Geophysical Research Abstracts
Vol. 19, EGU2017-10852, 2017
EGU General Assembly 2017

Lithospheric strength in the active boundary between the Pacific Plate and Baja California microplate constrained from lower crustal and upper mantle xenoliths

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The lower crust is the most poorly understood of the lithospheric layers in terms of its rheology, particularly at active plate boundaries. We studied naturally deformed lower crustal xenoliths within an active plate boundary, in order to link their microstructures and rheological parameters to the well-defined active tectonic context. The Baja California shear zone (BCSZ), located at the western boundary of the Baja California microplate, comprises the active boundary accommodating the relative motion between the Pacific plate and Baja California microplate. The basalts of the Holocene San Quintin volcanic field carry lower crustal and upper mantle xenoliths, which sample the Baja California microplate lithosphere in the vicinity of the BCSZ. The lower crustal xenoliths range from undeformed gabbros to granoblastic two-pyroxene granulites. Two-pyroxene geothermometry shows that the granulites equilibrated at temperatures of $\sim$690–920 oC. Phase equilibria (P-T pseudosections using Perple_X) indicate that symplectites with intergrown pyroxenes, plagioclase, olivine and spinel formed at 3.6–5.4 kbar, following decompression from pressures exceeding 6 kbar. FTIR spectroscopy shows that the water content of plagioclase varies among the analyzed xenoliths; plagioclase is relatively dry in two xenoliths while one xenolith contains hydrated plagioclase grains. Microstructural observations and analysis of the crystallographic texture provide evidence for deformation of plagioclase by a combination of dislocation creep and grain boundary sliding. To constrain the strength of the lower crust and upper mantle near the BCSZ we estimated the differential stress using plagioclase and olivine grain size paleopiezomtery, respectively. Differential stress estimates for plagioclase range from 10 to 32 MPa and for olivine are 30 MPa. Thus the active microplate boundary records elevated crustal temperatures, heterogeneous levels of hydration, and low strength in both the lower crust and upper mantle. To further investigate the relative strength of the two lithospheric layers, we calculated the strain rate of plagioclase in granulites and the strain rate of olivine in lherzolites using experimental flow laws. These flow laws predict that plagioclase deforms at higher strain rates than olivine. Our data provide constraints on the viscosity structure of active transform plate boundaries and insights on how rheological processes in the lithosphere may change during plate boundary evolution.