Geophysical Research Abstracts
Vol. 12, EGU2010-8862, 2010
EGU General Assembly 2010

Geodynamical evolution of the Southern Carpathians: inferences from computational models of lithospheric gravitational instability

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The Carpathians are a geologically young mountain chain which, together with the Alps and the Dinarides, surround the extensional Pannonian and Transylvanian basins of Central Europe. The tectonic evolution of the Alpine-Carpathian-Pannonian system was controlled by convergence between the Adriatic and European plates, by the extensional collapse of thickened Alpine crust and by the retreat of the Eastern Carpathians driven by either a brief episode of subduction or by gravitational instability of the continental lithospheric mantle. The Southeast corner of the Carpathians has been widely studied due to its strong seismic activity. The distribution and rate of moment release of this seismic activity provides convincing evidence of a mantle drip produced by gravitational instability of the lithospheric mantle developing beneath the Vrancea region now. The question of why gravitational instability is strongly evident beneath Vrancea and not elsewhere beneath the Southern Carpathians is unresolved. Geological and geophysical interpretations of the Southern Carpathians emphasise the transcurrent deformation that has dominated recent tectonic evolution of this mountain belt. We use computational models of gravitational instability in order to address the question of why the instability appears to have developed strongly only at the eastern end of this mountain chain. We use a parallelised 3D Lagrangean-frame finite deformation algorithm, which solves the equations of momentum and mass conservation in an incompressible viscous fluid, assuming a non-linear power-law that relates deviatoric stress and strain-rate. We consider a gravitationally unstable system, with a dense mantle lithosphere overlying a less dense asthenosphere, subject to boundary conditions which simulate the combination of shear and convergence that are thought to have governed the evolution of the South Carpathians. This program (OREGANO) allows 3D viscous flow fields to be computed for spatially variable density and viscosity and we assume that deformation is initially localized in the Carpathian region because its crust and/or mantle layers are weakened by some prior tectonic or magmatic process.