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Subduction following continent-continental fragment collision: insights from two-dimensional numerical experiments

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Oceanic subduction is a consequence of the negative buoyancy of the cold and dense lithosphere. Development of subduction with a continental sliver is more problematic, because continental lithosphere is positively buoyant, owing to the light, thick crust. In a subduction process, the collision between a continental fragment and a continent may result in different modes: either the subducted slab breaks off and the plate boundary ceases to be active, or the plate boundary reorganizes to continue plate convergence. One possibility for continued convergence is that the dense mantle of the fragment detaches from the buoyant crustal part. If such detachment does not take place the slab will break off, or the continental fragment will be subducted with the oceanic lithosphere. Our general aim is to identify the parameters that act as switches between the different modes of collision. We use a finite element method to solve the mechanical equilibrium equation with a plastic-powerlaw-elastic rheology and the heat equation, since the viscosity is temperature dependent. The model is driven by buoyancy forces. The subduction process is strongly sensitive to the viscosity structure. We adopt the rheology of Karato and Wu (1993), with dislocation creep in the hot and shallow mantle (non Newtonian rheology) and diffusion creep in the deep upper mantle and lower mantle (Newtonian rheology). We introduce a critical ingredient, a low viscosity wedge (LVW) which has been argued to result from added volatiles and especially water. The reason is that a LVW decouples the lithosphere and the slab and reduces the excessive dynamic topography in the overriding plate since the suction pressure is lower (Billen and Gurnis 2001). We present results of numerical experiments aimed at establishing the most significant parameters, like the horizontal dimension and strength of the continental material and length of the subducted slab. A small continental margin, even if characterized by a thick crust, results in a detach-

ment behavior. We infer from the model experiments that a continental margin with high topography does not subduct. A wide continental crust results in strong buoyancy forces, that, in case of strong mechanical coupling with the lithosphere may cause slab break off.