EGU General Assembly 2021

EGU21-13842
https://doi.org/10.5194/egusphere-egu21-13842
EGU General Assembly 2021

Dynamics of arc-continent collision: the role of crustal-mantle dynamics on controlling the spatio-temporal evolution of stress

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Arc-continent collision is the process by which intra-oceanic arc crust is accreted to continental margins and the most important mechanism that enables the growth of the continental crust since Phanerozoic times. We use numerical visco-plastic mechanical models to explore: (i) the role of lithospheric-mantle dynamics in controlling the spatio-temporal evolution of stress in arc-continent collision settings, and (ii) the role of density contrasts in the evolution of the stress regime. We performed a series of simulations only varying the thickness of the arc based on natural examples as the arc thickness controls the buoyancy of intra-oceanic arcs. Therefore, we investigated a range of density contrasts between the arc and the continental plate. Modelling results show that arc-continent collision can evolve into two contrasting scenarios: (i) slab-anchoring and arc transference in dense arcs where the density contrast between the arc and the adjacent continental lithosphere is above -3% (15-31 km in thickness); and (ii) slab break-off in buoyant arcs where the density contrast between the arc and the adjacent continental lithosphere is below -3% (32-35 km in thickness). We conclude that the large-scale mantle return flow emerged from slab-anchoring facilitates the simultaneous occurrence of compression and extension in the margin by enhancing: (i) compression and lithospheric thickening of the buoyant intra-oceanic arc crust; and (ii) the density contrast between the accreted arc and the continental margin that triggers the release of a gravitational flow. In the particular case of buoyant arcs, the compressional body force applied by the deformed arc to the subducting plate drives its passive retreat. The results of our numerical modelling highlight the importance of the role of lithospheric-mantle dynamics on controlling the spatio-temporal evolution of stress.