INTERPRETATION OF THE FLYSCH COVER STRUCTURE BASED ON MAGNETOTELLURIC DATA – EXAMPLES OF SIEKLÓWKA–NAWSIE AND DOMARADZ–ALBIGOWA CROSS–SECTIONS (POLISH OUTER CARPATHIANS)

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Abstract: An attempt at applying magnetotelluric data to structural interpretation of the flysch cover along two semi-detailed profiles in the Polish Outer Carpathians is described. Surface geological maps, borehole data, and results of 1-D inversion of MT sounding data were employed in interpretation. Resistivity distributions in a geological medium was combined with lithological and stratigrafic data using results of the interpretation of parametric soundings made close to deep drillholes.

Key words: Outer Carpathians, flysch cover, magnetotellurics, structural interpretation

Introduction

The recognition of the deep geological structure of flysch complexes in the Carpathians is a rather difficult problem since it involves intensive tectonic deformation and a specific distribution of lithofacies. The combination of these factors results in extremely inhomogeneous and anisotropic distribution of physical parameters describing the geological medium and, on the other hand, in a frequent lack of contrast of those parameters at stratigraphic and tectonic boundaries. Such situation is extremely inconvenient for the surface geophysical survey because the obtained patterns of physical parameter distribution is difficult to interpret and physical boundaries of the medium are often not concordant with the tectonic and stratigraphic boundaries .

Surface geophysical methods used to solve such problems include the magnetotelluric method which is based on the analysis of variations of the Earth's natural electromagnetic field and uses a model of a plane electromagnetic wave in mathematical description of its propagation in a geological medium. A classic low-frequency modification of this method was widely applied to the recognition of the Carpathian basement structure (Święcicka-Pawliszyn, Pawliszyn 1978, Jankowski et al. 1991, Ryłko, Tomaś 1995, Miecznik et al. 1996, Stefaniuk 1995, 2001, Żytko 1997) but it is not sufficiently accurate to investigate the flysch units. This was changed in 1997 when the Geophysical Exploration Company, Warsaw, started the high-frequency magnetotelluric survey (Stefaniuk at al. 1998a). During 1998-2001 semi-detailed magnetotelluric surveys, financed by the Polish Oil and Gas Company S.A., were made in the Kamienica Dolna - Gogołów and Hermanowa – Strzyżów areas (Fig.1). A relatively great number of measurement sites allows an attempt of interpretation of structures of the flysch cover to be made. It was made for the Sieklówka – Nawsie and Domaradz – Albigowa cross-sections, located close to a few deep boreholes, thus allowing geophysical data to be geologically verified.

Methodology of investigation

Magnetotelluric sounding sites were spaced about 1.5 km. Data registration and data processing were made with the use of MT-1 system produced by the Electro-Magnetic Instruments Inc. Investigation methodology developed for the Carpathian region was employed in field works (Stefaniuk et al. 1998b). Data processing gave magnetotelluric sounding curves which created the basic set for further data interpretation. The program for 1-D automatic LSQ inversion included to the MT-1 system was applied to magnetotelluric sounding data interpretation (MT-1 Operation Manual). The input model for inversion was prepared based on geological and geophysical borehole data and preliminary geological cross-sections constructed with the use of surface and borehole data.

The next stage in interpretation was the construction of a structural cross-section which included results of 1-D MT-soundings inversion, preceded by the analysis of resistivity distribution of distinguished litostratigraphic complexes in boreholes. Results of interpretation of parametric sounding data were used to evaluate relationships between lithology and stratigraphic data and resistivity distribution. Some general rules were established based on analysis of resistivity distribution along borehole profiles. Generally, the resistivity of flysch complexes decreases with depth. Maximum resistivity values and maximum resistivity diversification are observed in the Silesian Unit, while the minimum values and the lowest diversification in the Skole and Stebnik Units. As far the stratigraphic complexes are concerned, maximum resistivity and highest resistivity differentiation are observed in Oligocene formations, while minimum resistivity and its lowest differentiation - in Lower Cretaceous and Miocene sediments. Low resistivity values are characteristic of sediments of the autochthonous Miocene as well as paraautochthonous and transgressive ones.

It must be emphasized that resistivity boundaries between tectonic or stratigraphic units are usually not distinct and are rather connected with the general lithology differentiation. Geoelectric methods, including the high-frequency magnetotellurics, recognize the main lithology differentiation of flysch complexes which are reflected in the resistivity changes. The other problem is the tectonics of a geological medium. The flysch cover with intense tectonic deformations is usually characterized by strongly anisotropic resistivity distribution. The identification of individual geological structures is conditioned on relations of their dimension, depth of burial, and resistivity contrast.

Interpretation results

Structural cross-sections were constructed based on the analysis of resistivity distribution and the lithology and stratigraphy data (Fig.2). The magnetotelluric results are generally in accordance with structures hitherto known from surface geology and boreholes. Within the Scole Unit it is possible to distinguish three parts. The northern one is built of several steep thrust folds that became more flat near the main Carpathian overthrust. The central part, south of the Kielnarowa-1 borehole (Dynów and Niebylec folds), is characterised by more flat structures, secondary folded and faulted, probably with internal disharmonic structures or/and internal sub-horizontal thrusts as results of borehole Hermanowa-1 show. The inner part, in front of the Silesian and Sub-Silesian overthrusts, is built of more narrow and steep folds what is suggested by data from Przysietnica IG-1 borehole situated further to SE. In that part the conformity between magnetotelluric data and geology is lower than in the other parts of the Scole Unit. Further to south, beneath that overthrust, the structures became more flat and gently folded. The local unconformity between geological and magnetotelluric data within the Scole Unit is probably partly due to the facial changes of local physical properties of rocks and internal tectonics. The run of the Silesian and

Sub-Silesian overthrusts shows a good conformity between the magnetotelluric and geological data. That overthrust is relatively steep near the surface, becomes more flat in deeper, southern part and obliquely cuts structures of the Scole Unit.

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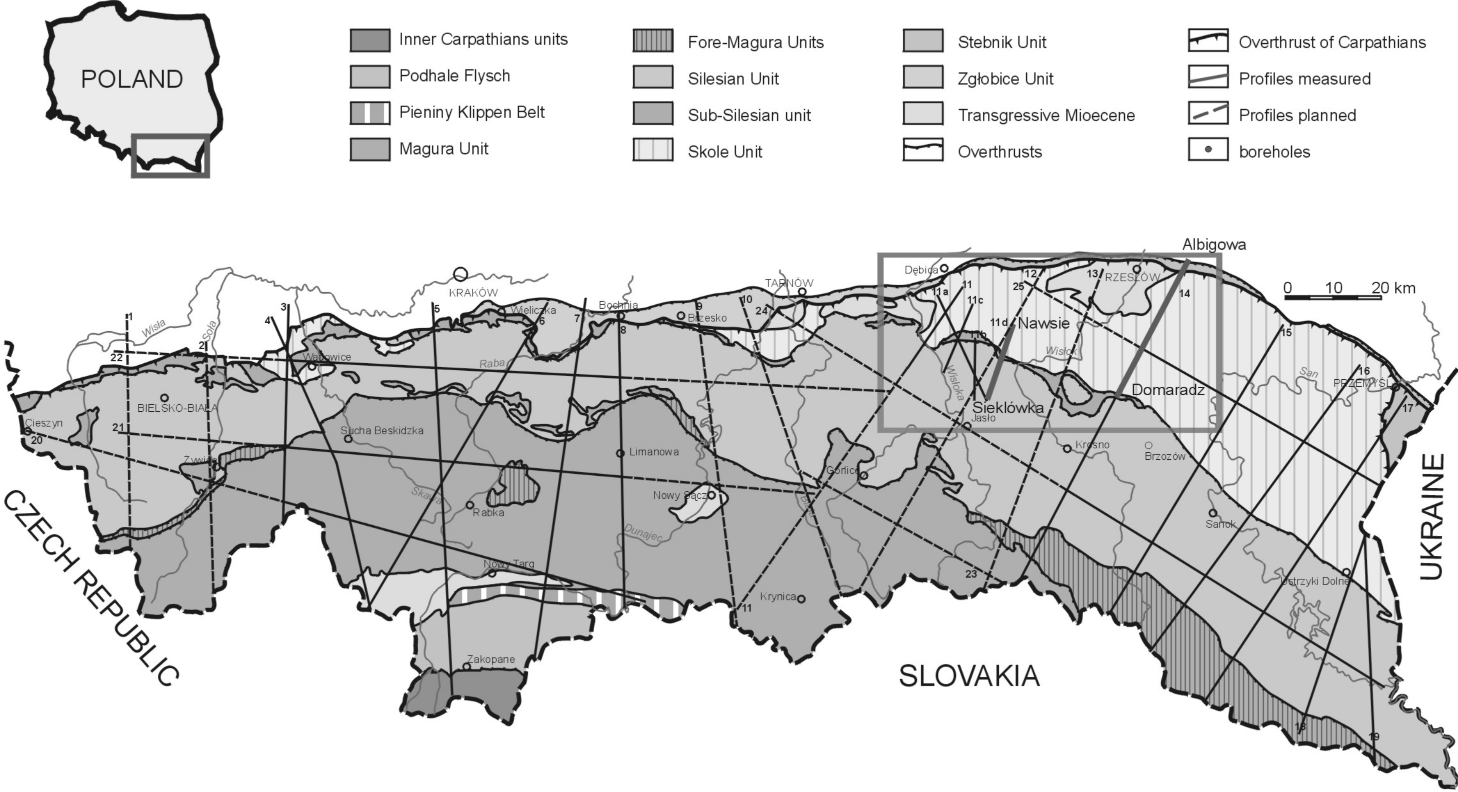

Fig. 1. Study area.

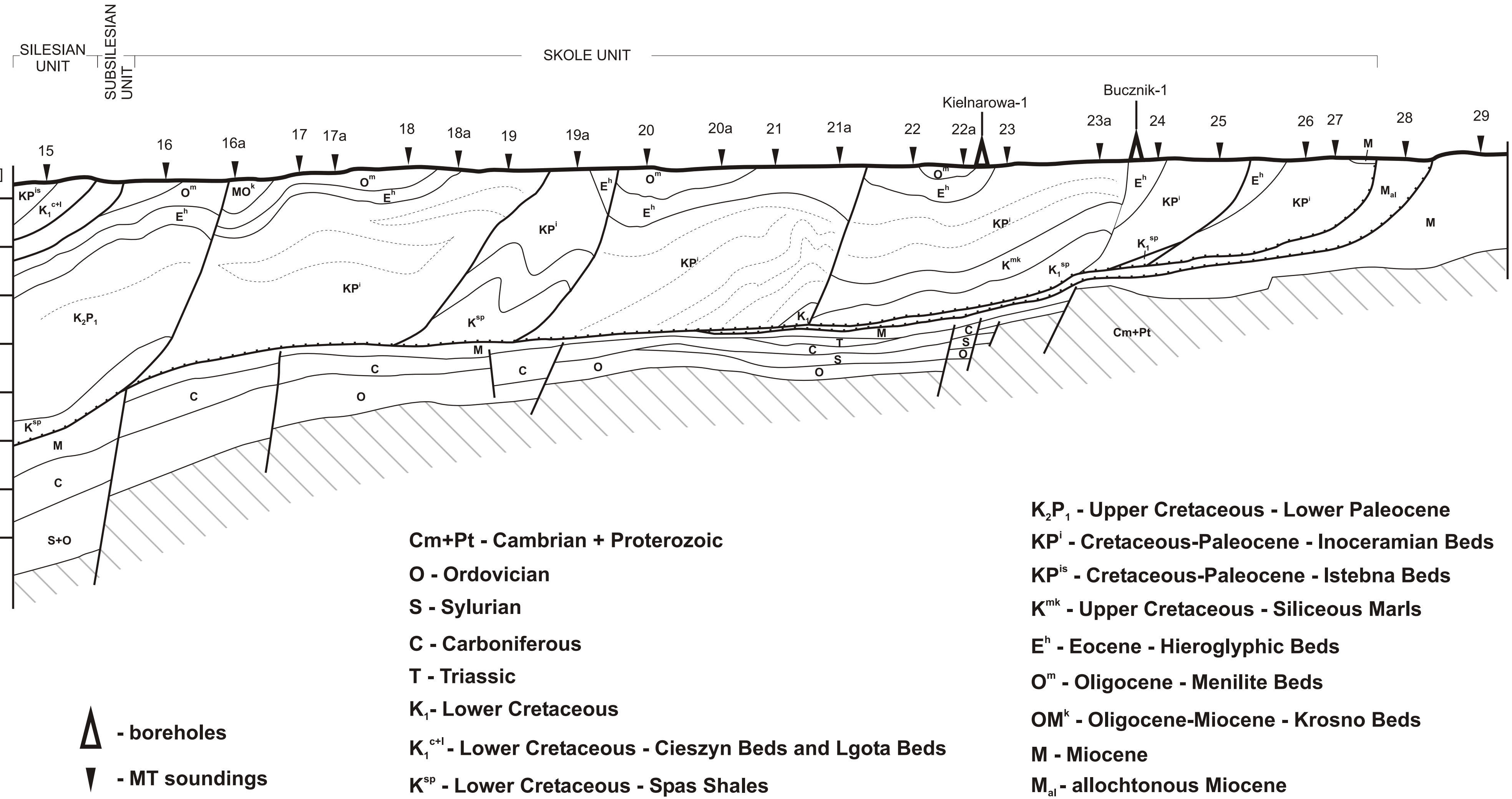

Fig. 2. Geological cross-section Domaradz-Albigowa