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Controls on continental strain partitioning above an oblique subduction zone, Northern Andes

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Strain partitioning is a common process at obliquely convergent plate margins dividing oblique convergence into margin-normal slip on the plate-bounding fault and horizontal shearing on a strike-slip system parallel to the subduction margin. In subduction zones, strain partitioning in the upper continental plate is mainly controlled by the shear forces acting on the plate interface and the strength of the continental crust. The plate interface forces are influenced by the subducting plate dip angle and the obliquity angle between the normal to the plate margin and the convergence velocity vector, and the crustal strength of the continent is strongly affected by the presence or absence of a volcanic arc, with the presence of the volcanic arcs being common at steep subduction zones. Along the ∼7000 km western margin of South America the convergence obliquity, subduction dip angles and presence of a volcanic arc all vary, but strain partitioning is only observed along parts of it. This raises the questions, to what extent do subduction zone characteristics control strain partitioning in the overriding continental plate, and which factors have the largest influence?

We address these questions using lithospheric-scale 3D numerical geodynamic experiments to investigate the influence of subduction dip angle, convergence obliquity, and weaknesses in the crust owing to the volcanic arc on strain partitioning behavior. We base the model design on the Northern Volcanic Zone of the Andes (5°N - 2°S), characterized by steep subduction (∼ 35°), a convergence obliquity between 31°-45° and extensive arc volcanism, and where strain partitioning is observed. The numerical modelling software (DOUAR) solves the Stokes flow and heat transfer equations for a viscous-plastic creeping flow to calculate velocity fields, thermal evolution, rock uplift and strain rates in a 1600 km x 1600 km box with depth 160 km. Subduction geometry and material properties are based on a simplified, generic subduction zone similar to the northern Andes. The upper surface is initially defined to resemble the Andes, but is free to deform during the experiments. We consider two main model designs, one with and one without a volcanic arc (weak continental zone). A relatively high angle of convergence obliquity is predicted to favor strain partitioning, but preliminary model results show no strain partitioning for a uniform continental crustal strength with a friction angle of $\Phi = 15^\circ$. However, strain partitioning does occur when including a weak zone in the continental crust resulting from arc volcanic activity with $\Phi = 5^\circ$. This results in margin-parallel northeastward translation of a continental sliver at 3.2 cm/year. The presence of the sliver agrees well with observations of a continental sliver identified by GPS measurements in the Northern Volcanic Zone with a translation velocity of about 1 cm/year, though the GPS-derived velocity may not be representative of the long-term rate of translation depending on whether the observation period includes one or more seismic cycles. Regardless, the observed behavior is consistent with the observed earthquake focal mechanisms and GPS measurements, suggesting significant northeastward transport of Andean crust along the margin of the northern Andes.