KARSTWATER-FLOW-CONTROLLING GEOLOGICAL CONDITIONS IN THE TRANSDANUBIAN CENTRAL MOUNTAINS OF HUNGARY

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SUMMARY

This paper renders account of the geological fators controlling the velocity and direction of the karst-water flow in the concerned region. The conclusion, and tectonic conditions have a bearing upon the development of the Karst-water table morphology i.e. the shape of the depression cones provoked by water production.

INTRODUCITON

The karst-water reservoir of the Transdanubian Central Mountains constitutes a uniform and communicating aquiferous system. The local coal and bauxite deposits are mostly situated below the karst-water level. This involves an increasing water hazard for the mining operations gradually penetrating downwards. After some passive protective measures against water inrush, a preventive lowering of water level has been implemented. Nevertheles, this has resulted in the decrease and even ending of the water yield of wells and springs of the region whose water budget has been fairly changed. To meet the requirements of mining production and natural environment protection, more and more hydrological institutions of Hungary /VITUKI, OVH, KBFI and geohydrological surveys of mining companies/ have been invited to co-operate in the solution of karst-water problems. After joining these works, we started to investigate the geological causes of the anomalies of subsurface water flow in our region. When concluding an early phase of this work, the unlike water-transmitting properties of the Triassic carbonate complexes of different age, monitored from the angle of changes in rock facies and in the extent of karstification, could be outlined [5,6].

In this paper we analyse the position in space and interrelation of the individual geological formations influencing the movement, yield and level of karst-water.

METHODS AND RESULTS

Data of about 6000 boreholes sunk into the Mesozoic basement rocks of the Transdanubian Central Mountains have been processed. Unfortunately, the areal distribution of these drilling sites is rather uneven so that among densely drilled mining districts there are zones with a few boreholes only.

Upont the data collected, [1,2,3] on some 1:25.000-scaled map sheets it has been plotted the subsurface geological map showing the position of the karst-water level in 1978. This map has finally been reduced to be on a scale of 1:100.000 /its sketch appears as Fig. 1/.

This map proves the fact that the areal extent of the karstic rocks corresponding to the karst-water level /1180 km^2/ is hardly greater than that of the uncovered karstic rocks occupying 830 km^2. The Cretaceous to Tertiary sedimentary series inside the Mountains are situated as deeply as 200 to 600 m below the karst-water level, forming a subsurface natural barrier impeding or influencing the compensation of water level differences and the way and speed of the water movements. Isopachs of these sedimentary complexes of low or -- at the most -- medium transmissivity is presented in Fig. 1.

These deep-rooted tectonic basin structures stand in the way of the horizontal subsurface water movements forcing them to compensatory motions which take place in major depths i.e. along fault surfaces /basins of Ajka-Urkut, Szentgál-Herend, Csehbánya-Németbánya, Bakonybél-Pénzeskut, Zirc, Dudar-Csetény/.

Another subsurface "barrier" is given by the Upper Triassic Carnian Marl complex in the inner parts of the Mountain as well. This underlies the Hauptdolomit but can be found in an elevated position as having been uplifted along upthrusts some ten kilometeres long. This impedes the free water flow and the free expansion of the depression cone /Iszkaszentgyörgy, Veszprém, Kádárta, Padragkut-Ajka-Kislőd/.

The impervious strata of Carnian Marls and Middle-Lower Triassic, Permian complexes forming the N and S margins of the Bakony Syncline impede the waterflow and subterranean discharge, consequently generate a high waterlevel, specially as they are directly in connection with uncovered karst, i.e. territories of excessive infiltration.

Lava rocks in pipes and fissures related to the Late Pannonian basalt volcanism constitute some subsurface "barriers" penetrating into greater depths /zone between Taliándörögd and Monostorapáti/.

Thick Tertiary sedimentary sequences resting on the mountain's margin may have two different roles. Accordingly,dependently

on their water transmissivity, they can raise the karstwater level or compensate it wherever they contact directly waters stored in karstic aquifers. /Graben between S-Bakony and Keszthely Mts., Mór Graben, further the NW, NE and SE mountain's margin./

REGIONAL CONNECTIONS

The geological factors referred to mostly prevail in controlling the karst-water table and the form of the depression cones as being undulating and irregular, respectively. Consequently, some areal units have been distinguished on this very basis.

1. The Nyirád depression /Fig. 2./. As early as 1972, the water production in this zone exceeded 2oo m^3/min., and even, by 198o it came to 3oo m^3/min. This has resulted in the appearence of the regionally largest fall of the karst-water level extending to an area of 3ooo km^2. In a surface projection, this area is elongated according to a NNW--SSE direction, being somewhere sinuous. To the west, it is limited by the Miocene to Pliocene beds of the Lesence graben 6oo-7oo m deep. Eastwardly, Pliocene strata with the associated bodies of intersecting volcanics cut the depression. However, a direct connection with the open karst of the Veszprém Plateau has come into being as attributable to the present-day karst-water level. In consequence, an eastward advance of the depression also might be dealt with, despite the fact that the pertaining section of seepage /about 5 km long/ is reduced by the presence of volcanic pipes and fissure filling materials from the Kabhegy volcanic extrusion. Towards the south /Tapolca Basin/ the sharpest change in water level and, by Tapolca, the minimum fall of level /o-lo m/ is experienced, which is partly attributable to a "barrier effect" exercised by a karst-contacting Miocene complex 3oo-4oo m thick. Beside this, some considerable lithological changes are presumed to exist in the deeper structure of the basement complex. Namely, there is obviously no contact between the Tapolca thermal springs and the near-surface karst-water reservoir of Nyirád, so the former may have tapped some deeper karst aquifer with water rising along fault surfaces therefrom This the lowering of the arst-water level at Nyirád there brings about a retarded and minor decrease of pressure in an aquifer isolated geo-structurally. The fault along which water moves may be identified with that limiting the Balaton Highland as a composite thrust fault giving rise to several thrust sheets built of Carnian marl.

Up to 1976, a Kössen-Marls-controlled quick northward advance of the Nyirád depression boundary was observable. Even today, at some places a hollowing out of the NW and SE boundaries is recorded. On the other hand, the central zone displays a fall of water level below the base level of the Kössen Marl, giving rise to a direct contact between the two fault-separated dolomite bodies and to the formation of a northward-stretching extension. Farther to the north of this marl zone, this extension is getting to take up the SW-NE strike of the

Mountains.For a distance, it tends to increase owing to the Upper Cretaceous and Eocene limestones, which are in contact with the main Karst on account of their overlying position and tectonics.Nevertheless, north of the line of Gyepükaján, a Miocene-Pliocene sequence appears becoming so thick as looo m in no distance. This sequence resting on the subsided basement complex constitutes again a "hidrogeological barrier".

2. The Halimba-Padragkut depression. This depression provoked by a water production of 5,5 m^3/min. extends to a very small area /13 km^2/, due to a strong interaction by the Nyirád depression. It is controlled geologically by Kössen Marl in the north and south, and by a Jurassic sequence in the east. A structural connection with the Hauptdolomit reservoir of Nyirád is given in a westward direction.

3. The"water peak" of the Veszprém Plateau and High Bakony region. There is hardly any lowering of water level here. The High Bkony is limited by the Carnian Marl range on the surface and by older and non-karstic rocks of the basin floor. Only under some grabens filled with Cretaceous and Tertiary sedimentary rocks towards W and E, a free way of contact with the zones of the Nyirád and Dudar-Bodajk may exist. Towards the south, this region is separated from that of the Veszprém Plateau by deep Cretaceous-Oligo-Miocene sub-basins.

The southern boundary of the Veszprém Plateau unit is formed by impervious Lower to Middle Triassic beds of the Balaton Highland or by Carnian Marl resting normally or tectonically on the older Triassic complexes. The northern boundaries towards the High Bakony are given by Kössen Marl /Szőc-Szentgál/, Oligo-Miocene strata /Herend Basin/ and, lastly, by deep grabens filled with Cretaceous deposits /Zirc-Dudar/. In the direction of the prevailing trend of strike, this unit is hydrogeologically open towards the westward-situated Nyirád depression and also eastwardly /depressions of Várpalota and Iszkaszentgyörgy/. The high karst-water level of this 3 rd unit can well be explained by the existence of impervious boundary rock complexes and also by the karstic rocks that are widely uncovered enabling a high rate of percolation.

4. The Veszprém-Kádárta depression. Inside the Veszprém Plateau area the local production for the local water supply has produced a drawdown. Because of its being open easterly, this depression is frequently attributed to the water production of Iszkaszentgyörgy.

5. The Dudar and Balinka depressions. /Fig. 3./. The pertinent water productions of 16 m^3/min. and 8 m^3/minute, respectively, have provoked a shallow but areally extensive withdrawal of the karst-water table. The reservoir is Dachsteinkalk of high transmissivity. It is delimited by the Cretaceous-filled graben of Zirc-Dudar in the west, moreover it is contacted directly by the dolomite-made Karstland of the Veszprém Plateau in the south-west. Towards SE, a minor "water peak" is found

between the depression cone in question and that of Iszkaszentgyörgy. Northerly, the karstic basement complex has subsided gradually due to step faults, coming into contact thereby with the Cretaceous sequence made of alternating permeable and impermeable rocks, together with their overlying Tertiary beds.

6. The Iszkaszentgyörgy depression /Fig.4./ The areal projection of this cone of water level withdrawal shows an oval shape elongated according to strike. The northern part of this water level "morphology" displays a particular steepness. The pertaining zone is closed lithologically or tectonically in all directions, except for one to the west, towards the Veszprém Plateau. The eastern boundary is given by the deep Mór Graben, and this margin is characterised by a greater sinking of water level. The southern boundary coincides with that of the adjacent Middle Triassic impermeable rocks. As for the steepness of the northern water-table-morphological forms, it cannot be explained exclusively by the flow-retarding effect of the Tertiary beds contacted by the Karst-zone along faults. As deduced from the geological makeup of the adjacent zones, between the Ladinian Diplopora-bearing dolomite and the Carnian Hauptdolomit, the Carnian marl sequence must also have developed, however, only the overlying and underlying formations of the latter have actually been drilled. The marls contact the Diplopora-bearing dolomite by reverse faults. Recently, thermal water was also welled up in this zone, a fact that seems testifying to the existence of a reverse-fault-contact between a deeper-situated Karstic unit and the coldwater-bearing one lying near the land surface. At the same time, upon the sharp cold-karst water table, the above-mentioned marl series is presumed to have been developed between the two Karst units referred to.

7. The Várpalota depression /Fig.3./. Because of its being much more related to the Iszkaszentgyörgy depression towards NE, it can hardly be outlined in the karst-water table morphology. It is worthmentioning, however, that a significant water discharge into the southward-lying Miocene complex which rests on an older and impervious basement, is recorded. Through this Miocene sequence, water from the karst aquifer is being supplied for public and industrial use, beside the karst-water production of the coal mining at Várpalota.

Summarily, the karst-water level peaks of the High Bakony and Veszprém Plateau, belonging to the Transdanubian Central Mountains in W Hungary, are surrounded by major and minor areas of water level withdrawal provoked by water production in the pertinent zones lying to the W, NW, NE, E and SE. The extent of the area of influence of the karst-water table lowering is controlled by strike-wise lithological changes as well as by cross-faults of the regional tectonic setting. The lithological / tectonic "barrier effect" plays an important role in directing subsurface water flow in the marginal zones to the Mountains, however, it has some significance in the intermontane region too.

EXPLANATION TO FIGURES

Fig. 1. Geological makeup according to the level of the karst-water table -- 1. Impervious Palaeozoic rocks covered by Tertiary beds, 2. Palaeozoic -- Lower and Middle Triassic sequence belonging to the Balaton Highland series, 3. Carnian marls, 4. Carnian-Norian Haupdolomit, 5. Kössen Marl Formation, 6. Norian-Rhaetian-Lowermost Jurassic dolomite and limestones, 7. Cretaceous sedimentary rocks, 8. Tertiary sedimentary rocks, 9. Basalt pipes, lo. Contour lines showing the height a.s.l. of the karst-water table, 11. Isopachs of the Tertiary complex below karst-water table.

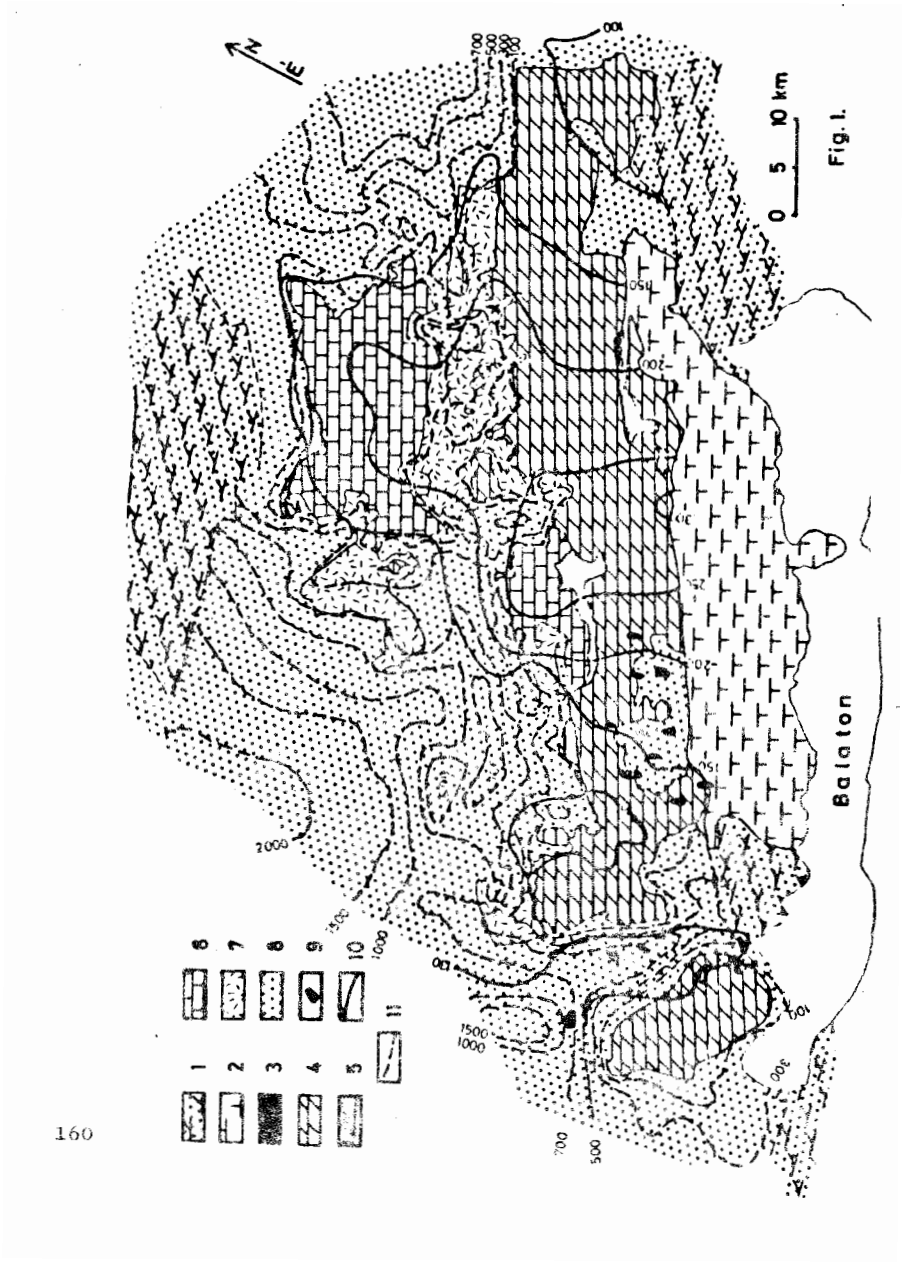
Fig. 1/a. Map showing localities and the karst-water table according to 1-1-1981.

Fig. 2. Sections through the area of the Nyirád depression -- 1. Karst-water-storing carbonate rocks, 2. Kössen Marl Formation, 3. Bauxite, 4. Eocene sedimentary rocks, 5. Tertiary sedimentary rocks younger as Eocene, 6. Lines showing the height a.s.l. of the karst-water table

Fig. 3. Section through the Dudar-Balinka and Várpalota depressions -- 1. Permian and Lower Triassic impervious complexes, 2. Ladinian Diplopora-bearing dolomite, 3. Carnian marls, 4. Carnian-Norian Hauptdolomit, 5. Norian-Rhaetian Dachstein limestone, 6. Jurassic sedimentary rocks, 7. Cretaceous complex, 8. Eocene sedimentary rocks, 9. Tertiary sedimentary complexes jounger as Eocene, lo. Karst-water table

Fig. 4. Sections through the Iszkaszentgyörgy depression -- 1. Ladinian Diplopra-bearing dolomite, 2. Carnian marls, 3. Carnian-Norian Hauptdolomit, 4. Bauxite, 5. Eocene sedimentary rocks, 6. Tertiary sedimentary complexes jounger as Eocene, 7. Karst-water table

Sections plotted by J. Kovács, figures designed by E. Rózsa and Mrs. K. Nagy-Gulyás.



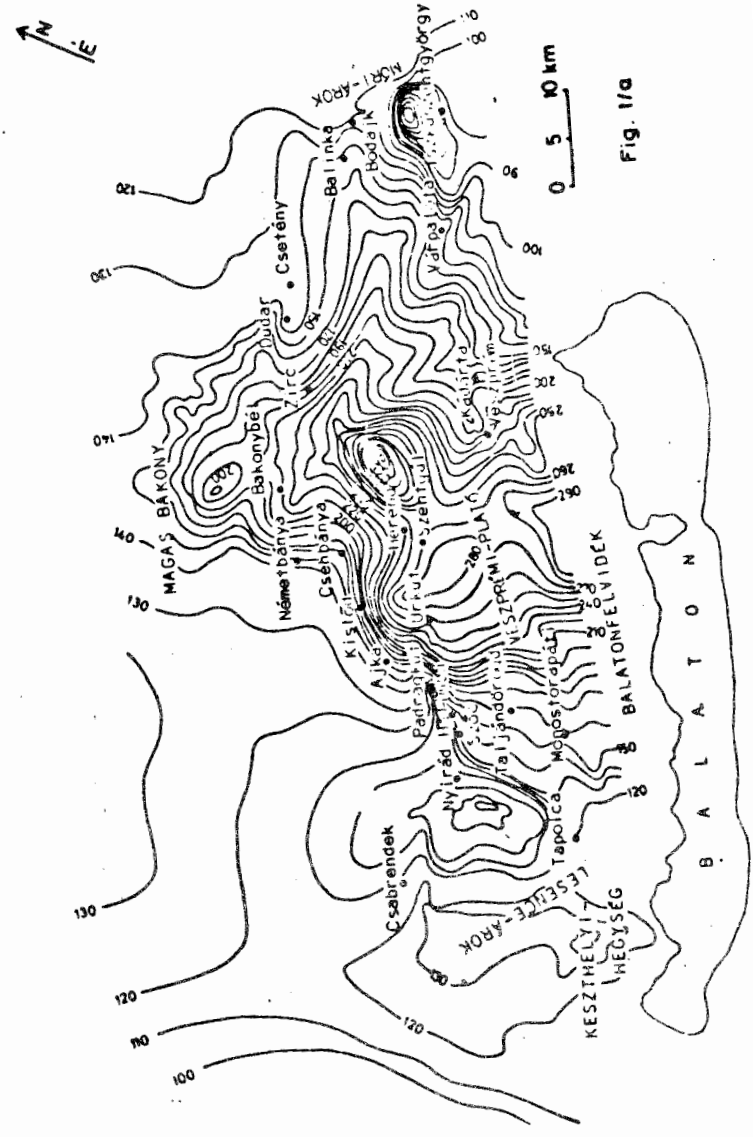


Fig. 1/a

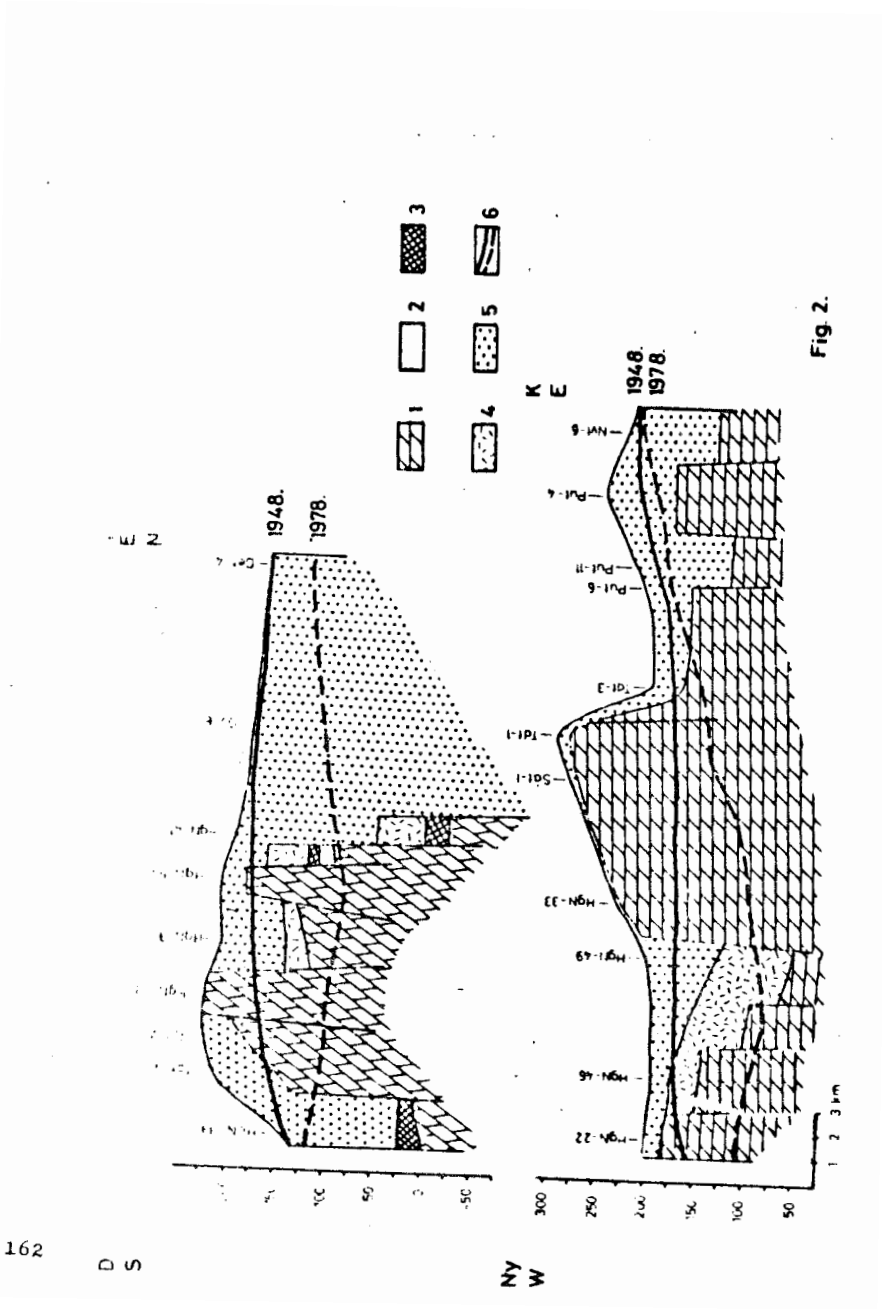
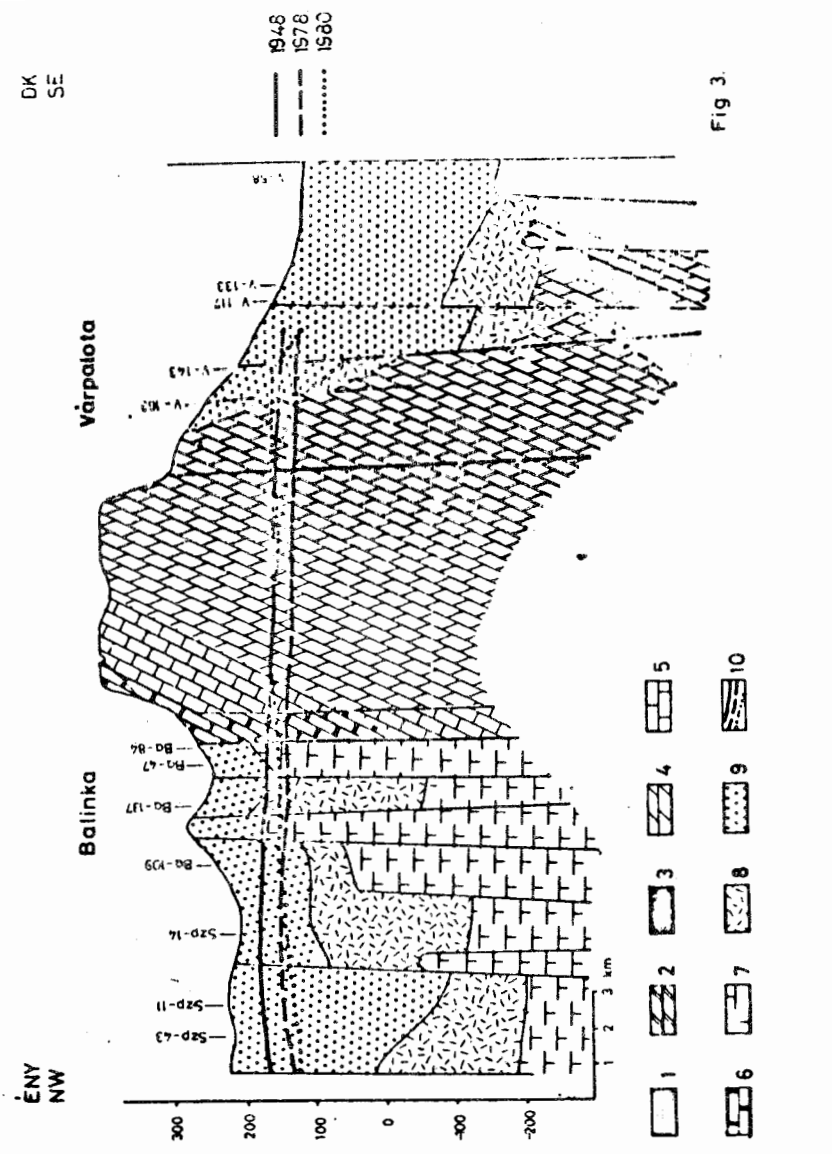


Fig. 2.



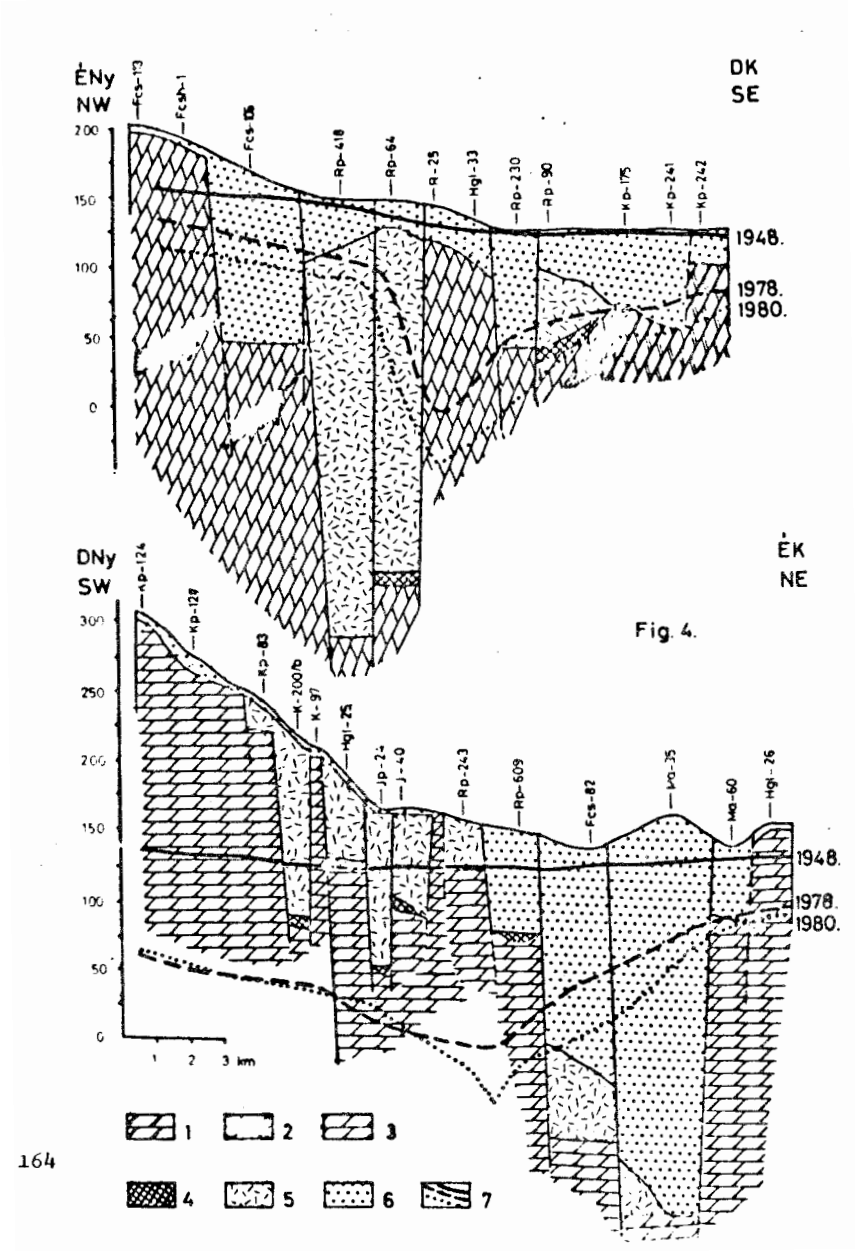


Fig. 4.