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Continental-scale wrench faults: how deep?

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Major wrench faults accommodate a large part of the deformation of the continental crust and thus, are the source of large earthquakes. These faults represent a complex mechanical system whose behavior is strongly dependent on interactions between fluids and strain, but also on the coupling between brittle and ductile deformation in the crust and between the crust and mantle deformation. Yet the geometry of these faults at depth is still poorly understood. How deep a major wrench fault penetrates within the Earth? Is it rooted somewhere into the crust, at the crust-mantle boundary or does it crosscut the entire lithosphere? How does the style of the fault change with depth? Is strain localized at all levels? These issues have major implications on the mechanical behavior of the faulted lithosphere during the seismic cycle as well as on the response of the lithosphere to new tectonic solicitations.

Geological and geophysical observations support a coherent deformation of the entire lithosphere in major intracontinental wrench faults, and thus a mechanical coupling between the crust and mantle deformation. Tectonic studies of wrench faults eroded down to the middle to lower crust show that, even when the lower to middle crust is partially melted, strain remains localized (although less efficiently) in transcurrent shear zones. Seismic profiling, seismic tomography and magnetotelluric soundings provide strong arguments in favour of major wrench faults crosscutting the Moho and deforming the upper mantle. Shear-wave splitting and electric conductivity anisotropy measurements over major wrench faults as well as in transpressional belts support that a wrench fault fabric exists over the entire lithosphere thickness. Indeed, the seismic anisotropy and probably also the electrical anisotropy deduced from long period MT data are due to the crystallographic preferred orientation of olivine developed in the mantle during the fault activity. When the deformation stops, this fabric is frozen in the lithospheric mantle. Because olivine is mechanically and thermally anisotropic, the preservation of such a "wrench fault-type" fabric within the upper mantle may

have major effects on the subsequent tectono-thermal behavior of continents. It may explain the frequent reactivation of ancient lithospheric-scale wrench faults and transpressional belts during subsequent tectonic events.