

LITHOLOGICAL AND STRATIGRAPHICAL FEATURES OF PATOS - MARINEZ - KOLONJË MONOCLINE IN ALBANIA (ADRIATIC DEPRESSION)

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Abstract. The Patos - Marinez - Kolonje region has been studied with geological and geophysical methods as well as by well drillings. These studies were carried out in the context of searches for oil and gas. In this region, there have been discovered pay beds in carbonate deposits of the Ionian Zone as well as in the Miocene terrigenous sediments of the Adriatic Depression. This last tectonic unit lies in a stratigraphic position over the Ionian tectonic zone. At the base of the transgressive Miocene sequence the bituminous pay sands are met. Geological and geophysical studies have identified two tectonic units: Hekal - Patos - Verbas anticline belt (the Ionian Zone) and Patos - Marinez - Kolonje monocline (the Adriatic Depression). The Ionian tectonic zone is represented by Patos - Verbas brachyanticline. This brachyanticline is eroded by the Miocene transgression. Hydrocarbons formed in the carbonate section (T_3 - Cr_2) of the Ionian Zone have migrated into the Miocene terrigenous deposits right through the transgression base. Patos - Marinez - Kolonje (PMK) monocline is a unit of the Adriatic Depression. This unit is represented by Tortonian up to Pliocene deposits. The lowermost horizon belongs to the *G. menardii* sl biozone. In the Tortonian - Messinian section of PMK monocline there are distinguished seven lithostratigraphic formations, which are: Bubullima and Guret e Zeze (Black Stones), Marinez, Driza, Goran, Kuçova and Polovina. The respective descriptions will be given following the separation of the above mentioned formations. Within each of these formations, different pay beds are found. PMK monocline represents a complex oilfield. The Pliocene deposits lie by discordance over the Messinian deposits. They are divided into Helmes Formation, mainly argillaceous with conglomerates at the base and upwards the mainly conglomeratic Rrogozhina Formation follows.

Keywords: monocline, Adriatic Depression, biozone, seismic section.

Rezumat. Caracteristici litologice și stratigrafice ale monoclinului Patos - Marinëz - Kolonjë din Albania (Depresiunea Adriatică). Regiunea Patos - Marinez - Kolonje a fost studiată cu metode geologice și geofizice, dar și cu ajutorul forajelor. Aceste studii au avut loc ca urmare a prospecțiunilor pentru identificarea zăcămintelor de petrol și gaze. În această regiune, au fost descoperite zone productive în depozitele carbonatice ale Zonei Ionice, precum și în sedimentele terigene miocene ale Depresiunii Adriatice. Această ultimă unitate tectonică, stratigrafic, este suprapusă zonei tectonice ionice. La baza secvenței transgresive miocene se găsesc nisipuri bituminoase rentabile. Studiile geologice și geofizice au dus la identificarea a două unități tectonice: anticlinalul (Zona Ionică) și monoclinul Patos - Marinez - Kolonje (Depresiunea Adriatică). Zona tectonică ionică este reprezentată de brahianticlinalul Patos - Verbas. Această cutare este erodată de transgresiunea miocenă. Hidrocarburile formate în secțiunea carbonatică (T_3 - Cr_2) a Zonei Ionice au migrat în depozitele terigene miocene exact prin baza de transgresiune. Monoclinul Patos - Marinez - Kolonje (PMK) este o unitate a Depresiunii Adriatice. Această unitate este reprezentată de depozite formate din Tortonian până în Pliocen. Orizontul inferior aparține biozonei *G. menardii* sl. În secțiunea tortonian - mesiniană a monoclinului PMK se disting șapte formațiuni litostratigrafice și anume: Bubullima și Guret e Zeze (Black Stones), Marinez, Driza, Goran, Kuçova și Polovina. Descrierile respective vor fi făcute urmând separarea formațiunilor menționate anterior. În cadrul fiecăreia dintre aceste formațiuni se regăsesc strate productive. Monoclinul PMK reprezintă un câmp petrolifer complex. Depozitele pliocene sunt dispuse discordant peste depozitele mesiniene. Acestea sunt împărțite în formațiunea Helmes Formation, alcătuită predominant din materiale argiloase cu conglomerate la bază, și Formațiunea Rrogozhina, predominant conglomeratică, deasupra.

Cuvinte cheie: monoclin, Depresiunea Adriatică, biozonă, secțiune seismică.

INTRODUCTION

The oilfield complex of Patos - Marinez - Kolonje is one of the largest in Europe. In the period 1925-1930 "Anglo-Persian Oil Company" (APOC) pierced 10 wells in Patos area. The oil in Driza Formation was discovered during 1929. In 1957, oil was discovered in Marinez area (542 well). 1974 year marks the highest value of oil production of 2.25 million tons. Presently, the production is 1.5 million tons (PRIFTI, 2011). The main contribution in the oil production is the oilfield complex of Patos - Marinez - Kolonje (GJOKA et al., 2002).

This paper deals briefly with the geological and tectonic properties of Patos - Marinez - Kolonje (PMK).

This unit is located in the western part of Albania and is geologically represented by the uppermost part deposits of the Adriatic Depression, which is included in the central Mediterranean Basins group (Fig. 1). The Adriatic Depression is stratigraphically represented by the terrigenous deposits of the Serravalian-Pleistocene age. These deposits are folded in the western part forming some anticlinal and synclinal structures placed linearly, while to the east, it is represented by some monoclines, one of them being PMK monocline, represented by deposits of Messinian and Pliocene age. These deposits are divided into formations; seven formations in the Messinian section and two in the Pliocene section (MYFTARI et al., 2002). The northwestern boundary of the monocline is the backthrust of -Ardenica anticline, while the south-eastern border is the transgression base of the Adriatic Depression (Fig. 6), while in southwest, the border with Kreshpan - Cakran monocline, is represented by a tectonic fault (NAÇO et al., 2012). In PMK region 2,300 vertical wells and 550 horizontal wells are drilled, so it is impossible to render the wells in the presented figures.

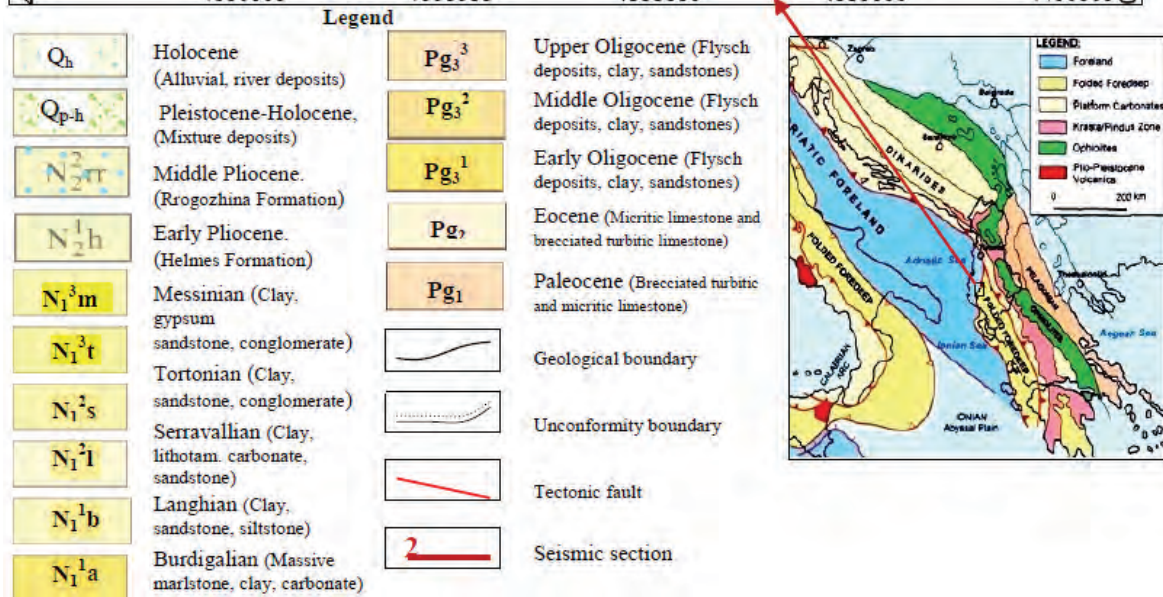


Figure 1. Geological map of PMK region, 1:200 000 (VRANAJ et al., 2002).

The thickness increases from the lateral parts of the basin towards its centre. The deposits are lithologically represented by clay, evaporate (gypsum), siltstone, sandstone and conglomerate. Based on the drilled wells, passing from the lateral parts towards the depression centre, data indicate that the facies change from coarse-grain to fine-grain ones i.e. from shallow facies to deep ones. Vertically, from the bottom to the top of this section, it is noticed a facies change from fine-grain facies to coarse-grain ones, which indicates the shallow direction of the depression.

MATERIAL AND METHODS

In the early stages of exploration for oil and gas detailed geological surveying to scale 1:10 000 are carried out.

The geological model of PMK region has been determined by geological and geophysical methods and by drilling wells. Age dating of the terrigenous section is performed with the method of palaeontology and micropaleontology, on the base of which the Tortonian and Messinian biozones are defined. In this regard, planktonic and benthic foraminifera have been used. So, in the western part of the region, biostratigraphic deciphering was realized using plankton foraminifera while in the east, where the section is represented mostly by sandstones, benthic foraminifera have been used (PRILLO et al., 2001; MYFTARI et al., 2002).

Geophysical studies were conducted following two directions: seismic surveys and well logs. This region represents a complex oil and gas bearing area, where many wells have been drilled, which have detailed the geological structure of the region.

The complex of the studies conducted in PMK region are accompanied with detailed paleontological, petrographic, geochemical and petrophysical studies.

Based on these studies, the geological structure of PMK region that represents the southern extremity of the Adriatic Depression has been evidenced.

RESULTS AND DISCUSSIONS

Based on geological and geophysical studies and drilled wells, we have interpreted the geological structure of PMK region. PMK region is characterized by two structural units that represent two different tectonic zones: the Adriatic Depression and the Ionian Zone (Fig. 2). In order to present the geological structure, we will bring out both the stratigraphy and tectonic features.

1. Stratigraphy

PMK region is formed by Upper Miocene (Fig. 3) and Pliocene deposits (PRILLO et al., 2001; MYFTARI et al., 2002; DORRE & MALO, 2008).

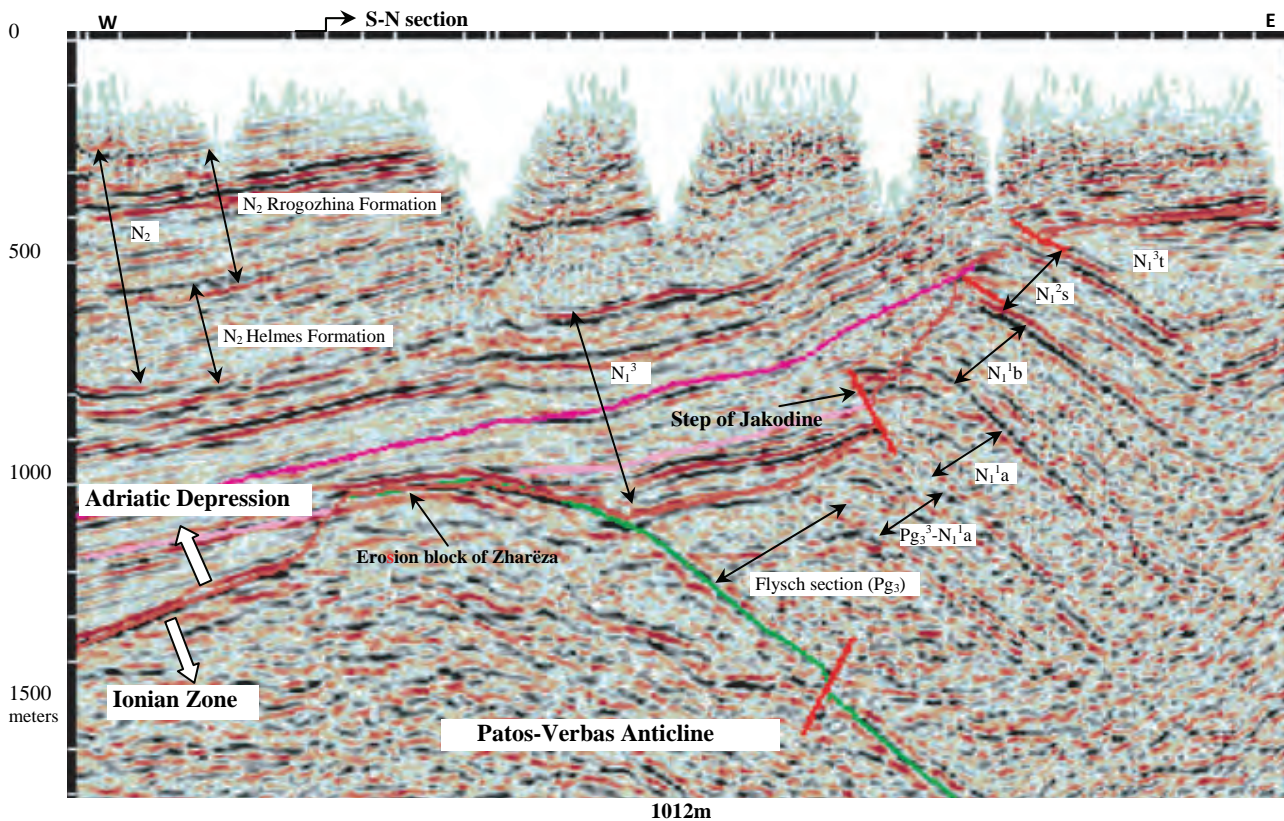


Figure 2. Seismic cross section 1-1 (migrated).

Tortonian deposits. Tortonian deposits crop out in the eastern part of the region, followed upward in the section by Messinian transgressive deposits. In PMK monocline, they are not exposed on the surface, but were met by drilled wells and studied by seismic exploration.

Tortonian deposits are represented by two lithofacies; sandy-clayey lithofacies that is propagated in the southern part of PMK region (southern extremity of the Adriatic Depression and the southern Adriatic area). The second lithofacies is characterized by an alternation of clays and sands and is met in the western Adriatic Depression.

Sandy-clayey lithofacies is characterized by sands and clays that alternate – with lithothamnic limestones. The sandstones are grey to yellow, while in fresh fracture they are of dark beige colour. They are compact, large to medium grained. The thickness of the layers varies from 0.5 - 1.5 m up to 5 - 6 m (GJOKA et al., 2002).

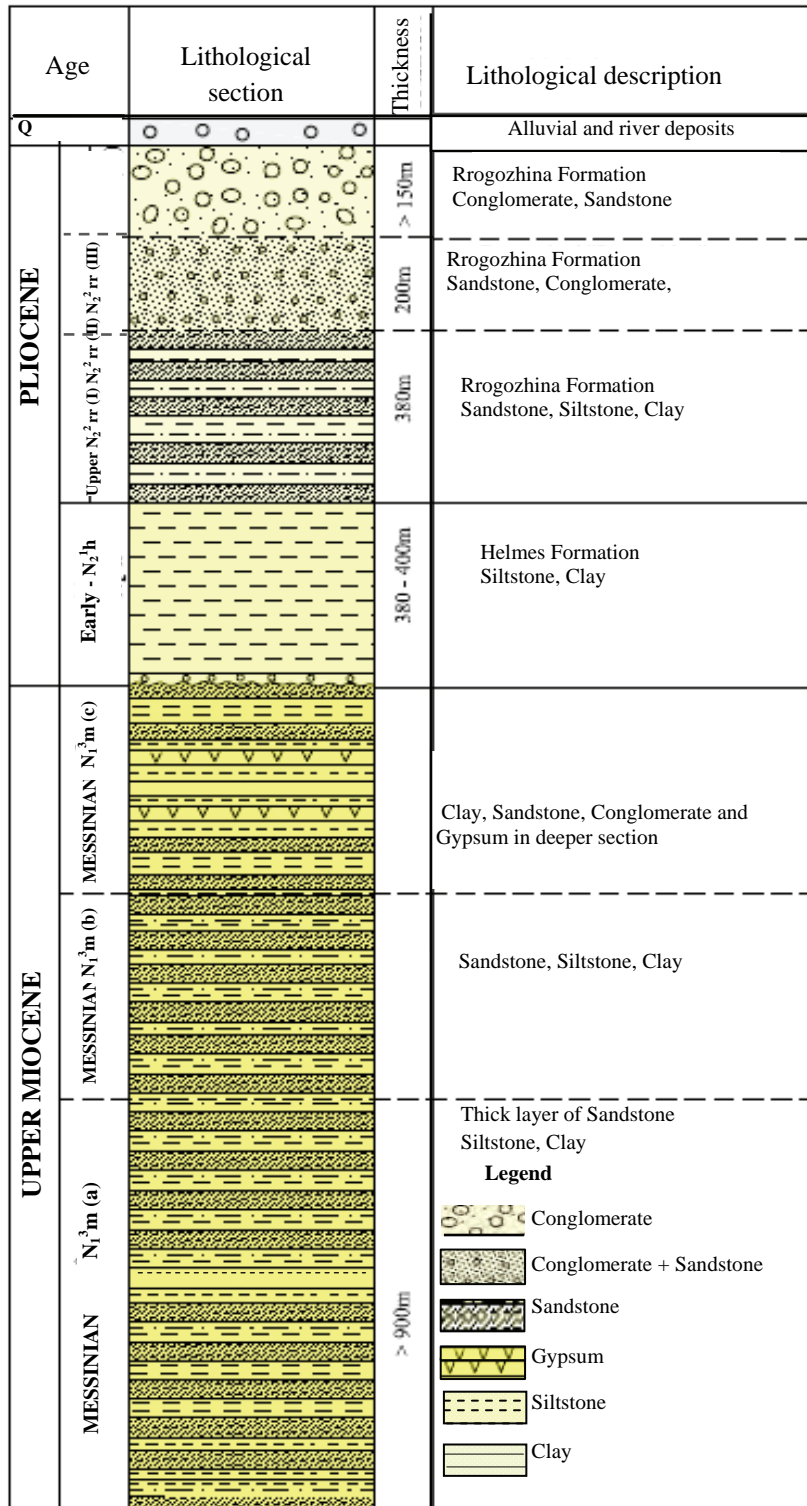


Figure 3. Lithological column of Messinian-Pliocene section.

Clays appear gray to blue with shell-like fracture and 2-3 m up to 15-20 m thick. Within them, resistant multicoloured layers rich in macrofauna, of 1-2 m thick, are often met. In some areas, within such horizons, there are met small crystals of gypsum.

This lithofacies is characterized by a shallow environment of sedimentation, mainly shelf deposits while clay sandy lithofacies denotes a deep environment. The latter - appears in the dipped sectors.

Messinian deposits

From the lithologic point of view, there also are separated two lithofacies, reflecting more or less the same history of sedimentation as during the Tortonian (sandy-clayey lithofacies, clayey-sandy lithofacies).

In the northwest of PMK region, *Globorotalia conomiozea* biozone deposits are met. The section is represented by Bubullima and Guret e Zeze (Black stones) formations. Bubullima Formation is propagated on the east while the Black stones formation on the west.

An important contribution in the lithologic deciphering is given by well logs. By the respective logs we have interpreted both the apparent resistance and spontaneous polarity.

Bubullima Formation lies by transgression on older deposits (Fig. 5). This formation is represented by bedded lithothamnian limestones. In Kallm - Kolonje sector, there have been distinguished 20 layers which, towards the west and northwest pass to clay deposits; the thickness of this formation varies from 20 to 200 m.

Guret e Zeze (Black Stones) Formation is represented by massive silty clays alternated with siltstones. Its thickness increases from south-east to north-west and to the west and varies in the range from 0-700 to 1100m. The Uppermost Messinian deposits belong to *Ammonia beccarii acme* zone.

Here are included Patos - Marinez - Kolonje (PMK) monocline deposits, where upward the lithological formations are separated between Marinez up to Polovina.

They are characterized by the presence of *Ammonia beccarii*, *A. beccarii beccarii*, *A. beccarii bradyi*, *A. latiseptata*, etc. Usually, in the lower part of this assemblage, *Elphidium decipiens*, *E. crispum* etc., are met (GJOKA et al., 2002).

Marinez Formation. In the framework of PMK monocline this formation takes part in the building of Patos and Marinez bays; in the western part, it lies in normal position on Bubullima Formation, while in the east and south, it lies discordantly on the buried erosion surface (Figs. 4; 5).

The lithofacies is represented by massive beds of loose sandstones containing carbonate sandstone concretions.

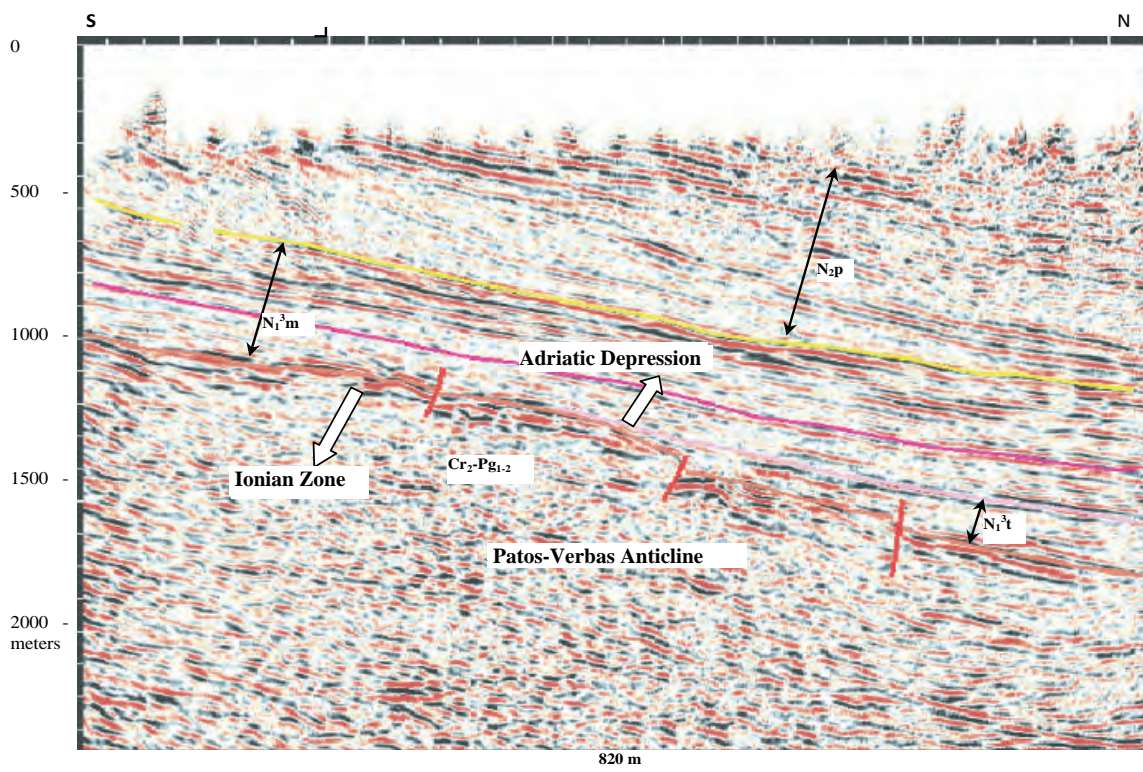


Figure 4. Seismic section 2-2 (migrated).

The sandstones alternate with clays containing carbonate concretions. From south to north, their thickness varies from 30 to 180m.

Driza Formation. It has a vast distribution in PMK monocline (Fig. 5). Horizontally, it presents accentuated lithologic changes. In Kasnic, it is mainly argillaceous alternating with sandstones and ostreidic banks, while in Marinez and Kolonje, the section is mainly argillaceous alternating with sandstones.

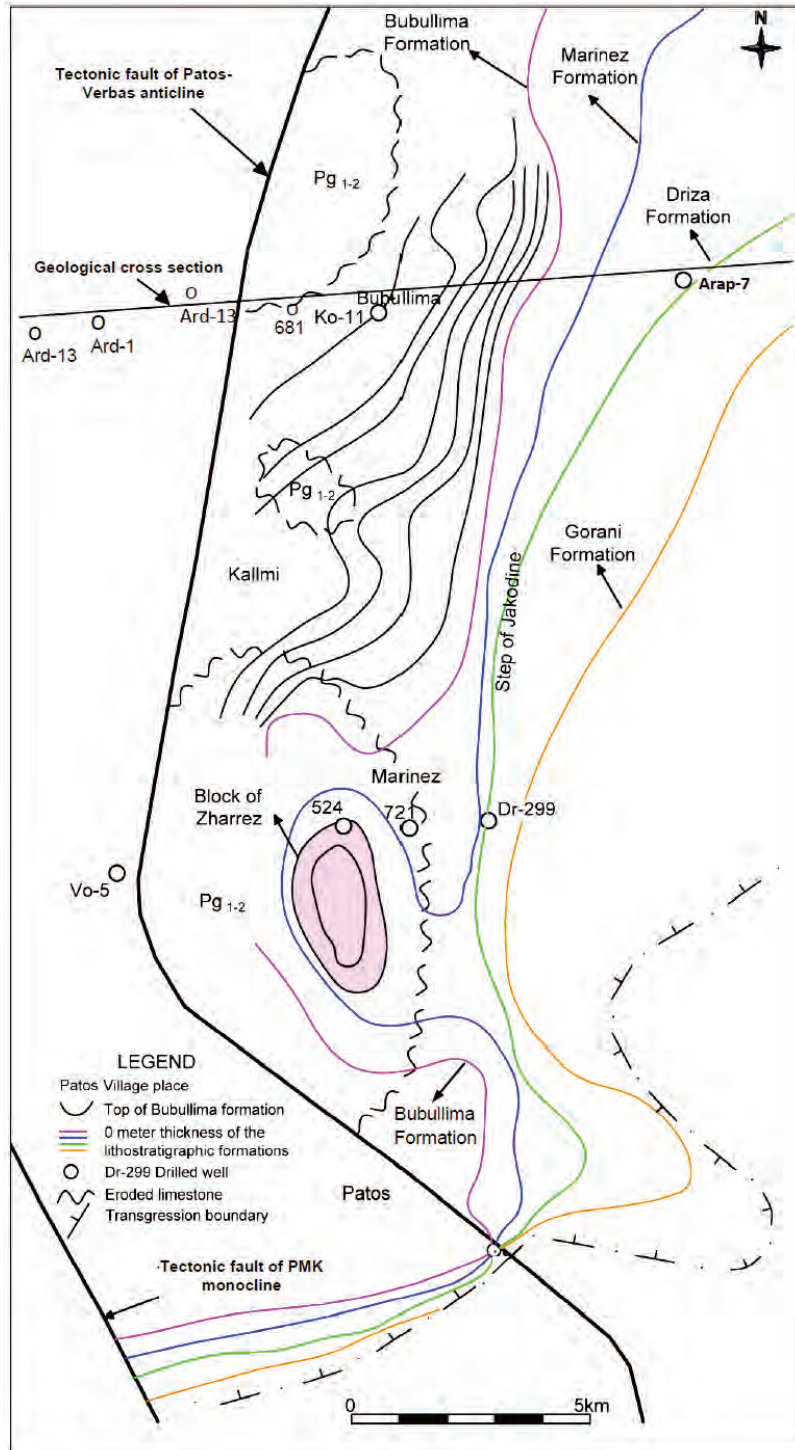


Figure 5. Scheme of the PMK lithostratigraphic formations.

Gorani Formation lies normally on Driza Formation (Fig. 5), but it lies through a stratigraphic break on the buried carbonate erosion of Zhareza. In Patos - Marinez sector, it is represented by an alternation of loose sandstones up to gravel with clays and carbonate aleurites. Its thickness varies from 100m in the south to 160 m in the north.

Kuçova Formation is propagated all over the region and lies normally on Gorani Formation. It is represented by an alternation between clays and loose sandstones. The thickness varies from 160 to 330 m.

Polovina Formation, with its vast propagation, lies normally on Kuçova Formation; in the eastern part of the Marinez sector it is eroded. It is characterized by the alternation between clays and loose sandstones, while in the western part (out of the region) in addition, gypsums alternated with clays. The respective thickness increases from Patos northwards from 200 to 300 m, while westwards, it increases even more.

As a conclusion, *Globorotalia menardii* s.l., *G. extremus* and *G. conomiozea* zones, from the west to the east come crashing to the eroded surface reducing their thickness.

As it concerns *G. conomiozea* zone, through a not well defined zone in Patos - Marinez - Kolonje sector (equivalent to both Bubullima and Black stones formations), eastwards, it is replaced by *Amonia gr. beccarii acme* zone. Generally speaking, the potential thickness of this zone reduces from east to west and from north to south.

Pliocene deposits. They include two lithological formations: Helmes and Rrogozhina.

Helmes Formation lies by transgression on the Messinian deposits, represented by clays and aleuritic clays with sandstones and aleurites intercalations. From down upward, it is represented by *Sphaeroidinellopsis* spp., *Globorotalia margaritae*, *G. punctulata* and *G. amiliana*.

Rrogozhina Formation; its lithofacies is represented by sandstones, conglomerates and gravels, alternated with clays and aleurites. In this formation, there can be separated three sub formations, in the base of dominant faction.

Pleistocene-Holocene depositions; in many cases they lie with a break on the older depositions. Their thickness varies from 40 to 140 m. The age is dated by benthos forms like *Ammonia papillosa*, *A. tepida* and *Hyalinea* sp.

2. Tectonics

The transgression of the Tortonian-Messinian basin was conditioned by the change of the structural plane of the Ionian zone and gradually it overlaps the Patos - Marinez - Kolonje region. The respective deposits increase their thickness from south to-north and from east to west. Whereas in the west, where it occurred a successive sedimentation, the biozones are well distinguished, in the east, where the deposits lie by transgression, on the contrary, the stratigraphic deciphering becomes difficult because of the high percentage of the sandstone lithofacies; in such conditions, the different planktonic zones characteristic in the west -are replaced by the one and - unique zone, the acme zone of *Ammonia beccarii*.

In the considered region, two tectonic units (Fig. 6) are separated (NAÇO et al., 2012):

1. Ionian zone (represented by Hekal - Ballsh - Patos - Verbas anticline belt);
2. Adriatic Depression (here represented by Patos - Marinez - Kolonje monocline).

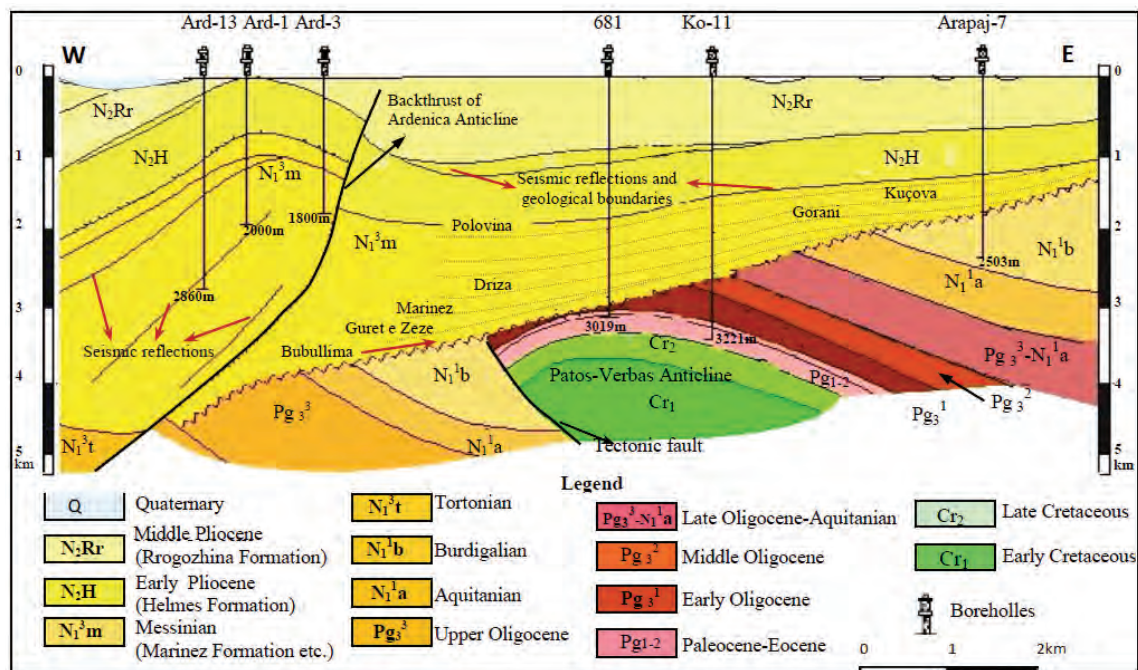


Figure 6. Geological cross-section in northern part of PMK monocline.

Patos - Verbas - Hekal - Ballsh anticline belt

This anticline belt is characterized by a step-like arrangement of the structural units in relation to one another. Its structures is related the hydrocarbon accumulations beginning with the tectonic block of Karbunara (PRIFTI & MUSKA, 2013) as well as Hekal fold. Ballsh anticline is in the north of that of Hekal and has the form of a cupola. The tectonic disjunction that complicates the western flank is the continuation of the flank of Hekal anticline and has an amplitude of 1500 to 2000 m. It conserves its southern orientation. Northwards, its orientation becomes northwest-southeast. Between the two structures, there is a pass below 1400 m absolute.

The main structure of this belt is Patos - Verbas brachyanticle with a southern prolonged pericline closing in Visoka. Actually, we have a buried structure with its apex eroded down to nearly Upper Cretaceous deposits.

Patos - Marinez - Kolonje monocline (PMK)

The monocline sinks north-westward and its deposits are constituted by different formations that lie transgressively, through an angular and azimuthal discordance on carbonate, flysch and flyschoid deposits of the eroded Patos - Verbas structure. The respective deposits pinch out over the erosion elevation of Zharëza and on the Kuman - Jagodina step. One part of them passes the erosion elevation and lies transgressively on Roskovec syncline deposits (in the east of the monocline).

Pliocene deposits lie through a transgressive break over different levels of the Messinian sediments; their thickness increases north-westwards. The Pliocene erosion on the Messinian deposits was considerable in the east of the monocline, concretely down to Gorani and Driza formations, while in the west it arrives only to Polovina and Kuçova Formations. The most powerful erosion is in Zharëza sector.

CONCLUSIONS

The geologic structure of Patos - Marinez - Kolonje region is characterized by the presence of two tectonic stages. In the central part and in the east, there lie the carbonate structures of the Ionian zone. Westwards, there exists a transgressive position of beds, while seaward the region is included in the Adriatic Depression.

Beginning with the change of the tectonic plane of Patos - Verbas structure, the Tortonian-Messinian transgression covers the region. The thickness of the respective deposits increases westwards and northwards. On the west, a successive position of the beds is observed, a good definition of plankton zones is realized (the oldest biozone is *Globorotalia miozea*), while in the east, where a transgressive position is observed, the lack of planktonic foraminifera makes the stratigraphic deciphering difficult. The younger deposits of the section are met in the east (*Ammonia beccarii* zone). The Messinian deposits are delimited by two erosion surfaces: the first is before the Tortonian-Messinian and the second before the Pliocene, the erosion surface thus denoting transgressive contacts.

The Miocene deposits of Patos - Marinez - Kolonje monocline increase their thickness north-westwards.

The Messinian deposits constitute seven lithostratigraphic formations: Bubullima, Guret e Zeze (Black Stones), Marinez, Gorani, Driza, Kuçova and Polovina. In these formations, there are met pay beds that constitute the oilfield complex of Patos-Marinez with estimated geological reserves of 258 394 000 tons. Part of these formations crop out thus forming the bituminous sands with reserves estimated to 540 000 000 tons.

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