Acta Geodyn. Geomater., Vol.2, No.3 (139), 139-144, 2005

INTERPRETATION OF HIGH RESOLUTION SEISMIC DATA FROM THE "PIAST" COALMINE, POLAND

Katarzyna MIREK

Department of Geoscience Informatics, Faculty of Geology, Geophysics and Environmental Protection
AGH University of Science and Technology, al. Mickiewicza 30, 30-059 Kraków, Poland
phone: +48 (12) 617 47 58; fax: +48 (12) 633 29 36
**Corresponding author's e-mail*: kmirek@geol.agh.edu.pl

(*Received* January 2005*, accepted* May 2005)

ABSTRACT

The High-Resolution Seismic (HRS) method is a method that can be used successfully to recognize complicated tectonic and geological formations in coalmining areas. This method is quick and relatively cheap, therefore it allows for the exploration of large geographical areas. Seismic sections obtained in this way, correlated with borehole data, give complete information about the geo-tectonic situation.

This article presents the results of a HRS investigation conducted on the area of the "Piast" coalmine in the Upper Silesian Coal Basin (USCB), Poland. This investigation was designed to observe the course of the Bojszowski fault, and to determine if this fault cuts the carboniferous roof and transmits water form the tertiary layers.

Interpretation showed three other faults, secondary to the main Bojszowski fault. Analysis by the FAPS system, used during the interpretation of the HRS data allowed for a precise description of the Bojszowski and secondary faults.

KEYWORDS: faults, tectonics, High-Resolution Seismic

INTRODUCTION

A precise understanding of the tectonic formation and geological background of a site is essential in mining. Knowledge of the tectonic formations is necessary for mine planning and exploitation, geological prospecting and environmental protection. For example the presence of faults cutting a coal seam constitutes a serious hazard: knowledge of the location of these faults, before mining commences, permits the planning of a system of exploitation that reduces safety risks. Also knowledge of tectonic, beside essential economic importance, can get information about geodynamic history of interesting area. In the case of the USCB, the precise geological history of the region can help to exploit coal safely and economically and to describe the migration of gas. Most importantly, it can give new information about complicated tectonic structures.

Seismic methods are basic methods used to map geological structures, evaluate seam continuity and detect potential seam anomalies (Gochioco, 1990; Henson and Sexton, 1991; Pietsch and Ślusarczyk, 1992; Tselentis and Paraksevopoulos, 2002). The HRS method has been used in coal prospecting since the 1970's. It has allowed for the exploitation of mines without stoppage caused by faults or seam anomalies.

One of the most important problems in the interpretation of seismic data is detection and identification of faults and fault zones. The traditional approach to this interpretation is based on the identification of discontinuity in the reflectors by visual checking of stacked sections. This method is most effective on data received from a site with an uncomplicated geological background. However, this approach is significantly more difficult to use on data received from an area with complicated tectonics, and, as occurs in the case of the USCB, on areas where exploitation creates discontinuities in the reflectors, decreasing the legibility of the seismic data. In such cases, interpretation of seismic data must be supplemented by interactive analysis systems, models of the investigated area and knowledge of the geological background of the site.

DATA ACQUISITION

The study area is located in the "Piast" coalmine area, USCB, Poland. During the exploitation of coal seam number 207, near the Bojszowski fault, water rushed into the heading, although the Bojszowski fault is considered a dry fault. The aim of the investigation was to determine if the Bojszowski fault cuts the carboniferous roof and transmits water from the tertiary layers.

Seismic lines were designed on the basis of mining maps and geological sections. Data for this study were collected along 5 seismic lines (Fig. 1). Data were acquired on the 48-channel digital recording system Terraloc MK3, using 100Hz

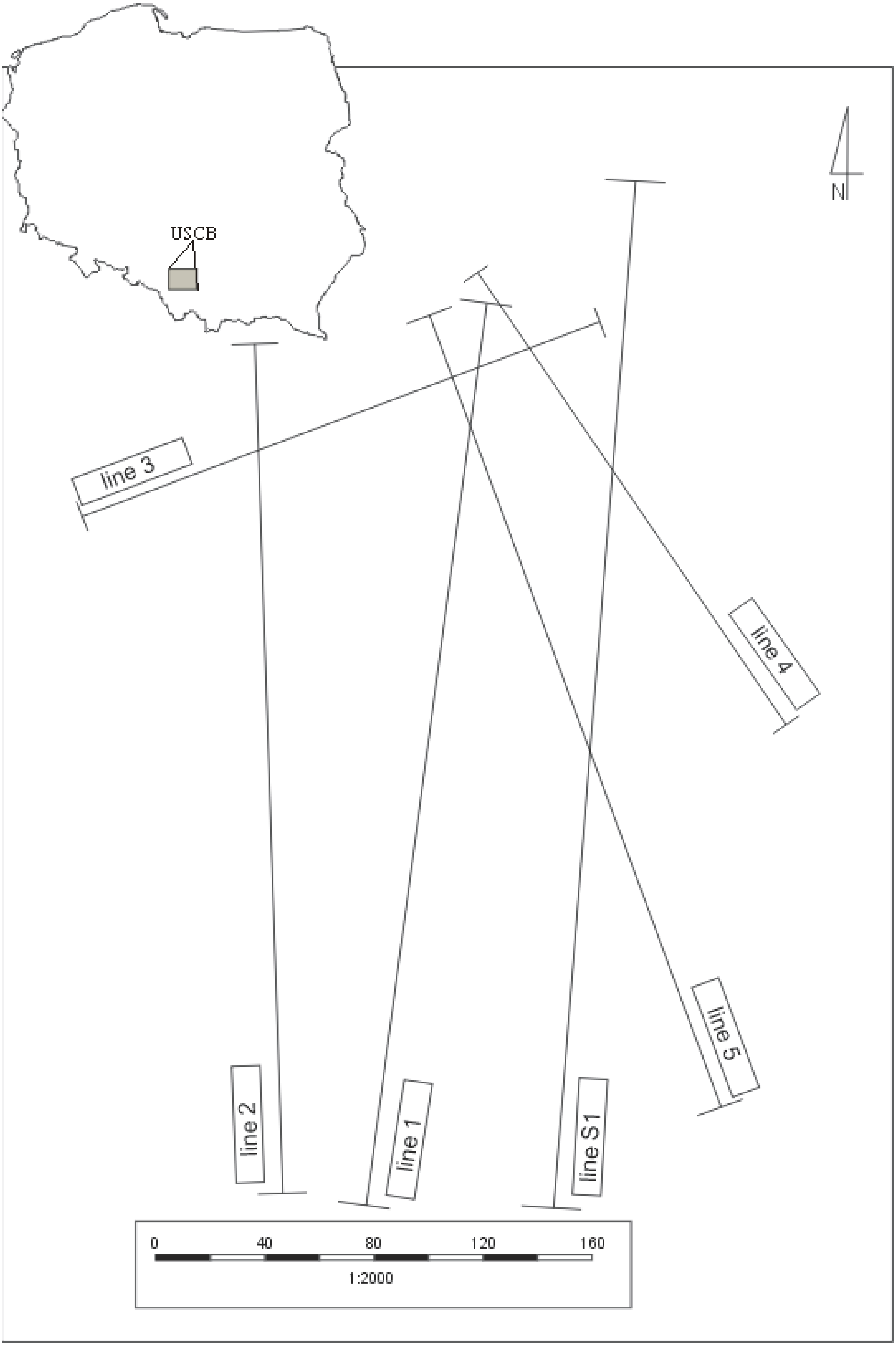

Fig. 1 Location of seismic lines on the "Piast" Coalmine area.

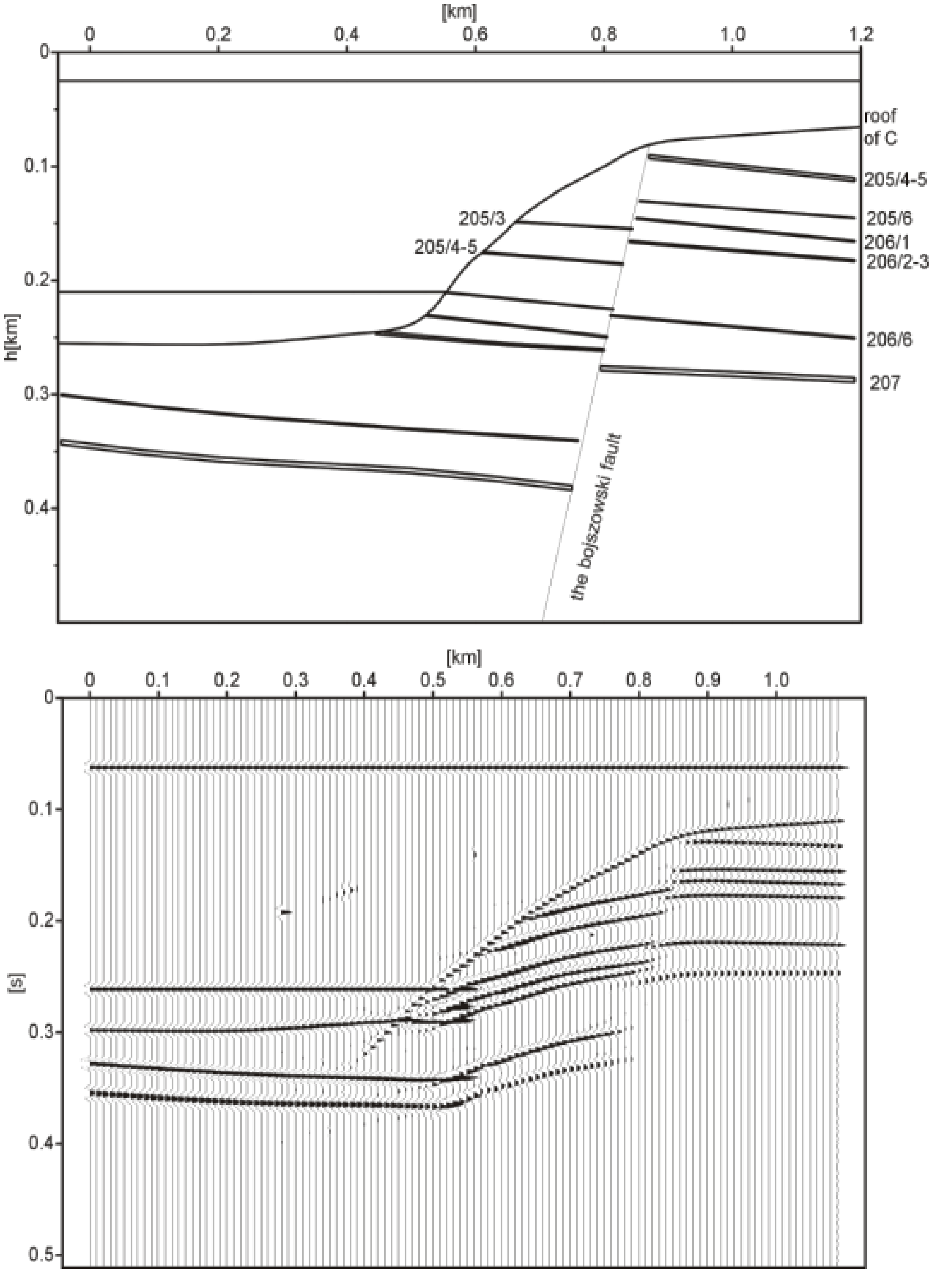

Fig. 2 Seismogeological model (upper) and synthetic section.

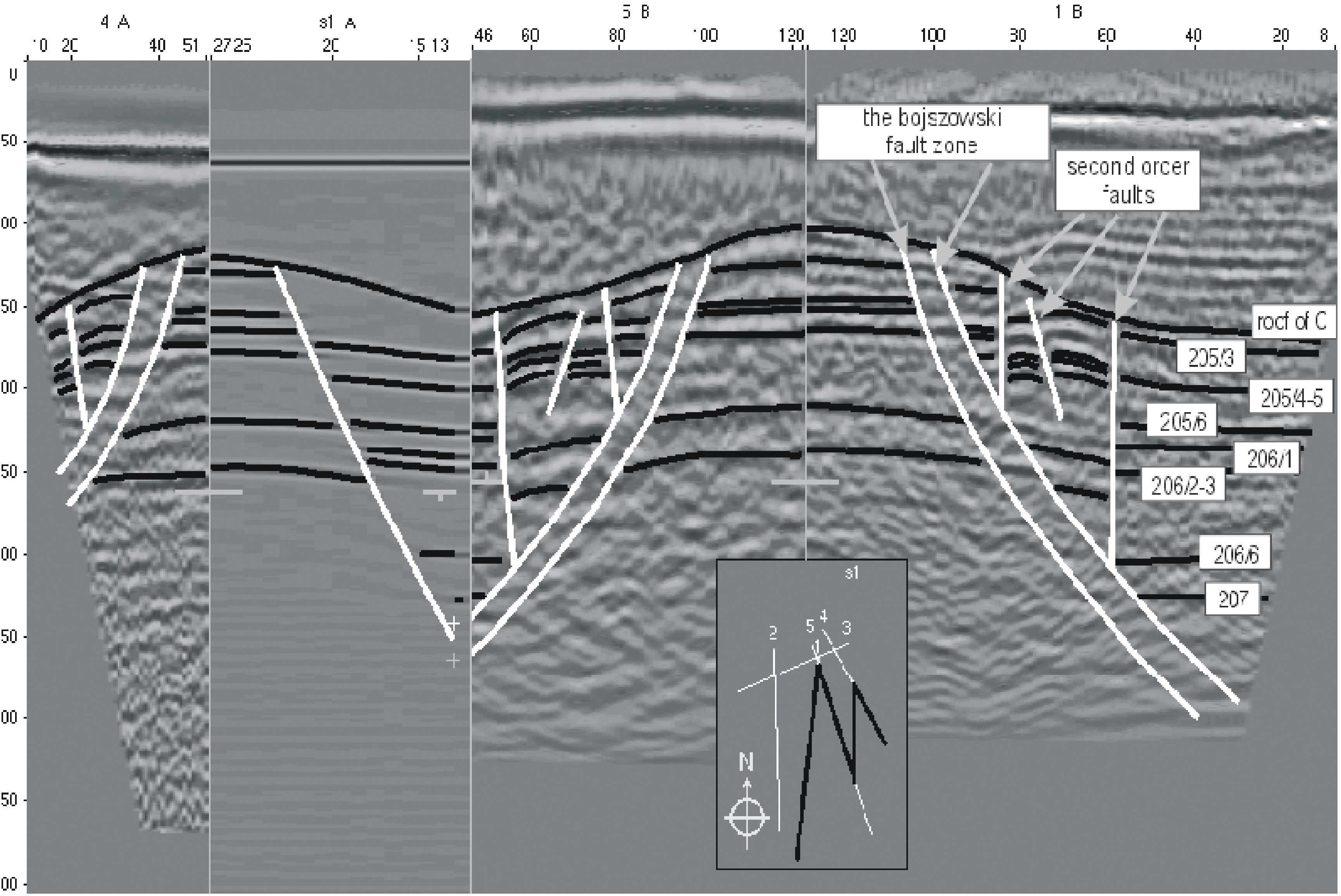

Fig. 3 Compose of synthetic section (s1) with seismic sections (p5 and p1). There is map of seismic lines in right lower corner (black marked lines make compose). Vertical scale: time (ms); horizontal scale: CDP (distance between next CDP is 2,5 m).

geophones L-40 (MARK PRODUCTS, USA) spaced at 5-m intervals. EWG III (BISON, USA) was used as a seismic source.

MODELLING

Models made in this investigation were calculated to assist in the interpretation of the seismic data. Synthetic sections were made for easier correlation of the main seismic horizons during the interpretation, i.e. the coal seam and the roof of the carboniferous layer. The models were made with the SeisUn*x program package (The Center for Wave Phenomena, Colorado School of Mines).

The seismogeological model was based on part of a geological cross-section E-E' and boreholes data MB-46, IG-27. The geological cross-section E-E' (oriented S-N) cut the Wola and Bieruń mining areas. The selected part of the geological cross-section contained only the Bojszowski fault with a throw of about 100m.

This model included layers up to 500 m (Fig. 2). The model was built with carboniferous, tertiary and quaternary layers. The actual carboniferous formation consisted of layers of coal, sandstone and a few thin layers of clay stone. However, the value of the coefficient of reflection in the coal-clay stone contact was very small (0.04) and the thickness of these layers was not large. Therefore, the clay stone layers were not included in the model. The tertiary formation was characterized by a variable thickness form 70m up to 256m and mainly consisted of clay with a floor composed of a sandstone layer of about 45m, drilled in the borehole MB-46. The quaternary layer consists of sand with a thickness of about 25 m.

RESULTS

The seismic data were analysed with two specialized computer programs: Charisma (GeoQuest) and FAPS (Badley Earth Sciences Limited). The correlation of the faults and reflection horizons was made with the Charisma system, whereas the analysis of the correlation and the correctness of the interpretation were done by FAPS.

The model of the investigated area was a great importance during the interpretation of the seismic system. The synthetic section was used as an additional seismic line within the interpretation system. Although the geological cross-section, which was the basis for the seismic-geological model, did not cross the area of HRS measurements, the author decided to include it in the measurement lines. The synthetic section kept the S-N orientation and cut one of the seismic lines, which was mainly used for the correlation of the seismic horizons. This assumption allowed for a correct correlation of the main seismic horizons.

The Bojszowski fault and its fault zone are seen clearly on the seismic sections. The fault zone's width is approximately 17 to 30 m in the lower part of the fault. The fault is a dip-slip normal fault, with threw layers to the south. The depth range of the Bojszowski fault is considerable and is therefore not correlated wholly on the seismic sections.

There are three other faults seen on the seismic sections, besides the Bojszowski fault. These three correlated faults are dip-slip reverse faults, second-order to the Bojszowski fault and their depth range is not as large (Fig. 3).

The interpretation showed that one of the second order faults was responsible for the water migration into the coal seam. This fault cut the carboniferous roof and transmitted water from the tertiary layers. Analysis of all the faults in the seismic section showed that the general strike direction of the fault surfaces was approximately W-E. The direction of the fault inclination was varied: for the Bojszowski fault and one of the second-order faults, the direction was south, for the other second-order fault, the direction was north.

The planes of picked horizons and throws of faults were checked. The courses of the horizon lines were smooth, without irregularity on either side of the faults. This shows that the correlation of the horizons was made correctly (Needham, et al., 1996; Mirek, 2000; Mirek and Ślusarczyk, 2001a). The regularly changing value of the throw, with only one maximum, indicates a correct correlation of fault planes (Chapman and Meneilly, 1990; Freeman et al., 1990; Needham, et al., 1996; Mirek, 2000; 2002; Mirek and Ślusarczyk, 2001a; 2001b).

In the area of the USCB, changes were observed in the inclination of fault surfaces. These changes are most frequently the result of heterogeneous lithology, however there are also changes that are not dependent on lithology (Herbich, 1981). Among these changes, the following can be specified:

- faults with the inclination of fault surfaces becoming less steep with depth;
- faults with the inclination of fault surfaces becoming steeper with depth;
- faults displaying in their central sections (in the vertical cross-section) the smallest dip angles and, at the same time the highest amplitudes.

The Bojszowski fault is a fault of the first kind; in this respect it has the shape of a shovel. This shape is common among normal faults and indicates that this fault was formed in an active tension zone (Dadlez and Jaroszewski, 1994).

The second-order faults that accompany the Bojszowski fault demonstrate that this fault is a strike-slip fault, which, in some period of its development, acquired a strike-slip component. Thus one can say that the Bojszowski fault is a strike-dip-slip normal fault. The occurrence of small faults accompanying large faults with significant amplitudes is frequently observed in the area of the USCB. The presence of smaller, second-order faults indicates a spatial changeability of stress fields and therefore a complexity of faulting in the area of the USCB.

ACKNOWLEDGEMENTS

This article was supported by Grant 11.11.140.144 from AGH University of Science and Technology.

Author thanks Badley Earth Sciences (Computed) Limited for free license of FAPS.

REFERENCES

Chapman, T.J. and Meneilly, A.W.: 1990, Fault displacement analysis in seismic exploration, First Break, 8, no. 1, 11-22.

Dadlez, R. and Jaroszewski, W.: 1994, Tektonika. Wydawnictwo Naukowe PWN.

Freeman, B., Yielding, G. and Badley, M.: 1990, Fault correlation during seismic interpretation, First Break, 8, no. 3, 87-95.

Gochioco, L.M.: 1990, High-Resolution Seismic profiling to map seam structure and anomalies in coal exploration, 60th Ann. Internat. Mtg.: Soc. of Expl. Geophys., 729-732.

Henson, H. Jr. and Sexton, J.L.: 1991, Premine study of shallow coal seams using high-resolution seismic reflection methods, Geophysics, 56, 1494-1503.

Herbich, E.: 1981, Analiza tektoniczna sieci uskokowej Górnośląskiego Zagłębia Węglowego, Rocznik PTG, 51, 3-4, 383-434.

Mirek, K.: 2000, Nowe techniki analizy uskoków w systemie FAPS, Materiały konferencyjne, VII KK KOWBAN, Polanica Zdrój, 163-166.

Mirek, K.: 2002, Wykorzystanie sejsmiki wysokiej rozdzielczości do rozpoznania tektoniki płytkich pokładów węgla, Praca doktorska, Biblioteka Główna AGH.

Mirek, K. and Ślusarczyk, R.: 2001a, Analiza uskoków przy pomocy systemu FAPS, Technika Poszukiwań Geologicznych, Geosynoptyka i Geotermia, 1, 63-68.

Mirek, K. and Ślusarczyk, R.: 2001b, Trójwymiarowa wizualizacja uskoków w metodzie sejsmiki wysokorozdzielczej, Mat. Konf. „Nauki o Ziemi w badaniach podstawowych, złożowych i ochronie środowiska na progu XXI wieku", 145-148.

Needham, D.T., Yielding, G. and Freeman, B.: 1996, Analysis of fault geometry and displacement patterns, W: Buchanan P.G. & Nieuwland D.A. (eds). Modern Development in Structural Interpretation, Validation and Modelling. Spec. Publ. Geol. Soc. London, 99, 189-199.

Pietsch, K. and Ślusarczyk, R.: 1992, The application of high-resolution seismics in Polish coal mining, Geophysics, 57, no. 1, 171-180.

Tselentis, G-A. and Paraksevopoulos, P.: 2002, Application of high-resolution seismic investigation in a Greek coal mine, Geophysics, 67, 50-59.