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Quartz Rheology and Short-Timescale Crustal Instabilities

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We present numerical results of thermal-mechanical feedback in crustal quartz rheology and contrast this behavior to the vastly different character of an olivine mantle. In the numerical experiments quartz is found to have a very strong tendency for short-timescale instabilities, while olivine has a decisive tendency for a stable thermally lubricated slip. At the same time olivine can also go through a transitional period of creep bursts, these are physically caused by multiple interacting ductile faults at various length and time scales. Since olivine has a strong propensity to self organize in a large apparently stable fault system, it lacks the dynamics of interacting ductile faults evident in other minerals. Quartz behaves totally different and keeps its jerky slip behavior for prolonged deformation. An example is shown here where a 30 x 50 km piece of a wet granitic crust is extended for about 2 Ma. The associated total displacement field clearly shows the unstable slipping events, which have a characteristic time frame of one to several years, In contrast, olivine is very stable and has a much longer time scale for thermal instability of 100 kyrs