INTERNATIONAL REPOSITORY PROJECT IN RUSSIA

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ABSTRACT

Safe and reliable confinement of already accumulated and continuously arising irradiated nuclear fuel is an important radiological problem faced by Russia and some other countries of the world having nuclear power plants (NPPs) in operation. Implementation of both national and multinational repository construction projects seems a reasonable solution for the problem of safe nuclear fuel management. It will provide for the consolidation of financial, technological, research and engineering efforts of the project participants and offer feasible solutions for the problem of non-proliferation of nuclear materials, as well as protection measures against the acts of international terrorism.

The Priargunsky Industrial Mining and Chemical Operations (PPGKhO) are located in an under-populated area of the Eastern Transbaikal Area (the town of Krasnokamensk, Chita Region). In terms of its geography, natural and geological conditions, as well as economic and technological potential this area seems rather promising for the implementation of the spent nuclear fuel (SNF) repository construction project. Eventually, the proposed repository may become a multinational facility of the kind.

The PPGKhO is developing molybdenum-uranium and uranium deposits, and it is the only producer of uranium oxides in Russia. This enterprise has a diversified branched production and energy-supply infrastructure and a great research and technological potential, highly skilled and experienced production and research personnel, which is able to competently and promptly solve the task of choosing a suitable site for the SNF underground repository construction project and to make an important contribution to its implementation.

The PPGKhO is the main source of job opportunities for the local population and the principal taxpayer to the local budget. Presently, the population of the town of Krasnokamensk amounts to nearly 60 thousand, of which 12 thousand citizens are the employees of the PPGKhO. The results of the local population polling show that most citizens support the idea of the repository construction in the area of the PPGKhO operation.

INTRODUCTION

Safe and reliable confinement of already accumulated and continuously arising irradiated nuclear fuel is an important radiological problem faced by Russia today. Some other countries of the world having nuclear power plants in operation also have to address the problems of the kind.
By present, SNF storage facilities of most Russian NPPs and the shore bases of the nuclear-powered Navy in the northwest and the eastern part of the country have been filled already to the design capacity, and some of them are now nearing this level. That is why the necessity for the construction of new SNF repositories providing for the environmentally safe storage of nuclear materials is one of the most essential problems of national importance.

For the implementation of this task the consolidated national efforts must be supported by the collaborative attemps of foreign researchers, engineers and experts, as well as economic resources of the international community. The laws and acts approved in 2001 and allowing the imports of foreign SNF to Russia that can give the country substantial economic benefits providing for the development of the regional and local economy, as well as the reduction of the risk of proliferation of nuclear materials, form another important factor in favour of the multinational repository project.

In 2001, in addition to the Decree "On Special Commission for the Issues Concerning the Importation of Irradiated Nuclear Fuel Assemblies of Foreign Origin to the Territory of the Russian Federation" the following Federal Laws and Acts were approved: "On Amendments to the Federal Law "On Nuclear Power Application", "On Amendments to the Article 50 of the RSFSR Law "On Environmental Control" and "On Special Environmental Programs for Rehabilitation of Territories Contaminated with Radiation" [1].

The first two laws call off the earlier established restrictions concerning the importation of SNF of foreign origin to the country, while the third one envisages the investing of a certain share of earnings from the importation in environmental programs. At the same time, a Draft Law was submitted for the examination to the Lower Chamber of the Russian Parliament. According to this document the irradiated fuel assemblies of foreign origin can be imported to the country's territory only based on the favorable decision of this Commission.

The territory of the PPGKhO can be viewed as one of the areas suitable, in terms of its geography, economic and technological potential, natural and geological conditions, for the construction of the SNF repository, which can eventually become a multinational facility of the kind. The PPGKhO is the only Russian uranium ore mining and processing facility. It is located in the Eastern Transbaikal Area (southeast of the Chita Region, the Krasnokamensk district), some 500 km to the southeast from the city of Chita (Fig. 1).

The PPGKhO is developing the deposits of the Streltsovskoe ore field located in the Tulukuevskaya caldera of the Mesozoic (~ 140 million years) age, with an area of nearly 200 km^2. The caldera contains 18 closely situated molybdenum-uranium and uranium deposits (Fig. 2) with unique total uranium reserves exceeding 250,000 t [2], nearly one half of these reserves has been extracted already.

Presently, the PPGKhO is also mining and processing zeolite materials, and developing gold and molybdenum deposits.

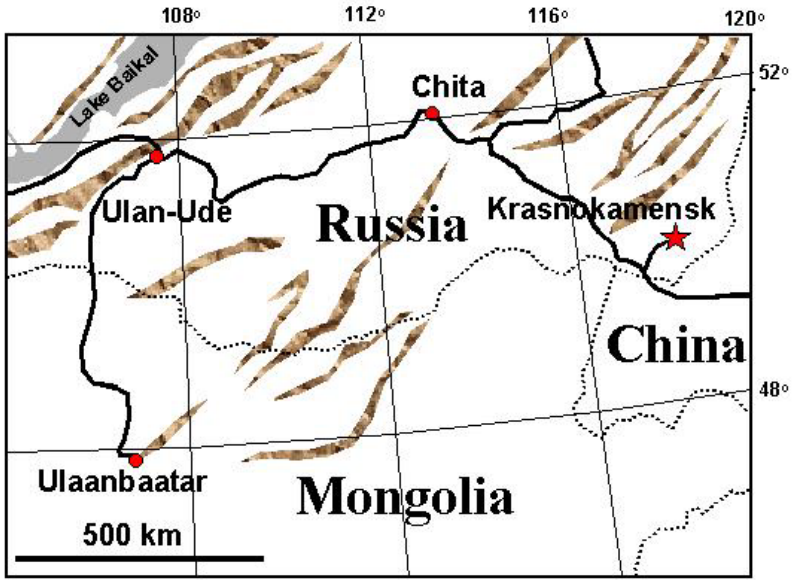

Fig. 1 Geography of the Eastern Transbaikal Area, main railway lines and location of the PPGKhO in the town of Krasnokamensk

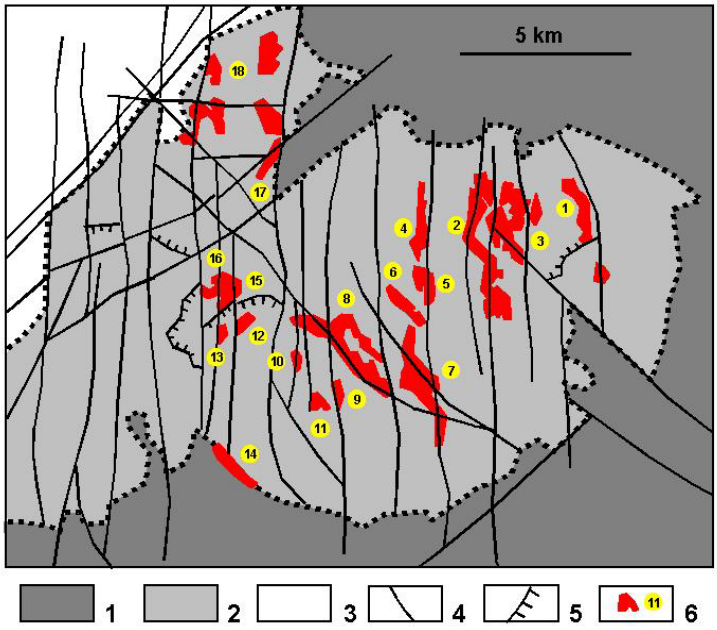

Fig. 2 Geologic sketch of the Streltsovskoe ore field. 1–lower structural complex (basement), 2–upper structural complex (caldera), 3–sediments, 4–dip-slip faults, 5–gently slip faults, 6 –uranium deposits with number: 1–Shirondukuevskoe, 2– Streltsovskoe, 3–Antei, 4–Oktyabrskoe, 5–Lichistoe, 6– Martovskoe, 7–Malo-Tulukuevskoe, 8–Tulukuevskoe, 9– Yubileinoe, 10–Vesennee, 11–Novogodnee, 12–Pyatiletnee, 13 – Krasnyi Kamen, 14 – Yugo-Zapadnoe, 15 – Zherlovoe, 16 – Argunskoe, 17 – Bezrechnoe, 18 – Dalnee.

ACTUAL DATA

Some issues concerning conditions for the multinational repository constructing within the territory of the PPGKhO are presented below.

Geography, natural and geological conditions

The PPGKhO is located in an under-populated area, at a substantial distance from large cities, towns and industrial centers, however, it is connected with other economically developed regions of Russia by a railway line and motor roads.

The area is situated in the zone with continental climate, hot summer and cold winter with little snow. The mean annual air temperature is –2.1° C. Southwestern, western and northwestern winds prevail in the area throughout a year.

The landscape of the area is a bare, dry highland steppe with the relief formed by small cone-shaped hills and flat valleys (ravines) of a 0.5-2.0 km width. The altitude of bottoms of the deepest valleys and the top points of the hills are +550 m a.s.l. and 1,100 m a.s.l. accordingly (Fig. 3).

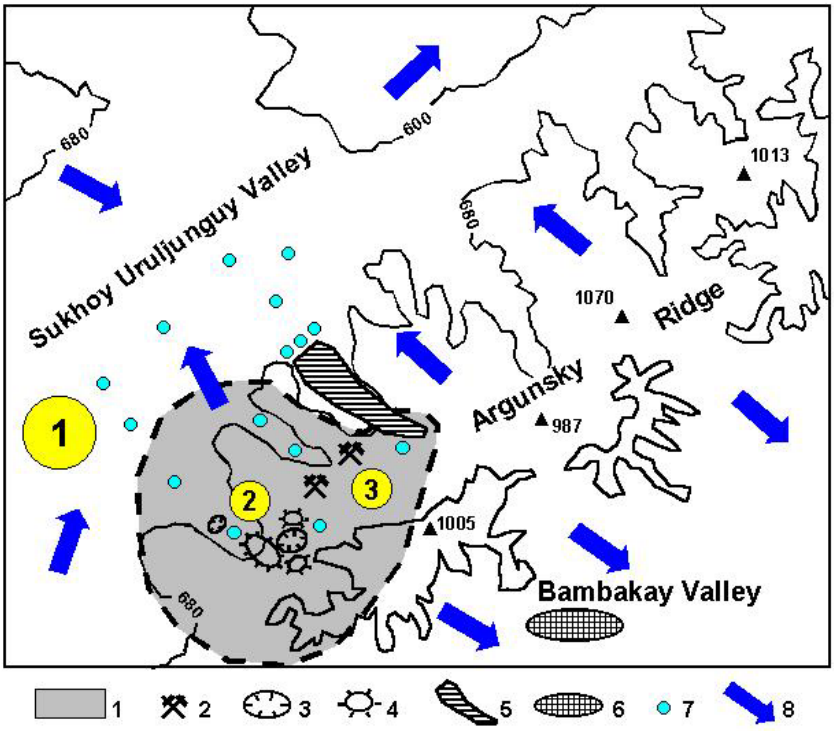

Fig. 3. Topography and production facility layout of the territory. Yellow circles: 1–The town of Krasnokamensk, 2–Krasnokamensky settlement, 3–Oktyabrsky settlement. Legend: 1–Tulukuevskaya caldera, 2–mines, 3 - open pits, 4–waste piles, 5–mill tailings, 6–marshland, 7–monitoring wells, 8–underground water flow.

Due to low moisture and insignificant precipitation (nearly 400 mm per year) the watering of the area and the density of its drainage network is relatively low. The main sources for the replenishment of underground water reserves are atmospheric precipitations and condensate of atmospheric moisture. The normal condensation of moisture from small surface water sources amounts to 650 mm. The altitude of

underground water table is +500÷+700 m a.s.l. The area under consideration belongs to the category of low-magnitude seismicity [3].

The geology of the PPGKhO territory has been thoroughly investigated in the course of long-term exploration, which included geological and geophysical investigations, a great scope of exploration drilling, shaft sinking and drivage of underground galleries, as well as a broad-scale research work. Mining and development processes, which are now under way there, present an important source of geological information.

The area is formed by rocks of two complexes differing in age, structure and characteristics [4] (see Fig. 2.).

The upper complex is formed by volcanogenic and terrigenous-carbonate rocks of the Mesozoic age. Volcanogenic rocks (rhyolites, dacites, basalts, tuffs and tuff-sandstones) form the filling of the Tulukuevskaya caldera enclosing all the working molybdenum-uranium and uranium deposits. These rocks are characterized by intensive tectonic faulting, alteration due to hydrothermal processes of different ages, and as a result, by low mechanical stability. Due to these factors they are not suitable for the construction of the repository for nuclear materials. The same is true for Mesozoic sedimentary rocks. They are also characterized by insufficient mechanical stability, and they occur in water-flooded depressed areas of the relief.

The lower complex, which is the basement and rim of the caldera, is formed mainly by granitoids of the Caledonian (coarse-grained gneissoid, pophyroid biotite, or in rare cases, amphibolic-biotitic granites) and Variscan (biotitic and leucocratic granites) ages, as well as by Proterozoic metamorphic rocks (schists and marble) occurring as xenoliths.

Non-altered granitoids are dense, massive rocks of low permeability and high strength characteristics. They mainly form the hilly part of the relief.

In granitoids forming the rim of the caldera some weakly altered blocks of the desired size can be found, with the view of investigating their structure, composition and condition, and among them a block can be identified, which is most suitable for the construction of the infrastructure for the SNF underground repository.

Design features of the proposed repository and the perspective sites for its construction

A gallery-type repository design seems most feasible in the conditions of the PPGKhO territory from the viewpoint of its surface relief, environmental, engineering and economic background, as well as safety considerations.

The following arguments can be given in favour of this SNF repository design realization in conditions of the PPGKhO territory:

- The location of the proposed repository in the rock massif and the presence of a 300 m thick safety rock pillar over the place of radioactive material storage substantially reduce the risk of exposure of the materials to uncontrolled external effects;

- High strength, low permeability and relatively slight tectonic alteration of crystalline rocks enclosing the repository significantly minimize the risk of the repository failure, as well as the ingress of underground waters and transport of radionuclides to the biosphere;

- In contrast to the shaft-type design option the gallery-type repository does not require the construction of underground hoist and stationary water drainage facilities, as well as sophisticated ventilation systems.

The interim examination of the probable location options for the proposed repository performed by the experts of the PPGKhO and the IGEM RAS has resulted in the identification of five sites in the field of the lower complex rock development (Fig. 4.). Their position in the relief is suitable for the implementation of a gallery-type repository design.

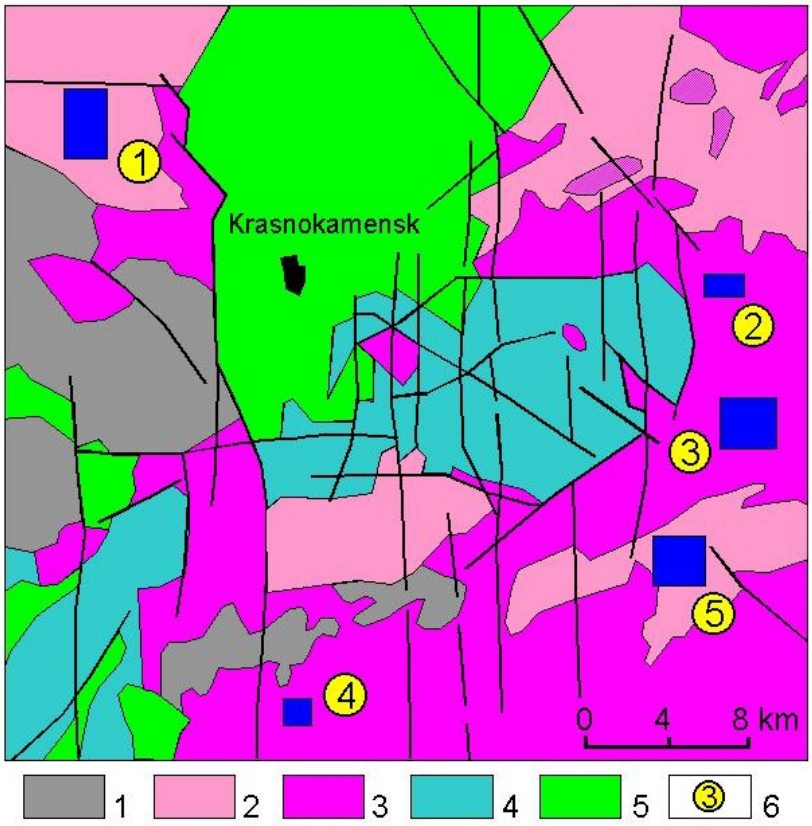

Fig. 4 Location of the granitic potential sites. Legend: 1-Paleozoic metamorphic rocks, 2-Caledonian granites and gneissic granites, 3-Variscan biotitic granites, 4-Mesozoic volcanic rocks, 5-Mesozoic sedimentary rocks, 6–number of the site.

The analysis has shown that site 1 is the most suitable one for the purpose. Weakly altered granites and gneissic granites form it, and the site is located at the shortest distance from the railway line. For the characterization of the structure, composition and properties of the geological environment of this site the first stage of field geological research was performed together with the sampling of materials, which analysis is now under way.

The above-considered SNF repository design option envisaging the use of underground galleries is economically feasible and it strictly meets the highest safety standards in terms of the repository exposure to external effects.

The location of the repository above the underground water table, i.e., in the zone of aeration [5] presents

no risk for nuclear materials confined for short- and medium-term storage, since with the gallery-type design the problem of the withdrawal of meteoric waters penetrating from the surface can be efficiently solved.

For the particular geological situation and peculiarities of the relief of the PPGKhO area an expanded design option can be also considered. This option may be a combination of SNF storage in underground galleries with a parallel construction of a repository for high-level waste (HLW) and defective SNF at deeper horizons and in suitable geological, hydrogeological and hydrogeochemical conditions.

According to this option, both the infrastructure for SNF storage and special sinking and tunneling equipment for the construction of a "blind" shaft or a spiral downward tunnel are accommodated in underground galleries. These vertical or inclined workings will provide an access to a depth, where the engineering complex for final disposal of HLW and defective SNF can be safely accommodated.

Manpower, engineering, economic potential of the PPGKhO and the social background in the area

Over a 35-year period of operation, the PPGKhO has accumulated great experience in uranium mining and processing, drilling, development and mine construction processes, as well as in radioactive waste management, environmental monitoring and rehabilitation of contaminated sites.

The PPGKhO has special divisions staffed with highly skilled personnel. Its operation in the above mentioned areas has a reliable continuous scientific and technological support. The PPGKhO experts work in close co-operation with their colleagues from the leading research and development establishments of the Russian Academy of Sciences, RF Minatom and RF Ministry of Natural Resources.

Thus, in the course of its diverse research and production activities the PPGKhO has assembled a highly skilled joint team of leading research associates from different research establishments, production experts and workers, who are able to competently and promptly implement the tasks, which may be set with a view of choosing a suitable site for the SNF underground repository construction project and to make an important contribution to its implementation.

In addition to underground ore mines, hydrometallurgical and sulphuric acid production facilities, the production infrastructure of the PPGKhO includes a coal open-cast mine, a thermal power plant, repair and engineering works, a concrete-mixing plant, a railway line and a motor road network, airport, a research laboratory, agricultural farms and a number of auxiliary service sections.
Power capacities of the operating thermal power plant completely meet the current electricity demand of the PPGKhO, and they can meet extra electricity demand, which may arise from the implementation of the SNF repository construction project. The operating drilling, heading and tunneling machinery and equipment are manufactured and repaired at the repair and engineering works.

The PPGKhO also operates two autonomous systems of potable and process water supply. The drinkable water supply of the town of Krasnokamensk is provided from several water intakes located at a 20 km distance from the Streltsovskoe ore field in the valley of the Vostochny Uruljungui River. The waters are characterized by high concentrations of fluorine that is typical of all natural underground waters in the area. Spent water is discharged to the local waste water system furnished with water purification facilities.

The Argun River is a source of the process water supply. A 20 mln. m^3 standby water-storage pond is available for the case of the river freezing. All ore mines have mine water inflows, which are used partially for production needs. Spent process waters are discharged from the hydrometallurgical facility to

a mill tailing pond, waste waters from the sulphuric acid production facility go to a cinder-slurry pond, while the thermal power plant discharges its waste waters to an ash-slurry pond.

Over long period of its uranium ore mining and processing activities the PPGKhO has been faced with numerous environmental problems. It produces various wastes, such as gases, solutions and solid materials, which pollute the environment. Uranium mines, spoil banks, hydrometallurgical, sulphuric acid production facilities and tailing ponds, the thermal power plant and its settling pond are the main sources of environmental pollution.

The PPGKhO has a system of air, water and soil pollution control. The analysis of the environment condition and the assessment of the environmental effect of the applied technological processes serve the basis for the elaboration of measures aimed at the optimization of the functioning of the natural-industrial complex and rehabilitation of contaminated territories.

The population of the PPGKhO area, i.e., mainly its personnel and the employees of the local public service establishments, live in the town of Krasnokamensk (~ 60,000 people), Oktyabrsky and Krasnokamensky settlements.

The results of the local population polling show that most citizens are inclined to support the idea of the repository construction in the area of the PPGKhO operation. Eventually, the proposed repository may become a multinational facility of the kind. Moreover, the higher is the level of education of those questioned, particularly in the group of 30 – 50-year old people, the higher is the percentage of advocates of the repository construction project.

CONCLUSION

1. The problem of safe and reliable confinement of spent nuclear fuel is rather pressing both for Russia and for some other countries of the world having nuclear power plants in operation.

2. From the viewpoint of the proposed multinational SNF repository location the territory of the PPGKhO, which is the only uranium mining facility of Russia, seems the most promising option. The PPGKhO operates in an under-populated part of the Eastern Transbaikal Area, however, it is connected with important industrial regions of the country by a railway line. The PPGKhO has a diversified, branched production and power-supply infrastructure, which can be successfully used for implementation of the most complicated mining and power supply tasks.

3. The PPGKhO is staffed with highly skilled engineers, workers and researchers having the abundant experience in radioactive material management, as well as drilling, mining, heading, tunneling and mine construction.

4. Natural and geological conditions of the PPGKhO territory by all parameters are estimated as favourable for the realization of the underground repository construction project. In massifs of dense rocks with weak permeability characteristics (granites, gneissic granites) forming the major part of the PPGKhO territory five sites have been identified already, which are viewed as promising for the realization of the proposed SNF underground repository.

5. In terms of characteristics of the natural conditions, as well as environmental, engineering and economic considerations and safety requirements, the most suitable option for the reliable confinement of SNF at the PPGKhO territory is an underground repository, which can be accommodated in underground gallery-type workings.

6. Major part of the able-bodied adult population of the area is not subject to radiation phobia and it is inclined to support the idea of the multinational SNF repository construction in the PPGKhO territory.

REFERENCES

1 Sobranie Zakonodatelstva Rossiiskoi Federatsii (Collected Laws of the Russian Federation), No 28 (2001) (*in Russian*)

2 Naumov, S.S. Re-evaluation of uranium reserves and resources of Russia after the disintegration of the USSR, and directions of exploration for the nearest future. Razvedka i okhrana nedr, No 3 (1996) (*in Russian*)

3 Seismic zoning of Eastern Siberia and its geological and geophysical fundamentals. Edit. by V.P. Solonenko. Novosibirsk, Nauka Publishers (1977) (*in Russian*)

4 Geology of the Uruljunguevsky ore region and molybdenum-uranium deposits of the Streltsovskoe ore field. Edit. by L.P. Ishchukova. Moscow, Geoinformmark (1998) (*in Russian*)

5 The scientific and regulatory basis for the geological disposal of radioactive waste. Edit. by D. Savage. Chichester, John Wiley and Sons Publ. (1995).