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Application of GPR and seismic methods in landslides investigation and determination of hydrogeological conditions

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Ground Penetrating Radar (GPR) belongs to non-invasive geophysical methods which use an artificially induced electromagnetic field as the way for inspection. GPR is applied not only to recognition of shallow geological structure but also to archeological studies.
The basic assumption of the applicability of GPR is the existance of a distinct boundary between two lithological horizons defined by a change in permittivity values, which results in a change in electromagnetic wave velocity. For that reason this method is used to locate empty spaces and saturated zones.
The purpose of this measurements was to determine the details of the sliding body, including the thickness and lateral extension of the landslide material, the depth of the sliding surface and water content of the subsurface. What is more correlation between GPR and seismic methods was searched. Studied area was located in the Southern part of Poland. Geological structure is characteristic for Carpathian flysch – overlaying claystones, shales and sandstones.
Measurements were carried out using GPR equipment from the Swedish company Mala Geoscience. Due to the required depth range and resolution unshielded antennas with frequencies from 25 MHz to 200 MHz were used. Profiles were traced parallel to the landslide axis. Following forms of GPR survey were applied: CO (common offset), CMP (common mid point), WARR (wide-angle reflection-refraction).
Modeling attempt electromagnetic field distribution in the medium was undertaken to select the most appropriate measurement parameters and to improve the interpretation. Programme GPRMax2D v. 2.0 was used to create models. The GPR numerical analysis uses the finite – difference time – domain method (FDTD). The FDTD approach to the numerical solution of Maxwell's equations consist of discretization both the space and the time continua.
Due to geological structure (presence of low resistivity clays and shales) attenuation of electromagnetic wave was high. In order to verify GPR interpretation seismic measurements was performed. The basic assumption of the applicability of seismic methods is the existance of a distinct boundary between two lithological horizons defined by a change in material density and elastic modulus, which results in an increase or a decrase in wave velocity. Seismic refraction and MASW (multichannel analysis of surface waves) were the main methods. Geophones with frequencies 4 Hz and 10 Hz were used.
Topographical variations were included during interpretation. It is possible to correlate GPR and seismic results especially during localization of water saturation zones. All applied methods gave also satisfactory results in recognition of the hydrogeological conditions.