CASE EXAMPLE ON ACID-RESISTENT BULKHEAD IN HUNGARY

Bagdy, I.
Senior Research Officer
Central Institute for Mining Development, Hungary

Sulyok, P.
Mine Manager
Cyongyosoroszi Ore Mine, Hungary

ABSTRACT

A polymetallic mine with strong acid minewater output has been abandoned temporarily. In order to control acid mine output an acid resistant bulkead was designed. Some details of the new bulkhead construction and the first experiences of its application are discussed with special regards to the acid water control, and to the economic aspects.

FOREWORD

The only lead-zinc ore mine of Hungary is found at Gyongyosoroszi/Mátra Mountains. Intensive production started in 1952 and closing the uneconomic extraction was decided by a government measure in 1985.

The mine water recharge originating from surface precipitation and infiltration though the workings had been polluted and caused unfavourable change on the water quality of the discharge stream and influenced even the agriculture indirectly.

Geological Conditions

The ore consists of lead, zinc, copper, gold and silver minerals. The complex sulfide ore is extracted from veins with bedding angle of 60-85º. The productive ore zone ranges from the subsurface level of "leached" ore, depending on the morphology (+460 - +700) down to, "banded vein" zones at +100 m above sea level. The extension of ore rocks is 200-800 m along the strike. Average thickness of veins ranges from 0,2 to 3 m. Based on the mining experiences the horizontal inhomegenity of the mineralization could be detected in "columnar" character of range system is more frequent.

The drilling from the surface isn't the best exploration method for the steep vein structure like this. The preliminary drilling exploration was underground drilling. Geological structure of mineralised zone is presented Fig. no 1.

Developing and Mining System

The developing system of Gyongyosoroszi Ore Mine is similar to the classical one. The horizontal adit of 2000 m length joints to the "Károly" vertical shaft sunk down to 250 m. The main veins of the central field were developed with horizontal drifts of 50 m vertical sequence from the Károly shaft. A sketch of the developing system is presented in Fig. 2.

The general mining method is back stoping, but other methods were also used.

ACID MINE WATER TREATMENT

The dynamic water recharge is estimated 40 m3/min. This means average rainfall intensity of 720 mm/year over an area of 310 Km2 with infiltration rate of 9%.

The quality of mine water is determined by the oxidation process taking place over the surface of openings in pyrite mineral. The effect of the pyrite oxidation in the dewatered mining opening appeared in form of increasing the acidity and the Fe and Zn concentration of the mine water.

The intensity of these chemical processes resulted in the abandonment of the workings in the North Field. The long term extraction period and the huge open surface of the mineralised cavern caused accumulation of acid mine water. The pH value, however, is changing reflecting the seasonal intensity of water recharge (determined by the precipitation), the average quality can be characterised with parameters as follows.

pH = 4; Zn = 55,6 mg/l; Mn = 18,6 mg/l; Fe = 300 mg/l.
Total acidity = 2300 mg/l.

The water treatment presented below has being been operated since 1983. The acid water collected in the abandoned mine is treated and outlet meets the quality-requirements of water for irrigation. Parallel system of settlers for cleaning the mine water from solid parts and sediments are used. Cleaning the settled rock sediments is necessary every ten days, but the floating parts are removed continuously. The water flows through a measuring cell into the outlet channel. Two sets of mixing tank of 50 m3 are used to neutralise the mine water with limewash of 6%. The neutralization is controlled by a feed apparatus. Lime solution is prepared in the building and next to it is placed the storage tank of 100 m3 capacity for lime. Three lime silos are installed in the buiding and pipelines carry the lime solution mixed by the measured mine water yield and controlled by mixing tank.

The limewash yield is determined and controlled on the basis of pH measurement in the mixture tank no 1. The treated water has got pH = 5,75 - 6/+0,5/ which results in the precipitation of zinc induced by water of pH = 8,5 - 8,75 prepared in mixer tank no 2. The neutralisation process and metallic-ion precipitation is complemented by ABTA aerator in both mixer tanks. A storage period in tanks depends on the water yield and the contamination condition (5-10 min). Both mixer tanks can be loaded separately or closed for cleaning periods simultaneously. The neutralised mine water is channeled to settler ponds, where the retention period depends is longer (1,5 - 3,5 day in general).

Settler ponds work as precipitators and the clean water is outlet with gravitation to the receiving stream. The last checking point of the treatment process is in the stream, and the final pH value is recorded in the mixing tank.

The slurry collected in settler ponds is pumped back to the waste dump.

ENVIRONMENTAL EFFECTS OF ABANDONMENT

After decided to abandon the ore mining in this region, a multipurpose environmental analysis was prepared to forecast environmental impacts. The effects of water quality are summarised below:

a) Water quality analysis recorded during the period of mining reflected the relationship between the acidity and ion concentration of the water and the extension of the open surface caverns having been dry before water leaching. The open caverns refilled with water from recharge rainfalls results in mine water with strongly alternating acidity and high ion-concentration. The pH and ion-concentration of steady mine water flows are stabilized.

b) Flooding the openings below the adit level has only a slightly effect on the quality of water, because the most part of the water volume is buffered and the actual seepage can transport little solid content because of its short retention time.

c) Consequently, the opening must be filled up to the highest level as possible without appearance of natural springs of periodical outflows. This way the oxidised surface can be minimised and the water quality can be stabilized.

Additional operations were aimed at achieving this more favourable condition. The openings below +400m were flooded when pumping stopped in the vertical shaft. This volume constituted 75% of the total openings. Before flooding limehydrate (over 380 tons) and limestone granulate was obtained in the mine field to improve the water quality. All water recharge was channeled to this part of the mine to speed up the process. The increase in water level, the yield of water recharge, the added lime hydrate, the pH factor, and ordinary laboratory tests were carried on regularly during the flooding period. General speed rising was 0,35 m/day.

The effect of chemical action was illustrated by changing the initial pH value of 3,5-4 up to the normal 6-7. The static water yield on the adit-level was 1,5 m3/min after filling up the deeper openings. The pH factor and ion concentration presented the normal trends depending on the intensity change of precipitation.

Flooding of the openings above the adit level was studied and analysed from geological and even technical aspects. The detailed project was also considered by mine safety, environmental control and water management authorithies.

More bulkheads were planned along the adit to stabilise the water level at a different height, but finally only two bulkheads were needed because of unexpected rock movements in the roadway. The bulkhead no. 1 on the stream of water from the opening above the central field. This water can communicate with deeper mine fields via natural seepage channels. The bulkhead no.2 produces back water level of +460m. This stop level is limited by an abandoned, but permeable backfilled adit where no outflow is allowed.

The bulkhead was constructed for two purposes:

- the periodical leakage of the sulfate and metallic ions is to be prevented, and

- to ensure the constant water yield for the optimal technology in the water treatment plant presented before.

BULKHEAD CONSTRUCTION

The bulkhead no. 1 was proposed with traditional technology in intact rocks. The surrounding rock zone and the contact face of the concrete dam and natural rocks was injected. Sulphate resistant cement was used for concrete mixing. The uniaxial strength of vibrated concrete reached 15,0 Mpa. The traditional technology of sulphate resistant concrete proved efficient even for longer period in practice. Water conduit pipes, were built in the bulkhead. After closing the pipes, the water pressure of upstream side reached 7-8 bars. After some months seepage and leakage started through the bulkhead and the stability and impermeability of the concrete dam was lost rapidly.

With opening of the valves the dam breaking could be avoided, but the capacity of the water treatment plant could not meet the extra high water yield and hard work was necessary to prevent an environmental catastrophy. The receiver surface waters were endangered by water volume of 300 000m3 with pH factor of 4 and high Zn, Fe and Mn concentration. Finally the staff could cope with the problem.

Professionals investigated the problem and the origin of the damage was concluded as follows:

- the sulphate concentration of the water was much higher that was allowed for the sulphate-proof cement.

- the behavior of the sulphate resistant concrete channel was known in mining practice under normal pressure, but the water body with extremely high sulphate concentration and over pressure could initiate unfavourable chemical action inside the concrete body.

Rock falling appeared around the bulkhead zone without maintenance, so repairing the damaged bulkhead was not economical. The repaired bulkhead no.2 was closen to meet both requirements. This bulkhead was designed and technically supervised by experts of mine water control section of the Central Institute for Mining Development(Budapest, Hungary).

The new bulkhead was designed according to new technology which eliminated the problems which arise previously, giving possibility for additional operations if necessary, and preventing filtration of the acid water into the bulkhead and surrounding rock zones.

The problem was solved by a combination of two patented bulkhead construction methods. The sketch of the bulkhead construction is presented on figure no. 7. This structure has more advantages:

- Open space inside the bulkhead structure gives possibility for testing the impermeability and pressure resistance of the concrete block;

- Special acid proof isolator is applied on the upstream side;

- Open space between bulkhead are filled with "quasi liquid material" with pressure higher than the water pressure. This ensures constant and effective impermeability.

This structure gives possibility even for additional injection in case of unforecasted damage or changing the stress field. Acid resistant steel pipes with valves can regulate the water yield for water treatment plant and the pressure loading on the bulkhead.

The tested overpressure was 18 bar during 72 hours period. During the testing period 0.03 m3/min was collected on the downstream side. The space between concrete bodies was filled with bentonite-slurry tested for acid resistance in laboratory previously. The slurry-pressure is 8 bars, while the operating pressure of the bulkhead is 6 bars.

The bulkhead described above has been under pressure without any seepage and damage for a year.

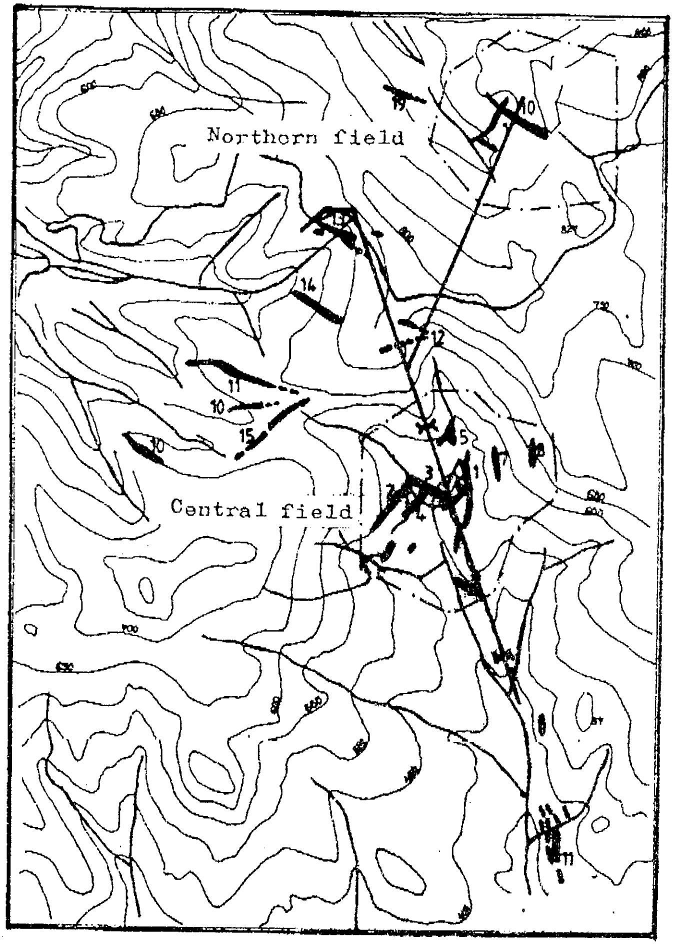
CONCLUSIONS, PROPOSALS

An acid mine water control problem was presented for mining period and abandoned conditions. This method reduces the possibility of the leakage to the oxidation zone by means of flooding most openings. This could be laid out with patented methods for special bulkhead construction. The water conduit pipes ensure the optimal working capacity of the water treatment plant. In case of higher water yield the energy consumption of treatment plant can be solved by hydraulic turbine.

New procedures for neutralisation in the flooded mine openings is being investigated. In this case the lime solution depending on the intensity of precipitation would be let into the mine via boreholes.

The chemical balance of the surrounding water body is unknown and modeling the chemical reaction and transport is complicated at the moment. The settling into the mine openings can make the water treatment capacity unnecessary in extremely advantageous situations.

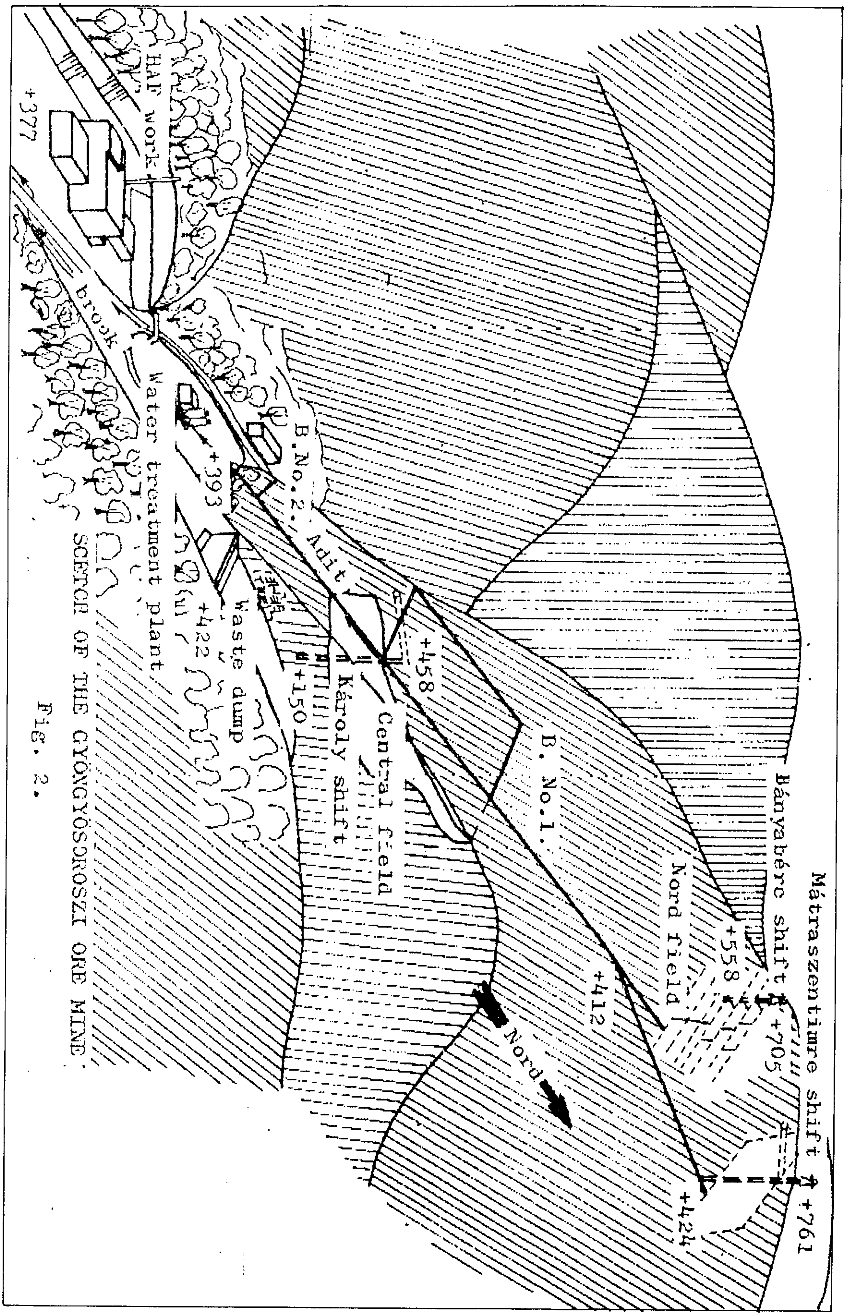
In mines pumping acid mine water can be proposed to select special mining methods for given fields to be blocked and separated for other workings. Using special bulkhead the water recharge of the abandoned area need not be pumped out uneconomically. We are sure, that environmental protection requires more measures and the pollution of the acid mine water must be reduced to minimum. Our paper may give you some idea to solve your own problems in this field.



——Adit 1 - 19 Veins ⊢⊣Bulkheads

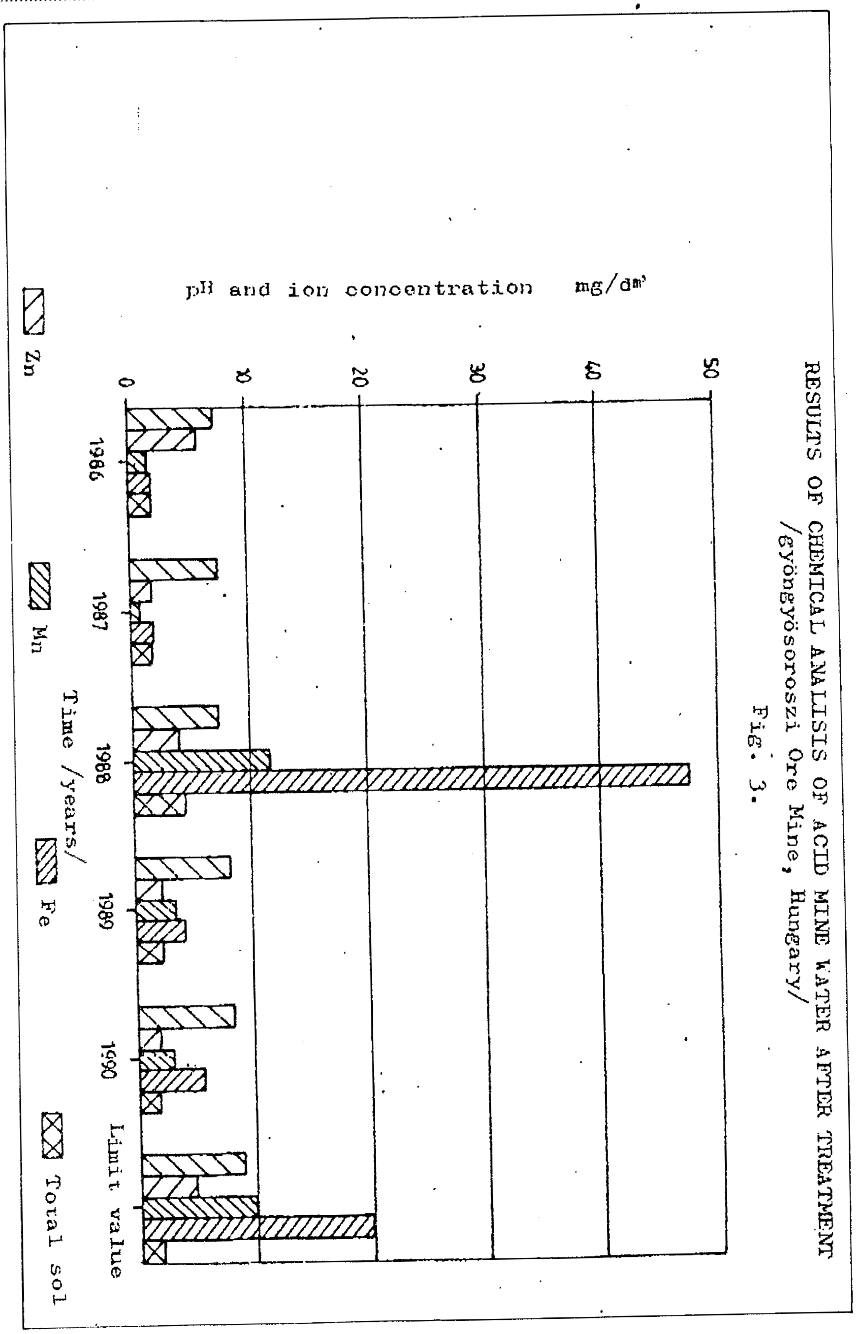
GEOLOGICAL AREAL MAP OF THE GYÖNGYÖSOROSZI
/Matra Mountains/

Fig. 1.

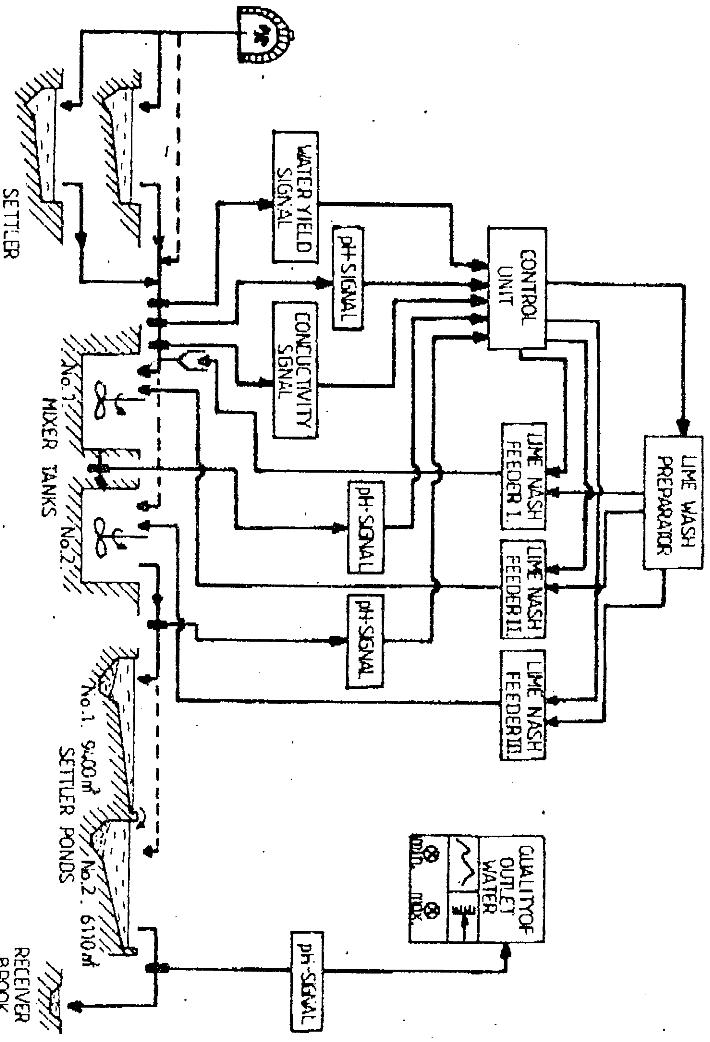


SCETCH OF THE GYÖNGYÖSOROSZI ORE MINE

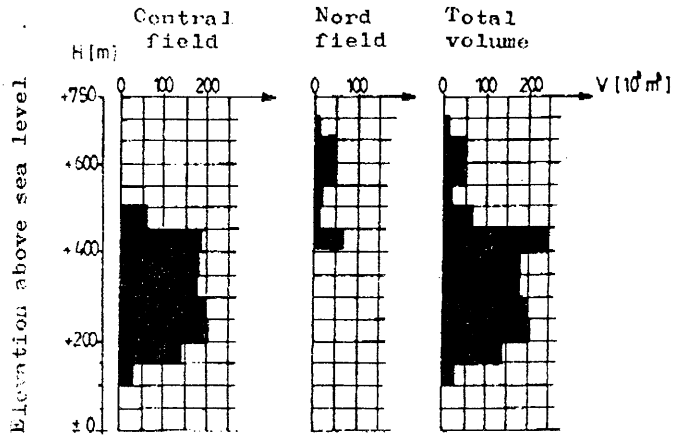
Fig. 2.



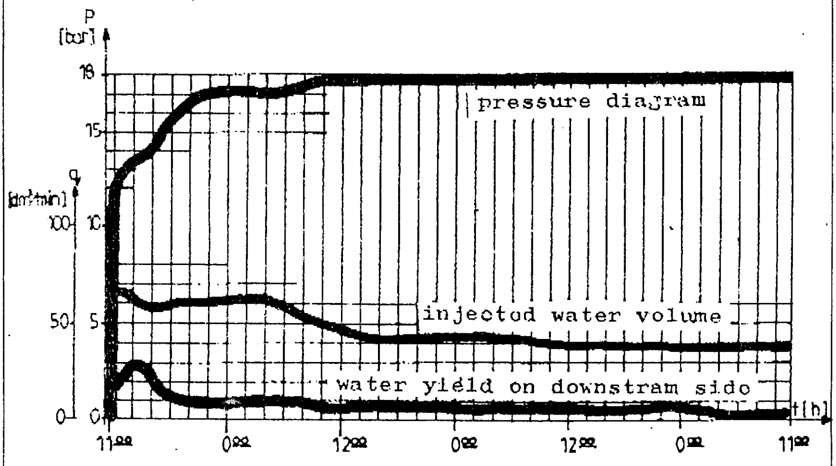
RESULTS OF CHEMICAL ANALISIS OF ACID MINE WATER AFTER TREATMENT /gyöngyösoroszi Ore Mine, Hungary/
Fig. 3.



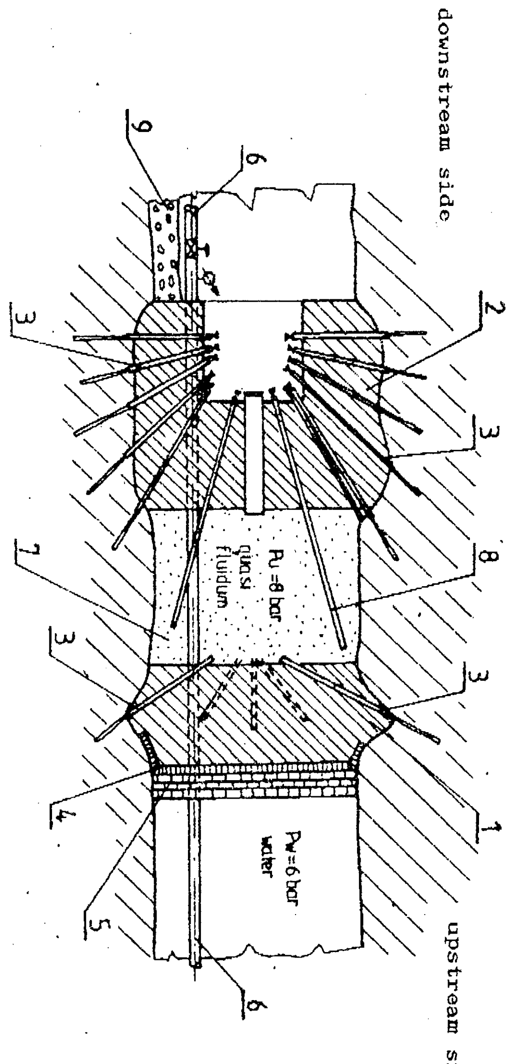
SHEME OF THE WATER TREATMENT
Fig. 4.



DISTRIBUTION OF THE ABANDONED SPENNINGS VERSUS DEPHT
Fig. 5.



RESULTS OF PRESSURE TEST
Fig. 6 .



1. Supporter body; 2. Main body of bulkhead; 3. Injection boreholes; 4. Acid-resistance isolator; 5. Cocrete wall; 6. Conduit pipeline; 7. Pressure space; 8. Pressure intensifier pipes; 9. Gravel filling

STRUCTURE OF THE BULKHEAD
Fig. 7.