A Physical Mechanism Explaining the Common Depth of Slab-Mantle Coupling and Formation of a Rheologic Backstop at ~80 km Depth

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Heat flow measurements and 2D kinematic-numerical models of modern subduction zones suggest that subducting slabs and over-riding mantle fully viscously couple at relatively uniform depths of ca. 80 km [1]. Many commonly referenced, 2D, kinematic-numerical models initiate corner flow in the mantle wedge at this depth (e.g. [2, 3]). The depth at which corner flow initiates defines a major increase in temperature at the slab-mantle interface and (indirectly) the depth of melting, and therefore has enormous implications for subduction zone thermal structure [2]. However, a physical mechanism explaining a common depth of slab-mantle coupling remains elusive.

Fully dynamic, 2D numerical models show that a common depth of 80 km for slab-mantle coupling forms self-consistently within the first several Ma after subduction initiation and remain stable through 10's of Ma (and possibly throughout the entire lifespan of a subduction zone). Dehydration reactions form a rheologic "backstop" at ~80 km depth which induces return flow of the serpentinized mantle wedge and entrained oceanic material. One implication of our models is that eclogites from >80 km depths should be much rarer than eclogites from <80 km depths. While UHP (>80 km) rocks have been documented in systems that terminate with continental collision, compilation of blueschist and eclogites P-T conditions show that the frequency of exhumed subduction zone rocks dramatically diminishes at 80 km depth [5], consistent with and supporting our numerical experiments.

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