basins formed due to sinistral wrench faulting where folds developed in response to either forced folding or contractional folding, but where the component of extension was equally important. In this way, by using the fill of Pliocene-Recent basins for temporal and paleogeographic control and documenting its syn- and post-depositional deformation as well as adjacent basement kinematics, the neotectonic deformation internal to the fore-arc uplift can be interpreted in terms of transtensional wrench faulting. Based on these results it is proposed that the Hellenic forearc is one of the few examples where oblique subduction resulted in transtensional rather than transpressional deformation. However, the mechanical coupling between the obliquely subducting lithosphere, the southward migrating subduction zone and deformation in the overriding plate is yet poorly understood. Future modeling, based on the new field data, may eventually help to solve these questions.

Coupling of lithospheric layers at wrenching plate boundaries: the clutch model

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Although geologists typically recognize that significant deformation at plate boundaries takes place in the mantle, the tie between mantle movement and crustal tectonics is not clear. Wrench settings are a particularly good place to evaluate this coupling. The critical tool to evaluate mantle flow is shear-wave splitting, which is thought to reflect strong crystallographic preferred orientation of olivine. Shear-wave splitting along most wrenching plate boundaries – including the San Andreas system, the Caribbean–South America plate margin, and the South Island of New Zealand – shows a delta t~1.0–2.0 s.

This large amount of splitting suggests the existence of a vertically-oriented shear zone extending downward to ~100–200 km. Using these data, we can qualitatively evaluate the interplay between these lithosphere-scale shear zones and the deformation of the crust. In the San Andreas region and the northern part of the South Island of New Zealand, the upper crust is broken into rigid slivers, typically 20 km wide, separated by strike-slip faults. However, the relationship between the structure of the upper crust and the lithospheric shear zone is unclear. Clues on the structure of the crust beneath the brittle layer can be found along the Caribbean-South America plate boundary. There, shear-wave splitting (delta t~2.0 s) has been interpreted as a mantle shear zone accommodating the westward translation of South America, relative to the relatively fixed Caribbean plate, over the last 50 million years. Deformation is concentrated on the northern lip of South America, from the eastern tip of Trinidad's Northern ranges to the Paría Peninsula in NE Venezuela. Here, metasediments of the South American paleo-margin were exhumed and display a cross section through the upper-mid crust, with metamorphic grade increasing westward (T~200 °C to ~400 °C). An EW cross section exposes several kilometers of crust, with subvertical foliations in the east, associated with upright folds, becoming subhorizontal eastward, through an interpreted brittle–ductile transition. In this zone, the lineations are east–west, subparallel to the plate margin.

Argon thermochronology suggests that these fabrics are Tertiary (20–30 Ma) and fission-track analysis has demonstrated that the metamorphic rocks were exhumed in the last 10 million years. Such fabrics may have formed to couple the plate-scale wrench zone in the mantle and lower crust to the overlying rigid upper crustal blocks. This coupling resulted in intense deformation within rheologically-controlled subhorizontal high-strain zones that transmitted deformation upward to the rigid blocks; this suggests that upper crustal deformation and mantle flow are connected. Subhorizontal reflectors recognized at ~10–20 km depth in the San Andreas region and most wrenching margins probably represent these coupling zones, which act as a clutch to connect the rigid upper crust to the lower part of the lithosphere.