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Research Paper

Spatial Correlations between P-wave Velocities Anomalies, Thermal Waters and Seismicity in Elbasani Zone

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Abstract: A detailed investigation of the earthquake's epicentre distribution, low velocity layers, thermal water sources and b-value beneath Elbasani Zone Albania were studied. In the Elbasani Zone, hot mineral water (thermal waters) spot out from natural springs which have been known since the 19th century. We interpret the 3D seismic velocity structure in the Elbasani zone to understand the factors controlling the genesis of temperature and level of seismicity. A narrow low-velocity zone is imaged within the Elbasani fault zone over a length of ~20 km, which partly penetrates 1-4 km and into 10-14 km depth. The low-velocity zone correlates in space with thermal water sources area, the trending of low seismicity compare to surrounding zones and trending of high b-value. A reactivation of thermal water fracture zone is probably related to the low-velocity anomaly. A comparison of the distribution of thermal water sources shows a relationship between thermal waters and the distribution of low seismicity. From Hidraj to Llinxha and up to Kozan the surface temperature of thermal waters varies from 50^0 to 60^0 and 65^0 Celsius. The b-value of the thermal water zones is high over 1.0 which shows that the accumulation of stress in this area is low.

Keywords: *Seismicity, Thermal Water, Velocity. b-value*

Introduction

The Albanides are found within the Alpine-Mediterranean seismic belt between Dinarides within the north and Helenides within the south and suit portion of the distortion due to the collision of the African plate with the Eurasian plate. The seismicity of Albania is caused by the collision of the African plate with the Eurasian plate. Within the system of this contact collision of the Adria microplate with Albanian orogen impacts longitudinal and transversal fractures interior Albania (Ormeni *et al*., 2013a; Aliaj et al., 210). In Albania there are many springs and wells of thermal waters with a low enthalpy (Fig 1). These water sources have temperatures that go up to 65.5^0C.The Elbasani zone is a particular zone because characterized by great geothermal potential and frequent seismicity (Shatro & Ormeni, 2014). In Albania there are numerous springs and wells of warm waters with a low enthalpy (Fig 1). These water sources have temperatures that go up to 65.50C. The Elbasani zone may be a specific zone since characterized by extraordinary geothermal potential and visit seismicity (Shatro & Ormeni, 2014).

The Elbasani fault zone is expressed by the diaper dome of Dumrea, Quaternary depression of Elbasani, and transversal structure of Labinoti (Shatro & Ormeni, 2014).Analyses of spatial and temporal characteristics of the earthquake activity may supply significant clues for revealing the future seismic hazard along the Elbasani fault zone (Koçiaj, 1986; Sulstarova et al, 2000; Ormeni & Fundo, 2011; Ormeni, 2015b; Ormeni & Daberdini, 2021; Ormeni et al 2022a; Ormeni et al 2023)..The low-velocity layer in the shallow earth's crust can be the promoter of triggering seismic activity in the Elbasani fault zone (Shatro & Ormeni, 2013; Ormeni et al 2023). The geothermal sources of Elbasani area, have medium temperatures varies from 50^0 to 60^0 and 65^0 Celsius. The thermal water comes up from the depths (800-3000 m) in the carbonate or sandy reservoirs. Kruja geothermal area start on the Adriatic coast, Northern of Durresi city, in Ishmi region, continues in Tirana, in Elbasani up to South-Eastern Albanian- Greek border and extends to the Konica district in Greece. Analysis of observed anomalies of P wave velocities in different depth layers allows us to develop our imaginations on the processes occurring inside the Earth (Anderson & Johnson, 1976). The Elbasani fracture zone is

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Using arguments based on heat flow, Anderson (1976) proposed that the low-velocity zone was due to the presence of a small amount of melt (Schorlemmer et al, 2005). The Elbasani zone is a particular area because has a considerable number of sources of thermal water and presents a different level of seismicity.

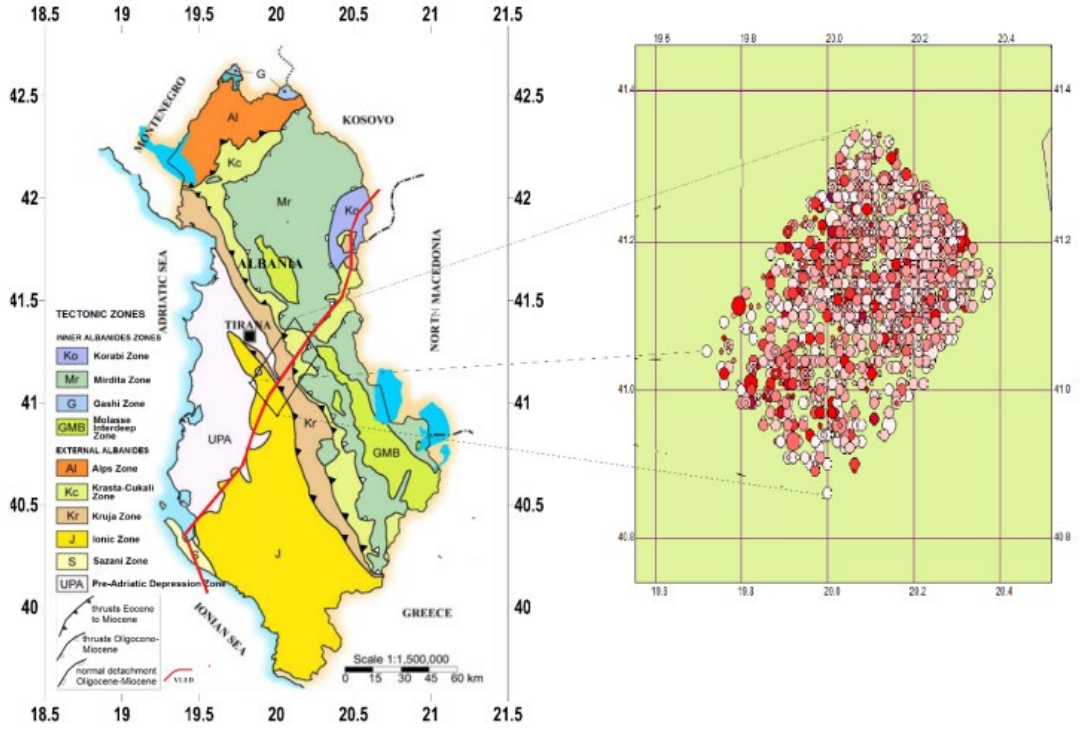

Figure 1. The Albania geothermal map and epicenters distribution of M_L>1.0 earthquakes during 1968-2022 in Elbasani zone.

Data and Methods

These earthquakes were recorded by permanent broadband seismological stations that are part of the Albanian Seismological Network, as well by neighbouring seismic networks AUTH, MSO, INGV and MEDNET (TIR) (www.geo.edu.al, 2023) The procedure uses for earthquake locations have been the program Hypo invers (Klein, 202) of the Atlas package, and the velocity model (Muco *et al*., 2001; Ormeni., 2011). In the Elbasani seizmogenic zone were located 1831 tectonic earthquakes with M_L>1.0, (Fig. 1) (Ormeni *et al*, 2023). From statistical analysis, every year, in the Elbasani fault zone, have occurred two earthquakes with magnitude M_L>3.5 Richter, and one earthquake with magnitude M_L>4.0.

The analysis of low-velocity layers discovered from 3D tomography shows their relation to geothermal energy resources which further develops our knowledge of geodynamic processes in this

area. The analysis of low-velocity layers determined from 3D seismic tomography is used for the interpretation of geothermal water sources and features of seismicity (Ormeni, 2011; Ormeni, 2013b).

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. This hot sulphur waters pushed by high pressure of gases get on the surface through the tectonic fractures of the zone. Analysis show that the low velocity layers in the Elbasan region are located in the earth's crust, at 2-4 km (Figure 2). At 2-4 km depths the velocity of P waves is reduced from 5.12 km/s to 4.40 km/s, and the difference is ΔV = 0.72 km/s or 14%. It is known that the low-velocity layer are characteristic for sizmoactive regions (Ormeni, 2009; Ormeni et al 2013a). 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 enthalpy and maximum temperature up to 80ºC (Frasheri, 2000). The existence of the low velocity layers might be the source of geothermal energy of hot water which has enough high temperature to generate frequent low seismic activity in this zone (Ormeni et al 2023). Sources of thermo-mineral water of Llixha begin around 12 km south of the city of Elbasan, thermo-mineral water resources of Hidrat appear around 13-14km south of the city of Elbasan and the Shijon thermal water resources appear around 10 km northwest of the city of Elbasan.

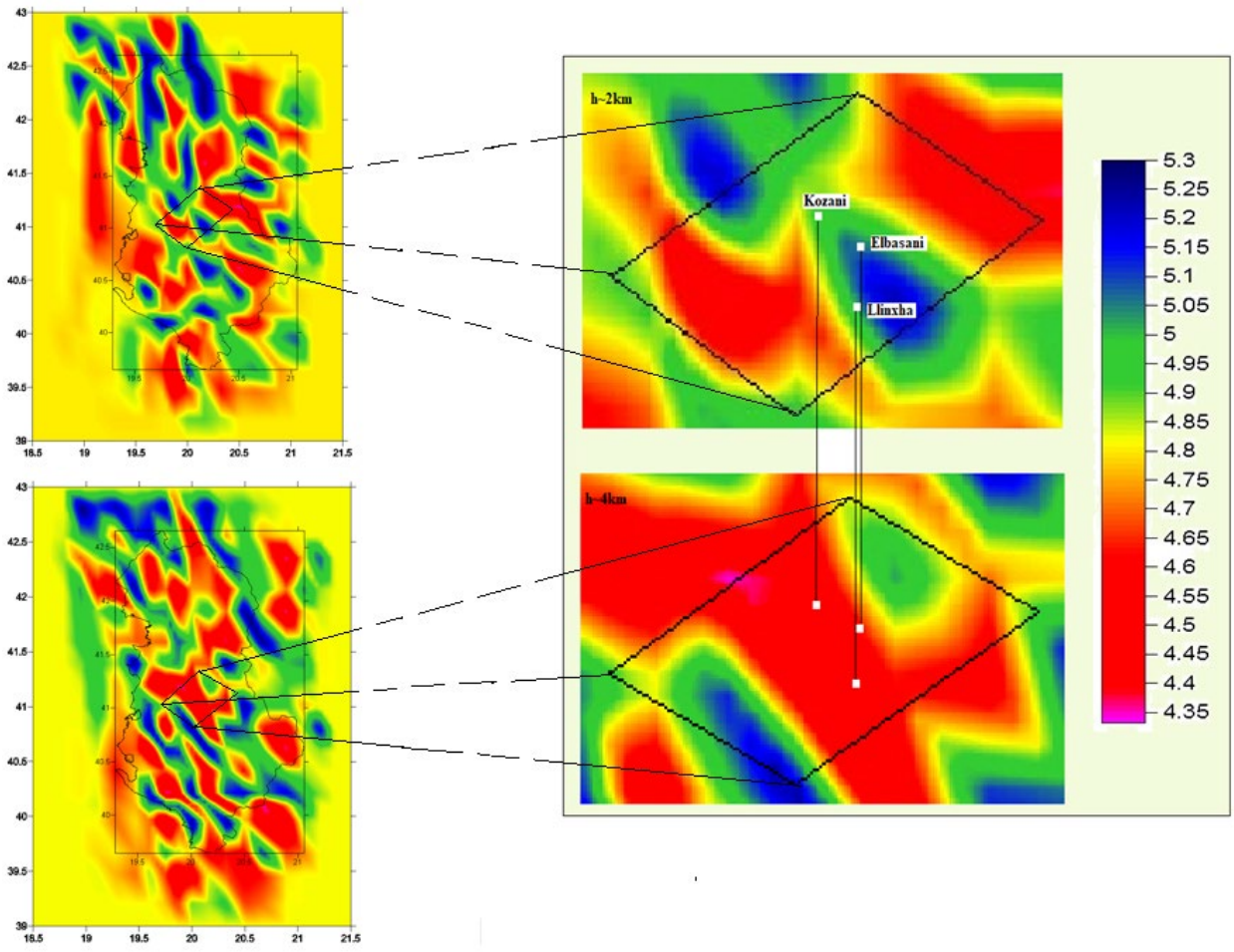

Figure 2. Lateral distribution of low velocities in-depth 2-4 km (Ormeni et al 2023).

Distribution of Seismicity and Thermal Water in Elbasan Zone

Elbasan zone in Albania, represents an earlier deep fracture, with springs of thermal water and which were hit by the frequent earthquakes, being active now. The results of the analysis, based on the parameters of events and some features of seismicity that have occurred in the Elbasan seismogenic

zone during period of time five decades, are presented. The goal is to shed light on the correlation between the seismicity of the area and the thermal water.

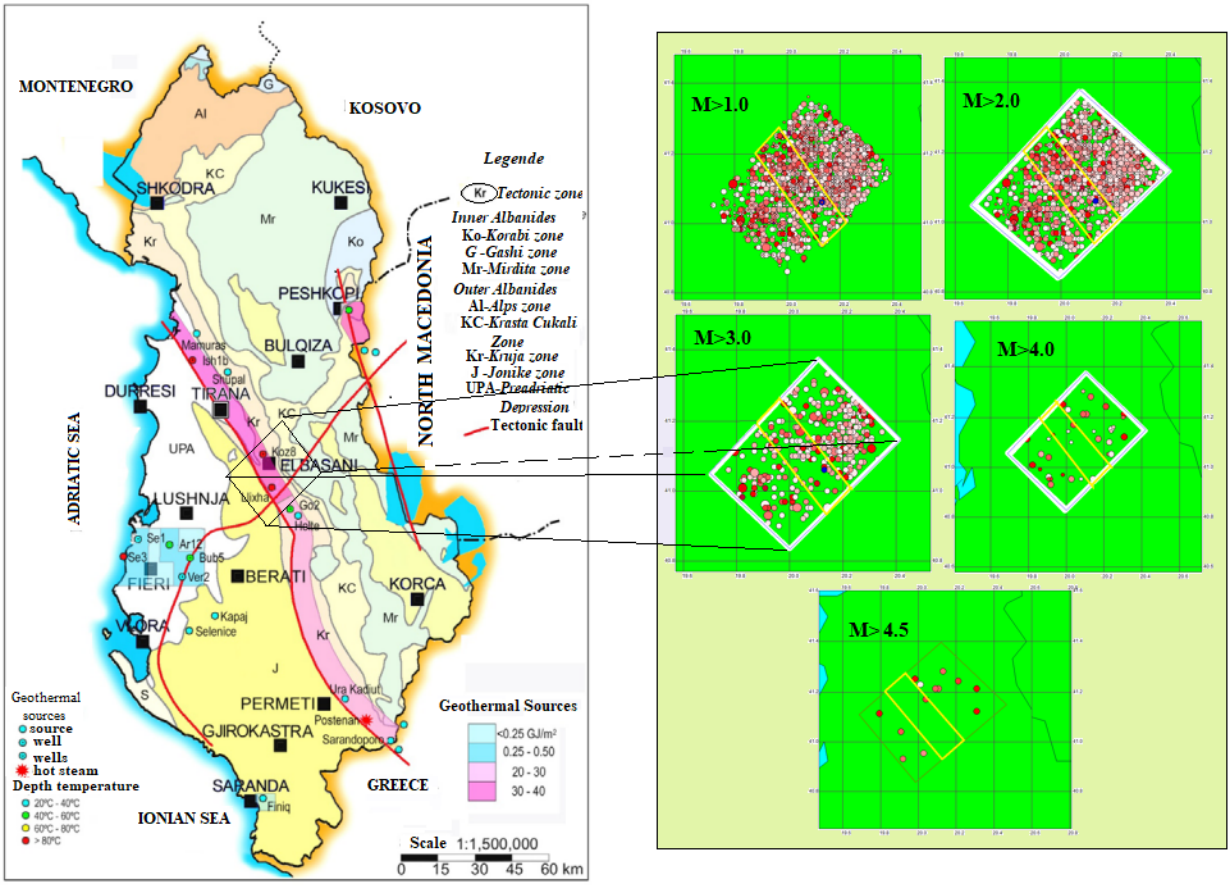

Figure 3. Map of geothermal sources and correlations of thermal water sources to different kind of earthquakes in Elbasan thermal waters.

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>1.0 shows as close a relationship between thermal waters and the distribution of seismicity (Fig 3). It appears that variations in the geothermal gradient influences the stress accumulation capability of the rocks at depth. Thus, areas with abundant thermal waters release stress that generate frequent micro-earthquakes. The distribution of earthquake epicentres in the figure 3, is proportional inverse for earthquakes with M_L>3.0.The high temperatures swelling the rock mass and as a consequence increase stresses which leads to the trigger of micro-earthquakes and small earthquakes.

Distribution of b-value and Thermal Water SOURCES in Elbasan Zone

Figure 4 shows the thermal water sources in this area and distribution of the b-value. The b-value in the zone of thermal water sources ranges from 1.05 to 1.15 (Fig 4). This shows that the accumulation of stress in Llinxha-Kozan thermal water belts low. In the south-western part of Llinxha-Kozan thermal water belt, the b-value is low at0.9 but in other parts is over 1.0. The b-value equal to 1 is normal for our country.

The 'b value' can serve as a proxy, for the accumulation of stress in this area. The b-value is the ratio of small to large earthquakes and Schorlemmer et al., (2005) contend that it's inversely related to the shear stress on the fault (Schorlemmer *et al*, 2005). A higher b value would mean the stress is lower (Ormeni, 2015b; Ormeni *et al*, 2017)) Conversely, a lower b value means the stress is higher, increasing the likelihood of a triggered event. In the southwestern part of the Elbasan zone the b-value is smaller than 1.0 which means the stress is higher, increasing the likelihood of a triggered event. There is a higher b value over 1.1 in the north-eastern of Elbasani zone which means that the stress is lower. In Llinxha-

Kozan thermal water belt the b-value is between 1.0 and 1.1 which means the stress is normal for this area not to be prone of moderate earthquakes in near future.

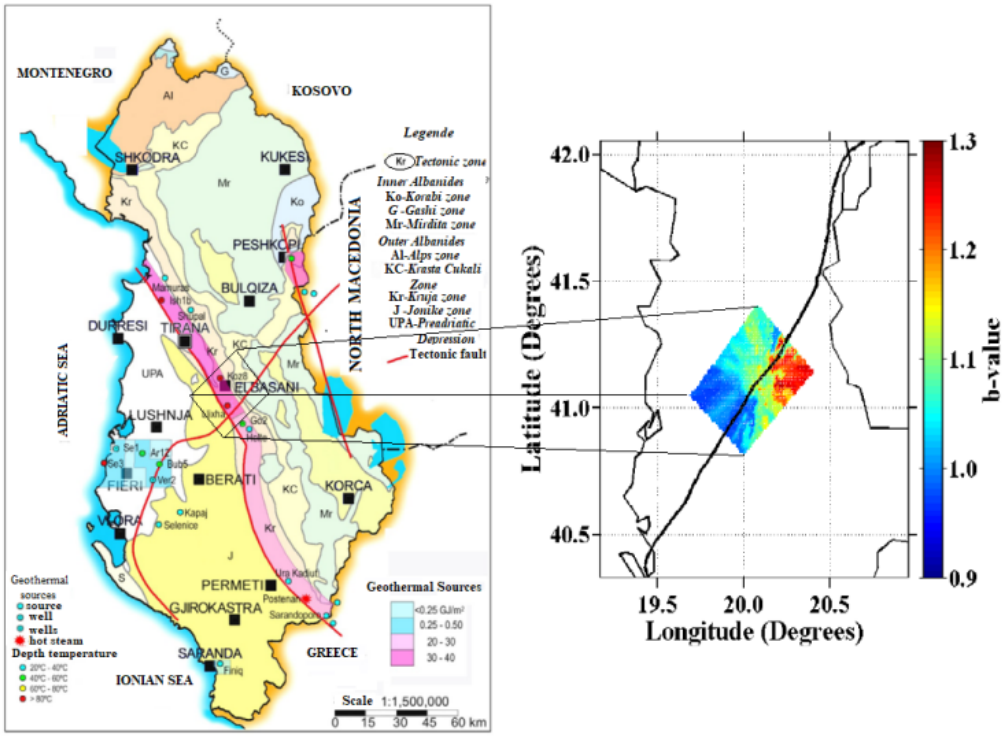

Figure 4. Map of geothermal sources and correlations of thermal water sources to b-value in Elbasani geothermal water

Conclusion

Studying how thermal water zones are distributed and how they relate to seismic activity helps us understand the structure and movement of the Earth's crust. The Elbasani region has not had many earthquakes between 1968 and 2022. Hot thermal water springs can be found in the Kozani to Llimxha area. Slow-velocity layers in the Earth's crust can help generate geothermal energy. The Elbasani area is a special place because it has a lot of underground heat energy and often experiences earthquakes. The low-velocity layer is a common feature in areas that have many small and medium-sized earthquakes. The Earth's crust layer in the Elbasani area has slow-velocity sections at depths of 2-4 km and 10-14 km. High temperatures in the low-velocity layers in this area can create the thermal-water.
As the effect of the pressure of gases, thermal water come to the surface through the lineament of tectonic fractures. The Elbasani zone could be a specific region since encompasses a significant number of sources with geothermal potential and frequent seismicity. Analysis appear a relationship between thermal waters sources locations, low velocity layers, the distribution of seismic parameters. A higher b-value in the thermal water sources zone would mean the stress is lower.

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