Application of Georadar in Cryosphere for the Study Engineering Constructions

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Abstract

Use of a georadar-location as the most mobile and detailed geophysical method, it is rather perspective for studying and monitoring of a condition of the bases of engineering constructions. Georadar-location solve problems of mapping frozen and thawed rocks, detect lithology contacts, faults, zones of fracturing, sites through and not through taliks, underground ice and water saturated zones. The georadar-location can be used for studying freezing processes and phenomena, including dynamics seasonal freezing and thawing, processes frazil-forming, surface bulging, thermokarst, frost-shattered bursting, etc. arising during exploitation of construction. But application of a method in many respects is complicated with a variety of surface conditions, including a microrelief and electric properties of sedimentary cover, and also influences of seasonal factors. The paper presents technology of preparation and taking under account the relief features of investigated objects, and also uses of seasonal conditions for solving engineering - geological problems by a method of a georadar-location in cryosphere.

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Keywords: georadar, cryosphere, geophysical monitoring; permafrost, engineering constractions

Introduction

The geophysical study of the state of engineering constructions basements in cryosphere is a complicate task. It is connected with geocryological pecularities of the sections - lithology, tectonic, hydrogeology and other features, like presence of talik zones. These peculiarities form substantial variability of physical properties along investigated sections. These factors are complicated also by seasonal variations which must be considered during radar data interpretation.

Application of a georadar-location for the control of the state of engineering constructions is very perspective in because of potential opportunity of carrying out "continuous observations" with high resolution and using “detector-generator” installations in many times smaller, than investigated elements of constructions. Others ground geophysical methods, where “detector-generator” installations (power lines for conductive methods of electroprospecting, generating and measuring loops for impulse electroprospecting methods, seismic braids, etc.), as a rule, have significant sizes. In this case received signal includes overlapped noise connected not with the investigated site of a hydro unit, but with different mechanisms and various designs and elements of a relief of the unit (dams for example).

But, nevertheless, a surface georadar-location, as well as others geophysical methods, has a number of essential restrictions on applicability. Firstly it is depth-determining and resolution which depend not only from electric (Finkelshtein et.al. 1977) properties of investigated sections (electro conductivity, dielectric permeability and magnetic susceptibility), but also from surface conditions, including condition of surface relief and its electric properties.

Ways of Improvement of Research Productivity

Above mentioned complexities, do not reduce efficiency application of a georadar-location for studying and diagnostics of a condition of the bases of engineering constructions. Productivity of a method can be essentially increased due to rational use of seasonally climatic conditions and special preparation of a probing surface (cleaning, smoothing, moistening, etc).

Use of distinctions of structure and character of georadar-tracking sections of the bases and road coverings of the engineering constructions observable in winter and summer time, before and after precipitations, i.e. in various geocryology and temperature-moiture condition is very informative.

Use of a priori information about lithology structure of investigated sections, changes of a temperature condition of basement soils and temperatures of the beginning of thawing-freezing give a key to an effective use of georadar technologies for studying and the control of the bases of engineering constructions, buildings and road coverings.

Authors of the present work, prosecuting subjects of development of a technique and technics of the geophysical control of a condition of engineering constructions in the Western Yakutia. Thus a number of original materials on

application of a georadar-location with application of various ways of preparation of a surface of investigated structures and accounting seasonally climatic and temperature-moiture condition have been received.

Despite of seeming ease and high efficiency of carrying out of georadar-tracking researches, reception of the qualitative information demands in many cases of separate works on preparation of a probing surface for measurement (cleaning from a snow and ice, smoothing of surface irregularities of microrelief, wetting of a surface).

Besides for many objects there are seasonal restrictions of applicability of a method. While, the problem can be solved only in the way of comparison of the results received in various seasonal and temperature-moisture condition (winter - summer), before and after a rain, during the maximal or minimal capacity of a seasonal - thawed layer, etc.

Results of Work

Expediency of preparation sounding surfaces illustrate results of studying of a georadar-tracking section of a site of road with a concrete covering (Fig. 1).

Measurements were carried out with the same equipment at presence small air-gap (4 cm) between a bottom of antenna and road (measurements on a support with wheels) and without it (shooting without a support). As follows from figure, georadarogramma in case of measurements with raised above the road antenna is considerably noisy in comparison with results of observation without a support that complicates studying section. On Figure 2 presented radarogramm along coping of reservoir of river Sitikan, received after clearing a surface of a road dirty. This simple measure has allowed revealing rather detailed elements of a structure of a dam which position in its section allows supervising the state of dam during conducting building actions (strengthening of a road cloth, cementation of the sites weakened while in service of object).

Opportunities of studying with the help of georadar-location from ice sheet of reservoir of a structure of a bottom and bottom sediments of a site of a reservoir where it was carried out filling a coastal adjunction for reduction of bypass filtration, are presented on Figure 3. Results have been received after clearing a surface of ice that has allowed to reduce considerably a level of noise and to solve a task of estimation of thickness of an underwater part of filling.

Important to note, that cleaning and smoothing of sounding surfaces, sharply improves radarogramm quality due to reduction of influence of a micro relief and a non-uniform covering of studied sites with dirty and sleet which can considerably deform and weaken signal.

On Figure 4 presented mapping of the basement of productive horizon and revealing of features of its structure with the help of a georadar-location. This can be possible only after removal of a soil - vegetative layer which was the strong screen because of the high humidity and presence of a clay layer.

Among other measures on preparation of probing surfaces it is necessary to note filling with a fine-grained material and smoothing of a surface of studied structures. In particular, on one of dams of the Western Yakutia it has allowed to reveal with the high resolution the weakened zone and a filtrational window in a body of a dam (Fig. 5).

Besides use of ways of preparation of probing surfaces, for carrying out of a georadar-location the good effect gives use of seasonal and weather factors, i.e. sounding in conditions freezing and thawing of investigated sections, before wetting by rain surface of horizons and some other.

On Figure 6 it is given an example regime researches on one of ranges of diamond alluvial deposit where in a consequence were planned dragging works. Researches were carried out during the winter period, i.e. in a cycle freezing of soils. During the study appeared, that regime georadar-tracking observations allow to estimate geocryology features of a section. Figure 6 results of researches in December, 2005 and February, 2006 are given. Appeared, that in December the freezing and summer maximumthawing borders rather precisely marked out, that has proved to be true by temperature observations (Fig. 6a). Further in January - February, during the further freezing of a section, on radarogramm begin distinctly stand out sharply lithological borders including roof and bottom of productive horizon that proves to be true by the geological data on a cores and description of prospecting shaft (Fig. 6c).

During processing the account of a relief of a day time surface has been carried out, and it has enabled to reveal confidently a bottom of productive horizon, to define its depth and thickness for the moment of the beginning dragging works. In a consequence it was possible to predict the state of soils developed section (time of thawing of productive horizon after filling dragging a foundation trench).

Conclusion

The results of researches presented in work show, that application during georadar-tracking works of various ways of preparation of studied surfaces (cleaning, filling, smoothing, wetting, etc.), and also use and the account of seasonal - climatic and weather factors allows to increase productivity of georadar-tracking works in many cases.

Besides the carried out researches have allowed to draw a conclusion, that, notwithstanding circumstance, that in a basis of a method of a georadar-location difference of rocks and soils on dielectric permeability and electro conductivity - the basic character of georadar-tracking sections lays, as a rule, reflects first of all position lithological boundaries. Borders connected with geocryological state frequently have secondary character and come to light on radarogramm less precisely. In many cases basic elements of geocryological structure come to light during the periods which are not corresponding seasonal geocryological state more brightly. In particular it concerns the border of maximal seasonal thawing during intensive freezing, etc.

References

Finkelshtein M.I., Mendelson V.L. and V.A. Kuteev 1977. *Radar-location of layered terrestrial covers*. Moscow: Soviet Radio, 176pp. (in Russian)

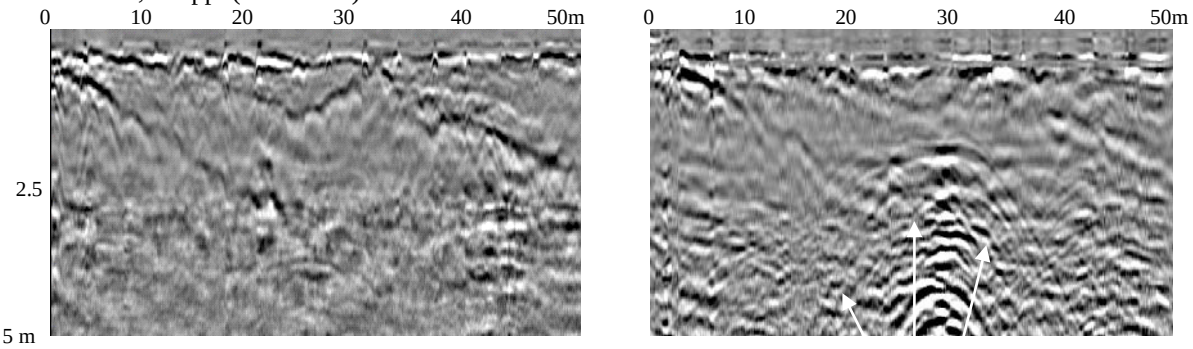

Fig. 1An example of influencing of a small air stratum (4cm) between the bottom of antenna (facility SIR2000 antenna FGMOD5106 f=200 MHz) and probing surface (concrete-sur-faced road on frozen foundation).

a) georadarogramm with antenna without air-gap(no support)

b) georadarogramm with uplifted antenna (4cm air-gap due to support on wheels)

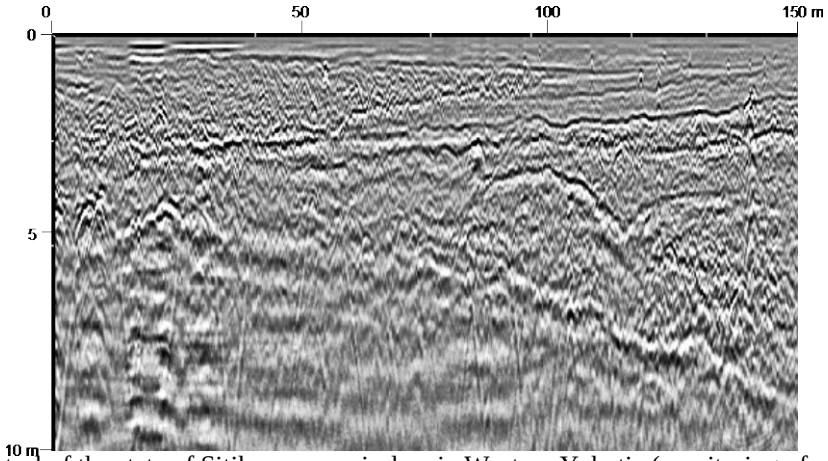

Fig.2 Georadar control of the state of Sitikan reservoir dam in Western Yakutia (monitoring of reflectors)

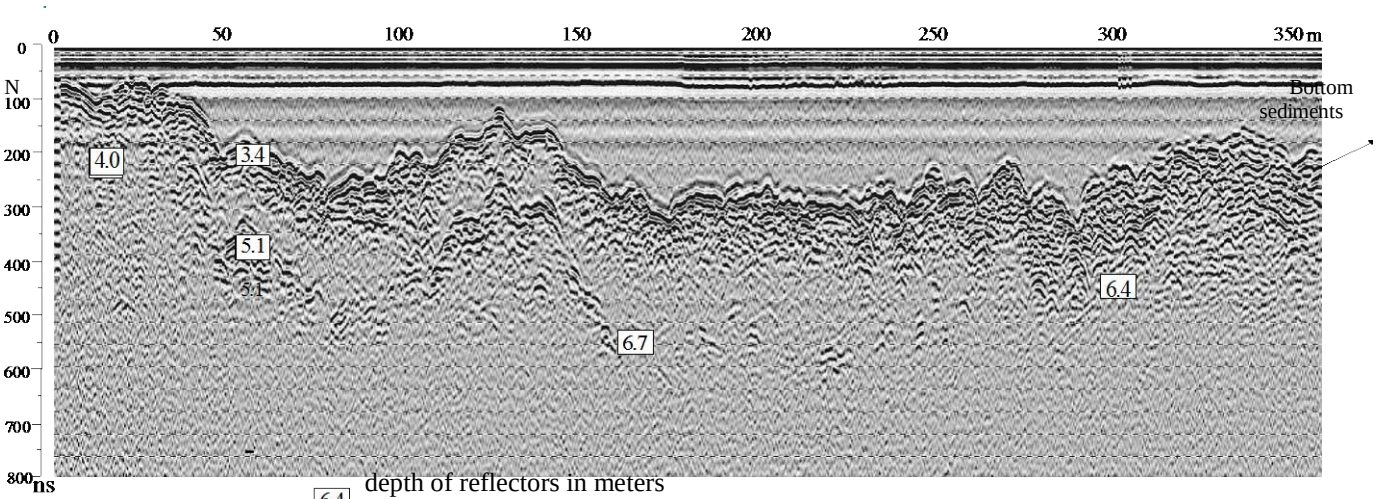

Fig.3 Georadar observation from ice sheet of reservoir (bottom sediments study)

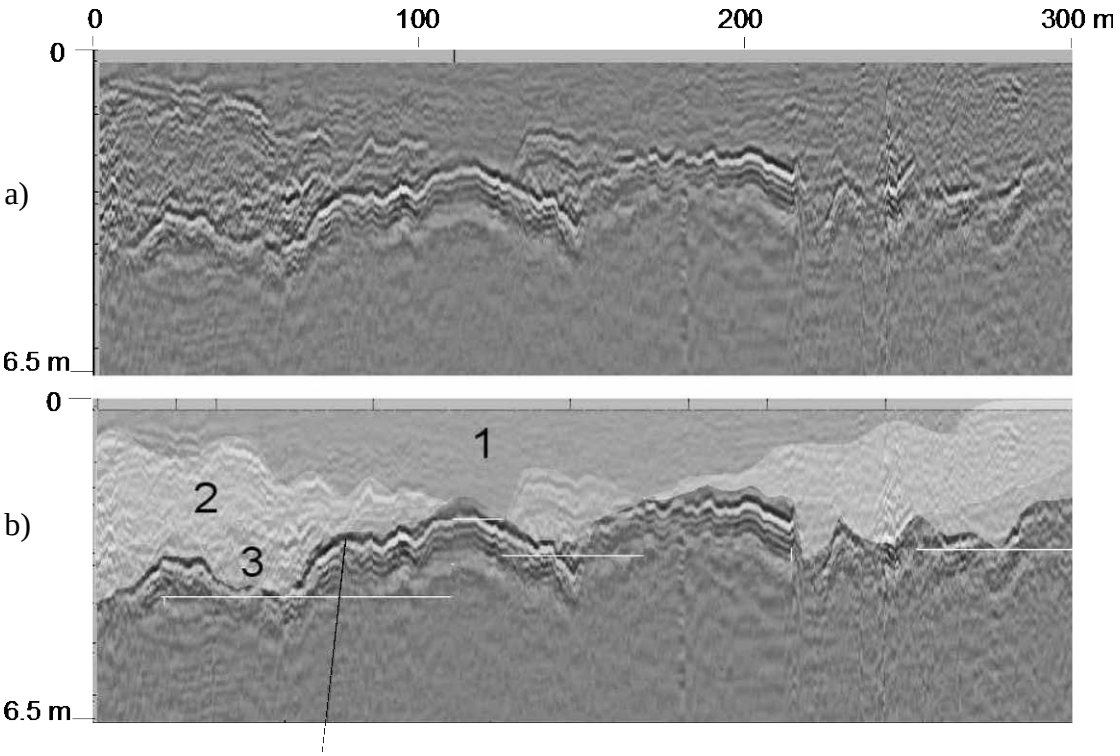

Fig.4 Georadar plot of diamond alluvial deposit from diamond-field in Western Yakutia:
a) radarogramm after preliminary processing
b) radarogramm with picked geoelectric horizons corresponding to different soils of terrace sediments

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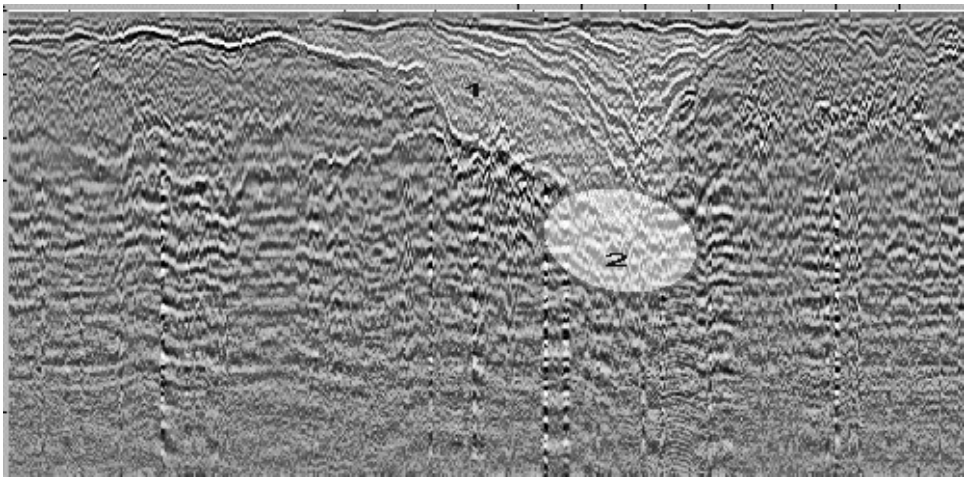
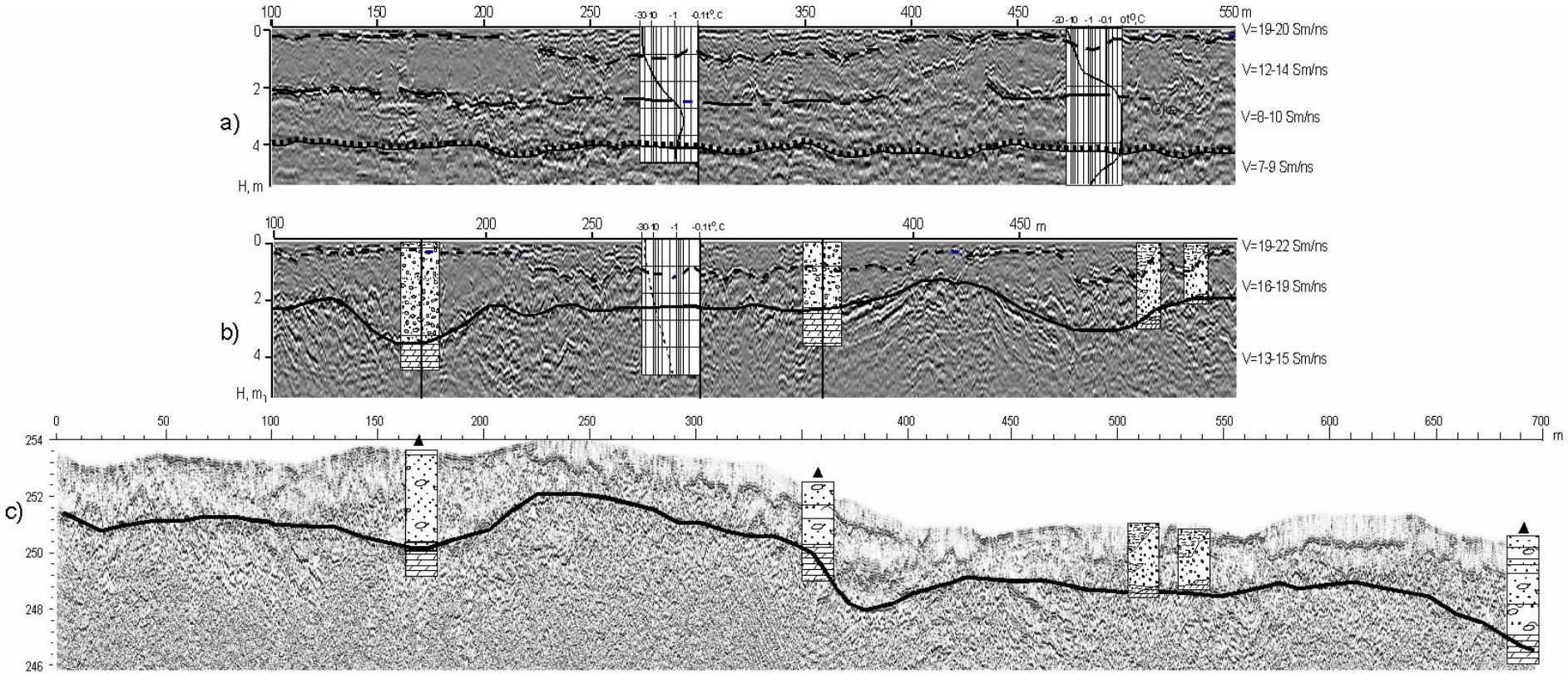


Fig. 5 Radarogramm along coping of settling pound.

Detecting seepage zone in the body of dam.1- outline of deconsolidation sink : 2- seepage zone



LEGEND:

Shingle-gravel-sand mixture

sandy loam with shingle и gravel

fine-grained sand without pebble

malm blasted

limestone arenaceous

temperature plot

V= 16-19 cm/ns – velocity of electromagnetic waves

roof of productive horizon

bottom of productive horizon

freezing oundary

maximum thawing boundary

Fig.6 Georadar crossections along profile 1: a) December 2005; b) February 2006; c) February 2006, taking into account the surface