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Geodynamical models of the intermediate depth seismicity of the SE Carpathians

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Strong earthquakes occur at intermediate depths beneath Vrancea (SE Carpathians) in a narrow, nearly vertical source volume (the epicentral area is about 80x30 km, with the strongest earthquakes between 70 and 200 km depth). This phenomenon is often attributed to subduction of oceanic lithosphere. However, there is no obvious zone of subduction associated with the Vrancea deep earthquakes. An alternative explanation to this deep seismicity is the downwelling of the continental lithosphere in the form of a Rayleigh Taylor instability. The fault plane solutions, for a time interval of 40 years, indicate maximum vertical extension rates on the order of 35% per Myr in the depth range 50-100 km, decreasing by about an order of magnitude in the depth range 100-150 km. Such rapid rates of deformation suggest a transient state, that has not persisted for long on the geological time scale, and almost certainly has developed after the accepted date for cessation of subduction at about 10 Ma. Three dimensional finite deformation models of the gravitational instability of the continental lithosphere, based on the finite element method, demonstrate that the Rayleigh Taylor mechanism can explain the present distribution of deformation within the downwelling lithosphere, both in terms of distribution of seismicity and amplitude of strain rates. The spatial width of the high stress zone that corresponds to the seismically active zone is realistically represented when we assume that the viscosity of the lithosphere decreases by an order of magnitude across the lithosphere. The downwelling is part of a planform for gravitational instability that is inherently three dimensional and was triggered in these experiments by a harmonic perturbation in the form of a first order Bessel function (with m=1 asymmetry). The mantle downwelling is associated

with crustal thickening, and is balanced by lithospheric thinning, associated with only minor crustal thinning, in an adjacent area which would correspond to the Transylvanian basin. The shape of the downwelling is comparable to that provided by seismic tomographic imaging.