THE HYDRODYNAMIC REGIME OF UNDERGROUND AND MINE WATERS IN THE PROCESS AND AFTER THE CESSATION OF UNDERGROUND MINING OF THE RESERVES OF THE SHUMIKHINSKOYE COAL DEPOSIT

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ABSTRACT

The article is concerned with underground and pit water hydrodynamic regime during Shumicha deposit Kizel coal basin storage underground treatment and after closure and inundation of self-titled mine. On the area of the deposit a heavy fissured-karst water level of Visean and Serpukhov stages carbonate deposits, fissured-stratal water complex of Visean stage coal-bearing series and fissured-stratal and fissured-karst water complex of Tourian stage of the lower carboniferous are developed. In vivo rivers Kosva and Usva, which were located on either side of the deposit, were underground water discharge area. Technogenic water transmissible fractures were formed as a result of rock movement after coal seams hollow broke the aquicludes and mine workings became the main drain of underground water during the operation of the mine. Groundwater inflows attained 802 square meters per hour and groundwater levels were reduced by more than one hundred meters. After mine closure and dump stop groundwater levels recovered incompletely. In submerged abandoned part of the mine field anthropogenic horizon of acid mine water, which is poured on the surface from the prospecting borehole, was formed. The article gives a brief description of chemical composition of acid mine water, acid sinks of the rock dump and groundwater before and after contamination by waste water from the waste dump.

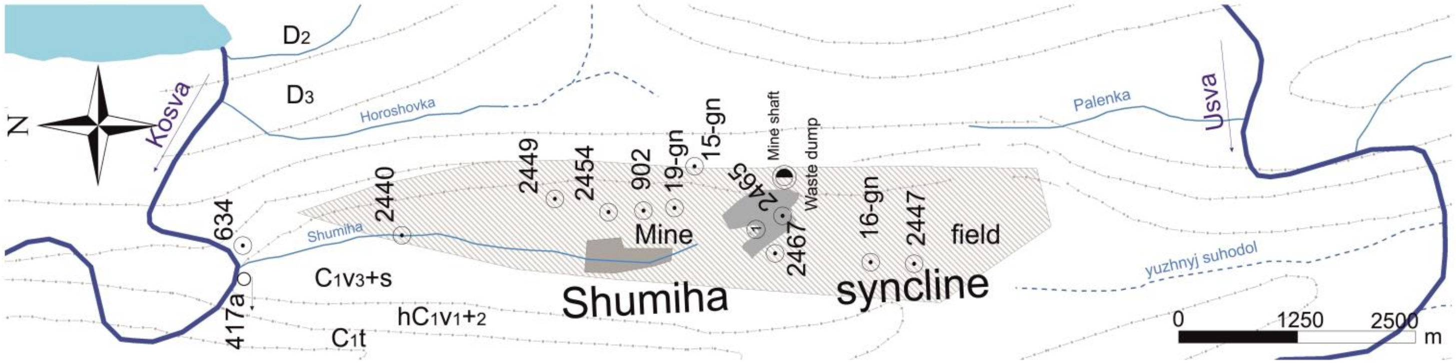
Keywords: the Kizel coal basin, Kosva coal deposit, mine waters, man-made horizon, hydrogeological forecast.

INTRODUCTION

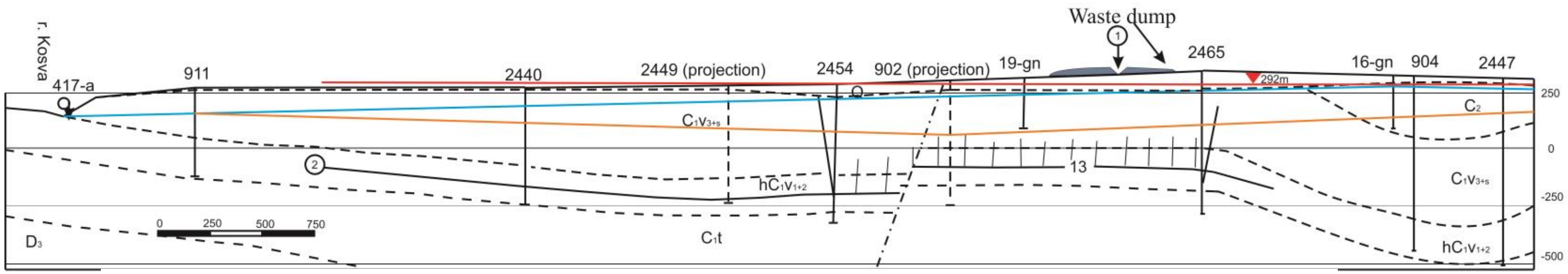
Schumikha coal deposit is part of Kizel coalfield located in the eastern part of Perm Krai. Field reserves were developed in 1968-2000 by self-titled mine. Mine field is geomorphologocally located between big rivers Kosva and Usva, waterfront mark in rivers are 163m and 202m relatively. Mine paysite and pit tip are located on the rivers divide. Small rivers Shumikha and Khoroshovka compraise hydrographic network, as Sukhoi Log and Palenka do (pic 1). Mine water was dumped into Shumikh river, so do the main part of pit tip washload before a park was formed in the bed of specified drain near the northern part of pit tip. The park was found by the authors in August 2016, its foundation was dated 2015 taking into account the data by shooting satellite.

METHODS OF RESEARCH

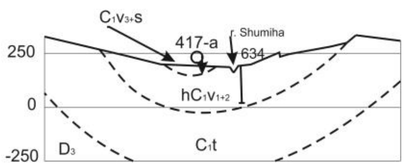
In the geological-structural way mine field refers to the eastern and paraxial parts of Shumikha syncline on the West Ural zone of folding.



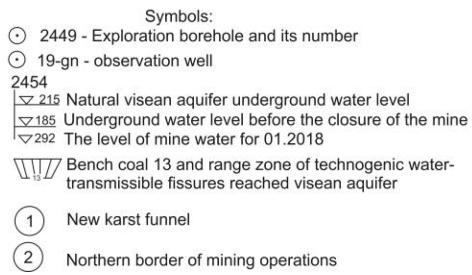
Pic. 1. Geological map of mine field " Shumikhinskaya" . The



Pic.2 .Longitudinal plan of Shumikha syncline from borehole 2447 to the Kosva



Pic. 3. Longitudinal plan of Shumikha syncline on the site of feeder 417-a location and borehole 634.

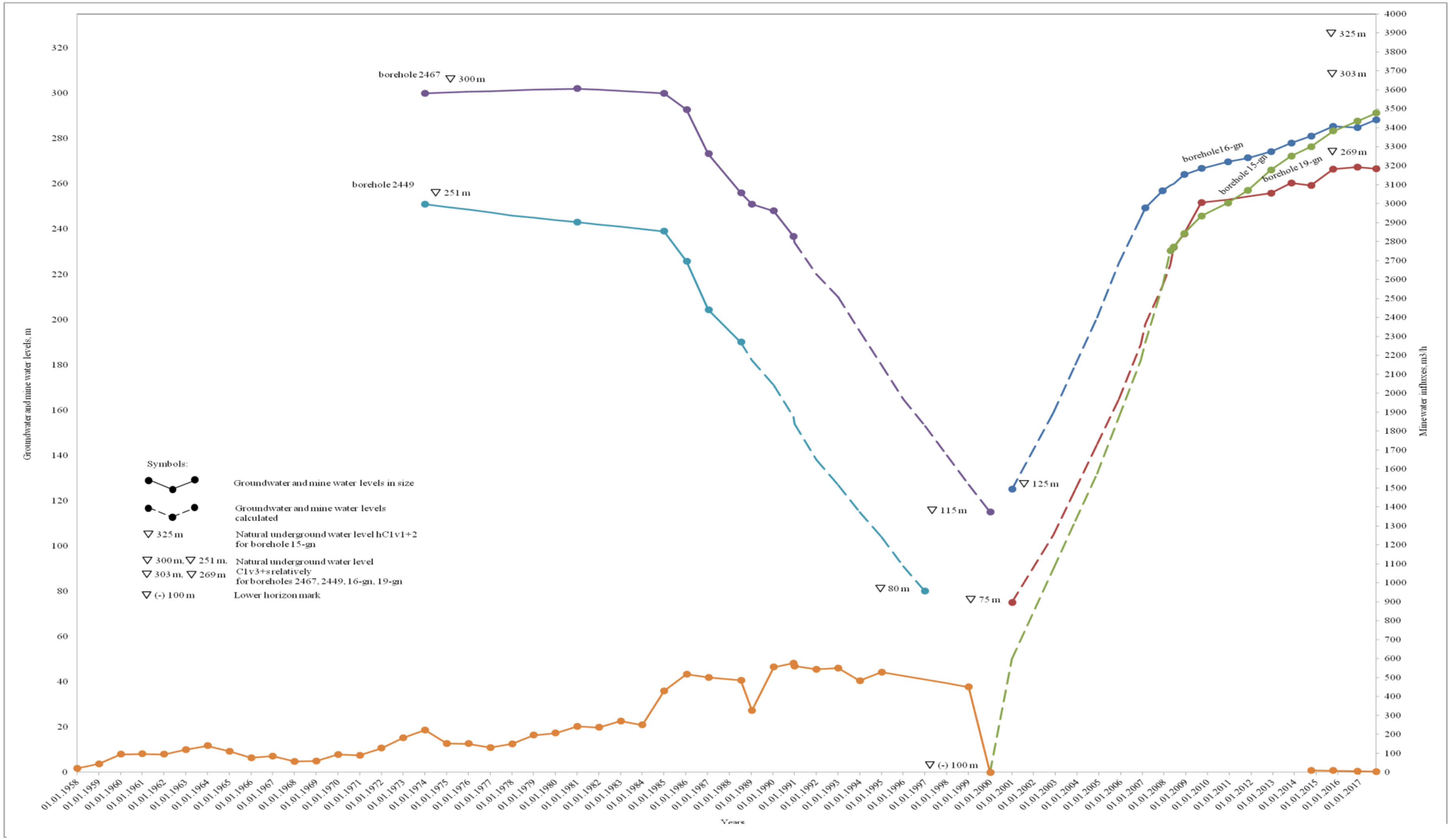


Geological record of mine field is folded of C_1 plies in the main, conformity D_3 and overlap quaternary formation; C_2 plies are on only limited area [4]. The lower carbon includes: tournaisian - C_1t, visean - C_1v, and Serpukhov - C_1s, stages. Tournaisian is folded of buhrs, redstones and sand rocks in thikness of 300m. Visean in the bottom part is a coal-bearing – hC_1v_{1+2}, folded of sand rocks, redstones, clay stones and coal strata in thikness of 190m, its top - C_1v_3 and Serpukhov-C_1s – is folded of karst limestone and dolomite in thikness of 340m. The average carbon is submitted carbonate rocks of Bashkir stage in the thikness of 50m and argillaceous rocks of moskovian in the thikness of to 170m (pic 2). Kizel basin coal including considered field coal characterized by high pyrite brimstone which is in average 6,5 % [1]. Quaternary crust are loam and clay in the main in thikness from 1-5 to 150m, on the area of 20 hectares it is blocked by flat dump of hC_1v_{1+2} with raft to 12m. Karst arrears in the form of a lot of sinkholes which fully absorb discharge of the Sukhoi Stock river. A new sinkhole fully absorb surface discharge on the adjacent area and the main part of the pit tip disgharge (pic 1,2).

On the mine field stand out visean horizon of crevice water of visean, Serpukhov and Bashkir stages, complex of fissure-bedded water hC_1v_{1+2} and complex of fissure-bedded and crevice water C_1t и D_3. The lower of water-bearing complex is considered further as a part of C_1t, because underground water D_3 did not experience the impact of mining work and has not been studied on the mine field. Visean reservoir is the most waterrich because of the high karst level of the carbonate rock and good terms of power. Before a mine working the water moved from hydrogeological divide located 0,7km to the south from pit tip to the Usva river and the waterhole 417-a on the left coast (pic 1,2,3). At the same underground water levels fell from 304-316m on the divide to the rivers brink mark. Underground water font hC_1v_{1+2} was not found, a little fond with debit 0.2 l/s is connected with C_1t on the left coast of the Kosva river and a fond with debit 1,5-2 l/s on the right coast of the Usva river. Some date about natural underground water level in both complexes shows that it was located above crevice water of visean horizon because of higher position in the relief of beats hC_1v_{1+2} and C_1t concerning to the outputs of visean carbonate deposit [4], (pic 3).

Mine work was carried out at the I, intermediate and II horizons, the lower mark is (-) 110 -(-) 100 м. Beds 13 and 11 in thikness from 0,7 to 3m were taken out, first of them is the upper in the column; roof control by cave-in. Distance from bed 13 to the lower bound of carbonate part C_1v is 100m, from bed 11 to the roof C_1t is about 60m. In fact normal thikness of rocks separating bed 13 from visean water horizon reaches 130 m because the lower carbonate member C_1v is not karsted. Bed occurrence at I horizon is steep, vertical and inverted, at the intermediate horizon is steep. The northern part of horizon II characterized by flat bed pitch under the conditions of the paraxial part of Shumikha syncline, in the southern part is steep and tilt bed pitch. In that conditions dilatation of technogenic water transmissible fractures was minimal at I horizon and mawimum in the northern part of II horizon. At the same time upper water horizons of Tourian were exposed by drainage impact of stoping work of I horizon.

During the building and in first years before 1973 mine feeder was formed with underground water hC_1v_{1+2}, its average value usually does not exceed 100 m^3/h (pic 4). A significant increase of the average mine feeder was in 1973 due to underground water inrush hC_1v_{1+2} and C_1t with the inflow to 1500 m^3/h from the techtonic violation to lateral drift 102. Just rapid decrease of the broken through water inflow saved the mine



Pic.4.Variation of underground water level C_1v_3+s and hC_1v_{1+2} and mine water influxes at the working time and after the closure of mine " Shumikhinskaya" .

by flooding. Mine water formation before 1983 had taken place at the expence of uneground water hC_1v_{1+2} and C_1t, in the end of the period visean water horizon begin to take a part in water encroachment in the northern part of minable horizon, where beds 13 and 11 in the total thikness of 3-4m were taken out in the condition of gradation. Situation with mine water feeders rapidly changed since the beginning of taking out the bed in the thikness to 2-2,5m at the horizon II in the condition flat close to horizontal bed. Technogenic water transmissible fractures in the roof rocks of abandoded flat reached visean water horizon and in 1985 mine water feeder increased from 250 to 429m^3/h, and next year it reached 518m^3/h. In 1990 unbridged ear work 902 caused growth or the average mine water feeder from 555 m^3/h to 802 m^3/h, while the average feeder for the horizon II was 476 m^3/h. After stoping in 2000 mine drainage was the flooding of mine with mine water technogenic horizon forming on the worked mine field area. In July 2014 mine water efflux to the surface with debit from 4 to 10 m^3/h began through a trial borehole 634 located on the left coast og the Kosva river, in 1250m near the northern bound of mine work area (pic 1-4).

RESEARCH RESULT

On the combined charts a clear connection between level regime of visean horizon underground water and the size of mine feeders (pic 4). During work of the mine levels of the water were controlled of observation wells 2467 and 2449 located in the middle and the northern part of mine field (pic 1,2). Before 1981 they experienced just seasonal fluctuations, by 1985 a slight decrease of visean underground water level was due to drainage impact of mine work [2]. Active taking part since 1984 this horizon in the water encroachment of horizon II led to noted above rapid increase of the mine feeder size and accompanied by a fast decrease of underground water level which was fixed for boreholes till the end of their observation (pic 4). Taking into account a preservation of big mine feeders before the pumping stopping it suggested that the rate of mine water levels decrease also preserves on the level observed for the borehole 2467 in 1986-90, till withdrawal from the mine will be stopped. At the same time visean horizon water level of borehole 2449 were decreasing to the beginning of 1996 to the bottom of aquifer marked 80m here, and of borehole 2467 – to the 115m to the beginning of 2000. Waterbearing complex hC_1v_{1+2} exrerienced the hardest impact durind mine work. Some aquifers turned up to be hydraulically connected technogenic water transmissible fractures. On the northern part of II horizon technogenic fractures and unbridged shaft of borehole 902 linked waterbearing complex hC_1v_{1+2} with visean aquifer, and on the northern part of horizon I, got hydravlic connection underground water hC_1v_{1+2} and the upper aquifers C_1t. From the exrerience is known that on the coal bed work area waterbearing complex hC_1v_{1+2} was drainaged almost to the lower mark of mine work. Taking into account the circumstances is accepted that underground water level hC_1v_{1+2} on the mine field “Shumikhinskaya” was decreased to the mark of horizon II.

The mine pumping stopping led to flooding of working with the forming of technogenic mine water horizon and underground water levels recovery. Monitoring of level regime of underground water and of mine flooding was not conducted because of the abcense of corresponding wells. In 2003 observation wells were drilled to the visean aquifer: 19-gn in the northern part of mine field and 16-gn in the southern part, in that year in the northern part in the bed hC_1v_{1+2} 15-gn well was drilled for control to mine water level (pic 1). Mine working flooding in Kizel was fast especially at the beginning; so for first six mounths of the flooding the biggest in the Kizel basin Lenin’s mine water level increased to 546m [3]. Basing on the data above it is suggested that in the end of 2000 mine water in mine working of the mine “Shumikhinskaya” was close to visean fissured-karst water level and its recovery began. New wells depth – to 200m - was not enough, that is why first data about underground water level were got in 2007-08 [5]. Mine working flooding took place at the expence of visean fissured-karst and its level was a few more than flooding level before (pic 4). On the final stage of visean aquifer dynamic regime recovery the biggest part of its sources routed to natural discharge area – rivers Kosva and Usva. In that conditions rise of mine water level of technogenic horizon, underground water hC_1v_{1+2} and the upper part C_1t became fasterand since 2016 the water turned up higher than visean fissured-karst water level. As of the beginning of 2018 visean underground water level in the northern part of Shumikha syncline was almost restored; while maintaining the trend observed for last 5 years that water level will rich normal position in the southern part of the syncline in 5-6 years, and technogenic horizon mine water will rise in 7-8 years to bod of the northest delve 19 occupying the lowest position in the relief with the mark 318,2m, and will began effuse to the surface. Mine water level at the same time will stabilized on the mark close to the effusing mark and in the northern part of mine field will be for tens meters higher than visean underground water; in this way conditions for mine water overflow to visean aquifer.Underground water level hC_1v_{1+2} connected on the mine field with technogenic aquifer will be determined by mine water position and will not reach its natural marks – to 350m, on the latitude of hydrogeological underground water divide. Underground water sources hC_1v_{1+2}, and therefore sources of tecnogenic mine water horizon on the mine field limited by little alimentation area and its location on divides local little rivers (pic 1). A part of sources of technogenic horizon mine water is reliefed by the well 634, another part flows and will flow into visean aquifer. Main water effux debit in the delve 19 in such conditions is expected to be not big, to $10m^2/h$, however in the spring flood period it can greatly increase.

Oxidation of pyrite concerning in the coal leads to acid mine water forming and acid rachel of slacktip characterized by lower value pH, high mineralization and high content of Fe, Al and some traces which are greatly exceed maximum permissible concentration for potable water and fishcultural water. It caused a great pollution of underground water getting into visean aquifer through sinkholes, technogenic fissures and unbridged well 902, it is proved by hydrochemical tests (table 1).

Table 1

The main results of hydrochemical tests of visean underground water, mine water and rachel of slacktip

Tested water	pH	Concerning, mg/dm^3								
		Relic	SO_4	Fe	Al	Mn	Ni	Co	Li	Be
Underground (feeder 417-a)	4,09	610	452	10,5	32,15	0,42	0,06	0,03	0,14	0,002
Mine (well 634)	5,28	3494	2358	865	0,2	4,96	0,28	0,26	0,05	0,002
Rachel of slacktip	2,39	5687	4032	1374	223	4,4	1,10	0,51	1,60	0,040

High concentration of Al and high concerning in underground water Be and a low value of pH shows defining role of rachel of slacktip in the visean aquifer pollution in 2016.

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