Maximovich, N. G., Kataev, V. N. & Blinov, S. M. (1995): Consequence of the Kizel Coafield acid mine water disposal into karst cavities. – In: Kharaka, Y. K. & Chudaev, O. V. (eds): Water-Rock Interaction 8. – p. 885-888, 1 Abb.; Rotterdam (Balkema).

Maximovich N.G., Kataev V.N., Blinov S.M. Consequence of the Kizel Coalfield acid mine water disposal into karst cavities // Water-rock interaction. Proc. symposium. - Vladivostok, 1995. - P. 885-888.

CONSEQUENCE OF THE KIZEL COALFIELD ACID MINE WATER DISPOSAL INTO KARST CAVITIES

N.G. Maximovich, V.N. Kataev & S.M.Blinov

ABSTRACT: Discharge of acid coal mine water into carbonate karst cavities leads to: 1 - changes of surface and underground water composition, 2 - filling of karst cavities with iron-bearing deposits, and 3 - changes in the hydrogeological and hydrological regimes of the region. This paper reviews the results of coal mine water discharge in the West Urals Kizel coal basin.

1 INTRODUCTION

Coal formations of the Lower Carboniferous Visean stage are being mined in the West Urals Kizel coal basin. The coal is characterized by high sulfur content (to 6 per cent). Out of 18 coal mines which are working in the region, 8 are characterized by karst water influxes which average more than 1000 m^3 per hour and the influxes can reach to 3200 m^3 per hour in case of sudden water breaks. Intensive karst and abundant karst water of the Carboniferous limestone are the main factors which complicate the mining-geological conditions of coal mining. The main ecological problem in the Kizel coal basin is utilization of the acidic mine waters. Mine waters discharged into the karst rivers or dry valleys have a major impact on the hydrochemical and hydro-dynamic situation in the region.

2 KARST HYDROGEOLOGY OF THE REGION

The present-day karst structures of the carbonate massifs formed during the Oligocene-Miocene period are a result of the activity of water. The flows have moved along the strike and dip of the joints in the limestones towards a very deep river valley. That is the reason why the karst cavities are found at depths about 1000-1100 m below the contemporary surface.

Hydrodynamically-connected karst drainage system is a result of karst massif development. The system includes the following elements: 1) main surface streams (karst rivers which cross massifs); 2) tributaries of the main surface streams which are localized in the karst-erosion depressions (gullies) - small karst rivers with surface and subsurface flow; and 3) underground streams which are localized along the lithologic boundaries or tectonic dislocations. As a rule, the karst water influxes into coal mines come through the large, wide fractures of the axial parts of the folds, from tectonic fault zones with displacement (tear faults, thrust faults, etc.), and from the karst cavities.

Limestone denudation in the area (7 -17 microns per year), organic acid of Taiga biomass and carbonic acid of soil have promoted the formation of HCO_3-Ca water with mineralization 0.06-1.5 gram per liter (g/l) and near-neutral pH (pH = 7.3-7.5) in karst aquifer and saturated zones.

Karst in the region is exposed or covered (under alluvial deposits), hence the karst water regime in the Vadose Zone depends on precipitation.

The regime of the surface streams also depends on precipitation and is related to the main karst rivers which cross the coal district, because the alluvial deposits fill the clay layers over and under the boulder bed. In this case the alluvial deposits are an impenetrable layer. The main karst rivers of the region under the conditions of artificial water-table lowering turn out to be "perched" over the karst water-table, isolated from underground water. Joint-karst water level in the limestones of the main karst river valley is nearly 28-30 meter (m) beneath the surface. At low water periods underground waters do not mix with surface waters. Water mixing may take place during rainfall periods (June and October-November) when the karst water-table rises and recharge is by filtration of river waters.

The small karst streams (tributaries of the main rivers) are characterized by the change of surface run-off by subsurface drainage and vice-versa. They have mixed (atmospheric and underground) recharge and very often flow into the main rivers as big springs. In winter the small rivers are fed only by mine waters. The small karst rivers are a very important link in the hydrodynamic and ecological systems of the region.

The karst springs in the limestones of the coal formation flow periodically. The losses of the springs increase after rainfalls to 40-50 liter per second (l/s) while the minimal losses are 1-3 l/s.

3 INFLUENCE OF COAL MINING TO UNDERGROUND WATERS

Coal has been mined since the 18th century in the region, and at the present time the natural-anthropogenic system has developed on the mine fields and the surrounding territory. This system is characterized by specific hydrodynamics, hydrochemistry, mineral formation and by ecological influence (Maximovich and Gorbunova, 1990). The karst water-table within the limits of the coal fields is not static. The water regime is affected by drawdown of the underground karst water-table (from 40-50 m) by pumping of mine waters. The water-table is dropping from year to year, but in autumn and in spring, in the periods of recharge the water-table rises from 25-50 m. This situation is not typical for the synclinal tectonic structures where coal beds dip to 1500 m and more below the surface and for the areas where coal is not mined. In such places the karst springs are permanent and the natural water-table exists.

The underground karst waters are partly isolated from the surface streams and active pollution, for natural-anthropogenic reasons. Nevertheless, filtration pollution takes place on the coal mining piles. Atmospheric waters, being filtered through them, bring about sulphate water pollution at depths of 30-50 m below the surface. The hydrochemical HCO_3-Ca facies changes on exposure to the pollution to SO_4-HCO_3-Ca (content SO_4 reaches 300-350 milligrams per liter (mg/l) when mineralization is 700-760 mg/l).

Chemical composition of the coal mine water depends on the contents of sulfur, carbonated and diffused elements in the coal formation. If the contents of sulfur in coal exceed 4%, karst water acquires acid reaction (pH = 2-3) and sulphate composition. SO_4-Fe-Al-Na-Ca water acquires mineralization 2.5-19 g/l. During the exploitation of the coal deposits, in connection with the increased water influxes, air exchange and volume of the rocks exposed, the mineralization can increase to 35 g/l. The content of lead, copper, zinc, silver, nickel, and cobalt in the mine water has raised ten-fold as compared with natural karst water.

4 THE RESULTS OF MINE WATER DISCHARGE INTO THE KARST CAVITIES

The main problem with the small karst rivers (for example Gubashka, Shumiha, Ladeinij Log, Kamenka) is that being a link in the technological chain of mining production they are often used for coal mine water discharge and thus underground and surface waters become polluted.

The small rivers of the Kizel coal mine district have HCO_3-Ca-Na hydrochemical facies with mineralizations of 90-150 mg/l; their water is fresh and slightly acid above where mine water tributaries fall into these rivers. However, below the mines the content of the waters is dominated by $S0_4$-Fe-Al with mineralization from 640 to 5000-6000 mg/l. Sulphate content ranges from 1000 to 3700 mg/l, iron from 160 to 900 mg/l, aluminum from 11 to 160 mg/l with pH from 2.5 to 2.9 (Fig. 1).

During the last few years mine water discharge has greatly changed the natural regime of the small karst rivers. Interaction of the acid mine waters with carbonate rocks increases the hydrogen index and fills karst cavities with iron-bearing deposits (containing up to 46% of hematite). Where mine waters are infiltrated, subsurface drainage decreases and the surface run-off increases. Polluted waters previously having been cleaned while going through the karst tunnels and cavities now fall into the main rivers of the region.

Ratios of surface and subsurface drainage of the small rivers depends on degree of filling of the karst cavities by deposits which in the first place depends on the extent, volume, duration, and composition of the mine water discharge and the dimensions of the karst cavities. For instance, Shumiha and Gubashka rivers in the unsaturated conditions had underground flows, but now they have only surface flows, because the karst cavities below surface of the valley are fully filled by deposits.

Karst cavities under the Kamenka river are in the initial stage of filling and the river has underground flow for the most part of valley. Chemical composition of water from karst springs which discharge in the mouth of the river gave evidence of selfcleansing of the acid mine waters when they filtrated through the cavities and cracks of the carbonate rocks. The chemical composition of the underground polluted karst water (mixed with mine water) does not change if the flow went through very large cavities (for example, Ladeinij Log river).

The chemical composition of the water of the main rivers does not differ greatly from that of the small rivers, especially in the regions of drainage and discharge of the mine waters. They have nitrate pollution, acid reaction (pH = 2.3-3.4), SO_4-Ca-Mg hydrochemical fades (SO_4 to 270 mg/l) and mineralization 450-500 mg/1.

Bottom sediments have very intensive pollution too. The water extracts showed the pollution by the change of its content from HCO_3-Ca to SO_4-Ca. The chemical salt content increases from 300 to 9700 mg/l. The reaction changes from slightly acid (pH = 5.5) to very acid (pH = 2.5-4.0).

At the present time the investigations about applications of the artificial geochemical barriers are being carried out to reduce the intensity of water pollution (Maximovich and Blinov, 1994).

So, discharge of the acid mine waters into karst cavities degrades the geological environment. This influence includes pollution of surface and underground waters by sulphate, iron, aluminum, hydrogen ions, and heavy metals. The hydrodynamics of regions are changing and karst landscapes are being destroyed as a result of this influence. The sediments from mine waters also become secondary sources of pollution of water and soil.

REFERENCES

Maximovich, N.G. & S.M. Blinov 1994. The use of geochemical methods for neutralization of surroundings aggressive to underground structures. Proc. 7 Int. Cong. MEG, 3159-3164. Lisboa: Balkema.

Maximovich, N.G. & K.A. Gorbunova 1990. Geochemical aspects of the geological medium changes in coalfields. Proc. 6 Int. congr. MEG 1457-1461. Rotterdam: Balkema.

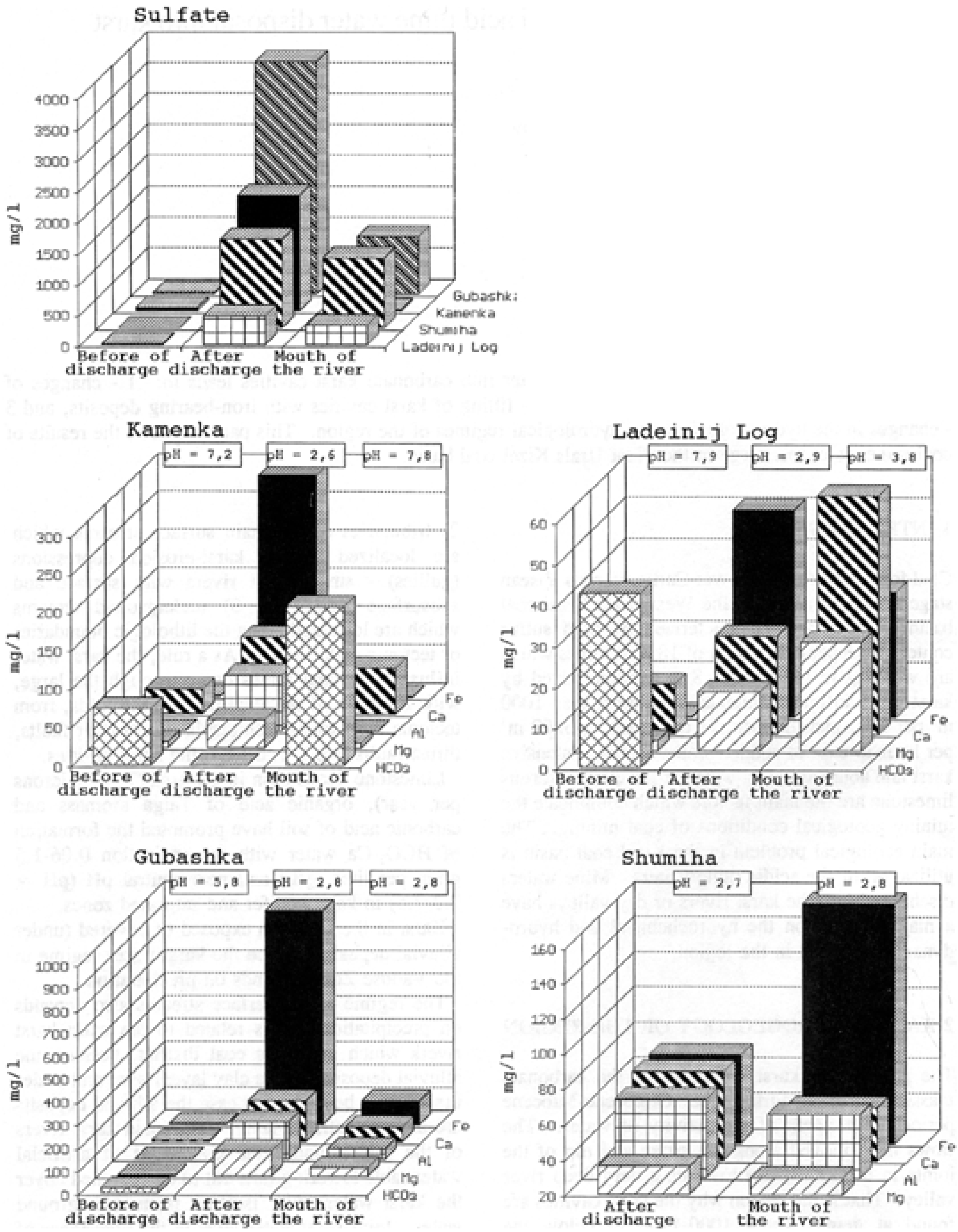

Figure 1. Chemical compositon of rivers.