Estimation of megathrust earthquake potential along the Peruvian subduction zone based on mechanical coupling model and the earthquake energy budget

Nelson Pulido[1], and Juan Carlos Villegas[2]
[1]National Research Institute for Earth Science and Disaster
nelson@bosai.go.jp
[2]Instituto Geofísico del Perú
jvillegas@igp.gob.pe

The assessment of megathrust earthquake potential in subduction zones is typically based on the historical record of earthquakes in the region. However, earthquakes catalogues often contain incomplete information, especially for large earthquakes. In addition, it is crucial to incorporate information on the physical processes that characterize large earthquake ruptures at the plate interface such as accumulation of stress and strain, and the fault resistance to rupture. Therefore, to investigate the physical conditions for earthquake generation, the concepts of mechanical coupling, and the earthquake energy budget have been proposed. Under that framework an earthquake rupture cannot occur unless the strain energy, overcomes the fault resistance to rupture (fracture energy). To that purpose we combine, the estimation of the strain energy distribution at the plate interface obtained from GNSS data, with the estimation of fault fracture energy of mega-thrust earthquakes based on a global dataset of slip rupture models in subduction zones, and apply it to the Peruvian subduction zone. To calculate fracture energy (G) we use the scaling law between average fault slip and G obtained for a global data-set of finite fault rupture models of subduction earthquakes and the 2D finite width slip dynamic rupture model (Pulido 2023) (Figure 1). To obtain strain energy we calculate the shear stress accumulation rate and total accumulated shear stress distributions along the Peruvian subduction margin (Figure 1), based on the inter-seismic coupling model (ISC) (Villegas-Lanza et al. 2016), and inter-seismic periods since the last largest historical earthquakes for each individual segment. Our results indicate that the subduction zones in Central Peru (Lima region) and Southernmost Peru (near Chile) will fulfill the required condition for generating earthquakes with Mw~8.9 and ~8.5 respectively, in few decades. The large availability of ISC studies globally in recent years, combined with scaling laws of fault fracture energy at the plate interface, make our method suitable to estimate the earthquake potential of subductions zones worldwide.

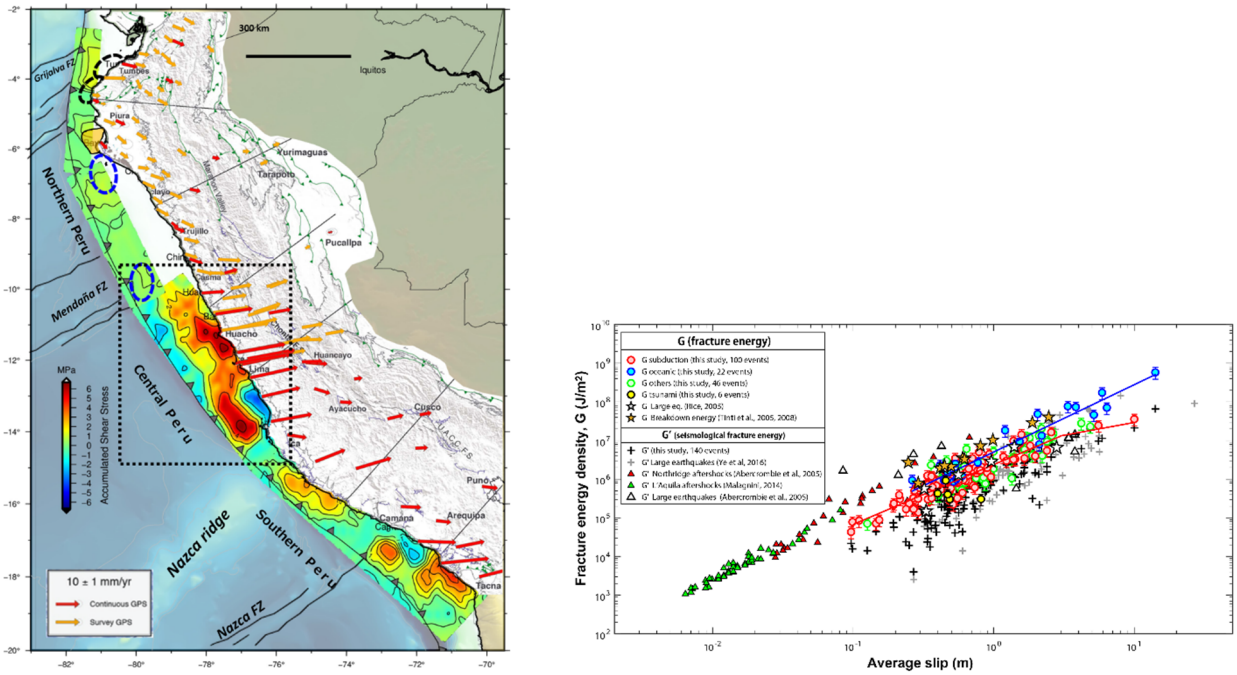

Figure 1 Mechanical coupling distribution along the Peru subduction margin (left) (this study). Scaling of fault fracture energy with slip (Pulido 2023) (right).