

ANOMALOUS OF LOW-VELOCITY ZONE, THERMAL WATER AND SEISMICITY IN THE ELBASAN-DIBRA FAULT ZONE

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ABSTRACT

A detailed investigation of the hypocenter distribution beneath Elbasani, Albania, reveals a NE-SW-trending linear alignment of seismicity within the Elbasani-Dibra transversal zone. In the zone of Elbasani, hot mineral water (thermal waters) spot out from natural springs which have been known since the 19th century. We estimate the 3D seismic velocity structure in the Elbasani zone to understand the factors controlling the genesis of such earthquakes. A narrow low-velocity zone is imaged within the transversal fault zone over a length of ~50 km, which partly penetrates into the mantle. The low-velocity zone correlates in space with the NE-SW trending earthquake cluster. A reactivation of thermal water fracture zone is probably related to the low-velocity anomaly. Where geological conditions are favourable, rainwater seeps through the surface and becomes trapped in vast underground reservoirs so deep below the Earth's surface that it becomes heated to high temperatures by the LVFZ. The typology of earthquakes in Elbasan-Dibra comprises all three main well-known types of earthquakes: the earthquakes with main-shock followed by aftershocks, the earthquakes with foreshocks, the compound earthquakes, and the swarms. Seismic hazard for series of earthquakes in this urban area is very high and direct connection with the geology and hydrogeology of the location.

Keywords: low-velocity, thermal water, seismicity, fault.

INTRODUCTION

The Albanian mountain belt is a segment of the Dinaride-Hellenide orogeny that trends NNW–SSE (Fig. 1). It was formed by Alpine orogenic processes related to the Apulia and Eurasia convergence and the closure of the Mesozoic Tethyan Ocean [1],[3]. Elbasani- Dibra segment with direction SW-NE in Albania, represent an earlier transversal deep fracture, which contain thermal water and was hit by the frequent and strong earthquakes, being active now[12]. In this study, low-velocity layers analyzed as a promoter of seismic and geothermal energy generation. During the last century, several devastating earthquakes have occurred, causing casualties and substantial damage [2],[9],[10]. The the NE-SW trending earthquake cluster correlates in space with low-velocity zone. Analysis of observed differences in the values of P wave velocities in different depth layers allows us to develop our imaginations on the processes occurring inside the Earth. Using arguments based on heat flow, Anderson (1967)[2] proposed that the low-velocity zone was due to the presence of small amount of melt. The Elbasani zone is a particular area because has a considerable number of sources with geothermal potential.

II.GEOLOGICAL AND HYDROGEOLOGICAL FEATURES OF THE ELBASANI ZONE

The Elbasani-Dibra transversal fault zone of ENE extension, which dislocates the Albanides along all their width is marked out by diapiric cupola of Dumrea, the Quaternary Depression of Elbasan, the belt of trasversal structure of Labinot which continue with the trasversal flysch elevation of Golloborda. From point of view of the geological and tectonics-neotectonics phenomena the region where the studied zone is included take part in Krasta sub-tectonic zone, which is included in external area of Alpine folding. It is strongly affected by pre-Pliocene tectonics movement. The Krasta sub-tectonic zone has been deformed by folds, normal faults, as well as by strike slips from the main Alpine movement phases which folded the above mentioned tectonic zone [1]. Generally, the structures Krasta sub-tectonic zone extend from North to South (fig.1). The Elbasani-Dibra fault zone (ED), which represent a deep fault that has played an important role in development and structuring of inner Albanides in both sites of it [15]. This transversal fault zone extends from Albania toward the FYROM to the NE. To this zone are related many geological phenomena:

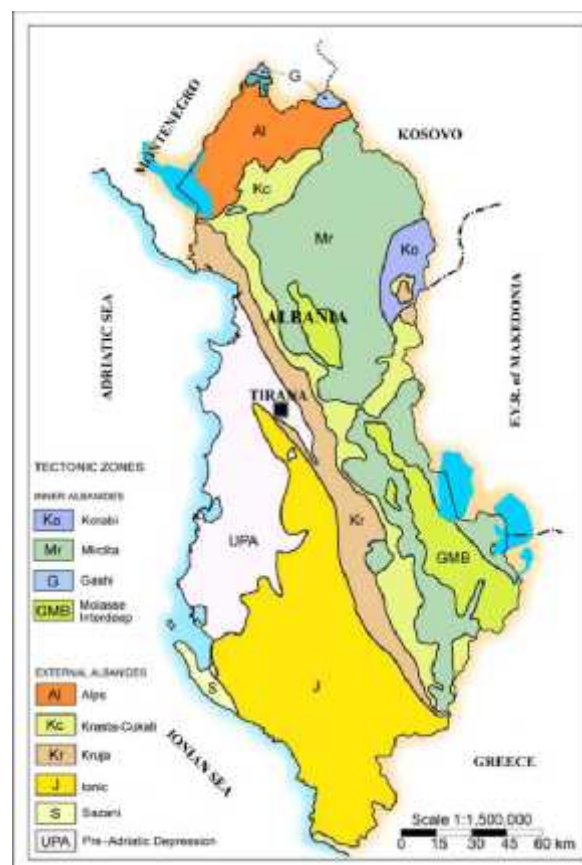


Fig. 1. Schematic tectonic map of Albani

The region is characterized by a high hydrodynamics regime, which comes from powerful movements of underground water with many resources. The thermal water resources of Elbasans are studied on general geolgo-geophysics done before. This characteristics show considerable influence of infiltracion water. What catches the attention is the contents of dissolved hydrocarbons, a fact which increases the interest of researcher for petrol or gas on this region.

I. DATA AND METHOD

These earthquakes were recorded by permanent broadband seismological stations that are part of the Albanian Seismological Network, as well by neighboring seismic networks AUTH, MSO, INGV and MEDNET (TIR). The V_p , V_s velocity model was computed with the SIMULPS program. To improve the stability and uniqueness of the inverse solution, a priori information on the model space may be used in the inversion process [6]. The procedure of the localization of P and S stage is fulfilled using the hypoinvers program [4] based on the velocities model of 1D Vel-Albanid [11],[13]. To enable a more accurate definition of low-velocity areas as a promoter of seismic activity, it is necessary to compile detailed velocities models to represent in the most accurate way the current wave velocity of a specific territory [8]. The analysis of low-velocity layers discovered from 3D tomography shows their relation to geothermal energy resources which further develops our knowledge on geodynamic processes in this area.

II. LOW-VELOCITY LAYERS AND GEOTHERMAL ENERGY

The existence of the low velocity layers might be the source of geothermal energy of hot water which has enough high temperature to be used as a source of energy in this zone.

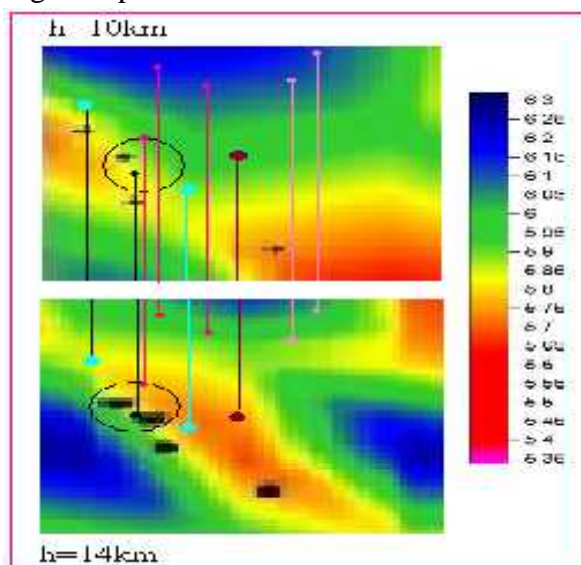


Fig 2. Lateral distribution of low velocities in-depth 10-14km.

This hot sulphur waters pushed by high pressure of gases get on the surface through the tectonic brakes of the lineaments of the zone. Analysis show that the low velocity layers in the Elbasan region are located in the earth's crust, at 1-3 km and 10-14 km depth (Figure 2). At 10-14 km depths the velocity of P waves is reduced from 5.82 km / s to 5.60 km / s, and the difference is $V = 0.22$ km / s or 3.8%. It is known that the low-velocity layer are characteristic for sismoactive regions [7],[11]. As a result of the high temperature in the lower velocity layers occur melting of materials. Geothermal energy resources in Elbasan area are evaluate as warmer water sources of underground layers, which have a temperature sufficient

to be used as an energy source. These thermal springs have low entalpi and maximum temperature up to 80°C [3]. The excistance of the low velocity layers might be the source of geothermal energy of hot water which has enough high temperature to be used as a source of energy in this zone [14].This hot sulphur waters pushed by high pressure of gases get on the surface through the tectonic brakes of the lineaments of the zone. In the south of Kozani-8, in the Shirjan valley, there are seven well-known thermal springs of Elbasani and Hidrati (fig 2, 3). Thermal sources of Elbasan have a constant flow of 15 to 18 l/sec for long periods of time [3]. Sources of thermo-mineral water of Llixha begin around 12 km south of the city of Elbasan while thermo-mineral water resources of Hidrat appear around 13-14km south of the city of Elbasan

II. THE THERMOTERMAL BASIN OF LLINXHA AND HIDRATI

This basin is one of the most famous and one of the most used in our country. On the surface it is identified through a number of sourcies placed like a chain form on the sector between Llixha and Hidrait(Fig.3).



Fig 3.. Location of hydrothermal resources of Llinxha and Hidratit

It consists of a thermo-mineral basin with a stable debit and high temperature. Geologically the sourcies are linked with the flishor formation with olistolite calcareous. This lithological formation is given with an age of the upper part of middle Oligocen. It is represented by huge calcareous blocks on olistolite and olistostrom forms dived on a clay matrix,which bulid the down part of the fat fromation. Calcareous are like baked, which indicate the constant movement of the underground water with high temperature on their composition. The olistolite formation has the role of a conductor horizont which makes possible the movement of thermal water from carbonic reservs of the depth to the surface. The thermo-mineral basin of Llixha today is buried in the depth of 1000-2000m (fig 4). Carbonic structure of this basin from the erosion area which had existed since the middle Oligocen geologic time –Burdigalian, are catched from inverse moves,dived on greater depth. On this conditions the basins have returned from surface basins to Thermo-mineral water basins,which drain naturally to the surface through

the horizon with olistolite. The geometrism of the depth for the carbonic ceiling of the thermo-mineral basin of the Llixha is done only with the help of sizmic profiles. The depth of this basin was found by an impale Elbasan 11, 1017 m deep, where the waters temperature goes to 32⁰C and from the impale Galigati -2, 2824 m deep, where the waters temperature goes to 64⁰C

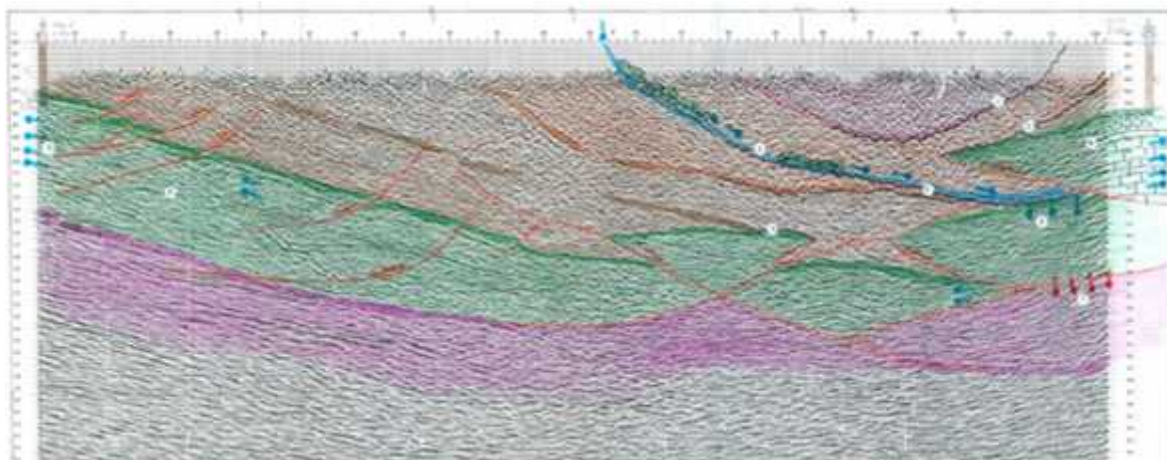


Fig.4. Thermomineral basin of Llixha

III. CLASS F CAT ON AND THE FEATURES OF LL NXHA SOURCE

Geo-thermal sources of Llixha area come out in a front with a length round 500m. (fig.3) and with Az.320⁰.

The exit front of the sources is located in the east side of the gravitative blocks (olistoliteve) of Kretak's limestones – Paleogene. In total are 20 water sources included in 7 groups. Classification and the division of the sources is made in groups. First group of sources is located in the southern extreme on the exit front of Llixha (Spa) sources, round 600 m. in north of Tregan village. This group is formed by two sources that are located round 1m. over creek level. Waters comes out from the limestone's gaps of gravitative block. Sources have respectively 0.5 and 0.2 l/s feeds with 53⁰ C temperature. In first group (table 1) are classified sources from 1-5. These sources are located round 170 m. in northern part of above group. In this group are included round 5 sources that are localized 2-2.5 m. over creek level, with a length 10-15 m. from each other, in an area round 300 m²

Table 1. The main information for thermal water source

Source Nr.	1	2	3	4	5	6	7	8	9
Temperature	52.5	51.7	46.2	52.2	52.5	56	55.6	gas	Gas
Feed Q(l/s)	0.3	0.4	0.03	0.05	0.22	3.01	6		

Table 2. The main information for thermal water source

Source Nr.	10	11	12	13	14	15	16	17	18
Temperature ⁰ C	54	50	51	52.5	53	41	49	38	51
Feed Q(l/s)	0.6	0.8	0.4	0.3	0.4	0.4	0.3		1.9

Nr.7, "NOSIT" source, which is located round 25 m. away from Nr.6 source, is an important source in third group. Nr. 11-13 sources in Table 2 are part of sixth group and are located in the most northern extreme exit front. This group is formed from 5 sources that comes out in an area round 400 m². General feed of Llixha source is round 15 l/s. The biggest part of this feed isn't used, it gets spilled in water surface circuit. This classification of mineral waters of Elbasan's Llixha are studied at the beginning in Polytechnic School of Prague. Nearly the same

composition of all Llixha (Elbasan) source and the identical geological conditions of their appearance prove the same origin. With no doubt, all Llixha sources are different exits from the horizon of mineral waters.

IV. THERMO-MINERAL SOURCES IN WELLS

In Dumrea area of Elbasan region, in well of Paper -1 are made some drillings in depth 700-1800 m and up to 6120m with purpose for fuel research. (Well of Dumre-7). These drilling in most cases have reached in depth limestone of buried structure. During the test in limestone are taken hydrogen sulfide thermo-mineral water sources as well as those of Llixha of Hidrati in a outfall temperature up to 50⁰C. Fig.5 presented the dependence between temperature and the depth in Paper-1,

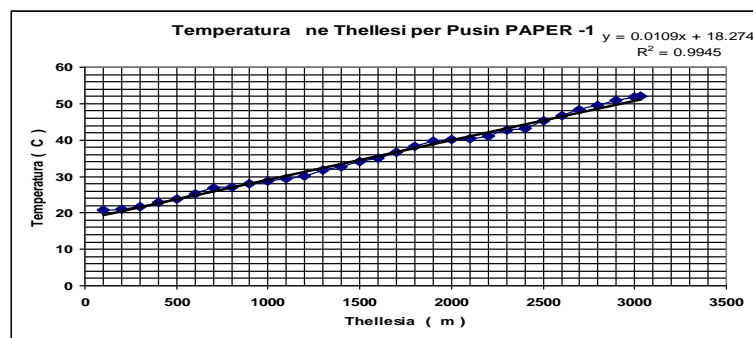


Fig 5. Geothermal gradient in Paper

V. CORRELATION BETWEEN SEISMICITY AND THERMAL WATER IN ELBASAN-DIBER ZONE

Elbasani- Dibra segment with direction SW-NE in Albania, represent an earlier transversal deep fracture, with springs of thermal water and which was hit by the frequent and strong earthquakes, being active now. During the last century, several devastating earthquakes have occurred, causing casualties and substantial damage [9],[10].

The results of the analysis, based on the parameters of events and some features of seismicity that have occurred in the Elbasan-Diber seismogenic zone during period of time 2001-2011, are presented in this paper. In total, 461 earthquakes are registered during overmentioned period in this zone., of which 163 are of magnitude $M_L > 3$ (Richter), 13 of them are of magnitude $M_L > 4$ and one with $M_L > 5,0$. The moderate earthquake were the 6 September 2009 ($M_L = 5.4$), the 24 October 2008 ($M_L = 4.5$) compound (fourplet) earthquake and 16 Aprile 2007 ($M_L = 4.5$) earthquake. These earthquakes are characteristic of the increased seismic activity of the Elbasan-Dibra seismogenic zone in this century. The goal of this study is to shed light on the correlation between seismicity of the area and the thermal water.

A comparison of the distribution of thermal and thermal-related springs and wells in Elbasani zone, with the abundance of earthquakes of magnitude $M_L > 2$ shows as close a relationship between thermal waters and the distribution of seismicity as to the distribution of active faults. It appears that the distribution of thermal water variations in the geothermal gradient in turn influences the stress accumulation capability of the rocks at depth. Thus, areas with abundant thermal waters release stress by frequent moderate earthquakes.

VI. CONCLUSION

Elbasan-Debar area, taking into consideration the period 2001-2010, is the most sismoactive zone in our country. The low-velocity layer are characteristic for sismoactive regions. Hot thermal springs are located mainly along the Elbasan Debra tectonic faults. Earth's crust in Elbasan-Debar area is characterized by low-layers layer at 1-3 km and 10-14km depth. Low velocity layers can be promotore of geothermal energy inside it. Having high temperature in the low velocity layers in this area can creating the thermale-water.As the efect of pressure of gases, thermal water come to the surface through lineament of tectonic fractures. The low velocities, the parameters of the reservoir, and stable thermo- hydrodynamic regime are indicator for existence of new sources of geothermal reserves in the area. The Elbasani zone is a particular area because has a considerable number of sources with geothermal potential and frequent seismicity.

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