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Slab geometry depending on absolute velocities and possibilities of cyclicity, Insights from numerical modelling.

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Recent analogical models of Heuret et al (2007) and Guillaume et al (2009) showed that the kinematical and mechanical role of the overriding plate is crucial for the slab geometry. We used Hassani et al (1997) 2D finite element numerical code to model subduction with parameters close to analogue models conditions. Our results are coherent with considered previous analogue models. As shown by Heuret et al (2007), after the subducting plate reaches the 660 km discontinuity modeled by a rigid foundation, we obtained two different styles of subduction depending on the overriding plate velocity v_{op}:

- if $v_{op} > 0$, the slab lays forward on the 660km discontinuity (style 1)
- if $v_{op} \leq 0$, the slab lays backward on the discontinuity (style 2).

We also light up two different processes: the subduction evolves in a steady-state regime when $v_{sp} \leq 0$ or $2v_{op} + v_{op} \leq 0$ (where v_{sp} stands for the subducting plate velocity) and in non steady-state regime when one of these two conditions is not fulfilled. This result is coherent with Guillaume et al (2009) non steady-state models at v_{op}=0. We checked these conditions by conducting several simulations varying subduction velocities (relative velocity), absolute plates velocities and plate viscosities. When the process is not steady-state, the slab is periodically folding on the 660 km discontinuity leading to episodes of slab flattening (minimal dip of 13°) followed by slab steepening phases (maximal value of 65°). The folding period is essentially controlled by slab viscosity and subduction velocity.

We then compared our models with the natural case of the Chilean flat slab. Fukao et al (2001) show that the Andean slab does not penetrate the 660 km discontinuity which make possible comparison between our models and nature. For the Andean case, actual velocities are $v_{op} \approx$ 4.3 cm.an^{-1} and $v_{sp} \approx$ 2.9 cm.an^{-1} for a relative velocity close to $v_s = v_{op} + v_{sp} \approx$ 7.2 cm.an^{-1}, which places us in the case of style 1 with cycles. If we model those velocities with a viscosity of η=2×10^{24} Pa.s, we obtain cycle duration of ca. 26 Ma with a period of ca. 3.6 Ma of low dip, with a minimal value of ca. 15°. Haschke et al (2002) work on Andean flat slab region magmatic rocks suggest that evolutionary cycles occurred during the Andean orogeny. Episodes of slab steepening and shallowing with a duration of 30-40 Ma might have occurred, explaining magmatic gaps of ca 5-10. Simplifications imposed by numerical modeling could explain the difference between our values and Andean values. Still, our values are in the range of Haschke et al (2002) estimation of the Andean case. Our models are coherent with Kay et al (2002) results on South American overriding plate: when the Nazca plate slab was steep, the South American margin underwent extension, and that when shallowing occurred, compression occurred in the margin. Therefore, style 1 with cycle may be considered as a possible answer for this natural speacial case.