Lithospheric Deformation within a Continental Strike-Slip Fault Zone: Marlborough Fault System, South Island, New Zealand

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Near-surface deformation associated with major continental strike-slip faults is easy to recognize simply by walking the surface trace of the fault system. Less clear are the mechanisms that accommodate slip between continental plates in the lower crust and upper mantle. Do strike-slip faults continue as narrow near-vertical shear zones into the mantle? Is strain in the lower crust distributed over a broad region with flow in the lower crust accommodating relative motion between the upper crust, lower crust, and mantle lithosphere? Answering these questions would help us to understand the depth and location of earthquakes and the coupling between the crust and mantle along strike-slip boundaries, as well as the strength of the continents as a function of depth.

The South Island of New Zealand straddles a major strike-slip fault system that delineates the boundary between the Pacific and Australian plates. The system is well developed with several hundred kilometers of right lateral offset. At the northern end of the South Island, present day relative motion is almost entirely strike-slip and is distributed across the 4 major faults of the Marlborough fault system with most of the total offset being absorbed along the northernmost strand, the Wairau fault.

From December, 2000, to June of 2002, we occupied over 100 sites across the Marlborough Fault System with short-period and broad-band three component instruments provided by IRIS-PASSCAL. Our scientific goals were to create crustal images of the fault system using teleseismic converted waves and to identify the presence or absence of seismic anisotropy in the crust and upper mantle beneath the fault system. Seismic images produced by the experiment showed a nearly 10-kilometer difference in crustal thickness from north to south beneath the Wairau fault that was connected by a Moho ramp. Azimuthal variations in the amplitude of the converted phases supported the ramp interpretation as well as the presence of crustal anisotropy at a mid-crustal interface. These observations indicate that strike-slip deformation associated with the relative motion between the Pacific and Australian plates becoming distributed over a broader region (~60 km) in the lower crust and upper mantle beneath the Wairau fault (Wilson et al., 2003).

Interpreted Common-Conversion-Point Stacked cross-section of depth-migrated teleseismic converted waves. We interpret the strong conversion from near 25 km depth that dips to the south beneath the Wairau as the Moho. The smooth transition in Moho depth and the presence of mid-crustal anisotropy beneath the Wairau fault support the conclusion that deformation is not confined to a narrow near-vertical shear zone in the lower crust but instead is distributed over a broad region.