Slow subduction initiation drives fast mantle upwelling and lithosphere formation

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Subduction zones are crucial features of Earth's plate tectonics, yet subduction initiation remains enigmatic and controversial. Herein, we reappraise the timing of formation of the first fragments detached from the leading edge of the downgoing slab during subduction initiation (i.e., the Semail metamorphic sole; Oman–United Arab Emirates). Based on geochronology and phase equilibrium modeling, we demonstrate that subduction initiated prior to 105 Ma and at a slow pace (< cm/yr). Subduction stagnated at relatively warm conditions (15–20°C/km) for at least 10 Myr before evolving into a faster (≥ 2–5 cm/yr) and colder (~7°C/km) self-sustained regime. Subduction unlocking at 95-96 Ma, through the progressive change of the interplate thermo-mechanical structure, triggered the onset of slab retreat, large-scale corner flow and fast ocean spreading in the overriding plate. These results reconcile conflicting analogue and numerical subduction initiation models and reveal the thermal, mechanical and kinematic complexity of early subduction steps.