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Comprehensive Program of Engineering and Geologic Surveys for Designing and Constructing Radioactive Waste Storage Facilities in Hard Rock Massifs

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DISCLAIMER

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Comprehensive Program of Engineering and Geologic Surveys for Designing and Constructing Radioactive Waste Storage Facilities in Hard Rock Massifs

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Abstract—*Geological, geophysical, and engineering-geological research conducted at the "Yeniseisky" site obtained data on climatic, geomorphologic, geological conditions, structure and properties of composing rocks, and conditions of underground water recharge and discharge. These results provide sufficient information to make an estimate of the suitability of locating a radioactive waste (RW) underground isolation facility at the Nizhnekansky granitoid massif.*

I. INTRODUCTION

Optimum technical and economic decisions to be followed in designing RW underground isolation facilities are developed on the basis of a whole set of parameters. The major items included are detailed information about structure, composition, degree of rock disturbance, tectonic processes, water exchange conditions and chemical composition of underground waters at the site for construction of the underground isolation facility.

The choice of siting for such a facility (RW storage or repository) is carried out step-wise and includes the search of the prospective district followed by subsequent allocation of sites and subsites for construction within its limits. Each stage of research requires conducting engineering surveys at specified scales and methods of work.

II. NIZHNEKANSKY GRANITOID MASSIF

At the beginning of the 1990s, studies for definition of the opportunity of underground isolation solid RW from the RT-2 plant were initiated within a radius of 500 km from the Mining and Chemical Combine (MCC) at Zheleznogorsk.

The analysis of geological and geophysical and hydrogeological materials and interpretation of satellite and aerial photographs of this territory have allowed us to locate within the limits of the southern part of the Yenisei ridge about two dozens sites situated in ancient metamorphic and intrusive rock complexes. The granitoids of the Nizhnekansky rock massif and host gneisses were considered the best prospective geological formations for solidified RW disposal. The subsequent work carried out in the territory of the Nizhnekansky granitoid massif allowed us to further identify within its borders several sites suitable for underground isolation facility construction.

In 2001, geologic and geophysical research conducted under the guidance of the V.G. Khlopin Radium Institute (NPO KRI) at sub-sites Itatsky and Kammeny in the Verhne-Itatsky site were completed. This research largely corresponds to work done for the Justification of Investment (JOI) stage of development.[1] Two major possible sites, the Verhne-Itatsky and the Yeniseisky, have been scheduled for further detailed study in the initial stage, the Declaration of Intent (DOI) for construction of the underground laboratory,[1] which calls for a study of primary and alternative sites.

The Yeniseisky site is the alternative site. Geologic, geophysical, and engineering geological research will be conducted there under the guidance of VNIPIPT. The scope of the futureYeniseisky studies is as specified for the later JOI stage of repository development.

II.A Site "Verhne-Itatsky"

Practically all experts from organizations of RF Minatom, including VNIPIpromtechnologii (VNIPIPT), the Russian Academy of Sciences, and geological organizations of the Krasnoyarsk region, primarily the Krasnoyarsk Research Institute of Geology and Mineral Products (KNIIGIMS) and the Krasnoyarsk State Research Institute (KGPII), who participated in carrying out the research, considered the site "Verhne-Itatsky" to be the major one with the "Yeniseisky" site as an alternative. This was stated in the DOI for underground laboratory construction at the Nizhnekansky granitoid massif, as accepted and signed in 2002 by the Krasnoyarsk region administration and representatives of the MCC.

Originally it was supposed that the "Verhne-Itatsky" site and the surrounding area would be studied comprehensively by geological and geophysical methods to select structural blocks suitable for development of the RW reposi-

tory. However, the major work completed under the guidance of NPO KRI, was concentrated in the eastern part of the selected area at the "Itatsky" and "Kamenny" subsites, which cover about one-third of the area of the "Verhne-Itatsky" site. A comprehensive complex of geophysical and geological surveys, hydro-geological work, and drilling of shallow mapping wells and deep stratigraphic boreholes was carried out in this area of the territory.

II.B Complex Research of the "Yeniseisky" Site

At present, geologic and geophysical and hydro-geological research is being carried out in the northwest part of the Nizhnekansky massif at the alternative "Yeniseisky" site, which has an area of about 70 sq. km (Fig. 1). The site occupies a watershed part of the Shumisha River headwaters and left tributaries of the middle current of the Bolshoy Tel River. The absolute relief varies from 280 m (in the down-cuttings of river valleys) up to 410 m (in the surrounding watersheds).

Because the extent of site knowledge appeared to be rather poor, a large complex of geological and geophysical and engineering geological work was planned to specify its geological structure and the hydro-geological conditions.

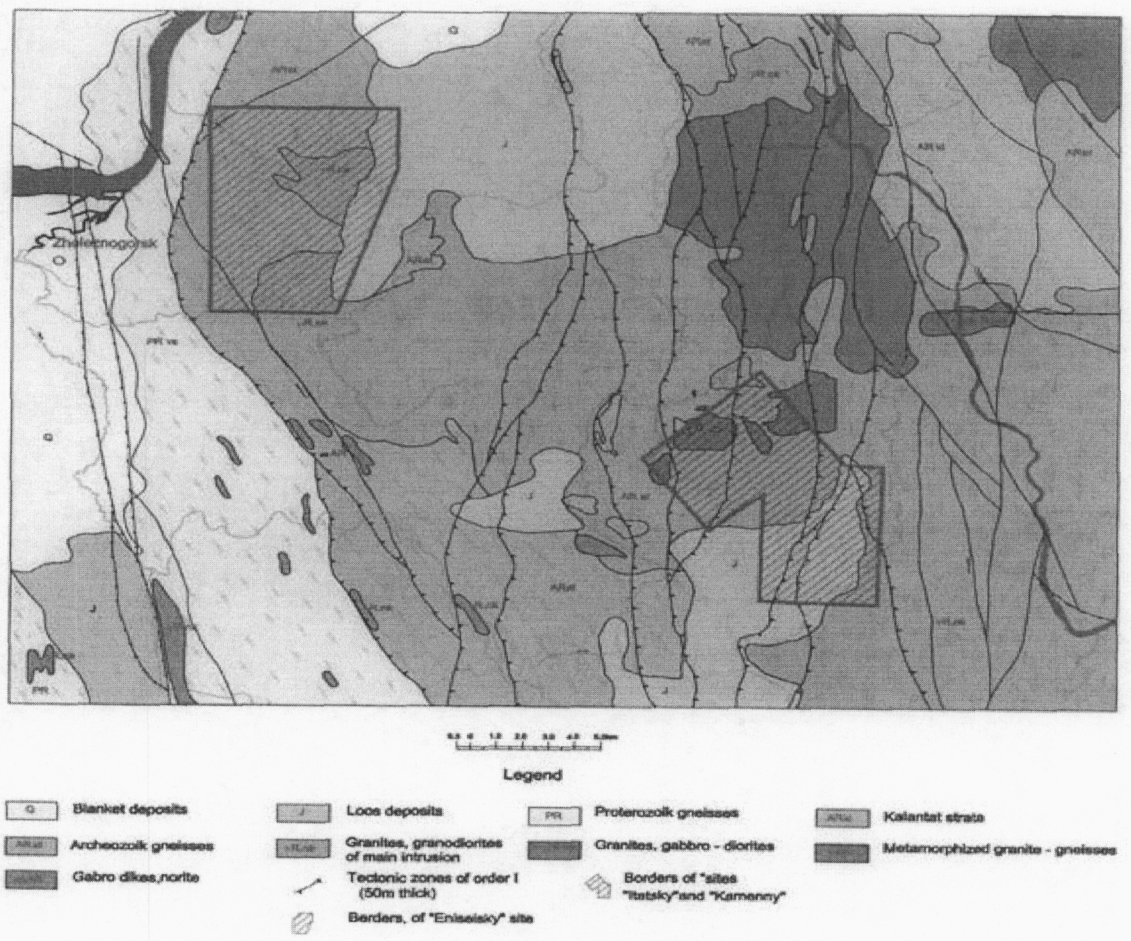

Fig. 1. Geologic-tectonic chart of the Nizhenkansky granitoid massif.

To establish the location of geological structures, tectonic disturbances, fracturing, and conditions of underground water spread (i.e., area of recharge, transit, and discharge), space and aerial photographs of the northwest part of the Nizhnekansky granitoid massif were interpreted. The materials obtained allowed us to draw up the preliminary geological and tectonic chart on a scale of 1:50000 (Fig. 1), and to estimate the newest and recent historic movements of the earth's crust in the territory investigated.

To carry out surface geophysical and engineering-geological work in the taiga, swaths were cut through the woods and a network of profiles was laid. Topographic and geodetic work ensured survey control of profiles and geophysical observation points. Five baselines of about 50 run-

ning kilometers long and three profiles of about 20 running kilometers long were made altogether, at a station distance of 250 meters.

Engineering surveys were carried out on the area and in profiles and included hydro-geological, emanation (radon), helium and engineering-geological surveys. In addition, regime hydrological and meteorological observations were carried out.

As a result of these surveys, we obtained data on climatic, geomorphological, and engineering-geological conditions of the site; host rock properties; hydrological characteristics of surface-stream flows; places of recharge and conditions of discharge of the underground waters and their chemistry.

Reconnaissance geological explorations were carried out in geophysical sections, including:

- Mapping original rock outcrops (lithologic and mineralogical structure, degree and character of fracturing were described, and elements of rock occurrence and degree of rock weathering were defined);
- Sampling for various kinds of analyses.

One of the main determinants of the efficient study of the "Yeniseisky" site was the priority of comprehensive geophysical work. The complex of methods was chosen so that knowledge of the site's structural-tectonic structure would be obtained at the initial phase of research. Surface geophysical works were carried out in a profile variant and included:

- Magnetic prospecting;
- Gravimetric prospecting;
- Seismic prospecting;
- Electromagnetic prospecting.

Several methods were used for electromagnetic prospecting, including use of the method of transients, i.e, the inductive pulse method. This is effective for mapping the upper part of a section, including the disintegrated surface of the granitoid massif.

Another electromagnetic method employed was vertical electric sounding, which is most widely used for studying geological sections at small depths up to 500 m. This method provides information on the change of specific electric resistivity in rocks in a section, their thickness and depth of occurrence.

A third method was audiomagnetotellurium sounding, which is the variety of electromagnetic prospecting based upon the natural (magnetotellurium) field of the earth, and is effective for research at greater depths.

As a result of surface geological and geophysical research, we obtained an understanding about the capacity of unconsolidated deposits distributed in the top part of a section, their depth of occurrence, petrographic structure, the relationship between the intrusive and metamorphic complexes of the site and the degree of their dislocations. The results of field geophysical studies have been transformed into charts, sections, and isoline maps of physical quantities such as that illustrated in Fig. 2. Interpretation of the geophysical data is continuing.

Geoelectric and density models (sections) and the tectonic chart and site block-diagram were constructed. Variations of geophysical fields have allowed the substantiation of a number of tectonic disturbances that are disclosed by the geological data and to discern homogeneous structural-tectonic blocks.

The complex of surface geophysical work carried out during the study of the Yeniseisky site will allow a complete assessment, by Russian standards, of the geological conditions of the territory before drilling of boreholes is started to confirm the suitability of locations for construction of the underground laboratory.

ACKNOWLEDGMENTS

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REFERENCES

1. Steps in the Repository Life Cycle (Fig. 3), Track 70428, elsewhere in this Proceedings or in T.A. Gupalo, L. J. Jardine, J. Williams, *Plan for Underground Radioactive Waste Isolation at the Nizhnekansky Massif*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-JC-150396 preprint, 2002.

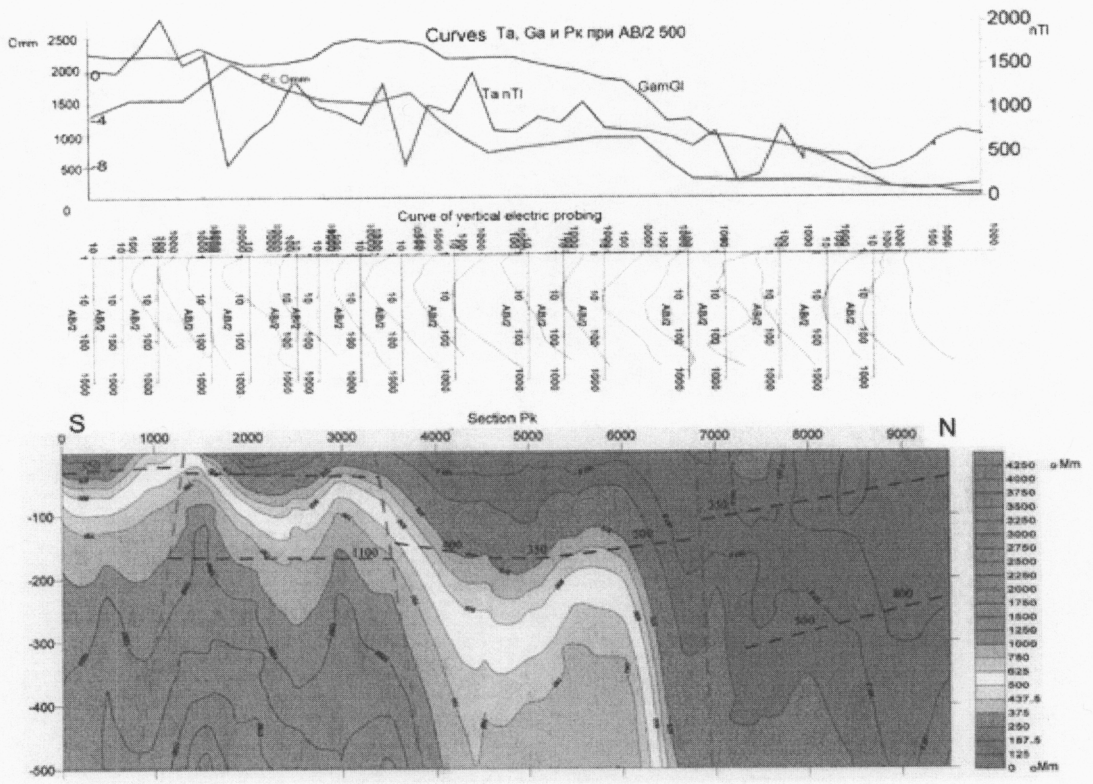

Fig. 2. Typical results of interpretation of geophysical data in baseline 2.