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GEOLOGY

Mine Water Drainage from Flooded Coal Mines

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The flooding of mines creates different hazards for natural objects and engineering constructions, since this can result in mine water inflow at the surface and to adjacent mines, pollution, and some other negative consequences. In this context, evaluation of the possibility of mine water drainage and its intensity are of great importance.

The mechanisms of this process are poorly understood. In the specialized literature, only data about the appearance of mine waters near the flooded coal mines are given. The potential for long-distance mine water spreading seems to be negligible due to the natural low permeability of rocks and the presence of a pressure gradient around the water body in mines. Nevertheless, there are quite reliable data on the possibility of mine water drainage far from coal mines.

In this work we consider a number of such cases that occurred in the Eastern Donbass, where there are hundreds of flooded mines, where hard coal and anthracite coal were mined in Carboniferous deposits.

Water seepages appeared after water pumping from these mines was stopped. They were established on the basis of some particular factors: a sharp change in the salinity and chemical composition of underground waters and their similarity with the chemical parameters of mine waters.

Note that the underground waters of abandoned mines in the region are characterized by a high salinity (4–22 g/dm^3) and a high amount of sulfate (up to 12 g/dm^3) and iron (up to 1.7 g/dm^3) ions. In addition the mine waters are sources of large-scale pollution of the environment by mineral substances. Background indexes of underground waters are usually much lower. A number of cases of long-distance water drainage were noted in the northeastern area of the Eastern Donbass, where all mines were flooded.

In 2001, in the settlement of Grachi, a sharp deterioration in water quality was recorded in a shallow well drilled in July 2000 in an aquiferous limestone layer of Carboniferous age. The water from this well was used earlier for drinking needs without any restrictions.

In the water an increase in the total content of mineral substances and the concentration of some specific components was noted. The dry residue and the sulfate ion content (g/dm^3) were 2.48 and 1.19, respectively, in August 2002; 6.42 and 3.4, in April 2003; and 8.5 and 5.96, in September 2005. These data are typical for the mine waters of the area studied. In our opinion, the changes observed are connected with inflow of mine waters into the well. A source of water inflow is likely to be the abandoned mine workings of the Kalitva mine, located near the well (7 km). The mine pumping was stopped in October 1998.

After being diluted by ground waters, the water flowing out the mine at the surface had the following chemical parameters in April 2005: the mineralization is 6.46 g/dm^3 and the sulfate ion concentration was 3.88 g/dm^3; that was, the diluted water was similar in composition to the water in the well.

An increase in the water salinity and sulfate ion content was noted also in dug wells located between the mine and the well.

A probable channel of the mine water inflow is the zone of the large Belokalitvinskii thrust. The disappearance of springs along the thrust zone after the mine was put into operation testifies to the existence of a hydraulic connection of underground waters and water bodies in the mine.

Since the summer of 2005, to the north of the studied water seepage, in the village of Karpovo-Obryvskii, a sharp deterioration in the water quality in sands and sandstones of Paleogene age was noted. It is confirmed by a sharp increase in the water salinity, the content of sulfate ions, magnesium, and iron, and a general deviation to the characteristics of mine waters. In this respect, the dynamics of the change in the water composition in a spring on the outskirts of the village is a distinguishing characteristic. In the period between June 2005 and July 2006, the chemical composition of

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the water changed from calcium–bicarbonate–sulfate to calcium–sodium–bicarbonate–sulfate. The water salinity (g/dm^3) increased from 0.33 to 0.63 as a result of an increase in the content of hydrocarbons, sulfate, and sodium ions (from 0.09 to 0.27, from 0.12 to 0.15, and from 0.01 to 0.1, respectively). The iron content in both cases varies from 0.00005 to 0.001 g/dm^3 (0.0005 g/dm^3 on average).

By August 2009, the water salinity had increased to 0.73 g/dm^3; the content of sulfate ions and iron was 0.26 and 0.0001 g/dm^3, respectively. As a result, the water became calcium–magnesium–bicarbonate–sulfate in composition. By November 2009, the water in the same sediments in the nearby village of Komissarov had chloride–sodium–sulfate or magnesium–calcium composition with the salinity of 4.05 g/dm^3 and a content of sulfate ions and iron of 1.72 and 0.0045 g/dm^3, respectively. This change in the water composition can be explained by the mine water inflow.

The identified area of changes manifested in the underground water composition is located 600 m or more from the mined-out space along the strike of coal-bearing strata of the Vostochnaya Mine, which is regarded as the probable source of the pollution. From mine workings, which have been flooded since January 2000, the magnesium–sulfate–sodium water flows out with a salinity of 6.91 g/dm^3 and a content of sulfate ions and iron of 3.34 and 0.043 g/dm^3, respectively (the data for November 2006). The changes were the fastest and maximal directly above the coal bed mined (in the village of Komissarov) and less fast and essential in the village of Karpovo-Obryvskii, located further away.

The channels of the mine water drainage are probably the Carboniferous sandstone layers in the active roof of the mined-out space.

In addition, a significant change in the characteristics of underground waters was found in the extreme southwestern area of the Eastern Donbass, where all mines were abandoned by flooding the wine workings.

Here, in the village of Bognenko a sharp deterioration in the quality of water in a sandstone layer of Carboniferous age was recorded in the early 2000s. According to the chemical analysis of water from dug wells and a spring (in September 2002), the reason for this was revealed. The dry residue was 3.3, the content (g/dm^3) of sulfate ions, calcium, magnesium, and iron was about 1.9, 0.38, 0.18, and 0.0003–0.002, respectively. In July 2009 the water had similar values of the dry residue and concentration of the basic macrocomponents.

These data testify to mine water inflow. A likely source of mine waters could be water bodies in the mines flooded and inflow channels are the sandstone layers in the roof of the mined-out space. The nearest one is Mine 4, located 4 km along the strike of layers. The salinity of the calcium–magnesium–sodium–sulfate water, which inflows from the mine, is 3.67 g/dm^3; the content (g/dm^3) of sulfate ions and iron is 1.85 and 0.073, respectively (data for October 2006). These parameters are similar to those for the water seepages mentioned.

The pollution of underground waters in the settlement of Bognenko occurred when the probable flood level of mines was at an elevation between +50, and +100, m. The underground water level near the settlement was at an elevation of +180, meters; that is, it was located hypsometrically above the flooded part of the mine workings.

A similar situation arose in the beginning of the active pollution of water in the settlement of Grachi in January 2001 (the flood level in the mine was at –70 m; the underground water level, +100 m), near the village of Karpovo-Obryvskii in January 2005 (the mine was flooded up to the depth mark of +21 m; the underground water level about +40 m). This points to the development of upward mine water flows.

The territorial and geostructural locality of centers of the water seepages examined and the probable directions of the mine water inflow to them are shown in Fig. 1. These data testify to the fast mine water drainage for a considerable distance through channels of different types at a rate of not less than 1–2 km/year.

Note that the possibility of further fast groundwater migration in the region studied was proved by tracer studies. For example, in the late 1980s in the central area of Donbass, where for over 100 years coal mines have been intensively exploited, significant hydraulic pressure gradients were noted and cases of water drainage along the major fault zones [1] for a distance of several kilometers with a rate of up to 1.5 km/day were established.

The direction of mine water movement in the coal-bearing stratum is controlled by lithological and structural peculiarities. Mine waters can inflow also into cover deposits, where the water movement is controlled by the same factors. In the case of a flat dip of rocks, the water drainage is areal.

One can state that the water drainage can occur as upward water flows. A possible reason for this may be impulses or the stress-strain state of rocks. A high rate of water drainage could be a result of the increment of the permeability of rocks upon flooding of the dried massif. As a result of our studies we have established that there is the possibility of manifestation of these effects around deeply flooded mine workings.

The above data confirm the results of observations in mines about the possibility of the occurrence of water permeable channels along the thrust fault planes. In addition, they show that counter flows of groundwater and mine waters take part in blanketing the depression formed by the mine water. During water drainage, the iron content decreases in the water.

The effects identified allow us to predict the time of appearance of the mine waters in low-hilly relief for a

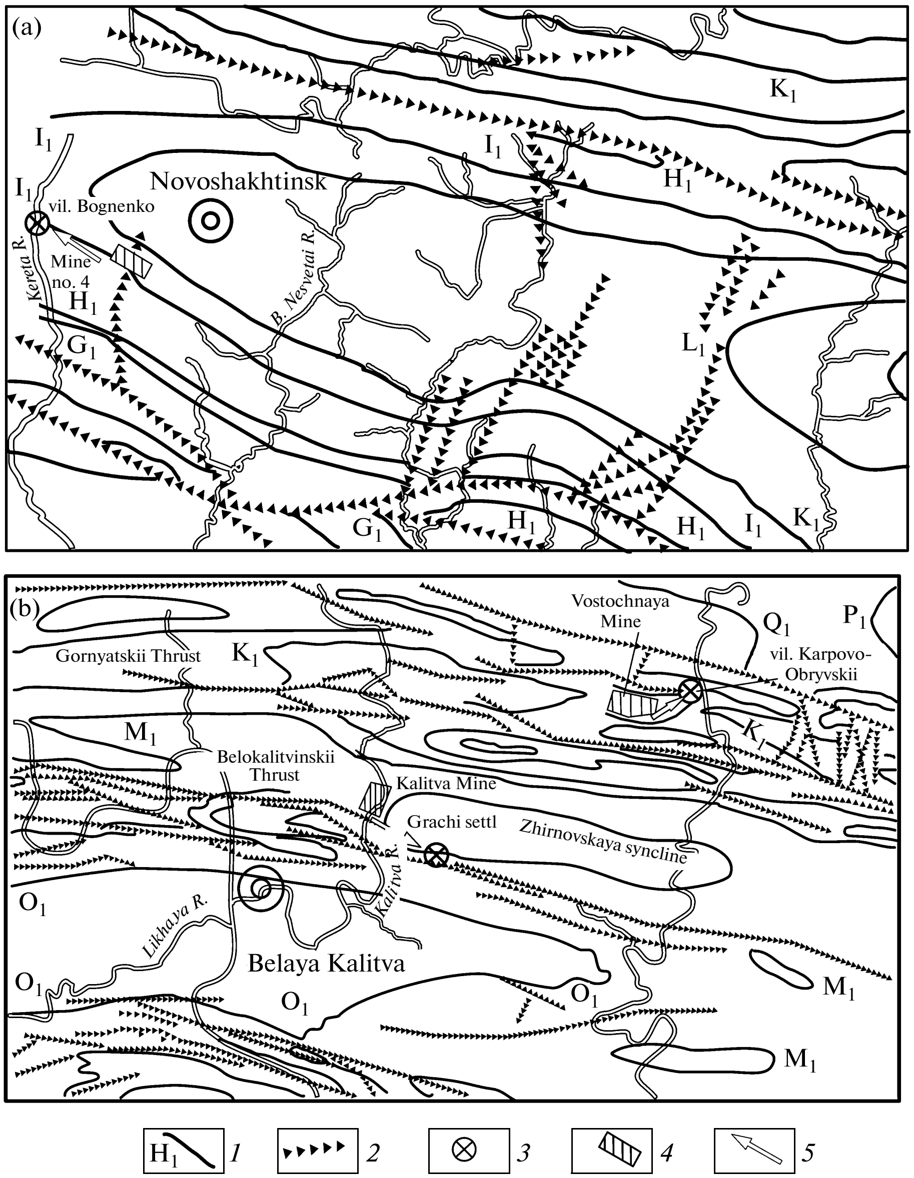

Fig. 1. Mine water drainage from flooded coal mines in the southwest (a) and northeast (b) of the Eastern Donbass. (*1*) The limestone layer and its index; (*2*) the fault zone; (*3*) water seepage; (*4*) the flooded mine; (*5*) mine water inflow.

distance of less than 10 km from the flooded mines, especially along the strike of the layers-collectors of the coal-bearing stratum and the major faults. The geological peculiarities of the Eastern Donbass control the predominant northwest–southeast direction of the mine water drainage along the general strike of the main structural elements of the region studied.

REFERENCES

1. M. G. Tarasov, N. M. Trunov, A. M. Nikanorov, and A. V. Mokhov, Problems of Geology and Exploitation of Mineral Resources in the South of Russia in *Proceedings International Conference*, Rostov-on-Don, Russia, 2002 (Izd-Vo YuNTs RAN, Rostov-on-Don, 2006), pp. 317–320.