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THE CONNECTION BETWEEN THE SEISMIC ACTIVITY AND GEOTHERMAL ENERGY ON THE TERRITORY OF R. OF MACEDONIA

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Abstract: *The occurrences of the thermal waters in Macedonia to the areas of young Neogene-Quarter valleys (neo-tectonic depressions) are been connected, i.e. To the terrains where newer tectonics being manifested, followed by a volcano activity appearance. Beside that, within the regions where natural thermal waters appears, there is a connection to the intensive seismic activity. By the practice, there is a close connection between the geothermia and the seismic activity, i.e. The existing natural sources almost allover are being connected to the seismic active fault structures. Very often, during the earthquake, there could be noticed direct influence to the existing natural sources either regarding the debut or the temperature.*

Key words: *geology, hydrogeology, termo-mineral water, geopathology, seismology*

Introduction

The magma activity is a kind of "laboratory" that is in the Earth's womb, and of that reason, there are continuous activities such as: active volcanoes, earthquakes, faults, fractures, both opening and closing of different channels within its womb, appearance and redirection of both ground flowing waters and geothermal waters, etc.

The magma, placed in the center of the planet Earth does not stay still. Its temperature is about several thousands degrees high.

All of these earth activities can cause different geological anomalies that are convincible indications of the presence of geothermal energy at certain localities.

The explorations up today in the Republic of Macedonia show that this country is very interesting concerning the geothermal potentiality. There are lots of geothermal systems within the valleys as well as several natural geothermal occurrences at the marginal parts. All this is connected to the litho-geological structure, tectonic texture and the seismic activity of the terrain. The special contribution to the appearance of the geothermal occurrences is the young magmatism.

During the geological history, the Macedonian terrain magmatically has been activated a couple of times of which the result is the nowadays presence of different magma tic rocks. Such a magma tic activity contributed to the existence of the geothermal

potentiality of the Macedonian territory.

The granitoides of Paleozoic and earlier age are present allover the Macedonian territory. They are most concentrated within both the Pelagonia massif and the Southeastern part of the Serbo-Macedonian massif. In the Vardar zone, i.e. in its most southern part, there are granitoides of age younger than Jurassic that is breaking through the ophiolite complex of the Vardar zone. Also, the large complex of basic diabase-gabbroide rocks (the main feature of Vardar zone) is of Jurassic age.

Within the Ohrid tectonic depression, at the Kosel village, there is a sulphatora that is concerned as a most remarkable relict of the youngest volcano activity in Republic of Macedonia.

Materials and methods

It is well known that earthquakes appear in different parts of the Earth Crust, but their location is closely connected to the stadium of the geological development of the certain region. Actually, the earthquakes are connected to those parts of the Earth Crust where characterized with high state of lability and strong tectonic movements.

The tectonic movements are a function of the exertions within the Earth Crust. The complex and somehow abstract influence of the exertions is most probably the result of many factors, starting with the mutual relationship between the hard blocks as particles through the state of differentiation of the material under the Earth Crust (the radioactive disintegration, etc.), further to the cosmic factors influence.

During the last several decades, there have been done a lot of explorations on the Macedonian territory. These explorations separately treated the reasons and the occurrences as for the seismics as for the geothermia. But, a special accent to the mutual relationship has not been given by now. However, beside the classic terrain methods of exploring by collecting geo-structural and hydro geological data, a special method of collecting data was planned, which resulted the defining of the testonical exertion. These results contributed to the better sight of the tension states, i.e. interpretation of the mechanisms of tectonic processes that influence both on the seismic energy accumulating and during the thermo mineral waters circling from the deeper parts, up to the surface.

Explored area

There have been studied about 300 occurrences of natural springs of mineral and thermo-mineral waters that also indicate the geothermal potentiality of certain areas in Republic of Macedonia.

In the Macedonian Eastern parts, i.e. within both the Vardar zone and Serbo-Macedonian Massif, there was an intensive magmatic activity during the younger Neogene and Quarter. During this activity, huge granitoide masses were intruded. These masses, as well as the older granite intrusions having radiogene

heat, are the principal causers of both over average and economically significant values of geothermal field, i.e. heat-flow in Eastern Macedonia. According to that, there could be very realistic prognoses of economic deposits and geothermal energy sources forming as a result of upper said. Numerous Paleozoic and younger hydrothermal occurrences confirm those prognoses. There have been confirmed over 30 natural springs of thermal waters having a temperature over 21^{o}C. The total quantity of these springs is at least 310 l/sec, i.e. 27.300m^{3}/day, and their geothermal energy is 402x106 kWh.

The mentioned occurrences of these sources of thermal water by their chemical characteristics, as well as the hydrological and general geothermal characteristics of their closer and wider surroundings, point to the existence of significant hydrothermal energy deposits, i.e. hydrothermal fluids having higher temperature value that, at certain localities is even over 100^{o}C. Especially more advantageous hydrothermal conditions are to be expected within young tectonic depressions filled by Tertiary and Quarter sediments, so that in their basic parts well as in the paleo-relief, there could be found huge quantities of thermal waters. Concerning this, characteristic valleys in Macedonia are: Kocani valley where has already been found a significant quantity of thermal water, than Strumica and Valandovo-Gevgelia valley. Skopje valley has also advantageous conditions because of its tectonic activity and Mio-Pliocene rocks covered with Quarter. Except for these, there are other also geothermal interesting valleys such as: Kumanovo valley, Dolni polog, Debar valley, the Kosel – Ohrid neighborhood and other localities prospective for geothermal energy exploration.

The direct way of using thermal water is very rare. There are many cases in the world where “the hart”, i.e. that heat concentration is being using in straight water heating purposes in a way that the straight water from one drill is been put in “the hart” where been heated and, through the other drill, under the hydrostatic pressure, comes out to the surface. About 5.000 flats in Melown City, about 73km far from Paris, have solved the heating problem this way. The water temperature in Melown is 73^{o}C with “0” from 100, up to 120 l/sec. This kind of opportunity offers Dolni Podlog with the water temperature of 79^{o}C, got at 307 meters of depth. It would be maybe good to add that the closed circling system of heating is specially being recommended for high mineralized and aggressive thermal waters.

There are a lot of GT power plants of lower or higher capacity. The biggest GT power plant in the USA is placed in California, in the geyser area, in New Zeeland within the Vairekei area, and there are GT power plants in Mexico, Japan, Italy – Pizza, Island, etc. It should be mentioned that besides the electricity production, the geothermal energy has

been used in other purposes in the world.

The example is Segedin City in Hungary where, been heated by geothermal water as well as the case in some quarts of Tashkent, Mahachala and other former SSSR territories.

The Japanese are pioneers in the field of geothermal energy using in the purposes of agriculture production, in aiming of getting vegetables of high quality. Their example followed Hungary, Bulgaria, former SSSR, Island, even R. Macedonia and other.

Certain experiments in Oregon – USA have given 50 – 60% better results in growing certain kinds of fruits in worm garden-beds. In Germany, there are significant results in fish rising in slightly heated waters at temperature of 23^{o}C.

In Ethiopia, there is a case of a geothermal drill that gives a magnesium chloride high concentrated solution that provides very easy and cheep production of magnesium (metal) whose market price is some over 700USD/tone.

In New Zeeland they use the geothermal energy as a hot water and as a mixture of water and steam in paper and cellulose production. It has also been used for desalting the seawater, mainly in drinking and other purposes in Italy, Japan, Mexico and other countries.

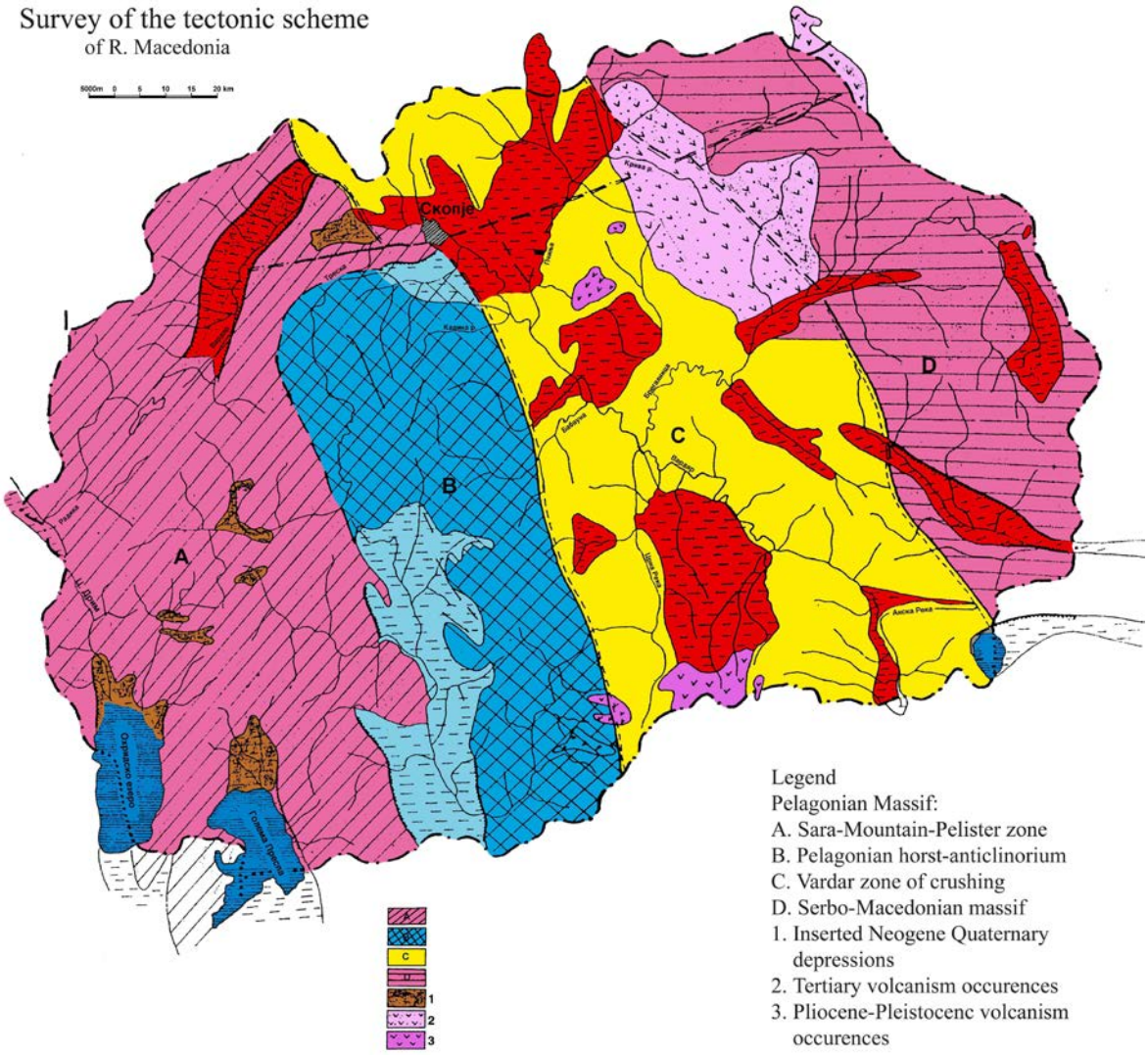
People have of many reasons always been very interested in the nowadays manifestation of seismic activity and the occurrences of the geothermal energy.

Both studding and getting acquainted with the earthquake phenomenon, as well as the thermal and thermo-mineral waters is of a huge importance both for the general understanding of the complex process acting nature, and of the practical aspect, because both the earthquakes and the thermo mineral waters present a significant subject in the mans life.

The texture deformations of the rock complexes are one of the exploring fields of the mutual relationship between the seismics and the geothermia, with special accent to the disjunctive forms as being direct and indirect carriers of the phenomenon itself.

The planet Earth is being an environment where many different processes manifesting, and the results of those manifestations sometimes reflect on the surface itself. One of these manifestations is the surface waving of the rocks, i.e. the earthquakes and breaking through the thermo mineral waters on the surface.

Both the earthquakes and the thermo mineral waters are the result of one complex process mechanism that took place within the Earth Crust and wider. The modern seismics and the thermo mineral waters mostly occurred within the zones of neo tectonic processes of development. That means that both phenomenons have many mutual characteristics (Fig. 1).



Results and discussion

The geothermal energy could be used in three ways, which depends on the conditions and circumstances on the terrain, where being concentrated, i.e.: using of thermal waters (directly), using of the rock heat and combined method. The first way is actually using the thermal water through the drills when being a transporter of the geothermal energy from the depth. The second way is being putting the cold water in the drill which has been drilled down to "the heart" i.e. the concentration of the heat. Here the water is being wormed up and, through the other drill, under the hydrostatic pressure, comes out to the surface. This way the geothermal energy could also be used. The third way is a combination of the previous two methods, and mostly used when thermal water not being sufficient for the planed purpose.

"Deposits" of priority, i.e. of potential, with convincing indications of concentrated geothermal energy that could be exploited are the area of Vinica and Stip that have already been explored. Of special geothermal interest is Kratovo-Zletovo volcano

area, as well as Slatino – Ohrid. Also, interesting for geothermal exploration are: Toplec – New Dojran, Raklis Village – Radovis, "Topli Dol" locality – Rzanovo, Mrezicko, Majdan Village, Demir Kapija, etc. All of the mentioned localities have convincing indications as well as surface manifestations (thermal waters) of concentrated geothermal energy (Fig. 1).

There could be different purposes and needs for the use of the geothermal energy, i.e. it has a universal and complex application. That is why during the single cycle and from one source could participate more than one consumer: electricity production over 130^{o}C; for public heating the water temperature needs to be 70-100^{o}C; for agriculture purposes 60-80^{o}C; for sports purposes 23-40^{o}C. During the summer when no need of heating, there is an alternative possibility for the geothermal energy to be used in industry, coolers and climatisation. According to the shown temperature needed in different purposes, we could claim that on the Macedonian territory it is possible, knowing that the certain geothermal energy surface manifestations have the following temperatures: Kocani's Spa - 65^{o}C, Dolni Podlog – Kocani area - 79^{o}C, Strumica Spa - 73^{o}C, Katlanovo Spa – 40-60^{o}C, Debar and Kosovrasti Spa – 40-50^{o}C. It could be added that when speaking about the heat value of the mentioned thermal waters, it should be foresight that they are surface manifestations, with exception of the Dolni Podlog thermal water. Surely, there could be expected significantly higher temperatures within the depth, and not only at the mentioned localities, but also, at the localities where the water temperature is lower.

The exertion regime activity determinates certain manifestations of stronger or slighter tectonically movements. So, the regional extensive regime activity results with radial deformations followed by terrain differentiation into morpho-textures of raising and sinking. The long-lasting deformations determinate a huge energy accumulation within both the surface and deeper parts of the Earth Crust. The continual energy accumulation is not infinite, i.e. there is an occasional exemption (very often as an earthquake) caused by the moment transforming of the potential energy of the deformed rocks into kinetic energy of the created elastic waves.

During the last few decades, there is intensive exploration aiming defining the correlative relations between the seismic activity and geothermal energy, because it is almost the rule that thermal waters occur within the seismic active zones and verse wise – the high heat gradient zones are almost always disturbed by occasional appearance of earthquakes.

The Macedonian territory as the region of intensive seismic activity and numerous localities with surface thermo mineral manifestations

is being an extraordinary polygon for exploring in many purposes. The results of this exploration could be used to define the relationship between the seismic activity and the geothermal energy, i.e. as useful data in geothermal deposits defining *(Kotevski et al.,).*

Even the significant results achieved, because of the complexity of the problem, there are still many questions opened. This results the need of further exploring by using modern methods with the aim of better knowing the processes that result the seismic and geothermal energy manifestations, i.e. their correlative characteristics, which concerns the Skopje valley too.

It is well known that while seismic activity there is an appearance of reinforced geomagnetic field. A part of the ground waters exploration (geothermal waters included) have been done in R. Macedonia by Soncev Zrak, leaded by D-r. Georgi Kotevski and D-r. Stojan Velkoski. Soncev Zrak has worked out numerous similar projects to this one, has several agreemants on scientific-technical cooperation in this field (Agreement with B.A.N - attached).

Conclusion

The up today researches in Macedonia point to the conclusion that Macedonia has all the conditions and possibilities of getting geothermal energy out from lots of deposits. Our territory by being an area of very intensive magmatic activity during the earliest geological époques actually is being a very interesting terrain for geothermal explorations. The surface manifestations of thermo-mineral waters as well as the other geothermal natural phenomenon are pointing to the existing of significant geothermal energy reserves at different regions that could be exploited and used in economy and other useful application.

From the upper said, it comes that the Macedonian territory has a solid geothermal potential but not exploited enough.

It should be mentioned that by extraction, one could get different minerals and gases from the geothermal waters. For example, UN helped in working out the Project for minerals extraction of 1 to 3 million dollars per drill. The minerals were lithium and cesium. By the mentioned, in most cases, also the geothermal water in Macedonia could be used in same purposes, but further exploration and investments are needed.

The Macedonian territory as a part of the active Alpian-Hymalai belt is almost allover characterized by intensive seismics.

The seismic activity is connected to the tectonic deformation processes that being characterized by a strong mobility during the Neogene-Quarter and later period. The mobility of the tectonic movements under the already mentioned regimes causes manifestation of destructive processes such as intensive faulting as well as

reactivation of older, pre-neotectonic ruptures.

Not having a complex Study on the problem of the correlative relations between the seismic activity and thermo mineral waters for the territory of R. of Macedonia, including the Skopje valley, points to the idea of realization of such exploration, which results could give the answer to the question of the mutual relationships between modern seismics and the thermo mineral waters, i.e. the geothermal energy. Even more, because of the fact that Macedonia is a quaking region within the Vardar Zone.

At the end we could conclude that the Macedonian territory is being a very interesting field for both geothermal exploration and geothermal energy exploitation in order to fulfill the goal which been treated in this paper.

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