O 4. TECTONIC MODEL OF THE KRESHPAN - VERBAS REGION AND OIL RESERVOIR RELATED WITH IT

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ABSTRACT: The study region is located in the Kurveleshi belt part of the Ionian tectonic zone (Outer Albanides). Kurveleshi belt (subzone) is characterized by anticlinal structures with different dimensions and tectonic model with northwest to southeast direction. The Kreshpan – Verbas anticlinal structure is the northernmost structure of the Kurveleshi belt (subzone). Based on the seismic works and drilled wells in this region, will be given some consideration of the tectonic model of this structure. The anticline structures of Kreshpan - Verbas is characterized by two tectonic floor. The lower floor is formed by carbonate and flysch deposits that build the core and limbs of the Kreshpan - Verbas anticlinal structure, which is folded before Burdigalian age. The upper floor is formed by Miocene molasses deposits that are placed transgressively on the top of lower structural floor. The hinge of the Kreshpan-Verbas anticlinal structure is eroded up to the level of Jurassic deposits. The eroded limestone of this structure have served as source rocks and has formed oil reservoir in the sandy deposits of Messinian.

Keywords: *Anticlinal, Kreshpan – Verbas, Tectonic model.*

1. INTRODUCTION

The Ionian tectonic zone begins outside the Albanian territory, from the Peloponnese and continues towards the northwest in Albanian territory until the transverse tectonic faults Vlora-Elbasan. (Xhomo et al, 2002). To the east the Ionian tectonic zone is bordered with Kruja tectonic zone and in the southwest its contacts tectonically with the Sazan tectonic zone. Ionian tectonic zone overlap to the west and completely hide some structural units. From the south towards the north within the Albanian territory, the Ionian tectonic zone gradually reduces its width (Roure, et al., 2004) as a result of the interruption of structural units and the subzones and their overlapping toward the west (Fig.1). The north and northeast boundary of the Ionian zone coincides with the orogeny border overlapping to the Southern Adriatic zone. The Ionian zone is divided in three main structural subzones as follows from West to East:

- The western subzone of Çika
- The central subzone of Kurveleshi
- The eastern subzone of Berati (Xhomo A. et al, 2002).

In the Ionian tectonic zone are the main oil and fields in Albania, especially in the Kurveleshi subzone where are dicoverd several oil field. In this subzone also are made a large number of geological studies, seismic works and considerable number of drilled wells. All these studies are taken into consideration to give the tectonic model of the Kreshpan –Verbas anticlinal structures that is the most northern structures of the Kurveleshi subzone (belt) (Velaj T., 2015). Also with this structure are related the Patos- Marinza oil field in Messinian deposits (Fig.1). The Patos- Marinza oil field is located in the north - eastern part of Fier city in southern Albania.

2. GEOLOGICAL SETTINGS

In Ionian tectonic zone and in Kurveleshi subzone are distinguished three main sedimentary formation. The Permo- Triassic evaporites, Upper Triassic to Eocene carbonate and terrigenous formation from Eocene to Quaternar. The evaporitic formation in Kurveleshi subzone are associated with deep tectonic faults of the anticline structures. The largest outcorp of this formation is in the Dumrea diapire with an area of about 210 km^2 in the north part of the study region. These formation generaly are represented by gypsum, anhydrite, dolomite, potassium salt limestone and multicolored clay (Velaj et al., 1999). The geological data obtained from deep wells (Dumre, Paper, Grekan, Bogaz, Butrint, Delvine, Picar) (Xhomo et al, 2002) and seismic data show that these deposits in all cases have tectonic contact with surrounding rocks. The carbonate formation in Ionian zone is divided in two large megasequences (Roure et al., 2004) (Fig.2).

- The megasequence before rift of Permo-Triassic age to the Lower and Middle Liassic, which are considered as deposits of neritic facies.
- The megasequences of the post-rift deposits of Toarian to Paleocene in age. These post-rift deposits are interpreted as pelagic facies.

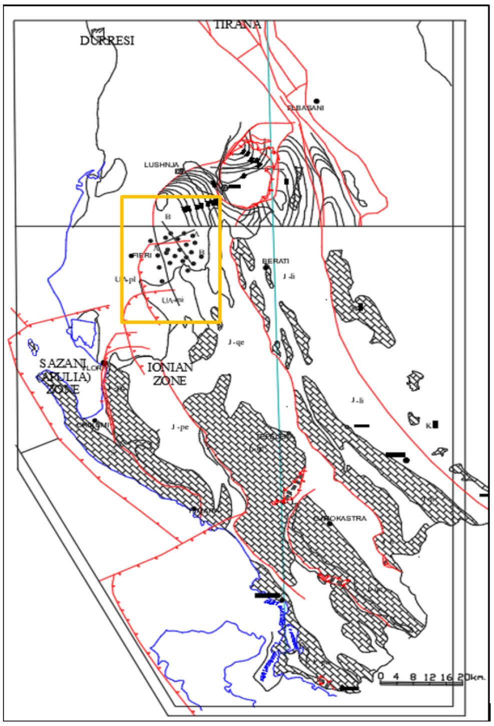

Figure 1. Geological-tectonic map of southern Albania (Study location) Xhomo et al, 2002)

The deposits of the both these megasequences belong to the passive edge of the Adria tectonic microplate. The neritic facies are lithologically represented by dolomite and limestone (Rahimi Q, et al., 1987). The pelagic facies within Ionian tectonic zone and Kurveleshi subzone are lithologically represented by “schists with Posidonia”, “Ammonitico rosso” which are transgressively placed on the horst tectonic blocks. This kind of sedimentation of the pelagic facies continued until the end of Paleocene - Eocene. The big changes in thickness and facies variations, which are documented for the Triassic- Liassic deposits of Ionian zone, can be well explained with the presence of the big bended platformic carbonate or dolomitic blocks of the pre-rifting megasequence.

The terrigenous formation in Kurveleshi subzone lithologically are represented by turbidite limestone and biomicritic and micritic limestone in the lower part of the stratigraphic columns (Korroveshi et al., 1981). The transition from Eocene limestone deposits to flysch of Oligocene deposits is done through a transitional marl package. Flysch deposits are represented by claystone-sandstone layers mainly of medium rhythm with micritic, biomicritic and turbiditic limestone layers (Bakia H, et al., 1998). Neogene deposits are represented by those of the Miocene and Pliocene (Bandilli L, et al 1976). The Aquitanian, Burdigalian and Serravalian deposits lithologically are represented by marls, lithothamnic limestone and sandstone. The deposits from Tortonian, Messinian and the Pliocene are lithologically represented by sandstone, siltstone and claystone (Myftari S, et al 1995). Messinian deposits are most prevalent and lithologically from bottom to the upper part of the stratigraphic columns are represented by the formations Bubullima and Gurët e Zesë, Marinza, Driza, Gorani, Kucova and Polovina as follow (Gjoka M, et al., 1986). The Bubullima formation is placed transgressively on the oldest deposits and is represented by lithothamnic limestone which at the base have large grain sandstone and conglomerates. In the plan these deposits have several lithological changes, passing from carbonate gravelly sandstones with lithotamnia and limestone sandstones with lithotamnia in the east to siltstones in the west. In the area of Kallm
- Kolonjë this formation have 20 layers which in the west and in the northwest directiom passing into claystone. This formation have thickness that varies from 20 to 200m (Fig.3) (Gjoka M, et al., 1988). The Guret e zezë formation are lithologically represented by massive claystone with siltstones. The

claystone are blue-gray with reddish-yellow spots and many macrofauna. The thickness of this formation increases from southeast to northwest direction and varies from intervals 0 – 700 up to 1100m (Fig.3).The Marinza formation in the western part lies normally above the Bubullima formation and with discordance with the eroded surface in the east and south part of the Patos – Marinza monoclinal structure. Lithologically it is represented by massive layers of sandstones that contain carbonate sandstone concretions. Sandstones are interbedded with claystone with carbonate concretions. The thickness of this formation varies in an interval from 30 - 120m from south to the north direction. (Gjoka M, et al., 1988)

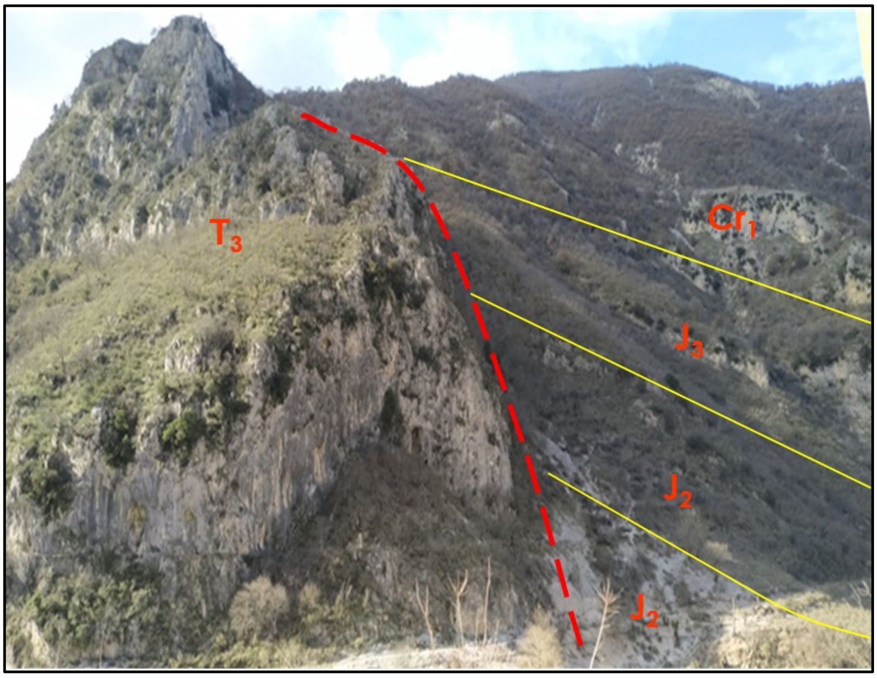

Figure 2. The main tectonic event T_3-J_1 (Lower & Middle Liassic)/Middle-Upper Jurassic – Eocene (Ionian tectonic zone) (Photo Bence Village Albania).

The Driza formation have widespread in Patos - Marinëz - Kolonjë monoclinal structure and deposits of this formation have also been documented in the Gorishove - Kreshpan monoclinal structure. It is placed transgressively on the oldest deposits and builds the bay of Patos - Marinza. This formation in the plan undergoes in significant lithological changes, in the region of Patos is claystone - sandstone layers, while in Marinza and Kolonjë it is sandstone –claystone layers. The thickness is about 60 - 120 m (Fig. 3) from south to the north of the region (Gjoka M, et al., 1988). In the outcrop of the Driza formation are easily distinguished the oil signs and fosalizaied wood in the sandstone formation (Fig. 4).

The Gorani formation is normally placed above the Driza formation and has the same spread. In the Zharrza eroded uplift (Fig. 7), Gorani formations is placed transgressively on carbonate deposits, especially the Go_5 and Go_6 layers. In Patos - Marinza is represented by the combination of not well cemented sandstones till gravel with claystone and carbonate siltstone. The thickness of this formation from south to north goes from 100 - 160m. The Kucova formation is widespread throughout the Patos - Marinza monoclinal structure and is placed transgressively on the Gorani formation. While on the Kuman - Jagodina structural scale it is placed transgressively on the flysch and carbonate oldest deposits. Lithologically it is represented by the combination of sandstone - claystone layer with conglomerate lenses. The thickness of the Kucova formation varies from 160 - 330m. The Polovina formation is widespread in Patos-Marinza monoclinal structure and is normally placed on the deposits of the Kucova formation while in the eastern part of the Marinza region it is eroded. Lithologically, it is represented by a combination of claystone with not well cemented sandstones, while in the western part Picar-Buzmadh, Kreshpan – 1 and Frakull further in the west, are documented gypsum intertlayerd with claystone. The thickness of this formation from Patos to Këmishtaj is from 200 - 300m and in the west direction increases even more. (Gjoka M, et al., 1988)

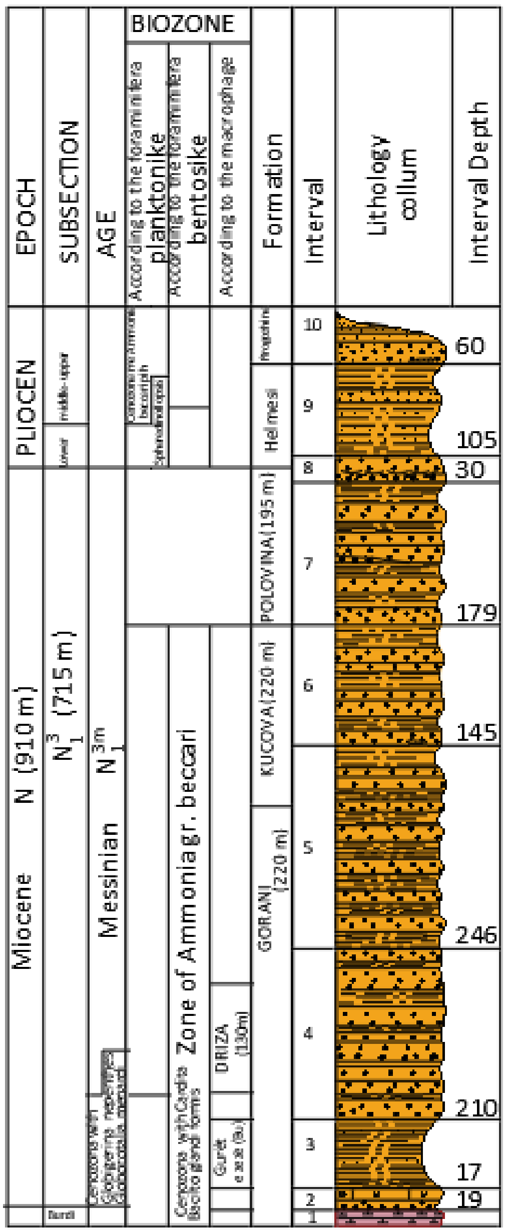

Figure 3. Gurët e zezë lithological column

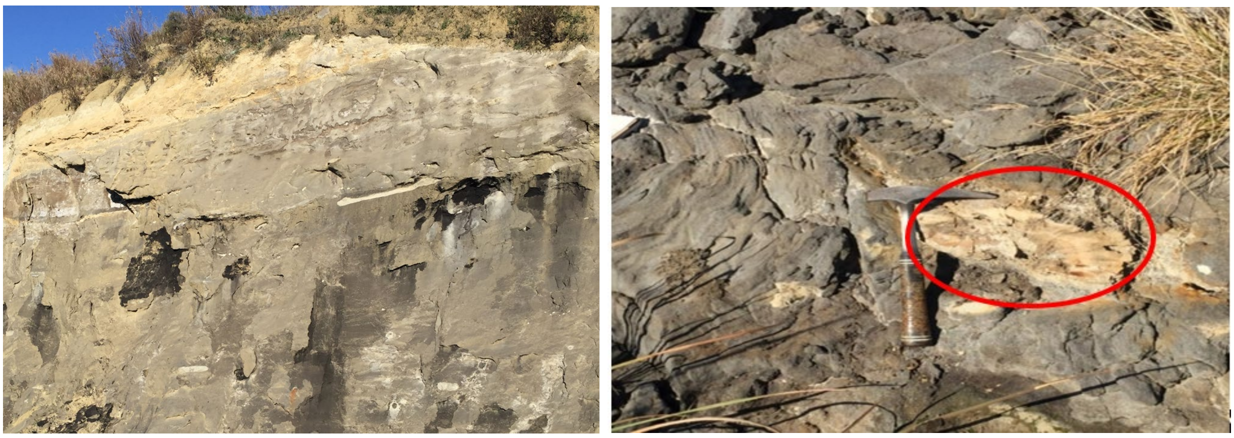

Figure 4. The outcrop of Driza Formation in the south part of the study region (the oil sings are easily distinguished in the sandstone formation and the fosalizaied wood)

Tectonic Model

From the geological works, seismic profiles and of the drilled wells have been obtained necessary data to give the tectonic model of the Kreshpan - Verbas region. Messinian transgression is clearly visible on the surface in the in the Gurët e zezë outcorp where Messinian deposits are placed transgressively over the Burdigalian deposites. (Fig. 5). There are also data on transgressive of the Burdigalian deposits east of the Ballsh anticline and partly on the western flank of the structure and in the southern part of Visoka structure, while in Cakran they have normal contact with the Akutanian deposits, so they are placed successfully(Bakia H, et al 1985) Mehillka L, et al 1988).

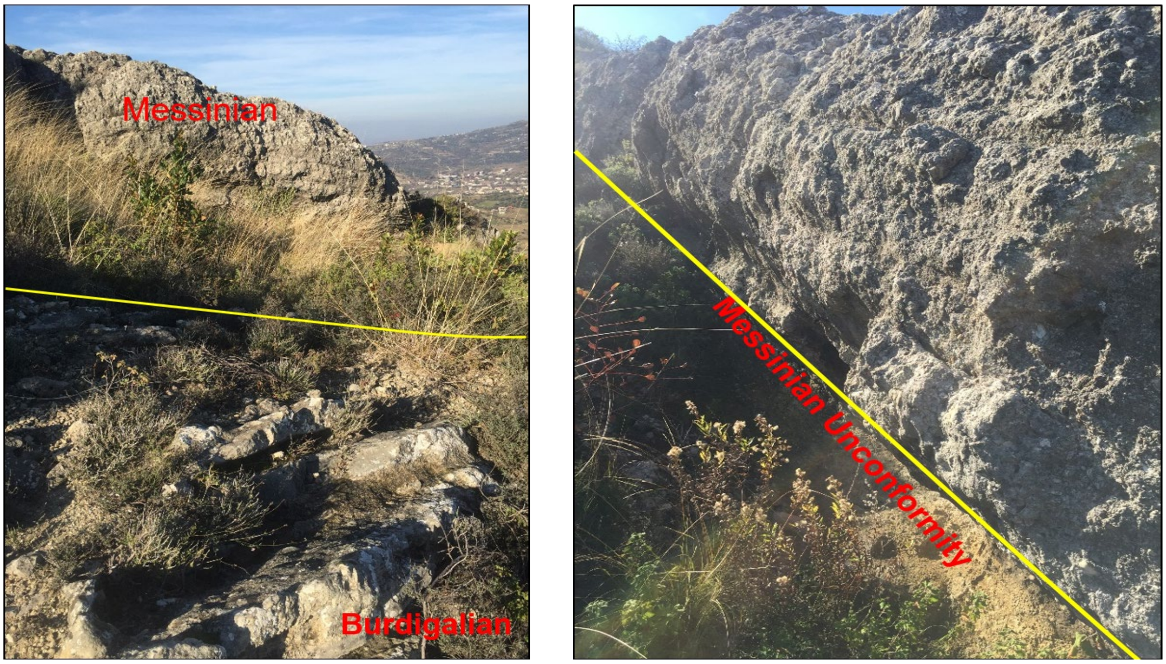

Figure 5. Messinian Unconformity (Gurët e zezë outcrop) northern part of the study region.

Lower Structural Floor

Lower structural floor deposits on the surface emerge only south of the study region at the Ballsh and Cakran anticlinal structure. In the other part of the region these deposites are covered by upper tectonic floor deposits (Fig.6). The data obtained from geological works and drilled wells in this area have provided considerable information for the construction of the lower structural floor. It should be noted that in this region is a very large number of seismic works and drilled wells. The most important structures in this region are the brahianticlinal structure of Patos - Verbas and to its west the anticlinal structure of Kreshpan. The brahianticline structure of Patos - Verbas has a northwestern direction (Sadiku Y, et al 1990). At the core this anticlinal structure is built from old Triassic and Jurassic deposits but the presence of evaporites is not excluded (Fig.6). The hinge of the structure is eroded up to the levels of Lower Jurassic deposits. At the same time, the Cretaceous deposits up to the Paleocene-Eocene are eroded and Messinian deposits are placed placed with angular and azimuthal unconformity (Fig.6). Its periclinals are extended and the northern part is more eroded, indicating that the Patos - Verbas anticlinal structure has been most elevated to the north, the southern periclinal is shallow forming favorable structural conditions for the formation of oil reservoir layers. In this area of the structure is formed the Visoka oil field which is a hydrodynamic oil reservoir.

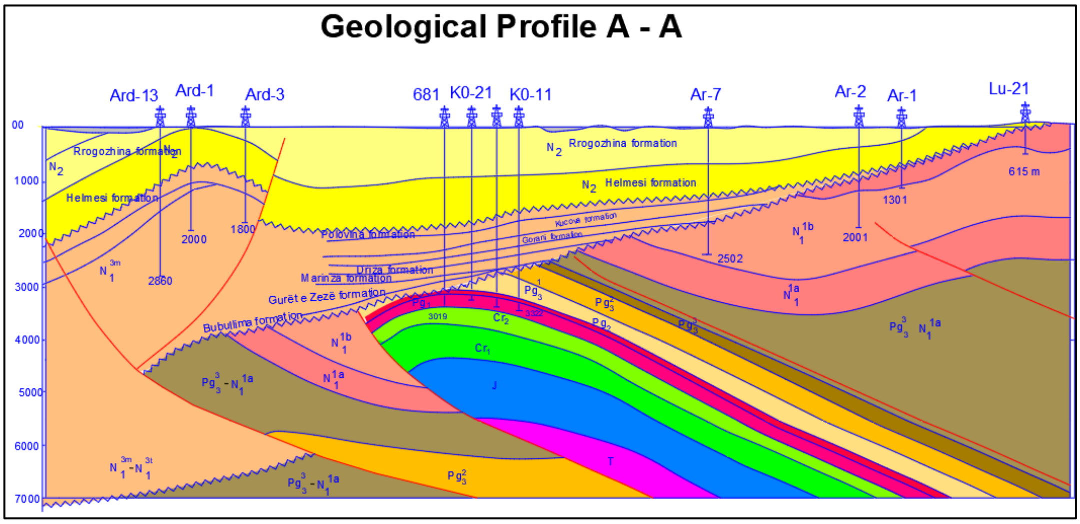

Figure 6. Transversal geological profile modified from (Gjoka M, et al. 1988).

The eastern flank of the Patos-Verbas anticlinale structure is relatively is less steep and constructed by Cretaceous, Paleocene - Eocene deposits and successively by the terrigenous flysch and molasses deposits and dips eastward with angles 20º-30° (Fig. 6).The western flank is steeper confirmed by drilled wells and gjeological works and tectonically faulted, so the wells V-3, 695, 655 have documented this tectonic fault. Where the first one from the Triassic carbonate deposits has passed to those of the Hatian-Akutanian and the other two wells from flysch deposits of the Middle Oligocene with those of the Burdigalian and Akutanian deposits.The western tectonic fault of the Patos - Verbas anticlinal structure puts carbonate deposits in contact on the east side, with the Burdigalian deposits in the west (Fig. 6). This fault in northward direction takes a northeast turn and interrupt the Patos - Verbas anticlinal structure for carbonate levels in the northern part of the study region (Sadiku Y, et al 1990). This tectonic fault is a structural fault and coincides with the trace of the transeval fault Vlora – Elbasan. Characteristic of this structure is the presence of interflysch tectonic faults with eastern dips angle of 35º - 40º, formed after the Messinian and Pliocene (Fig. 6). Towards the north this faults places on the deposits of the Burdigalian and Messinian the oldest deposits of the Oligocene age. This tectonic fault is not the same with the old limestone fault of the Patos - Verbas anticlinal structure. It is thought that the tectonic fault of the western flank of the Ballshi anticlinal structure is the same with the fault of the western flank of Patos – Verbas anticlinal structure (Sadiku Y, et al 1990). In the central and northern part of the Patos – Verbas anticlinal structure the fault also affects the Burdigalian deposits so is post-Burdigalian age. The anticlinal structure of Kreshpan is located directly in the northern continuation of the anticline of Cakran and in the west of the brahianticlinal of Patos - Verbas. Geological works and drilled wells, indicate the existence of anticlinal structure in the north - northwest of Cakran for the carbonate levels and is called Kreshpan anticlinal structure. The Kreshpan anticlinal structure is proven by some wells that have been drilled in the region and has produced very little oil. Geological works show that the Kreshpan anticlinal structure on the surface is constructed from Oligocene flysch deposits, which in the northern part are covered transgressively by Burdigalian deposits and newer deposits. Due to the effect of the flysch movement to the west direction as a result of the overlapping of the eastern structures the roof of the carbonate deposits has a displacement to the east direction. As a result of this phenomenon are caused the faults that occur in the western flank of the structure and are interformational faults. (Sadiku Y, et al 1990). The roofs of these structures are eroded for different stratigraphic levels.

The Upper Structural Floor

Previous seismic works and in the recent years also the drilled wells have further clarified the structural construction of the upper structural floor. This structural floor forms the monoclinal structure of Patos – Marinza and extends southeast to northwest direction and dips in the north- western direction. This monoclinal structure is built from several formation (Fig. 3). The geological profile show that the upper structural floor is less tectonically folded and is placed with angular and azimuthal unconformity on the carbonate and in the flysch deposits of the Patos – Verbasi eroded anticlinal structure (Fig.6).

This deposits from west to east wedge stratigraphically on the uplift of Zharrza and the Kuman- Jogodine scale (Fig.7). Also partially the Gorani formation and newer deposits pass the erosive uplift of Zharrza and are placed transgressively on the deposits of Roskoveci synclinal structure. In the north of Marinza village pass the uplift of Zharrza also the Driza formation (Fig.7) (Gjoka M, et al. 1988). Aslo another transgression is between Pliocene deposits and Messinian deposits (Fig.6). Throughout the region the Messinian deposits is eroded in varies levels. In the eastern part of this monoclinal the erosion of the Messinian deposits from the Pliocene goes up to the levels of the Gorani and Driza formations while in the west the erosion goes up to the levels of the Kucova and Polovina formations(Gjoka M, et al. 1988). In the geological profiles it is obvious that the area with the highest erosion is Zharrza area (Fig.7). In the Patos-Marinza monoclinal structure is characteristic that the contours of the lithological-stratigraphic wedge of the oil reservoir layers are not in accordance with the isolines of the structural maps that have gradual and continuous dipping in the south-west direction (Gjoka M, et al. 1988). This comes as a result of the change of the structural plan of Messinian deposits, during the time of the Pliocene. At the levels of the Driza formation, is documented a ripple structure from west to east direction forming synclinal structure of Lalës. At the synclinal structure of Lalës, near the eroded surface are observed the wedges of Tortonian deposits in a west to east direction while in the north - south direction are observed more. Also reductions of thickness of this deposits are observed. The width of the Lalës synclinal reaches 2 - 3 km and with an extension north - west up to 7 km. To the north of the well Kr - 5 is seem that the synclinal structure of Lalës is unified with other structural units. The Neogene deposits in the west of the Lalës synclinal structure bends with relatively is less steep eastern flank and forming the Neogene “structural nose” of Krapsi (reference). This is conditioned by new neotectonic movements. Based on this and according to the surface geology, the Neogene “structural nose” of Kraps seems to have its origin directly in the northern periclinal of Cakran structure (Janopulli V, et al., 1980). As a result of this, it is not excluded that the Neogene deposits of Kraps have previously been united in a single fold with the Neogene deposits (Tortonian and newer one) of the western flank of the Cakrani structure. This “structural nose” extends northwest until the well Fieri - 2, and further to the north does not continue, but the anticlinal structure of the Ardenica is formed. The eastern flank Krapsi structure dips with angles of 10^o - 15^o, while the western flank with angles 75^o - 80^o and is tectonically faulted, on the surface has a small amplitude (emerges within the Pliocene deposits) but at the base of eroded surface in the east and west this amplitude increases. This fault plan have east direction with small angle but in the vicinity of the eroded surface and in the depth direction the angle should increase. Although in the east of the eroded surface apparently remains static to the folds of the upper structural floor. Analyzing the equal thicknesses of the Tortonian deposits on both sides of the fault, it is concluded that in the west the eroded surface must have been inclined, as well as the western flank of the Neogene uplift. The transgressive contact of the upper tectonic floor is clearly visible at the beginning of the structural nose of the Krapsi (Janopulli V, et al., 1980). This surface has been confirmed by the wells drilled in this area, where from deposits of Tortonian has passed to those of Hatian - Akutanian. In the Kreshpani region in the west of Cakran area the Neogene deposits of the upper structural floor have the form of a monoclinal near the tectonic fault and further to the west they fill the Selisht - Cakran synclinal structure. To the northwest direction the Neogene deposits of upper tectonic floor take full synclinal form with continuous decreasing trend. The eroded surface dips to the north, so do the upper structural floor deposits, especially those of Messinian. The continuation of the eroded surface to the west of the Krapsi tectonic fault is drawn on the basis of direct well data and with the help of seismic and geological profiles (Janopulli et al., 1980).

Oil Reservoir Related With the Anticlinal Structure

All studies conducted for oil and gas exploration in the study area have shown that in the Patos - Marinza oil field the oil is secondary and genetically related to the eroded limestone (Barbullushi R., 2013) of the anticlinal structure of Patos - Verbas. The oil field in Patos - Marinza is the largest oil field onshore discovered in Albania. The geological works in the Patos-Marinza oil field indicate that the oil field have reservoir in different oil conditions phase. Three are the main oil reservoir formation in Patos – Marinza Gorani, Driza and Marinza (Çobo L., 2002).The deposits of the Bubullima formation in the sedimentation bays of Kolonjë and Kallmi, are represented by the combination of gascondensate reservoir with the oil (layers from B_1 to B_{14}). This oil reservoir have limited spread near the eroded surface and are placed vertically one after the other and displaced in the horizontal plane, thus forming a transgressive series. Oil and gas reservoir thicknesses that are associated with deposits of Marinza formations, include mainly oil with gas cap reservoirs. Oil reservoir are found all over the Patos-Marinza-Kallm area, including formations from Driza to Kucova of the transgressive-regressive series. Bituminous thicknesses include the bituminous sand of pure natural bitumen and bituminous gravel. The bituminous thickness of the sandstones is widespread in the Patos oil field. The bituminous thicknesses are related to the Driza formation layer D_4 - D_5 and the Marinza formations layers M0, M1, M2.

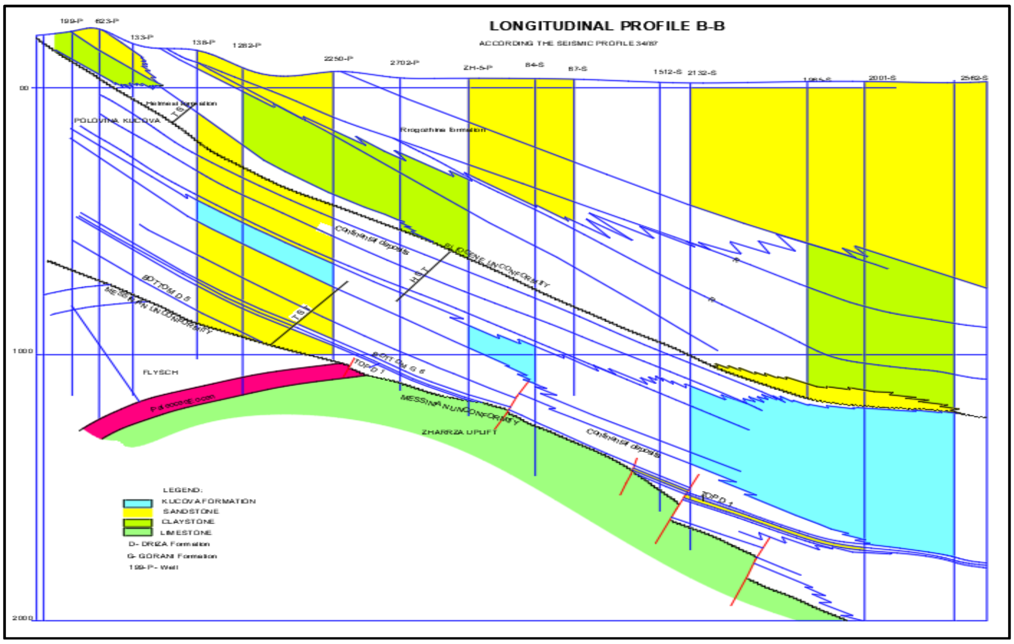

Figure 7. Longitudinal geological profile in the Patos Marinza Oil field

Geological works in the Patos - Marinza oil field indicate that the hydrocarbon generation in carbonate rocks have continued throughout all the geological time after the source rocks have entered in the main stage of oil generation. In the all oil fields of Neogene and carbonate deposits, the phenomenon of the association of biodegradated oils with normal oils is observed. This is observed also in Patos – Marinza oil field. The oil in Patos - Marinza oil field belong to the early generation phase (Driza formation). The oil that belong to the late generation phase are found in the Marinza and Bubullima formations. The the oil formation of Patos - Marinza are found in Messinian molasses deposits that are placed transgressively on the eroded limestones of the Patos - Verbas anticlinal structure (Gjoka M, et al. 1988). This indicates that the main routes of hydrocarbon migration for the accumulation of the oil in molasses deposits are the transgressive contacts with eroded limestones which serve as hydrocarbon migration path (fig 7). Oil reservoir thicknesses that contact with limestone favor the migration of hydrocarbons vertically, also favor the formation of deposits even at those thicknesses that do not have transgressive contacts with the eroded limestone. In these cases, migration is also favored by the presence of tectonic faults. Migration through the tectonic faults is observed in several layers of the Gorani formation in the eastern part of the Marinza village and in the Kucova formation (Fig. 7). The direction and distance of the migration of hydrocarbons in the Patos - Marinza oil field depends on the contact of the source rocks and accumulation formation that during the geological development is not always the same throughout the oil field. In Patos - Marinza - Kolonjë area the eroded surface has a very large surface on which are placed the deposits of the formations Bubullima, Marinza, Driza and Gorani (Gjoka M, et al. 1988). While in Cakran - Kreshpan area the features of the source rock and the accumulation zone also depend on the conditions of oil migration. The oil reservoir layers of the Bubullima, Marinza, Driza and Gorani formations in the southern part (Patos) and in the south-western part (Kreshpan) where they outcorps in the surface have many oil marks. This indicates that oil has migrated in the horizontal direction from the eroded uplift of Zharrza located further to the north (Fig.7). So we can say that horizontal migration has been made in relatively large distances. For the Driza formation in the Marinza village, horizontal migration of the oil has been made also in the northern part of the eroded uplift of Zharrze until Kallm village where these deposits dips (Fig.7). The vertical migration has in Patos – Marinza been less intense, thus conditioning the small number of oil reservoir in the Gorani formation. The Patos and Cakran-Kreshpan monoclinals structure from the paleotectonic point of view have been a unique unit with the same deposits and for this the oil reservoir of the Kreshpan region are related to the Bubullima formation (Janopulli V, et al., 1980). For this reason it is accepted that the source rock are related to the anticlinal structure of Patos – Verbas (Gjoka M, et al. 1988). The oil reservoir thickness of the upper Messinian deposits are found displaced further in the west in relation to its initial position. The upper part has been displaced by at least 10 km to the west in relation to its initial position, taking into consideration the Neogene depsits outcrop at Gegaj and Bishqethëm villages. The eastern and north - eastern parts of the Neogene deposits are thought to be almost in the initial sedimentation position. This variant is also supported by the fact that the oil reservoir and the oil mark in the geological log are mainly concentrated in the upper part of the geological log until 1000 - 1200 m deep.

3. CONCLUSION

1. The sudy region has two structural floor model, where the lower floor deposits are constructed of carbonate formations and partly terrigenous formation, covered with angular and azimuthall unconformity by the molasses deposits of the upper structural floor mainly those of the Messinian age.
2. The lower structural floor has anticlinal structures which on the western side are tectonically faulted and overlapped towards the west, sometimes masking the northern structures.
3. The transverse tectonic faults Vlore - Elbasan has interrupted in the north the anticlianle structure of Patos - Verbas. This fault is a combination of longitudinal faults with transverse faults.
4. The deposits of upper structural floor are transgressively placed on older deposits of the lower structural floor and they form the monoclinal structures of Patos - Verbas and Cakran - Kreshpan.
5. The Messinian transgression based on geological data and drilled wells is not interrupted by structural faults. So this shows that the orogenesis of the Pliocene floor is displaced further to the west and the movement of the structures is done according to a plan with a smaller and deeper angle, compared to the structural faults.
6. The oil Patos - Marinza field is secondary, genetically is related to the eroded limestone of the anticlinal structure of Patos – Verbas and faund in Messinian deposits. This deposits are transgressively placed on the eroded limestones of the Patos-Verbas anticline structure. The eroded surface has served as the main path of hydrocarbon migration from limestone reservoir to the Messinian deposits.
7. Most important oil reservoir in the Patos - Marinza oil field from the depth are:
   Bubullima formation
   Marinza formation
   Driza formaconi

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