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Deep subsurface geological phenomena and related processes in the Elbasani-Tirana region, Albania

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Abstract: Important geological phenomena occur in the Elbasani-Tirana region in central Albania. The evaporite diapir of Dumrea represents a spectacular surface exposure of Permian-Triassic evaporites. It is still tectonically active. The Vlora-Elbasan-Dibra deep-seated fault has influenced the structure of the Albanides through generation of deep faults and rheology toward the axis of regional compression. This deep-seated fault is still active, generating frequently strong earthquakes. Thermo-mineral water springs occur near Elbasani City. Their temperature on the surface reaches up to 60 ºC. They generate from the deep subsurface and their geological model is conceived based on seismic works. The Tirana Depression consists of molasse formations transgressively overlying the Kruja and Ionian tectonic zones. Its western flank is composed of a range of hills with very steep slopes and geological strata with 90º dip. Faults that reach almost to the surface are evidenced by studying the deep subsurface with seismic works. These important geological phenomena of the deep subsurface and related processes must be carefully studied as they have a notable impact on urban and industrial developments.

Key words: Dumrea evaporite diapir, thermo-mineral waters, Tirana Depression

Introduction

The planet earth is a dynamic evolving system. Forces deep within the earth drive geologic processes. They form the mountain ranges, the ocean basins, the continents. Geologic processes condition the pattern of hydrographic system, the movement of underground waters, the formation of hydrocarbon deposits, create earthquakes, landslides etc. A detailed understanding of geologic processes would aid to better benefit from geological resources and for a better response to geological hazards.

Elbasani-Tirana region is one of the most inhabited regions of Albania, due to the favourable geographical position that has induced strong urban and industrial developments. This paper focuses on the use of seismic data to evidence deep subsurface geological phenomena that have impact on the community and urban developments in Elbasani-Tirana region, central Albania. Concretely, we will focus on the Dumrea evaporite diapir, Vlora-Elbasan-Dibra deep-seated fault, Llixha thermal water springs and Tirana Depression (Figure 1).

Dumrea evaporite diapir

The Dumrea evaporite diapir represents a spectacular extrusion of Permian-Triassic evaporites from the deep subsurface in the Albanides (Figure 1). In the normal stratigraphic section, the evaporites underlie carbonates and flysch formations of Triassic-Paleogene age. In the present position, they overlie Paleogene flysch formation. Deep hydrocarbon exploration wells show that the evaporites are thrusted over the Paleogene flysch evidencing the time of the diapiric movement. The evaporite massif of Dumrea is more than 5000 m thick. These facts are very important to understand the formation mechanism of this evaporite massif, especially when accompanied with information obtained from seismic profiles. Considering the surface outcrop of about 250 km^2 and the thickness of 5000 m of the Dumrea diapir and the considerable thickness of about 1000 m (Zirngast, 1996) of the evaporite layer in the normal stratigraphic position, we think that the formation of this evaporite massif has had strong influence on the structure of the Albanides. Due to their ductility the evaporites promote and transmit strong tectonic movements. They have played a primary role in the orogenic

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processes and have stimulated reverse faulting. In such a tectonic regime, continue to develop the mountainous area of southern Albania, Berati structural belt, Kruja-Dajti mountain range, *etc*.

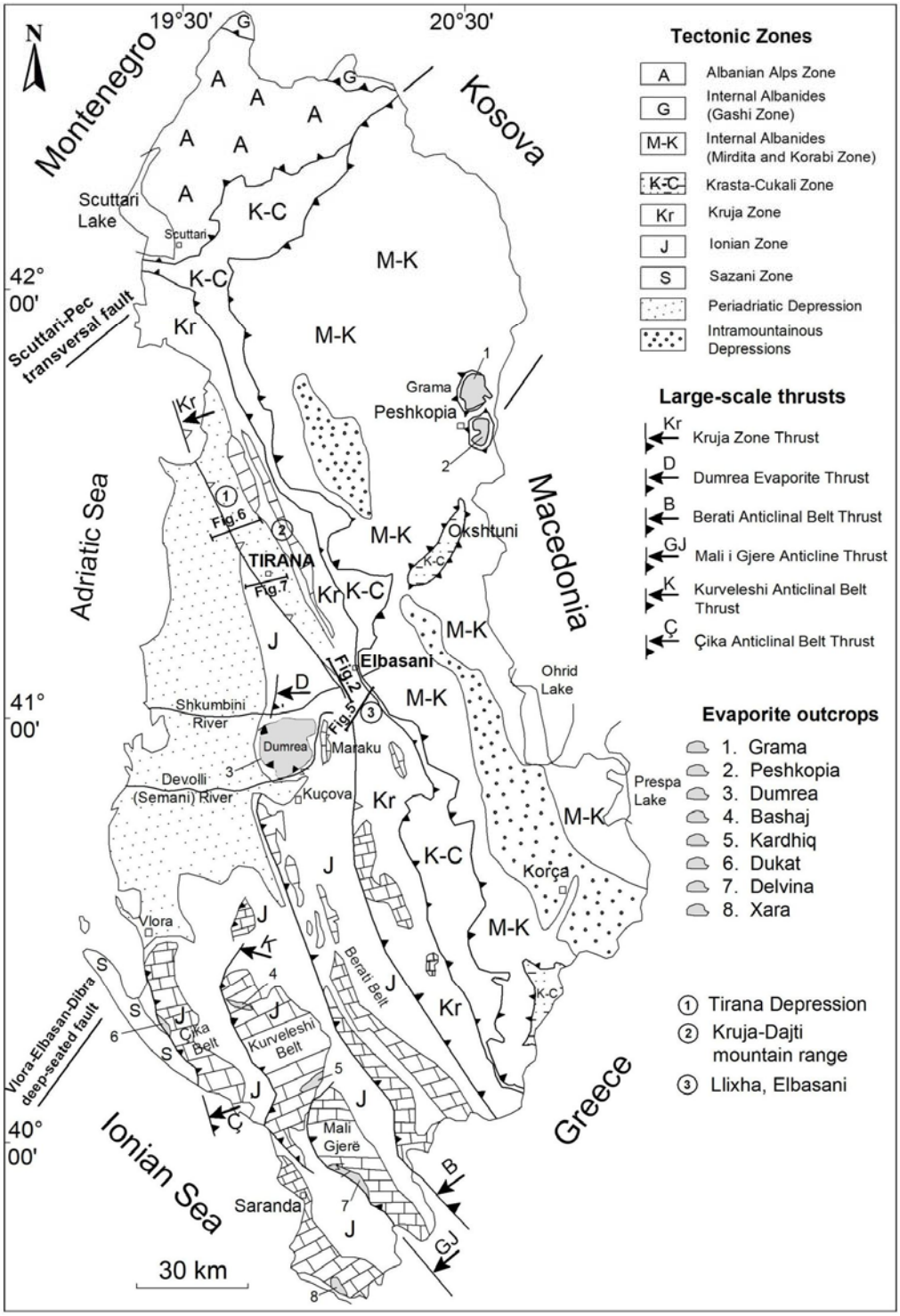

Figure 1. Regional map of the Albanides with the tectonic zones, large-scale thrusts and evaporite outcrops

After the diapiric event (somewhere in the last stages of Lower Oligocene) the evaporites have promoted inverse movements. Entire regions like Dumrea, Kuçova, Patos-Verbasi, Selenica, Tirana-Ishmi regions, etc., which are generally situated west of old faults have been involved in subsiding tectonic regime that continues to the present days. This was caused by the extrusion of the evaporites

that formed the Dumrea evaporite diapir. In these conditions the Dumrea evaporite massif constitutes a continuously extruding and moving unit, being a source of earthquakes (Naço *et al*., 2005). The southwestern part of the massif is subjected to a compressive tectonic regime whereas the eastern part to an extensive tectonic regime, stimulating the formation of wide river valleys and activation of normal faults (Figures 2 - 4). Devolli River tends to pass close to the periphery of the evaporite massif, whereas the western slopes of Sulova Mountain tend to slide toward the valley.

Vlora-Elbasan-Dibra deep-seated fault

The area of the Vlora-Elbasan-Dibra deep-seated fault is delineated as one of the most notable and active tectonic lineaments of the Albanides. This transversal deep-seated fault has been activated since the time the region was involved in a compressional tectonic regime. The rheology of this fault toward the axis of the regional compression has dictated the structure of the Albanides on both sides of it and made possible the development of important geological phenomena like the Dumrea evaporite diapir, Okshtuni tectonic window, Peshkopia evaporite tectonic windows, *etc*., (Figure 1). The extrusion of evaporites, which in the normal stratigraphic section underlie about 5000 m of carbonate and flysch formations, suggest for the deep nature of this fault. Frequent earthquakes, wide river valleys, fresh normal faults suggest for the activity of this fault to the present days.

The solution of the mechanism of the earthquake foci shows that in the area of Vlora-Elbasan-Dibra deep-seated fault predominate right lateral strike-slip faults with northeastern strike. All the series of earthquakes along this fault are generated in an extensional tectonic regime. The earthquakes have had a Richter Magnitude of 6-6.6 with a focal centre from 3 km up to the upper mantle (Sulstarova, 1987). Earthquakes along this fault zone have been frequent and accompanied by many aftershocks with visible imprints on the surface in the form of normal faults.

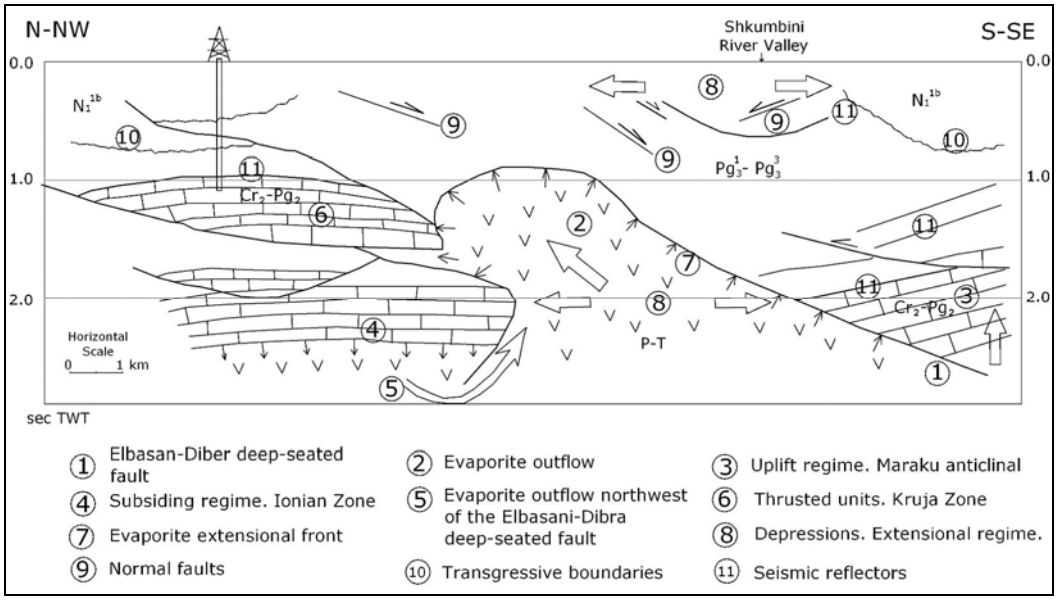

Figure 2 – Geological profile, geotectonic and geodynamic model of Kozani-Elbasan-Llixha region based on field observations, seismic data and information from deep wells.

These earthquakes have often been very hazardous for the community of these areas. In the segment of Elbasani, earthquakes are characterized by low magnitude and large number of aftershocks during a long time interval. Probably this is related with the extrusion of Dumrea diapir that leaves behind the front of the thrust an extensional tectonic regime. In this tectonic conditions is formed the graben of Elbasan-Cerrik-Devolli, well expressed by the wide river valleys, the over 200 m thick quaternary deposits, the erosional step of Krraba, and fresh faults on the surface (Naço *et al*., 2006a), (Figures 2 - 4).

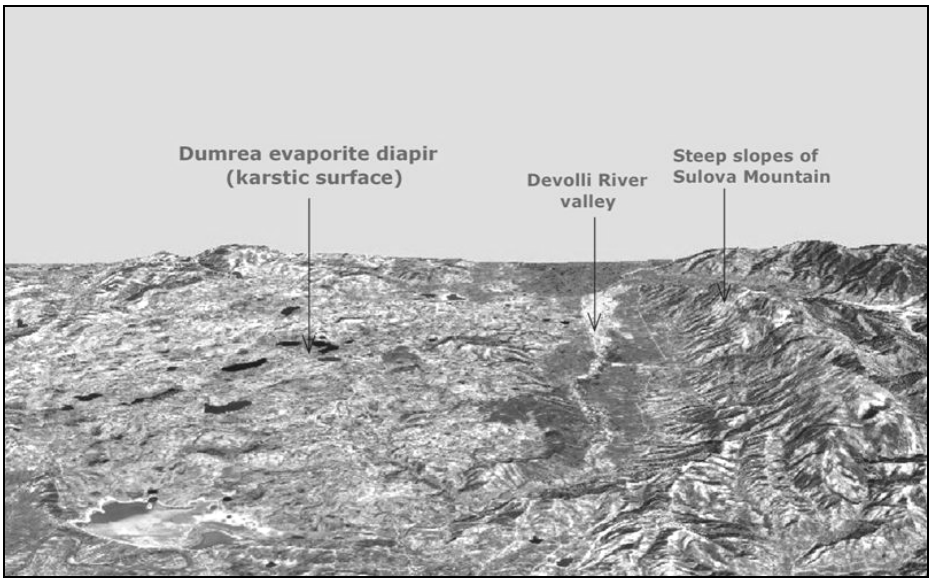

Figure 3. The Dumrea evaporite diapir, the wide Devolli River valley and the steep slopes of Sulova Mountain in a perspective view of Dumrea area viewed from south. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) image (recorded in September 2003) draped over SRTM digital elevation model.

Figure 4. Normal fault. Sulova Mountain (Maraku structure)

Using the seismic profile carried out west of Elbasani (cross-cutting the active lineament) we managed to delineate at the time interval 1.5-2.5 seconds the deep-seated fault of Elbasani (Figure 2). Due to the pushing force of the diapir (since the diapiric event at the end of Lower Oligocene) both sides of the roof of the carbonates are spread 3-4 km apart (Figure 2). It is clear that the evaporite diapir in the conditions of a continuous extensional tectonic regime generates frequent earthquakes. This dynamic geological situation must be assessed in order to better plan urban, infrastructure and industrial developments in the area.

Thermo-mineral waters of Llixha, Elbasani

Springs of thermo-mineral waters demonstrate the communication of the deep subsurface geology with the surface. Elbasani and Peshkopia regions are two of the most important regions of thermo-mineral waters in Albania (Naço *et al*., 2006b). They occur close to Dumrea and Peshkopia evaporite extrusions, respectively, suggesting their relation with the Vlora-Elbasan-Dibra deep-seated fault (Figure 1). Seismic energy is discharged to the surface through earthquakes; thermal energy is

discharged to the surface through thermo-mineral water springs. In both cases, the discharged energy is transmitted through tectonical, lithological and stratigraphical elements.

Below, based on a seismic profile, it is given the geotectonic model of the thermo-mineral waters of Llixha, Elbasani (Figure 5). The environment of formation and the storing tank of the thermo-mineral waters is the Triassic-Eocene carbonate formation with a thickness of 2000 m. This formation could be relatively well delineated as a seismic facies. Its roof in both sides of the profile has been intersected by wells.

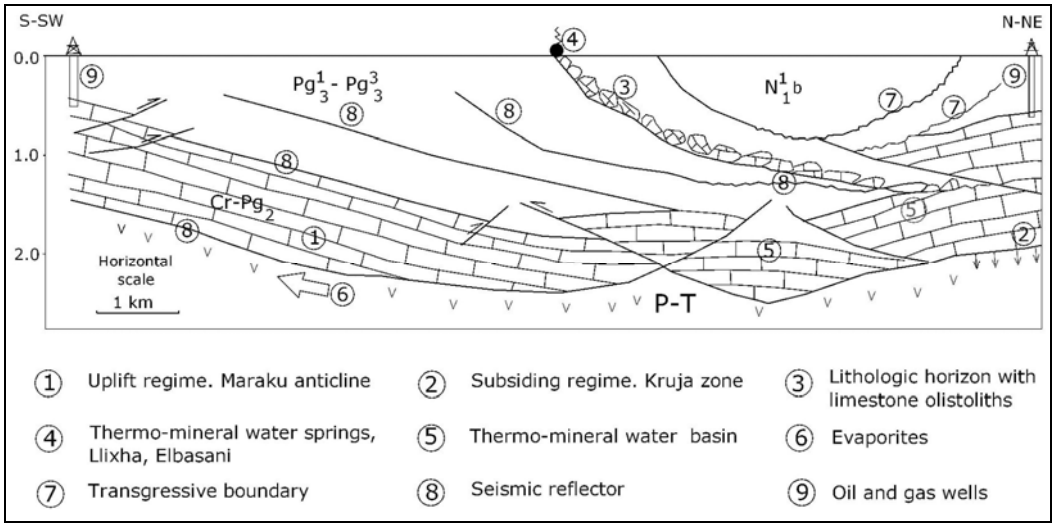

Figure 5. Geotectonic model of thermo-mineral water springs of Llixha, Elbasani

Surface waters enter into the deep subsurface through carbonate outcrops and transform in thermo-mineral waters charged with thermal energy. Interacting with evaporites and in appropriate structural conditions, these waters have formed the thermal-water basin of Elbasani. These waters flow up to the surface through defined lithological horizons predominated by limestone olistoliths 20-50 m thick. This lithological horizon plays the role of the discharging artery for the basin, due its high porosity and permeability. The formation of this lithological horizon within Middle-Upper Oligocene flysch formation argues for important geological events. During this geological time interval the structures that generated and included this horizon, have been involved in strong tectonization and erosion, depositing numerous pieces and olistoliths of carbonates into the nearby sedimenting basin. Later on, due to inverse movements derived from the evaporite extrusion, the erosive terrains were transformed in buried structures appropriate for the formation of thermo-mineral water basins. More or less this is the geotectonical model of these geological phenomena, which was restored according to seismic profiles (Figure 5). Understanding the geotectonic model of the thermo-mineral waters is very important for their use and management to the benefit of the community.

Tirana Depression

The Tirana Depression is a structural unit with many important geological phenomena that could be observed on the surface or from seismic profiles (Figure 6 & 7). It consists of a molassic synclinal unit transgressively overlying an erosive geological unit, suggesting for strong tectonic movement. Concretely, during the beginning of Middle Oligocene up to pre-Serravallian age, the region uplifted, transforming from a sedimenting basin to an erosive terrain. Later on, but still before the Serravallian the region subsided creating the conditions for the formation of transgressive marginal basins. The Tirana depression formed in these tectonical conditions. It constitutes a classical example of transgression with stratigraphic break. This phenomenon could be observed on the surface and at depth through seismic data (Figure 6 & 7).

The eastern flank and the central part of the Tirana Depression could be noted from strong seismic reflectors clearly showing the discordant emplacement onto the Kruja tectonic zone. The eastern flank is characterized by a gentle dip of the seismic reflectors and rock formations on the surface (25º-30º) and by an undisturbed, non-complicated structural continuity, arguing for a stable tectonic regime.

The western flank, in the sector from Tirana to Elbasani is characterized by an abrupt interruption of seismic reflectors. In the surface the geological strata of the western flank of the depression have vertical dip (80º-90º) or are overturned. In the sector north of Tirana could be observed a confrontation of seismic reflectors and on the surface the western flank is missing.

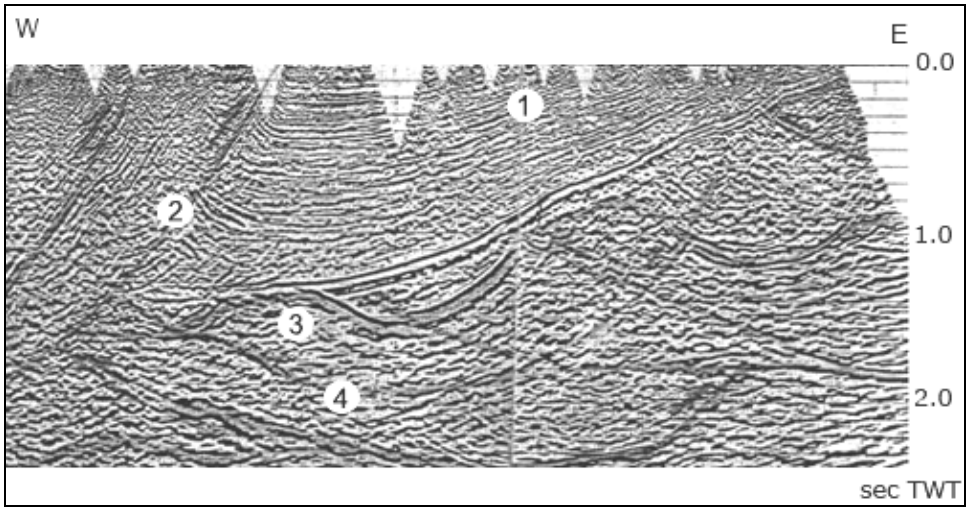

Figure 6. Seismic profile across the northern part of Tirana Depression. Legend: 1. Tirana Depression; 2. Backthrust; 3. Kruja tectonic zone, carbonates; 4. Thrusting front of Kruja tectonic zone onto the Ionian tectonic zone. The profile is ca. 12 km long.

The western flank of Tirana depression is subjected to the activity of a backthrust tectonic regime (Figure 6 & 7). This tectonic regime is active to present-days. This situation is observable in seismic profiles. The backthrust system reaches almost to the surface. On the surface the strata of the western flank have been uplifted, overturned or totally consumed. They build a range of hills with very steep slopes toward the east, accompanied by landslides and intensive erosion.

The western flank of Tirana Depression represents a narrow belt that is continuously consuming due to the backthrust tectonic regime. Based on the depth of the molasse base (about 2500 m), its surface outcrop in the western flank of Tirana Depression, and the activity of the backthrust tectonics since the beginning of Pliocene, it could be inferred a vertical uplift rate of 0.5 mm/year for the western flank of Tirana Depression.

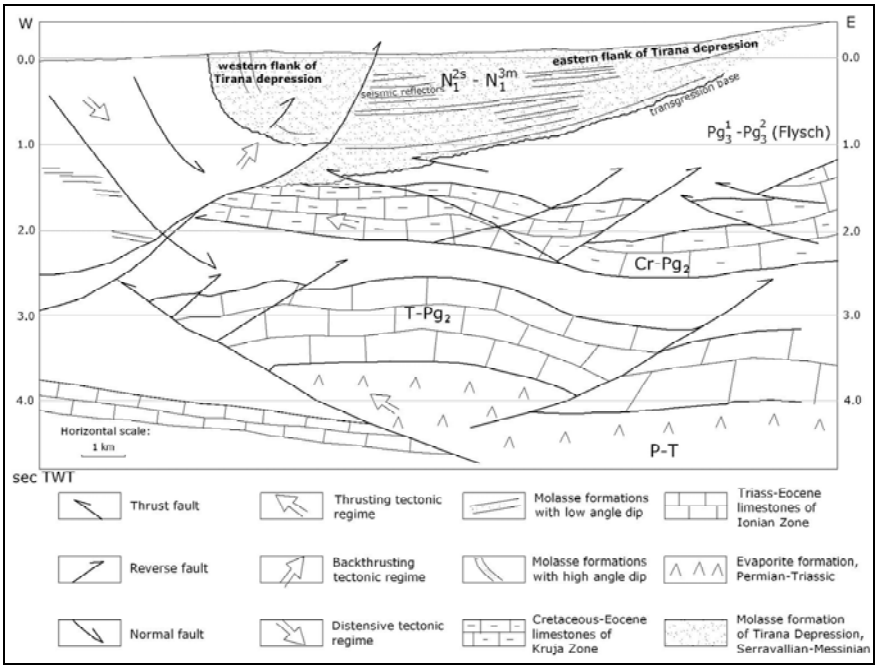

Figure 7. Geological-seismic profile across the southern part of Tirana Depression.

Conclusions

The evaporite diapir of Dumrea represents a spectacular surface exposure of deep subsurface geological layers. The Dumrea diapir is active to present-days, promoting frequent earthquakes in the region.

The Vlora-Elbasan-Dibra deep-seated fault is one of the most important faults of the Albanides. It is still active. Its neotectonic activity could be noted by the wide Shkumbini and Devolli river valleys and the large thickness of quaternary deposits in the area of Elbasani, the erosional step of Krraba, fresh normal faults in Sulova Mountain etc.

Thermo-mineral water springs of Llixha, Elbasani represent an important fact of the communication of the deep subsurface geology with the surface. The geotectonic model of these thermo-mineral springs has been constructed based on surface observations, seismic profiles and information from drilled wells.

The Tirana Depression is one of the most interesting structures of the Albanides. Its western flank and central part are characterized by a non-disturbed uncomplicated structure. Strong tectonic movements of the backthrust type characterize the western belt. This tectonic regime is active to the present-days.

The Dumrea evaporite diapir, Vlora-Elbasan-Dibra deep-seated fault, thermo-mineral water springs of Llixha, and the Tirana Depression are some of the major geological phenomena of the Tirana-Elbasani region. Understanding the model and the function mechanism of these geological phenomena is important for the community and urban developments in this region.

References

Naço P, Kodra A, Çina A, Bedini E, (2005) Active tectonics, evaporites and permanent seismicity of Elbasani area (Albania). Poster. Natural hazards related to recent geological processes and regional evolution. *16th Meeting of the Association of European Geological Societies*. Turin, Italy.

Naço P, Hysenaj R, Bedini E, (2006a) The Aquifer Basin of Elbasani and the problems of its management. C*onference on Water Observation and Information System for Decision Support. BALWOIS 2006.* Ohrid, Macedonia, May, 23-26.

Naço P, Çina A, Bedini E, (2006b) Geothermal Energy in Albania. Extended abstract. *5th European Congress on Regional Geoscientific Cartography and Information Systems.* Barcelona, Spain.

Sulstarova E, (1987) Mekanizmi i vatrave te termeteve ne Shqiperi dhe fusha e sforcimeve tektonike te sotme. *Buletini i Shkencave Gjeologjike* no. 4, 133-170, Tirana, Albania.

Zirngast M, (1996) The development of the Gorleben salt dome (northwest Germany) based on quantitative analysis of peripheral sinks. In Alsop G.I., Blundell D.J., Davison I. (Eds.). *Salt Tectonics*, 203-226. Geological Society Special Publication. London.