EXPERIENCE ON THE CONSTRUCTION AND APPLICATION OF WATER CONTROL GATES

Schoppel, J.

Dorog Coal Company
Dorog, P.O.B. 28, Hungary

SUMMARY

Water control gate is an effective means of passive mine water control. Experience is given on water control gates, having been gathered in the Dorog coal field of high karstic water hazard, during the last half century. It is possible to construct perfectly closing gates using the presented guidelines. Test operation as prescribed by the mining authority is described from practical points. Conditions of effective application are determined from experience of subsequent gating of water inrushes.

ON WATER CONTROL GATES IN GENERAL

In mines of high karstic water hazard in the Dorog coalfield, preventive and passive water control methods have been used.

An important means of passive control is the water control gate. It is applied when in spite of preventive methods /such as protection pillar, separation of mining fields by boundary pillars, exploration and mining schedule according to increasing water hazard, and other mining measures/ such a high water inrush /or several smaller ones with a high total yield/ occurs which endangers the existence or economics of mining.

The water control gate consists of the gate body, the adjacent roadway sections /water-side and safe-side/, the equipment and the adjacent rock.

Water control gates are used for the increase of mine safety with due regard to engineering and economics. Purposes of these structures are:

- to protect the shaft and its equipment /pumping station, electricity metwork, transporters/ against flooding in case of a mine water yield higher than pumping capacity;

- the separation of mining fields, the closure or disconnection of a mining field if necessary;

- the closure of areas where mining is terminated, in order to stop pumping from there;

- to establish steady-state conditions necessary for the grouting of inrushes, or to control grouting material input through boreholes by controlled flow velocity in case of roadway grouting.

General application conditions, sizing, construction and supervision of water control gates are regulated in various sections of the Mine Safety Regulations /ÁBBSZ/. Later, a special mining standard "The location, sizing, and construction of water control gates" was prepared, summarizing and further developing the above regulations.

CONSTRUCTION EXPERIENCE OF WATER CONTROL GATES

Among earlier constructions it is worthwhile to mention:

- control structures without gates in shaft VI to separate oligocene mine fields and lower eocene mine fields under water hazard, as well as to isolate drained water in mined areas,

- the low-level gate in shaft I, protecting the main water control station and

- the Tokod-Altáró I. incline and gates protecting main water control stations of incline VI.

As mining depths were increasing between 1955 and 1969, mine openings required the construction of high-performance water control gates. As result, double gates were constructed for shaft XVII in 1956-57, and for shaft XXI in 1961-62, and a control gate was completed in the mid-eocene layers of shaft XII/A in 1969.

Construction questions of water control gates came into prominence in 1958 when an inrush of 0,75 m^3/s occured at the -17 m a.s.l. level of the transverse roadway of shaft XVII. In fact, inrush water flowed round the closed gate and the mine flooded. This gate was constructed in 1956 and 1957 in portions without grouting.

Later, in 1970, other gates performed sufficiently after regrouting.

Main factors governing the construction and performance of gates are as follows:

- quality of rock around the gate /safer and less expensive gates can be constructed in the marl overlying the lower-eocene coal seam than in the high-conductivity, heterogeneous layers of mid-eocene;

- excavation of the gate contour by taking care of the surrounding rock material /contour-blasting and chipping hammer or a mechanized mode/;

- a proper provisional support of gate contour, leading to minimal rock displacement /shot-concrete support immediately following excavation may be of high importance/;

- amount and quality of concrete components such as the choice of particle size classes for gravel and optimum water-cement coefficient;

- concreting technology /traditional vibrating, or shot-concrete technology but continuous work by all means/ and the sprinkling of the concrete gate;

- problems of setting accelarators /decreasing concrete strength and its sulphate resistance, increasing the corrosion of steel fittings inbedded in the concrete as well as shrinking/;

- construction, material, test-operation and corrosion control of various gate structures;

- grouting of the gate and adjacent roadway sections.

This latter operation is one of the most important phases of gate construction, requiring great care and considerable time.

Grouting made generally with cement liquid can be divided into three parts:

- the fractured rock is grouted,

- the interface between gate and rock is grouted,

- grouting against shrinkage and its effect after 6-9 months of construction.

Concrete shrinking is a rapid process at the beginning and a gradually slower one later on. About half of total shrinkage takes place within the first 28 days, while the other half lasts a year. Shrinkage of a larger gate body may be as long as 10-15 years. According to our experience the first grouting pertaining to gate construction process should be followed by an other grouting after 2-5 years.

After the completement of gate concreting work, drilling of grouting holes can be commenced. The magnitude of this operation is illustrated by the following data: 560 grouting holes were drilled in 50 archs for the water control gate of shaft XXI at level -17 m /length of the gate is 6,3 m, grouted lengths of roadway are 9 m at the safe-side and 14.7 m at the water-side/. Grouting had to be accomplished from the centre of the gate in both directions continuously - without jump and interruption - in order to drive out inbedded water and air in both directions. Grouting must be continued as long as pressure test for every borehole gives satisfactory result.

Our experience recommends Portland cement 600 for grouting, with particle sizes 0,002-0,005 mm and not older than six weeks. Water-cement ratio is 1:1. Since setting time is 90 min, no connected hole system can be pressurised longer than 90 min. Grouting can be repeated after 48 hours passed.

During the construction of the gate for shaft XXI, only the third grouting, using cement-mortar, could assure impermeable gate and rock vicinity. One of the reasons was the strong fluctuation of cement quality: strength of the applied cement, type 500 changed between 40-70 MPa. This experience raised not only the necessity of cement testing in advance but also the use of other grouting materials beside cement. Criteria for grouting materials are: no shrinkage, proper strength parameters, impermeability, good adhearing even to wet surfaces, sulphate resistance, easy groutability.

Special attention should be given to the weathering of clayey, marl rocks, caused by the effect of water during gate construction. Especially endangered is, in this respect, the inverted arch surface due to gravitational water movement.

Torcreting of gate beds or silicate grouting can be used against this weathering effect.

The application of shot-concrete also solves this problem, in addition to regulating rock stresses.

TEST OPERATION

According to the specification, test operation should use a pressure head 1,5 times higher than design head is, throughout 72 hours. Test operation is compulsory even after regrouting. The magnitude of the above pressure head can be discussed, since our experience shows that such a test pressure head opens fractures which would not open in case of the design pressure. A gate for shaft XXI should have been tested with a pressure of 2,2 MPa. However, seepage occured in the lead packing of the gate at 0,25 MPa. Seepage through the gate was experienced above 2,0 MPa, but this seepage did not stopped even at the design pressure of 1,4 MPa.

The actual pressure head, as loading to the gate, can be higher than the design pressure only for a short period during a grouting operation to close a water inrush. In that case, weight of the slurry in the borehole may cause short extra loading.

It would be more appropriate to accomplish the test operation by using design pressure head /or its 1,2 times at most/ for a longer period and observing seepage flow and carried sediment more frequently /e.g. in every second hour/. A gate can be accepted if seepage water is clean and its rate is constant.

OPERATION EXPERIENCE WITH WATER CONTROL GATES

In the Dorog coalfield, only one mine flooding has occured due to construction defects of a water control gate.

It was already mentioned that elementary defects during the construction of the double gate for shaft XXII led to mine flooding after mine water had flowed round the gate.

Flooding was caused in two other cases when the gates could not be closed.

These cases underline the importance of a proper lead-time for manpower evacuation and the preparation and execution of gate closure. The necessary lead-time in case of a high inrush flow /as 1,25 m^3/s in 1971 at shaft XVII or 2,33 in 1970 at shaft XII/a/ can be assured only by the help of an underground water storage space under gate level. As a result of the lack of such spaces, in the two above cases, there was not enough lead-time for gate closure.

There are two basic preconditions of successful gate closure:

1./ the gate body, its equipment and the surrounding rock must be impermeable /construction criterium/;

2./ necessary lead-time for closure must be available even in case of an inrush considerably greater than pumping capacity /gate siting criterium/.

If the above preconditions are fulfilled, the application of water control gates is economic as the next example demonstrates it.

Controlled closure of gates for shaft XXI took place on June 26, 1976 when mining of the western coalfield, behind the gäte, was completed.

Mine water flow was 0,3 m³/s that time. This was the upper capacity limit of the water conveyance system as far as the sumps of the main pumping station.

After gate closure, karstic water level raised up to +110 m a.s.l., but the gates safely resisted this load.

In the second year after closure, a gated pipe of diameter of 200 mm in the gate body failed due to corrosion. Gate was reopened after water had been released through in-take pipes, the failed pipe was repaired and the gate was closed again.

In 1979, under steady-state conditions reached by the gates, an inrush of 0,27 m³/s dated back to 1966, was grouted. Grouting was performed from the surface through a borehole using 14.800 m³ sand and 3000 m³ flyash.

This successful application results in saving 3400 kWs annually. Also, grouting of the 0,27 m³/s inrush made possible to mine valuable coal resources contained in the gate pillar in the following way. If mining on level -120 m a.s.l. proceeds to reach coal in the gate pillar, gates are opened and a flow of 0,03 m³/s from smaller inrushes will be conveyed to the sump system of the new pumping station located at level -56 m a.s.l.

Abundant experience has been gathered in the Dorog coalfield on the construction and operation of water control gates during the last decades. Experience shows that this element of water control is reliable and leads to cost reduction through energy saving, so important in these days.

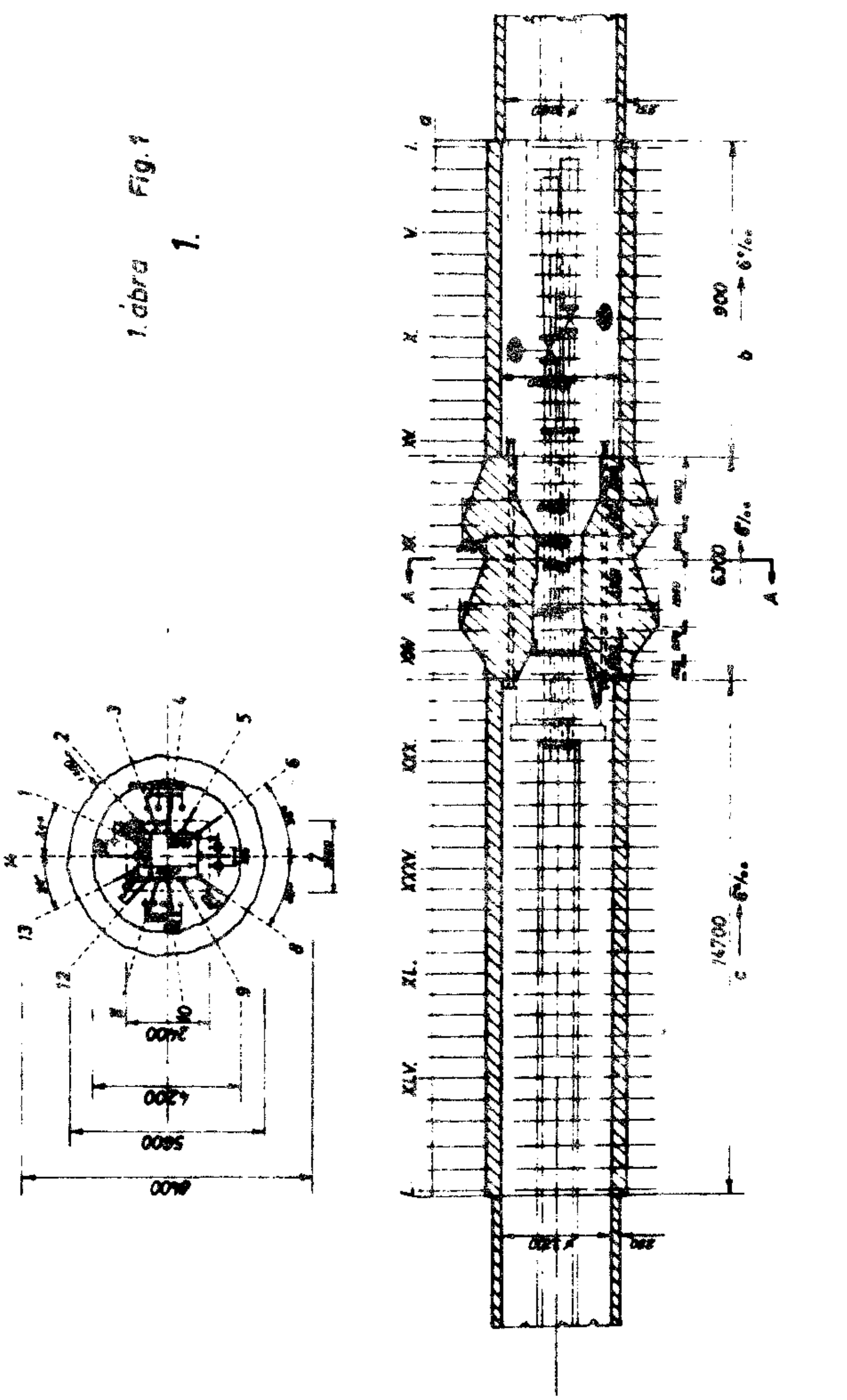
The knowledge and following of proved gate construction technology make possible to construct safe gates, that is, safe operation can be guaranteed.

Safe and economic operation of water control gates is constrained by two conditions of gate closure: proper gate impermeability and the necessary lead-time.

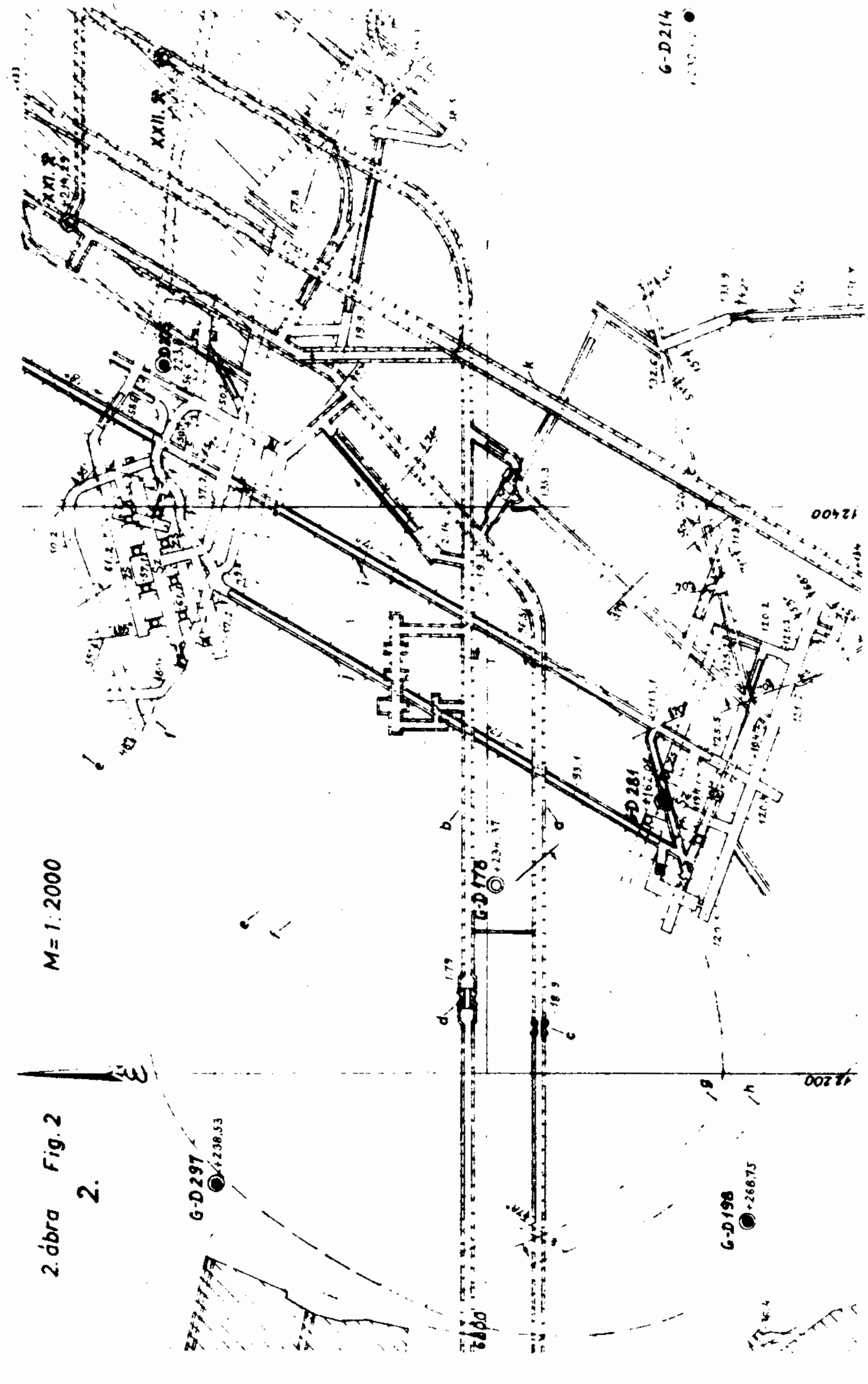
This illustration of water control gates is based on a water control system operated with centrifugal pumps.

The application of large-capacity submergible pumps has resulted in considerable development of water control systems for present and future mines under water hazard. Water control gates may, however, play significant role in these systems, too.

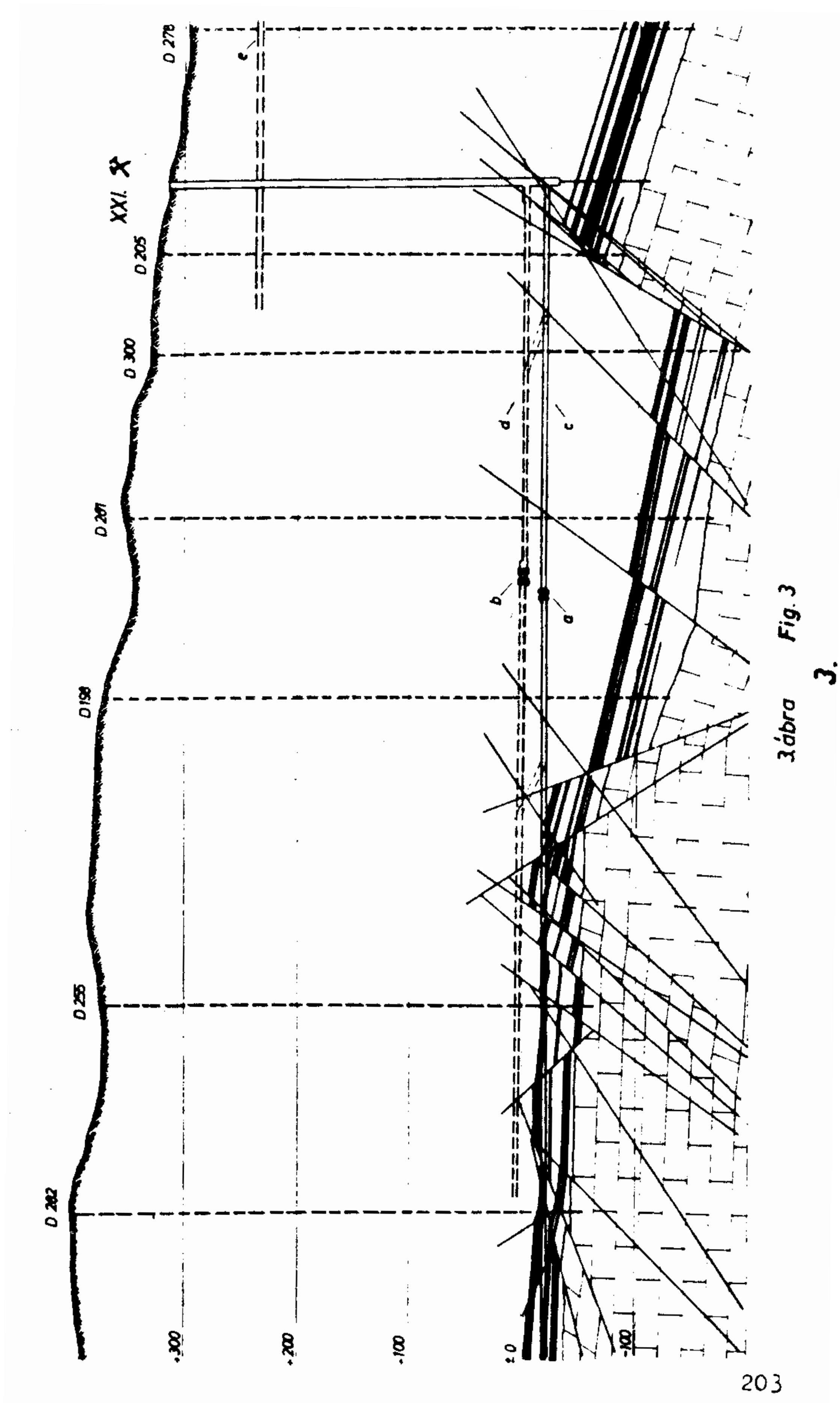
List of Figures



1. ábra Fig.1


M= 1: 2000
G-D214
XXI.R
XXII.R
12400
12200
G-D176
D 281
G-D297
+238,53
G-D198
+268,75

2.ábra Fig. 2
2.



3.

3.ábra Fig. 3