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Discriminating between possible causes for active tectonics of the SE Carpathians

R. Govers and P. Langebroek
Faculty of Earth Sciences, Utrecht University, Netherlands

The Vrancea region in the South-East Carpathians is the last remainder of subduction-strike slip tectonics along the Alpine-Carpathian-Pannonian region. Here, a near vertical slab is imaged by seismic tomography to a depth of about 300 km, coincident with up to magnitude 7.5 earthquakes in the depth range 90-140 km. Focal mechanisms show vertical extension in the slab, probably indicating that the slab is mechanically continuous and that slab detachment is ongoing.

Regional GPS measurements were initiated in 1995 and substantially expanded in 2001 to register the seismic and tectonic evidence of subcrustal processes. The current GPS network consists of more than 50 campaign points and six permanent GPS stations and is operated by ISES (Netherlands) in collaboration with SFB-461 (Germany), the National Institute for Earth Physics (Romania), and the University of Bucharest (Romania). Here, we seek to interpret the velocity solution of Van der Hoeven et al. (2005) which shows up to 4 mm/yr horizontal motions relative to stable Europe.

We separately explore various possible causes of the observed velocity field; post-seismic relaxation, wedge collapse and slab-related processes. Using a finite element method, we compute the post-seismic relaxation of the 1977 (Mw=7.5), 1986 (Mw=7.2) and 1990 (Mw=6.9) events in a three-dimensional model with a slab geometry that is appropriate for the region. We consider a wide range of models with realistic visco-elastic rheologies to conclude that the current contribution of post-seismic relaxation to the observed horizontal velocity field is below the noise level of the data.

The Carpathians are typically considered as a fold-and-thrust belt which is why we consider the possibility that GPS velocities are the response to post-collisional collapse. We show that site velocities are mostly not directed downhill (at different wavelengths) and conclude that wedge collapse is not causing the GPS velocities.

Finally, we use our regional geodynamic model to compute the contribution of break-off and sinking of the Vrancea slab. The directions and magnitudes of the predicted surface velocities are roughly similar to the GPS velocities up to 5-10 (depending on model parameters) asthenospheric Maxwell times after detachment. For typical earth parameters this means that current GPS velocities may reflect the response to total failure of the Vrancea slab somewhere during the last 16,000 years.