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WATER BALANCE MODEL OF THE TRANSDANUBIAN MOUNTAIN RANGE IN HUNGARY FOR MINING PURPOSES

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ABSTRACT

The Transdanubian mountain range can be called "the industrial shaft" in Hungary. The most important bauxite and coal mines have been situated here for a long time. More than 50 percent of bauxite and coal resources can be found under the karst water level therefore the hazard of the karst water inrashes into the mines is very high. Since the karst water in a good quality is as valuable as the bauxite and coal mineral resources and the enviromental impacts of dewatering have reached a high degree, a yearly water balance should have been prepaired for 1978, by water balance model based on the finete elements with a surface of 4 km^2 for the total area of the TMR /extends over 15 000 km^2/. The model takes into account the water balence elements /ie. infiltration etc./ and thier areal distribution and thier standard deviation estimated by a methods used in geostatistics. The water balance units of the TMR can be seen in Figure 1. The lack of infiltration and the discharge are illustrated by Figure 2 and the Figure 3 shows the change in the water level. The summarized yearly water balances is shown by Fig. 4.

The water balance model based on its simple algorytms worked by field tests and experiments up can well characterize the water development situation of this area and it seems to be a suitable one to desing the resonable utilazition of karst water resources, the mining dewatering and its results on the enviroment.

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1. INTRODUCTION

The Transdanubian mountain range /further the TMR/ can be called "the industrial shaft" in Hungary. The most important bauxite and coal mines have been situated here for a long time.

The main karst water system of the TMR is stored predominantly in fissures and cavities of Dachsteinkalk Limestone and Hauptdolomite formations of Upper Triasic. More than 50 percents of bauxite and coal resourches can be found under the karst water level therefore the hazard of the karst water inrushes into the mines is very high. Coal mining first came up against karst water inrush into the mining spaces early in this century; bauxite mining encountered them in the 1950'S.

Under the natural conditions /prior to the impact of waterworks and mining /the rate of infiltration of precipitations used to be at equilibrum with the rate of discharge of karstic springs, karst moors in the foothills and the change in stored karstwater resourches.

The demands in water supply have been on the rise, the mining has got deeper and deeper under the karst water level, therefore the yield of pumped karst water needed has been grown year by year.According to this human activity in the fields of karst water intake from the rocks, the natural equilibrum of karst water balance has been overturned for a long time.

Since the karst water in a good quality is as valuable as the bauxite and coal mineral resourches and the enviromental impacts of dewatering have reached a high degree a yearly water balance should have been prepaired for 1978.

The yearly water balances serve for the reasons as follow:

- to study the influence of mining dewatering of the karst water systems,
- to weigh the utilizations of karst water resources,
- to produce the basis of forecasting for impact of karst water intake in the future.

Solving this work a water balance model was formed for the karst water systems of the TMR. The main karst water system constituting a single continouos, communicating hydraulic system /confined and unconfined/ extends over 15 000 km^2 of the area of the TMR distributed for finite elements with a surface of 4 km^2. The number of objects used for makin the water balances is follow:

- 480 of waterworks,
- 93 of mines,
- 155 of meteorological stations,
- 270 of observation wells.

The annual water balances are closly connected with the yearly balances of mineral resources. The change in water resources may be caused by both natural /meteorological/ and human reasons.

2. MODEL CONSTRUCTION

The elements of water balances /ie. infiltrarion, discharge, change in the stored water resources etc./ can be made separatly by model for closed water units bounded by subsurface watersheds. Horizontal flow is not supposed between the units in this case. The condition has to be counted is as follow

$$R \text{ /reacharge/} \neq D \text{ /discharge/} \qquad 1.$$

The error in estimation of hydrological parameters /ie. infiltration/ would be reached 30-35 % therefore the probability of R=D condition could be rare. The reliability of water balances /made by this way/ can be shown by condition n. 2.

$$E = \frac{/R-D/}{D} \; ; \; E = AE \qquad 2.$$

where the error /E/ of water balances is less than the acceptable error /AE/which is 10% of total discharge.

The model can be used to make water balances for unclosed water units /there is horizontal flow between the units/ too taking into account the condition number 2.

The areal distribution of water balance elements and their standard deviations are estimated by methods used in geostatistics.
The parameters of finite elements used for the model can be given by this way.

Infiltration. The surface for infiltration, the morphology and the vegetation were determined for each finite elements. The algorythm of infiltration has been based on the data of a 15 year long field experiment. The infiltration under a Δt period can be counted as follow

$$I = P - PL \qquad 3.$$
$$PL = SR + EP \pm \Delta w \qquad 4.$$

where I = infiltration; P = precipitation; PL = precipitation limit; SR = surface rum off; EP = evapotranspiration; Δ w = change of soil humidity.

According to the equations n,3. and n.4 an empirical function was determined between the yearly precipitation and infiltration for each meteorological stations:

$$I = a + b.\ln P \qquad 5.$$

The 50 year long average infiltration was estimated by n.5. which becomes the bases of comparison for annual water balances.

Discharge. The separate objects of discharges can be determined by their coordinates and they are summarized by the model for each finite elements.

Water level. The yearly change in water level /$\pm\Delta H$/ can be estimated by the water data measured in monitoring wells, waterworks and mines. This analysis has been made for area of unconfined karst water system which is two time more than the infiltration surface becouse some parts of original confined karst system have became unconfined ones according to the mining dewatering activity. The model is able to follow the change in the area of unconfined karst water system automatically.

Porosity, permeability. The porosity of karstic rocks was estimated by a long time experience in the field of geology, mining and drilling, further on analysing the data of fissure statistics, pumping tests etc. The world wide experiences and a lot of flow tests made by the author been do shown that the permeability of karstic rocks should not be estimated separatly of the porosity. By the way; if the porosity of karstic rocks is determin , the permeability becomes also determined becouse the porosity can be formed by the karstic chanels and fissures which serve the flov passes too. The relation between the porosity and permeability has been established by empirical way:

$$k = a.e^{b.n} \qquad 6.$$

where k = permeability; n = porosity

Hidrogeological connections. The hydrogeological connection among the karstic waters and the other type of ground waters as well as the surface waters a their quantitative values can be estimated by differences in the water levels and their related surfaces.

3. CONCLUSIONS

The water balances form 1978 to 1983 have given good possibilities to analyse the karstwater development situation on the TMR.
The total area of this type of water system can be devided into three quasy indipendent water balance units /Figure 1./. They are as follow:

- the Eastern,
- the Central,
- the Western units.

Precipitaion. The precipitation was under the long year average value during the examined period taking into account the total area of the TMR. The lack of precipitation reached seven hundred millimeters in 1978, 1981 and 1983. Seeing the water balance units; in the Eastern unit the average value in 1980 only; in the Central unit it was the same situation in 1980 and 1983, however in the Western one the precipitation was under the average value in each year of this period.

Infiltration. The infiltration counted by equation n.3. and n.5. gave different pictures among the units. **Eastern unit:** The summarized lack of infiltration was -34 million m^3 comparasing it to the 50 year average. **Central unit:** It is the only one where surplus was given by the infiltration balance / +16 million m^3/. Western unit: The most critical situation was shown in this unit becouse the lack of infiltration reached the - 222 million m^3! The total lack of infiltration was - 236 million m^3 for the TMR /see Figure 2.a./.

Discharge. There was no practically change in the dicharges during this perion both in the units and on the TMR /see Figure 2.b./.

Water level change. The change in the water level can be illustrated by Figure 3. The average water level change year by year can be seen on Figure 3.a. both for the units and the TMR. The water level continously decreased during the examined period. Those parts of decreasing which were caused by the natural conditions could be estimated on the differences of yearly and 50 year long average infiltration /Fig.3.a./.
Eastern unit: The natural increasing of karst water level might be observable in 1979, 1980 and 1983. The lack of infiltration /see above/ however could make a summarized decreasing of the water table which had been of - 1.0 meter. It was of 15 % of the total negative change between 1978 and 1983.
Central unit: A positive change of water level of 0.8 meter could be counted from 1978 to 1983 according to the total surlpus of infiltration. Consecquently the total decreasing of karstwater table can put down to account of human activity.
Western unit: The consequences of the enormous lack of infiltration might be a hard natural decreasing in the karstwater level. According to the estimation the value of this decreasing would have been of -48 % of the total negative change had followed the unfavourable meteorological conditions.
Transdanubian mountain range. Decreasing of the water level was caused by both natural and human conditions. The value of natural decreasing was of 30% the total one.

The change of the water level in the centre of depression cones formed by dewatering ativity of mines can be seen on the Figure 3.b. On the area of Eastern unit the depression for six years caused by coal mining dewatering has been greater than 28 meters which is four time more than the natural decreasing in this unit. The difference between the average water level change and the decreasing of water nivou in the centre of depression cone less than 10 percent in the Central unit. The unifor distribution of dewatering /water works and mines/ is shown by this fact. The situation of the dewatering influences in the Western unit likes to be the same one as it is in the Eastern unit.

The summarized yearly water balances for the TMR is shown by Figure 4. Taking into consideration of realization of the condition n.2. it can be proved that the water development sitation of the TMR has been well caracterized by the water balance model. The rate of the reacharge from 27,6 to 77,7 % of the water intake, consequently the rest of the yields could be compensated from the decreasing of the stored karstwater resources.

The debits of mining dewatering continously have take a higher rate of water than the yearly infiltrations have been able to compensate and the results of these situations are an unbrokenly decreasing in the water level and the stored water resources too.

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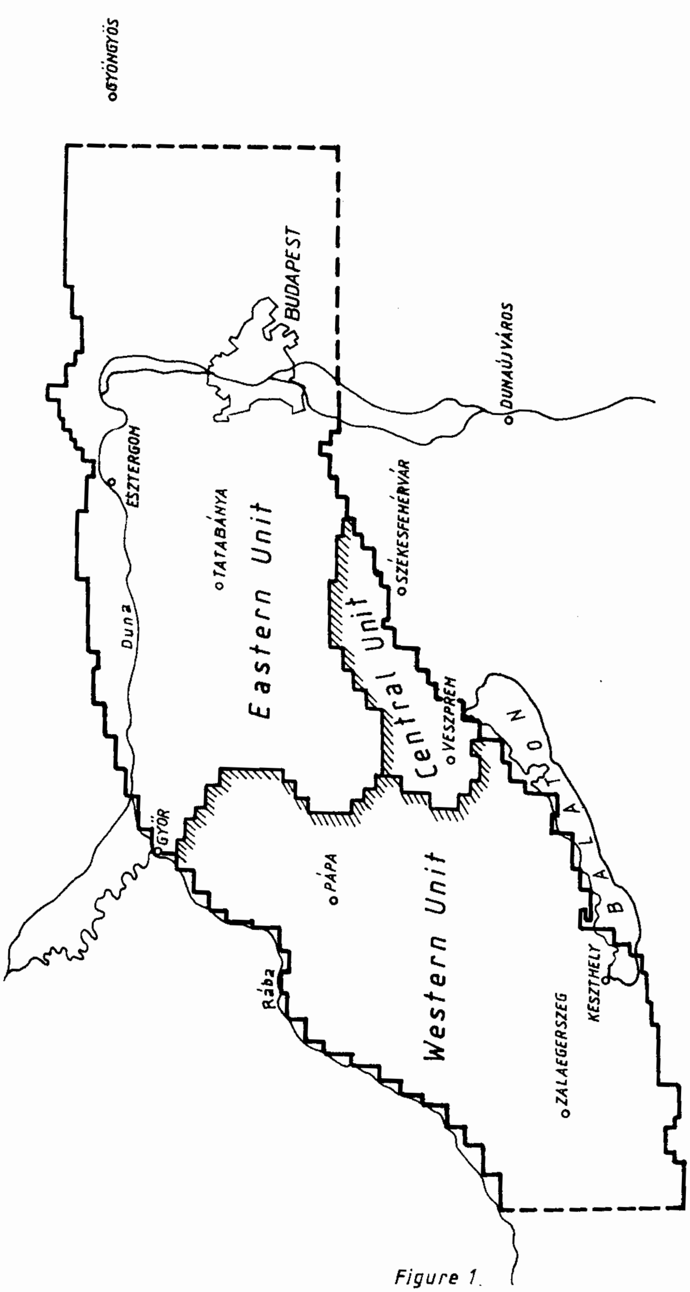
The years of poor precipitation and infiltration causes the water enviroment greater troubles than the wet years can make. The lack of reacharge can fasten the unfavourable results of minig dewatering on the enviroment.

The water balance model of the TMR based on the simple algorytms worked by field tests and experiments up can well characterize the water development situation of this area and it seems to be a suitable one to design the reasonable utilization of karst water resources, the mining dewatering and its results on the enviroment.

/The author expresses his thanks for all of his collegues working at oil, coal, bauxite mining companies and water works for their valuable helps and advices for the development of this water balance model./



WATER BALANCE MODEL
OF THE TRANSDANUBIAN MOUNTAIN RANGE

Figure 1.

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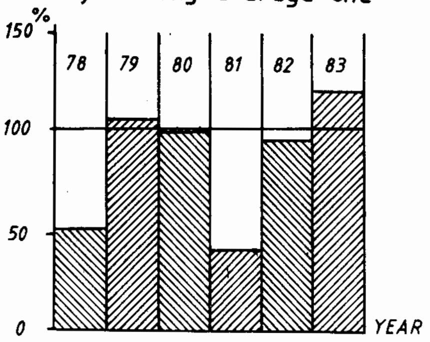
INFILTRATION AND DISCHARGE

2a. Yearly infiltration in the percentage of 50 year long average one



2b. Discharge and its distribution

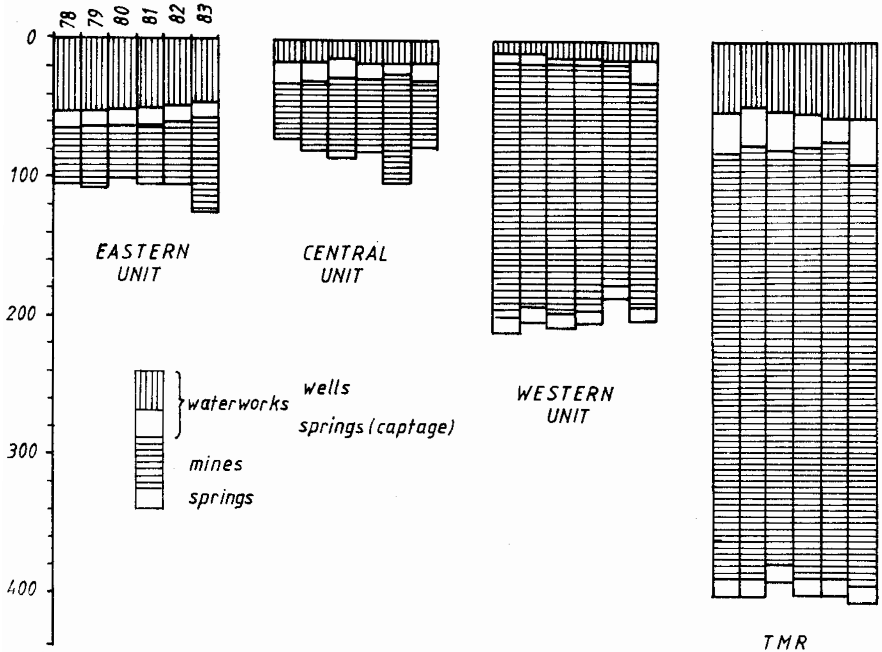
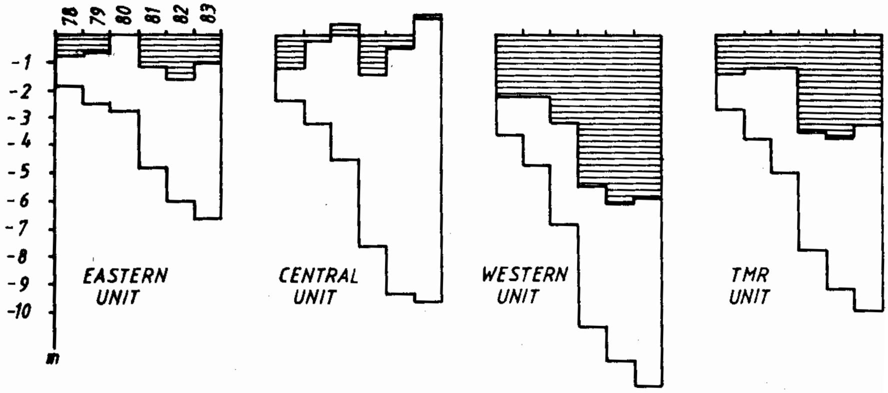


Figure 2.

CHANGE OF THE YEARLY WATER LEVEL

3.a Average change in the water levels



3.b Water level change inside the depression cones

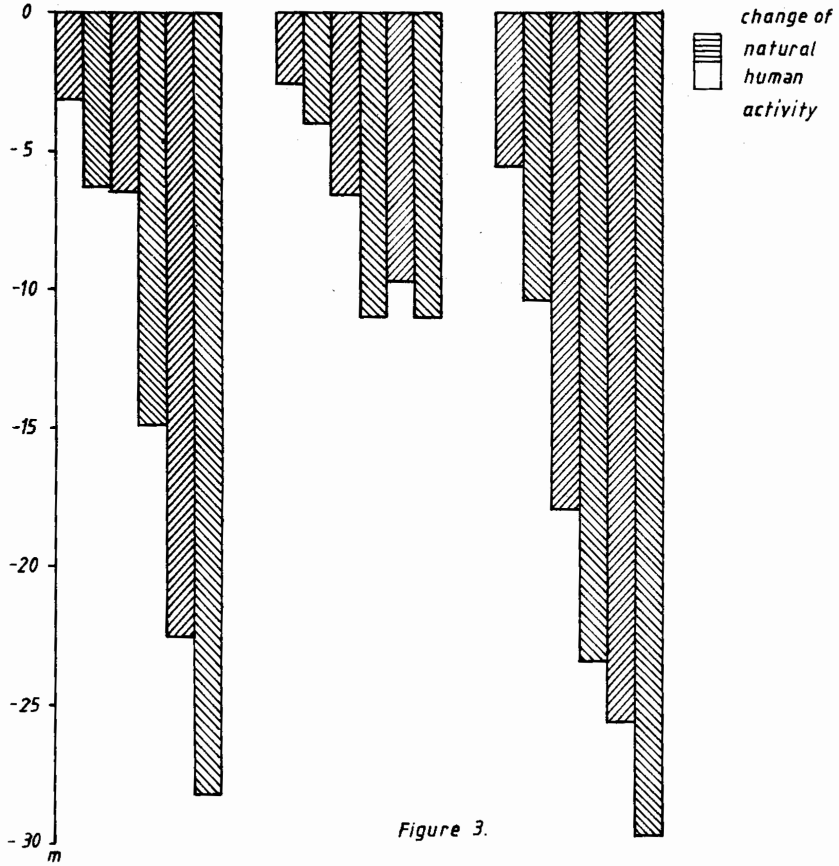


Figure 3.

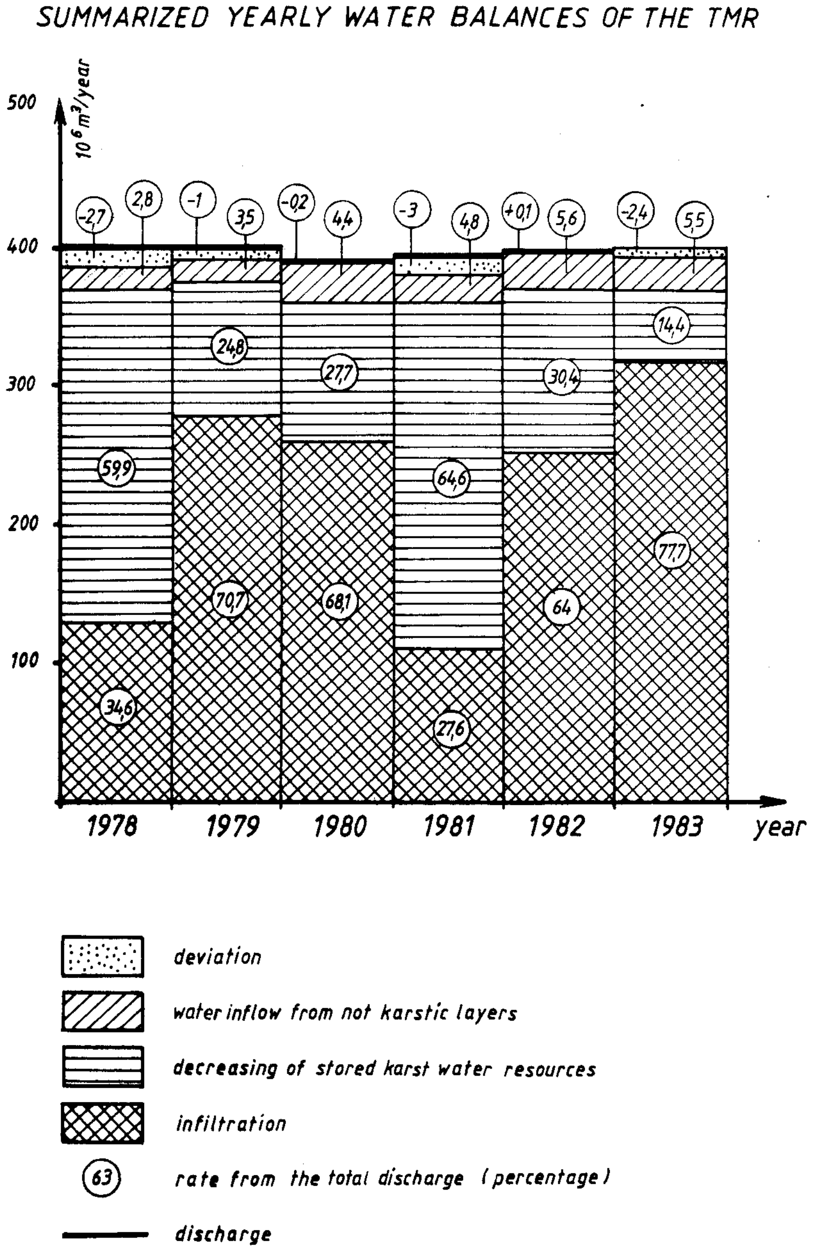


Figure 4.

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