MINE WATER. GRANADA, SPAIN. 1985.

THE SIGNIFICANCE OF STRUCTUROLOGICAL INVESTIGATIONS IN DEFINING OF POSSIBLE DIRECTIONS OF INFLOW OF GROUND WATER INTO UNDERGROUND MINING WORKS

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ABSTRACT

The results of part of investigations which were undertaken for prognosis of possible directions of inflow of ground water into mining works of Jelovica brown coal mine in east Serbia are presented in this work. Among others, these investigations included neotectonic and photogeological analysis of fabric of the terrain, as well as detailed structurological investigations of water-bearing on numerous localities by empirical-graphoanalytical methods. All these investigations were performed without a detailed knowledge of geological features of the deposit, conditions of exploitation and results of other investigations (exploratory drilling, geological mapping, geophysical investigations etc.). Unfortunately, the study serving as the basis for the further development of the mine was not completed when a large quantity of ground water burst into the underground mining works. The real significance of the methods presented in this work was later shown by correlation of all the undertaken investigations.

GEOLOGICAL COMPOSITION OF THE INVESTIGATED AREA

The Jelovac Brown coal mine is located within kilometric size overthrust of red Permian sandstones over younger sediments of Cretaceous and Neogen age. The coal strata of various thickness are situated between layers of marls, marly limestones and clavstones. Due to the overthrusting of the red sandstones and intesive tectonic activity in the past, the thickness of the Neogene serie is highly variable. The uppermost layers are mostly destroyed and over the productive part of Neogene are red sandstones, but also ofthen is the case when Neogene sediments are included into the red sandstones. The base of the investigated area is composed of the intensively karstified Cretaceous limestones, over which sporadically lie basal conglomerates and coal bearing sediments. The karstification even underneath the water level of Resava River (the main erosional basis of ground water in the investigated area) was established by geoelectrical investigations. Geological map of coal deposit area is shown on Fig. 1.

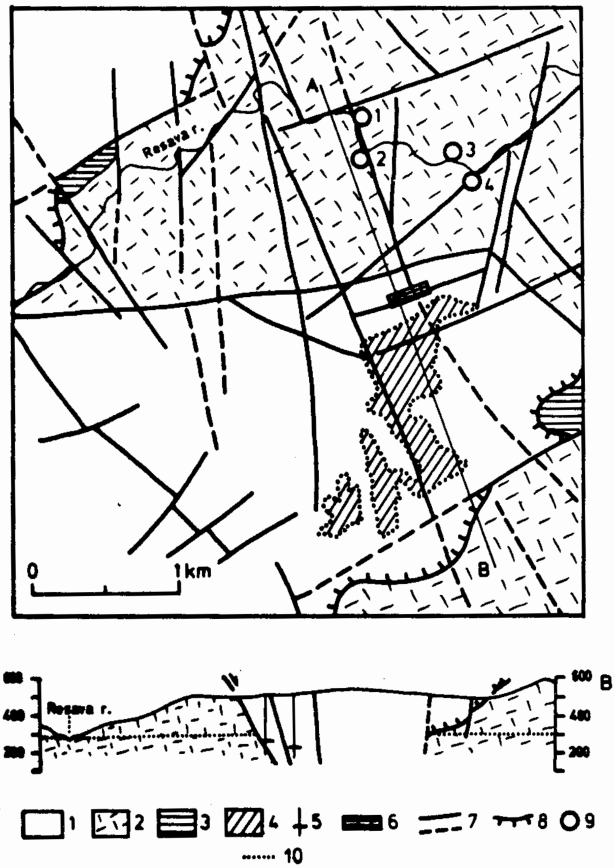

Fig. 1. Geological map of Jelovica brown coal mine deposit: 1-Red Permian sandstone, 2-Karstified Cretaceous limestone, 3-Neogene, 4-Old mining works, 5-Coal-bearing drill hole, 6-New mining works, 7-Photogeologicaly established fault, 8-Overthrust, 9-Point of determination of parameters of fracturing and water-bearing of rocks, 10-Persumed level of kars-

tic ground water

Up to date exploitation of coal was carried out within the red sandstone overthrust, further away from the contact with the limestones and practically without any problems conserning ground water.

THE RESULTS OF NEOTECTONIC INVESTIGATIONS

Neotectonically active zones in the areas with fractured and karst type of porosity may often indicate directions of increased circulation of ground water. Different methods of quantitative geomorphological analysis are applied in distinguishment of neotectonically active zones such as analysis of partial hydraulical gradient, analysis of relief energy, generalisation of relief etc. (Marković, 1983). In intensively karstified areas with disintegrated relief and destroyed drainage pattern practically only method of generalisation (reconstruction) can be applied. In terrains with combined karstic and non-karstic areas, useful data are obtained by analysis of relief energy (Krešić, Tasić 1984).In this case method of relief energy analysis was selected (Fig. 2). Values and orientation of isollines

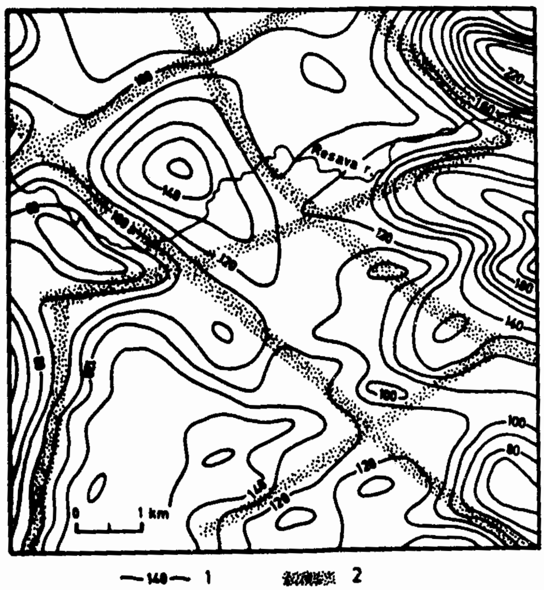

Fig. 2. Neotectonic map of Jelovica brown coal mine area: 1–Isoline of the first trend of relief energy, 2–Neotectonically active zone

clerly indicate the existence of two regional zones of neotectonic activity whose orientation generally coincides with the orientation of photogeologically established ruptures (see Fig. 3.). Very importan fact is that in the area of mining works is the intersection of these two neotectonic zones.

THE RESULTS OF PHOTOGEOLOGICAL INVESTIGATIONS

Well depicted area with gray limestones with rare vegetation enabled distinguishment of ruptural forms much easier and faster than it would be possible by field work. Due to the weathered condition of the red san dstones also disables detection of ruptures in the field. Analysis of areal photographs yielded valuable data about the ruptural pattern of the investigated area where the coal mine is located and enabled distinguishment of potential directions of inflow of ground water into the mining works. Two dominant fault systems were identified (Fig. 1 and 3.), where large faults, with strike NW-SE, which intersect new and old mining works were separately presented. These younger faults were formed in

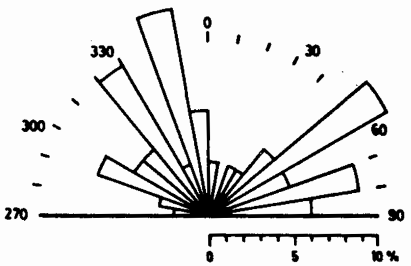

Fig. 3. Rose diagram of orientation of photogeologically determined ruptures

the period after the overthrusting of red sandstones (Pliocen and post-Pliocene) intersect the boundaries of non-karstic areas, connect two large limestone units and are perpendicular to the flow of Resava River. The above mentioned facts undoubtedly indicate potential danger of inflow of ground water during the excavations beneath the level of Resava River even if these works are further away from the contact of the limestones with sandstones.

THE RESULTS OF INVESTIGATIONS OF PARAMETERS OF FRACTURING AND WATER-BEARING IN LIMESTONES

On the basis of defining of " macroruptural " fabric of the investigated area, by methods of neotectonical and photogeological analysis, a large number of localities was selected for detailed field investigations of fracture systems. The results obtained on four points which are characteristic for the whole investigated area are presented on Fig. 4. The method

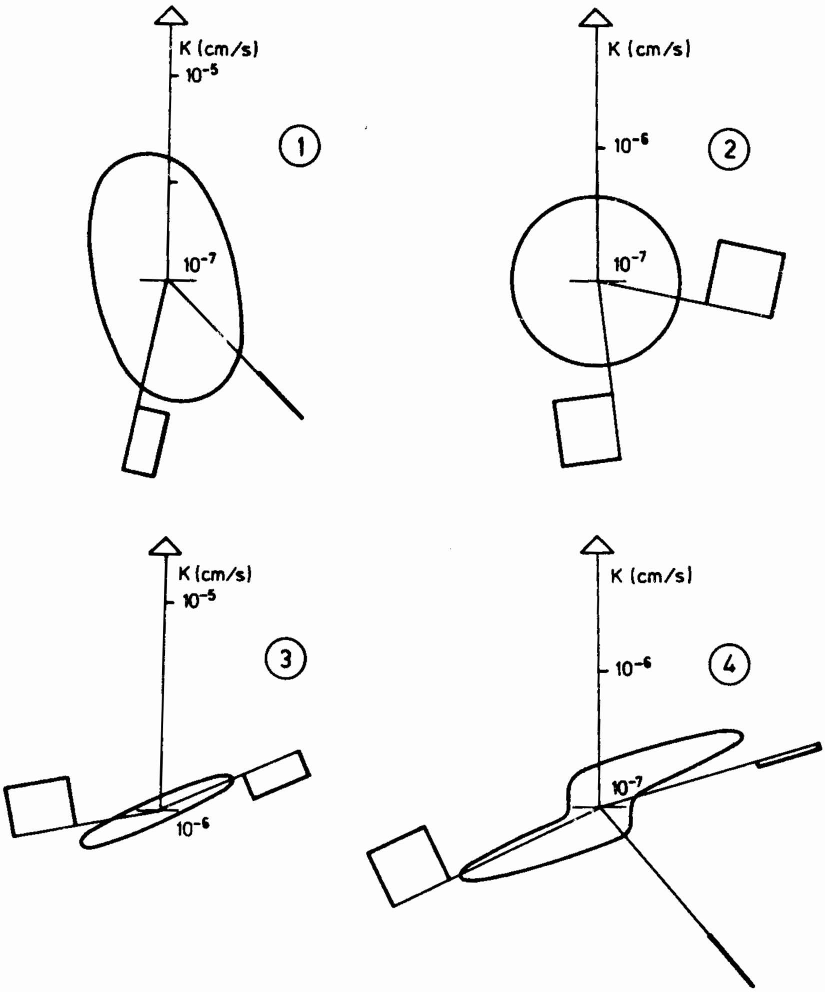

Fig. 4. Millers diagrams and elipsoids of permeability of fracture systems on particular points (see Fig. 1.)

of E. Castillo (1972) was used for determination of porosity of the limestones, which is based on elementary parameters of fracturing.

$$\sum_{i=1}^{m} n_i = \sum_{i=1}^{m} G_i \times b_i \qquad (1)$$

n_i - **effective porosity of the fracture system (family) (i)**
G_i - **intensity of the fracturing of the analysed family (i)**
b_i - **active opening of the investigated family (i)**

Permeability coefficient in fractures was determined without the influence of degrees of karstification by the metod of V.Vanham (1962)

$$K_i = b_i \times G_i^2 \times \varsigma \qquad (2)$$

K_i - permeability coefficient of systems of fractures (i)
b_i - active opening of the systems of fractures (i)
G_i - intensity of fracturing of the family (system) of fractures (i)
ς_i - kynematic viscosity coefficient of water (ς = o,olol cm^2/sec)

Effective porosity was calculated for the families of fractures, but karstic forms (channels and caverns) were not considered. According to our analysis on the basis of E. Castillos method the value of effective porosity of the limestones reaches:

$$n = 3,7\%$$

Permeability was analysed in horizontal plane of observation. The results of investigations of permeability in limestones in some localites represent contribution to the knowledge about anisotropy of water yieled, which is conditioned by complex ruptural fabric. The spatial position and permeability of dominant families (systems) of discontinuity supplement and confirm the presence of significiant faults (ruptures) (Fig. 4.).

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