THE GRAVITY EFFECT OF THE SUBDUCTED SLAB BENEATH THE VRANCEA REGION, ROMANIA

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Abstract: This paper presents the results of three-dimensional gravity modelling of the subducting slab beneath the seismically active Vrancea region in south-eastern Romania. A model slab was constructed based on constraints from a preliminary seismic tomography model. The gravity effect of this slab appears to be represented in the gravity field over the foreland basin south of the southern Carpathians, and the model is consistent with a scenario in which seismicity is related to slab break-off.

Keywords: Carpathians, Vrancea, gravity, slab break-off, Romania.

Introduction

Geological and geophysical studies of the Vrancea region are driven by the existence of intense earthquake activity in a remarkably confined volume (e.g. Wenzel et al., 1999). In this region, earthquakes occurring within the depth range 70–180 km are confined to an almost vertical volume with a surface area of about 30 by 80 km (e.g. Oncescu et al., 1999). Earthquake locations also coincide with regions of fast seismic velocity in tomographic models of the Vrancea region (Wenzel et al., 1999; Martin et al., 2001).

The confined seismic activity is generally explained by models proposing Miocene roll-back of the Carpathian subduction zone that resulted in steepening and segmentation of the slab into smaller pieces (e.g. Wenzel et al., 1999). As convergence ceased, post-collisional break-off of the slab was triggered. The break migrated from north to south and each segment was progressively severed and left to sink through the mantle. Slab break-off models suggest that

the last segment of the Carpathian lithospheric slab lies beneath the Vrancea region. This segment is believed to be still attached or in the process of detaching.

The aim of this study was to investigate the three-dimensional geoid and gravity signature of the last remaining piece of the Vrancea slab and to compare this signature with observed potential field data from Romania.

Data

This study relies on geoid undulations in Romania (Figure 1a) from the EGM96 global geopotential model (Lemoine et al., 1998) and gravity data (Figure 1b) described by Ioane & Atanasiu (1998). The foreland basin to the east and south of the Carpathian mountain range dominates both the geoid and gravity field (gravity anomaly amplitude up to –120 mGal). In recent seismic tomography studies (Martin et al., 2001), the Vrancea slab was defined to 350 km depth over an area of 1000 x 1000 km centred on the Vrancea region, by a P-wave velocity difference of 2–3%.

Method and Results

Seismic velocities in the preliminary tomographic model of Martin et al. (2001) were converted to density using previously determined, pressure-dependant relationships. The effect of temperature variations is not included at this stage. With the assumption that the boundaries of the slab coincide with the 25 kg/m^3 density contrast contour, a series of east–west cross-sections were constructed through the Vrancea region and subsequently included in the IGMAS potential field modelling software (e.g. Schmidt & Götze, 1998). A three-dimensional body representing the Vrancea slab was generated in IGMAS by triangulating between each of these cross-sections. The resulting body (Figure 2) extends to a depth of 350 km (the maximum depth extent of the tomography model), is elongate in a NE–SW direction and, at mid-depth, has a thickness of about 100 km. The top of the slab lies at greater depth in the NE, which is consistent with slab break-off models in which detachment progresses from N to S.

The geoid anomaly caused by the model slab is shown in Figure 1c and its gravity effect is shown in Figure 1d. The predicted gravity effect of the model slab reaches about 20 mGal and

the predicted geoid anomaly about 5 m. The peak gravity anomaly predicted for the slab coincides with a saddle in the E–W-trending gravity anomaly pattern associated with the foreland basin south of the southern Carpathians. Both predicted geoid and gravity anomaly patterns are circular in shape (despite the seismically-defined NE–SW trend of the Vrancea slab) and are offset to the SW of the main zone of Vrancea seismicity. The shape discrepancy reflects the depth of the mass-excess causing the anomalies, and the offset suggests that earthquake activity is mainly associated with a smaller mass-excess in the NE, presumably where the slab is most-rapidly stretching.

Conclusions

The effect of the mass excess associated with the Vrancea slab appears to exert a small influence on the gravity anomaly pattern of the southern Carpathian foreland basin system. The offset between the mass-excess of the Vrancea slab and the main zone of seismicity is consistent with a scenario in which the NE part of the slab is stretching, or has broken off, thereby distributing the slab mass-excess to greater depths within the mantle. Towards the SW, where the slab is still attached but probably continuing to break-off, the mass-excess of the slab is closer to the surface and, therefore, dominates the gravity anomalies associated with the Vrancea slab.

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References

Ioane, D. & Atanasiu, L. (1998), Gravimetric geoids and geophysical significances in Romania, *in* Ioane, D., Monograph of Southern Carpathians, Reports on Geodesy **7**, Institute of Geodesy and Geodetic Astronomy, Warsaw University of Technology, Warsaw, Poland, pp157–175.

Lemoine, F. G. et al. (1998), The development of the joint NASA GSFC and the National Imagery and Mapping Agency (NIMA) geopotential model EGM96, National Aeronautics and Space Administration, NASA/TP 1998-206861.

Martin, M., Wenzel, F., Achauer, U., Kissling, E., Mocanu, V., Musacchio, G. & Radulian, M. (2001), High-resolution images of a slab detachment process, submitted to *Seismological Research Letters*.

Oncescu, M. C., Marza, V. I., Rizescu, M. & Popa, M. (1999), The Romanian earthquake catalogue between 1984–1997, *in* Wenzel, F., Lungu, D. & Novak, O., *Vrancea Earthquakes: Tectonics, Hazard and Risk Mitigation*, Kluwer Academic Publishers, Dordrecht, Netherlands, pp43–47.

Schmidt, S. & Götze, H.-J. (1998), Interactive visualisation and modification of 3D models using GIS functions, *Physics and Chemistry of the Earth*, **23**(3), 289–295.
Wenzel, F., Lorenz, F. P., Sperner, B. & Oncescu, M. C. (1999), Seismotectonics of the Romanian Vrancea area, *in* Wenzel, F., Lungu, D. & Novak, O., *Vrancea Earthquakes: Tectonics, Hazard and Risk Mitigation*, Kluwer Academic Publishers, Dordrecht, Netherlands, pp15–25.

Figure 1: (a) EGM96 geoid (to degree and order 360) and (b) Bouguer anomalies in Romania. (c) Predicted geoid and (d) gravity anomalies resulting from the seismically-defined excess mass of the Vrancea slab. Dashed lines show international borders, the star marks the approximate centre of Vrancea earthquake activity. Geoid heights are shown in metres, gravity values in mGal.

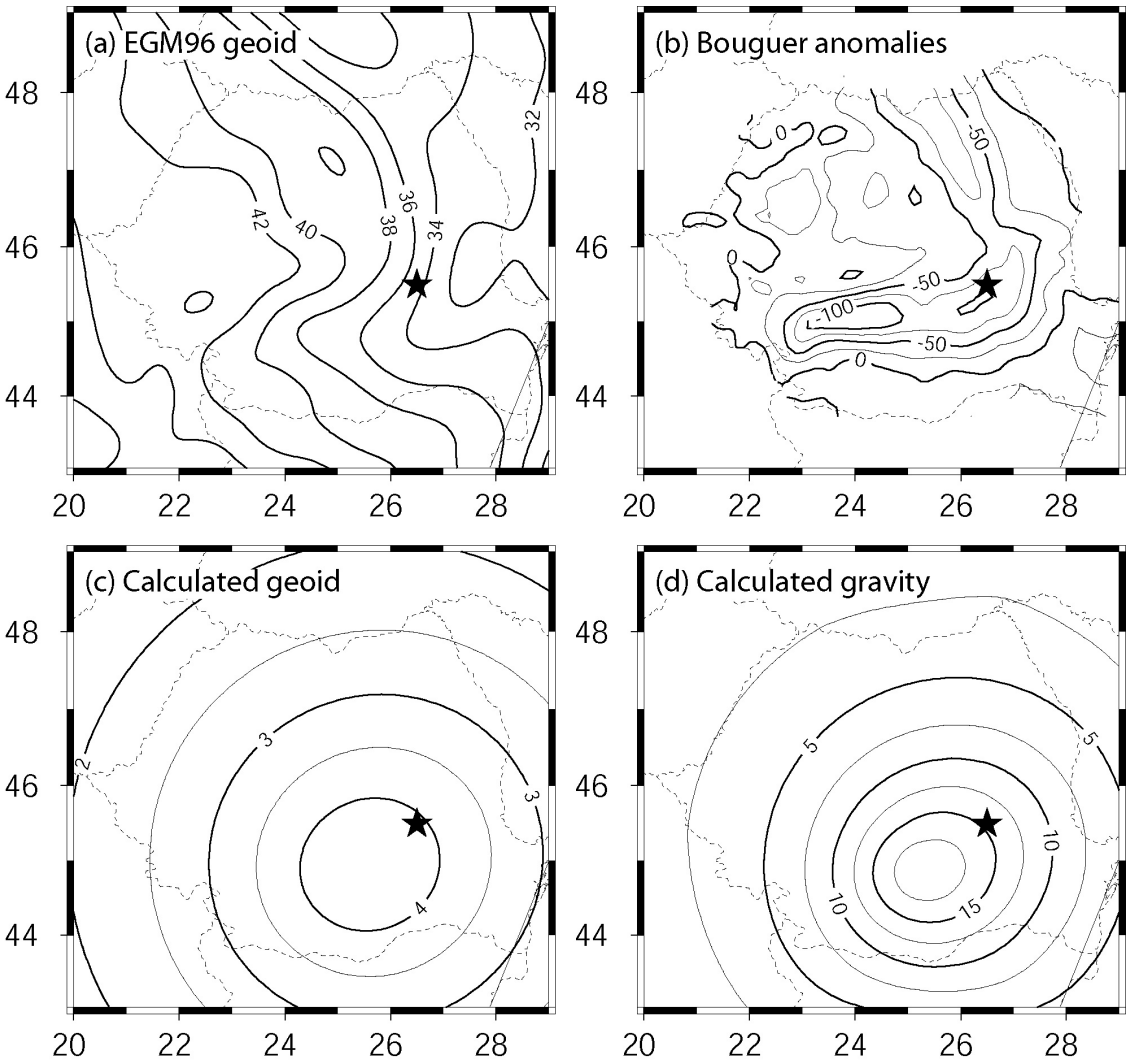

Figure 2: Three-dimensional images of the model Vrancea slab viewed toward the NW (left) and SE (right). The slab in this image extends to a depth of about 350 km.