Crustal structure of the SE Carpathians and its foreland from densely spaced geophysical data

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Summary

This PhD research thesis was funded by the ISES (Netherlands Research Centre for Integrated Solid Earth Sciences) and it was accomplished within the framework of the PannCarp integrated programme (The Pannonian-Carpathian area: Tectonic topography and the aftermath of continental collision). **The fundamental objectives** of this study were: to solve *the riddle* of the upper crustal architecture puzzle of the south-eastern Carpathians and its foreland using geophysical data sets and give a robust interpretation of the whole crust beneath this area; and, to understand the neotectonic processes and make valid inferences about the tectonic and geodynamic evolution associated to the landscape formation processes before and after the continental collision within the Pannonian basin - Carpathian System.

One might say that the Earth structure as it is on physical/material grounds can be divided into a number of successive dependable layers, each of them with specific properties. Let us assume for a minute that the crust, the supporting life Earth external thin layer, represents a medium as in communication theory. Therefore, apart from whatever signal is transmitted through and whatever impact has to individuals and society, the medium itself through its characteristics impacts the way we acquire the signals. As the content of a new medium is an old medium (McLuhan theory), the crust itself as a medium is changing continuously while defining and impacting the contents of new media. While every new intercepted signal through this medium is changing our perception, this study changes the placement of continental boundaries throughout Earth history and the way we interpret the south-eastern Carpathians and its foreland. Effectively this thesis completes the series of previous geological and geophysical investigations and shares new data sets (densely spaced seismic, gravity and magnetic data) and inferences (geologic and tectonic) about the south-eastern Carpathians bending zone and its surrounding.

The Carpathians represent a highly arcuate orogenic belt in the central and eastern Europe. The south-eastern Carpathians were formed as the result of the Triassic to Early Cretaceous extension between the European and Apulian plates and the result of the Tertiary convergent shortening and rotations processes coeval with its foreland basin emplacement on a highly deformed complexes of plates (microplates). The research area includes the Brasov/Targu Secuiesc Basin in the

hinterland, the Vrancea zone and its orogenic wedge and the foreland Focsani Basin. The Vrancea zone represents an active seismogenic area comprising of crustal and intermediate earthquakes, with magnitudes up to 7.5 (Richter scale) that lies above a high-velocity recorded mantle anisotropy zone. The Focsani foreland Basin was developed during Middle Miocene to Quaternary by overlying two large stable platforms, the East European Platform and the Moesian Platform, separated by what is called the North Dobrogean zone.

The first part of this thesis concentrates on a deep reflection seismic survey DACIA-PLAN (Danube and Carpathian Integrated Action on Processes in the Lithosphere and Neotectonics) data analysis, modelling and interpretation. The second and third chapters consists of two independent seismic velocity modelling experiments, a tomographic inversion (the second) and a forward ray tracing (the third). The overlapping of these two chapters is obvious and it was intended within a certain limit. Each approach is independent and customized to fit the statement of each study.

The tomographic experiment is carried out using an inversion algorithm where the parameterisation and the initial velocity model represent the creative individual judgment of the modeller about the geological structure, while the modelling itself is the mathematical approximation of the visualised structure. The main tomography results show that the data accurately resolve the transition from sediment to crystalline basement beneath the Focsani Basin constraining the thickness of the basin, while beneath the external Carpathians nappes lies shallow basement material, more superficial than previously surmised on the basis of geological observations. The significant lateral structural heterogeneity (in terms of velocity anomalies) on the apparent basement surface in this area implies that the basement may be involved in Carpathian thrusting.

The ray tracing experiment is not a **per se** application of ray tracing algorithms but a modeller controlled forward exercise that integrates information from multidisciplinary sources and test them against a very dense set of seismic data. The permanent control over the model and the preferred succession of constraints gives an outcome that is geologically interpretable. This interpretation confirmed and resolved a number of partly new issues and led to new discoveries about the basement structure beneath the south-eastern Carpathian nappe stack and Focsani Basin. It was concluded that: the reverse faulting uplifts crystalline rocks or highly metamorphosed sedimentary cover to quite shallow levels and leads to the conclusion of Carpathian Vrancea Zone uplift. Also, through model mapped faults the adjacent Focsani Basin is subsiding on normal faults and flower structures. Added value to geological interpretation is the seismic activity on the traces of the inferred faults which reveals a coevally synchronous uplift-subsidence play between blocks correlatable with the larger regional Pannonian-Carpathian system topographic evolution.

The second part of the thesis focuses on the potential field data acquisition, processing and interpretation of a densely spaced gravity and magnetic survey DACIA PLAN GRAV MAN'S (Danube and Carpathian Integrated Action on Processes in the Lithosphere and Neotectonics Gravity and Magnetic Survey). The fourth chapter contains an extended presentation of the data acquisition and processing. The fifth chapter presents the gravity and magnetic data modelling and interpretation.

The gravity and magnetic modelling results and the integration with previous seismic experiments shows different crustal affinities between crustal blocks beneath the south-eastern Carpathians and its foreland. The results within the geophysical model shows a westward less dense and less magnetically susceptible block in contact with an eastward denser and more magnetically susceptible block. Furthermore, the Moesian Platform contains a sedimentary sequence that is specific to the Palaeozoic Europe but has a Precambrian metamorphosed basement that yields typical East-European geophysical signal but also areas of the Moesian Platform displays Palaeozoic metamorphism (specifically the Danubian block) that yield Palaeozoic Europe characteristic geophysical signal. Therefore, the typical geophysical contrasts and also the crustal affinities inferred in this study lead to the conclusion that the Teisseyre-Tornquist Zone is localized beneath the south-eastern Carpathians.