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Insights into the dynamics of subduction from statistical observations and laboratory experiments

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Statistical observations on current subduction zones parameters (kinematics and geometry, extracted from global datasets) have been performed over 160 transects from all oceanic subductions. We have compared these observations to laboratory experiments results in order to understand the complexity of the subduction styles. Indeed, from one trench-system to another, kinematics and geometry of current subduction zones exhibit a great variability: (1) in the respective contribution of subducting plate and trench absolute motion in the overall convergence rate; (2) in the absolute motion of the subducting plate; (3) in the sense of trench motion (there are as many advancing trenches as retreating ones); (4) in the radius of curvature of the plate; (5) in the overall shape of the slab when interacting with the lower mantle (forward or rearward deflection of the slab). 3-D laboratory experiments in which a viscous plate of silicone (lithosphere) subducts under its own weight in a viscous layer of honey (mantle) have reproduced similar variability. Testing a wide range of possible controlling parameters (plate thickness, width, density and viscosity, and mantle thickness and viscosity), two main styles of subduction are observed in the stationary phase of subduction (slab lie on the lower mantle) : style I associates a retreating trench, with a thick subducting plate, high slab radius of curvature and a forward deflected slab, style II associates an advancing trench, with a thin subducting plate, low slab radius of curvature and a rearward deflected slab. Lithospheric bending is the dominant resisting force and the slab radius of curvature, which mainly depends upon plate and mantle thickness, exerts a primary control on the subduction behaviour. This observation suggests that the complexity of subduction style could be controlled by geometrical rules of a plate

bending within a stratified mantle. Cross-checks between statistical observations and the theoretical framework given by experimental models enlighten interesting similarities (e.g., plates radius of curvature roughly increases with slab thickness) but also contradictions (e.g., advancing trenches are not systematically associated with overturned slabs as in models and conversely, some overturned slabs are associated with fast retreating trenches). The transient nature of current subduction zones may explain some of the observed discrepancies, but there is also, in statistical observations some evidences of an upper plate control (namely its motion and nature) on several parameters as trench motion or upper plate strain or slab dip. Upper plate influence, neglected in the discussed models, may thus need to be investigated in the future ones.