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Subduction initiation in the Scotia Sea region and opening of the Drake Passage: when and why?

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During evolution of the South Sandwich subduction zone, which has consumed South American plate oceanic lithosphere, somehow continental crust of both the South American and Antarctic plates have become incorporated into its upper plate. Continental fragments of both plates are currently separated by small oceanic basins in the upper plate above the South Sandwich subduction zone, in the Scotia Sea region, but how fragments of both continents became incorporated in the same upper plate remains enigmatic. Here we present an updated kinematic reconstruction of the Scotia Sea region using the latest published marine magnetic anomaly constraints, and place this in a South America-Africa-Antarctica plate circuit in which we take intracontinental deformation into account. We show that a change in fracture zone orientation in the Weddell Sea requires that previously inferred initiation of subduction of South American oceanic crust of the northern Weddell below the eastern margin of South Orkney Islands continental crust, then still attached to the Antarctic Peninsula, already occurred around 80 Ma. We propose that subsequently, between ~71-50 Ma, the trench propagated northwards into South America by delamination of South American lithosphere: this resulted in the transfer of delaminated South American continental crust to the overriding plate of the South Sandwich subduction zone. We show continental delamination may have been facilitated by absolute southward motion of South America that was resisted by South Sandwich slab dragging. Pre-drift extension preceding the oceanic Scotia Sea basins led around 50 Ma to opening of the Drake Passage, preconditioning the southern ocean for the Antarctic Circumpolar Current. This 50 Ma extension was concurrent with a strong change in absolute plate motion of the South American Plate that changed from S to WNW, leading to upper plate retreat relative to the more or less mantle stationary South Sandwich Trench that did not partake in the absolute plate motion change. While subduction continued, this mantle-stationary trench setting lasted until ~30 Ma, after which rollback started to contribute to back-arc extension. We find that roll-back and upper plate retreat have contributed more or less equally to the total amount of ~2000 km of extension accommodated in the Scotia Sea basins. We highlight that viewing tectonic motions in a context of absolute plate motion is key for identifying slab motion (e.g. rollback, trench-parallel slab dragging) and consequently mantle-forcing of geological processes.