Geophysical Research Abstracts, Vol. 7, 02588, 2005
SRef-ID: 1607-7962/gra/EGU05-A-02588

The Influence of Gravitational Instability on Regional Tectonics in the Carpathian-Pannonian System

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The mechanisms controlling the evolution of the Neogene Carpathian-Pannonian system have been the research focus of numerous previous geological and geophysical investigations. Although the tectonic activity in this region is generally attributed to subduction of oceanic lithosphere, the observed interplay between convergence and extension in the area is still under debate. Extension in the Pannonian Basin occurred during the Miocene simultaneously with contractional deformation in the surrounding Carpathian and Alpine orogens. In addition, the formation of the Pannonian Basin is associated with dramatic thinning of the mantle part of the lithosphere, more so than the crust.

Previous studies have shown that gravitational instabilities may play a fundamental role in the tectonics of mountain ranges. In general, the lithosphere is colder and thereby denser than the underlying asthenosphere. Under some circumstances this may cause the lithosphere to sink into the asthenosphere. In this study we investigate whether lithospheric gravitational instabilities may drive simultaneous extension and convergence of the order of magnitude that is observed in the Carpathian-Pannonian region.

The Carpathian-Pannonian system is characterized by a roughly circular region of extension surrounded by arc-shaped mountain belts. Therefore we use 2D axisymmetric and 3D finite element models to quantify the mechanisms that control the evolution of the system. We show how a crust initially thickened by localized convergence may promote lithospheric gravitational instabilities that cause the collapse of high topography and focused, depth-variable lithospheric thinning that is observed in Carpathian-Pannonian region. We investigate the relative importance of buoyancy and regional

tectonics in convergent continental orogens and show how parameters, such as density and viscosity (Newtonian or non-Newtonian) affect the evolution of this type of system.

We investigate how the shape and extent of the initially thickened region affect the distribution and amplitude of lithospheric downwelling and examine how the instability develops adjacent to the corner of an initially rectangular region of thickened crust. The Carpathian lithospheric thicknesses vary from 140 km in the northwest to 200 km in the Vrancea region in the southeastern corner of the Carpathians, where a remarkable zone of deep seismicity shows that the gravitational instability is still active.