Modelling slab age and crustal thickness: numerical approaches to drivers of compression in the overriding plate in Andean style subduction zone systems

Craig Withers, Jeroen van Hunen, and Mark Allen
Durham University, Earth Sciences, Durham, United Kingdom of Great Britain and Northern Ireland
(craig.withers@durham.ac.uk)

The Andes Mountains are formed at a destructive plate margin, where dense oceanic crust descends beneath relatively buoyant continental crust. In this geological setting, we typically would not expect to see such a high and wide mountain belt forming. Numerical modelling shows that if slabs roll back, continents are stretched, causing tension and potentially back-arc extension. The formation of the Andes has been hypothesized to be due to anchoring of the slab in the lower mantle, subduction of buoyant features in the Nazca plate, or compression driven by large-scale convection cells underneath South America.

Previous research suggests a clear correlation between slab age and overriding plate crustal thickness, globally, but in particular for South America. In this project, we hypothesize that this age variation plays a significant role in the formation of the Andes. As subducting slabs descend into the mantle, their properties differ in conjunction with their age affecting their buoyancy and strength, thereby generating different dynamics, surface tectonics, and slab morphologies. Using numerical modelling code ASPECT, we examined the role of slab properties and related dynamics on the state of stress in the overriding plate.

We quantify how much compression occurs in the overriding plate to use as a proxy for topographic growth. Typically, older slabs anchor more readily, causing more rollback and therefore extension. Our models however, predict that a stronger pull force acting on the overriding plate from older slabs causes stronger coupling than their younger counterparts, due to these buoyancy controls and increased density, resulting in greater compression. But, in doing so mantle convection contributes to corner flow in the static mantle wedge, increasing compression further. An increase in overriding plate thickness from 50 to 100km increases the amount of compression in the overriding plate by 10 Mpa, while an increase in slab age from 40 to 80 Myrs generates a similar increase in compression. Finally, slab morphology effects the geometry and vigour of convection cells beneath the overriding plate, which also affects the compressional state of the plate. This is in qualitative agreement with previous work.