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Hidden gully erosion – detection and characterization of piping systems using geomorphological and geophysical methods (GPR, ERT)

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The significance of piping in gully formation and hillslope hydrology has been discussed for many years. However, piping as a subsurface erosion caused by water flowing through the soil is still considered as one of the most difficult erosion processes to study, because it occurs below the soil surface and traces of piping become visible on the surface only when a pipe roof collapses, or a pipe inlet or a pipe outlet has been located. Detection of pipes and their complex characterization is still a methodological challenge.

Therefore, this study aims at a better detection and characterization of piping systems in a mountainous area under a temperate climate using geomorphological mapping and geophysical methods (ground penetrating radar and electrical resistivity tomography). The survey was carried out in the Bereźnica Wyżna catchment, in the Bieszczady Mts. (Eastern Carpathians, Poland), where pipes develop in Cambisols at a depth ranging from ca 0.70 to 1.00 m. The geomorphological mapping was carried out in the in the whole catchment (2.96 km2), whereas the geophysical survey was limited to two zones (zone A – ca 32 x 82 m, zone B – ca 58 x 115 m). In this study a standard RAMAC GPR system (Malå GeoScience) with shielded 500 MHz antenna was used. The electrical resistivity tomography (ERT) was performed using electrical imaging system LUND with Terrameter SAS 4000 produced by company ABEM. The ERT and GPR data were interpreted in the RES2DINV (Geotomo Software) and RadExplorer software (DECO Geophysical Ltd) respectively. In total, 3 longitudinal and 26 transverse GPR profiles and five ERTs were performed.

The used geophysical techniques are shown to be successful in identifying pipes tested in the pilot catchment. Pipes identified by GPR and ERT were verified by the surface indicators (i.e. lowering of surface above pipes). The GPR and ERT applications suggest that piping systems density is much greater than could be detected from surface observation alone. The length of pipes may be more than 8-12% higher than surface mapping suggests. It means that the significance of piping in hillslope hydrology and gully formation can be much higher than it has been supposed.

To summarize, GPR and ERT provide non-destructive, relatively fast techniques which can indicate pipe locations across survey profiles. However, the interpretation of radargrams and ERT should be always accompanied by the detailed terrain mapping, because of the possible disturbances which may affect the geophysical profiles. The combination of results from the geomorphological mapping and geophysical survey enable the detection and complex characterization of pipes.

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