EVAPORITE DIAPIRISM AND ITS CONTRIBUTION TO THE TECTONICAL REGIME OF ALBANIA

PRIFTI Irakli, DURMISHI Çerçis, DORRE Piro, BOÇARI Arben

Abstract. The Albanides extend in the central area of the Dinaric-Albanian-Hellenic belt. A lot of tectonics and geological phenomena are evidenced on them. The Albanides can be subdivided in the Internal Albanides, an intensely tectonised zone dominated by ophiolites and metamorphic complexes, and the External Albanides, a series of thrust sheets in front of the Internal Albanides, made up of Triassic to Pliocene sedimentary rocks. It is sometimes interrupted by the Upper Triassic evaporite rocks that have emerged from their normal position due to a common effect of tectonic forces and diapiric process. The geological data show that the Upper Triassic evaporite formation has a wide extension, both in the orogenic zones of the continued margin (throughout the Albanides-Hellenides-Dinarides tectonic assembly), and so as in Adria platform. They are the basement of all the above tectonic zones playing a significant role both in the structuralunits and for the orogene itself vs. the platform as well as the evaporite rocks are a perfect detachment formation.

Keywords: overthrust, evaporite formation, diapir, anticline, Çika belt.

Rezumat. Diapirismul evaporitelor şi contribuţia lor la regimul tectonic din Albania. Albanidele se extind în zona centrală a arcului montan Dinaric-Albanezo-Elenic. În această regiune sunt evidențiate numeroase fenomene tectonice și geologice. Albanidele pot fi împărțite în Albanide interne, o zonă intens tectonizată, dominată de ofiolite și complexe metamorfice, și Albanidele externe, o serie de falii de încălecare, situate în fața Albanidelor interne, formate din roci sedimentare ce datează din Triasic până în Pliocen. Acestea sunt uneori întrerupte de evaporite ce datează din Triasicul superior, care au fost deplasate din poziția lor normală, atât datorită forțelor tectonice cât şi a procesului de diapirism. Datele geologice arată că formarea evaporitelor în Triasicul superior are o extindere mare, atât în zonele orogenice ale marginii continue (pe parcursul ansamblului tectonic format de Albanide-Helenide-Dinaride), precum şi în platforma Adria. Ele reprezintă substratul tuturor zonelor tectonice superioare şi joacă un rol semnificativ, atât în unitățile structurale cât și pentru orogen în sine vs. platformă, precum evaporitele reprezintă o formaţiune de detașare perfectă.

Cuvinte cheie: șariaj, formațiune evaporitică, diapir, anticlinal, centura Çika.

INTRODUCTION

Numerous geological-geophysical integrated syntheses have made out that diapirism of the evaporate formation has been a main factor in development of tectonic complications and movement of Albanides fold and thrust belts.

Dumre area means a rather wideoval-shaped outlined evaporite surface, exposed on 210 km^2. It is surrounded by flysch deposits of Oligocene age. On the southwestern part, the molasses deposits of Tortonian-Messinian occur. Around the evaporite formation, especially on the southwestern part (Kuçove, Pekisht, Raseregions), numerous oil and bitumen seep are evidenced (PRIFTI, 2008).

Lakes of Dumre represent a unique wetland complex site of the country, composed of 85 individual lakes, thus representing one of the most characteristic and important sites of Albania wetlands. The total cover of the lakes is estimated at 14.2 km^2, with a total water volume of 24 million m^3. They are situated on akarst hilly plain of evaporite formation, from diapir of Dumre (http://wikimapia.org/16348904/Dumre).

Based on geological-geophysical studies, the western faults of the anticline of Marakare accepted.

Diapir of Peshkopia had penetrated three tectonic zones (Korabi, Krasta-Cukali and Kruja), which show a global allochthony of the Internal Albanides.

In the southern part of Albania evaporate diapirs are related to local faults, back thrust fault plane and the core of the anticline, which are illustrated in the following figures and photos.

EXTENSION OF THE EVAPORITE ROCKS IN ALBANIA

In the Periadriatic continental orogene, evaporite sedimentary rocks have a wide extension, both on surface and in subsurface (Fig. 1) in the Ionian zone (Albania, Greece), in Kruja zone (Dalmatia-Montenegro), in Umbro-Marches zone (Italy) and in Apulia zone. They are encountered as well as in the Internal Albanides e.g. in Korabi (Fig. 2), Albania and inTuscany (Italy).

Additionally, evaporites appear also as vertical diapir like that of Navarica in the centre of Krongji anticline, or that of Xara in Bogazi anticline (VELAJ et al., 1995; PRIFTI et al., 2004).

The wells drilled both in Albania and Greece emphasized a wide extension of evaporites in the subsurface. Some wells drilled on the carbonate anticline crossed evaporites in depth (e.g. the wells: Delvina-12, Aitolikon-1, Astokos-1, etc.).

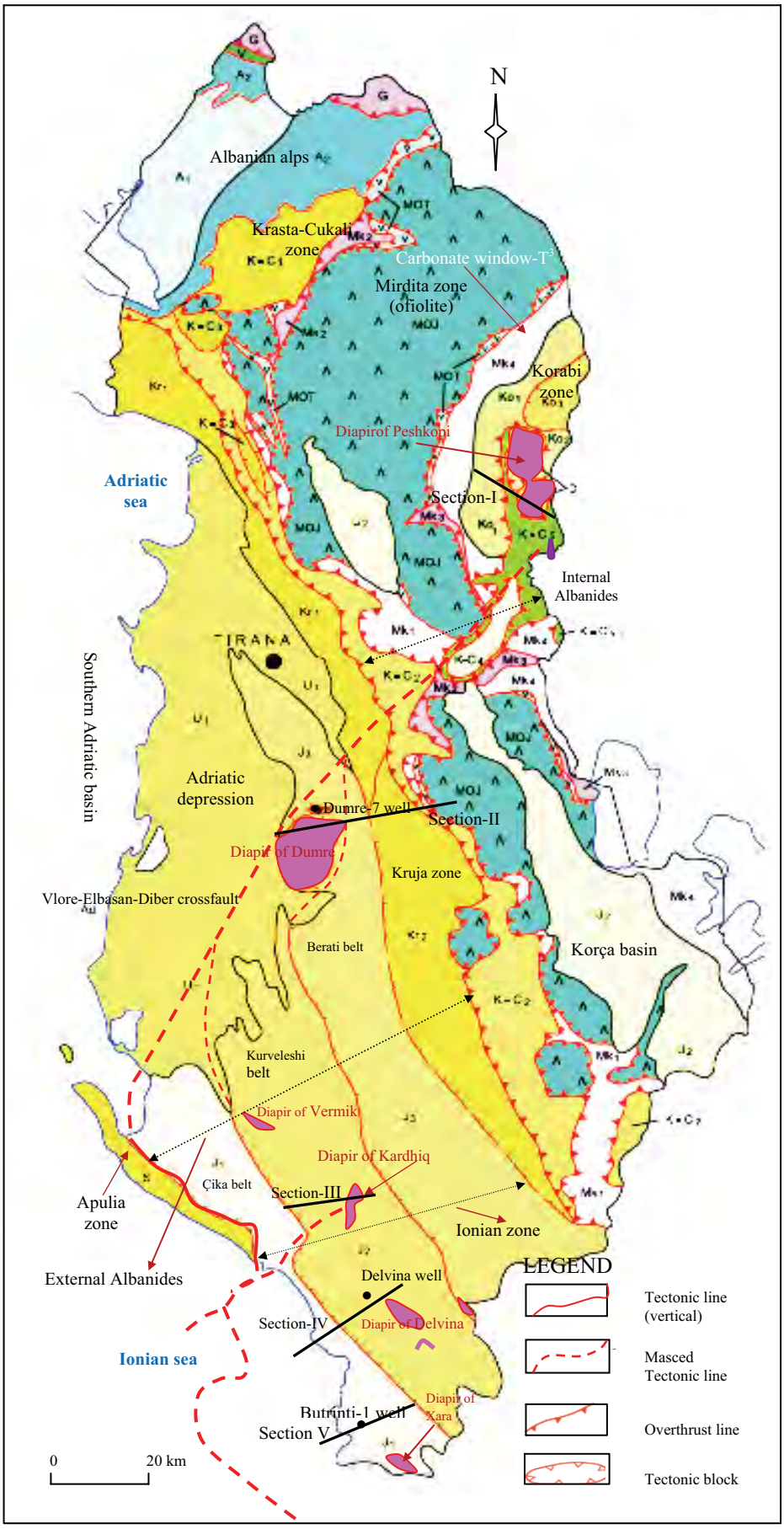

Figure 1. Evaporitediapirs on the schematic tectonic map of Albania.

The well Filiati-1, after the penetration of the diapir (3700 m) encountered younger deposits (Serravallian), showing an overthrust of the orogene on the platform. The well Dumre-7, after penetrating Dumre diapir (6100 m) encountered Oligocene flysch of the Ionian zone (VELAJ et al., 1995).

In Kruja zone and its analogue zone (Gavrova-Greece) evaporates rarely appear in outcrops except some small outcrops of gypsum among the Lower Oligocene flysch on the southern flank of Letani (north side of Elbasani town).

In the southern part of Kruja zone, sulphurous water seephas been recorded.

There are hot and curative waters in Elbasan and Fushkruja regions. These occurrences of the subsurface waters to surface evidence the evaporite presence in the depth of Kruja zone.

The lack of the surface and subsurface data in Krasta-Cukali zone makes difficult to presume the presence of the evaporite rocks in this zone. The presence of sulphur water source (Strikçan, region of Peshkopi) and native sulphur (region of Kerçisht) indicates the presence of evaporite rocks under Krasta zone (VELAJ et al., 1995).

In all cases the diapir outcrops are a result of their eruption and, in general, they are coincident with thrusting tectonics. Their location is related to the depression (with low lithostatic regime) and tectonic zones, those in conformity with the intersection areas of the longitudinal faults with transversal ones. These faults occurred since the rifting stage and are developed, complicated and transformed during the subsequent compression stage.

In the Ionian zone evaporate diapirs extend both along the regional tectonic faults and along the western faults of the particular structures.

In the Dalmato-Montenegro zone of the Dinarides the evaporite formations encountered on the surface in Vis Island, where they form the diapir root along with basaltic-andesitic intrusions of the Cretaceous carbonate anticline. The wells drilled along the coast of Dalmatia showed a wide extension of evaporites in the subsurface.

In the Apennine evaporite outcrops according the tectonic fault planes of the structural units with an eastern vergence of Umbro-Marchigiano, Tuscany and Calabri zones. Also the wells drilled in these zones evidence the subsurface presence of the evaporite formation.

The diapir influence in the Apulia platform is still unclear. The fact that above the Apulia platform extends now the Periadriatic depression with a thickness of 6-8 km and the evaporite formation occurs 7-12 km in depth, creates conditions for its "flow" toward the depressive sectors, which favours the blocky construction model.

In Korabi (Pelagone) zone the evaporite formation appears inside three tectonic windows of cupola shape named: "Mali i Bardhe" (white mount), "Banjat e Peshkopisë" (curative water of Peshkopi) and the southern, Kërçisht. The cupolas extend southward and represent tectonic windows within Korabi zone, which is allochthonous. The evaporate formation is in contact with Krasta Eocene Flysch and with the Upper Cenomanian carbonate (Fig. 2).

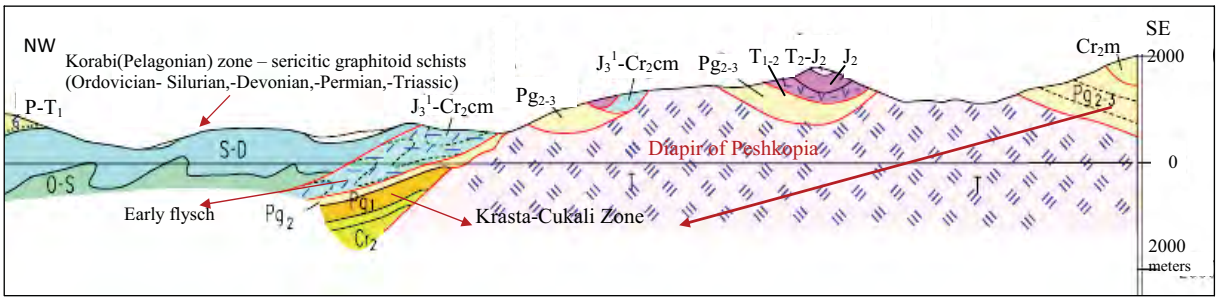

Figure 2. Diapir of Peshkopia (based on geological map of Albania, scale 1:200 000), which penetrated Krasta-Cukali and Korabi zones (geological section I).

The evaporate formation contacts also the Mesozoic and Palaeozoic deposits of Korabi Zone.

These facts lead to the presumption that the evaporites rocks from Korabi Zone would belong to Kruja Zone, which shows a global allochthony of the Internal Albanides, underthrusting the External Albanides (VELAJ et al., 1995).

MINERALOGY OF EVAPORITE ROCKS

Concerning their mineralogy, the evaporite deposits are represented by gypsum, anhydrite, halite, interbedded by dolomites and terrigenous deposits (only for diapir of Dumre). A considerable heterogeneity of evaporites is evident on the well logs. According to log diagrams and cores collected from the wells, dolomite and terrigenous deposits are present in section. Gypsum, anhydrite and halite predominate in the diapir up to 1400-1500 m in depth. Further down, there predominate the halite, anhydrites and gypsum rarely interbedded with dolomites and terrigenous deposits.

The exposures of Triassic evaporites in Albania had been and still remain useful case studies for prospecting – exploration and mining of gypsum, anhydrite, halite, various salts, etc. In this context, there have been identified all outcrops and important deposits. The perspective areas for further exploration are delineated (HOXHA et al., 2012).

Based on the studies (SOTA et al., 2002), the mineral composition of the samples collected during the borehole drillings in the area of the diapir of Dumre is a sit follows:

Anhydrite, gypsum= 45-80%

Halite = 15-55%

Clay minerals = 15%

Contents of salts are from a few percents up to 85-90%. According to the data of wells, gypsum and dolomite recorded a weak participation. In most cases, gypsum is massive and rarely appears as thin layers, interrupted by cracks and cavers filled by clay. With increasing depth, the compactness increases too.

Halite is of crystal appearance, with white to gray colours, but it also has the aspectof melted glass, in dark gray colour. There are often encountered dolomites inside the halite mass, 0.5-6 cm big, rarely reaching 20 cm. The dolomite {Ca, Mg (CO_3)} are of average to big grains with massive texture, of gray to dark graycolour. The gypsum is of small to big grains, re-crystallized, dark gray, heterogeneous. Often, it contains clay material. The terrigenous input concerns clay silts and small to medium grain sands of gray colour. There are also block of limestone of gray to black colour.

Fragments of diabase rocks are met in Vermikut diaper (Fig.3), while in Kardhiqi diaper there are met fragments of effusive rocks which are metamorphosed (VRANAJ et al., 2002).

According to the spore-pollen analyses, the evaporitic rocks are Late Triassic (*Cancrosporites* forms and *Ovalispollis*, characteristic for the Late Triassic). The evaporites of Çika belt (Palasë-Vuno), according to the same analyses are Jurassic-Cretaceous (RUSI & GJANI, 2012).

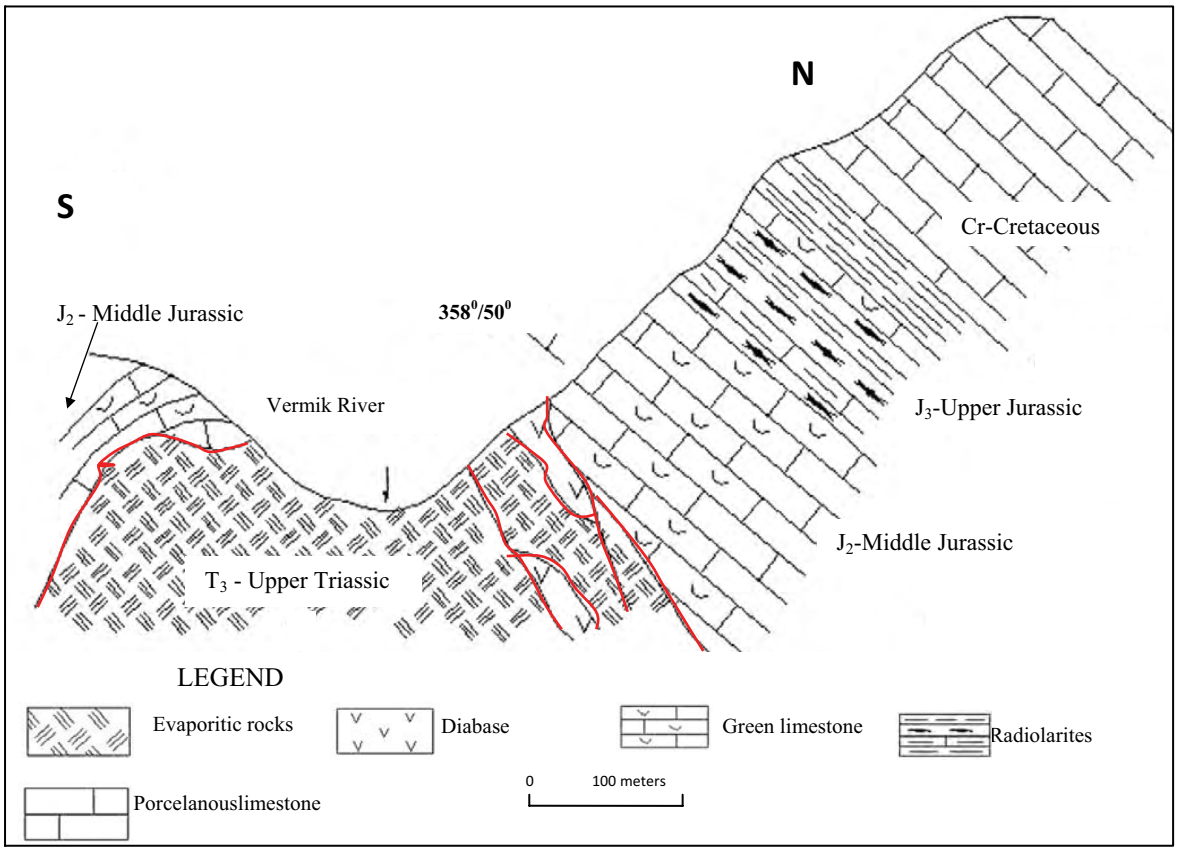

Figure 3. Cross section on the evaporate diapir (Vermik River).

TECTONIC SETTING OF THE EVAPORITE FORMATION

Evaporite diapers may be encountered in three tectonic settings:

A. Evaporite diapers are erupted through regional fault planes.

1. In the western front of Berati belt (the external subzone of the Ionian Zone) a regional overthrusting fault of 20-30 km throw can be traced. This overthrust is controlled by a big diaper cropping out, where associated depressed sectors occur such as the diapir of Dumre. The evaporite rocks trended the thrusting process westward (VELAJ et al., 1995).

There are many data arguing that under this overthrusting there occur distinct anticlines (carbonate formation) such as Dumre anticline. The Upper Triassic evaporitic rocks from Dumre diapir have the main participation in the evaporite formation (PRIFTI & SILO, 2010).

2. In the western front of Çika anticline belt (external subzone of the Ionian zone) there exists also a regional fault, which in its northern sector deviates east-northward (Fig. 1) interrupting Çika and Kurveleshi belts. Tonorth, it joints Berati belt fault. This fault is named ”Vlore-Elbasan-Diber cross fault”. It is more evident the effect of this crossfault reflected especially in the different tectonic styles, south and north to this fault. So, while in the southern area of the Ionian unit, carbonate structures extend by clearly outlined structural elements of different sizes, in its northern

side, the nonfolded South Adriatic Basin extends (Figs. 1; 4), anticlines such as Kardhiqi (Fig. 5) and Delvina diapirs (Fig. 6). It must be mentioned that is also affected by the diapirs activity (PRIFTI et al., 2004).

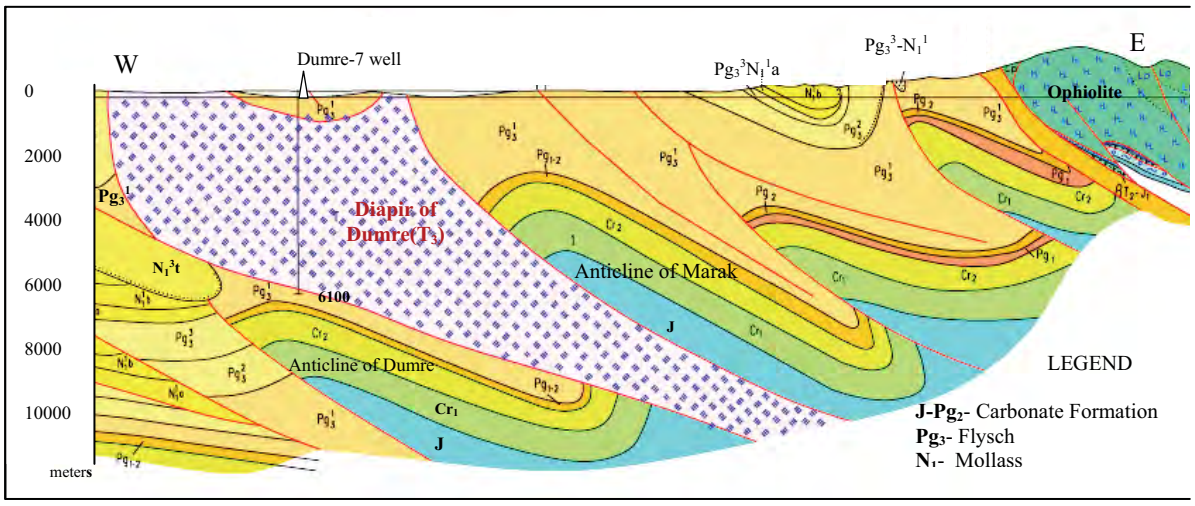

Figure 4. Diapir of Dumre (based on geological map of Albania, scale 1:200 000), crossedby Dumre-7 well (geological section II).

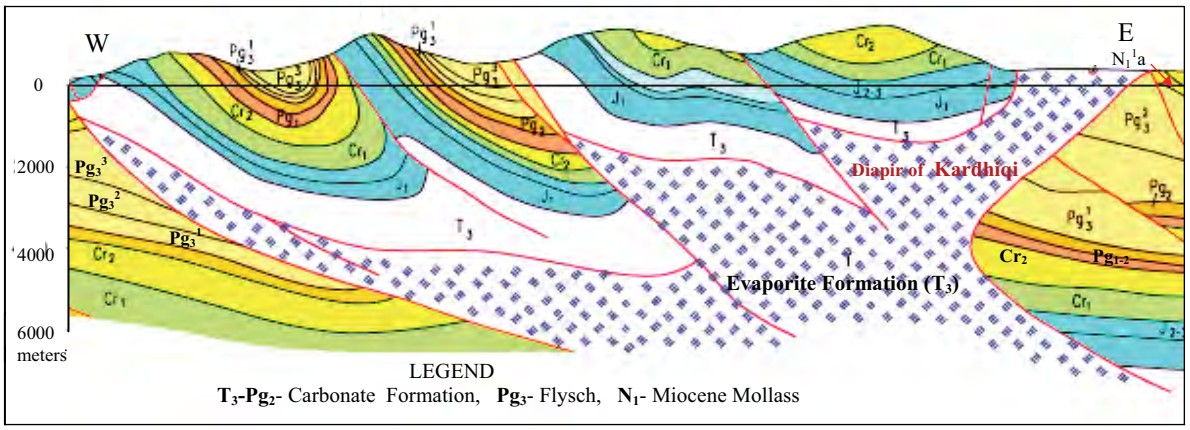

Figure 5. Diapir of Kardhiqi (based on geological map of Albania, scale 1:200 000, geological section III).

B. Evaporite diapirs erupted through local faults and backthrust fault plane of the individual.

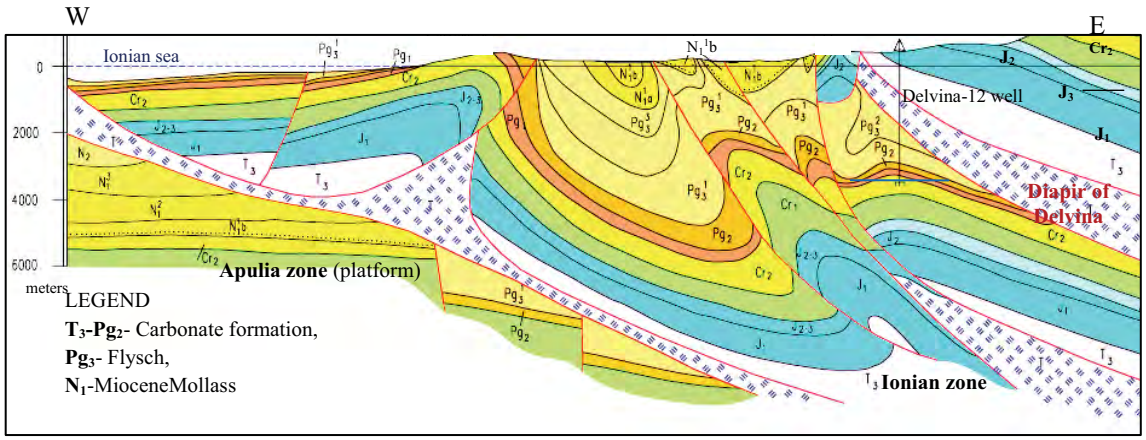

Figure 6. Plane of overthrust on the western front of Çika anticline belt and the diapir of Delvina (based on geological map of Albania, scale 1:200 000, geological section IV).

In the case of Delvina region, the borehole data indicate the presence of evaporates from 500 m to 800 m in thickness that acted as a sliding "pillow", locking the development of tectonic blocks. In both cases the tectonic plan dip eastward with sharp boundaries, outlined by log measurements.

C. Nearly vertical evaporate diapirs in anticline cores (Carbonate Formation) such as Nevarica or Xaradiapirs (Figs. 6, 7).

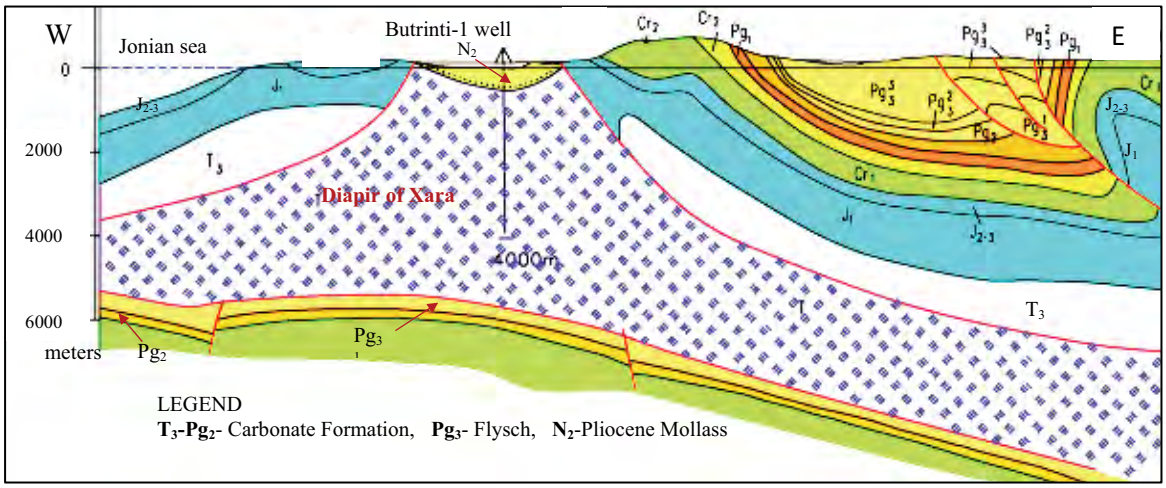

Figure 7. Near vertical evaporate diaperin Xara anticline core
(based on geological map of Albania, scale 1:200 000, geological section 5).

THE INFLUENCE OF DIAPIRISM IN THE OVERTHRUSTING PROCESS

The tectonic pattern of the External Albanides is the result of the orogenesis and diapirism phenomena, which has been in unity with each-other.

In different stages of the geological evolution, the evaporate diapiric process acted with different speed, related to the intensity of the tectonic forces, pressure extension, etc.

Based on the worldwide experience, it is accepted that thebasic condition for the evaporites movement is reached when and where the evaporites cover thickness is about over 1000m and where evaporates thickness exceed 300 m. Such conditions are established since the Early Toarcian, which caused evaporites movement toward the sectors where lithostatic pressures were lower (to horst blocks) and to weak tectonic loops (VELAJ et al., 1995).

As a result of the tangential forces the gradual folding happened and the structures increased their dimensions continuously. In these conditions the lithostatic pressures applied to the evaporate rocks were different, in terms of the different positions. In addition, by the early collision time, the longitudinal faults would start to reactivate by passing into thrusting faults.

Meantime, the Evaporate Formation was not in equilibrium, and started to move toward the lower pressure sectors, which in general were the top of the folded structures.

In this manner, the complication of the structures and structural belts and tectonic zones happened and the evaporite formation erupted following the fault planes. During the post collision stage, this lasted from Serravallian to Pliocene the orogenic process of the thrusting of the Ionian zone over Apulia zone continued.

So, a further modification of this structural model happened, chiefly towards increasing their thrusting scale westward. In this case both local thrusts and regional ones were not only realised through old collision but through new faults as well, which included flysch deposits. These faults were used as passage ways by evaporites for their diapiric penetration.

As a result of the complex action of all the tectonic factors, Ionian and Kruja zones overthrust considerably westward the Apulia platform (Fig. 6).

CONCLUSIONS

Diapirism of the evaporite formation is one of the main processesin the geological setting of Albania. Orogenesis and diapirism phenomena have conditioned the tectonic setting of Albanides. New phases of tectogenesis are indicated by the diapir phenomenon.

The main minerals of the evaporite rocks are anhydrite (45-80%), halite (15-55%), clay minerals (15%). The evaporite formation of Wermik embedded fragments of dibasic rocks, where as the evaporite formation of Kardhiq embedded fragments of effusive rocks. This formation contains also tectonicblocks (cap rock) originating in the surrounding rocks.

Based on sporo-pollen analyses, the evaporite rocks are Late Triassic.

There are three types of evaporitic diapirs;

i. Diapirs erupted through regional fault planes, especially on tectonic planes of the anticline belts in the Ionian zone (diapir of Dumre);

ii. diapirs erupted through local faults and backthrust fault planes of the individual anticline (in southern part of Albania);

iii. nearly vertical diapirs in the anticlines cores (Carbonate Formation).

Diapirs of Peshkopi and Delvina are in highlands. This is conditioned by the prevalence ofhard rocks.

The region of Dumre diaper is settled, while other diapirs are not populated. Gypsum andanhydrite of Delvina diaper are layered, but this is an exceptional case while other evaporates are generally chaotic.

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PLATE I

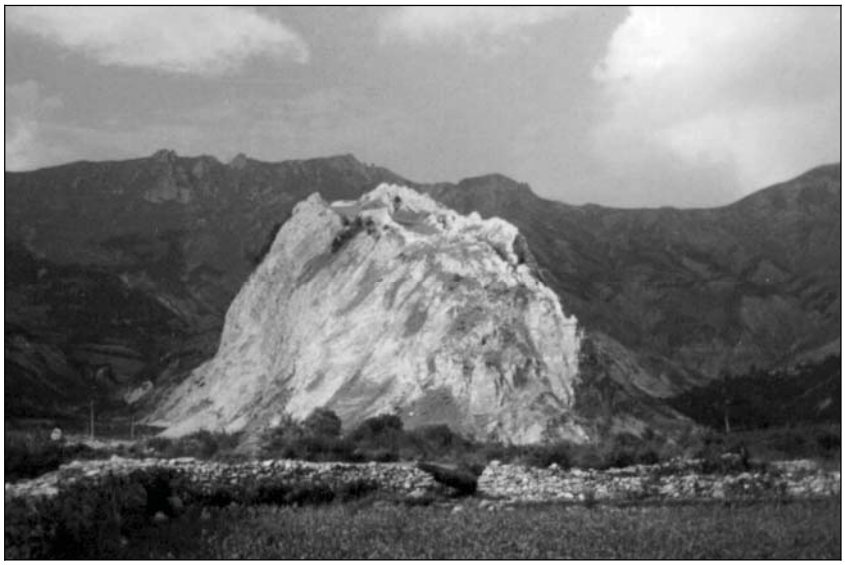

Photo 1. “White mount” of the diapir of Peshkopia (gypsum).

Photo 2. Lake of Belshi in the area of Dumrea`s diapir (touristic area).

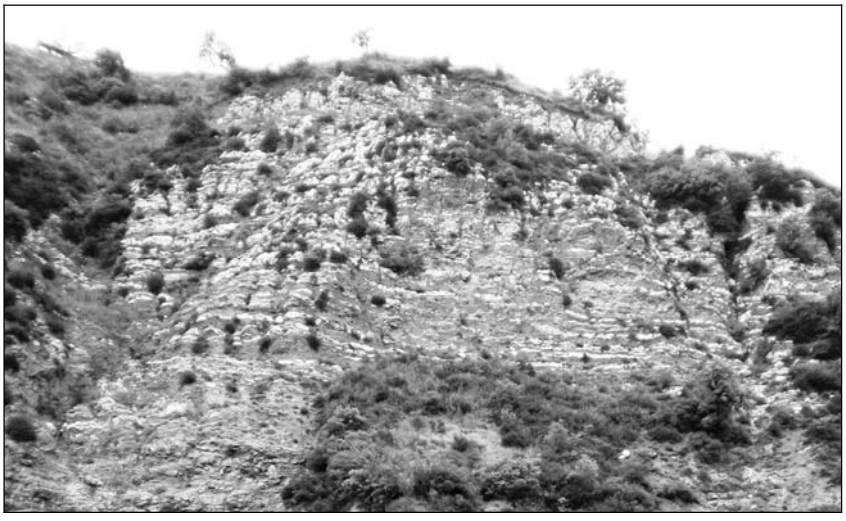

Photo 3. Diapir of Delvina with layered gypsum andanhydride.

PLATE 2

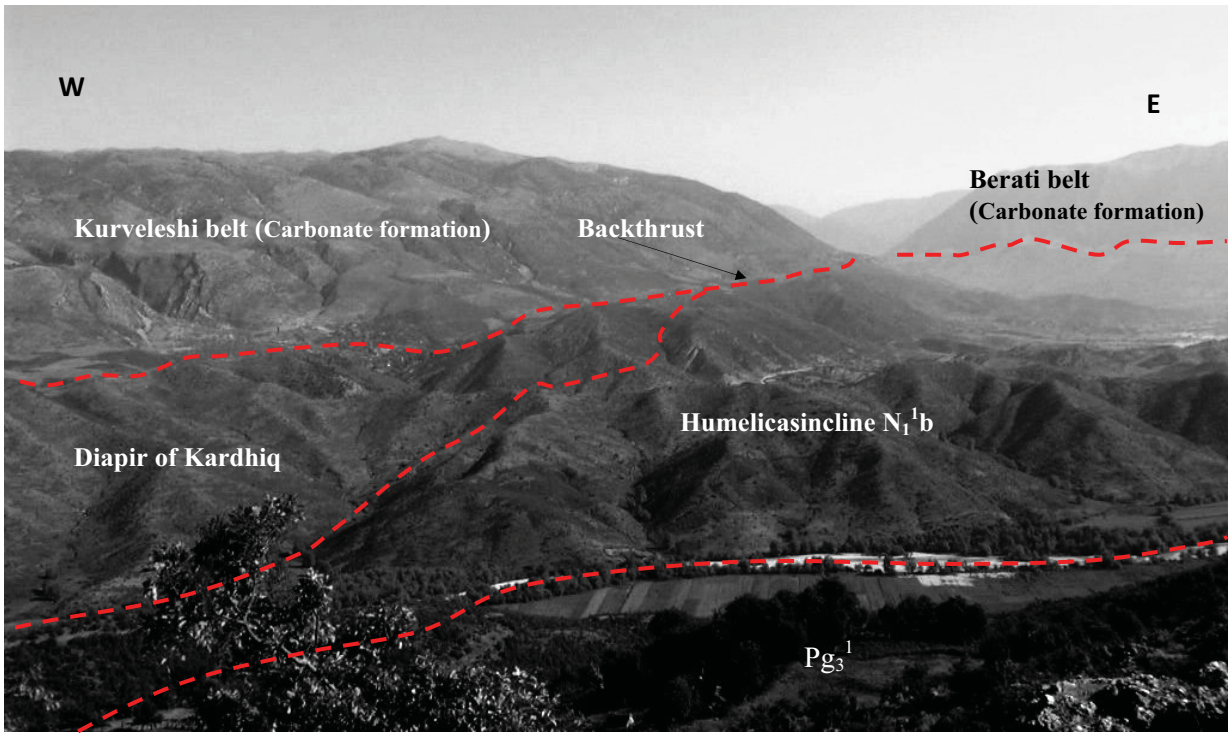

Photo 4. Relation between the diapir of Kardhiq and surrounding structures.

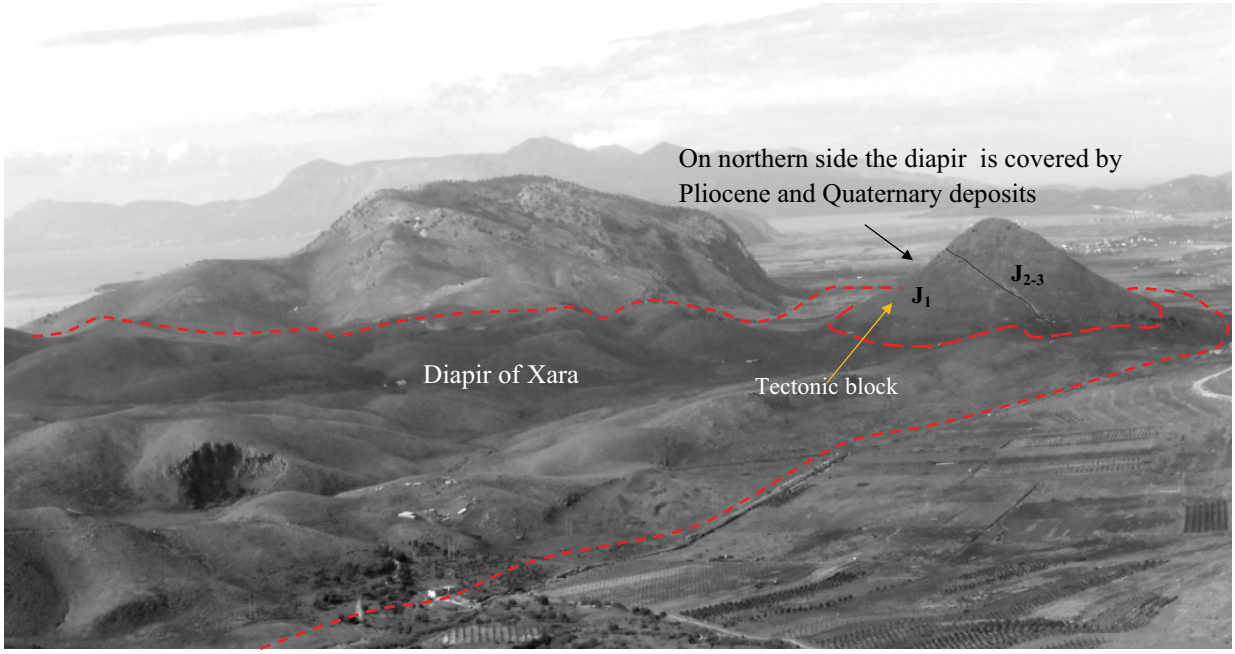

Photo 5. Diapir of Xara.