Spontaneous episodic initiation of one-sided subduction using visco-elasto-plastic colloidal dispersions

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One-sided subduction is a fundamental characteristics of the convective regime of plate tectonics on Earth, but its initiation and morphology are still not well-understood. We report new laboratory experiments using colloidal dispersions whose rheology varies from viscous to elasto-visco-plastic to brittle when their water content decreases (fig.1, [1]). So as an analogy to cooling from above, the fluid is dryed from above. Humidity, temperature, fluid thickness and solution concentration were systematically varied, which resulted in changing the intensity of convection and the magnitude of the rheological parameters of the fluid. As the fluid surface dries, a denser chemical boundary layer (CBL) develops, constituted of a thin brittle film on top of a more ductile layer; and convection develops under this stagnant lid. However, drying-induced stresses cause the skin to buckle, which then induces plastic failure, thereby initiating subduction of the gravitationally unstable skin (fig.2). Subduction is always one-sided and proceeds quickly by trench roll-back. Then the whole process starts again. Shear banding and a lubrication layer on the top of the subducting slab seem to be key ingredients to break the surface plate and initiate subduction episods.

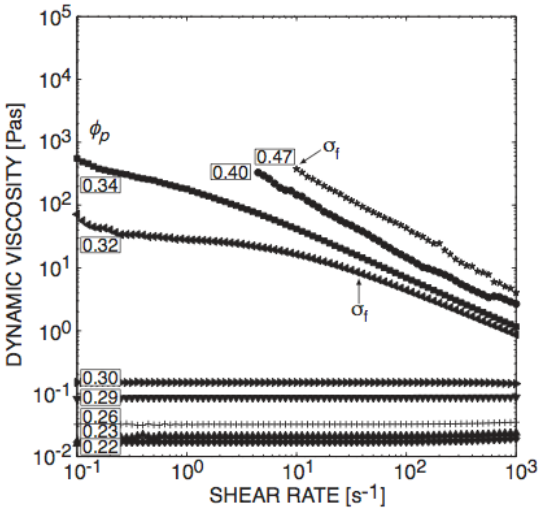

Figure 1. Rheology of Ludox HS40 for different particle volume fraction φ_p. Viscosity as a function of shear rate. σ_f corresponds to the stress above which the particle network is destroyed, the solution becomes shear-thinning and the viscosity can be described by a power law. [1].

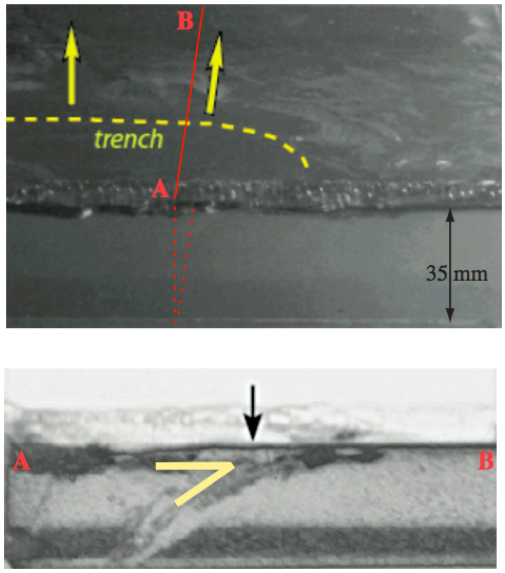

Figure 2. Spontaneous asymmetric subduction in a layer of colloids dried from above at constant temperature and humidity. a) view from above. The "trench" is outlined in yellow and the direction of trench rollback is indicated by the yellow arrows. b) view from the side. The contrast has been enhanced to better see the subducting plate. The trench position is marked with a black arrow.

References

[1] Di Giuseppe E., Davaille A., Mittlestaedt E., François M. (2012) *Rheol. Acta* 51(5), 451-465.