ELECTRICAL RESISTIVITY TOMOGRAPHY AS A TOOL IN GEOLOGICAL MAPPING

Szymon OSTROWSKI*, Grzegorz PACANOWSKI, Marcin LASOCKI
PBG GEOPHYSICAL EXPLORATION CO., LTD Warsaw - PL

e-mail: s.ostrowski@pbg.com.pl

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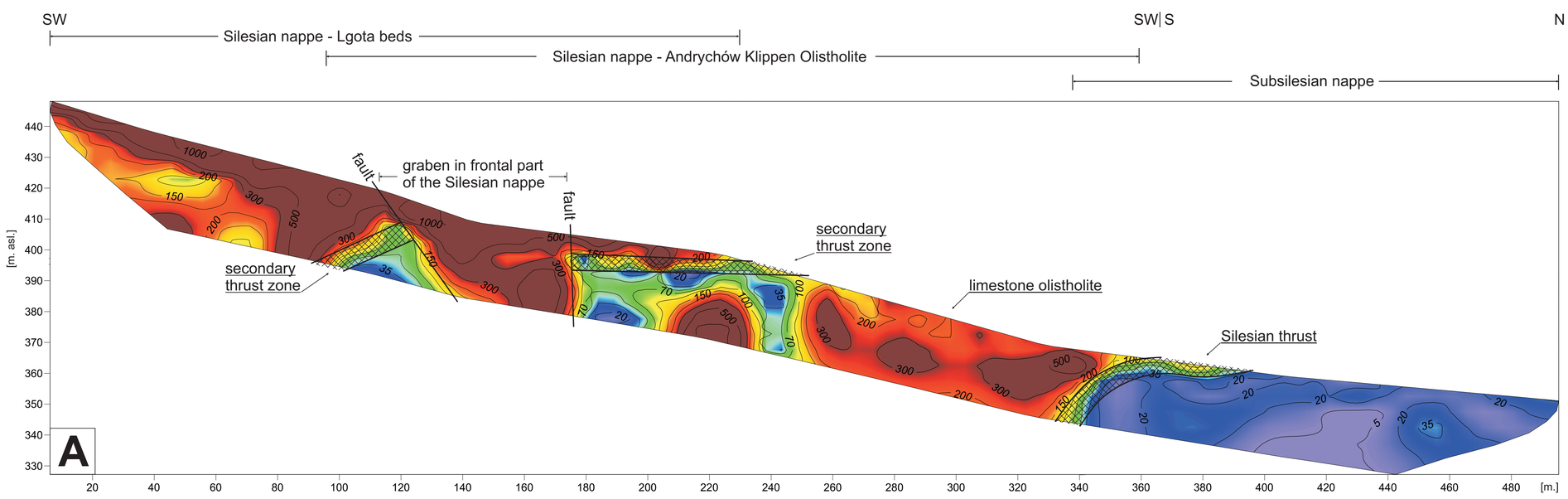
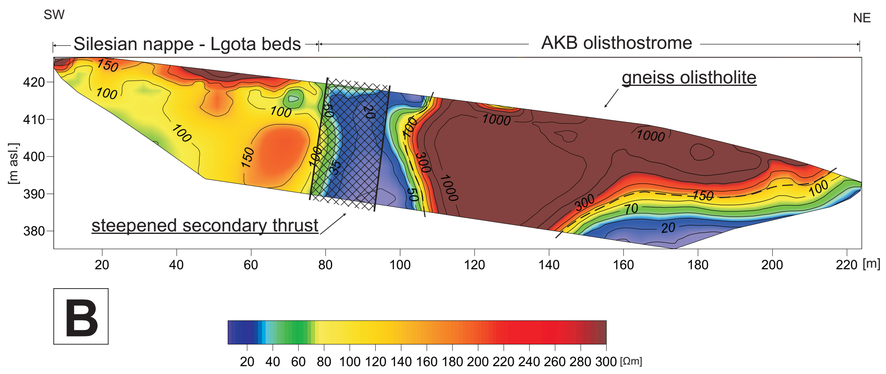
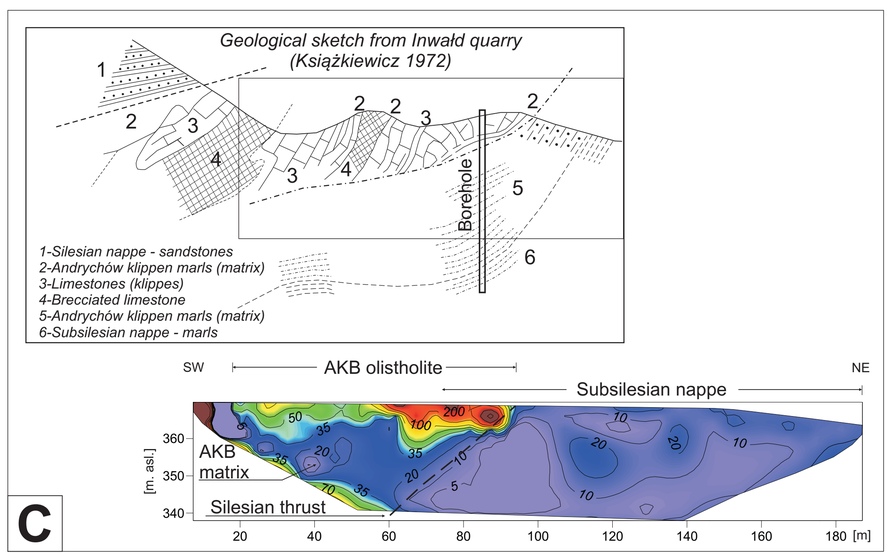




A - ERT section through Andrychów Klippen belt and adjacent Silesian and Subsilesian nappes in the Invałd village. Central part of the section is composed of blocks of olistholites in low resistivity matrix (olisthostrome). Note small graben in the front of the overlying Lgota beds

B - ERT section through Andrychów Klippen belt and adjacentpart of the Silesian nappe in the town Andrychów. The thrust zone is locally steepened due to occurence of incompetent block of gneiss olistholite.



C - ERT section through Andrychów Klippen belt within old Inwałd quarry compared to geological section based on drill core and field data (after Książkiewicz 1972). Notice general similarities in internal composition and the exact match with the drill core.

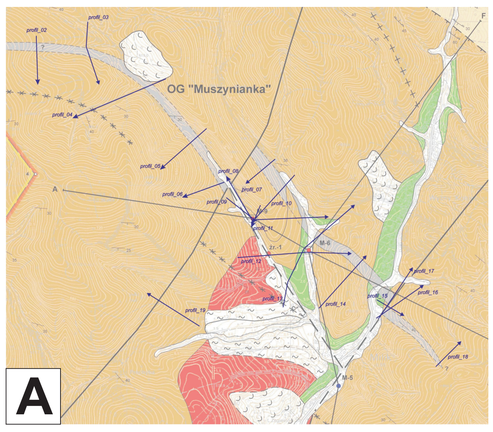
The **Andrychów Klippen Belt** (AKB) is located in the Western Carpathians, in the base of Silesian nappe. The Belt is latitudinally elongated. Its length is several kilometres and width does not exceed the quarter of kilometre. AKB is composed of blocks of Upper Jurassic to Lower Cretaceous reef (stramberg facies) limestone (Olszewska et al., 2008; Waśkowska-Oliwa et al., 2008) and Proterozoic metamorphic rocks (Książkiewicz 1972). Size of the blocks range from tens to one hundred meters in diameter. Blocks of AKB lay on siliciclastic siltstone and mudstone composing Subsilesian nappe and infill of the Carpathians foredeep and are overlain by sequence of flysch type alternations of sandstone and siltstone beds, composing the Silesian nappe. Both underlying and overlying flysch rocks are Cainozoic in age (Książkiewicz, 1972).

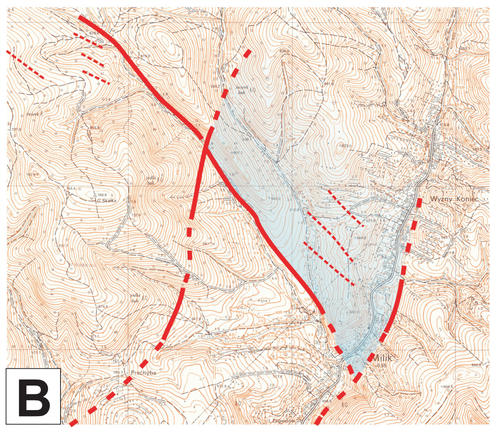
The nature of the AKB is the matter of debate. It is widely accepted, that the Belt is an olistostrom and was formed by redeposition of rock blocks from the edge of the Silesian flysch basin to its centre (Cieszkowski, Golonka 2006; Golonka et al. 2005). The alternative explanation of the occurrence of exotic blocks is, that they were tectonically incorporated into the base of Silesian nappe during orogenesis. Although limestones of the AKB were exploited, and mapped carefully, its inner composition, and size and shape of blocks are poorly recognised.
The aim of the ERT surveys, was to detail inner composition of the AKB – size and shape of blocks, nature of contacts between blocks and surrounding rocks, and definition of borders of the Belt.
Three parallel ERT sections were measured near the Inwałd village where AKB is prominently exposed.

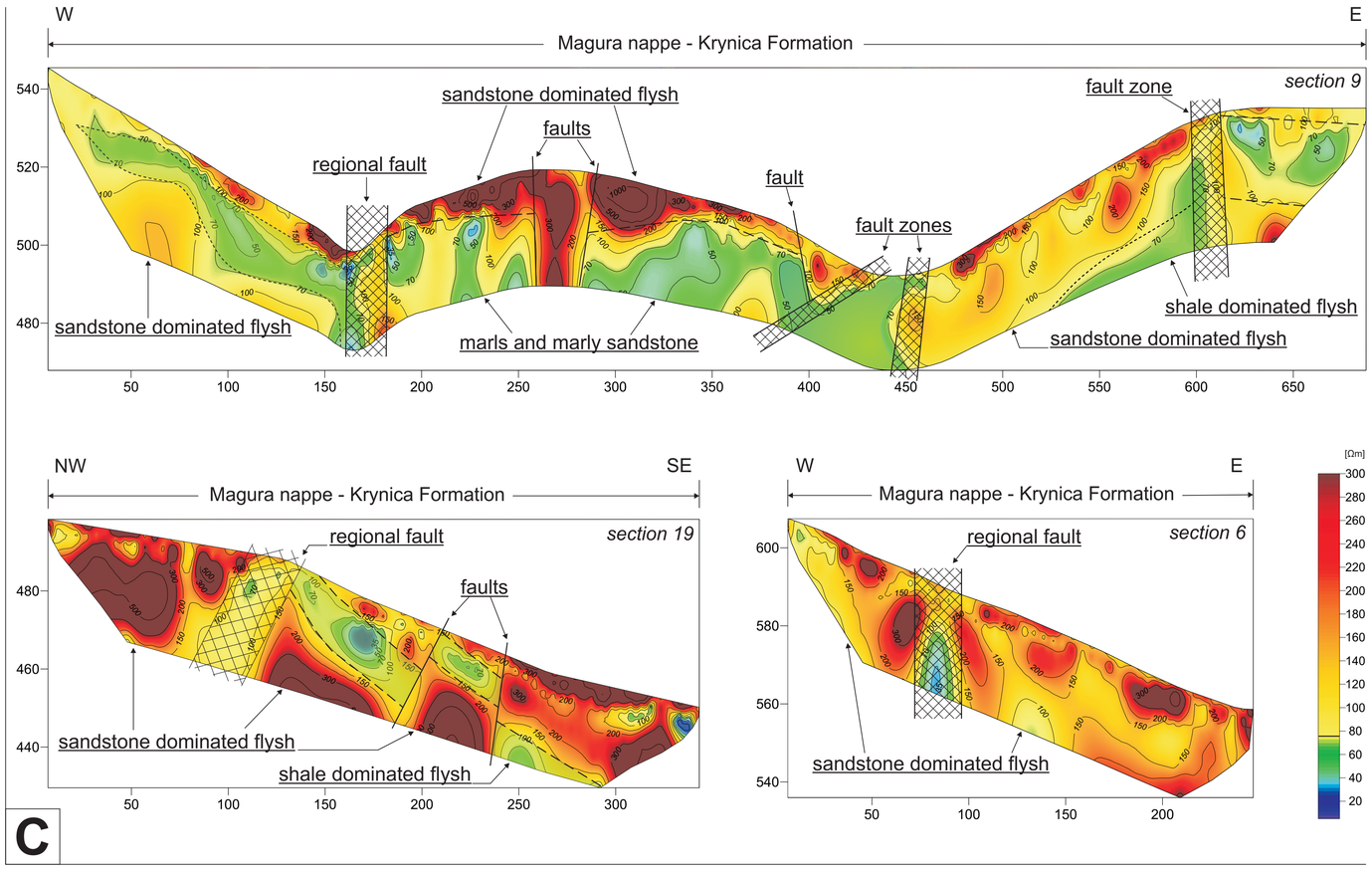
The medium in the analysed area can be divided into three main categories of different resistivity characteristics:
Homogenous zone of high resistivity ranging from 70 up to 300 Ωm interpreted as flysch sandstone containing minor intercalations of siltstone and mudstone. Zones of lowered resistivity correspond to rocks of increased content of fine grained beds. This type of medium represent rocks of Silesian nappe.
Homogenous complex of low (below 20 Ωm) resistivity, interpreted as siltstone and mudstone of Subsilesian nappe and the Carpathians foredeep infill.
Complex of highly variable resistivity, containing irregular blocks with resistivity exceeding 100 Ωm and matrix of resistivity ranging from 20 to 70-100 Ωm. Blocks of high resistivity were interpreted as blocks of exotic rocks in Andrychów Klippen belt, while medium of reduced resistivity is interpreted as fine clastic matrix of the belt.
Zones of high resistivity gradient on the basis and top of the variable resistivity medium were identified as thrust or fault zones.

Interpretation of ERT imaging allowed to:
Estimate the size of exotic blocks, which range between 20 and up to 100 in diameter
Ilustrate the irregular shape of exotic blocks, that exclude simple tectonic origin of the AKB
Demonstrate the variability of the matrix of the AKB caused by admixture of exotic clasts smaller than ERT resolution
Ilustrate local steepening of trust zone below AKB caused by mechanic heterogeneity of the belt
Indicate the possibility of occurrence of secondary trust between AKB and Silesian nappe
Ilustrate the effect of brittle deformations (tectonic graben) in front of the Silesian nappe

The quality of ERT imaging and its usefulness in detailed geological mapping was shown by comparing geological interpretation of the ERT image with geological data obtained from archival drill cores and section logs of old quarry (figure 1 bottom).







The Muszyna region (central part of the Polish Carpathians) is well known for its mineral springs. Intensive exploitation of aquifer demanded new estimation of water resources. Location and spread of horizon of marls confining sandstone aquifer were regarded as a key factor in aquifer recognition, thus ERT survey was employed.
Examined area is located within the Magura nappe, Outer Carpathians. Rocks are composed of Paleogene thick bedded flysch type sandstone (Chrząstowski et al. 1991). Two distinct horizons of marls and marly shales reaching a few tens of meters are known from the lower part of the sandstone sequence (Birkenmajer, Oszczypko 1989). Beds are generally dipping gently to south-west and are undulated locally. The system of regional faults cuts Magura nappe from NE to SW.

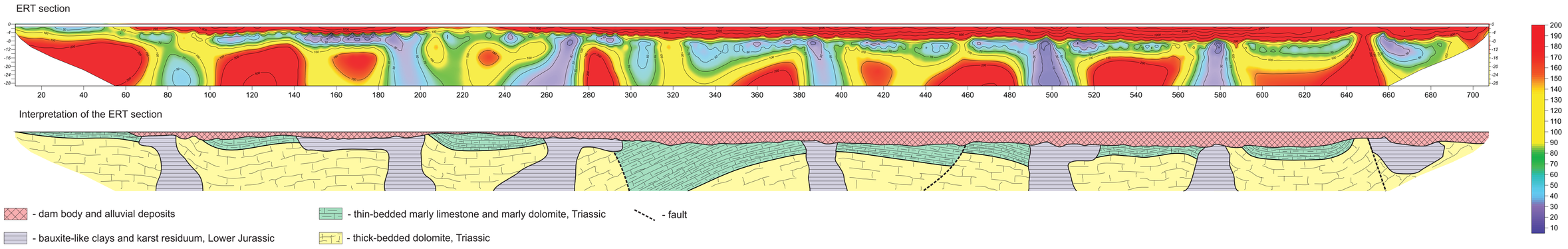
A set of parallel ERT sections were measured in the area of interest that allowed to recognise three main categories of medium:
Homogenous complex of high resistivity exceeding 100-150 Ωm interpreted as sandstone beds
Homogenous complex of low resistivity not exceeding 50 Ωm interpreted as impermeable marly horizon confining the aquifer
Complex of variable resistivity ranging between 35 and 100 Ωm, corresponding to water saturated sandstones or complexes of-thin bedded sandstones and shales.
Zones of high resistivity gradient were interpreted as fault zones.

Analysis of the obtained results allowed to:
Determine the position of impermeable marly horizon
Precise the location and geometry of regional faults and describe unknown faults featuring geology of the investigated area
Indicate the existence of tectonic horst in which confining horizon is uplifted
Demonstration of block tectonics of the investigated area, and relationship of tectonic features and aquifer geometry allowed to better understand hydrogeology of the aquifer.

A - Geological map of the area covered with ERT study. Map provided by the investor is obtained by surface mapping.
Impermable marls are gray; Krynica Formation sandstone - brown and red; alluvial deposits - green and white; solid black lines - faults of the regional importance. ERT sections marked with arrowed lines

B - Map of tectonic features of area presented on figure A. Shaded part on the map covers tectonic horst where impermeable marly horizon is uplifted. The edges of this block are perspective locations of productive wells. Solid red lines - faults of regional importance of certain strike; dashed, thick lines - fragments of regional faults with uncertain strike; thin dashed lines - minor faults

C - Three selected ERT sections from Muszyna area. Section 9 - uplifted marly horizon in tectonic block; section 19 - fault zone of regional fault and minor faults associated with regional fault, note ca. 10 m dislocated bed of lowered resistivity; section 6 - regional fault zone in predominantly sandstone flysh, note abrupt decrease of resistivity in the fault zone.



Przeczyce earth dam is located on the Czarna Przemsza river, in northern part of Silesia region. Spread of the dam is above 600 m and its height reach 12 m in the centre of the valley. Deformations of the dam motivated its operator to apply geophysical investigation of the dam body and basement to identify possible hazards. Set of geophysics tools applied revealed that the cause of deformation is exterior to the dam body, thus geology of the basement must be investigated. ERT imaging was performed to determine the resistivity of the basement, and interpret its geology.

The valley of Czarna Przemsza river is cut in Middle Triassic beds composed of limestone and dolomite. Triassic beds form monocline of gentle regional dip toward north-east (Biernat, 1955), locally undulated. In the direct vicinity of dam, Triassic strata are composed of thick-bedded dolomite covered by thin-bedded intercalations of limestones and marls. Lower Jurassic deposits composed of bauxite-like clays filling paleokarst cavities are known from the region. The valley is partly filled by Quaternary alluvial sands and gravels of thickness not exceeding 10 m.

The medium in the analysed area was divided to four categories of different resistivity characteristics:
Near-surface, homogenous complex of resistivity exceeding 200 Ωm, corresponding to lower part of dam body and alluvial infill of the valley.
Complex of resistivity ranging from approximately 50 to 100 Ωm, interpreted as Triassic thin-bedded limestones and marls
Complex of resistivity exceeding 100 Ωm, reaching locally over 300 Ωm interpreted as Triassic thick-bedded dolomites
Complex of resistivity bellow 50-70 Ωm, composing irregular bodies up to 30 m in diameter, penetrating basement. Such bodies are interpreted as Lower Jurassic bauxite-like clays filling paleokarst cavities.

ERT imaging in the area of Przeczyce dam allowed to recognise the geology of valley basement. The main features of the basement geology are:
Slightly undulated, two layer composition of the basement
Occurrence of fault zones in the Triassic rocks
Occurrence of paleokarst cavities filled by Lower Jurassic bauxite-like clays
Existence of paleokarst cavities filled with ductile clay, surrounded by rigid Triassic carbonate rocks may explain the deformation of the dam. Until our survey, possibility of existence of basement heterogeneity was not recognised as a cause of dam deformations.

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