ERI surveys of embankment dam with petrophysical aspects of data interpretation

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Abstract

In order to delineate frozen rocks and taliks within the rock embankment dam body, situated on fractured rock foundation in presence of continuous permafrost, the electrical resistivity imaging survey along with water electrical conductivity and temperature measurements were performed. The goal was achieved by applying the advanced petrophysical approach when interpreting the data acquired.

Keywords: electrical resistivity imaging, electropetrophysical modelling, talik, tailing, permafrost.

Introduction

Dams are among the most important development infrastructures in any country, and are used for many different purposes including irrigation, water supply, flood control, electricity production and storage of mine wastes (Vallejo & Mercedes, 2011).

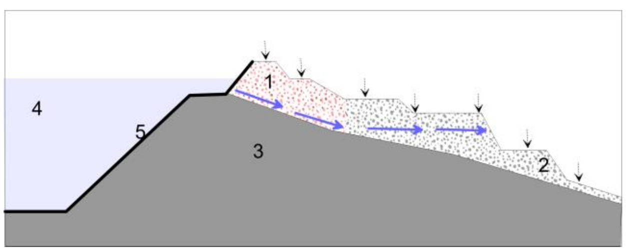

Figure 1. Dam scheme: 1 – thawed rockfill material; 2 – frozen rockfill material; 3 – frozen foundation; 4 – tailing; 5 – damp-proof membrane; black arrows – ERI profiles.

The object of the study is an embankment dam with a rock foundation on fractured andesites and tuffaceous sandstones of continuous permafrost (Figure 1). The dam is composed of coarse-grain material about 20-30 m in thickness.

Taliks and frozen rocks were detected and delineated through geophysical surveys (specifically, electrical resistivity imaging (ERI), water electrical conductivity and temperature measurements).

Petrophysical modelling and statistical analysis

Petrophysical modelling was accomplished by means of PetroWin program (Matveev & Ryzhov, 2006). For thawed rock fill material (Fig. 2) the model was fixed with porosity and temperature, according to core sample analysis and thermometry in surface water seepages and boreholes. Other properties, such as water content and brine conductivity, were varied within the values observed, corresponding to the sample analysis and water electrical conductivity measurements.

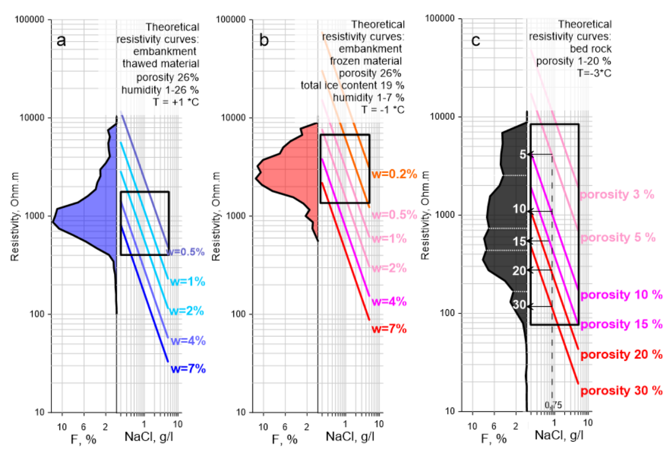

Figure 2. Electrical resistivity histograms combined with petrophysical modelling: a – thawed rockfill material; b – frozen rockfill material; c – foundation (bedrock).

In case of frozen rock fill material (Fig. 2), the model was corrected due to ice occurrence: the initial volumetric porosity was reduced by the total ice content.

In the upper part of the geological cross-section (Fig. 3) the frozen rockfill material is observed along almost all ERI profiles except for the middle part of the profile closest to the tailing where the talik is located and for the bigger part of the lower profile.

Petrophysical modelling of bedrocks was performed with fixing temperature and supposing that all voids in rocks are fully filled with water. Such parameters as effective porosity and brine mineralization correspondingly varied between 3-30% and 0.2-7 g/l.

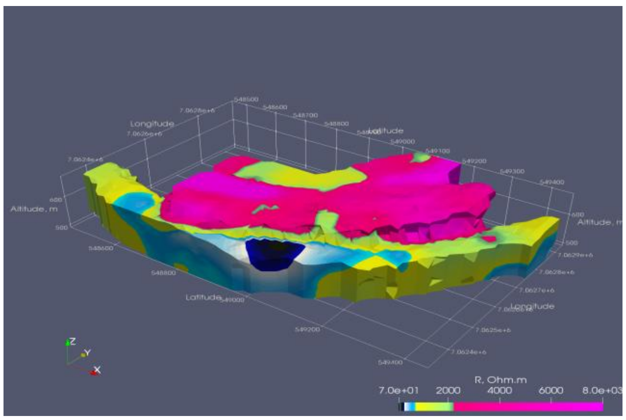

Figure 3. Upper part of the cross-section.

According to the histogram, the electrical resistivity of bedrock lies between 70 and 9000 Ohm·m. Furthermore, modelling shows a huge variety of bedrock porosity (3–30%). As is known a massive or slightly fractured igneous rocks are generally watertight. This statement is compatible with 0-5% porosity interval for bedrocks (>2200 Ohm·m). Porous sandstones and certain volcanic rocks are generally not watertight. This type of material collates with 5-10% (700-2200 Ohm·m) and 10-30% (<700 Ohm·m) effective porosity intervals.

The lower part of the cross-section (Fig. 4) shows that a half of the survey plot can be qualified as massive rocks with high resistivity values (>2200 Ohm·m), and the other half can be divided into permeable semi porous (700-2200 Ohm·m) rocks and huge low-resistivity taliks (<700 Ohm·m).

Conclusions

The combination of ERI with thermometry and water conductivity measurements is an effective method to delineate between frozen ground and talik zones.

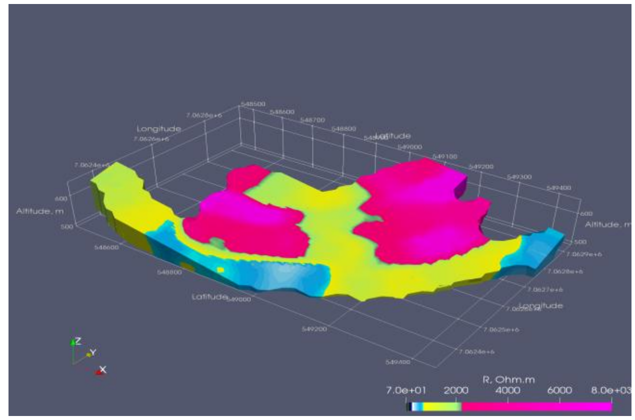

Figure 4. Lower part of the cross-section.

Using petrophysical modelling combined with statistical analysis we divided the cross-section into frozen and unfrozen parts, separated massive and porous units in bedrocks and traced three-dimensional heterogeneities in dam body and footing.

The presence of a detected 3D complicated permeable structure in the axial region may mean that the seepage from the storage reservoir flows in between the rockfill and foundation or dives into the lower part of the cross-section. This may lead to erosion processes which can affect the stability of the foundation with the negative expected results.

References

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