Forward and Inverse Modeling of GPR Data to use in Snow, Ice and Glaciological, A Case Study: Alam Kuh Glacier, Mazandaran Province

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Extended Abstract

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Introduction

Ground-penetrating radar (GPR) method is a pretty new, non-destructive and high-resolution geophysical method that is widely used to identify the thickness of snow and ice layers and glaciers bed, because snow and ice are transparent for electromagnetic (EM) waves. Therefore, this method has been used to determine the thickness and basement topography of Alam-kooh glacier. In this research, only the GPR acquired data using unshielded antenna with central frequency of 25 MHz along one line in Alam-kuh glacier, Kelardasht- Mazandaran, have been processed and interpreted. The GPR data acquisition has been done by using common offset method, and transmitter-receiver separation of 6 meters. The final real radargram related to one of the surveyed GPR profiles in this region has been prepared after applying various processing operations containing signal saturation correction, amplitude gain, f-k migration filtering and static (topography) correction on the raw data. After applying processing sequences on the acquired data, the EM waves reflection off the interfaces of different layers including the reflections from the glacier basement have been detected, and by assigning a suitable EM wave velocity in the ice (0.16 m/ns), the thickness of 50 m for the ice layer laid under the survey line has been estimated. Also, in present research, forward and inverse modeling of GPR

data have been performed to employ for snow, ice and glaciological investigations in the AlamKooh region of Mazandaran. To achieve this goal, GPR response of synthetic model corresponding to the real radargram was simulated first, by 2-D finite-difference time domain (FDTD) method. Afterward the inversion method by solving an optimization problem was employed to validate the interpretation of real GPR data.

Methodology and Approaches

Based on the nature, physical and geometric properties of the subsurface target in the field data, their synthetic model have been built and their two-dimensional GPR responses forward modeling using ReflexW software and finite difference algorithms improved in the frequency domain, have been obtained. Also, it has been used an effective algorithm, coded in GUI environment of MATLAB programming software and as a result, a reliable and accurate inverse modeling has been carried out. In the present study, to simulate the behavior of the propagation of EM waves in GPR method, two-dimensional finite difference method has been used. The main advantage of this method is its comparative simplicity of the concept, high accuracy and simple implementation for complex and arbitrary models as well as easily adjusting the antenna when applied. In this study, acquisition of GPR field data and synthetic data modeling have been carried out in TM mode. The radargrams of the GPR data have been demonstrated using ReflexW software after performing necessary processing sequences.

Results and Conclusions

The obtained results reveal that moraine materials covering the surface of the area are mainly fine-grained granite. The bed-rock or basement in the area is also granite. The polarity representing ice-bed rock is clearly seen on the GPR profiles. The topography of the glacier basement has successfully been detectable using just by GPR method. The electrical resistive nature of the glacier has caused large penetration depth of GPR pulses in this research. Furthermore, the results of the research for presented profiles on the basis of forward and inverse modeling output of GPR data in comparison with real GPR radargrams in the region validated the accuracy of GPR investigations

in the area. Although with a quick glance, the error obtained by the inverse modeling for real GPR data seems unexpected and unacceptable, absolutely the high rate of error depends on many factors influencing on the real earth models containing various limitations existing in all forward modeling algorithms and software packages, impossibility of making forward modeling exactly according to the real models (due to the complex nature of the ground), taking into account the homogeneity and uniform host environment and targets in the modeling process unlike the diversity, the presence of different types of noises and so on. Therefore, making a controlled geophysical test site and trying performance of inverse modeling algorithm for field GPR data in this site, as well as determining the important physical parameters such as dielectric permittivity and electrical conductivity by experimental method through sampling from different depths for complex geological environments are suggested.

Keywords: Ground-penetrating radar (GPR), Snow, ice and glaciology, Alam-Kooh Glacier of Mazandaran, Forward modeling, Inverse modeling

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