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ENVIRONMENTAL EFFECTS OF CLOSING HUNGARIAN NON-FERROUS ORE MINE

by
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SUMMARY

In the Hungarian non-ferrous ore mine (Cu, Zn, Pb, Co, Ni) at Gyongyosoroszi which had been working for 30 years, production was finished in 1985. The final closure of that mine will be allowed by the environmental and water authorities if the closure would be realised by an agree procedure complying with the requirements of environmental protection and water quality. The untreated mine water from this mine has low pH, high dissolved material and heavy metal ion contents, causing a toxic effect on the environment. The aim of this paper is to summarize the possibilities of the final closure of the mine and its expected results on the basis of taking into account the natural endowments and water quality characteristics of the area.

INTRODUCTION

The non-ferrous ore mine at Gyongyosoroszi can be found in the NE of Hungary on the territory of Matra mountains (Figure 1).

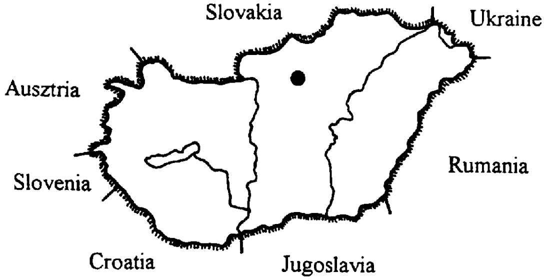

Figure 1 Location map of the site of investigation

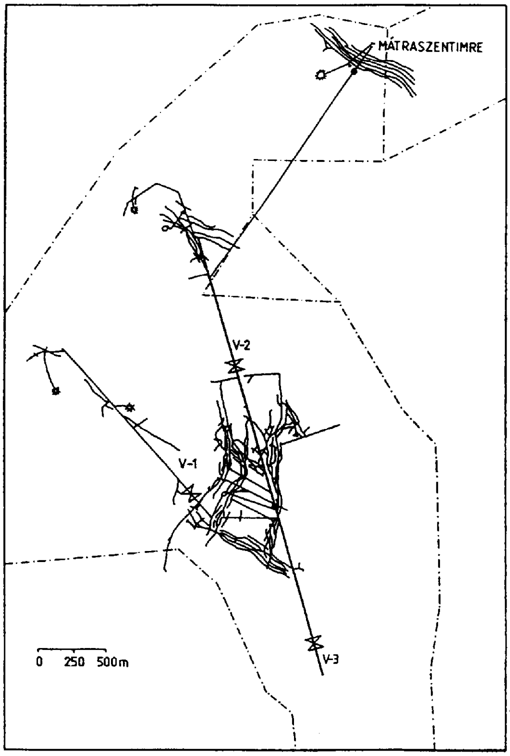

Figure 2.
Map of mining area of Gyöngyösoroszi

Legends

shaft and adit

surface boundary of mining area

V-2
sign and number of underground dam

mine opening

wein

Figure 2 Geographical map of mining area at Gyongyosoroszi

After 30 years of production, mining became uneconomical, so the mining operations discontinued in 1985. As the mining activity was performed at a depth of +100 and +760 m (a.B.s.), protective advance mine drainage was carried out and the water management balance of the mountain deteriorated significantly during the 3 decades of dewatering. The first step in the discontinuance of mining was to recharge the depression cone from +100 to +400 m (a.B.s.). From that time on, the water entering into the abandoned mining workings through veins, caverns and mining drifts has been discharged from an adit's opening at +400 m (a.B.s.) with low pH, high dissolved material and heavy metal ion contents. In order to decrease the water quantity flowing through the veins, caverns and drifts, an attempt was made at breaking into the abandoned mine workings by building underground dams between 1986 and 1989 (Figure 2.). Dam V-2 broke through in 1988 and caused catastrophic deterioration of the water quality. Dam V-1 is unapproachable, dam V-3 could be used for closing the adit's opening if necessary. Since 1986, in order to decrease pollution of the environment, water purification has been carried out by using $Ca(OH)_2$ for precipitation of heavy metal ions in the form of metal hydroxides. But the sludge originating in this manner is hazardous waste, and after disposal into a reservoir closed by a barrage in a valley it has created contamination. The natural endowments and the possible solutions are discussed in this paper.

MORPHOLOGICAL AND HYDROLOGICAL CHARACTERISTICS

The volcanic mass of maximum height of 1015 m in Matra mountains is divided by parallel watercourses in north-south direction. The height of the southern slope is 200-260 m (ASL). The number of its springs was given to be 440 (Schmidt, 1962) for the period prior to mining with a total yield of 20 million m^3/year from a catchment area of 320 km^2. There are detritus and fissure springs which often occur in the form of springs series. The yield of the springs is highly variable and they feed temporary streams and brooks. In spite of the numerous water-courses (Figure 3), the area became poor in surface water supply due to lowering of water table caused by mine drainage. The total height of precipitation in the area is 600-800 mm/year, its brown forest soil is covered with oak and beech forestry.

GEOLOGICAL AND HYDROGEOLOGICAL CONSTRUCTION, STRUCTURAL CHARACTERISTICS

The oldest explored formation of the area and its surroundings is Miocene " under rhyolite-tuff ". It didn't originate from volcanic centers but from tuff-flood coming from fissures and flowing gravitationally (Hamor, 1985). Above the rhyolite-tuff schliers can be found, after that submarine andesite was deposited. It was covered by " middle rhyolite-tuff " then by "middle andesite-tuff" which created a stratovolcanic series fed from a large number of volcanic centers. The veins and their country rocks at the Gyongyosoroszi ore mine are members of the middle stratovolcanic sequence of various development. The average thickness of the veins of steep dip is 1-2 m. They possess hydrothermal facie and are accompanied by epithermal and in a smaller part by mezothermal mineral associations. Six main ore-minerals (galenite, sphalerite, chalcopyrite, pyrite, wurtzite, marcasite) and 15 main gangue minerals (calcite, quartz, chalcedony, amethyst, barite, etc.) can be separated by microscopic examination. Effects of post volcanic activity can also be noticed in the area. Blanket-andesite is the next eruptive production, which has a good permeability along its fissure and faults. The "upper rhyolite-tuff" is the last member of the volcanic activity. Sandy, clayey and andesite- rolling deposits were deposited on it. The total thickness of the Pleistocene clay and red-clay is only 1-2 m. On the slopes detritus gravel has been deposited .

The age of tectonic elements of the area can be divided into 3 groups: before the ore formation, during the ore formation and after the ore formation.

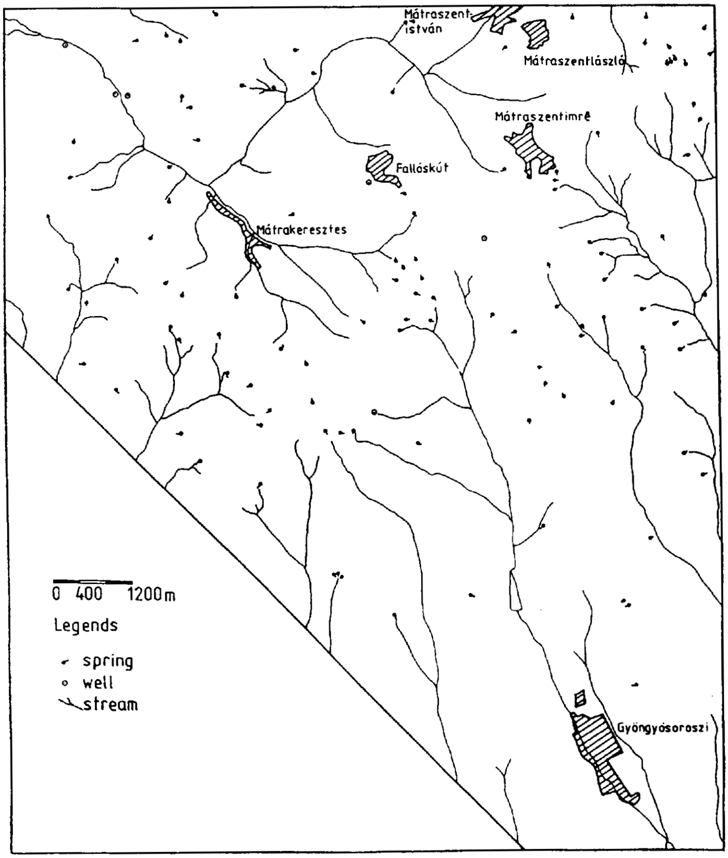

Figure 3 Hydrogeological map of mining district Gyongyosoroszi

The fillings of the fissures belonging to the group developed before the ore formation are mainly fine-grained, silicified in various degrees and of low permeability. The tectonic elements developing during the ore formation occur in series and have good permeability. The faults belonging to the third group open ranges, cause large horizontal and vertical displacements so they are very important in hydrogeological respect.

In addition to the good permeability of faults and veins, the hard, rigid rocks intensified the displacements and the blasting mining technology often caused fissures extending as far as the surface. In this way natural and artificial fault-crack-systems were formed and through them the surface waters can move downwards through the veins and caverns or upwards and appear in the valleys and conglomerates covering the bottom of the valleys. The mine openings connected the natural and artificial fissures and so made the hydraulic conditions more complicated.

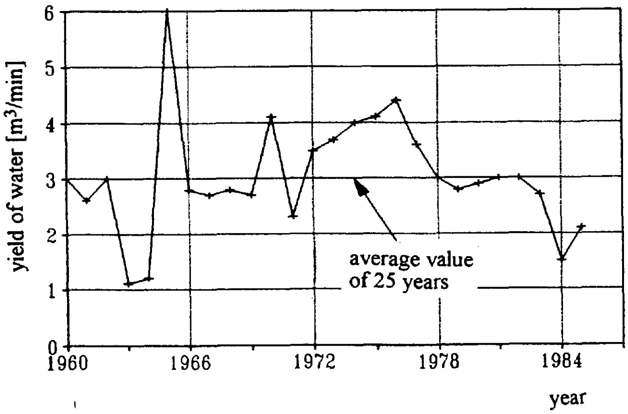

Figure 4 Yearly average mine drainage

The time curve of the total quantity of mining drainage can be seen in Figure 4, with Figure 5, showing the yield of the mining water coming out of mine at +400 m (above sea level). According to the measurements the average quantity of mining waters is 2000-2500 m^3/day, 1000 m^3/day in a dry meteorological period and may be more than 4500 m^3/day in wet periods. At the same time during our investigation springs couldn't be found above the adit level.

- During the mine drainage the mine water quality was worse in respect of all observed components than after recharging to the level of +400 m (a.B.s.).

- The quality of the water body coming from the area Matraszentimre after the failure of dam V-2 strongly impaired all of the water quality components coming out of the adit.

- After elimination of the effects of the dam failure the quality of mine water showed a tendency to improve in respect of all observed water quality components, but the heavy metal ions content remained above the permissible limit for drinking water, fishing or irrigation.

- All of the water quality components contaminating the environment depend on the quantity of precipitation. It is forbidden to conduct mining water into surface waters without purification because of danger of environmental pollution.

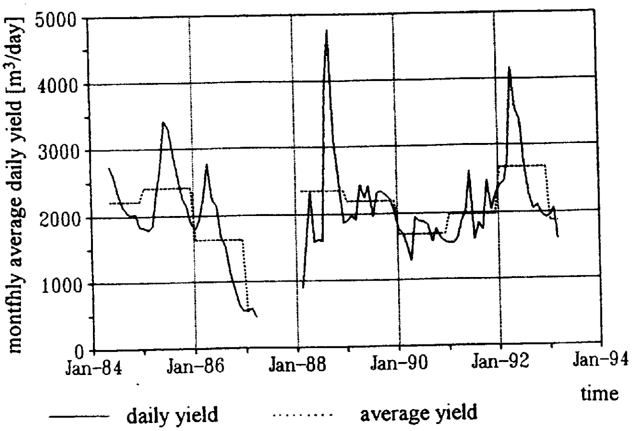

Figure 5 Mine water discharge from the drift

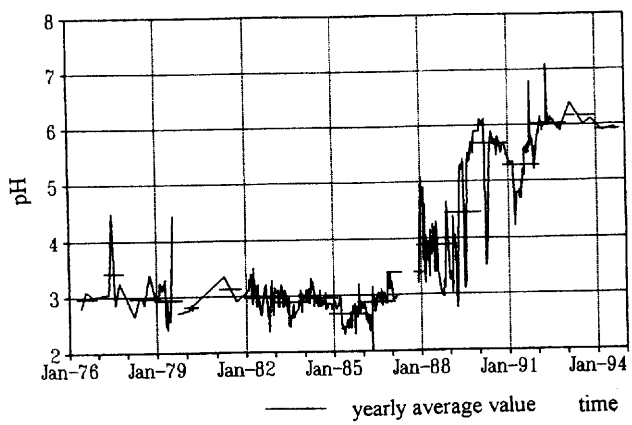

Figure 6 Quality of mine water discharge - pH variations

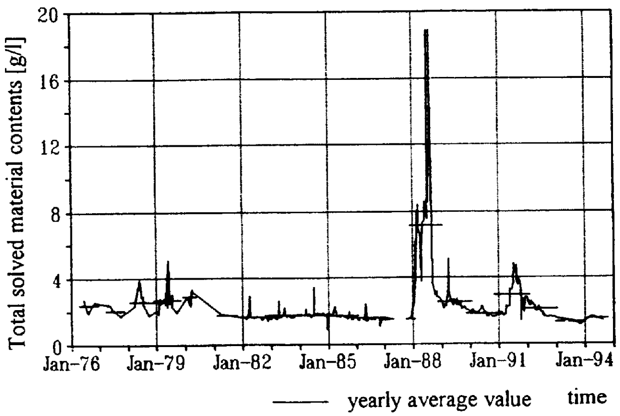

Figure 7 Quality of mine water discharge- TDS

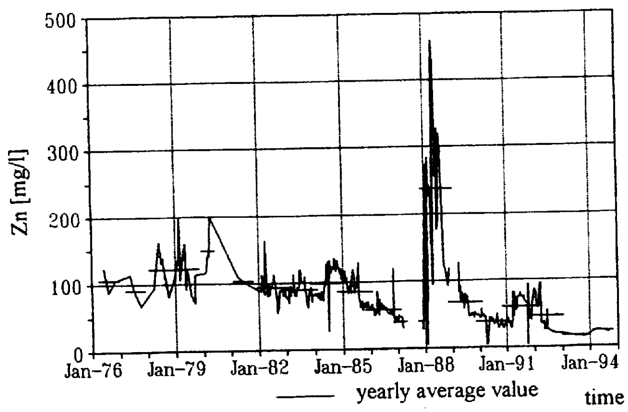

Figure 8 Quality of mine water - Zinc content

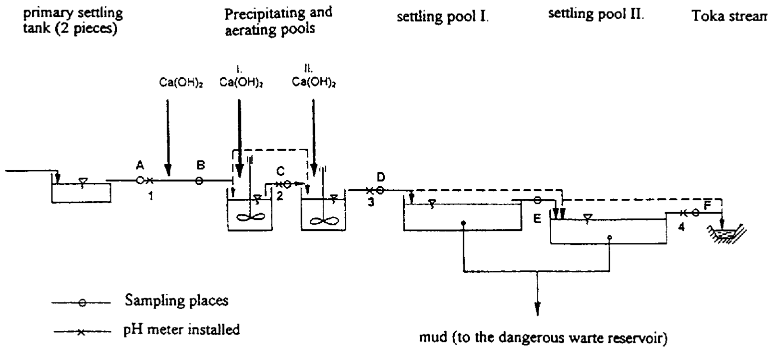

Figure 9 Technology of mine water treatment

PURIFICATION OF MINING WATER

The water purification system used at present was built in 1984. Its aims are as follows:

- neutralization of acid water,
- filtration of solid matter,
- precipitation of dangerous heavy metal ions,
- separation of precipitate and
- the cleaned water which can be conducted into surface water,
- storage of heavy metal hydroxides.

The technological scheme of the water purification system can be seen in Figure 9.

The first stage of the purification system consists of two settling pools. These are followed by two aerating pools connected in series and provided with a paddle mixer. Neutralization of mining water and precipitation of metal ions in the form of hydroxides takes place in those pools by using Ca(OH)2 and putting it into the polluted mining water at 3 points.

After that the water with chemicals is conducted from aerating pool II, to two segregation pools, where the metal hydroxide precipitate settles from the water. The overflow of purified water is conducted to Toka stream, while the hydroxide mud is lifted to Bence valley where it is stored.

The purification system working continuously meets the regulations concerning the water quality of the given category of surface waters. In spite of that forming an opinion of the system carries a number of conflicts:

- the settled metal hydroxides are concentrated hazardous wastes in the Bence valley,
- the dams of settling pools are soggy, polluted water seepage of uncontrolled quality and quantity can be seen on their slopes,

- lifting of the settled mud across the dam of Bence valley is carried out periodically,

- the quantity of the mud is already about 114,000 m^3 in the pulp reservoir and it is a hazardous waste,

- the pulp reservoir is an isolated valley, closed by a simple earth dam and so the mud containing different heavy metals can cause environmental pollution both on the surface and in the underground waters.

POSSIBILITIES OF MODERATION OF ENVIRONMENTAL POLLUTION

Some possibilities of moderation of deleterious environmental effects were investigated:

(1) The regulation of water quantity infiltrating into the fractured underground water reservoir or leaking from mining caverns to the surface waters cannot be carried out because:

- the places of water movement are not known from before the mining activity, the uncertainty of information was highly increased by human activity;

- the slopes and valleys are covered with a thick masses of clastic deposits so the indeterminable places of water flow cannot be closed either from the surface or from the mining caverns;

- the places of subsequent closing of the connections between the surface and underground waters can be found in the narrow surroundings of shafts and adits, but the success of the operations is also uncertain.

(2) The separation of the stored waters or the stored and moving water by using underground dams was not successful formerly; this solution cannot be recommended for the future either. Because of the geological and tectonic structure and the hydrogeological characteristics of the area the connections between water bodies of the fractured underground water reservoirs are unexplorable, those water bodies cannot be separated.

(3) An "upper-flowing system" can be formed by closing dam V-3.
Dam V-3 was built for closing the adit opening at the level of +400 m (a.B.s.) and it was proportioned for 6 bar. Its closure facilitates the recharging of the mining cavern system from +400 to +460 m (a.B.s.). The result of the recharging process is doubtful because of uncertainty of the knowledge of locations of water movement. However, it was proved by observations that the cracks/faults/breaks extending to the surface cannot be closed either from the surface or from the mining spaces. It means that after closing dam V-3 underground water will come out of the fractured water reservoir at the level of +460 m (a.B.s.).

On the basis of the geological and tectonic properties the following effects of closing dam V-3 can be predicted:

- If water emergence does not occur between the levels of +400 and +460 m (a.B.s.) the cavern system of the central part of the mining area will be filled in 4-6 months - depending on the meteorological conditions.

- The output of water rate of flow will decrease to the average value of 1500-1800 m^3/day or to the maximum value of 3500-4000 m^3/day because of the decrease in the catchment area.

- This water output will appear in forms of springs with variable yields and in places in the catchment area of Toka stream. Finally the water will get into Toka stream.

- The surface waters coming from the catchment area between the levels of +400 and +460 m (a.B.s.) will not flow through the mine, so the quality of that water will be better than that of the water coming from the mine. In this manner the quality of the total quantity of surface waters will change for the better. The average quality of the surface waters flowing into Toka stream can be predicted as follows:

Average quality of surface water

Water Quality Parameters	Value	Range
pH	6	6.3- to 6.8
Total dissolved material mg/l	<2000	1200-1600
Total suspended solid mg/l	<500	100-300
Sulphate mg/l	250	NA
Copper mg/l	< 2 mg/l	NA
Lead mg/l	< 0.2	NA
Cadmium mg/l	< 0.05	NA

The following components will cause the most serious environmental problems:

- o Fe - contents > 20 mg(l
- o MN - contents > 5 mg/l
- o Zn - contents > 5 mg/l

(4) In the case of **using the present purification system** the following problems have to be solved:

- Disposal of heavy metal hydroxides, whose quantity will be about 10,000-12,000 m3/year.

- Modernization of the purification technology, introduction of automatic pH-control.

- Elimination of the present settling system, building of a new modern settling system.

- Stabilization of the dams of dangerous waste reservoirs.
- Conversion of dangerous wastes to non-dangerous materials, or utilization of dangerous wastes.
- Prevention of the pollution of surface or underground waters caused by dangerous wastes.
- Elimination or regeneration of polluted industrial and agricultural water reservoirs.
- Building and operation of an automatic monitoring system for monitoring the quality and quantity of mining waters.

CONCLUSIONS

(i) Mine water causes environmental pollution, therefore it must not be discharged into surface water without treatment.

(ii) Closure of dam V-3 causes the discharge of acid mine water at several points instead of a single main discharge, thus causing pollution of a larger area.

(iii) The quantity of water flowing through the mining voids cannot be reduced either by using inner isolation methods or by building underground dams.

(iv) The present purification system can only be operated after modernization.

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