Seafloor geodesy reveals megathrust segmentation by a subducted seamount in northern Chile

M. Moreno[1,2]

[1] Department of Structural and Geotechnical Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile.
[2] Millennium Institute of Oceanography (IMO), Chile.

ABSTRACT

Subduction trenches host the shallowest portion of megathrust faults, where deformation directly influences tsunami generation. Yet this near-trench region remains poorly constrained because conventional geodetic networks are restricted to land. Seamounts are common features of incoming oceanic plates and can strongly modify plate-boundary geometry, stress, fracturing, and fluid circulation as they enter the subduction zone, but their effect on megathrust locking remains debated.

Here, we combine seafloor geodesy, onshore GNSS, seismic reflection imaging, seismicity, and seismic tomography to investigate deformation around a large subducting seamount beneath the Taltal Ridge in northern Chile. Vertical velocities measured by ocean-bottom pressure gauges reveal near-trench subsidence and define an offshore transition from subsidence to uplift that cannot be resolved from land-based observations alone. Joint inversion of offshore and onshore geodetic data indicates that the shallow megathrust is strongly coupled up to the trench, becomes locally weakly coupled above the subducting seamount, and is coupled again downdip.

Seismic reflection and tomographic observations suggest that the seamount is progressively fractured beneath the forearc and associated with enhanced fluid circulation, while seismicity is concentrated around its margins. Rather than producing a uniformly locked or weak interface, the subducting relief generates pronounced along-dip segmentation of the megathrust, separating shallow and deeper coupled regions.

These results show that subducting topography can reorganize deformation within the trench and shallow forearc. Resolving such near-trench heterogeneity is essential for understanding the mechanics of tsunami-generating earthquakes and for improving seismic and tsunami hazard assessment along subduction margins.

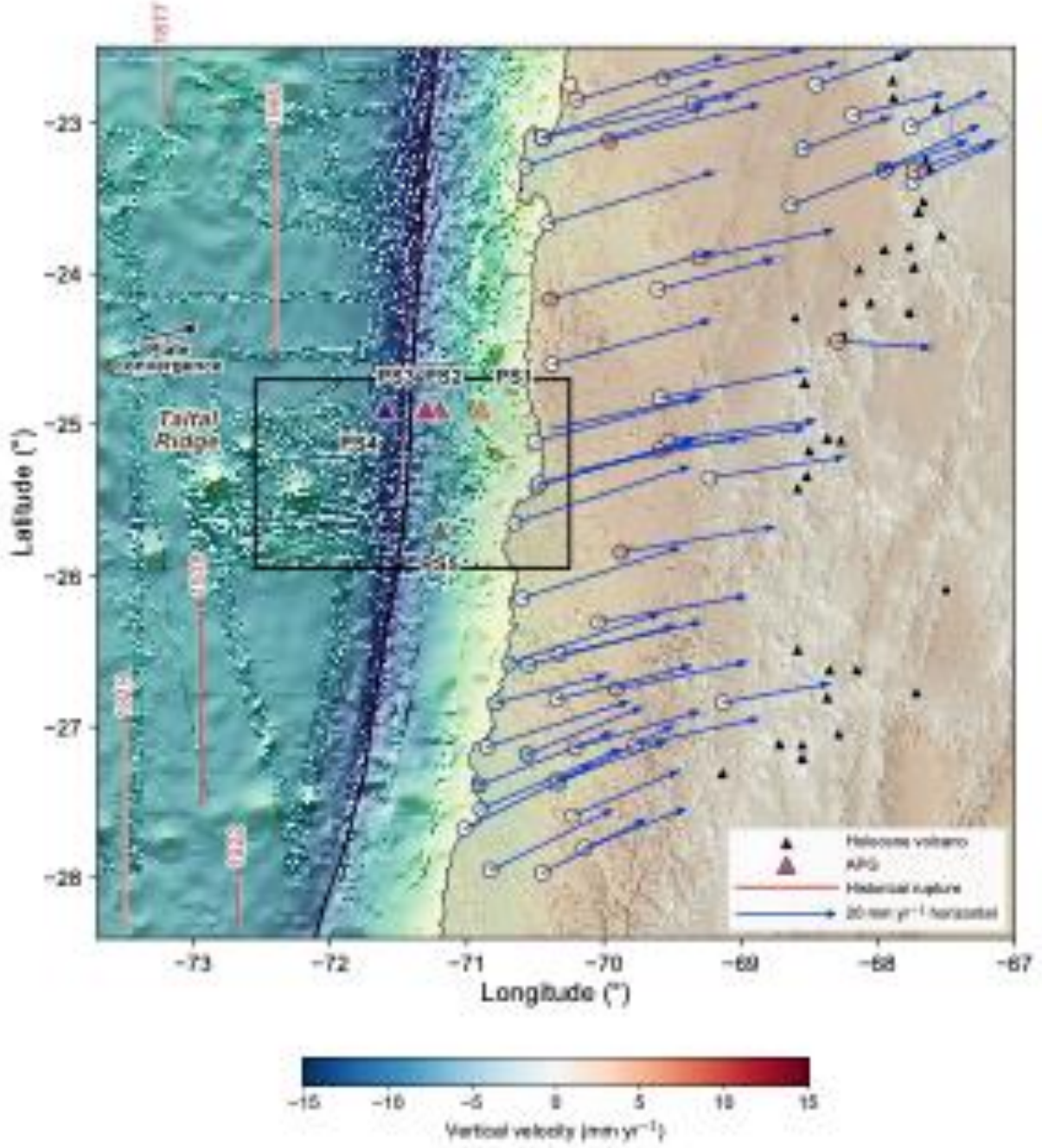

Figure 1. Seafloor and onshore geodetic observations across the northern Chile trench. Ocean-bottom pressure gauges (PS1–PS5) span the Taltal Ridge and record vertical deformation across the shallow megathrust, while GNSS vectors show horizontal interseismic deformation onshore. Historical rupture limits provide the regional context of the long-standing seismic gap surrounding the ridge.