APPLICATION OF GPR AND SEISMIC METHODS FOR NONINVASIVE EXAMINATION OF GLACIAL AND POSTGLACIAL SEDIMENT IN THE PSIA TRAWKA GLADE AND THE SUCHA WODA VALLEY - THE TATRA MTS., POLAND

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Introduction

Objectives of the geophysical survey in the Psia Trawka glade and the Sucha Woda valley (Tatra Mountains, Poland) were imaging the morphology of bedrock top under the drift (glacial and postglacial) sediments and determination of thickness of the drift and its composition.

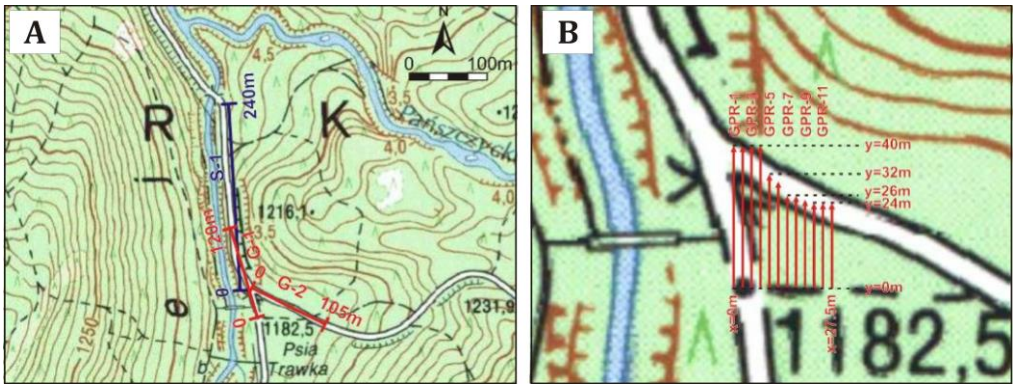

Figure 1. *A) Profiles designed for 2D seismic and 2D GPR surveys with the use of 50 MHz antennae; B) Parallel profiles designed for 3D GPR surveys with the use of 100 MHz antennae (Backdrop: topographic map – www.geoportal.gov.pl).*

Samples and methods

Two methods were applied: GPR (Ground Penetrating Radar) and seismic refraction profiling. GPR was used to examine drift sediments due to its high resolution and low depth of penetration. Seismic method with lower resolution but higher depth penetration gave an image of boundary between bedrock and drift.

Standard GPR technique (Short-Offset Reflection Profiling - SORP) was applied. Two GPR profiles (G-1 and G-2) were designed for 2D SORP survey and 50 MHz antennae were used (Fig. 1A). 12 parallel GPR profiles were designed for 3D SORP surveys and 100 MHz antennae were applied for examination of the central part of the glade (Fig. 1B). The following intervals between traces were set: Δx=0.2m (for 50 MHz) and Δx=0.1m (for 100 MHz). All GPR surveys were carried out with ProEx georadar (MALA, Sweden).

For evaluation of velocity of electromagnetic wave and for proper time-depth conversion of radargrams, WARR (Wide Angle Reflection Refraction) surveys were carried out. Velocity in shallow part of the postglacial deposits varied form 0.093 m/ns - 0.098 m/ns and the mean value was equal 0.096 m/ns.

The seismic refraction profile (235 m long) was located along the axis of the Sucha Woda valley (Fig. 1A). During field works 48-channel seismometer Terraloc Mk-6 (ABEM, Sweden) and the high-frequency geophones L–40a 100 Hz (Mark Products, USA) were used. Receivers interval was equal 5 m. Shot points were located at coordinates: -40, 0, 30, 60, 90, 120, 150, 180, 210, 235 and 275m along the profile.

Results

GPR revealed, up to 10 m of depth, thick layer of highly inhomogeneous sediment forms sub-surface structure (Fig. 2). It is probably a mixture of gravel and pebble located in silt; This layer (L1) is well seen on the depth section (Fig. 3, interval velocity around 930 m/s). Two more events are visible there: a layer L2, 7 -

30 m thick, with interval velocity around 2,100 m/s and a hard bedrock (L3, interval velocity around 3,750 m/s). Solid lines visible on fig.3 represent refractors interpreted by applying generalized reciprocal method. Also mentioned interval velocities values was estimated by this method. As a background the tomographic solution is visible. Intermediate layer represents probably strongly compacted sediment consisting of various fractions from silt to boulders up to several decimeters in diameter. The two layers fit well to the known model of the glacial (s.l.) sedimentation: the lower one represents subglacial till, the top one - an outwash (fluvioglacial sediment) laid down on a fore field of retreating front of the Sucha Woda (or Panszczyca) glacier.

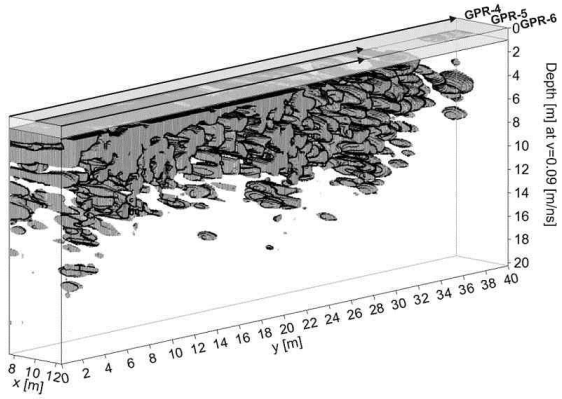

***Figure 2**. Results of 3D GPR surveys carried out along profiles from GPR-4 to GPR-6 (Fig. 1B), with the use of 100 MHz antennae. 3D visualisation was performed by outlying of the highest amplitudes of GPR signals – for this purpose Hilbert transform of signals and shading procedure were applied.*

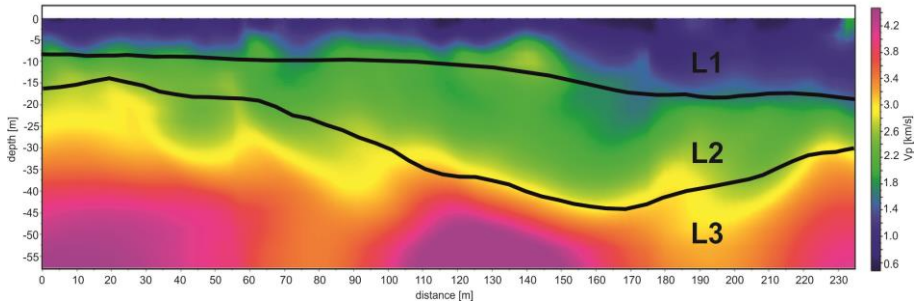

***Figure 3.** Seismic velocity* imaging *- tomographic solution. Solid lines - horizons interpreted by applying generalized reciprocal method, L1 - non compacted postglacial deposits, L2 - strongly compacted deposits, L3 – limestone.*

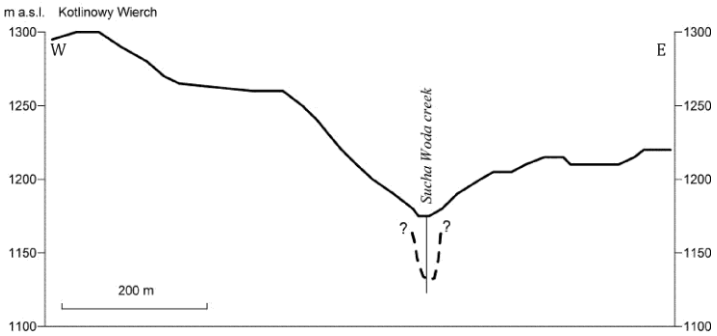

***Figure 4**. Morphologic section across the Sucha Woda valley (Psia Trawka glade). Hypothetical subglacial through is marked.*

A deep depression occurs in the top surface of the bedrock (Fig. 4). Its depth is up to nearly 45 m below the present terrain surface and up to 30 m below surrounding area of the bedrock. This is probably a section of a trough, visible on the seismic profile as the depression. A single 2D seismic profile allows us only for a very conservative prediction of its orientation. Its origin can be related to strong erosion of highly energetic subglacial water, flowing under a very high hydrostatic pressure.

Conclusions

Present study gives an insight into general proportions of the actual geomorphology, subglacial morphology and thickness of the drift (Quaternary sediments) in the area of, on one hand, particularly well pronounced glacial morphology in the Tatras and, on the other, of general scarcity of the data in this field.