Ecological Reliability of Burial and Reverse Pumping of Drainage Brines on Open Pits of Almazy Rossii-Sakha Co. Ltd.

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Mining of diamond deposits is carried out by open pits in conditions of brines drainage.

Mining technology of deposits includes construction of tailings depository and reservoirs of mineralized water containing toxic components. All these constructions inevitably become the sources of constant or occasional entry of brines into surface watercourses of the adjoining sites. Technological decisions can not provide ecological security. It is also practically impossible to isolate on the earth's surface many millions of cubic meters of brines in conditions of multi-year everfrozen rocks. Satisfactory technology of their purification and disposal are not available either.

The most rational and safe from ecological point of view in conditions of Western Yakutia is burial of drainage brines into the massif of multi-year everfrozen rocks and reverse pumping into the drained aquiferous complex. This provides rather lasting, reliable and their isolation under control from the surface.

Burial of drainage brines into the massif of multi-year everfrozen rocks (MER) has been carried out on one at the open pits in the region of watershed site since 1986. By chemical composition coming to the open pit underground waters are chloride calcium strong brines with general mineralization up to 400 g/l with high content of toxic elements, disposal of which into surface watercourses is impermissable.

In order to create the technology of burial, as well as to substantiate and work out the methods of evaluation of real volume of MER and forecast the development of mass transportation process on definite areas, ensuring exclusion of harmful environmental consequences, at the stage of prospecting the sites for burial, projecting, construction and industrial exploitation of the system of absorbing boreholes, a broad complex of special investigations is carried out, including experimental-filtration and geophysical works, hydrochemical, hydrodynamic, hydrothermal, gas and regime observations.

In the course of the passed period burial into MER of more than 5 mln. m^3 of drainage brines with average concentration of 270 g/l order has been performed. The principal scheme and the achieved effect of underground burial are shown in Fig. 1 and 2.

The analysis of the received information has shown that the main factors, which determine regularities of the underground burial process on the whole and final parameters of the technology, are the processes of phase transition on contacts "ice-brine". The development of these processes determines in the final score both filtration (intake capacity) and capacity properties of MER. The problem lies in impossibility of a priori experimental determination of these properties, so far as additionally "directed" values of penetrability and capacity arise and alter in the course of underground burial, and they (at least in conditions of the proving ground under investigation) sufficiently exceed natural initial values of these parameters.

Natural temperature of MER in the area of burial changes from -2° to -5° C, at average value of about -3° C. For these temperatures the balanced concentration of the brine, at which "leaching" of ice stops, constitutes approximately 70 g/l.

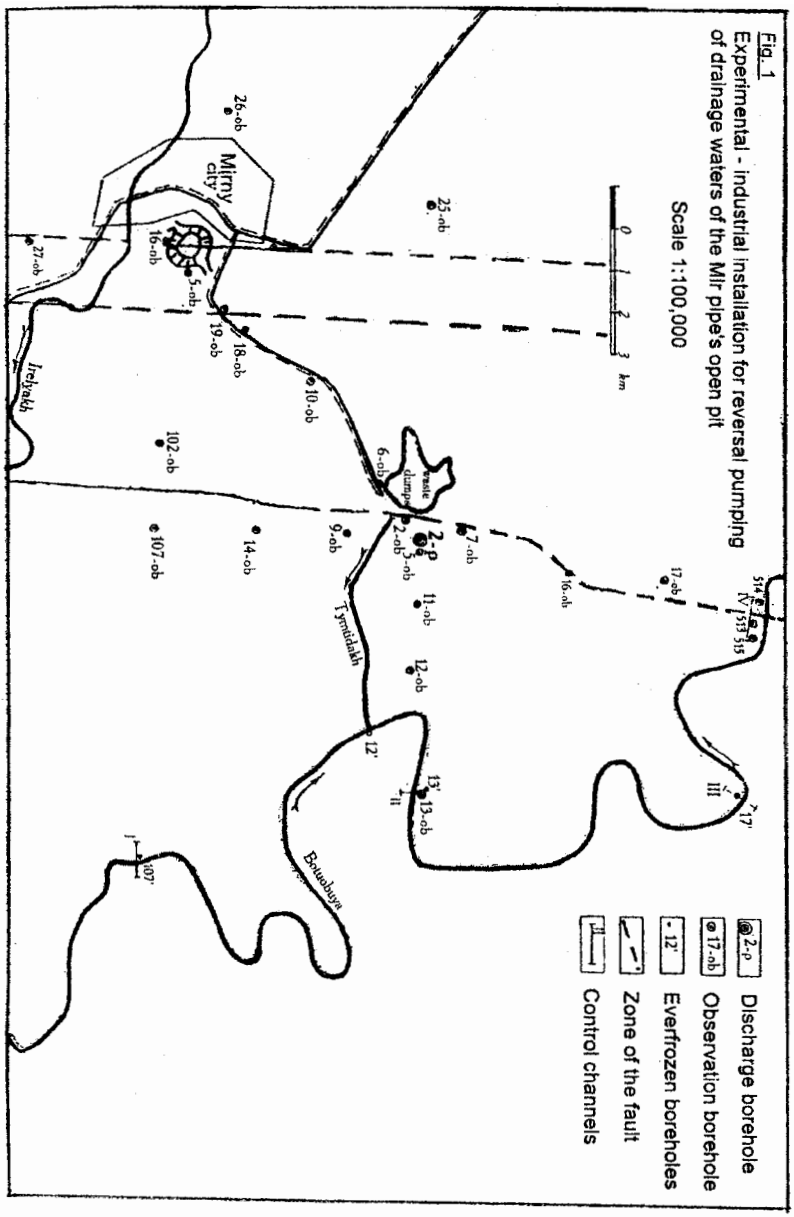

Fig. 1
Experimental - industrial installation for reversal pumping of drainage waters of the Mir pipe's open pit

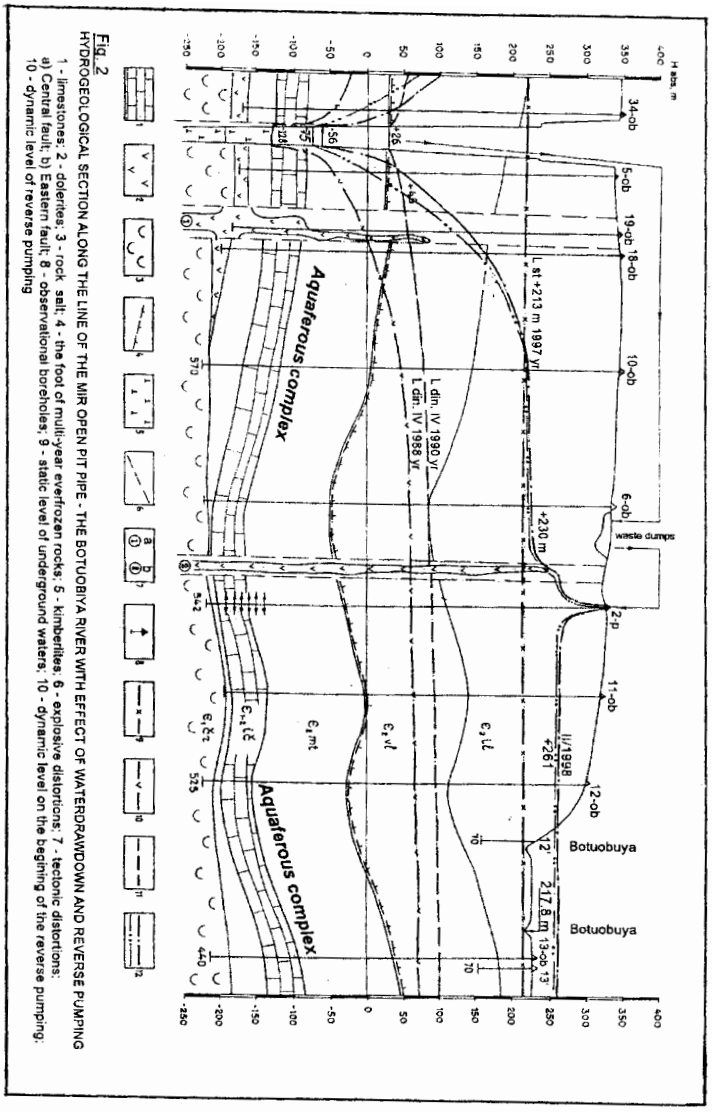

Fig. 2
HYDROGEOLOGICAL SECTION ALONG THE LINE OF THE MIR OPEN PIT PIPE - THE BOTUOBIYA RIVER WITH EFFECT OF WATERDRAWDOWN AND REVERSE PUMPING

1 - limestones; 2 - dolerites; 3 - rock salt; 4 - the foot of multi-year everfrozen rocks; 5 - kimberlites; 6 - explosive distortions; 7 - tectonic distortions; a) Central fault; b) Eastern fault; 8 - observational boreholes; 9 - static level of underground waters; 10 - dynamic level on the begining of the reverse pumping; 10 - dynamic level of reverse pumping

During pumping into the boreholes of brines with concentration 270 g/l in the initial period intensive increase of conductivity (and water-accepting capability of boreholes) due to leaching of fractured ice takes place. The brine, therewith, can in a rather fast way disappear through the initially opened fractures to distances of 2 and more kilometres. With thickening of the net of the washed fractures the area of contact of brines with frozen porous blocks increases, leaching of porous ice, formation of "directed" capacity constituting 9% of volume of the leached porous ice. the analysis of natural data with application of mathematical modelling has shown that initial natural capacity of MER on the proving ground of burial in average on the flooded massif does not exceed 0.1%. The above mentined "directed" capacity at average porosity of flooded rocks of 10% order will constitute about 1.0%, which is an order higher than natural value.

In case of pumping into MER of brines with lower than balanced concentration their freezing with formation of slush ice will take place. Packing of fractures and corresponding decrease of conductivity in hte close to the borehole zone is possible therewith.

Saturation of MER massif is over after complete leaching of porous ice by brine. Capacity reaches the final value therewith. In the zone of complete saturation concentration of fracture brine must be close to concentration of the pumped in brine. In the zones where the process of porous ice leaching is not completed concentration of fracture brine will be lower than the initial concentration of the pumped in brine. Thus, the process of brine burial is reliably controlled by observations after alteration of mineralization and level regime. In real conditions of drainage brines' burial site, in spite of general duration of the process for 9 years, even in the central part of the site mineralization of fracture waters in the majority of the selected samples does not exceed 150 g/l at mineralization of pumped in brines in recent years not less than 270 g/l.

On the basis of the received experimental results and theoretical ideas about basic regularities of mass transportation the following is carried out during underground burial:

- development of practical recommendations on technology and regime of burial, increasing environmental security;
- evaluation of burial's levels of environmental security for protected territories and objects;
- determination of the sources of territories' contamination by underground brines in technological complex of mining deposits and evaluation of the degree of their danger;
- evaluation of forecasted water entry into the open pit and final capacity of perspective sites of underground burial of drainage brines.

Reverse pumping of drainage brines into the drained aquiferous complex is performed at the deposit the Mir pipe. Aquiferous complex lies under the thick layer of multi-year everfrozen rocks composed by marls with thickness of up to 320 metres. Water-hosting rocks are represented by dolomites and limestones, with total thickness of 170 metres. Underground waters are under pressure. The value of pressure is 190 m. Water entry into the open pit with taking relapse into account constitute 1100 - 1200 m^3/h. By chemical composition the brines belong to hydrosulfide chloride sodium. General mineralization - up to 130 g/l, the content of hydrosulfide reaches 137 mg/l.

In order to protect mining works from underground waters a system was designed, including the open pit pumping out, tamponage protection, buffer accumulator of drainage brines, proving ground of reverse pumping and complex system of observation and monitoring (Fig. 3). Construction of the main element of the system - tamponage protection - has not been completed yet. Nevertheless, mining of the open pit under protection of this system has been going on since July 1992. The load on the system of reverse pumping therewith has exceeded the one which had been foreseen by the project. General volume of

the reverse pumping by present time has exceeded 60 mln. m^3, with productivity of reverse pumping in the course of the whole period higher than actual dynamic entry into the open pit, due to pumping out of static volumes from the flooded open pit (about 15 mln. m^3) and additional entry into the system of torrential and flood tide waters.

In the course of the passed period of exploitation of the described system of mining works' protection, in spite of the fact that construction of the tamponage protection has not been completed in the foreseen by project volumes, no dangerous for environment phenomena connected with draining of the deposit have been marked. This makes it possible to state that the adopted at the Mir pipe system of protection and control provides opportunity to carry out mining works with minimum impact on nature. Reliability of the system will sufficiently increase after completing the construction of tamponage protection.

The existing complex system of observation and control includes the net of boreholes and watching points on the most ecologically dangerous objects and provides the receipt of required information for operative engineering-scientific analysis of the current situation with the goal of giving out recommendations and statistic reasons on separate elements of the drainage complex. However severe climatic and complicated hydro-geological conditions do not permit to supply the system of control by modern tools for automatization of observations.