Geophysical Research Abstracts, Vol. 9, 06193, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-06193

Subduction dynamics as revealed by trench migration

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We use the arc - back-arc region as a strain sensor to determine whether significant stress is transmitted, from one plate to the other, across the subduction interface in a direction normal to the plate boundary. No significant strain (strain rate $V_d < 1$ cm/yr) in the upper plate means that a balance of forces including slab pull, bending, or anchoring is almost reached along plates interface. We show that neutral subduction zones ($V_d \approx 0$) satisfy the kinematic relation between upper and subducting absolute plate motions : V_{up} = 2.5 – 0.5 V_{sub} (in cm/yr). Deformation within the upper plate occurs when the combination of velocities deviates from the previous kinematic equilibrium, i.e., compression in the upper plate is favored when $V_{up} > 2.5 – 0.5$ V_{sub}, whereas extension is only observed when $V_{up} < 2.5 – 0.5$ V_{sub}. The tectonic regime of the upper plate is thus twice more sensitive to the absolute motion of the upper plate than the subducting one (with respect to HS3 reference frame ; Gripp and Gordon, 2002). We derive from the previous relation that « spontaneous or free » trench motion in nature depends on the velocity of the subducting plate. It can reach 3 or even 4 cm/yr in both oceanward (rollback) and arcward (advance) directions. Based on a simple balance between torque components of the main forces acting at trench, we infer that advancing behavior of trenches is facilitated for strong (old) subducting plates, characterized by a high bending resistance.