Problem of Utilization of Highly Mineralized Mine and Pit Water Under Iron Ore Deposit Mining and Methods of Its Realization

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ABSTRACT

Studies, performed by NPO VIOGEM in Krivbass and Angaro-Ilimsk iron ore region, have outlined some trends in solution of a problem of highly mineralized water utilization, namely:
- partial utilization of mine and pit water for technical purposes directly in mines and pits
- use of pumped water for reclaimed water supply for ferruginous quartzite benefication
- disposal of mineralized water in abandoned mines and pits
- discharge and accumulation of mine and pit water into evaporating pools
- burial of highly mineralized water into deeply laid geological structures
- desalination of mine and pit water by physico-chemical methods resulting in yield of salt products and fresh water

Complex application of the above methods of utilization is the most effective one.

INTRODUCTION

Practically at all ore deposits, mined at depths over 500 m, highly mineralized ground water, originated in the zone of poor water exchange, is pumped to the surface. As a rule, at such deposits quantity of Na, K, and Cl-ion in mine and pit water as well as Ca exceeds many times values of maximum permissible concentration for drinking water and water reservoirs used for fish breeding. For example, mineralization ratio of mine and pit water at some iron ore deposits exceeds 100 g/l. The feasibility of utilization of mine and pit water with such mineralization ratio in mine-related areas is rather poor, so this problem is to be solved in order ecological damage to be prevented. The possible ways of this problem solution at one of the ecologically unfavourable mining areas - Krivorozhskii iron ore deposit (Krivbass), taken as an example, are considered below.

KRIVBASS CASE

The Krivorozhskii iron ore deposit, being one of the greatest in the Soviet Union as proved iron ore reserves and overall mine production is concerned, gives about 40% of All-

Union iron ore production with 5,5% (or in excess of 30 M t) of so-called rich iron ores which are used in blast furnaces after their being sintereed without any beneficiation at Iron and Steel Works of the South of the country and are exported in certain amounts to the countries of the CMEA (Council of Mutual Economic Assistance).

Mining of rich iron ores of the Krivbass by underground method is accompanied by annual pumping of about 40 M m^3 of mine water with average mineralization ratio 30000 mg/l. At some mines this ratio ranges within 2600-96600 mg/l, sum total of Na and K - 569-324874 mg/l, Ca - 90-969 mg/l, Mg - 82-2602 mg/l, Cl-anion - 1000-57800 mg/l, sulphate-anion - 402-1474 mg/l, hydrocarbonate-anion - 2-647 mg/l, pH of mine water - 6,5-7,6, oxidizability - 0-25,6 mg/l, general hardness - 11,5-248,6 mg-eq/l, permament hardness - 7.4-248,6 mg-eq/l, removable hardness - 0,2-9,2 mg/eq/l. Toxic heavy metals such as Cu, Pb and Cd are also available in mine water. Besides increased content of salts and toxic heavy metals this water is polluted with oil products, organic matters, bacterial flora.

Direct discharge of mine water into open water bodies and streams is dangerous, so it is directed to tailing disposals of Iron and steel Works with iron ore being mined by opencut method where it, being mixed with the less mineralized pumped pit water and underpurified domestic discharge, is used in reclaimed water cycle for ferruginous quartzite beneficiation. It is necessary to note, however, that amount of mine water, being pumped, substantially exceeds the requirement of fresh water of reclaimed water supply which results in accumulation of reclaimed water in excess in tailing disposals. Such method of utilization of mine water, widely used in Krivbass now, cannot eliminate, however, the source of mine and surface pollution which has been observed there during recent decades.

Ground water pollution is a result of seepage losses from tailing disposals because of uneffective means of their bed and bank protection against seepage. Surface water is polluted with ground water at sites of its drainage by the rivers Ingulets and Saksagan and due to periodic discharge of excess of reclaimed water from tailing disposals during vegetation period. The said factors resulted in developing rather strenous ecological situation in Krivbass and first of all in deterioration of potable water supply quality as mineralization ratio of surface and ground water has reached 2,5-3,0 mg/l which substantially exceeds sanitary norm values. Use of river water for irrigation purposes resulted in alkalinization of irrigated lands and considerable crop losses. In the watershed of Ingulets river, the main water artery of the region, some plant species, indicated in the Red Book, have been extinted, fishing has been ceased.

Thus, deterioration of ecological situation in Krivbass turned to be closely connected with a problem of utilization of mineralized mine water which is pumped to the surface. Now some tendencies of this problem solution have been outlined and among them are the following of the primary importance:

1) partial utilization of mineralized mine water for technical purposes directly in mines, replacing fresh water used for the same purposes;
2) utilization of some amount of mine water for recharge of reclaimed water systems used for ferruginous quartizite beneficiation;
3) mine water storage in abandoned mines and pits;
4) burial and accumulation of mine water in evaporating pools;
5) burial of mineralized mine water in deep geological structures of the earth crust;
6) desalination of mineralized mine water by physico-chemical methods, resulting in hard salty products and fresh water.

Annally about 9 M m^3 of fresh water are supplied to mines for technical purposes. Analysis of available data shows that about 7,5 M m^3 of this water can be advantageously replaced by the mine one, taken from the upper levels (up to depth of 350-400 m) where its chloride-sulphate type occurs. It will make it possible the amount of mine water, pumped to the surface, to be reduced by 18,5%.

Model studies showed that some amount of mine water, characterized by the highest mineralization, can be stored in abandoned mines and pits without any ecological damage to the area concerned, however their capacity will be overcome in 5 to 10 years, Hence these measures will provide only temporary ecological relief.

Study of alternative of mine water utilization in reclaimed water supply for ferruginous quartzite beneficiation showed that general mineralization of reclaimed water will give a permanent rise with the time and when it reaches 25,6 g/l it cannot be used for recharge of reclaimed water supply of beneficiation mills without avoiding violation of beneficiation process and damage of the equipment. Besides, as technical water pools are not provided with seepage barriers irretrievable seepage losses may occur resulting in ground water pollution. Since nowadays all mine water is supplied for recharge of reclaimed water cycle it is necessary its volume to be reduced by stages (starting with the most mineralized one) in order mine water utilization in beneficiation cycle to be completely ceased in 5 - 6 years, replacing it by the less mineralized mine and pit water after additional treatment.

As an example of evaporating pool exploitation the one of the Zaporozhskii Iron Ore Works, situated in the Utluk estuary of the Sivash lake, is to be considered. This evaporating pool is a reservoir of 43 km^2 , being an isolated area of the Utluk estuary separated with two dams with evaporation of 5000 m^3/year per ha. Annual delivery of mineralized mine water from Zaporozhskii Iron Ore Works is about 17,0 M m^3 . If to look into feasibility of dams height increment the said evaporating pool may take additional quantity of 15 M m^3 of highly mineralized Krivbass mine water annually.

As to mine water burial in geological structures the By-Black Sea Depression near Kherson city meets the requirements in this respect and is the most suitable place for it now. Depressions of meteoritic origin, the so-called astrolabias, are also promising prospects for deep mine water storage. Such structures (the Boltyshskaya and the Rotmistrovskaya) as deep as 1200 m were found to the north-west from Krivbass. In order to use these depressions a complex of exploration and test field works on discharge burial into deep levels should be done with ecological conservation of upper water-bearing layers and surrounding area taken into consideration.

Thermal method of mine water desalination, being the physico-chemical one, is under approvement now. At one of the mines pilot and commercial plant with capacity of 100 m^3/h is under construction where technologies are being developed, construction materials being selected, initial data and parameters of filtration, thickening, centrifuging, crystallization, drying of the removed salts (mainly sodium chloride, K and Mg) are being identified.

Analysis of the above ways of mine water utilization shows that for Krivbass conditions its complex application will be the most effective one and the realization of these measures is necessary to be divided into two stages, namely: the 1st stage - 1990-1995; the 2nd one starting from 1996 after completion of exploration and commercial work.

At the first stage, which is preparatory for the second one, mineralized mine water utilization is carried out in accordance with temporary scheme, including the following: its utilization in reclaimed water cycle of mine and beneficiation works and directly in mines for technological purposes as well, temporary storage of the most mineralized water in abandoned pits, mine water desalination at pilot and commercial plant, exploration of geological structures and test field work on such water burial into deep geological structures.

At the second stage a long-term complex utilization program will be carried out, namely: mine water discharge into the Utluk evaporating pool, its burial into deep geological structures, evaporation of highly mineralized mine water at desalination plants, mine water utilization in mining and developing processes in mines.

Positive results obtained in Krivbass in mineralized mine water utilization can be used in other mine-related areas characterized by intense technogenic loads.