

ANNOTATION

dissertation for the degree of Philosophy Doctor (PhD) in the specialty
6D070700 – «Mining»

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DEVELOPMENT OF TECHNOLOGY OF INCREASING THE PRODUCTIVITY OF TECHNOLOGICAL WELLS BY AIRLIFT DRILLING AND HYDRAULIC PULSE ACTION

Topicality of the theme.

In-situ leaching is a progressive method widely used in the Kazakhstan for uranium mining. This method has passed all stages of research, development and industrial implementation in the hydrogenic deposits of the Shu-Sarysu and Syrdarya uranium provinces, lying in permeable sedimentary rocks of the depression zones of the earth's crust, where the opening and preparation of ore bodies and uranium extraction are carried out through wells.

When mining this type of deposits, the entire production cycle consists of the following processes:

1. Drilling and equipment of technological wells;
2. Leaching of uranium from ore bodies, i.e. transfer of metal into solution;
3. Pumping of technological solutions from the subsoil and transportation;
4. Sorption of uranium from productive solutions and desorption;

The advantage of the ISL method lies not only in a significant reduction in processing, but also in the fact that the extraction processes have acquired a completely different qualitative characteristic in terms of the costs of human labor, tools and means of production.

When using this method, there is no need to build expensive mines or open pit mines, as well as hydrometallurgical plants, the consumption of many materials; the number of workers on the construction and operation of deposits is reduced; natural raw materials are increased as a result of the mining deposits with poor uranium content, located in complex hydrogeological conditions (their mining by traditional methods is not feasible).

Despite all the advantages, this method has a number of disadvantages, one of which is a periodic decrease in the flow rate of wells, the reason for which is the initial encirclement of the near-filter zone of the ore-bearing seam while drilling of technological wells, which causes an increase in hydraulic resistances and a decrease in the flow of solution into wells. The colmatating substance during the cutting of the ore-bearing horizon is crushed clay particles and infiltrate of drilling mud, which, interacting with seam water, causes some products to precipitate as a result of chemical reactions. At the same time, the flow rate of the well decreases, and uranium production decreases accordingly. When the flow rate decreases by 50%, the work of a group of wells stops for 3-5 days, RRW (repair and restoration work) is carried out.

The urgency of developing a new method of drilling technological wells has arisen based on the analysis of research works and patterns of falling flow rate of geotechnological wells, which will be aimed at preserving the natural conditions of porosity and permeability of the seam, increasing the rate of cutting the ore-bearing horizon, increasing the productivity of production wells and reducing the number of repair and restoration work during drilling operations.

The purpose of the research is the development of an innovative method of drilling technological wells, which provides a reduction in the encirclement and improvement of the filtration properties of the ore-bearing horizon by reducing the amount of infiltrate crushed by the hydrostatic pressure of the washing solution column into the near face zone of wells.

The idea of the research is the use of the established regularities of the airlift effect during the cutting of the ore zone, from the depression parameters on the near face zone, to improve the filtration characteristics of ores and prevent colmatation of the walls of the well.

Tasks of the research:

In accordance with the stated purpose, the following tasks, requiring a solution, are formulated in the dissertation:

1. Identification of regularities of changes in the filtration characteristics of ores in the filter zone of wells from the parameters of airlift drilling;
2. Development of technology and substantiation of rational regimes of the airlift method of drilling technological wells to increase the effectiveness of the ISL of uranium.
3. Determination of the effective parameters of a hydraulic-pulse face machine for restoring the filtration characteristics of wells during repair and restoration work;

Scientific statements submitted for defense

1. A technology has been developed to preserve the filtration properties of the ore-bearing horizon for low-permeable ores through the use of an airlift method of drilling technological wells.
2. The rational parameters of the application of airlift drilling modes are justified depending on the increase in the pressure of the supplied air, the flow rate of the washing solution and the granulometric characteristics of the ores of the productive horizon.
3. Substantiation of the dependence of the parameters of the use of a hydraulic-pulse face machine on the density of sedimentary materials.

Main results of the research:

1. The main sedimentary components during the well uranium mining at the Inkuduk and Mynkuduk productive horizons of the Inkai deposit contain feldspar 5-10%, quartz 80-90%, albite 1-5%. The ratio of aggregates of feldspar, quartz, albite in the mass of sedimentation determines its density.
2. The developed technology of opening productive seams using the airlift

method of drilling wells in low permeable ores with uranium ISL provides air supply to the space between two drilling pipes, with a pressure of 7-15 bar, depending on the granulometric characteristics of ores, clay content, filtration coefficient in the productive formation. The effective parameters of the proposed technology are substantiated, which will reduce the period of mining the block and operating costs by 5%, depending on the mineralogical characteristics of the ores of the host rocks of the productive horizon. In general, the intensification of uranium leaching at the stage of mining operational blocks and reduction of specific norms of chemical reagents and electricity at uranium mining enterprises of the Republic of Kazakhstan is ensured.

3. Rational parameters of the hydroimpulsive effect on the seam have been established, based on the physical and chemical properties of ore-bearing rocks and sedimentary components of the Inkai uranium deposit, to prevent sedimentation due to the destruction of the colmatant structure by the pressure of the flow pulse of the washing solution of 10 MPa, which ensures the active removal of dispersed particles to the surface.

Object of the research is technology of drilling technological wells in the extraction of uranium ores by the ISL method.

Subjects of the research are the modes of airlift drilling of technological wells.

Methodological base of scientific research

When performing scientific research, the analysis and generalization of scientific and technical information, methods of mathematical statistics for processing experimental data and feasibility studies of various technology options were used. Experimental work on geotechnological wells confirmed the results obtained using the developed test methodology. It provides for the collection and monitoring of data, tracking, comparative analysis of the geotechnological characteristics of wells before and after testing using the hydroimpulse processing method and the airlift method of drilling wells.

The scientific novelty consists in establishing the regularity of changes in the filtration characteristics of ores of the productive horizon from the parameters of airlift drilling and mineralogical composition during the well mining of infiltration uranium deposits. The regularities of changes in the flow rate of the washing solution and air pressure from the granulometric characteristics of the ores of the productive horizon during the airlift drilling method are established. The effective parameters of the hydroimpulse method of influencing the near the face zone of the seam to increase productivity and the period of continuous operation of technological wells are found.

The practical significance of the work lies in the development and implementation of effective methods of opening productive seams and decolmatization of wells to reduce operating costs, preserve the filtration properties of rocks of the ore-bearing horizon, reduce the degree of clay formation, improve the permeability of rocks of the productive formation, reduce the amount of infiltration, as well as the costs of washing and mining of wells taking into account the mining and geological conditions of the uranium deposit. The results obtained can be used in designing the mining of a uranium deposit and planning mining operations at uranium mining enterprises.

Compliance of the work with the directions of science development or state programs

The scientific work was carried out during the Project №0379 of the CP dated 03.11.2017. «Production of technological equipment and tooling for the drilling method while preserving the original filtration properties of the ore-bearing horizon», (2017-2020).

The author's personal contribution consists in setting research objectives, carrying out the main volume of theoretical and experimental research of the dissertation, generalizing the obtained results, developing experimental research methods, conducting research, developing conclusions and recommendations, analyzing and formatting the results in the form of publications and scientific reports.

Publications and test of the work.

The technology of airlift drilling of technological wells was tested as part of a commercialization project on the topic: «Production of technological equipment and tooling for the drilling method while preserving the original filtration properties of the ore-bearing horizon», (2017-2020), at the Inkai deposits. The results of the study were reported and discussed at the international scientific and practical conferences «Rational use of mineral and man-made raw materials in the conditions of Industry 4.0» (2019), as well as at the Scientific and Technical Council of JSC «NAC «Kazatomprom» (2021).

Ten works have been published on the topic of the dissertation. Two in journals included in the 43rd percentile according to the Scopus database, three are recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan (CQAFSHE MSHE RK) and three in conferences. A worthy contribution was made to each published article by the doctoral student, they reflect the provisions submitted for defense, the results obtained by the doctoral student in the course of the research. The author of the dissertation formulated goals and objectives, research methods, description of the research, discussion of their results, as well as formulated conclusions and carried out a search for literary sources when preparing articles.

Two patents of the Republic of Kazakhstan on the technology of intensification of well uranium mining on the following topics were obtained:

- «Device for vibration processing of the filter of technological wells during uranium mining» Patent for Useful Model №3864, №15, 12.04.2019;
- - «Drilling rig for direct airlift washing» Invention № 34990, №14, 09.04.2021;

Volume and structure of work.

The dissertation consists of an introduction, four sections, a conclusion, a list of references and appendices. The dissertation consists of 133 typewritten pages, 16 tables, 41 figures, a list of references, including 82 titles and 7 appendices.

Conclusion

1. The composition of sedimentary components of the Inkuduk and Mynkuduk

productive horizons of the Inkai deposit mainly consists of quartz (80-90%), albite (1-5%), feldspar (5-10%). Their density varies in the range of 1.5-2.0 g/m³ and depends on the ratio of sedimentation components.

2. The effective pressure of the washing solution is 15-20 bar per the near-filter zone of wells, as a result, the productivity of production wells increased from 12 to 18 m³/h, the average period of continuous operation of wells increased from 120 to 180 days.

3. The developed and tested airlift method of drilling technological wells when opening productive seams of low-permeable ores, taking into account the filtration and mineralogical characteristics of ores, allows the pore space of the productive horizon to maintain natural permeability. This makes it possible to increase the uranium content in the productive solution by 20%, increase the productivity of production and the intake capacity of injection wells by 20-30%, shorten the period of mining a block and cut operating costs by 5%.

1. The effective parameters of the hydro-pulse method of impact on the seam for destruction and prevention of sedimentation depend on the physical and chemical properties of ore-host rocks and sedimentary components of the Inkai uranium deposit.