Young Tectonics of the Orava Basin and Southern Magura Nappe, Polish Western Carpathians, in the Light of Gravity Studies: A New Research Proposal

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The Department of Geophysics, AGH University of Science and Technology in Kraków initiated in 2004 a new research proposal, the aim of which is to compare the results of studies throughout the Polish segment of the Western Outer Carpathians showing differentiated young tectonic movements. It is a multidisciplinary project; analysis of young crustal movements will be conducted basing on the results of three years long gravimetric, geodetic, geological and morphostructural studies. The problem consists in quantitative interpretation of the obtained gravimetric results, i.e. in combining temporal gravity changes with those of geodynamic crustal processes.

From the geodynamic point of view, the Orava-Nowy Targ Basin is an extremely interesting structure. This is a bi-partite basin, formed in Miocene time and superimposed on structural units that build the contact between the Inner and Outer Carpathians, namely: the Central Carpathian Palaeogene Basin, Pieniny Klippen Belt, and Magura Nappe. The maximum drilled thickness of sedimentary infill of the Orava Basin is 950 m, including 922 m of fresh-water Neogene molasses (Watycha 1976). The thickest Quaternary sediments (117 m) are confined to the Wróblówka Trough, in the northern part of this basin.

The Orava Basin is a tectonic trough which is bounded to the north and south by a system of longitudinal normal faults of throws up to a few hundred metres. These are cut by several transverse, mostly strike-slip faults that are oriented NNW-SSE and NE-SW (Pomianowski 1995, 2003). The basin-bounding faults became reactivated in Quaternary times (cf. Baumgart-Kotarba 1996), and their recent activity is indicated by earthquakes of magnitudes up to 4.3 (Guterch et al. 2005).

Our studies concentrate along a ca. 40-km-long, N-S trending, transect: Dzianisz–Czarny Dunajec–Wróblówka–Spytkowice–Wysoka, which cuts the contact between the Inner and Outer Carpathians, showing contrasting tendencies of young (Pliocene-Quaternary) tectonic movements. The Wróblówka Trough, situated in the medial segment of the transect, reveals Late Pleistocene and Holocene subsidence, while the southern portion of the Magura Nappe, in the northern portion of the transect, displays minor uplift. The location of stationary points was selected in such a way that each of them represents a different structural unit (Central Carpathian Palaeogene, Pieniny Klippen Belt, Orava Basin, Krynica and Bystrica subunits of the Magura Nappe). The construction of individual benchmarks enables for both gravity and geodetic measurements.

Gravity surveys across the profile will be carried out at yearly intervals. The choice of such methodology results from the fact that we want to study changes of the gravity field statistically, taking into account the expected small values of temporal anomalies of the gravity field and, first of all, their changes with time.

In July 2004 and July 2005, the first and second series of gravity measurements were made at fixed benchmarks of the profile, using three gravimeters (two CG-3 SCINTREX, and one La Coste & Romberg). Errors were calculated after each series. The calculation error was determined for each gravity value between the stations and for the average gravity value. The measurement precision was ca. 0.01 mGal, or 0.005 mGal during cycling measurement. An analysis of errors showed that in several cases only, i.e. for the measuring date, the error was larger than 0.005 mGal, and the overall error credibility limit attained a value of 0.01 mGal.

The average gravity error has a little bigger value, although not exceeding 0.01 mGal. This maybe a result of too small a number of gravimeters used. Therefore, the temporal gravity analysis will be done basing on gravity measurement values for each gravimeter, and not for the average gravity value.

The first measurement series made in July 2004 is a base series, to which measurements of successive series will be referred. Additional measurements were conducted at points situated 1 km apart along the profile steps. These results, combined with geological data, will be used in gravity modelling aiming at determining mutual connections between gravity anomalies and geological structures. This modelling will also be helpful in describing the source of changes of the gravity field. The second measurement series, conducted in July 2005, enables for the first comparison between gravity changes measured in 2004 and 2005. The determined trend will be verified by successive measuring campaigns.

A series of earthquakes occurred in the Orava Basin in November 2004, pointing to recent tectonic mobility of this area. Hence, changes of the gravity field observed between July 2004 and July 2005 appear to be particularly interesting.

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Structural Position and Metamorphism of Peridotite and Eclogite Bodies within Granulite in the Bestvina Unit, Bohemian Massif

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The Bestvina unit represents the westernmost part of the Kutná Hora crystalline complex and occurs in the central part of the Bohemian Massif. It tectonically overlies the Varied group of the Moladnubian domain in the SW and consists mainly of retrogressed felsic granulites, biotite gneisses, migmatites and several small isolated bodies of peridotite and eclogite (Pouba et.al. 1987, Synek and Oliveriová 1993). Two different deformation planar fabrics have been recognized during field works in the Bestvina unit. The older F_1 fabric has been observed in coarse-grained and weakly retrogressed granulites and in eclogites. It is parallel to layers of olivine and garnet-bearing pyroxenite occuring in peridotites. This planar fabric strikes NE-SW and dips under steep angles to NW or SE. Isoclinal fold of the F_1 fabric has been observed inside the eclogite body having steep axial plane striking SW-NE and subhorizontal fold axis. A younger F_2 fabric is extensively developed in the majority of the unit, where F_1 fabric is preserved in the low-strain domains only. The F_2 fabric moderately dips towards ENE to NE and it is developed in retrogressed and mylonitized granulites and migmatites. The mylonitic foliation F_2 is parallel to the foliation observed in paragneisses of the Varied group below the Běstvina unit.

Detailed petrological study has been carried out on ultramafic and eclogite bodies near Spačice and on peridotite at Doubrava and Úhrov in order to constraint PT conditions of the studied rocks. The Spačice eclogite forms ca 60 m long sigmoidal lens that occurs within retrogressed granulite. The original metamorphic assemblage of eclogite consists of omphacite, garnet, kyanite and rutile. Two textural and compositional varieties of garnet and of clinopyroxene are present in this eclogite. The eclogite facies garnet – Gr I (Py_{36}, Grs_{34}, Alm_{28}) contains rutile inclusions and associates with omphacite Cpx- I (Jd_{29}). Omphacite in some samples is characterized by the presence of quartz rods that usually occurs in ultrahigh-pressure metamorphic rocks. Garnet I is partly replaced by Al-rich clinopyroxene (Cpx II) and anorthite. A new Ca-rich garnet Gr-II (Py_{10}, Grs_{65}, Alm_{23}) that forms either individual grains or rims of the coarse-grained eclogite facies garnet, indicate textural equilibrium with Al-rich clinopyroxene and plagioclase. There is a sharp compositional jump with a very weak diffusion profile between these two garnet varieties. Mn content is low in both garnet, but the Ca-rich garnet has relatively higher Mn, suggesting decomposition of older garnet. Small amount of tschermakitic amphibole replacing Ca-rich garnet is also present. The Doubrava peridotite forms ca 40 m wide lens-shaped body surrounded by coarse-grained and retrogressed granulites. Within the peridotite body, there is small body of garnet rich eclogite, and olivine and garnet-bearing pyroxenites. Pyroxenites form up to 30 cm wide parallel oriented and steeply dipping layers providing primary anisotropy of peridotite body. The garnet peridotite has relicts of olivine, orthopyroxene, clinopyroxene, spinel and rarely of amphibole. Chromium-rich spinel forms inclusions in garnet and in clinopyroxene. Compositional maps indicate progressive formation of garnet after spinel. Garnet is rich in Mg (Py_{69},$Grs_{11}Alm_{18}$) and forsterite content in olivine is about 93 mol %. Clinopyroxene is diopside with X_{Mg} = 0.9. Orthopyroxene with X_{Mg} = 0.8 has Al_2O_3 about 1.7 wt.%. Spinel corresponds to Al-chromite with composition of $Mg_{0.54}Fe_{0.47}Al_{0.73\text{-}1.0}Cr_{0.8\text{-}1.19}O_8$. The eclogite within garnet peridotite has relatively high-Mg garnet (Py_{42}, Grs_{34}, Alm_{22}) and omphacite with Jd_{30}. Similar to eclogite from granulite, garnet is replaced by Al-rich clinopyroxene and anorthite ± amphibole and kyanite by anorthite, spinel and locally clinopyroxene. Garnet contains rutile needles that mostly have parallel orientation. The Úhrov peridotite is poorly outcropped and does not provide any strain features in the field our analyses showed its textural and mineralogical similarity to the Doubrava petridotite. Maximum PT conditions of ~4 GPa at 700 °C were calculated for Spačice eclogite as well as for eclogites inside the Doubrava and the Úhrov peridotites. Garnet peridotites reveal pressure conditions similar to eclogite but at high temperature of about 1000 °C. Textural relations and chemical composition in all rock types, but mainly the presence of Ca-rich garnet in eclogite, suggest that decompression was followed by rapid cooling.

Field structural data suggest that peridotites penetrate granulites during large scale folding of coarse-grained granulites along steep axial plane striking SW-NE. Pyroxenite layers provide very likely compositional as well as mechanical anisotropy in peridotite that helped to dismember mantle rocks to small bodies during variscan exhumation. However, PT estimated form peridotites, eclogites and granulites (Medaris et. al. 1995, Medaris et.al. 1998) show large disagreement between each oth-