Geophysical Research Abstracts, Vol. 8, 00963, 2006
SRef-ID: 1607-7962/gra/EGU06-A-00963

Earthquakes and nonvolcanic tremor in the lower continental crust: open questions

J. Strehlau

Institute of Geosciences, Christian-Albrechts-University, 24098 Kiel, Germany (strehlau@pclab.ifg.uni-kiel.de)

Seismic activity extending deeper than 20 km has been observed in low-heat flow Precambrian shields and in a broad variety of young tectonic regions with moderate to high heat flow (e.g., rift zones, continental margins, forelands of mountain ranges). Lower crustal seismicity in shields is consistent with the conventional view that earthquakes can only occur at temperatures below a few hundred °C (depending on crustal composition). In regions with elevated heat flow, the lower crust is generally believed to be too hot for seismogenic faulting: Deformation is thought to be aseismic at high temperatures because laboratory friction tests show stable sliding under hydrothermal conditions (at constant fluid pressure) and steady-state flow experiments show viscous creep (at constant strain rate). Current strength models can therefore accommodate lower crustal seismicity in young regions only by deepening the frictional-viscous transition due to mafic composition, high strain rates, low temperatures, or any combination thereof.

Basic assumptions of these models include: isochemical composition, preexistence of faults (i.e., application of Byerlee's law), and dichotomy of deformation mode (either friction or flow). Evidence suggests, however, that combined semi-brittle/semi-ductile processes (e.g., ductile fractures) as well as time- and composition-dependent deformation mechanisms (e.g., short-term creep bursts, metamorphic reaction-induced flow instabilities) may be quite important in the lower crust. Geologic studies have in fact shown that brittle and viscous deformation is often intertwined on small (∼cm) spatial and short (seismogenic?) time scales, thus pointing to close coupling between these processes. Petrologic evidence indicates that high-temperature embrittlement and fault melting may be associated with metastable hydration and/or dehydration reactions. Consequently, coupled chemo-hydro-thermo-mechanical processes may play a more significant role in deep crustal deformation than recognized thus far. How such processes can generate earthquakes and tremors is yet to be fully determined.

Deep crustal seismic activity, therefore, poses fundamental questions about the strength and rheology of the lower crust, the role and origin of fluids, and the thermal and metamorphic regime (prograde vs. retrograde). This paper summarizes available observations of the depth extent of seismicity and attempts a correlation with source parameters, seismic velocities, crustal structure (including evidence from xenoliths), tectonic setting, stress fields, and heat flow (calculation of geotherms with temperature-dependent thermal conductivities). I discuss key questions to be resolved if one hopes to achieve an improved understanding of deep crustal processes. I suggest open questions are perhaps best addressed in a multidisciplinary, multiple working hypothesis-type approach.