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GPR monitoring of rock mass stability in selected post-mining region in Poland

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Mining activity conducted over a period of many years may cause significant changes in the geological medium and in effect leads to strong degradation of the surface in mining and post-mining regions. One of the most dangerous effects of mining activity is appearance of sinkholes on the ground surface. These phenomena are related to the changes of initial stress-strain state of the rock mass as a result of mining works and the creation of fractures which migrate from excavations to the ground surface.
The paper presents the results of selected GPR surveys carried out in the area of the coal mine "Siersza" in two sites, i.e. in the town of Siersza and in the village of Mloszowa (Upper Silesia, South Poland).
The aim of the GPR research was 3D visualisation of fractured zones distribution generated by the mining activity and an attempt to make prediction where sinkholes would appear. In order to realize this aim the measurements were conducted in 4D mode (i.e. time-space analysis), which allowed to observe the fractured zones migration towards the ground surface.
In order to obtain 4D information (x-y-z-t) GPR surveys were conducted for several years, along the same parallel profiles, separated by a constant distance equals 2.5m. The terrain measurements were carried out with RAMAC and PROEX GPR systems using 250, 200, 100 and 50 MHz antennae. Because of the limited length of this paper, only selected results from the 200-250 MHz antennae are presented. The results were presented in the form of the distribution of GPR signals energies calculated from Hilbert transform, applying the technique of energy inversion.
In the site of Siersza, on the basis of 4D GPR visualisation, regions threatened with the formation of sinkholes were distinguished. A few years after the research, 2 cavities appeared in this site which proved that the interpretation was correct. Another fractured zone in this site was confirmed by a borehole.
In the site of Mloszowa the GPR measurements were carried out in the region of already existing sinkhole (with the diameter of about 15m and the depth of about 10m) in order to detect the distribution of dangerous fractures around this sinkhole. As the results of GPR research has shown, fractured zones in this site developed quickly as a result of superimposition of fractures induced by mining activity and the processes of suffusion and congelifraction.
GPR monitoring of the rock mass stability in mining and post-mining areas is very important because sinkholes threaten the live of people and stability of structures and installations. As it was shown in the paper, the GPR method gives very good results for the prediction of sinkholes creation if it is applied in 4D mode. A limitation of this method is the depth penetration, i.e. a dozen or so meters with resolution which allows to detect fractures and strong attenuation of electromagnetic waves in the clay formations.

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