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Ductile deformation of passive margins: a new mechanism for subduction initiation

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The onset of subduction at passive margins has been extensively investigated and debated. However, the force constellations and mechanisms that enable the development of a subduction system from a passive margin remain unclear. The difficulty arises when comparing the sum of the driving forces to the sum of the resisting forces. Such a calculation suggests that subduction cannot initiate spontaneously at passive margins, despite geological observations that indicate otherwise.

This study presents new insights into the conditions and processes by which lateral density differences between oceanic and continental lithospheres in passive margins may lead to initiation of a low-angle subduction system. The presented study consists of (1) analytical calculations of flow fields generated in passive margins, and (2) analogue experiments of mature passive margins performed in a centrifuge. The analytical formulation predicts temporal and spatial evolution of an interface between the oceanic and continental lithospheres, and demonstrates that oceanic underthrusting may occur by rotation of this interface. The analogue experiments show that incipient subduction may develop by ductile deformation within the lithosphere, involving no sliding along the ocean-continent interface, so that the frictional resistance between the plates need not be overcome. The force induced by the negative buoyancy of the oceanic plate with respect to the asthenosphere, is found to be in some cases irrelevant to subduction nucleation. Results of both the analogue experiments and the analytical calculation are compared to the south-east Australian passive margin, and show an excellent fit to its geometry and stress distribution. A suggestion is made concerning subduction initiation mechanism in the Atlantic Ocean.