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Can mantle suction flow trigger subduction initiation at passive margins?

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In spite of lack of any Cenozoic examples of conversion of passive margins into active plate boundaries [1,2], passive margins are among the first, which have been proposed as candidate locations for nucleation of subduction zones. The broad acceptance of these tectonic settings are mainly due to the key role that they play in the Wilson cycle, which describes repeated opening and closing of ocean basins. Previous modelling studies [3,4] show that closing phase of Wilson cycle, which begins with subduction of old oceanic plate along a passive margin, is impeded by the high viscosity of the cold lithosphere of the continental margin and adjacent oceanic plate. This makes the process of spontaneously conversion of passive margins into active ones very difficult/unlikely, as the lack of observations since Cenozoic supports that. Here, we propose that additional forcing provided by mantle suction flow, induced by mid-mantle slabs triggers formation of a new converging plate boundary along a passive margin. Based on this proposal, we suggest a modification of Wilson Cycle concept. Following opening and extension of oceanic basin, continental passive margin moves over the slabs in deep mantle. Such slab remnants of former active subduction zones or deep slabs of neighbouring active plate boundaries produce a suction mantle flow, complementing compressions at the passive margin. This eventually leads to the lithospheric break-up and initiation of a new subduction zone. This process is facilitated by the far-field topographic gradient within the continent and weakness of continental crust near the passive margin, which is inherited from the rifting phase.

To test this scenario, we use thermo-mechanical models, based on finite element method. We set-up two series of modelling experiments, indicating two end members of our proposed scenario. In the first set of models, we consider the suction flow coming from slabs in deep mantle below passive margin. In the second series of experiments, we examine whether suction flow coming from slabs in deep mantle, located far away from passive margin can trigger subduction nucleation. Results indicate that in both cases mantle suction flow can convert a passive margin into an active one. In most of our experiments subduction initiation occurs after more than 40Myr, implying that subduction nucleation along passive margins is a long-term process, which can explain the lack of any Cenozoic examples.

References:

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