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Formation of drainage waters of Tyrnyauz deposit in ecological aspect

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Abstract. Features of formation of drainage waters of the field Tyrnyauz are considered. Chemical composition of drainage waters is investigated; major factors of its formation are established. High ecological danger of installing drainage waters in hydrographical network of the district is defined and concretized.

1. Introduction

Research on the formation of a drainage water of ore fields have indisputable relevance first of all in connection with the environmental problems arising in mining districts in recent years [1, 2].

The tungsten-molybdenum deposit Tirniauz is located within the Elbrus volcanic district on the left bank of the river Baksan. The field is bound to a complex of the granitoids formed during activation of tektono-magmatic processes on the southern border of the Scythian plate in the meso-Cenozoic and introduced in carbonate, terrigenous and volcanogenic breeds of devon, carbon fabrics and yura (Figure 1).

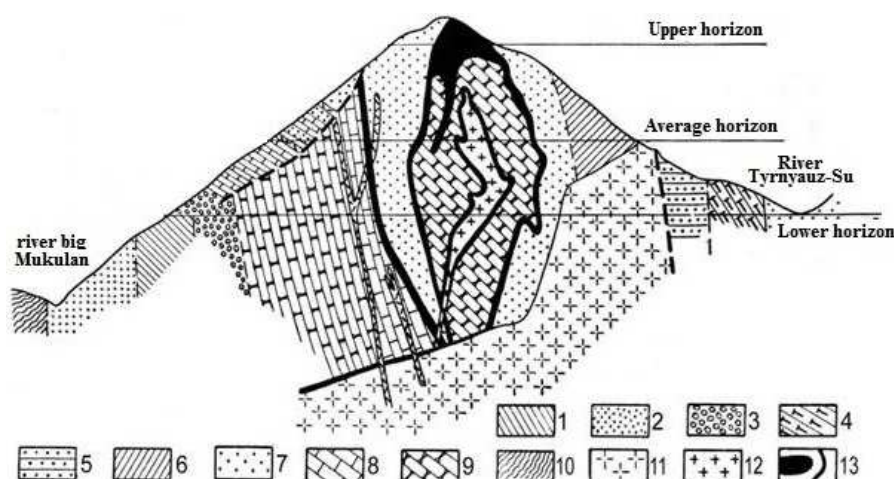


Figure 1. Schematic geological section of Tyrnyauz ore field (by Pak A.V., 1962). 1 - black shales; 2 - sandstones; 3 - conglomerates; 4 - igneous rocks; 5 - arkosic sandstones; 6 - quartz plagioporphyr; 7 - biotite hornstones; 8 - stratose marble; 9 - solid marble; 10 - migmatites; 11 - granites; 12 - leucocratic granitoid; 13 - skarn.

The bulk of ore-bearing skarn is dated for a zone of contact of hornfels and marble, which, repeating plaited structure, form potent having fanned in its arched part. In ore half of the field (vertically, the mineralization zone exceeds 1 km), the Ore occurrence of gold, an arsenic, antimony, copper, lead, zincum, silver take place.

The Tyrnyauz field was mined by underground and open methods for five decades, providing 20% of the world production of tungsten concentrates with the associated extraction of Cu, Bi, Au, Ag. Now production and processing of ores on the field is suspended for economic reasons. But the further prospects of development of not yet exhausted mineral values of Tyrnyauz are bound to need use of effective technologies of production and enrichment of ores with extraction together with molybdenum and tungsten of precious, infrequent and non-ferrous metals, and also nonmetallic raw materials.

However, even preserved by Tyrnyauz tungsten - the molybdenic field continues to exert appreciable negative impact on natural complexes of the adjacent district. Among various factors of impact on the environment, the noticeable place is taken by a drainage drain, and features of the hypsometric position of the field cause its active entering in the local hydrographic network. Subsequently ore elements with other serious metals and other pollyutants migrate in the main waterway of the district of the river Baksan to appreciable distances.

2. Results and Discussion

The underground waters forming a drainage waters belong mainly to fissure type of groundwater. On the field, they represent a uniform water-bearing system, within which, under the terms of food, two hydrogeological zones with the dividing them subband of mixing are distinguished by the nature of circulation and the chemical composition.

Waters of infiltration genesis, which mode is closely connected with superficial processes (the course of an atmospheric precipitation, temperature, and so forth), belong to the top hydrogeological zone; they are characterized by low mineralization (to 0,4 g/l) and mainly by the hydrocarbonate calcium composition.

The lower hydrogeological zone is formed by pressure head carbonic waters with the raised mineralization which on the field Tyrnyauz were opened with excavations for the last decades of operation, and their inflow constantly increased with development of the front of mining operations, and by 2000, they formed about 50% of drainage waters [3]. The first data on these waters belong to 1958 when they have been opened with the well (No. 104), passed in a body the granites on the 1st fluvial terrace above floodplain of a right bank of the river Baksan. In borders of the ore field, the shows of carbonic waters are assigned to large disjunctive violations, which in the near-surface horizons are shown in the form of zones of the raised jointing (feathering faults).

Waters differ in a high gas-saturated (as a rule, it is higher than 500 ml/l) and stythe or carbonic and nitrogen composition of gas. The ratio of the dissolved gases makes (in vol. %): CO₂ - 55÷90; N₂ - 1÷39; H₂ - 13÷43; CH₄ - 0.1÷1,2. Waters of the lower hydrogeochemical zone are characterized by the carbonate-chloride or, more rarely, chloride-carbonate anion structure, among cations sodium dominates. The mineralization varies them in the range of 2÷12 of g/l, enrichment by their microcomponents - K, Li, Rb, Cs, F, B, I, As, etc. is noted. The general distinctive feature of the majority of carbonic waters of the Elbrus volcanic district, including fields Tyrnyauz, is the raised relative and absolute content of chlorine ion.

Fracturing waters of deep circulation are opened, generally with prospecting adits of the Northern site, within the central ore field there are their single water points. By 2000, the general water inflow to system of excavations of the field made about 1500 m³/hour.

The main water content on the field contacts the massifs of karst marbles since intrusive, metamorphic and volcanogenic and sedimentary rocks (even on condition of an intensive jointing) represent less favorable environment for accumulation of reserves of underground waters. Static reserves of karst waters of marble of the ore field had been generally worked (data of geological service of Tyrnyauz mountain plant) by 1983, which explains relative stabilization of average annual

volumes of the underground waters coming to excavations. The small gain of average annual volumes of drainage waters is obliged to increase in inflows of underground waters of the lower hydrogeochemical zone.

Formation of the chemical composition of drainage waters is carried out at the expense of natural and technogenic factors and processes (Figure 2).

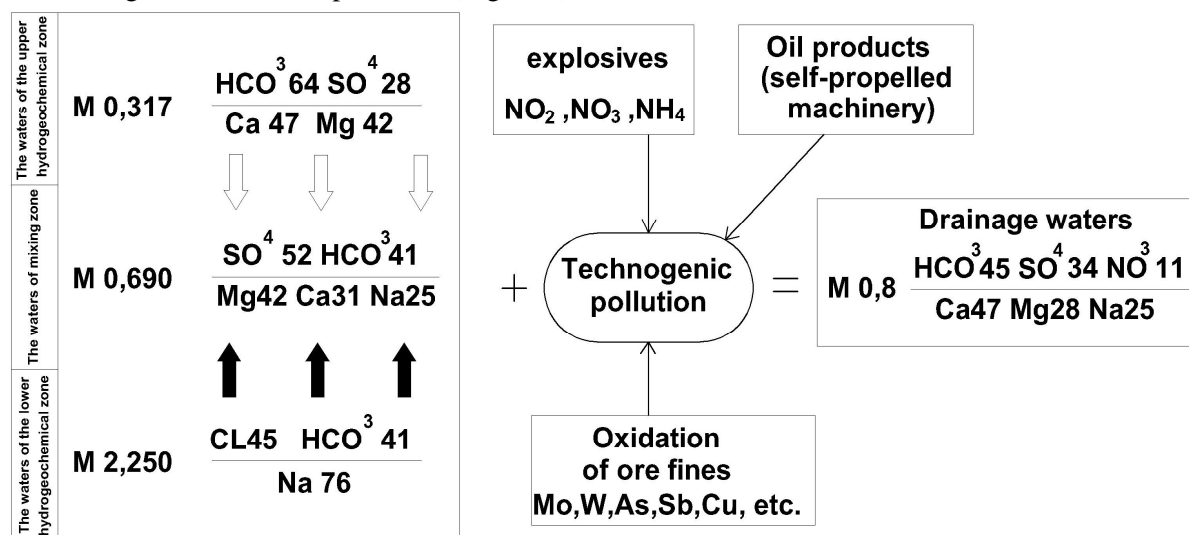


Figure 2. Scheme of formation of chemical composition of drainage waters

As volumes of drainage waters are formed, generally at the expense of underground waters of the top and lower hydrogeochemical zones, drainage are obliged by the "initial" chemical composition to the process of their mixture. When drainage waters on excavations (on drainage flutes) circulate up to an exit onto a day surface, there is the following change of their chemical composition:

1. Further enrichment of drainage waters heavy metals. In the course of various technological operations (a tunnelling, release and loading of ores, transportation and so forth), there is a dispersion on excavations of large volumes of the ore trifle making one of the main articles of the general losses of mineral. The ore trifle, owing to dissociation and dispersion, has a big specific surface and therefore is actively oxidized [4, 5]. Heavy metals at the same time turn into mobile connections and are involved in water migration.

2. Receipt in waters of connections of group of nitrogen. Ammonium nitrate as a basis of the explosives used when conducting mining operations is a source in drainage waters of nitric connections. So, during the explosive works in pits when carrying out "mine" explosion the amount of at a time used explosives can reach tens and, more rare, hundreds of tons; on the mine – the first tons every day. Within the central ore field underground waters on fracture systems, mine workings and crossover drill holes flow from the top horizons on lower. Therefore, the most informative in the context of pollution of drainage waters ions of group of nitrogen is the lowermost horizon (the main haulage horizon) of the field – an absolute mark of 2015 m, i.e. on sites of the greatest fitness of rocks.

3. Receipt in drainage waters of considerable concentration of oil products. In the last decades on the mine, during loading and delivery works, the self-propelled equipment has been actively introduced, which is forcing out the rail transportation as less productive. However, the self-propelled equipment consumes a significant amount of fuels and lubricants and, therefore, it is a source of pollution of drainage waters oil products.

4. The bacterial pollution resulting from continuous stay in the mine workings of considerable number of miners and lack of constructions of sanitary and hygienic appointment.

As a result drainage waters are dumped in superficial waterways of the area of the field with the following average chemical composition (mg/l): suspended solids – 500, dry particles – 400, chlorine

– 38, sulfate ion – 115, BOD – 4.2, oil products – 5.7, nitrates – 95, nitrites – 6.8, tungsten – 0.3, molybdenum – 0.7, arsenic – 0.3, zinc – 0.01, copper – 0.04, lead – 0.08.

The close correlation relations of macrocomponents and the ore-bearing metals in drainage waters have allowed describing them the regression equations according to observed natural and technogenic processes of formation of the chemical composition of drainage waters of the field (coefficients of multiple correlation are given in brackets):

$$\ln M = 1.8 \ln Cl + 0.8 \ln Na + 5.7, (r_{M_{Cl, Na}} = 0.85);$$

$$\ln M = 1.1 \ln SO_4 + 7.1 \ln As - 3.4 \ln Mo + 4.6, (r_{M_{SO_4, As, Mo}} = 0.86);$$

$$\ln M = 0.8 \ln Ca + 2.9 \ln HCO_3 + 6.0, (r_{M_{Ca, HCO_3}} = 0.71);$$

$$\ln M = 1.2 \ln Mg - 5.2 \ln Fe + 5.1 \ln As + 5.3 \ln Mo + 5.3, (r_{M_{Mg, Fe, As, Mo}} = 0.85);$$

$$\ln M = 3.6 \ln NO_2 - 0.7 \ln NO_3 - 8.6 \ln Pb + 6.3, (r_{M_{NO_2, NO_3, Pb}} = 0.58);$$

$$\ln SO_4 = 3.8 \ln Mo - 4.2 \ln Fe - 4.3 \ln As + 4.3, (r_{SO_4, Mo, Fe, As} = 0.66);$$

$$\ln Mo = 0.009 - 5.8 \ln Ca + 0.5 \ln Fe, (r_{Mo_{Ca, Fe}} = 0.44).$$

Comparison of data on the maximum content of microcomponents in drainage and carbonic waters of Tyrnyauz with the similar information, provided by authors [6] on other objects, allows noting that in waters of the Tyrnyauz field, the concentration of some minerals exceeds the known earlier maxima several times. First of all, it belongs to ore-bearing metals. So, concentration of molybdenum in passing faintly alkaline waters exceeds 24 times, in carbonic – 5-8 times in comparison with carbonic terms of areas of a modern volcanism, etc. (Table 1).

Table 1. Comparison of the maximum contents of some chemical elements in various natural waters (according to [7]) and underground waters of the Tyrnyauzsky field, mg/l

Elements	Passing faintly alkaline waters			Underground waters of deep horizon					Waters of hypergenesis zone	MPC of natural reservoirs
	A. Ore fields	B. Tyrnyauz fields	B/A	C. carbonic mineral	D. carbonic waters of Tyrnyauz	E. terms of areas of a volcanism	D/C	D/E		
As	0.2	0.60	3	150	0.250	80	0.001	0.008	0.002	0.05
Cu	1.1	0.04	0.036	0.65	10.002	51	15.38	0.196	0.006	1.00
W	0.5	0.50	1	0.017	0.200	0.072	11.76	2.777	-	0.10
Mo	0.07	1.70	24.28	0.061	0.500	0.080	8.19	6.250	0.002	0.50
Mn	1.4	0.02	0.014	44.3	0.138	30	0.003	0.004	0.049	0.05
Ni	0.24	0.005	0.030	0.005	0.005	0.100	1	0.050	0.003	0.10
Pb	0.2	0.08	0.4	1.8	10.005	32	5.55	0.310	0.002	0.10
Sb	0.025	0.01	0.4	-	0.031	0.700	-	0.045	0.001	0.05
Zn	1.5	0.01	0.006	0.93	27.000	150	29.03	0.160	0.034	1.00
Br	44	1.20	0.027	66	6.300	7.800	0.095	0.800	0.193	-
B	5	0.83	0.166	1200	1246	110	1.038	11.32	0.042	-
F	1500	2.80	0.001	8.1	4.300	50.40	0.530	0.085	0.450	1.50
I	4.3	2.00	0.460	13.4	8.800	2.400	0.65	3.660	0.016	-
Li	18.6	1.40	0.075	100.8	280.00	2.200	2.77	22.95	0.014	-
Rb	6.6	0.50	0.075	10	1.900	2.100	0.19	0.904	0.002	-
Cs	-	0.60	-	3.3	2.200	1.800	0.66	1.220	0.001	-

3. Conclusion

Thus, the analysis of conditions of formation of the chemical composition of drainage waters of Tyrnyauz tungsten - molybdenic field is evidence of the following:

- the stopping of mining and preservation of excavations with possible in this regard changes of technological operations do not allow one to exclude danger of further deterioration of drainage waters and their entering the surrounding environment;
- drainage waters significantly differ by the chemical composition from background underground waters of the field. These differences are bound first of all to the increased concentration of serious metals, bonds of nitrogen, oil products, an indicator of bacterial pollution that turns them into an object of the increased ecological danger;
- hypsometric conditionality of inevitability of dumping of drainage waters into superficial waterways of the district of the ore field of Tyrnyauz leads to pollution of the last and further the main waterway – the river Baksan; rate and scales of distribution of pollution under the conditions of a mountainous terrain and the corresponding hydrological regimen are very significant;
- in connection with pollution of the basin of the river Baksan exerting sharp negative impact on efficiency of development, and development of recreational resources of the region issues of purification of drainage waters of the field Tyrnyauz have to be resolved urgently.

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