Mechanical modeling of interseismic deformation in the Central Andes: implications for back-arc shortening

*Shaoyang Li[1,2], Fuqiang Shi[3], Marcos Moreno[4], Jun'ichi Fukuda[1]

1. Earthquake Research Institute, University of Tokyo, Tokyo, Japan, 2. Department of Earth and Environmental Sciences, The University of Iowa, Iowa City, IA, USA, 3. Shaanxi Earthquake Agency, Xi' an, China, 4. Departamento de Geofísica, Facultad de Ciencias Físicas y Matemáticas, Universidad de Concepción, Concepción, Chile

Coupling in the plate interface is considered the primary mechanical process transferring tectonic forces into interseismic deformation at subduction zones. Given that interseismic deformation affects the whole volume of the margin, the spreading of the deformation field across the continental plate not only depends on the pure-plate coupling deformation but is also affected by the rheological properties and active continental faulting. Here, we use numerical mechanical models, including viscoelastic mantle wedge and frictional back-arc fault, to investigate the interseismic GPS-derived velocity field in both horizontal and vertical directions in the Central Andes. In this region, GPS observations show a slow decrease of velocities over a significantly far-reaching area from the trench, with a sharp localized shortening gradient across a major back-arc fault at the trench distance > 800 km. These signals cannot be explained only by modeling plate locking and back-arc shortening. We first implement a grid-searching method to test the contribution and interaction of subduction locking and viscous mantle flow in the velocity field. Our simulation results show that these two processes produce similar horizontal deformation patterns, while the vertical deformation is particularly sensitive to the locking depth. We further perform mechanical viscoelastic models with a frictional back-arc fault and examine the effects of subduction locking, viscous mantle flow, and frictional strength of the back-arc fault on the activation of the back-arc fault (attached Figure). We find that the back-arc fault should be remarkably weak and is active only under considerable viscous mantle flow to reproduce the observed sharp localized shortening across the back-arc fault. Our results, therefore, suggest that the preexisting weakness of the crust plays an important role on the distribution of interseismic deformation and shortening the continental crust, highlighting a generic feedback between long-term mantle structure and present-day deformation.

Keywords: Interseismic deformation, GPS velocities, Back-arc shortening, Viscoelastic mantle relaxation, Central Andes