Hydromineral Resources of Mineral Deposits in the USSR

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ABSTRACT

The paper reviews the problems of complex use of hydromineral resources of mineral deposits. A special attention is paid to technological aspects of purification and utilization of the accompanied water of industrial-genetically different mineral deposits. The recommendations are given for step-wise technological studies during exploration and exploitation of ore coal and oil deposits.(3 Tables, 3 References)

INTRODUCTION

During exploration and exploitation of mineral deposits, alongside useful minerals, a considerable amount of ground water is extracted which is rich in chemical compounds. Such kind of water is usually called as accompanied water with regard to a related basic mineral mined (e.g. ore-water, coal-water, oil-water, gas-water and other).

Amounts of accompanied ground water extracted reach tens of cubic kilometers per year and contain millions of tons of solutable salts. Only coal and oil industries produce accompanied water in amounts exceeding 4 km^3/year. Analysis of dynamics of accompanied-water extraction has shown that it has a tendency of growth of 200-250 M m^3/year.

Practical utilization of water extracted during geological prospecting and mining works is limited due to its increased mineralization and hazardous admixtures which considerably exceed the maximum allowable concentrations. Discharge of accompanied water to the earth's surface deteriorates the quality of water resources and adversely affects the ecological situation in areas of mineral deposits.

According to the tentative estimates, an annual damage from polluted accompanied water, which comes to the surface hydrosphere, reckons by the hundreds of millions of roubles.

By today, there is a great amount of the factual information on chemical composition and specific concentrations of microelements in the accompanied water of mineral deposits (Table 1).

Table 1. Chemical composition of water extracted as associated with some particular industries

Industry	Water type utilized	Minerali-zation, g/l	Chemical composi-tion	Element content, mg/l	Minimum industrial concentra-tions, mg/l
1	2	3	4	5	6
Oil industry	Accompanied water	50-320	Cl-Na-Ca Cl-Na SO_4-Ca	J=5,0-80; Br=50-9050; Li=1,0-50; Rb=0,4-18; Cs=0,02-12,8; B=10-500; Sr=90-8000; Mg=400-20000; K=20-22000; Fe=10-2800; Hg=0,01-0,5	Iodine - 10 Bromine - 200 Lithium - 10 Rubidium - 1 Cesium - 0,5 Stroncium - 300 Manganese - 1000
Coal industry	Mine and open-cast water	0,6-85,0	Cl-Na SO_4-Ca HCO_3-Cl-Na	B=1,2-5; As=0,01-0,04; F=0,3-5; Ge=0,001-0,015; Hg=0,001-0,053; J=0,5-4,2; Rb=0,01-0,02; Sr=2-210; Fe=0,2-150; Ni=0,03-0,9; Mo=0,01-0,6; Ti=0,006-4,67.	Calium - 100 Iron - 50 Arsenic - 5 Fluorine - 500 Germanium - 0,02 Molibdenum - 0,1
Chemical industry (mineral-salt production)	Waste water	35-270	Cl-Ca-Na Cl-Na SO_4-Ca-Na	Mg=170-4500; K=130-810; Sr=40-860; B=10-70; Li=1,0-6,5; Rb=0,2-1,3; J=15-45; Br=250-400	Titanium - 10 Aluminium - 100 Copper - 50 Zinc - 50
Mining industry	Mine and ore water	30-150	Cl-Na SO_4-Ca-Na HCO_3-Naa	Ca=60-340; Mg=20-145; Fe=0,5-1500; Al=1,0-215; Sr=2-15; As=0,6-750; Cu=0,2-4500; Zn=0,4-5600; Pb=0,1-3000; Ca=0,05-360; U=0,05-8,0	Lead - 1 Cobalt - 0,1 Nickel - 1

Formation of chemical composition of accompanied water depends on a spectrum of the main natural and technogenic factors and scales of geochemical transformations, as well as on a specific impact of human activity upon the geoenvironment when producing ferrous, non-ferrous, rare and noble metals, chemical and non-ore resources, coal, oil, gas and oil-shales.

Because of the increased mineralization and anomalous concentrations of hazardous and toxic compounds, the accompanied water requires, before being disposed to surface reservoirs, to be cleaned up. At the same time high contents of the chemical-composition ingredients are important to be extracted as useful products. Both of the above objectives are interrelated and aimed at solving the problem of complex utilization of mineral resources and protection of the environment against manmade pollution.

One of the main criteria in selecting a way of using the accompanied water are the maximum allowable concentrations and minimum industrial contents of chemical elements. Maximum allowable concentrations in water reservoirs used for domestic/drinking and fishing purposes are determined by national standards. Minimum industrial contents presented in Table 1 are of an arbitrary character and determined mainly by economic aspects. Standard contents of useful components in accompanied water should be established for each particular deposit, basing on the results of technological testing and geologic-and-industrial assessment.

REVIEW OF APPLIED TECHNOLOGIES

The technological methods used for processing of accompanied water together with the purification of initial solutions from toxic and hazardous compounds enable obtaining chemical products which are in agreement with the standard regulations.

The technological results are taken into account in evaluating mineral reserves and developing projects of deposit mining.

Technological efficiency of the methods used is determined by a qualitative composition of accompanied water, observed before and after purification (Table 2).

Accompanied water is purified using usually mechanical (e.g. settling, filtration), chemical (e.g. neutralization, oxidation and reduction) and physico-chemical (e.g. ion-exchange, reverse osmosis, electrochemistry, etc.) methods. Biological methods do not find presently a wide use, although they, if used in industrial scales, can considerably increase ecological efficiency of purification plants.

Selection of a method depends on amounts and qualitative composition of water to be purified, sanitary and technological regulations, as well as on availability of the required materials and energetic resources.

Water treatment is carried out by steps including preliminary, primary and deep purification.

Table 2. Technological efficiency of different methods for purification of accompanied water, %

Ingredient	Mecha-nical purifi-	Chemi-cal settling	Electro-dialysis	Ion-exchange	Reverse osmosis
1	2	3	4	5	6
Dry residual	5	30	85	80	85
Suspended substances	60	50	95	80	95
Lithium	3	90	80	85	95
Stroncium	3	95	90	90	95
Boron	5	35	10	90	75
Iodine	3	20	60	95	85
Bromine	3	45	60	95	85
Iron	30	60	90	80	95
Manganese	5	65	30	80	95
Zinc	3	90	30	80	85
Barium	3	85	95	95	95
Fluorine	2	99	10	80	90
Lead	3	95	30	80	95
Copper	3	80	30	80	95
Arsenic	2	80	30	80	85
Mercury	5	40	30	80	85
Selenium	3	80	30	99	85
Chromium	3	60	30	80	85
Silver	5	95	30	85	85
Cadmium	3	85	30	80	85

Note: The Table includes the data from (References 2 & 3) and the research results.

Preliminarily the water is cleaned up of suspended substances and oil products by means of settling and filtration. Here, reagentless methods are expedient in terms of land use, but they have a low productivity. So, the purification process is intensified by adding coagulants and flocculants.

The primary purification includes the removal of the majority of fine-dispersed suspended substances, dissolved organic compounds and reduction of hazardous substances to a standard level. A complex of the technological methods is used at this stage, of a wide usage among which is reagent precipitation of salt-containing components in a form of low-soluble compounds. Precipitation process results in forming large-amount wastes which possess low hydraulic and sedimentation capacity. Moreover, usage of reagents requires additional costs for their acquisition, storage and preparation.

Deep purification improves the quality of accompanied water and provides obtaining chemical products in the course of extraction of useful chemical components from aqueous solutions. Of a priority here are physico-chemical methods which enable a low-waste production and a growth of the coefficient of developing hydromineral resources.

Each of the methods has certain advantages and disadvantages and is selected with regard to the technological and economic characteristics.

Table 3. Economic characteristics of water-purification methods in coal industry

Specific expenses, roubles/m3	Water purification method		
	Mechanical	Physico-chemical	Biological
Capital	0,18	0,40	0,60
Current	0,015	0,072	0,085
Reduced	0,04	0,13	0,18

Note: The data are taken from Reference 1.

The highest economic effect is achieved through combining mechanical, physico-chemical and biological methods, which enable a complex processing of accompanied water.

For the accompanied water having different chemical composition, the typical technological schemes are developed which incorporate a process of water preparation, reagent- and electrochemical methods, sorption, distillation and reverse osmosis. Many useful chemical components can be extracted drom accompanied water, including carbonates of lithium and strontium, boric acid, magnesia, iodine, bromine, calcium hypochlorite, sodium chloride and others. Geotechnological tests of complex processing of accompanied water with obtaining chemical products have been carried out at the deposits of the nothern Caucasus, Middle Asia and Far East.

The development of complex schemes of cleaning the accompanied water with extraction of useful components is being made in a certain succession that provides for technological studies on laboratory-, stand- and pilot plants. Each stage of studying results in working out the technical-and-economic documentation that substantiates the efficiency of the proposed technologies and contain the recommendations for identification of further works in much greater scales.

A particular attention is given to the use of mobile technological laboratories. They present a set of moduli, the successive assembling of which depends on a scheme of processing of hydromineral products. Mobile laboratories enable an arrangement of technological studies on a particular site and improvement of the quality of reference data used to design industrial facilities.

Economic expediency of usage of accompanied water extracted at industrial-genetically different mineral deposits depends on quantitative and qualitative composition, a technology of purification and extraction of useful components, capacity of purification facilities, costs of trade products, profits and exploitation period.

Development of hydromineral resources provides not only economic, but also social effect. Wasteless technologies can be developed only through complex use of mineral resources and are one of the cardinal ways of solving the problem of the environmental protection.

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