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GPS velocity field of the Southern Andes revisited: New insights from scaled analogue experiments

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Dextral transpessive deformation in the Southern Andean Volcanic Zone (SAVZ) caused by oblique subduction of the Nazca Plate below the South American Plate is widely believed to be resolved chiefly on the 1200 km long Liquiñe-Ofqui Fault Zone (LOFZ). The GPS vector pattern of the SAVZ in particular is often interpreted in support of this view and, more specifically, of post-seismic mantle relaxation after the 1960 Valdivia earthquake.
Notably, west of the LOFZ, GPS sites indicate uniform NE-directed velocities co-linear with the obliquity in plate convergence on the order of several centimetres per year, indicating that the plate interface is currently locked. East of the LOFZ, GPS velocities diminish abruptly to a few millimetres per year and westward motion. At the northern terminus of the LOFZ, GPS vectors change from NE-directed to SE-directed velocities. Thus, the velocity field seems to be kinematically related to deformation associated with the LOFZ. However, west of the LOFZ velocities indicate an absence of deformation partitioning. By contrast, the abrupt West-East GPS velocity gradient at the LOFZ points not only to a large component of dextral displacement, but also to a considerable horizontal shortening on the LOFZ.
In addition to previous interpretations of the GPS vector field, we also consider the influence of orogen-parallel variations in upper crustal strength. For this purpose, two-layer models are designed using silicone for the viscous lower crust and variable thicknesses of quartz sand causing strength gradients of the brittle upper crust. Displacement vector fields obtained from 3-D digital image correlation of scaled analogue experiments are compared with the observed GPS vector field.
Analogue modelling results suggest that orogen-parallel strike-slip faults do not fully portray the GPS vector field in a compression-dominated transpressive setting such as the SAVZ. The experiments point to the importance of rhomb-shaped deformation domains bound by oblique reverse faults in accomplishing transpression on the orogen scale. The orogen-parallel change in upper-crustal strength is conducive for the development of deformation domains and can explain the regional variation in the GPS vector field. Comparison with new remote sensing data, structural field observations, geodetic data and the GPS vector field support the model observations.