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GEOPHYSICAL INVESTIGATIONS OF THE CARPATHIAN SLIDE SLOPES

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Abstract. Application of geophysical methods as part of the old landslide stability determination and forecasting stability for Carpathian slopes is described. Physical base of the seismic refraction and electrical-resistance methods have been outlined in view of the tasks which are to be solved, namely delineation of the landslide geometry, especially depth and shape of the slide boundary, and horizontal range of the slide. Geophysical classification index KFG with adjustment factors proposed by Romano used for preliminary evaluating and forecasting the stability of flysch rock slopes, have been presented. Some examples of seismic refraction and electrical-resistance methods for geometrical definition of landslide on the area of Carpathian flysch have been outlined. All experiences of geophysical investigations of the Carpathian landslide slopes were gathered on the basis of investigations for over hundred landslides, on water reservoir slopes, mainly.

Key words: landslide slope, slide boundary, seismic refraction method, electrical-resistance method, classification index KFG, Slope Mass Rating (SMR).

Abstrakt. W artykule omówiono zastosowanie metod geofizycznych w badaniu i prognozowaniu stateczności karpackich stoków. Przedstawiono podstawy fizyczne wykorzystania metody sejsmicznej refrakcyjnej i geoelektrycznej elektrooporowej dla rozpoznania geometrii istniejących osuwisk, w szczególności głębokości i przebiegu strefy poślizgu oraz poziomego zasięgu zsuwu. Wskazano na możliwość wykorzystania indeksu KFG geofizycznej klasyfikacji fliszu, po wprowadzeniu wskaźników korygujących zaproponowanych przez Romano, do wstępnej oceny i prognozy stateczności karpackich stoków.
Przedstawiono przykłady zastosowania metody sejsmicznej refrakcyjnej i geoelektrycznej elektrooporowej do określenia przebiegu strefy poślizgu i poziomego zasięgu zsuwu osuwisk wykształconych na fliszowych zboczach Karpat.
Doświadczenie zdobyte na podstawie badań ponad stu osuwisk, zlokalizowanych głównie na zboczach sztucznych zbiorników wodnych, wykorzystano w badaniu karpackich stoków osuwiskowych metodami geofizycznymi.

Słowa kluczowe: zbocze osuwiska, strefa poślizgu, metoda sejsmiki refrakcyjnej, metoda elektrooporowa, indeks KFG, współczynnik SMR.

INTRODUCTION

Carpathian slide slopes built up from alternate "hard" sandstones and "soft" shales are vulnerable for loss of stability if equilibrium of forces at the slope will change. This will occur after long and/or intensive rainfall. In 2000 and 2001, several old and some new landslides were activated after long rainfall periods.

Study of the Carpathian slides started in 1970 as a part of State Program PR-7 *Technical conditions for hydraulic constructions and shoreline of water reservoirs*. Over 100 landslides have been investigated at the slopes of Tresna, Myczkowce, Solina, Dobczyce, Świnna–Poręba, Czorsztyn–Niedzica and Krempna reservoirs. As a result of these investigations, methodology of the field geophysical investigations for the slope landslides have been elaborated. These investigations were based on the seismic refraction and electrical-resistance methods. Results of these investigations have been presented at the international and national symposia (Bestyński, Trojan, 1975; Bestyński, 2001; Farbisz, Honczaruk, 2002). Recently, several new techniques have been implemented, such as seismic share waves V_{SH} registration, resistance of the underlying rocks representation by using tomography processing and GPR (ground penetration radar) techniques. In the paper, conditions for implementing geophysical methods at the landslide slope investigations and some of the field cases are presented.

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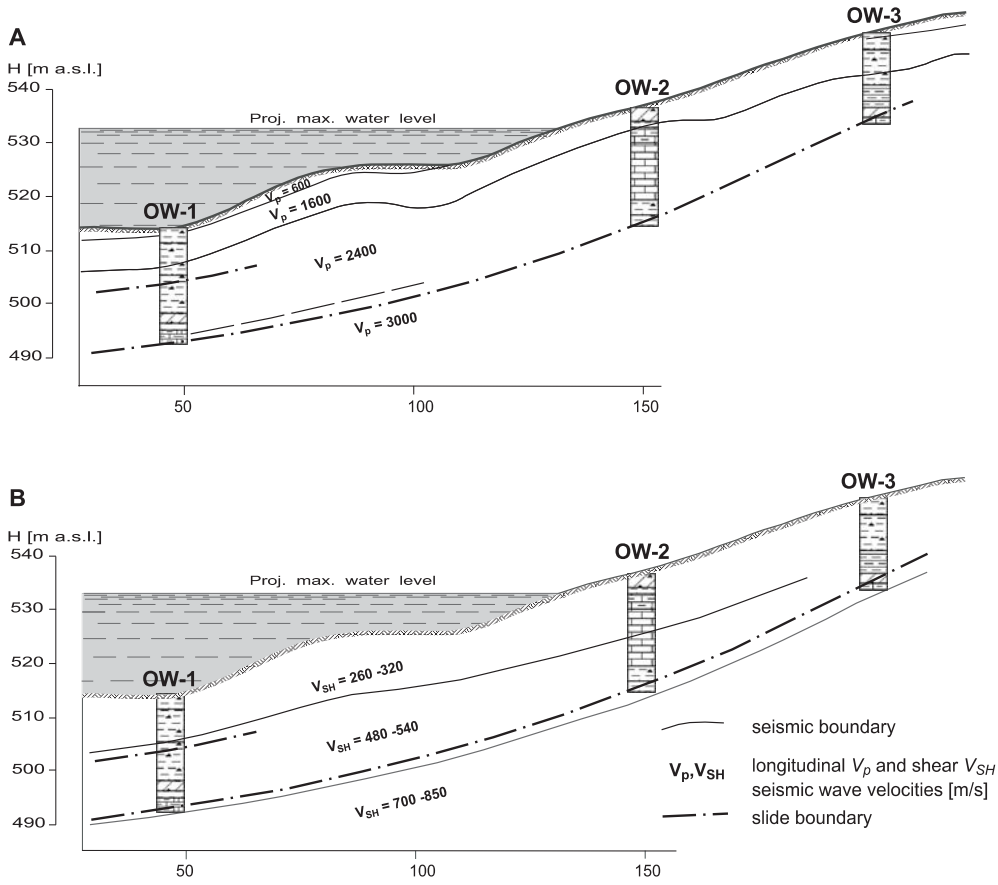

Fig. 2. Seismic vertical sections 113/2

A — V_p waves seismic section,

B — V_{SH} waves seismic section

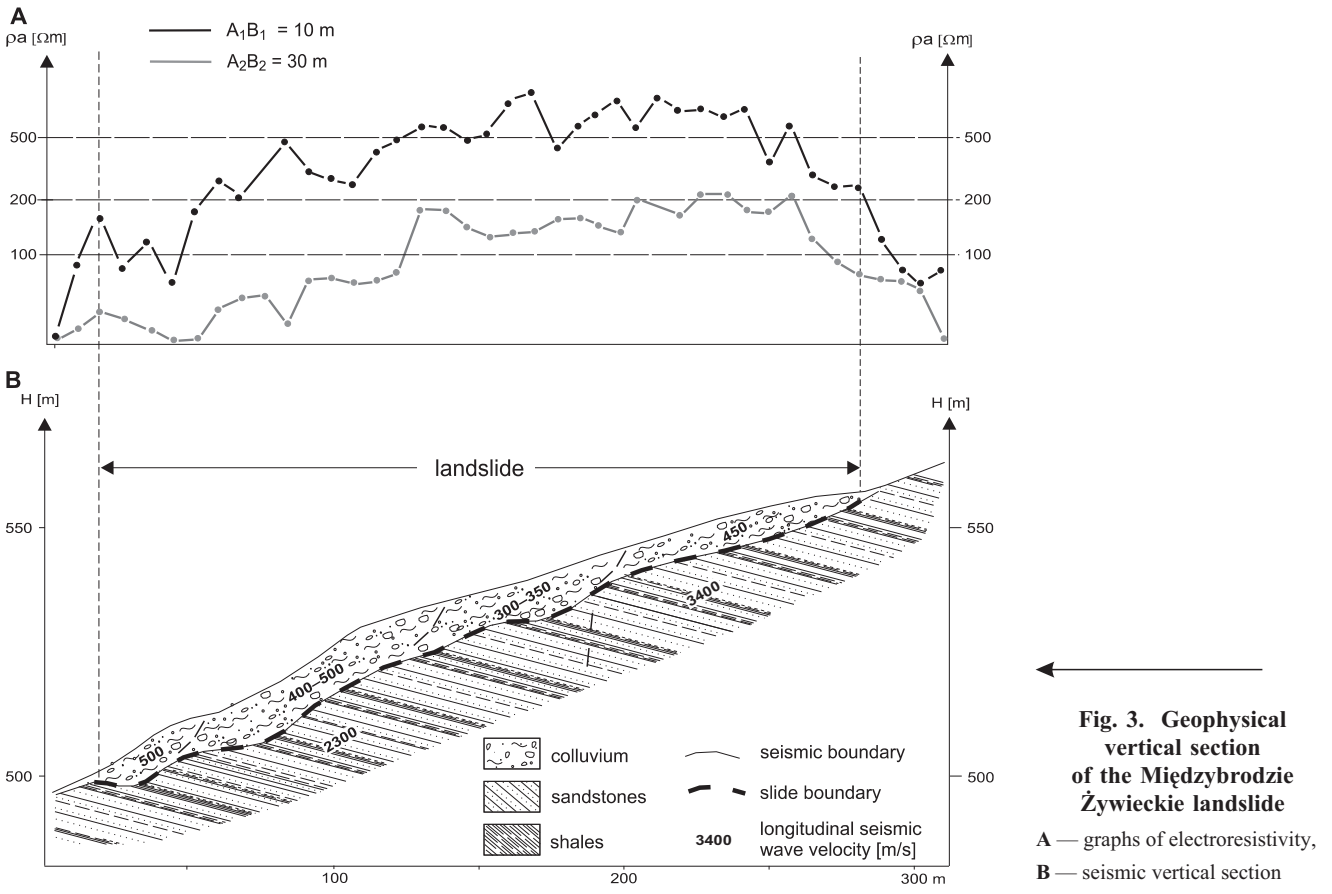

Fig. 3. Geophysical vertical section of the Międzybrodzie Żywieckie landslide

A — graphs of electroresistivity,

B — seismic vertical section

Lipowica Landslide. Landslide is located near Lipowica quarry, on the slope with several old landslide formations. Lithology consists of thick-layered sandstones. Electrical resistance method has been used and deta ils of lithology of the top layer and tectonic faults were delineated (Fig. 4). Geological map on the basis of geophysical results has been worked out and checked by geological pits.

Dubiecko Landslide. Landslide is an old stabilised slide on the slope of the San River. Along the main axis of the landslide, electrical resistance investigations have been done and results have been processed by using tomography method. This method required measurements of horizontal and vertical continuous distribution of electrical resistance. It was achieved by the field lay-out of the electrodes and special measurements procedure. Because of the difference in the loose and solid rocks resistance, it was possible to delineate slide boundary of the landslide. Some examples of the measurements done by PBG-Warszawa are displayed on the Figures 5A, B.

CONCLUSIONS

1. Seismic refraction and electrical-resistance methods are used for investigations of the Carpathian slopes for over 30 years. These methods are used for delineating landslide geometry and position of the slide boundary.

2. By using KFG geotechnical class of the rocks, Romano's method for preliminary estimation of slope's stability could be implemented.

3. Seismic refraction and electrical-resistance methods are the most effective, while in favourable conditions GPR (ground penetration radar) method could be used.

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