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EXPERIENCE AND IDEAS OF DEVELOPMENT ON THE CONTROL OF MINING UNDER KARSTIC WATER HAZARD

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SUMMARY

Mining and hydrogeological relationships in the huge karstic water resources stored in the Hungarian Transdanubian Mountain are described. The importance of the knowledge of tectonics and physico-chemical aquifer properties is emphasized.

Result and related high cost of passive mine water control are briefly discussed.

Details are given on the successful application of active-preventive control applied in bauxite mining.

A drilled-well system based on a shaft and transversal drains is recommended for local mines. This system can operate as a water works independently from, or in close cooperation with mining operations.

The suggested system operates with submersible pumps in a booster mode, eliminates mine flooding and makes exploitable the considerable mineral resources of the water control pillar. As a result, both its construction and operation are more economic and it may operate further after mining terminates.

Karstic water resources of the Transdanubian Mountain have caused much problem and hazard for mines in the region. Mining is compelled to exploite deeper and deeper layers in order to meet growing industrial demand, and so, karstic water hazard increases even more rapidly.

The geological structure and composition of this mountain have been broadly studied. Geological and hydrogeological investigations demonstrate that the regional mesozoic carbonate aquifer has no hydraulic connection either with the Kisalföld hot water aquifers or the mesozoic hot water aquifer located South of "Lake Balaton line", though some ancient geographic connection can be shown. Thus, it is sufficient to study the regional mesozoic aquifer and the younger paleocene and eocene overlying rocks. Also, connections with the upper-Pannonian aquifer and the quaternary formations related to the river network and drainage basins should be considered.

Mine water control depends mostly on the hydrogeologic properties such as the physico-chemical parameters and tectonics of the mesozoic main aquifer.

The main mesozoic aquifer consists mostly of limestone and dolomite. Earlier, almost exclusively the limestone was studied from mine water point. This is natural since the solving effect and mechanical degradation caused by water is relevant principally to this carbonate rock. Pure dolomite resists the solving effect of water. However, it was shown that the regional dolomite is limy and pure dolomite can be found only in a very small area. Physico-chemical properties of the limy dolomite are often more adverse than those of pure limestone as far as water hazard is concerned. For certain CaO-MgO ratio the rock is quite rigid and of cataclastic structure and it become powderised or clayey where it contacted with emerging hot water. Consequently, its water conductivity may be quite high. Having this in mind, a more detailed chemical and structural analysis of the dolomite is advisable in places of karstic water hazard.

Mining is generally connected to areas of highly disturbed tectonics. Longitudinal and transversal faults and displacements characterizing regional tectonics can be traced over the whole area. There are two main types of faults influencing water hazard:

- preforming faults connected only to mesozoic rocks,
- faults influencing also eocene and more younger layers.

The second type of faults are often the renewals of earlier fracture lines. These faults can be even more dangerous from water hazard points, than the great preforming faults. It is incorrect to consider faults characterized by a fracture plain, except the great preforming faults. It is more appropriate to regard fracture zones whithin which the rigid cataclastic limy dolomite disaggregated possibly in several steps. Since these zones are not filled up or fixed by any sealing material, karstic water may freely flow through them.

A complicated three-dimensional underground flow process has been going on in the regionally connected main mesozoic aquifer even in the natural state between inflows and outflow. Artificial recharge and intake further complicate this process. As a result, a longer observation period is needed even in the local scale in order to give a relatively reliable answer to all questions related to karstic water. Earlier, only water authorities observed and registered data on surface water budget.

During the recent decades, a great number of regularly observed data have been measured over the region of bauxite mining, as a result of large-scale dewatering operation. In addition, a considerable amount of data has been observed by coal mines in the region, and by various research institutes.

Karstic water hazard occurred as early as more than 100 years ago in the Dorog coal mining. Mining controlled this natural hazard always by equipment corresponding to the given technical level. As for passive control, water control pillars, protection layers, grouting of openings and water inrushes were used. The principle was followed to stop inrushes by all means, and to eliminate them from mine workings.

These methods were, however, very expensive. Ample data are available on the Dorog situation where more than 100 drillholes of several tens of thousand meter length were sunk, several hundreds m^3 of chlorhydric acid were used for enlarging fractures, and, as grouting material, tens of thousand tonnes of cement and more than 10^6 m^3 of sand were applied.

At the same, about 10^8 tons of coal are represented by the water control pillars of mines flooded earlier and to be opened again. In fact, these mines flooded in spite of the great control expenditures and coal losses refained in the pillars.

In our times, mining production has increased but passive-preventive control has resulted in less and less success when, at the same time, mining authorities prescribed the strict preventive protection of mine workers and property. Water inrush events and mine floodings in Dorog between 1950 and 1970 show a sad picture. Altogether 18 inrushes leading to flooding and production losses were observed. As a result, in 1976 less than 40 % of the originally planned mining capacity was available. Reopening of the flooded mines would require some hundred millions Forints and several year very hard and dangereous work. This means practically the failure of passive-preventive control.

Bauxite mining in the Transdanubian Mountain reached the karstic water level in the beginning of the fifties. First, passive-preventive control methods were used according to earlier Dorog experience. After one-two years it became evident that this control method could not assure undisturbed and safe mining even at the loss of high ore amounts. The difficulties were even greater than in the Dorog coal mining since here the protection layer between bauxite and the aquifer was missing. Mining practice showed that either a great part of passive-preventive control regulations could not be met, or more than 70 % of ore losses occurred. Also, bauxite mining is very sensitive to water aggravating manual mining methods and transportation, and making mechanized mining inpossible.

Consequently, the introduction of active-preventive mine water control was decided on. This method aims at water table lowering corresponding to the regional dynamic karstic water flow by a large-capacity pumping system.

This method should take into consideration both the physicochemical properties of the aquifer, and local micro and macro tectonics. It is evident that not only the dynamic water resources but a part of the static water should be also pumped temporarily for local mining dewatering. Local dewatering may exert regional effects and, thus cause environmental damages, depending on mining technology, aquifer properties and tectonic loading. Mining should exploit the ore from under the original karstic water by the highest possible production capacity within the shortest time, with due regard to the decrease of static water resources.

It cannot be neglected that the amount of dynamic water resources to be pumped during mining period is much greater than the pumped ratio of static water resources. As a result, the rate of mining determines economic efficiency since a greater part of water to be pumped is independent from the production rate. Active-preventive control has several alternatives and can be combined even with passive control methods.

In the initial period, in 1955 bauxite mining developed a local dewatering system for the exploration of mine Iszka II. A traditional pumping station was constructed 60 m below the original karstic water level in the overlying rock and the main exploration roadway of 2 km long was driven in the underlying dolomite aquifer at the same level. Also, the main haulage roadway at level +80 m, then at 2 m higher the parallel main ventilation roadway, finally the water roadway were constructed. This latter roadway included a proper settling system from where water flowed down to the sump system under the pump chamber.

This control method based on direct local head reduction by direct drainage, called nowdays scientifically instantan protection, was successful: the main exploration roadway system gradually dewatered the ore body to be mined by draining 1,2-1,5 m^3/s/100 m of water /Fig. 1/.

When new mines are opened in this region, no traditional pumping stations are used but water shafts and submersible pumps. At the same time, transversal drillings from the exploration roadway system to under the bauxite body are applied in order to accelerate the rate of dewatering.

In one of the most important bauxite mines, in Nyirád, the solution of mine water hazard was the key problem of mining. This area was and is being explored in great details: the density of test bores is greater than 3/ha over an area of 2200 ha. The degree of regional tectonics can be illustrated by the fact that some 200 bauxite lenses of various magnitude were found in the holes and sinks of preformed faults, mostly under the regional karstic water level of +178 m.

Karstic water appeared at level +178 m first in 1950 at the sloping shaft Táncsics. This was taken into account during subsequent mine openings. Bauxite lenses of Izamajor were explored in groups by a central sloping shaft reaching the base roadway placed above karstic water at level +180 m. The different lenses were explored by main inclines from the basic roadway. In such a way, a possible flooding of a lense could be restricted to the same lense. Mining of these lenses had been undisturbed as long as the mining reached a level 30-40 m deeper than the critical karstic water level. However, at level +149 m, an inrush of 17m^3/min flooded the bauxite lense Iza I in September 1956. It was repeatedly unsuccessful to groute this inrush in the underlying limy dolomite of heavy cataclastical structure by the grouting methods extensively used at Dorog. The solution of this problem became the key point of mining.

Bauxite mining experts have investigated the water problem in several studies. As best solution was recommended the pumping by submersible pumps from boreholes. Outside consultants considered this solution as non feasible due to the insufficient drainage capacity of drilled holes in the underlying dolomite. Next, ALUTERV developed a plan for direct drainage in the area. Based on detailed exploration data, water shafts were sunk in the centre of bauxite lenses to be mined, where dolomite outcropped. From these shafts transversal drains were planned under the bauxite lenses at level +110 m. After a lengthy approval of the plan construction of the water shaft started at the end of 1959 and was completed when 8,5 m^3/min of drained water occurred. Then submersible pumps were installed and the drainage cuts were started to be driven in 1962. This work was going on under heavy water conditions until February 1963 when, unexpectedly an inrush of 150 m^3/min was experienced. The final pumping capacity was installed and active dewatering started with a water amount of 35 m^3/min.

In the meantime, geological prospecting resulted in considerable bauxite resources also over the neighbouring areas. Consequently, haulage shaft for Izamajor I was started to be sunk in Fall 1962. Since dewatering by the water shaft was not yet effective, the haulage shaft was sunk to a level of +120 m with great difficulties since the amount of mine water was higher than 18 m^3/min and repeated grouting efforts proved to be unsuccessful. Finally, dewatering was effected by a mammoth pump from a drilled well. Due to the excessive drainage, an individual auxiliary shaft for the capacity of proper submersible pump was sunk during sump system driving to the sump roadway system. Here was the equalizing sump system applied first in order to assure the undisturbed operation of submersible pumps. From this auxiliary sump the steady pumping rate was as high as 101 m^3/min in 1967. Exploration roadways were driven in a very slow rate owing to the excessive drainage.

This negative experience and a better knowledge of the limy dolomite induced ALUTERV to propose again a dewatering system using drilled shafts. With the agreement of bauxite mining decision makers, the Bauxite Prospecting Company executed a successful experiment on shaft boring. It has been demonstrated that this technology is applicable to establish proper intake works over the area. There are more such shafts with a steady water amount of more than 20 m^3/min. As a result, Izamajor II and all subsequent mine openings have used this dewatering technology.

Karstic water level has been sinking as planned, and in July 1972 submersible pumps of the water shaft at level +110 m were above the water level. The present total pumping rate of about 300 m^3/min through water shafts has resulted in a water level lowering of 120 m in the centre of the area. This has made possible to extract more than 100 bauxite lenses using highly mechanized mining technology. The borehole system has produced drinking quality water.

However, the construction of drilled shafts becomes gradually more difficult, slower and expensive due to the increasing depth but mostly because of the emerging flushing problems caused by the low karstic water level.

Consequently, the technology was further developed in the Nyirád area toward local intensive drainage by transversal drains from shafts.

The principle of the method is to drive large transversal drains in two directions at or 10 m below the piezometric level from the shaft, possibly in the mesozoic overlying or underlying rock. From these drains, boreholes of diameter 450 mm are sunk into the mesozoic underlying aquifer in distances of 10-25 m corresponding to rock parameters and to depths according to drawdown. Submersible pumps are placed in these boreholes, lifting water to the level of the transversal drains, from where it flows to a settling system then the equalizing sump system near the shaft.

Large capacity submersible pumps lift drinking quality water from the shafts to the surface. The total pumping capacity of such a shaft is 60-120 m^3/min. It is possible to use the transversal drains for the air-supply that is ventilation, of prospecting works for or even whole new mines /Fig. 2/.

This active-preventive method of water control satisfies safety conditions, techno-economic conditions of mining and the possibility of mine water utilization. Several alternatives of the method using transversal drains from shafts are available for either the reopening of flooded mines or the construction of new ones. This system must have a water shaft or a ventilation shaft with the necessary pumping facility which directs water drained from the mesozoic aquifer, through a settler and a sump system up to the surface as a waterworks.

Advantages of this recommended method from engineering, economic and mostly safety aspects are without doubt.

Its most important advantage over passive-preventive methods is that no protection layer and water control pillar are required. This is of high importance in countries with scarce mineral resources since the mineral reserve retained in the pillar is minimally 20 %.

Another advantage of the system is that pumping is effected more or less independently from the mining roadway system, thus it can be maintained even after mining is terminated. Also, drinking quality water is generally obtained in a permanent way.

Both the local and regional dewatering systems result in less mineral losses and higher mining efficiency due to full-scale mechanization. The application of submersible pumps has several advantages. They can control higher inrush volumes than expected by a provisional increase of pumping capacity /size and/or number/ even within a given shaft size. Installation of a submersible pump unit requires one-two working shifts at most.

The method is less expensive and can be constructed faster than the procedure with drilled shafts. This is the reason of scale economy, considering the concentrated sitting of the system.

It would be highly advisable to prescribe an increased application of active-preventive mine water control over karstic areas, based on recent decade experience. This would result in a more efficient protection of the nation's mineral resources.

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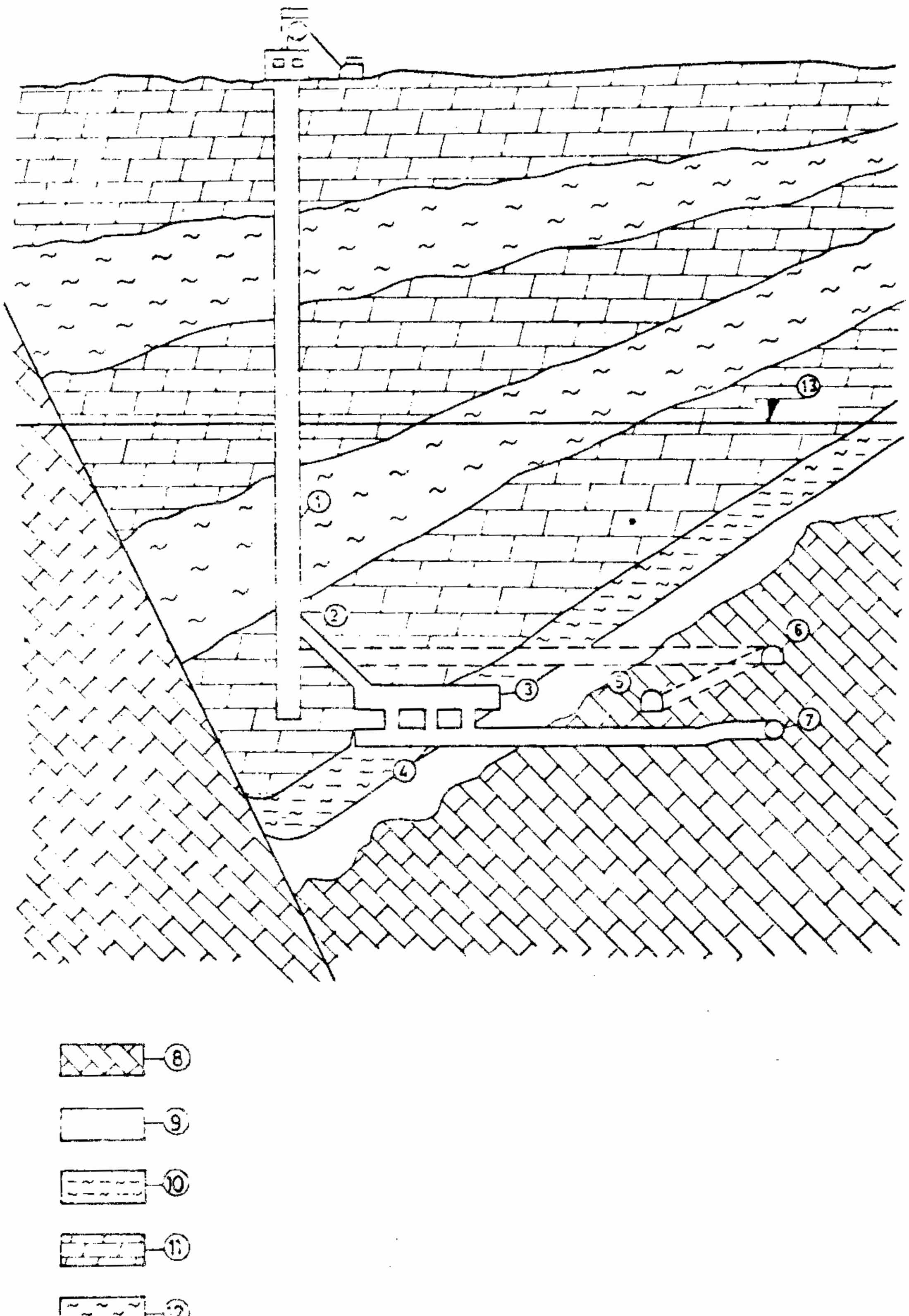

Figure 1.

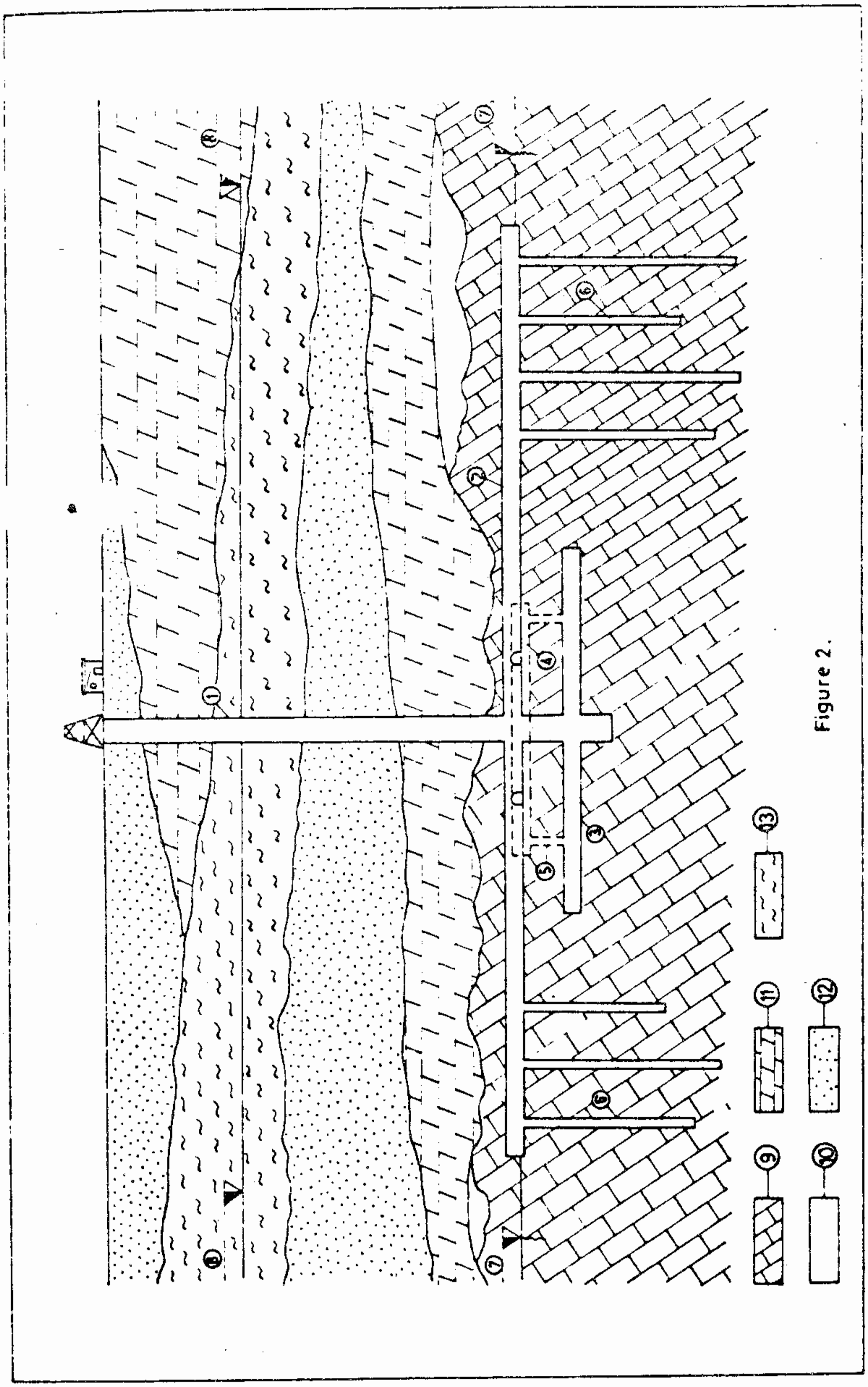

Figure 2.