Thermal Water and Compond Earthquakes in The Elbasan-Dibra Fault Zone

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Abstract :- In Elbasani-Dibra fault zone, hot mineral water (thermal waters) spot out from natural springs which have been known since the 19th century. The thermal water zone correlates in space with seismic activity and compound earthquakes occurred. Activation of thermal water in this fracture zone is probably related to the cause of compound earthquakes. Where geological conditions are favourable, rainwater seeps through the surface and becames trapped in vast underground reservoirs so deep below the Earth"s surface that it becomes heated to high temperatures by the low velocity zones. Thermal waters flow out through the contact of conglomerate layer with calcolistolith. The 24 October 2008 Kuturman (Elbasan) earthquake sequence was a compound earthquake consisting of four nearly identical events. These earthquakes have occurred in a four-hour period successively migrated fron Weast to East and reverse. It is important to express that main shock is a compound (fourplet) earthquake. These are cases of earthquakes (dublete, triplet, fourplet, multiplet.) with almost the same size and occurred near in time caused by different faults.

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

I. INTRODUCTION

The main geological structures found within the Albanian territory are called the Albanides, which are part of the Dinaric-Albanid-Hellenic arc of the Alpine orogen. They are located between Helenides in the south and Dinarides in the north, which together form the Dinaric branch of the Mediterranean Alpine Belt (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],[6]. 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 moderate compound earthquakes, being active now [9][11]. In this study, compound earthquake analyzed as a correlation with geothermal energy generation. 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 and has generate compound earthquakes.

II. GEOLOGYCAL SETTING AND HYDROGEOLOGICAL FEATURES

The Lushnje-Elbasani-Dibra transversal fault with north-east strike dislocates the structure of the Albanides along their entire width. It is expressed by the Lushnja flexure, Dumrea diapire dome, Elbasani Quaternary depression, Labinoti transversal structure, marked by important quaternary infill, Golloborda transversal horst continues toward the Tetova Quaternary graben in FYROM [1]. 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 [5]. This transversal fault zone extends from Albania toward the FYROM to the NE. To this zone are related many geological phenomena: 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.

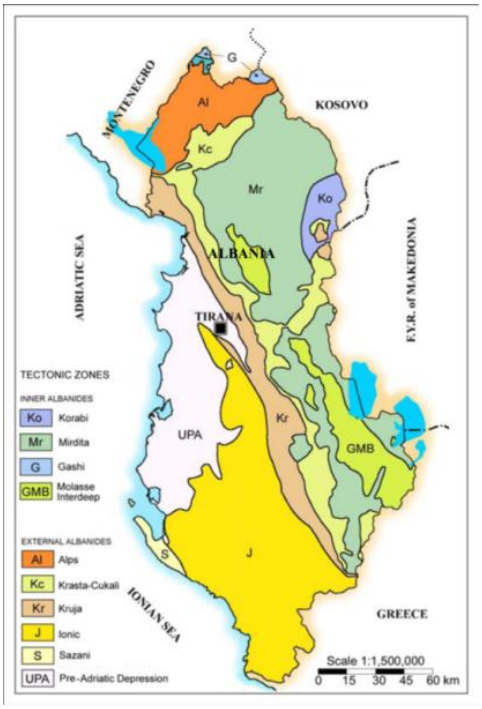

Fig. 1. Schematic tectonic map of Albani

III. DATA AND METHOD

Seismic phases recorded by the Albanian Seismic Network (ASN), integrated with data from the INGV, Montenegro, Thessalonica and Macedonia networks, were assembled to develop the database for this study. The Vp, Vs velocity model was computed with the SIMULPS program. 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 [7]. To enable a more accurate definition of low-velocity areas as a promoter of compound earthquakes, it is necessary to compile detailed velocities models to represent in the most accurate way the current wave velocity of a specific territory [10]. The analysis of low- velocity layers discovered from 3D tomography shows their relation to geothermal energy resources and seismic energy which further develops our knowledge on geodynamic processes in this area.

IV. FEATURES OF ELBASANI THERMOTERMAL BASINS

IV.1. Llinxha and Hidraty basins

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.2). 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 midle 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.

Fig 2. Location of hydrothermal resources of Llinxha and Hidratit

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 3). Carbonic structure of this basin from the erosion area which had existed since the midle Oligocen geologic time –Burdigalian, are catched from inverse moves,dived on greater depth [3]. On this conditions the basins have returned from surface basins to Thermo-mineral water basins,which drain naturaly to the surface through the horizon with olistolite. The geometrizm of the depth for the carbonic ceiling of the thermo-mineral basin of the Llixha is done only with the help of sizmic profiles.Surface water temperatures in the Tirana-Elbasani zone vary from 60°C to 65.5°C. At the depth on the top of the aquifer the temperature of water is 80°C. The difference between thetemperatures of thermal water and limestone section shows that a mixture of waters has occurred: water of the reservoir mixed with thermal water which comes from the greater depth.

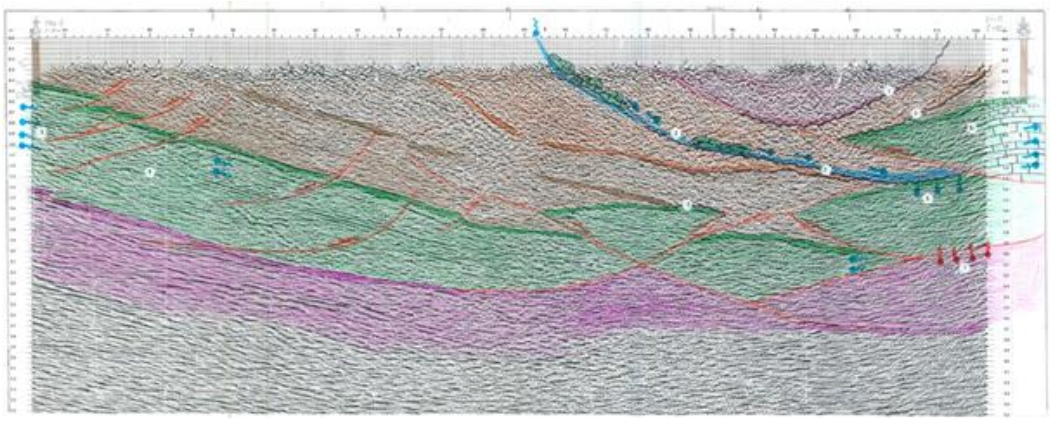

Fig.3. Thermomineral basin of Llinxha

Thermo-mineral basin of the Llixha on a geotecnic view is placed on the overthrast of the structure of the tectonic zone of Kruja, and linked to the Jonic tectonic zone, in the anticlinal of Maraku. The most of structures of Kruja zone is formed from powerful inverse movements, dived in greater depth under the influence of the evaporite of Dumre [3].

V. CHARACTERİSTİCS OF COMPOUND EARTHQUAKES İN ELBASANİ ZONE

Earthquakes seldom occur as isolated events, but are usually part of a sequence with variably well-defined characteristics fig (4). Foreshock and aftershock sequences are closely associated with larger event called the mainshock, whereas sequences of earthquakes not associated with a dominant earthquake are called swarms. Occasionally, two or more mainshocks may be closely in time and space. These have been called doublets and multipletes.

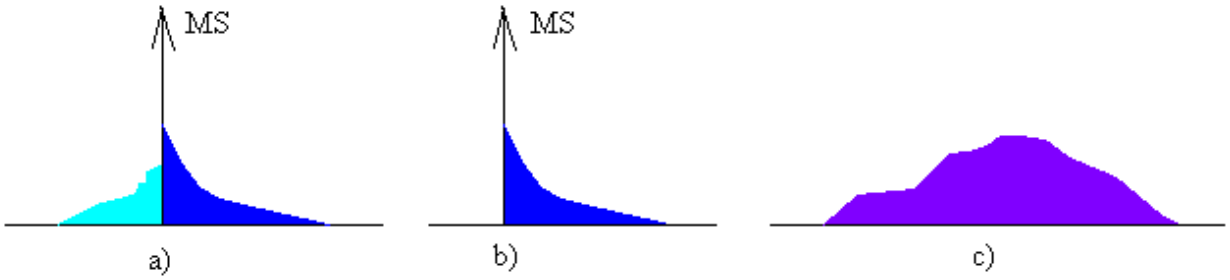

Fig 4. Schematic diagram illustrating the various types of earthquake sequences:
a) Mainshock (MS) with foreshocks and aftershocks; b)mainshock-aftershock sequence; c) swarm and compound earthquakes.

We considered these together as compound earthquakes. Earthquakes are invariably complex in their rupture characteristics because of the geometrical regularity of faults and heterogeneity in the various parameters in the rupture resistance. In many cases this heterogeneity may be pronounced enough to generate distinct seismic waves, in which case various sub events can be recognized. However, two or more events, often of similar size occur on nearby but different rupture surfaces close together in time, but with a delay such that their rupture times do not overlap. We call this classes of earthquakes compound earthquakes. They are considerable interest because they imply rupture processes other then those predicted by elastic fracture mechanics. Perhaps the most common type of compound earthquake is when the rupture surfaces of two events are contiguous. The two Gazli, USSR, earthquakes of 1976 occurred 39 days apart on conjugate and contiguous oblique-slip faults (Kristy, Burdick, and Simpson, 1980). The several events in the sequence need not have the same mechanism. Table 1 present parameters events in the seris of compound earthquakes of Kuturman. The first ruptures in 24 October 2008 Kuturman earthquake in Albania, for example were thrust and oblique-faulting events but they were followed closely from dominant rupture by normal-faulting and the fourth rupture by normal-faulting earthquake. These earthquakes have occurred in a four-hour period successively migrated fron W to E. Compound earthquakes sometimes progress in a single direction, thereby define an earthquake migration. The earthquake of Kuturman progressed from west to east.

Table 1. The parameters of compound earthquakes

N	Date Y/m/d	Time h:m:s	Lat	Long	Depth (km)	ML	Strike	Dip	Rake	Type of Mechanism .
1	08/08/24	16:56:41	41.21	20.28	3	3.9	180	50	-90	
2	08/08/24	17:00:15	41.21	20.22	3	4.0	190.2	52.8	-64	
3	08/08/24	19:31:18	41.21	20.30	5	4.5	249	40	-90	
4	08/08/24	20:52:18	41.25	20.35	7	4.1	229.3	40	-90	

VI. CORRELATION OF COMPOUND EARTHQUAKES AND THERMAL WATER SOURCES

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]. During period of time 2001-2013, in total, 641 earthquakes are registered in this zone, of which 196 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 of the 24 October 2008 (M_L =4.5) was compound (fourplet) earthquake. 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 and compound earthquakes show as close a relationship between thermal waters and the distribution of seismicity and mechanisms of compound earthquakes. 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 and compound earthquakes. It is known that raising the low speed layer in the earth crust is characteristic of sizmoactive and thermomineral water regions. As a result of the high temperature in these areas may occur melting of the case, and therefore, will have the rock volume expansion, which will lead to increased vertical and horizontal strain, while, at the generate of the earthquake and especially compound earthquakes. These compound earthquakes cannot be explained with linear elastic fracture mechanics because the time delays between the individual events are to long to result from elastic processes. Because an earthquake dynamically loads the surrounding region, compound earthquakes can result from viscoelastic relaxation. 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 [7] [10].This hot sulphur waters pushed by high pressure of gases get on the surface through the tectonic brakes of the lineaments of the zone.

VII. CONCLUSION

Hot thermal springs are located mainly along the Elbasan-Dibra tectonic faults. Earth's crust in Elbasan-Debar area is characterized by low-velocity 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 thermal-water. As the efect of pressure of gases, thermal water come to the surface through lineament of tectonic fractures. Thus, areas with abundant thermal waters release stress by frequent moderate earthquakes and compound earthquakes. It is known that raising the low speed layer in the earth crust is characteristic of sizmoactive and thermomineral water regions. The 24 October earthquakes may not be considered a single earthquake with four subevents, because the rupture times of each event do not overlap and are much less than the time delay between the four events. The earthquake sequence may be called an earthquake fourplet, which is a subset of compound earthquake. The existence of the low velocity layers might be the source of geothermal energy of hot water. The compound earthquake cannot be explained with linear elastic fracture mechanics because the time delays between the individual events are to long to result from elastic processes. The existence of the low velocity layers might be generate compound earthquakes. There is a correlation between thermal water zones and compound earthquakes occurred in the same zones.

REFERENCES

[1]. Aliaj Sh., Sulstarova E., Muço B., Koçiu S., 2001. *Seismotectonic map of Albania, schale 1:500.000*: Seismologi..cal Institute Tirane

[2]. Anderson, L.A., Johnson, G.R., 1976. Application of the self-potential method to Geothermal exploration in Long Valley, California. Journal of Geophysical Research 81, 1527–1532. [4].Doglioni et al., 2007;

[3]. Frasheri, A. (2000). The exploitation of waters of geotermal wells and springs in Albania represent great importance and fruitful investment. Twenty-Fifth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 24-26, 2000

[4]. Fred.W.Klein (2002). "Users Guide to Hypoinverse-2000, a Fortran program tosolve for earthquake location and Magnitude", USGS.

[5]. Ormeni Rr (2009). Some features of Lushnja-Elbasani-Dibra (Albania) trasversal fault zone and its recently seismic activity. International Earthquake Simposium, August 2009, Kocaely Turkey

[6]. Ormeni Rr., Daja Sh., Doda V., (2010). " The strongest earthquakes occurred in Albania during 2009 and their seismogenic zones" 6 workshop of ILP Task Force on Sedimentary Basins, Tirana, October 2010

[7]. Ormeni Rr. (2011). "P- & S-Wave Velocity Model of the crust and uppermost mantle of the Albania region" ELSEVIER, Journal of Tectonophysic, Vol 497, 2011

[9]. Ormeni Rr, Milushi I. (2012). "Analysis of feature of recently earthquakes occurred in Elbasani-Dibra seismogenic zone and its associated hazard". Jubilee Conference of Geology October 2012, Tirana, Albania

[10]. Rrapo Ormeni, Ilir Vullkaj, Astrit Shatro.2011 "Shtresat sizmoaktive dhe aspekte te energjisë te kores se tokes ne zonen Elbasan-Diber" Konferenca Kombëtare "Studime të avancuara në Inxhinierinë Matematike dhe Fizike". Tetor 2011, UPT, Tirane

[11]. Shatro A, Ormeni Rr. (2014). The low-velocity layers, thermal water sources and Seismicity in the ElbasanI zone, Albania. J. Int. Environmental Application & Science,Vol. 9 (2). Turkey