Shrinking and draining continental lower crust: its binary effects of stress and fluid on crustal activities

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Basically, the continental crust itself is presumed to be static passive polycrystalline rocks with its ductility in the aseismic deep. However, this ductility seems difficult to explain crustal activities still debated: not only the long-standing stability (the resistivity to the isostatic decay) but also the short-term activities, e.g., inland horizontal compressive state (Zoback, et al. (1989)), intracrustal seismicity (Calais, et al. (2016)), and rare lower crustal earthquakes (Simpson (1999)).

Then, can we rethink the crust, especially its controversial lower? Actually, I presented a possibility of the shrinking and draining of the continental crust through "phase separation or phase demixing" at JpGU in 2012. Thus, I will propose a new lower crust causing the deformation, qualitatively but comprehensively discussing the activities.

As basic components of the lower crust, I consider SiO_2 and H_2O (with other elements and volatiles). Their melt mixtures cause phase separation under lower crustal temperatures and pressures (Kawamoto (2006), Hack, et al. (2007)). Furthermore, melt SiO_2 forms 3-dimensional macromolecular network (Stebbins (2016)). Thus, I regard this process as the volume shrinking of this elastic SiO_2 network separating from an aqueous fluid (Tanaka (2012), Koyama, et al. (2009), Koyama and Tanaka (2018); also the shrinking SiO_2 in Tognonvi, et al. (2011)): This network macroscopically behaves as a phase-separating glass (before crystallization) or an elastically hard self-squeezing wet sponge.

Then, the new lower crust, constructed by the shrinking SiO_2 network draining the H_2O fluid, combines and interacts with the usual upper crust (Figure): The elastic shrinking laterally compress the upper crust from below, bringing the long-term stability and intermittent drained-fluid injections triggering the intra-upper-crustal earthquakes. Importantly, this lower crust, aiming at shrinking, must follow some degree of external compression: the aseismicity or the apparent ductility. However, when the elastic SiO_2 network suffers a large local differential stresses under the stress/fluid interlayer interactions, the brittleness should arise as lower crustal seismicity.

Therefore, assuming the lower crust to be not monistic solid but dualistic solid/fluid coexisting during their phase separation, we can qualitatively explain the crustal movements using the actively shrinkable/drainable lower crust mechanically/materially interacting with the upper crust.

Keywords: Continental crust, Stability, Stress, Seismicity, Phase separation

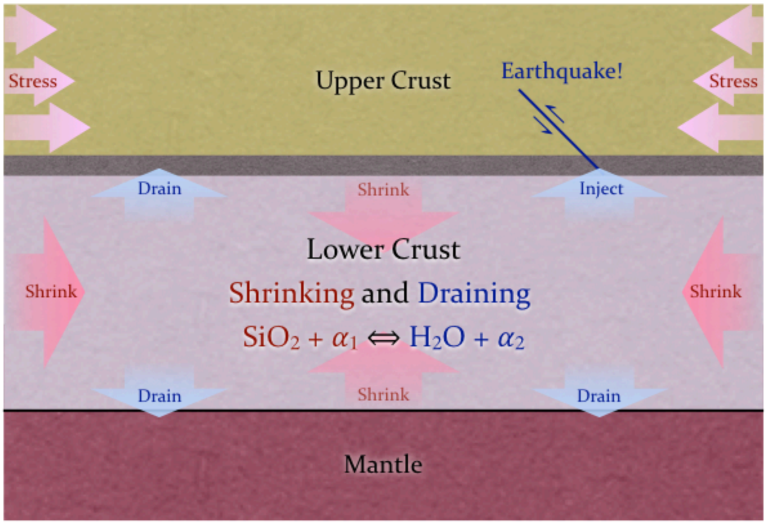

Figure: Self-squeezing lower crust mechanically and materially affecting the static and passive upper crust above.