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Buoyancy, collision, and densification of the subducting Nazca slab inferred from focal mechanisms of small earthquakes

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In the Central Andean subduction system the oceanic Nazca plate subducts beneath the continental South American Plate. We recorded slab-related earthquakes at depths between 20 km and 120 km, both in the oceanic crust and mantle. We determined the focal mechanisms of 152 small earthquakes ($2 < M < 5$) using the HASH algorithm and further substantiate 10 of the these mechanisms by inverting the full waveform. The mechanisms allow us to infer the stresses that act on the slab upon subduction.

Our results show the exact down-dip extent of the plate coupling zone that is dominated by compressional forces and the range that is dominated by slab pull. We observe an arc-ward (down-dip) increase of differential stress at intermediate depth. This increase can be explained by the densification of the slab rocks that is demanded by the mineral dehydration hypothesis for intermediate depth earthquakes. The density increase of the slab must be substantial enough to affect the local stress field. The lower differential stress trench-ward (up-dip) favors the interpretation that the slab is buoyant relative to the underlying asthenosphere at the trench and in the whole forearc region. Only below the arc it becomes dense enough to sink into the mantle due to its own weight and to exert slab-pull.