THE TRANSFORMATION OF THE COMPOSITION OF THE GROUNDWATER IN THE AREA OF HIGH TECHNOGENIC LOAD MINING PRODUCTIONS

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ABSTRACT

Stoilensky GOK is one of the leading enterprises in Russia in terms of production of raw materials for ferrous metallurgy. From the ecological point of view, ore deposits are natural sources of pollution because they contain many chemical elements. According hydrogeology, drainage, operation of the tailings dump, technical water after treatment process can be sources of pollution of the underlying aquifers. At the enterprise the operation of the seepage pit is mainly aimed at protecting from the Alb - Cenomanian aquifer groundwater. The technogenic influence and use of the reverse water supply system suggest that the quality of groundwater in the Alb - Cenomanian aquifer is changing.

Underground waters of the Alb-Cenomanian aquifer are widely used for the purpose of municipal water supply of nearby settlements. In this regard, constant monitoring of the hydrochemical regime of the Alb-Cenomanian aquifer and identification of sources of anthropogenic pollution are required.

The qualitative composition of groundwater of the Alb-Cenomanian aquifer in the zone of influence of mining facilities is analyzed. The graphs of the content of several chemical components are built. The conclusions about the changes in the composition of groundwater in the zone of increased anthropogenic load are achieved. It is revealed that one of the objects of influence on groundwater is the tailings dump of JSC "Stoilensky GOK". There are no regional water-resistant layers at the base of the basing of the tailings dump, which creates favorable conditions for the hydraulic connection of technogenic waters with natural aquifers. The content of a number of substances exceeding the MAC value was found. The main source of pollution of the Alb-Cenomanian aquifer within Stoilensky GOK is determined.

Keywords: groundwater, Alb-Cenomanian aquifer, observation well, MAC, groundwater quality.

INTRODUCTION

One of the features of the development of mineral deposits is a sharp increase in the rate of geochemical circulation of substances, leading to the entry into the natural environment of toxic components [1, 2].

The presented results of the study are devoted to one of the aspects of the technogenesis of the mining profile on the example of Stoilensky mining and processing plant (SGOK) – the influence of infiltration of technogenic waters of the existing tailings on the chemical composition of the waters of the Alb-Cenomanian aquifer.

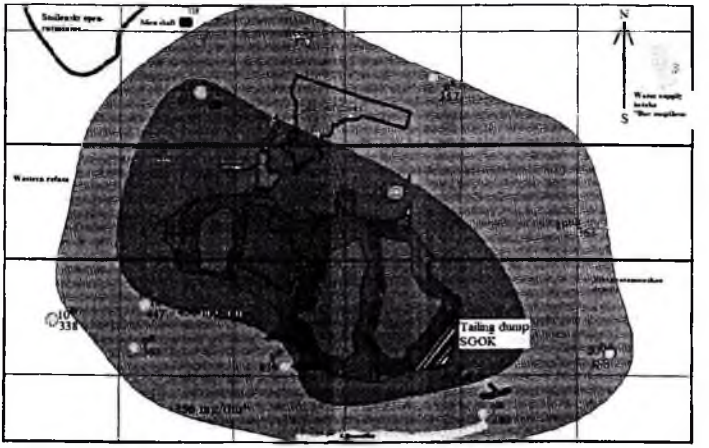
The plant operates on the basis of the Stoilensky iron ore deposit of ferrous quartzites, located in the Central part of the North-Eastern strip of KMA, in the Belgorod region, within the Stary Oskol administrative district, 8 km South-West of the city of Stary Oskol

The hydrogeological section in the study area are presented Maastricht-Turanian, Albian-Cenomanian, Aptian-neokomsky, the Volga, the Callovian-batskin, lower Carboniferous aquifers and fracture waters of the ore crystalline foundation [3, 4].

From the standpoint of economic and drinking water supply, the most interesting is the Alb-Cenomanian aquifer (K_{1-2} al-s), dedicated to medium - coarse-grained sands with a capacity of 20÷40 m, as the most sustained and watery [5]. The filtration coefficient of water-containing sands varies within 5÷20 m/day. The aquifer, being in the zone of intensive water exchange, has a close hydraulic connection with the alluvial and chalk-marl horizons, surface waters lying above.

Background waters of Alb-Cenomanian are fresh, with mineralization 0,3÷0,6 g/dm^3, on chemical composition - hydrocarbonate calcium (hydrocarbonate calcium-sodium). Violation of the natural hydrodynamic regime of the aquifer occurs due to drainage of the pit by the drainage complex, drainage for drinking water supply of the district (120 thousand m^3 of water per day), infiltration from the bowl of the tailings dump.

One of the adverse environmental consequences of the operation of the tailing dump is the pollution of groundwater, which can affect even their macro-component composition. Groundwater quality control of the Alb-Cenomanian aquifer is carried out through 19 observation borehole of the regime network The results of the pilot studies are given below.



18нв Observation hole.From above- hole number. From below- the contents of the element in water (mg/dm³)

23

Mineralisation of water 450 mg/dm³

Mineralisation of water 350 mg/dm³

Fig.1 Degree of mineralization of waters of the alb-cenomanian aquifer Scale 1:10000

Hydrogeochemical situation of the study area has the following features.

Hydrocarbonate calcium waters in the alb-cenomanian aquifer are observed to the South-East of the head dam of the tailing dump of the SGOK (Hole 7ᴵᴵ). These waters correspond to the background composition and are characterized within the described area by the content of sulfate ion – 58.0÷60.0 mg/dm³, chlorine – 24.33÷27.62 mg/dm³, mineralization is 495 mg/dm³.

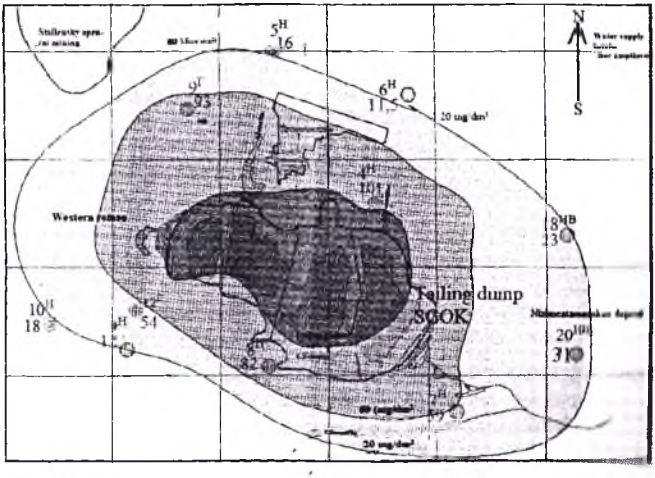
Hydrocarbonate magnesium-calcium waters are widespread on the considerable area and are observed to the North (Hole 3ᴵᴵ, 5ᴵᴵ, 6ᴵᴵ and 9ᴵ), South (Hole 8ᴵᴵ), southwest (Hole 9ᴵᴵ, 10ᴵᴵ, 12ᴵ) and East (Hole 18ᴵᴵᴮ, 20ᴵᴵᴮ) from the tailing dump of SGOK. They are characterized by the content of sulfate ion – 7÷108 mg/dm³, chlorine – 5,12÷55,98 mg/dm³, mineralization – 472÷694 mg/dm³

In groundwater, selected from wells 5h, 8h, 9h, 10h and 12g, recorded silicon content of 10.18 (Hole 10ᴵᴵ) to 17.62 mg/dm³ (Hole 12ᴵ) at MAC = 10 mg/dm³. Water from the well 2ᴵᴵ is characterized by increased hardness* (7.12=7.68 J) and contains nitrates up to 69.12 mg/ dm³ (MAC = 45 mg/dm³), which directly indicates groundwater pollution. Water pollution in Hole 2ᴵᴵ, apparently, occurs at the expense of water of a surface drain as location of a well is dated to the settlement. At this point in the geological section there are no clay Quaternary deposits that isolate the aquifer from contamination from the surface.

Hydrocarbonate sodium-calcium waters are typical for the site of the well location 30, between the railway dump of Lebedinsky GOK (LGOK) and the dump of self-propelled equipment "Northern" SGOK. Such waters are characteristic only for this area and have a constant chemical composition throughout the observation period (since 2004), characterized by concentrations of sulfate ion 15.0÷22.0 mg/dm^3, chlorine 57.12÷70.01 mg/dm^3, mineralization from 493 to 522 mg/ dm^3.

Sulphate-hydrocarbonate calcium waters are fixed on the site located to the North of the mine site and the «Streliza» dump - Hole 19^г, 3, 1^н (Fig. 3). Such waters have a sulfate ion content of 120÷170 mg/dm3, chlorides of 26.52÷33.54 mg/dm^3, mineralization varies from 629 to 833 mg/dm^3. In the areas of well location 111 and 3 groundwater is characterized by increased hardness up to 8.65 ° C, due to the increased content of calcium ions (up to 137.87 mg/dm^3) and sulfate ion (up to 170 mg/dm^3)/

* Water hardness - a set of dissolved in water calcium and magnesium cations (Ca2+and Mg2+) ,expressed in degrees of hardness (°F)



18HB / 23 — Observation hole.From above- hole number. From below- the contents of the element in water (mg/dm^3)

The content of sulfate ion 100 mg/dm^3

The content of sulfate ion 60 mg/dm^3

The content of sulfate ion 20 mg/dm^3

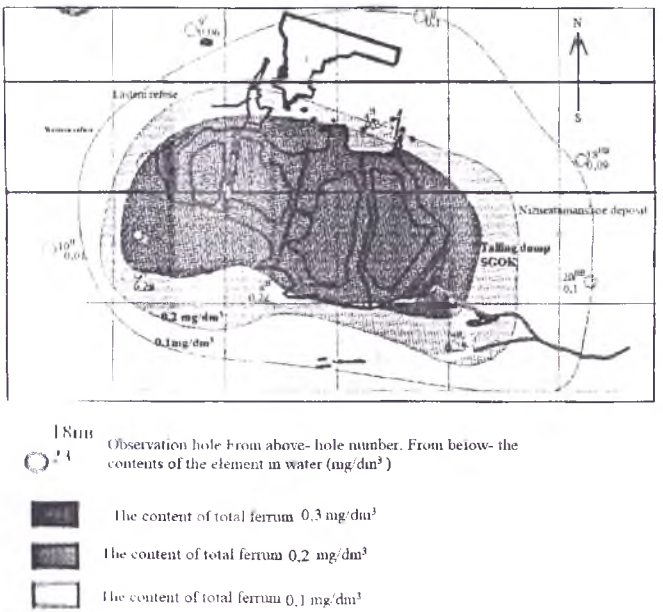
Fig.2 The scheme of the isolines of the content of sulfate ions in the waters of the cenomanian aquifer. Scale 1:10000

Sulphate-bicarbonate sodium waters were observed in 2017. in the well 20[г]. In general, the groundwater of the Alb-Cenomanian in this area is characterized by a significant excess of MAC in hardness, dry residue, content of ion-ammonium, silicon, ferrum total and oxidation of permanganate. The latter indicates the presence of organic substances in the water, the source of which can be a yeast plant located on the left Bank of The Oskolets river. Oxidation of organic substances is associated with the formation of carbon dioxide, which contributes to the dissolution of calcium carbonate host rocks and increase the concentration of bicarbonate ions.

Sulphate-hydrocarbonate sodium-calcium waters have been found in recent years at the site of the 4[в] well, where groundwater is characterized by an increased content of sulfate ion (94–108 mg/dm^3).

The given materials of hydrochemical testing of waters of the Alb-Cenomanian aquifer suggest that the main source of violation of its natural hydrochemical regime in the study area is the tailings dump of the SGOK. It is essential that at the base of the tailings dump there is no any water resistance and this contributes to a closer hydraulic connection of technogenic waters with groundwater hydrogeological section.

In holes located within the boundaries of the tailing dump (12[г], 9[г], 8[в], 7[в], 4[в]) the content of total ferrum varies from 0.2 mg/dm^3 to 0.6 mg/dm^3 (Fig. 3).



18пв — Observation hole From above- hole number. From below- the contents of the element in water (mg/dm^3)

The content of total ferrum 0.3 mg/dm^3

The content of total ferrum 0.2 mg/dm^3

The content of total ferrum 0.1 mg/dm^3

Fig 3. The scheme of the isolines of the content of total ferrum in waters of the Alb-Cenomanian aquifer. Scale 1:10000

[illegible] from the sides of the tailing dump, the content of total ferrum is reduced [illegible] mg/dm^3) (see Fig. 3). The increase in the content is observed only in hole [illegible] mg/dm^3) located in the area of the mine site, as well as in the well

5г located near the mine shaft No. 3 (0.35 mg/dm^3). In tailings pond solutions, the total ferrum content exceeds the MAC and averages 0.3÷0.5 mg/dm^3.
Mineralization in the well waters of 12г, 9г, 8н, 4н varies from 439 to 466 mg/dm^3, also decreasing as the distance from the tailings to 338÷388 mg/dm^3 (Fig. 1). In the surface waters of the tailing dump, the concentration of this component is 500-570 mg/dm^3
The increased content of sulfate ion is also observed in wells near the tailings 12г, 9г, 8н, 7н, 4н (from 54 to 104 mg/dm^3). When moving from the tailing dump, the sulfate ion content is reduced to 11.5÷31.0 mg/dm^3 (Fig. 2). In wells 19г, 20г, 3, 1н sulfate ion content increases to 121÷361 mg/dm^3. The sulphate ion content in the tailings pond is about 170 mg/dm^3. Consequently, the object of sulphate pollution of underground waters is the drainage water of the open-cut mining, which together with mine waters are used in the technological cycle of enrichment and subsequently enter the tailings [6, 7]. The degree of contamination of groundwater of a particular site depends on its location in relation to the tailings, the intensity of infiltration losses from the latter and the intensity of mass transfer. It should be noted that as we approach the tailing dump(20нв, 7н , 12г , 8н), there is a predominant trend of increasing sulphate concentrations in the waters of the Alb-Cenomanian aquifer over time (table 1). While in hole located further (Hole 5н, 18нв, 6н, 10н, 9н) above,the growth and fall of the sulfate ion concentration are variable.

Table 1

Changes in the content of sulfate ion in groundwater of the alb-cenomanian aquifer in time (data of STC Novotek»)

№ hole	Average annual sulphate ion content, mg/dm3												Distance from well to the tailing dump, m
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
5н	-	-	-	-	-	18	15	15	16	14	14	16	3300
18нв	17	20	27	23	19	20	17	12	17	16	17	23	2700
20нв	18	21	31	30	19	22	22	13	25	23	27	32	2700
6н	-	-	-	-	-	20	18	17	15	14	14	18	2500
10н	-	-	-	-	-	20	20	19	19	18	17	17	2300
9н	-	-	-	-	-	24	23	19	15	14	16	17	1500
7н	-	-	-	-	-	48	56	61	60	59	57	59	1000
12г	29	36	38	37	34	32	42	53	32	48	53	57	870
8н	-	-	-	-	-	72	71	72	73	79	79	80	400

Thus, in the process of pilot analysis of the results of hydrogeochemical testing of the Alb-Cenomanian aquifer, the following can be concluded.
In general, the content of components (primarily macro components) of the hydrochemical composition of groundwater does not exceed the MAC and more often corresponds to the background. Nevertheless, the trend of growth of sulphate-ion concentrations in some regime wells over time in the period from 2006 to 2017 was revealed.
There is also a tendency to increase the total ferrum and the degree of mineralization of underground waters of the Alb-Cenomanian as it approaches the tailing dump [8].

there are no water-resistant rocks under the basin of tailings dump, this contributes to the active infiltration of technogenic water from the tailings dump down the hydrogeological section. Consequently, the tailings dump of Stoilensky GOK a significant role in violation of the natural hydrochemical regime of the Alb-Cenomanian aquifer.

CONCLUSION

The presented studies are devoted to one of the aspects of the mining industry's technogenesis on the example of the Stoilensky Mining enterprise - the effect of the infiltration of technogenic waters of the existing tailing dump on the chemical composition of Alb-Cenomanian aquifer. Alb-Cenomanian aquifer is of the greatest interest from the standpoint of drinking water supply in the study area, as the most sustained in distribution and water-rich. It is shown that the background waters of alb-cenomanian are fresh, with mineralization of 0.3÷0.6 g/dm^3, according to chemical composition - calcium bicarbonate (calcium bicarbonate-sodium). Violations of the natural hydrodynamic and hydrogeochemical regimes of the aquifer under consideration, occurring due to the drainage of the Stoylensky open-cast iron ore quarry under development by the drainage complex, intensive water withdrawal for drinking water supply of the area, and infiltration of man-made water from the tailing storage bowl. Studied hydrogeochemical situation of the study area, represented by hydrocarbonate calcium, calcium-magnesium hydrocarbonate, hydrocarbonate sodium-calcium, sulfate-carbonate calcium, sulphate-hydrocarbonate sodium and sulphate-hydrocarbonate sodium-calcium waters of the predominant component. It has been established that the violation of the hydrogeochemical regime can affect even the macrocomponent composition of groundwater, the growth of their hardness. In addition, the maximum permissible concentration of the concentration of silicon (from 10.18 to 17.62 mg/dm^3), nitrates to 69.12 mg/ dm^3, total iron - from 0.2 to 0.6 mg/dm^3. It was established that the main source of pollution of groundwater in the study area is the Stoilensky Mining enterprise tailing dump. It was recorded that at the base of the tailing dump there is no water stop and this contributes to a closer hydraulic connection of industrial waters with groundwater of a hydrogeological section. When moving away from the sides of the tailings, the content of these microcomponents naturally decreases. The prevailing general trend of increasing sulfate concentrations in the waters of the Alb-Cenomanian aquifer over time has been revealed. It was established that the degree of pollution of groundwater at a particular site depends on its location in relation to the tailing dump, the intensity of infiltration losses from the latter and the intensity of mass transfer.

The presented study needs further deepening. It is necessary to continue and expand the hydrochemical monitoring of both the study area and the number of pollutants. The formulation and implementation of physical and numerical modeling of the processes of migration of technogenic tailings water in aquifers for the development of specific environmental measures is required [9]. The active use of groundwater in the study area for domestic drinking water supply dictates a significant relevance of these prospective studies.

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