerical models of subduction to investigate this mystery: they identified the signatures of cold slabs penetrating the lower mantle (*Nature* **451**, 981–984; 2008). This inspired part of my own MSc thesis project, and triggered a snowball of ideas; eventually I questioned if subduction into the lower mantle itself could cause the break-up and drift of supercontinents, without the need for mantle plumes. To find out more, I studied the dynamic feedback between deep subduction and the break-up of supercontinents (*Tectonophysics* http://doi.org/ck7w; 2017). I discovered that plates subducting into the lower mantle may generate extensional stresses that could conceivably contribute to continental break-up.



Slab-driven plate drift. Illustration of the dynamic feedback between mantle flow induced by the subduction of the Farallon slab into the lower mantle and drifting of the North American plate. Sketch courtesy of L.D.Z.

Nevertheless, the hypothesis of subduction-induced break-up of supercontinents is likely to remain controversial. Attempts to establish high-resolution, three-dimensional computer models of subduction, and to integrate the results with geological and geophysical constraints, could be the next step that brings us closer to understanding how supercontinents deform on geological time scales.

For now, the question of whether deeply subducting slabs can break up continents and create a new ocean, or whether continents rift apart under stresses generated by mantle plumes, remains open. The answer is, probably, a bit of both. ❐

Luca Dal Zilio
A winner of the Geostory competition

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