

Geotechnical Parameters for Exploitation of Hydrogenous Uranium Deposits in Mongolia

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Abstract — *The parameters of the opening for exploitation of hydrogenous uranium deposits in Mongolia and recommendations on the technology for their development.*

Keywords — *uranium, geotechnology, hydrogenous, in-situ recovering*

I. INTRODUCTION

Over the next 20 years, as predicted by IAEA, demand for energy is expected to increase up to 2 times. Traditional energy sources - oil, coal and gas - will not cover the growing energy needs of humanity, as well as alternative. In this case, from the point of view of deteriorating environment, the advantages of nuclear power are clear. For countries that do not have their own reserves of organic fuels, development of nuclear power is the only way out. Uranium is much easier to transport and cost of generating electricity from uranium is 4 – 6 times less than carbon or gas. Today, uranium is turned into a strategic product of the global economy, and the share of uranium production now accounts for over 15% of the world's electricity. Overcoming growing global shortage of energy depends on the development of nuclear power around the world. [1].

Exploration of uranium is carried out intensively in the following countries:

- North and South America: Canada – 21 deposits, Greenland and Mexico – 1, United States – 35, Brazil – 4, Argentina – 2;
- Europe: Sweden, Germany, Poland and France – 1 deposit for each, Czech Republic – 5, Romania and Spain – 2, Ukraine – 3;
- Asia: Russia and Kazakhstan – 16 deposits, Uzbekistan – 15, Mongolia – 3, China – 11, South Korea and India – 1 for each;
- Africa: Morocco – 4 deposits, Algeria – 3, Niger – 12, Cameroon, Tanzania, Malawi, Madagascar, CAR 1, Somalia and Zambia 2, Namibia and South Africa 12.
- Australia – 22.

However intensive exploitation of uranium is carried out in Canada – 21 deposits, USA – 35, Brazil – 4, Sweden – 1, Czech Republic – 5, Romania – 2, Ukraine – 3, Russia – 16, Kazakhstan – 16, Uzbekistan – 15, China – 11, India – 1, Niger, Namibia and South Africa – 12, Australia – 22 [2]. Uranium reserves in different countries are constantly changing due to discovery of new properties and mining of old deposits. In addition, assessment of economical reserve for development is changed. Published data on uranium reserve is very contradictory. In the present sources we can find other order of countries with the largest reserves of uranium dioxide: Australia – United States – South Africa – Canada – Russia – Kazakhstan – Nigeria.

The contradiction is explained by the fact that the data on the details of proven uranium resources that can be recovered from ore at cost no more than \$ 100/kg (total reserves of 3.3 billion kg on U_3O_8), while stocks are not bound to the price of production. By proven reserves of uranium Mongolia is one of the leading countries in the world. However, due to its political and territorial isolation between Russia and China, the adverse climatic and geographical conditions, low development and population of the territory of the country's resources, the rate of economic development is low. Thus, when colossal reserves of strategic minerals current situation is characterized by a low level of development and the rate of return on the investment of funds.

According to recent geological studies a proven uranium reserve in Mongolia is 1.475 million tons. The country pays great attention to exploration work on uranium and is actively taking steps to exploit these resources. In 2009 Law on Nuclear Energy was adopted and State policy on nuclear energy and uranium industry was approved. In the same year "Mon-Atom", the State owned uranium company, was established which functions to meet government objectives in the uranium industry and the nuclear power industry.

Besides exploration of deposits that were discovered earlier "Mon-Atom" also has been active in other prospective areas [3].

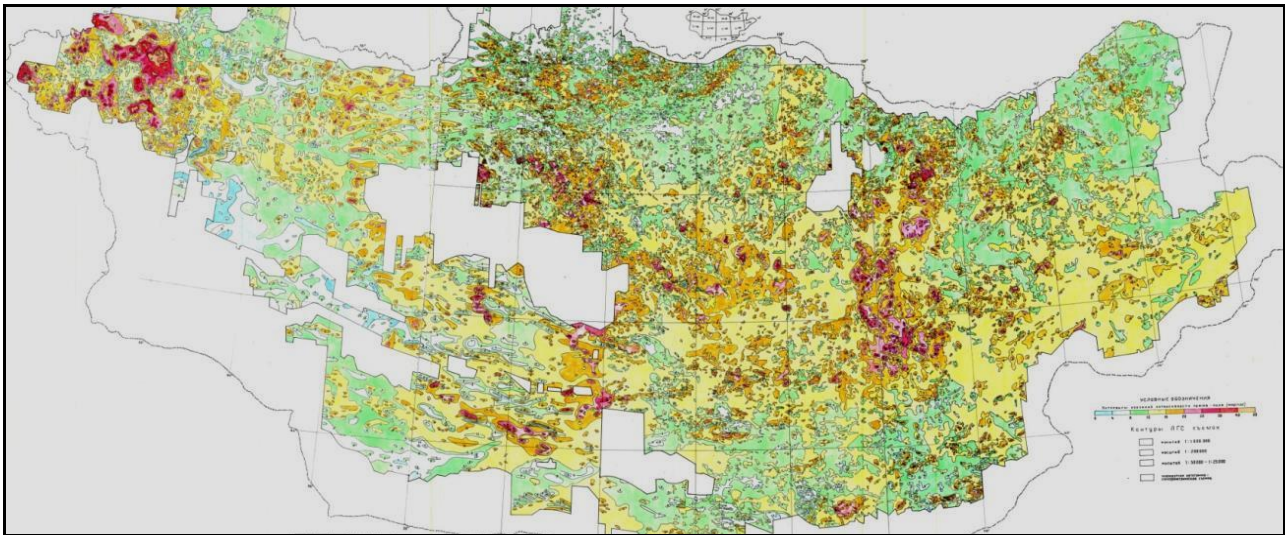


Fig. 1. Map of identified uranium deposits in Mongolia

II. PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE HYDROGENIC URANIUM DEPOSITS

By the number of uranium reserves, today Mongolia is among the 10 richest countries in the world. The nearest goal of the country is taking leading position (3 – 5 places) among the countries hold uranium mineral.

Recent studies have shown that Mongolia could soon join the ranks of top countries in the world for mining and processing of radioactive minerals and rare earth elements. In addition to the known reserves of uranium which is 1475.0 thousand tons, Mongolia has high potential for exploration in the future. [4]

For example, the latest drilling works confirmed the presence of significant uranium mineralization zone with length of not less than 1000 m from north to south and width of 600 – 700 m in the north-eastern portion of the Ulziit depression. Uranium mineralization of Ulziit is located on three hypsometric levels 30 – 50 m 90 – 130 m and 165 – 180 m and has a litho-facies and structural control. Some ore bodies have thickness of 0.2 – 7.0 m and are mostly in the permeable part of sedimentary deposit. Total thickness is 10m in boreholes.

Development of uranium-bearing zones delineated to the east and partly to the west on the profiles PR-71 and PR – 40. In the area of PR-70 the zone changes the direction to the north-west.

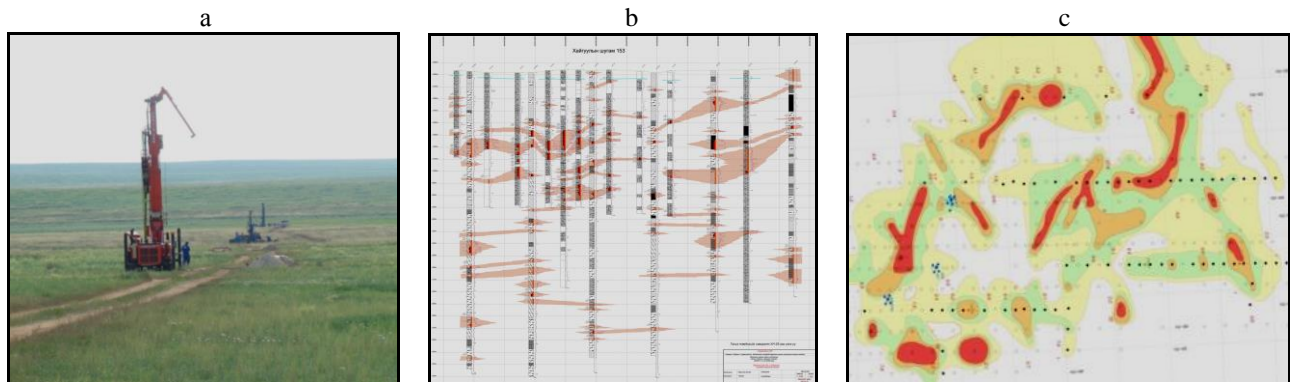


Fig. 2. Drilling work on the PR-90 in Ulziit deposit (a) cross section by profile PR-153 (b), and the horizontal projection of ore body (c) in Hairhan deposit

Results of geophysical and hydrogeological studies on uranium deposits in Mongolia in the exploration of ore deposits are as follow: In Khaikhan area there are prospective occurrences were identified at 100m of depth on the western flank of the site which was not explored yet. These results indicate the development of hydrogenic uranium mineralization in entire thickness of gray-colored uranium deposits which thickness reaches 220 m.

In Choir depression on the northeastern flank of "Kharaat" deposit confirmed the presence of a new ore zone, located in the transitional part of the crosssection from coarse grained primary oxidized red delluvial-proalluvial deposits to small-fine grained gray-colored sediments of alluvial-lacustrine facies. The ore zone is traced along strike for 2,000 meters. Width is 200 – 400 m. Mineralization located on different levels, much of it is below water level.

The newly identified ore zone should be considered as areserve increase of Kharaat deposit. In Gurvansaikhan depression, as result of exploration work parameters, morphology, conditions of occurrence and ore composition of the

deposit was identified. Based on the characteristics the deposit is similar to "Kharaat" and "Khairkhan" deposits and has commercial value.

In Ulziit area, as a result of drilling in the "Shand-Bulag" and "Suldjur-Hudug" sites there were new ore bodies with conditioned parameters discovered. According to recent exploration data, a mineralized zone with length of 1000 m and a width of 600 – 700 m is identified.

The mineralization is located in the three depth intervals: 30 – 50 m, 90 – 130 m and 165 – 180 m. Ores are localized mainly in permeable sediments and are in below water table. On the area of "Urt Tsav" as a result of the geochemical sampling increased concentration of not only uranium but other elements (Th, Rb, Cs, Cu, Zn, Pb, Ni, V).

These elements are characterized by consistent correlation with uranium and can be indicator of hydrogic uranium ore process. Further geochemical method can be used together with other methods for exploration on uranium mineralization in the Late Mesozoic basins in Gobi region of Mongolia [5].

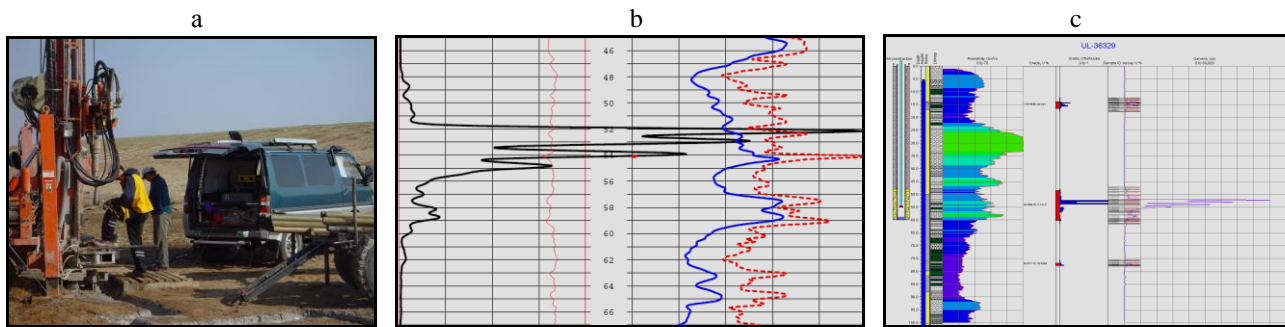


Fig. 3. Logging unit mounted on vehicle (a), results of geophysical study for features of ore-rock mass by gamma logging (b) and electric logging (c) in Ulziit

For all hydrogenic deposits of Mongolia - "Kharaat", "Khairkhan", "Gurvansaikhan" and "Ulziit" indicators for uranium-bearing components were determined by area, depth and distribution. Also type, structure and origin as well as type, composition, quantity, shape, uranium grade and hydrogeological conditions of the ore bodies were defined (see table).

Parameters of deposit indicate that they are identical in nature origin. This defines a similar form of deposits, geological structure and composition of the host rocks.

In addition, some parameters are within the ore bodies which are typical uranium hydrogenous form and shape (horizontal ribbon, lenticular, layered and socket-shaped body, rolls), size (200 – 4000 m) and the average uranium grade (0.036 – 0.066%). Also found that all ore deposits are located in water-saturated layer, which is characterized by the following conditions: water conductivity of 0.2 – 370 m²/day, filter coefficient 0.1 – 10 m / day, mineralization 0.7 – 7.0 g / l.

Parameters of deposits "Kharaat", "Khairkhan", "Gurvansaikhan" are more favorable than for the "Ulziit." This indicates technological parameters for the two groups are different and study should be performed separately.

Simple structure of the ore bodies with their oriented strike and constant thickness leads to choose a hexagen scheme for mining.

Cells for injection and pumping wells should be placed across the strike of the ore bodies with the direction of groundwater flow oriented along the ore-hosting paleovalleys. Location of technological wells needs to be confirmed by mathematical modeling, and preparation work during premining stage.

Table

Geotechnical parameters of discovering hydrogenic uranium deposit in Mongolia

Options field	«Kharaat»	«Khairkhan»	«Gurvansaikhan»	«Ulziit»
The host rocks	Sedimentary, unconsolidated rocks (sand, silt, clay) river bed of ancient river basin			
Mineral composition of ores	Ore-bearing – enriched with sulphide of sand, silt, clay, organic carbonate			
	Pitchblende, uranium mobile, coffinite, otenite, uranophane, ningionit	Pitchblende, coffinite, otenite, uranophane	Pitchblende, uranium mobile, coffinite, otenite	Uranium mobile (Pcoffinite, ningionit), Autun
Parameters of orebodies (appearance, shape, depth,	View ores aluminosilicate, bezkarbonatny			
	Horizontal layers, ribbon-like body	Horizontal, ribbon, lenticular, layers, and nest-shaped body, rolls	Horizontal, layered, ribbon-like body	Horizontal, flax, then, lenticular, layer-shaped body, rolls

quantity, size, average uranium grade)	Depth: 28 – 800 m, number 1 – 5., Length: 500 – 3000 m, width: 100 – 600 m Power: 0.6 – 42.5 m, content of U: 0,036%	Depth: 18 – 195 m, number 2 – 10 pcs., Length: 200 – 1200 m, Width: 50 – 600 m Power: 0.5 – 22.0 m, content of U: 0,066%	Depth: 25 – 70 m, number 1 – 3 pcs., Length: 1500 – 3200 m, width: 100 – 900 m, Power: 0.6 – 12.9 m, content of U: 0,04%	Depth: 30 – 200 m, number 1 – 3 pcs., Length: 4,000 m width: 300 – 800 m, Power: 0.5 – 14 m, content of U: 0,036%
Hydrogeological conditions	Ores located in the aqueous layer			
	Water conductivity: 50 – 250 m2/day coefficient. filtration: 1 – 10 m/day mineralization: 3 to 7 g/l	Water conductivity: 10 – 370 m2/day, coefficient. filtration: 1 – 10 m / day mineralization: 4 - 6 g/l	Water conductivity: 17 – 29 m2/day, coefficient. filtration: 4 – 7.6 m / day, mineralization: 3 – 5 g/l	Water conductivity: 0.2 – 5.3 m2 / day coefficient. filtration: 0.1 – 1.2 m / day mineralization: 0.7 – 2.3 g/l

III. GEOTECHNICAL PARAMETERS OF THE HYDROGENOUS URANIUM DEPOSITS

To date, in the "Gurvansaikhan" area there are 4 ore bodies that are economically favorable discovered. As result of exploration drilling that was carried out on three deposits uranium reserves which is suitable for ISL method were determined. The reserves are 2,479.1 tons.

This reserve is possible to be operated for more than 10 years with 100 – 200 tons/year. It should be noted that in "Gurvansaikhan" deposit there are real prospects for reserve increase on the basis of exploration work on the existing deposit also other 3 ore deposits which is not explored yet.

According to the mining plan "Gurvansaikhan" includes the preparation of the mine site, which will be the development of uranium, depositing it on the resin with a further form of saturated solutions. Processing solutions and finished products in the form of nitrous oxide-enriched uranium is planned on "Khairhan", which will operate a uranium enrichment plant.

The distance between the parts of the field, "Gurvansaikhan" and "Khairhan" is 60 km. Such a scheme with mine production capacity of 100 tons / year, and a further increase to 200 tons/year seems to be quite profitable.

"Gurvansaikhan" area on the Genesis, the terms of localization, the material composition of ores, ore deposits, morphology and other characteristics is a complete analog areas "Kharaat" and "Khairhan." And is similar to the aqueous medium, which may have an impact on the in-situ leaching.

The water from the aquifer host ore bodies has a similar chemical composition. Laboratory test trials on leaching of uranium ores "Gurvansaikhan" fully confirmed the similarity in the kinetics and spatial character of the leaching of uranium. The most effective of these deposits is added to the acid leaching oxidant.

Deposit "Kharaat", "Khairkhan" and "Ulzit" studied in detail, they conducted full-scale development and technological research, the results of which are defined scheme and technology of their mining. Such a scheme and plan to use the technology of production and on the field "Gurvansaikhan."

Before discovering all the deposits including "Ulzit", will be carried out preparatory work aimed at a detailed study of the operating units. In carrying out the preparatory work will be carefully studied the distribution of uranium in the dynamics of groundwater, hydrogeological characteristics of the host rocks, ore processing properties and other settings.

This phase of work is required in the fields, the operation of which provides a way situ leaching. According to the results of preparatory work specified layout zakachnyh and the pumping wells, their design and depth, and production rates are calculated on this basis is determined by the performance of the filtration plant for solutions.

Also addresses a number of other issues related to the process of production.

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