Three-dimensional depth-to-basement modelling based on seismic and potential field data – basement configuration in the westernmost Polish Outer Carpathians

Mateusz Mikołajczak* Jan Barmuta **, Małgorzata Ponikowska*, Stanisław Mazur*, and Krzysztof Starzec**

* Institute of Geological Sciences, Polish Academy of Sciences, Senacka 1; 31-002 Kraków, Poland (m.mikolajczak@ingpan.krakow.pl)

** AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, Kraków, Poland

Introduction & Geological setting

The Precambrian crystalline basement of the westernmost Polish Outer Carpathians is one of the least-recognized aspects of the structure of these mountains. Generally, archival boreholes do not reach the top of the crystalline basement, and geophysical surveys have rarely been focused on identifying the basement architecture. Therefore, the main purpose of the study is to use good gravity and magnetic data coverage to map basement structure and depth, and identify possible fault patterns in the potential field data.

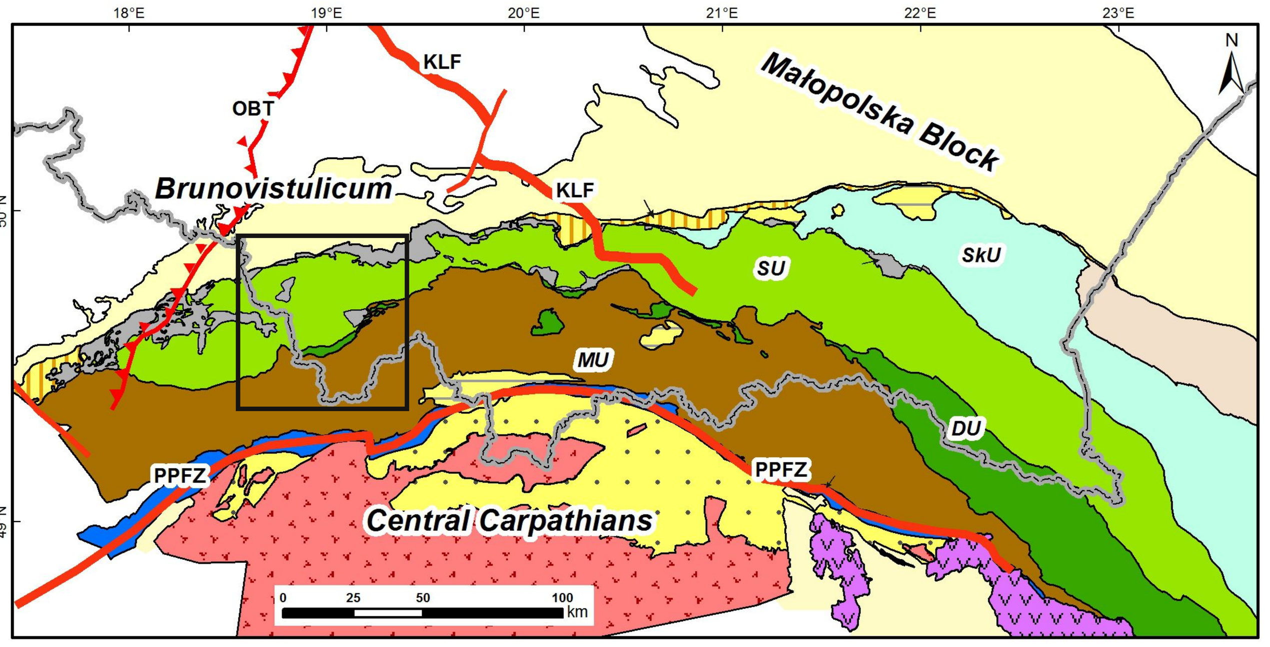


Fig.1 Simplified geological map of the research area. Inset: MU – Magura Unit, DU – Dukla Unit, SU – Silesian Unit, SkU – Skole Unit, PPFZ – Peri Pieniny Fault Zone, OBT – Orłowa-Boguszowice Thrust, KLF – Kraków-Lubliniec Fault. The black rectangle indicate research area.

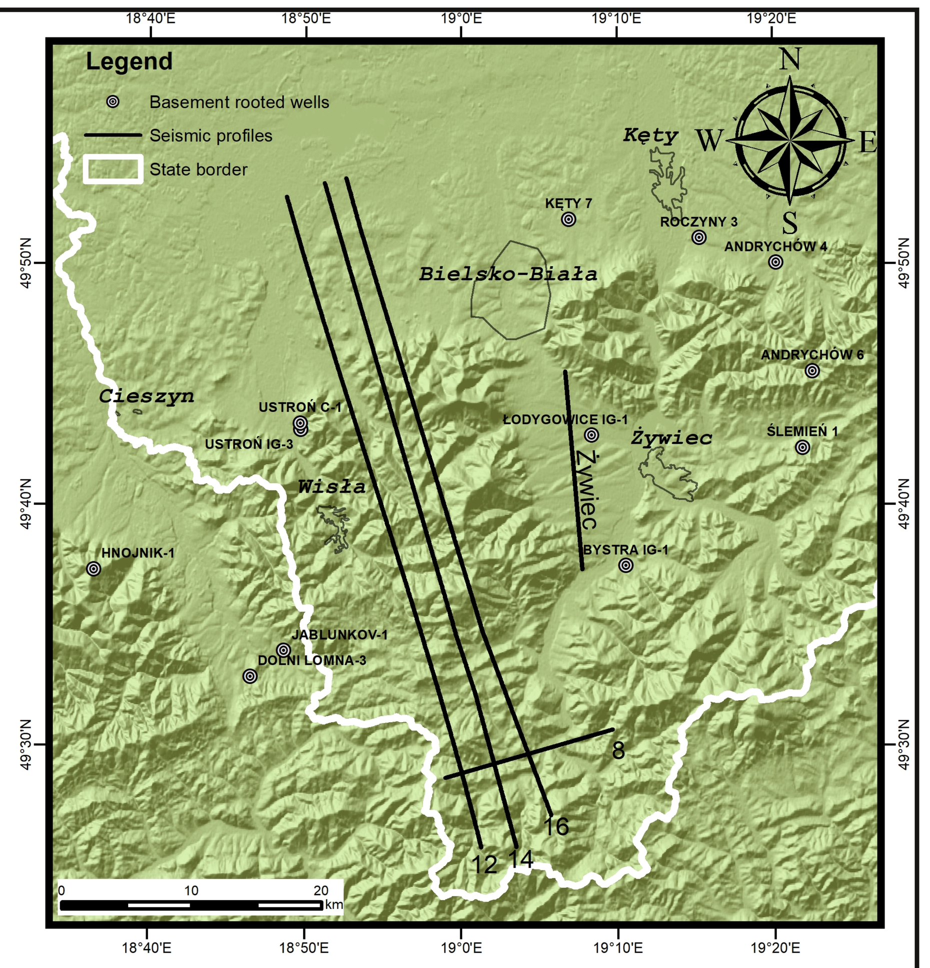


Fig.2 Location of the study area overlaid on the terrain map (STRM30 Plus). The map shows boreholes and regional cross-sections (black line) that were used in this study. Projection: Poland CS92 – Transverse Mercator.

3D Gravity Inversion

A first step of the modelling workflow was to calculate a gravity response from upper mantle that is constrained from top by Moho. As input gravity data a Bouguer grid has been used with a grid pitch of 0.5km. Reduction density applied for the terrain correction of gravity data was 2.67 g/cc. A forward model was calculated using upper mantle density of 3.3 g/cc and a density contrast across Moho assumed at 0.25g/cc. The modelled gravity response from upper mantle was then subtracted from the total gravity signal. The gravity residual obtained (Fig. 6) should ideally represent a gravity signal generated by crystalline crust and sedimentary cover.

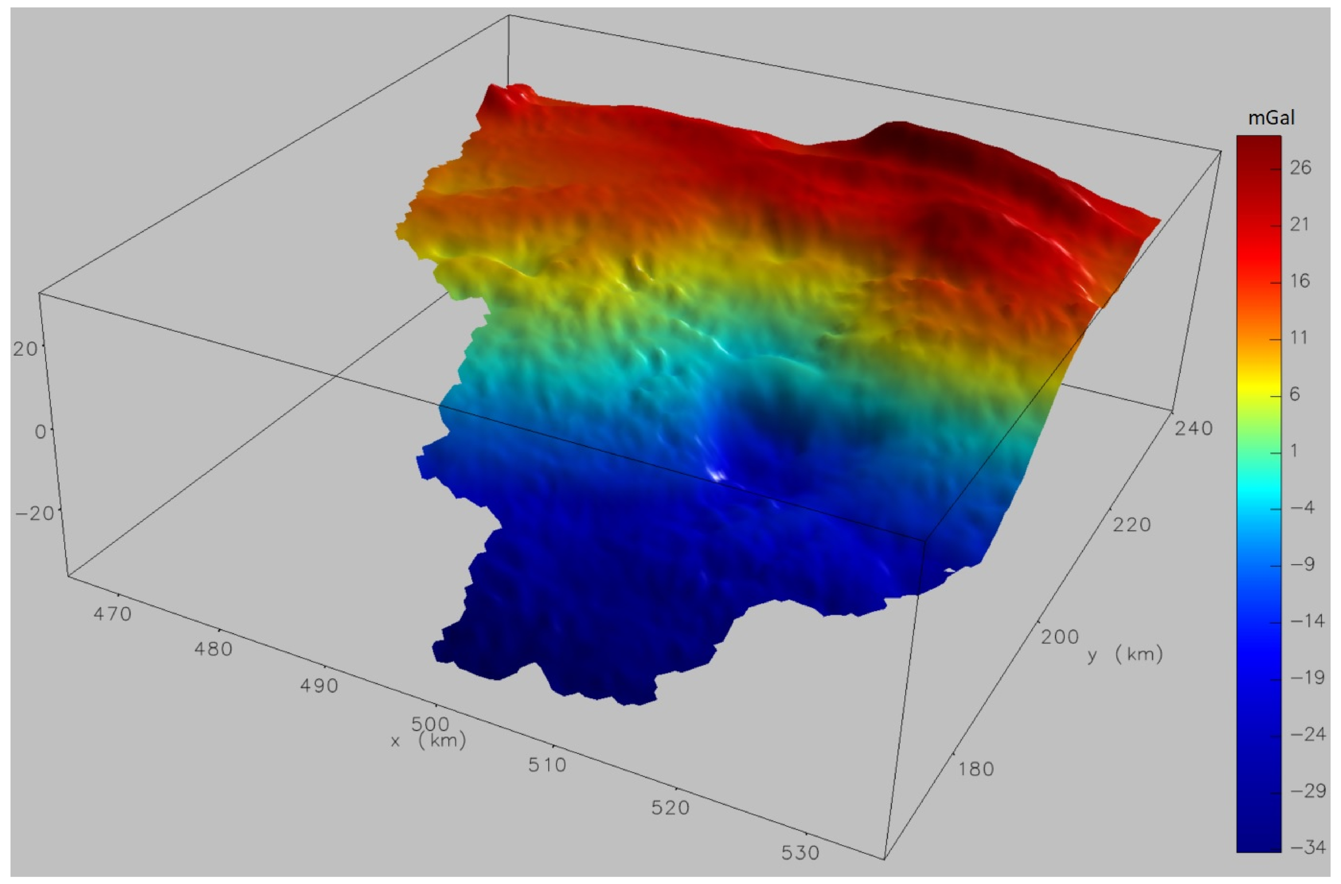


Fig.6 Gravity residual obtained after removing the modelled response of upper mantle from a total gravity signal.

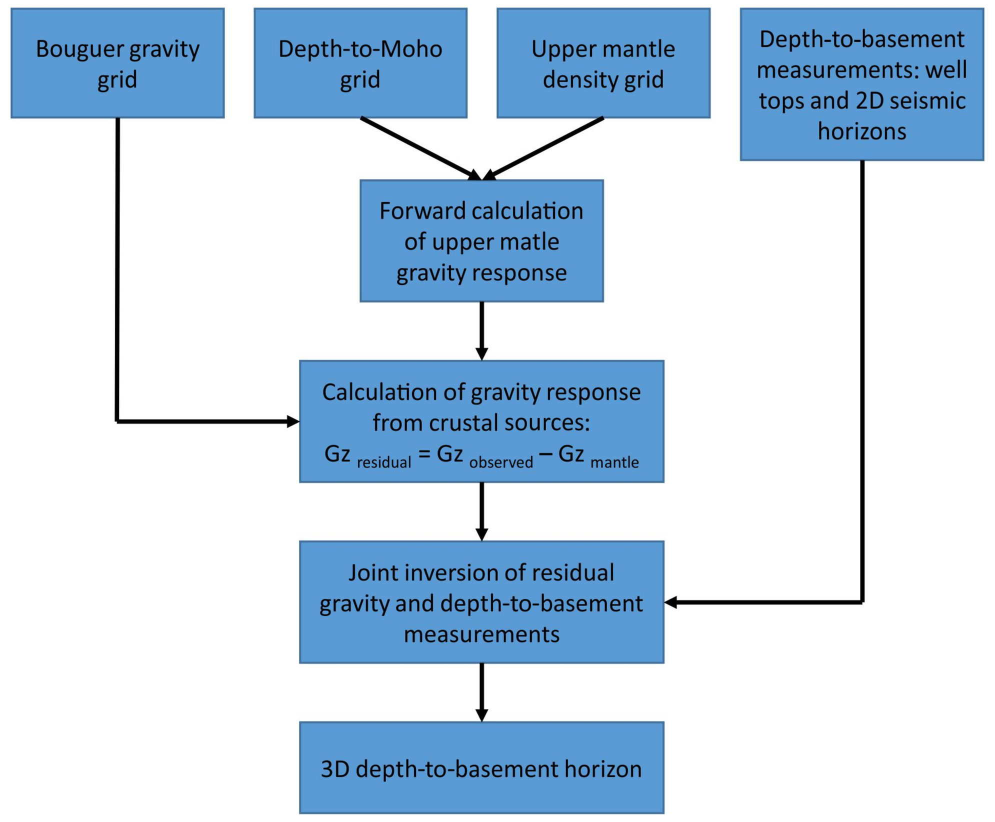


Fig. 5. Three-dimensional gravity inversion workflow diagram.

Qualitative Interpretatin

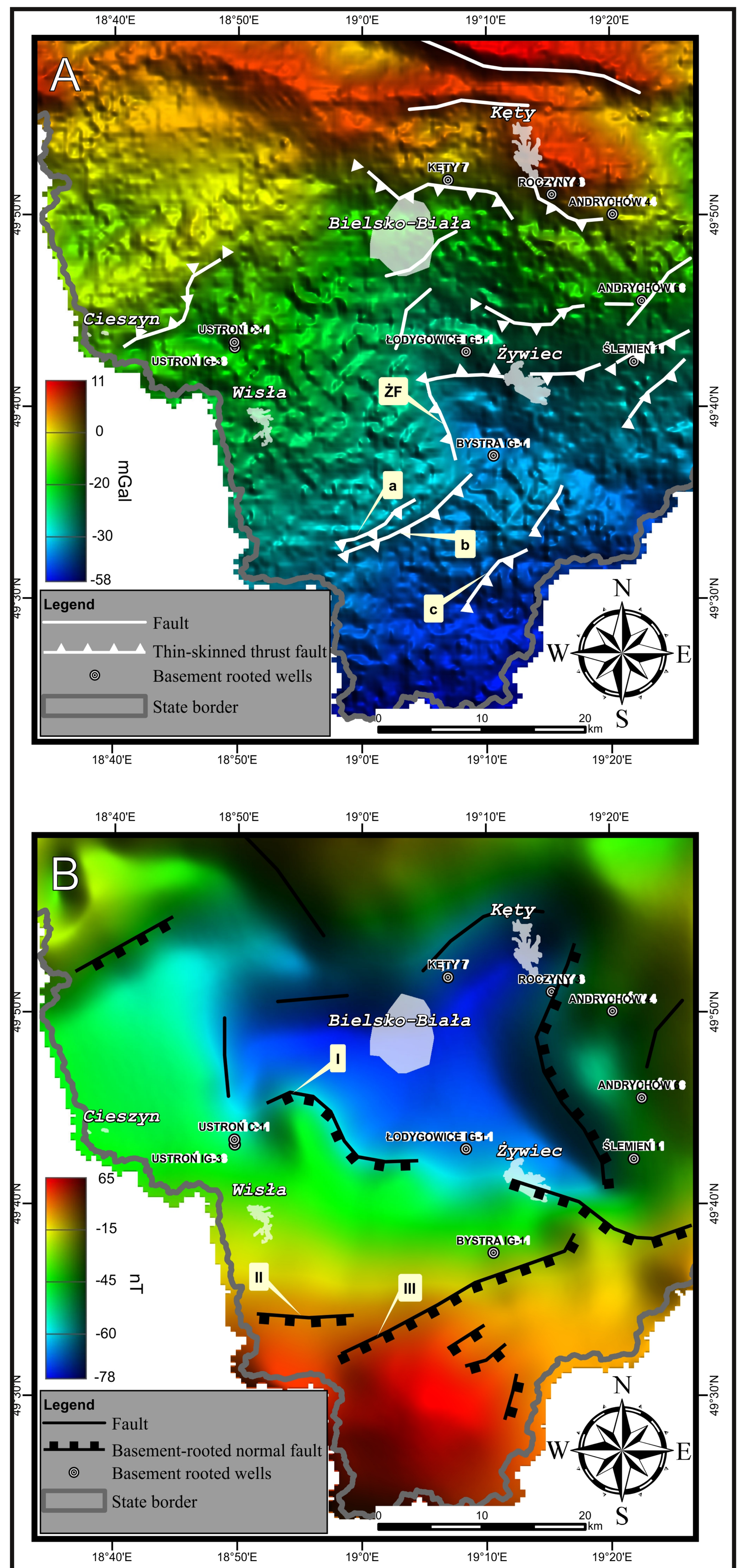
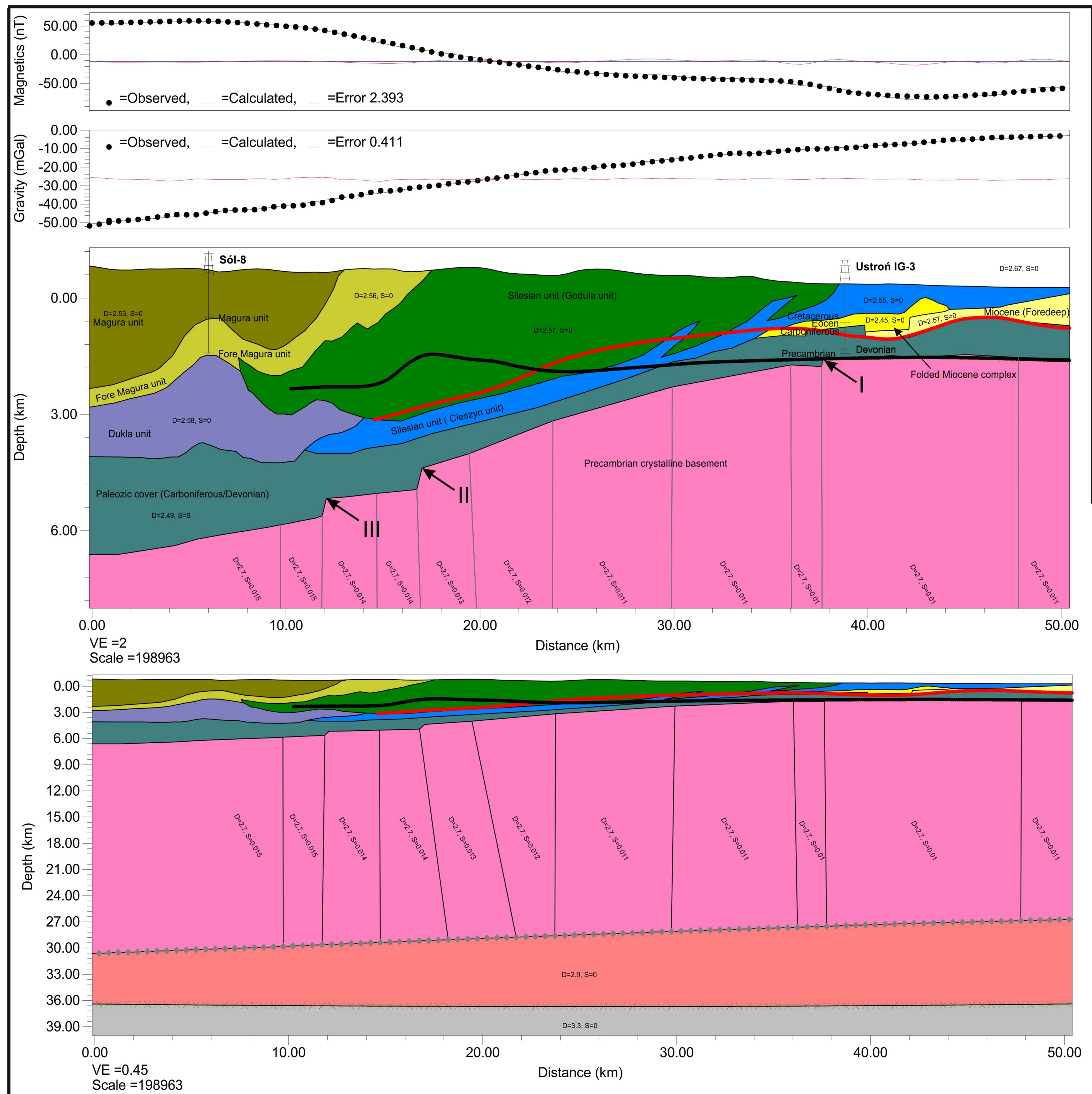


Fig. 3. Key structural elements of the study area overlaid on: Bouguer anomaly map (A) and (B) Reduced-to-Pole (RTP) magnetic anomaly map filtered by 2 km low pass filter.

Quantitative Interpretation



Layer/block	Density (g/cc)	Susceptibility (cgs)
Magura unit	2.53	0
Foremagura unit	2.56	0
Dukla unit	2.58	0
Silesian unit (Godula unit)	2.57	0
Silesian unit (Cieszyn unit)	2.55	0
Folded Miocene complex	2.45	0
Miocene (Foredeep)	2.57	0
Paleozoic cover (Carboniferous/ Devonian)	2.49	0
Precambrian crystalline basement	2.7	0.01-0.015
Lower Crust	2.9	0
Upper Mantle	3.3	0

Tab.1 Colour patterns of stratigraphic subdivisions used in geological models of Figure 6 and the values of density and susceptibility used in modelling.

Fig.4 Two-dimensional gravity and magnetic forward model along seismic line 12 (fig. 2.). Upper part of the figure shows gravity and magnetic data. Dotted lines and solid black lines signify observed and modelled, respectively. Red hair line means magnitude of error. Middle and lower parts of the figure shows upper part of the geological model and full geological model, respectively. The colours has been decrypt in the table 1. Abbreviations means: D – densities in g/cm3; S – susceptibilities in cgs units; VE – vertical exaggerations. Signs I, II and III indicates the same structures as on Fig. 3B. Red and black bold lines represents the top of consolidated basement (Paul et al., 1996) and top of the pre-Permian Paleozoic and Precambrian basement (Buła & Habryn, 2008), respectively. Grey marks and green 'X' signify lower crust and Moho horizons, respectively, derived from joint results of refraction surveys.

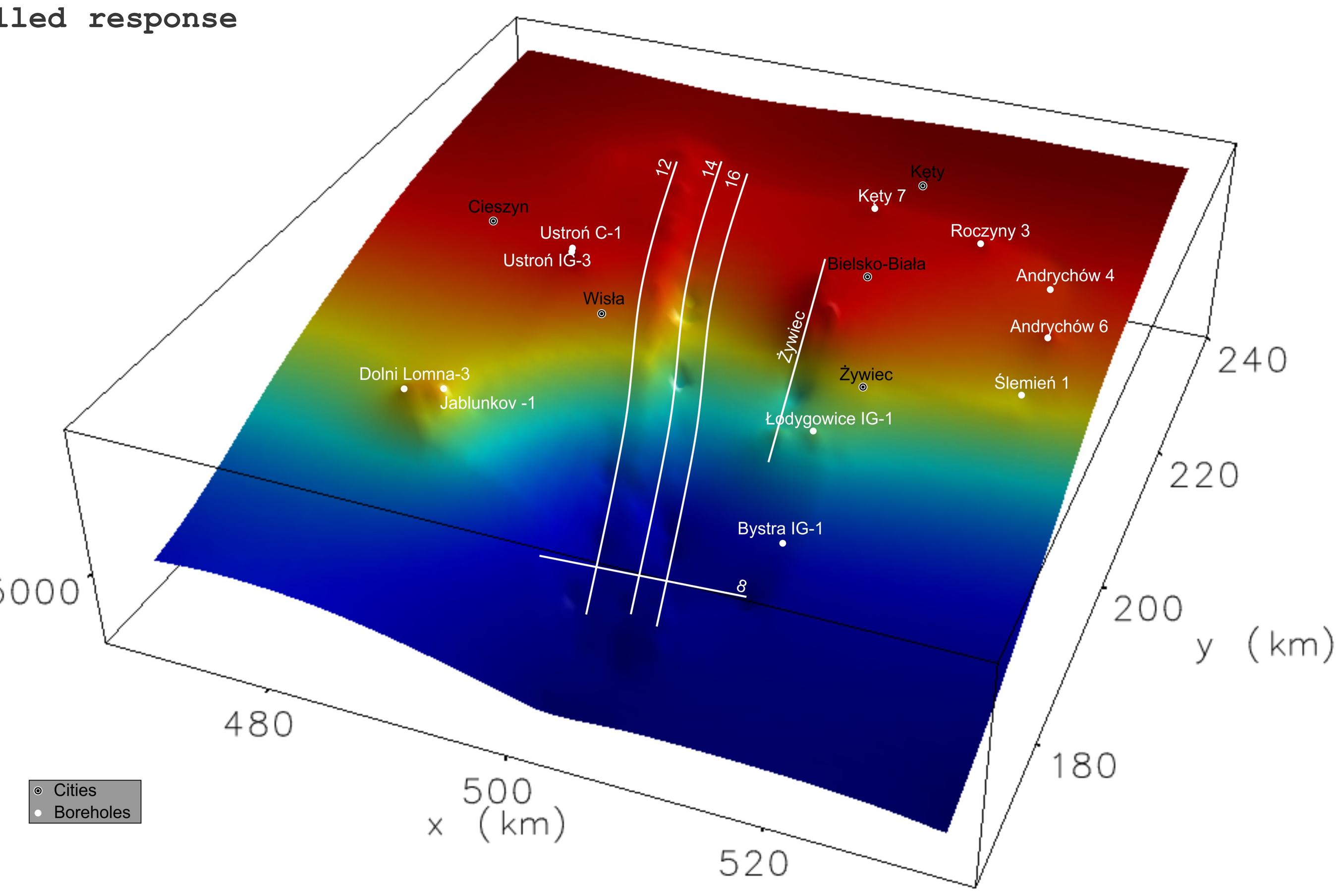
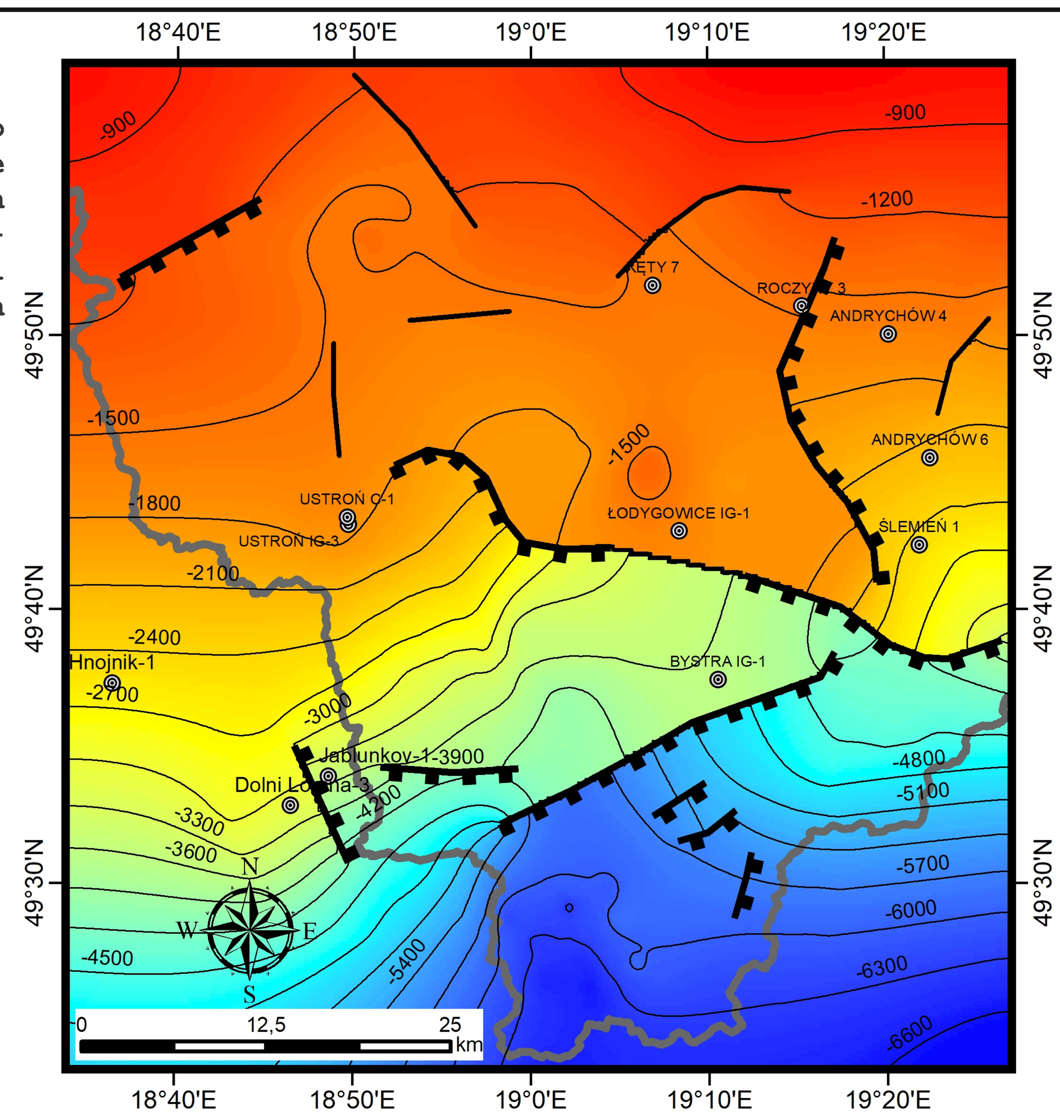


Fig.7 Perspective view of the depth to crystalline basement derived from three-dimensional joint inversion of gravity, borehole data and the 2-D horizon from the 12, 14, 16, 8 and Żywiec model. The root-mean-square (RMS) deviation describing the fit of the model is 3.25.

Fig.9 Depth to Precambrian crystalline basement together with interpreted basement-rooted structural elements and isobath contour lines.



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Paul Z., Ryłko W. & Tomaś, A. 1996: Influence of tectonic of the consolidated basement of the Carpathians on distribution of flysch masses in the Polish part of the Western Carpathians, Geological Quarterly, 40(4), 487-500.

Acknowledgements

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