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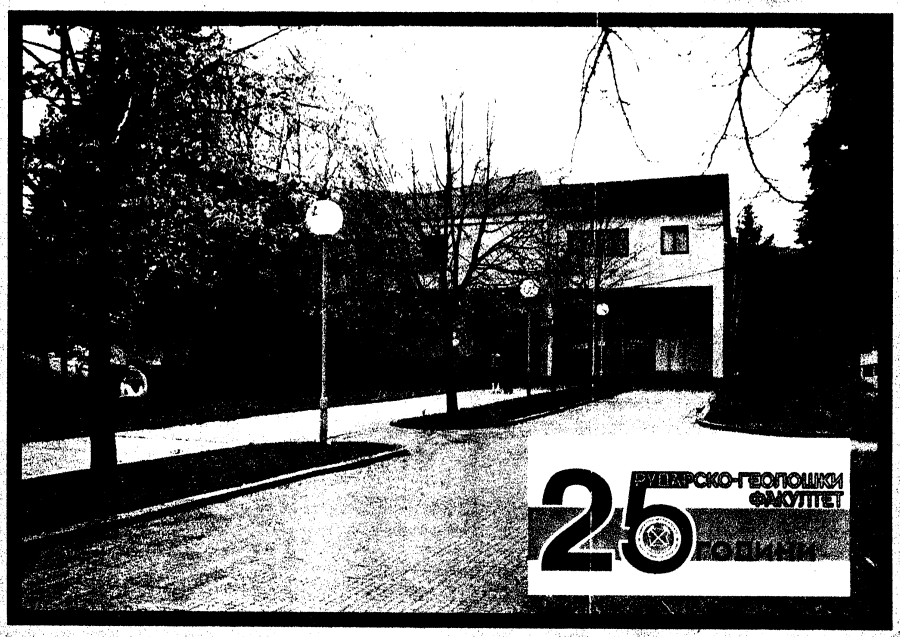

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INVESTIGATIONS CARRIED OUT ON THE INTAKE OF THE THERMOMINERAL WATER OF THE KEŽOVICA SPA NEAR THE TOWN OF ŠTIP

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Abstract: One exploration borehole of 500 meters in depth was carried near the Kežovica spa in 1975/76 in order to find out the possibility for the utilization of the thermomineral water. Granites in which the thermomineral waters are located are intensely fractured by tectonic movements 450 meters in depth. In the parts lying deeper than 150 meters the fractures are filled with calcite precipitated by warm waters. The thermomineral water near the Kežovica spa is not self-potential and it is subartesian. The temperature of the water in the boreholes ranges from 23 to 50°C and the capacity amounts from 0.165 to 0.200 l/s.

Key words: thermomineral water; exploration borehole; Kežovica spa; granites; Upper Eocene sediments; water temperature

INTRODUCTION

The Kežovica thermomineral spa is situated in the eastern part of the Republic of Macedonia some 2 km southwest of the town of Štip (Fig. 1). The water of the spa was utilized as early as the period of Turkish domination. Today, the water is obtained from exploitation wells. Only in the Ldži locality, which is close to the Bregalnica River it rises to the surface.

Милоевиќ (1953) carried out the first detailed investigations of the water with 6 boreholes of 10 to 43.2 meters to depth. Михолиќ (1953) carried out the first chemical analysis of the thermomineral water. Баиќ et al. (1954) gives detailed data about the water capacity and its utilization. Lado (1955) reported on data of test pumping with 3 boreholes. Data about geological and hydrogeological characteristics of the water of the Kežovica and the Ldži localities are given by Настиќ (1968). Ђузелковски et al. (1973) point out that the structural-tectonic patterns in the area round the spa provided good conditions for the occurrences of thermomineral waters. A synthesized data from all early investigations about the mineral waters in the vicinity of the town of Štip can be found in the paper of Котевски (1974). Кекиќ (1973–1978) gives data about the geological-structural-tectonic characteristics of the terrain including also data about the hydrological, chemical, temperature characteristics, the water capacity, as well as the system and the origin of these thermal waters.

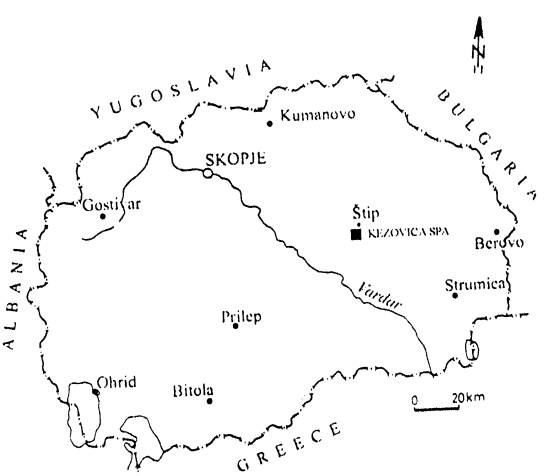

Fig.1. Geographic position of the Kežovica spa

GEOLOGICAL COMPOSITION OF THE SUROUNDING

Based on the tectonic setting of Macedonia the area around Kežovica belongs to the Vardar zone (Арсовски, 1997). The geological composition of the immediate surrounding of Kežovica is shown using the data of Ракичевиќ et al. (1969). It consists of

- Quaternary sediments,
- Pliocene sediments,
- Upper Eocene sediments,
- Jurassic granites.

Quaternary sediments occur along the Bregalnica River valley present as old river terraces made up of andesite round pebble and rarely of quartz and gneisses as well as of alluvial sediments made up of gravel and sand.

Pliocene sediments are present west of Štip and in the Lakavica graben. They are made up of sandstones, loams and gravels.

Upper Eocene sediments are present as a basal series made up of conglomerates, marls and sandstones and flysch sediments as sandstones, marls, conglomerates and limestones that make up the upper parts of the Upper Eocene sediments.

Jurassic granites are known as Štip granites. They are heterogeneous in composition and are made up of biotite adamellite, as well as biotite and aplite granites. The thermomineral water occurs in a fault zone extending along the contact between Jurassic granites and Upper Eocene sediments. The Ldži spring that is located close to the spa occurs in a fault zone of the granites.

EXPLORATIONS

In 1975/76 one borehole was carried out 500 meters to depth in order to investigate the possible use of the thermomineral water. The borehole was made 60 meters from the building between the spa and the Bregalnica River. The top part of the borehole consists of riverbank silt (sand and rockfall) 5 meters in depth. The lower part of the borehole was in granites.

DATA OBTAINED

Petrographic types of granites

Based on the mineralogic-petrological characteristics of the samples taken from the drill-core at various depths rocks distinguished were as follows:

- biotite-monzonite granites of pink and brown colour were distinguished 33 m in depth;
- leucocratic monzonite granites grey to dark grey in colour are present 55 m in depth;
- grey-brown granite porphyry can be found 144 and 278 m in depth;
- biotite dark grey monzonite-granite 378 m in depth;
- biotite-amphibole (cordierite) granite of dark grey and green colour can be found in the depth of 434 meters.

Data show that, in terms of its lithology, the Štip granitoid massif near Kežovica is a very heterogeneous magmatic body made up of several types of granites.

The core showed that the granites were intensely fractured 450 meters in depth by tectonic movements. It was also determined that most of the fractures are filled with calcite precipitated by warm water.

Water temperature

Measurements of water temperatures are shown in the diagram of Fig. 2. It shows that water temperature increases at the depth of 160 meters and decrease with depth. This is due to filling of fractures with calcite, due also to the smaller number of fractures compared with the parts near the surface. Water temperature at 3 to 24 meters in depth varies from 23 to 30 °C. The largest increase of temperature was registered from 112 to 125 meters in depth where it increases by 1 °C every 1.5 meters. Water temperature 112 meters in depth amounts to 45 °C and that of 125 meters in depth amounts to 54 °C. This data indicates that the drilling was carried out across a fracture zone with warm waters of greater depth. The broken core showed that 120 to 150 meters in depth the granites are very fractured. The borehole deeper than 160 meters did not cut any fracture zone with warm water. In this manner mixing of warm and

cold waters took place in the upper parts and reached a uniform value of 50 °C at 25 to 470 meters in depth.

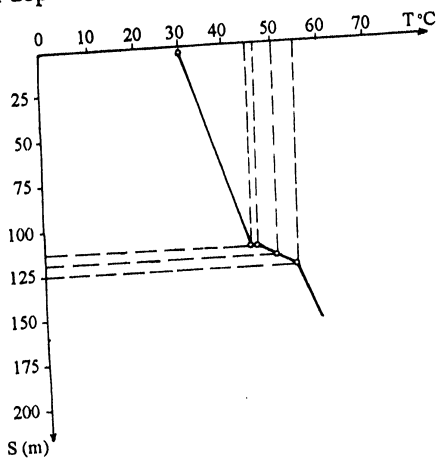

Fig. 2. Diagram of water temperature 160 meters in depth

Water temperature was also measured during test drawdown of water. The results obtained are given in the diagram (Fig. 3). Prior to measurements of water yield in the drill-hole, water temperature at 2.07 meters in depth was 28 °C, but 15 minutes later when water level was at 7.20 meters temperature increased to 39 °C. After one hour and ten minutes (at 7.38 meters) temperature increased to 40 °C, and to 43.5 °C after 17.38 hours. Data show that geothermal degree in test drawdown of water 7.38 meters in depth is 0.33 meters or a meter decrease in the level results in a decrease of water temperature of 3 °C.

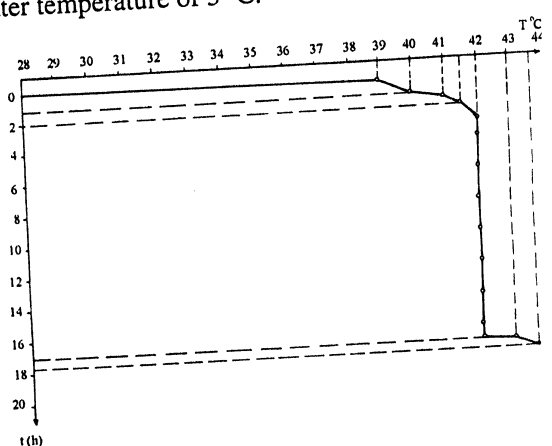

Fig. 3. Diagram of water temperature in the exploration borehole measured during test drawdown from 2.07 to 7.38 meters in depth

The above mentioned indicates that the temperature increase of water is influenced by water circulation caused by test drawdown to depth where drawdown conducted washing of fractures – a process that activated warm waters at depth. This means that temperatures would increase if washing of borehole was done.

Hydrostatic pressures

Hydrostatic pressures on thermomineral waters during drilling were insignificant. In the beginning of drilling water level amounted to 2.65 meter in depth. During the drilling water level varied. At depth of 120 meters it went up to 1.40 meters and at 125 meters fell down to 2 meters. These were the highest variations during the drilling and, as said earlier, at 120 to 125 meters the highest increase of temperature of 49.5 to 54 °C was registered. This shows that rocks here are intensely fractured and warm water is transported through the fractures from depth. Taking in consideration the rise of water at this depth it follows that the real pressures of thermomineral waters in the locality are fairly higher than those registered at 140 meters in depth. Nevertheless, the thermomineral water in the spa is not self-potential as it is above the level of the Bregalnica riverbed and it is subartesian mineral water.

Water capacity of the exploration borehole

The capacity of water was determined by the use of Pa–80 pump. Test drawdown was done over a time period of 80 hours. Results obtained are shown in the diagram in Fig. 4. Test drawdowns yielded two decreases of the capacity consisting of:

Q_1 – 0.165 l/s, as first decrease, 7.16 m in depth,

Q_1 – 0.200 l/s, as second decrease, 7.60 m in depth.

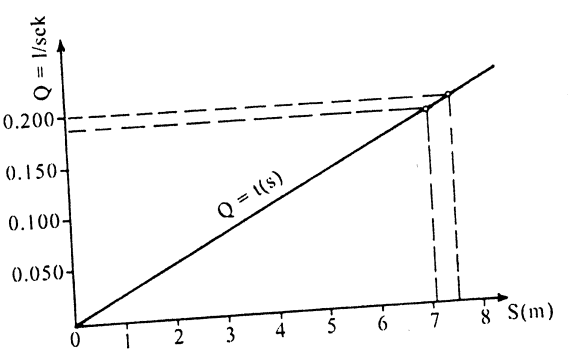

Fig. 4. Water capacity in drill-hole obtained by test water draw

The first water steadiness was reached after 15 hours and the second 18 hours later. Replenish occurred within 9 minutes, which means that there was a very good water recharge and there is good porosity of rocks to the depth.

Chemical composition of thermomineral waters

Chemical composition was studied at various depths during and after drilling and washing of the borehole. Results obtained in both cases indicate that the water is first degree chlorite-sodic type after the Alekin classification. Water differs with depth with regard to the total mineralization, hardness, and the decrease of Ca and absence of Mg in the analyses carried out on samples taken after washing the borehole. Homogenized residues with these analyses can not be determined because of melting which is contrary to the samples taken during the drilling. The poorer mineralization determined during drilling is due to mixing of thermomineral warm water and cold water of the Bregalnica River. Nevertheless, analyses performed after drilling and washing the borehole with warm water from the spa showed greater mineralization. Chlorite-sodic waters in the borehole are produced by dissolving products of decomposition of magmatic rock during replacement of calcium to sodium. The thermomineral water of this borehole is most similar to the thermomineral water of the Ldži spring in which magnesium is not found.

Origin of water

Taking in consideration the very complex tectonic fracture system of the granites, their decomposition and radioactivity of the waters of Kežovica and Ldži and based on the studies of the radioactivity of the waters performed by Аљатовски (1973) it can be inferred that they are the second category radioactive waters. They are underground waters in deep tectonic fractures taking place under pressure in distortion zones of granite rocks and areas of late Orogene distortions (of Alpine age).

Rainfalls that penetrate deep along faults recharge the waters and circulating through fractures increase their temperature and the specific chemical and gaseous composition. The higher radioactivity of the thermomineral water in the spa compared with that in the Ldži spring is probably due to the large fault that extends through Strumica, near the spa, towards Sveti Nikole and Kumanovo known as one of the major dislocations in Macedonia.

CONCLUSION

The exploration borehole carried out near the Kežovica spa determined that the granites are fractured 450 meters in depth. Fractures 150 meters in depth are filled with calcite that precipitated from warm waters. Thus, during further drillings boreholes should be carried out 150 to 200 in depth. As pressures of thermomineral waters are low (do not ascend to the surface except for that at the Ldži spring) future explorations should consist of drilling wells and drawdowns with pumps that can be used at temperatures of up to 60 °C. Drilling of such wells should be done using clean water, particularly near the capture well in order to avoid closing of fractures that drain the warm water from depth.

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Р е з и м е

ИСТРАЖУВАЊА ЗА ЗАФАЌАЊЕ НА ТЕРМОМИНЕРАЛНА ВОДА ВО БАЊАТА КЕЖОВИЦА КАЈ ШТИП ОД ПОГОЛЕМА ДЛАБОЧИНА

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Клучни зборови: термоминерална вода; истражна дупнатина; бања Кежовица; гранити; горноеоценски седименти; температура на водата

Во текот на 1975/76 година, заради зафаќање на термоминерални води од поголема длабочина, во непосредна близина на бањата Кежовица се изведени истражувања со една истражна дупнатина за длабина од 500 метри.

Гранитите во кои се јавуваат термоминералните води и во кои е изведена дупнатината, под влијание на тектонските движења се интензивно испукани до преку 450 m длабочина, а во деловите подлабоки од 150 m пукнатините се исполнети главно со калцит, кој е наталожуван од топлите води.

Термоминералната вода кај бањата Кежовица не е самоизливна, таа има субартески карактер.

Температурата на термоминералната вода од истражната дупнатина се движи од 23 до 50 °C, а капацитетот е од 0,165 до 0,200 l/s.