RELATIONSHIP OF SAZANI AND IONIAN ZONES BASED ON BIOSTRATIGRAPHICAL DATA AND TECTONIC FACTS

PRIFTI Irakli, UŢĂ Andreea

Abstract. Karaburun-Sazan-Zvernec region is a part of a tectonic area with very intensive activity due to the collision of two tectonic zones, Ionian and Apulia (Sazani). New geological data obtained in seismic exploration and well drilling in the Albanian offshore are giving a much better explanation about the relationships between Sazani and Ionian zones. The identified micropaleontologic associations from studied areas indicate deposits from Middle Eocene-Upper Eocene to Lower Oligocene-Upper Oligocene and in this paper a special attention is accorded to Oligocene carbonate section belonging to Sazani Zone. The Sazani Zone is represented by two tectonic blocks with different orientations; a northern block dipping to east and a southern block dipping towards the west where the Oligocene carbonate deposits are emerging.

Keywords: Microfacies, Sazani Zone, Apulia Platform, transversal fault, monocline, structures, biostratigraphical data.

Rezumat. Relaţia dintre zonele Sazani şi Ionică pe baza datelor biostratigrafice şi a dovezilor tectonice. Karaburun-Sazan-Zvernec este o regiune caracterizată de o activitate tectonică foarte intensă ca urmare a coliziunii a două zone structurale, Ionică şi Apulia (Sazani). Date geologice noi obţinute în explorare seismică şi de foraj în largul coastelor albaneze oferă o mult mai bună explicaţie cu privire la relaţiile existente între zonele structurale Sazani şi Ionică. Asociaţiile micropaleontologice identificate depozitele carbonatice din zonele studiate indică depozite de varstă Eocen mediu-Eocen superior Eocen şi Oligocen inferior-Oligocen superior. În această lucrare, o atenţie specială este acordată depozitelor carbonatice oligocene aparţinând zonei Sazani. Această zonă este reprezentată de două blocuri tectonice, cu orientări diferite, un bloc nordic scufundat spre est şi unul sudic-scufundat spre vest, unde depozitele de carbonatice oligocene au fost emerse.

Cuvinte cheie: microfacies, zona Sazani, platforma Apulia, falie transversală, monoclin, structuri, date biostratigrafice.

INTRODUCTION

Sazani Zone is the westernmost geological zone in Albania and extends parallel to the Preapulian or Paxos Zone of Hellenides (Greece) and at east to Apulian Platform (Italy) and is formed by two main structures: the anticlinal structure of Sazani-Karaburni and the monocline of Mali e Kanali (Kanali Mountain). A general feature of Sazani Zone is the predominance of an oppressive and intense overthrust tectonics in transversal direction from east to west and a total dipping of all structural lines toward the northeast. The Ionian Zone is an adjacent zone, occupying a large part in Albania, exceeding other external zones in the area and is characterized by a series of anticlines and synclines belt parallel and sub-parallel through almost the entire length of the zone in a sub-meridional position.

The relationship between Sazani and Ionian zones has been subject of many geological, geophysical and paleontological studies focusing on identifying the unconformities in carbonate deposits.

Issues that need clarification are: setting the unconformity of Burdigalian sediments on the Late Cretaceous carbonate sediments (Sazani-1/s, Zverneci-3, Falcon-1, A4-1X well); the placement of Serravalian deposits on those of the Late Cretaceous (A4-2X well); the placement of Messinian deposits on those of Burdigalian (A4-1X well); the placement of Tortonian deposits on those Burdigalan (Falcon-1 well); the placement of Pliocene deposits with unconformity in almost all land-sea region (MEZINI *et al*., 2001).

These facts are closely related to the tectonic development of the region and show that this development has been the effect of gradual and sudden impulses that led to the phenomena described above and to the relationship between Sazani Zone and Ionian Zone. All tectonics phases have controlled the sediment distribution in the basin. During the cycle of sedimentation, in Sazani Zone, the transgression phase begins with the Oligocene deposits represented by thick-bedding massive brecciated limestones and becomes more intense in Burdigalian, which is represented by interbeddings of marly and terrigenous deposits. These deposits are present almost anywhere in the area of the platform slope and lie discordantly on the carbonate deposits. During the Late Miocene, the regressive phase is marked by the end of sedimentation of the evaporate formation. Then, the Pliocene transgression phase covers the entire northern part of the region.

Geological setting of Sazani Zone

In the framework of the External Albanides, the Sazani Zone outcrops in southwestern part and includes Sazani Island, Karaburuni Peninsula and Kanali Mountain (Mali Kanalit). This zone refers to two monoclines separated from each other by a longitudinal fault (FILI & XHAFA, 1982).

The principal extension of this zone in the Albanian (Ionian and Adriatic) offshore is completely covered by molassic Miocene-Pliocene deposits. This zone represents an eastern continuation of the Apulia platform (part of the Adriatic plate).

The different geological studies regarding the Sazani Zone have demonstrated the existence of a typical neritic platform at least since Late Triassic until Oligocene (BRAHIMI *et al.*, 1992; SOTA *et al*., 1980).

Surface geological observations show that the Burdigalian deposits (*Globigerinoides bisphaericus* Zone) lays transgressively over the Karaburuni carbonate ("Rrëza" Channel, "Shën Jani" Bay, and "Sazani" Island, Fig. 1) deposits. This phenomenon shows an older folding phase of Apulia Zone and also the later folding phase of Çika belt anticline (Western part of Ionian Zone).

In surface, the Sazani eastern border serves as overthrusting tectonic contact with the Ionian zone, which is very evident in Dukati "Qafa e Llogarase" region up to Palasa (Fig. 1) (XHOMO *et al*., 2002).

Eastward, it dips under the Ionian Sea and extends up to the north of Corfu, where it is deviated nearly 25-35 km westward. This deviation probably has been caused by the rifting phase through a transversal fault, putting in front of each other completely different facies.

The two structures, which are well distinguished on land mainly, consist of Early Cretaceous-Late Cretaceous carbonate deposits and very rare Paleogene ones. In the Sazani-Karaburni, the eastern flanks weakly dip at 20-40 degrees and are overridden on the Apulian platform, while the flank of Mali Kanalit monocline dips at angles between 30 to 50 degrees.

The passage of these deposits from the east to the west dipping is done through a transversal passing sinistral sideways displacement with a north-northwest to east-southeast strike developed.

Stratigraphy

The stratigraphy of this zone was treated in different studies and papers. The principal aim of this study is to present new data on the stratigraphy of Paleogene and especially Oligocene deposits. The geological and micropaleontological data are very representative in the regions where these deposits are fair cropping out (BRAHIMI *et al*., 1992).

Based on the mapping data of these zones, it is noticed that the extension of the Paleogene deposits is along the western slope of Kanali Mountain up to Arusha Bay, at Gjuza Cape and Rreza Channel. It is important to specify that the Paleogene section in all mentioned above regions is incomplete. According to the stratigraphical data (BRAHIMI & SADUSHI, 1993), the oldest Paleogene deposits outcropping there belong to Middle Eocene, which is successively followed by the Upper Oligocene deposits (SOTA *et al*., 1980).

Our aim consists in clearing up the time of the arrival of detritic sedimentation in Sazani Zone. The outcrop of Gjuheza Cape, situated in the northeastern extreme edge of Karaburuni Peninsula (Fig. 1), is the single outcrop where the oldest terrigenous can be observed (Plate IV, Photo 17).

Middle Eocene-Upper Eocene

The Middle-Upper Eocene deposits are laying unconformably on the Maastrichtian deposits (Fig. 1). At the base of these deposits, a conglo-breccia layer of about 2-3 m thick is present. It is constituted of angular and sub angular pebbles and boulders with different sizes reaching about 5-6 cm up to 0.5 m. In some cases, the boulders reach the size of 0.5÷2 m and are not all rounded. There are blocks deposited in place. In many outcrops, the Eocene carbonate section seems to be as a very rough breccious mass, mainly represented by micritic limestones, dolomitic limestones and rarely by bioclastic limestones.

Generally, the section consists of thick-bedded wackestones and mudstones. The rock fragments are about of 1 mm in size and only in some cases, there are bigger blocks, reflecting in this way a great irregularity during the depositional time. The most frequent fauna present in these deposits is represented by *Discocyclina nummulitica* GUMBEL*, Chapmanina gassinensis* SILVESTRI*, Melobesioidea, Alveolina fusiformis* SOWERBY, *Nummulites* sp. Besides them, corals are reported as well. The thickness of deposits reaches up to 130-170 cm.

Oligocene

The Oligocene is represented by Lower Oligocene-Upper Oligocene deposits exposed in "Rreza e Kanalit" and in some restricted areas in "Gjuhza Cape" region.

Lower Oligocene

The Lower Oligocene deposits are present only in the southernmost extreme of Karaburuni monocline (Rreza e Kanalit) and are exposed in a tectonic block in contact with the Upper Cretaceous deposits (Fig. 1). They are cavernous rocks without any stratification, represented by limestones of beige colour of wackstone type. The limestone fragments show different composition and sizes up to 2-3cm. The microfaunal assemblage refers to *Lepidocyclina* (*Nephrolepidina* sp.)*, Lepidocyclina* (*Eulepidina* sp.), *Spiroclypeus* sp., *Amphistegina* sp., *Austrotrillina* sp., *Microcodium elegans* GLUECK and *Subterraniphyllum thomasi* ELLIOT, confirming Lower Oligocene age (Plate I, Photos 3-6. Plate II, Photos 7-12. Plate III, Photo 13).

Upper Oligocene

These deposits are present on restricted area only at Gjuza Cape and are lying unconformably on the Middle-Upper Eocene deposits where an evident angular unconformity is also visible.

The base of Upper Oligocene deposits is characterized by a conglo-breccious layer of 0.5-1.0 m thick. The constituent clasts are semi-rounded and cemented by a marly-carbonate mass of grey-yellow colour. Toward the top, the section becomes more clayey and is interbedding with some breccious limestone layers, whose thickness increases gradually upward (Plate IV, Photos 18, 19, 20). In all the previous works, these deposits had been considered to be Aquitanian (SOTA 1980). The micropaleontological analyses (microfauna and especially calcareous nannofossils) performed recently in the terrigenous section samples and cementing material of the lowermost bed, show the presence

of *Globigerina gr. ciperoensis, G. trilocularis, G. venezueliana, Globorotalia kugleri* BOLLI, *Globorotalia pseudokugleri* Blow, *G. opima nana, Globigerinoides* sp., *Miogypsinoides* sp., *Sphenolithus ciperoensis* BRAMLETTE & WILCOXON , *S. conicus, S. moriformis, C. eopelagicus, H. euphratis, T. carinatus, P.hermosus, P. ovat, E. fenestrata*, etc., confirming the Late Oligocene.

The other part of the following terrigenous section consists of micritic limestones and conglo-breccias layers belonging to the Chattian-Aquitanian up to Burdigalian (*Globigerinoides trilobus* subzone, Plate III, Photos 14, 15, 16). The presence of *Globigerinoides trilobus* in the upper part of the terrigenous section should be carefully interpreted due to the presence of some Quaternary deposits above.

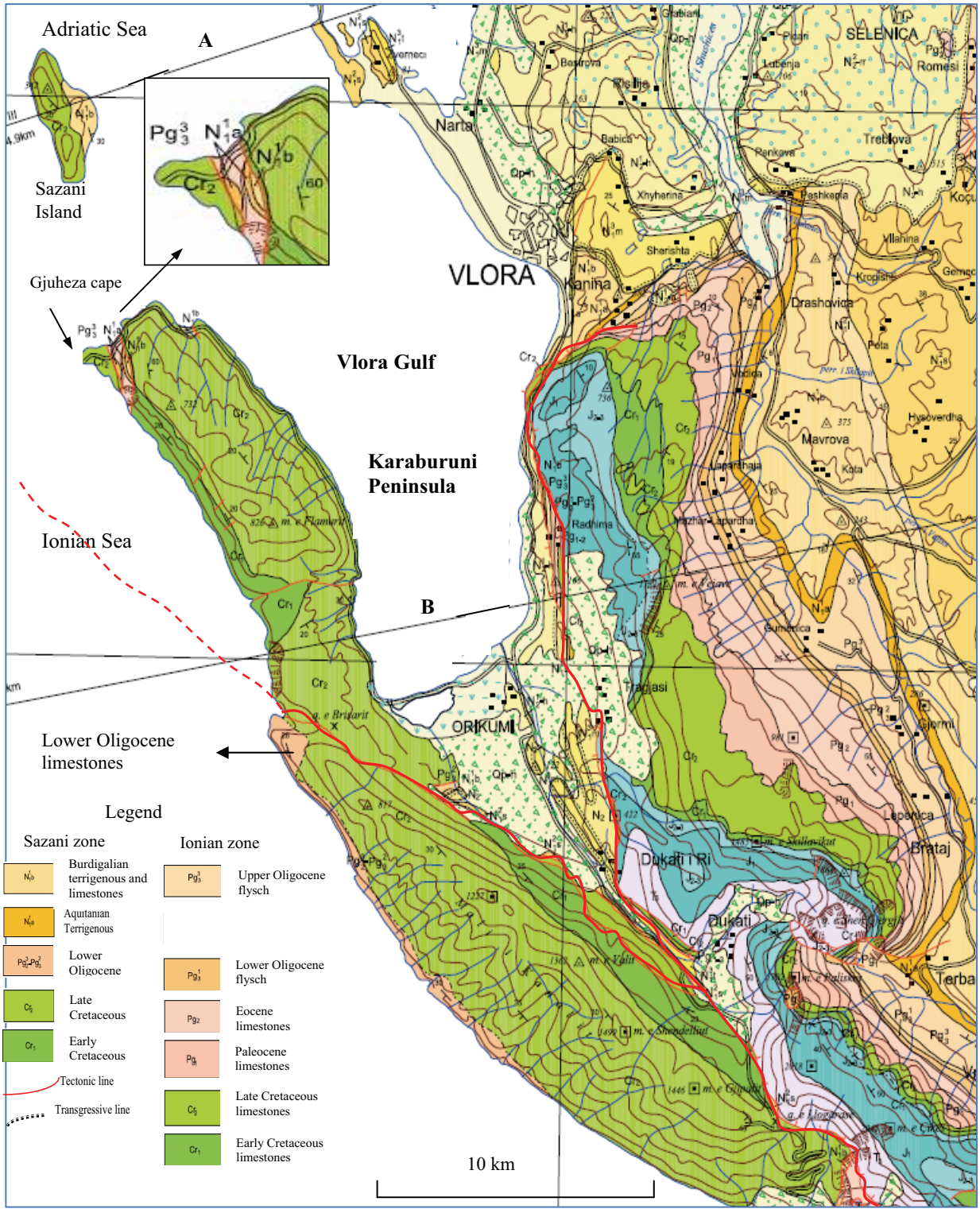

Figure 1. Geological map of Karaburuni-Vlora region (based on geological map of Albania, 1:200.000).
Figura 1. Harta geologică a regiunii Karaburuni-Vlora (după Harta geologică a Albaniei, 1:200.000).

Based on the geological and micropaleontological data it is fully confirmed that the terrigenous cycle in the Sazani Zone begun with the Upper Oligocene subduction. The same situation was also evidenced even in a long distance from Sazani Zone, in northwest (MEZINI *et al*., 2001). These results show that this zone should be included in a transitory zone in comparison with the Apulia platform or Paxos Zone, where the carbonate deposits are considered to be of Aquitanian or Burdigalian age.

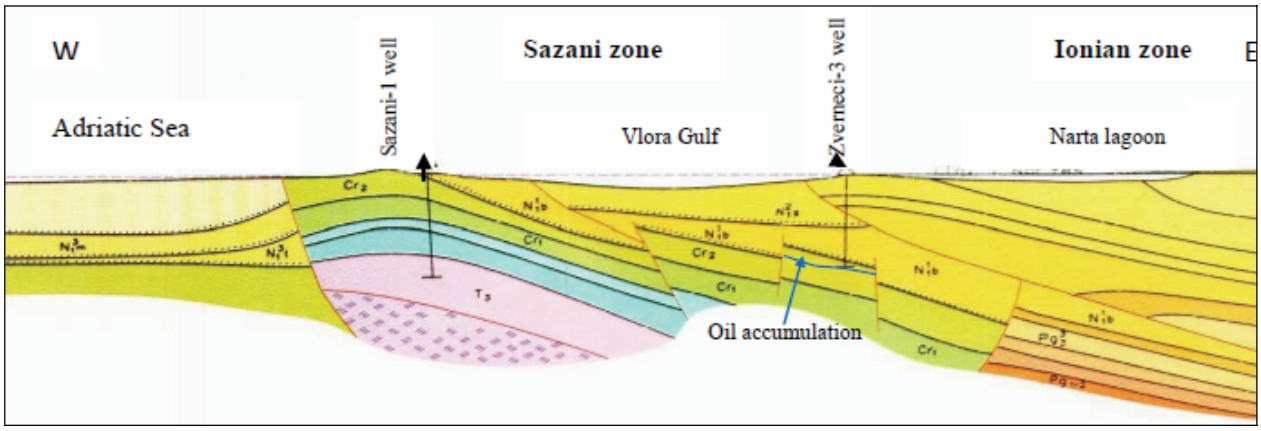

Figure 2. Geological section "A", between Sazani-1 and Zverneci-3 wells (Geological map of Albania, 1:200,000).
Figura 2. Profil geologic între Sazani 1 şi Zverneci 3 (Harta geologică a Albaniei, 1:200.000).

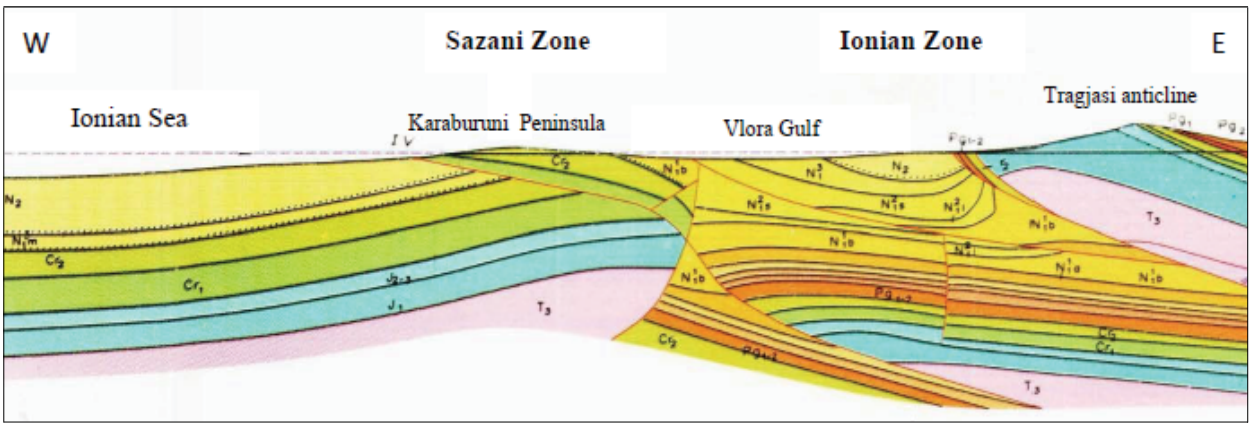

Figure 3. Geological section "B" on southern part of Vlora Gulf (Geological map of Albania, 1:200,000).
Figura 3. Profil geologic al părtii sudice a golfului Vlora (Harta geologică a Albaniei, 1:200.000).

Tectonic and basin geodynamic

The Sazani Zone was underthrusted during the compressional phases taking place especially in Upper Cretaceous-Early Paleogene. This zone situated between the Apulia platform (represented by deposits of nearly horizontal dipping) and the orogene of the eastern zones underwent a fracturing of the deposits (Figs. 2 and 3).

Karaburun-Sazan-Zvernec region is included in a tectonic area with a very intensive activity due to the collision of two tectonic zones: Ionian and Apulia (Sazani). The eastern part of the region (Vlora) belongs to the Ionian zone while its western edge is represented by Sazani (Apulia) tectonic zone. The lithofacies features and the tectonic style vary from one area to another or from east to west. In Vlora region limestones have been found covered by a thick Oligocene flysch (Pg3). In the Zverneci-3well is confirmed the transgressively placement of Burdigalian sediments (N_1 b) on the eroded limestone of the Late Cretaceous. This fact indicates a different tectonic regime (between the two tectonic zones). The Sazani Zone has been emerged above the sea level and eroded, while the eastern part has been submerged below sea level and where the sedimentary rocks of Oligocene, Aquitanian and Burdigalian have been settled.

From Late Cretaceous to Burdigalian, the region had the appearance of a monocline, which retreated from the west to the east. Moving from east to west, this monocline was gradually covered by younger deposits from Oligocene (Vlore), Aquitanian and Burdigalian. Taking into account these data, the region represents the area of platform-slope transition in the Ionian zone (Fig. 4).

The Karaburuni peninsula appears as a regional backthrust over the transition zone from the platform to slope-basin.

South of Vlora, it is visible the development of a triangular zone, where the Dukati syncline (Ionian zone) is entirely covered from the Karaburuni backthrust and Cika overthrust. This backthrust starts from Eastern side of the Sazani Island and continues toward the South.

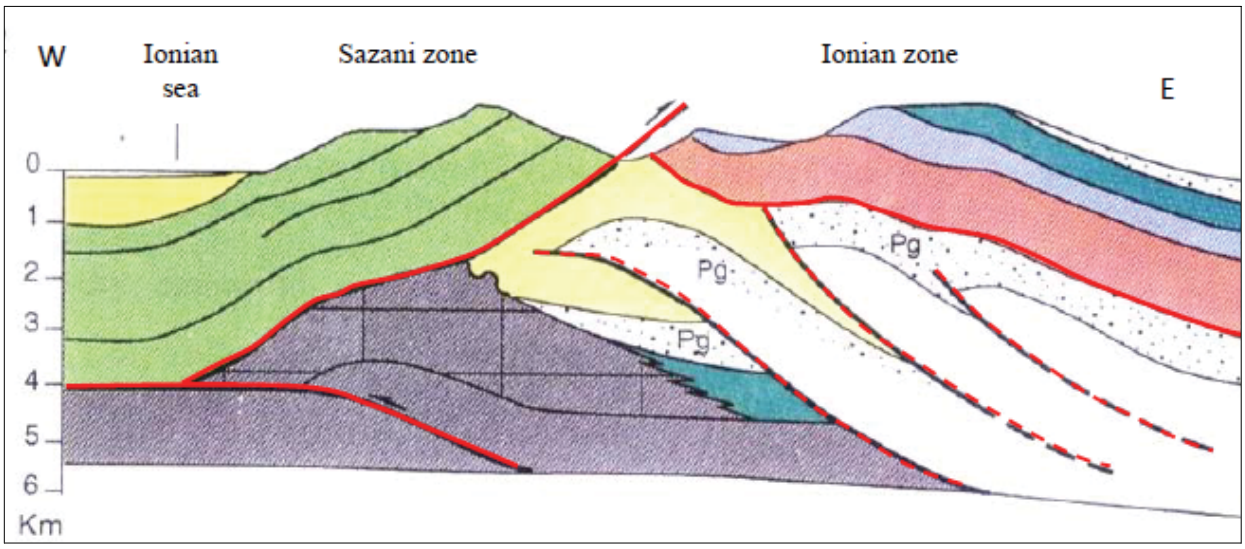

Figure 4. Geological section - the contact between Sazani and Ionian zones (Geological map of Albania, 1:200,000).
Figura 4. Secţiune geologică - contactul dintre zonele Sazani şi Ionică (Harta geologică a Albaniei, 1:200.000).

The central part of the region from Dukati towards the north to Narta represents the deepest part of the syncline separating the transverse anticline of Vlora by raising the Karaburuni unit. The general feature of Sazani Zone is the predominance of a strong onlap in transversal direction from east to west and the total dipping of all structural lines toward the northeast (FILI & XHAFA, 1982)

The eastern part of the Sazani Island and Karaburuni Peninsula (northern part, block I) represents a monocline which dips to east, tectonically complicated with transverse and longitudinal shifts.

In all transverse seismic profiles it is clearly shown the eastern side of Sazani dipping to 30^0-35^0 degrees, which close to Zverneci slowly becomes nearly horizontal or creates a sharped block.

Based on the regional seismic lines in the Albanian offshore it was outlined the orogenic front of the External Albanides. In the Albanian onshore, this front continues between the Karaburuni and Kanali mountains and to southern part to Llogara, outcropping as a "pop up" structure.

If during the structural balancing Sazani Island and Karaburuni peninsula were displaced toward SSW, after the displacement, these structures have formed an anticlinal structure because the Kanali Mountain has western dipping (~70° W), while Karaburuni Peninsula and Sazani Island have eastern dipping (~30° E), (MEZINI *et al*., 2001).

The reservoir qualities of these rocks are adequate for the hydrocarbons. The problem consists in finding the stratigraphical type of the traps in these deposits, sealed by a certain sedimentary cover presence.

CONCLUSIONS

The deposits participating to the geological architecture of the region have been studied from data of complex geological studies where the main role is played by the micropaleontological studies.

The oldest deposits are those of Late Triassic-Early Jurassic (T3-J1), while the carbonate deposits are Oligocene.

The micropaleontological studies show microfauna from Eocene, Upper Eocene-Lower Oligocene and Upper Oligocene. In Sazani Zone, the Zverneci-3 well drilled about 730m depth in limestones shows a sedimentary succession starting from the Late Cretaceous (Cr2), Early Cretaceous (Cr1) and stopping in the Upper Jurassic deposits (J_3, Tithonian) this order being peculiar for drilling data.

Tectonically, the Sazani Zone is represented by two tectonic blocks with different orientations: the northern block dips to east, while the southern one dips towards the west and where Oligocenene carbonate deposits are emerging. The relationship between these two blocks is tectonic.

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Prifti Irakli
Polytechnic University of Tirana, Fakulteti I Gjeologjisë dhe i Minierave,
Rruga e Elbasanit Tiranë
E-mail: irakliprifti@yahoo.com; fgeolmin@yahoo.com

Uţă Andreea
Polytechnic University of Tirana, Institute of Geosciences,
Energy, Water and Environment, 60 Don Bosko Street
E-mail: andreauta@yahoo.com

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PLATE I / PLANŞA I

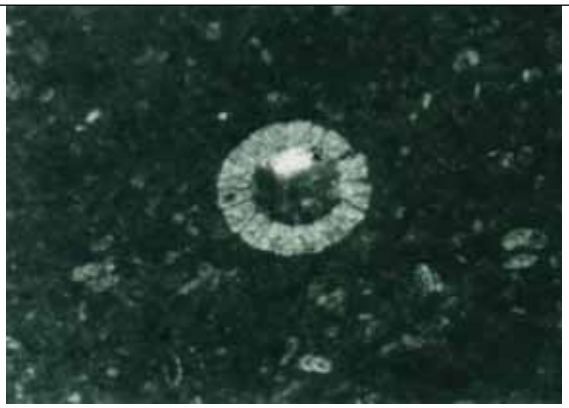

Photo 1. Mudstone with Characeae and Discorbidae (X60), Late Cretaceous, "Mali Kanalit" block. / Foto 1. Calcar micritic cu Characeae şi Discorbidae (X60), Cretacic superior, blocul "Mali Kanalit" (original).

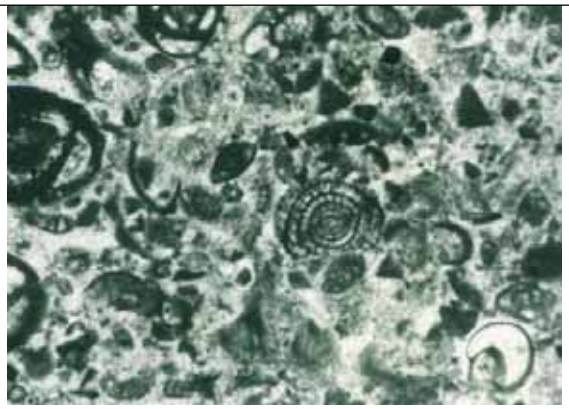

Photo 2. Packstone with *Borelis* sp., *Austrotrillina* sp. And Miliolidae (X20), Upper Eocene-Lower Oligocene, "Reza e Kanalit" block. / Foto 2. Packestone cu *Borelis* sp., *Austrotrillina* sp. and Miliolidae (X20). Eocen superior-Oligocen inferior, blocul "Reza e Kanalit" (original).

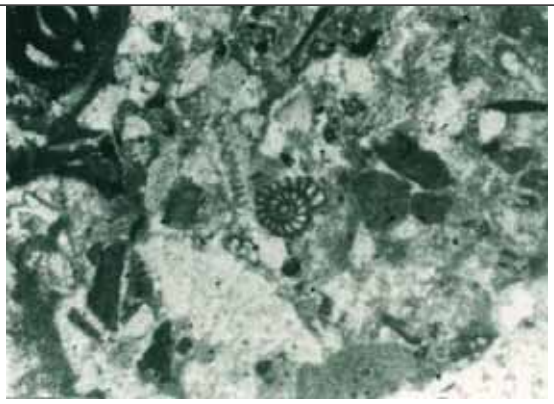

Photo 3. Packstone with *Amphistegina* sp. and corals (X60), Lower Oligocene, "Reza e Kanalit" block. / Foto 3. Packestone cu *Amphistegina* sp. şi corali (X60), Oligocen inferior, blocul "Reza e Kanalit" (original).

Photo 4. Grainstone with *Austrotrillina* sp, *Lepidocyclina* sp. and *Pseudocyclamina sphaeroidea* (resedimented) (X60), Lower Oligocene, "Reza e Kanalit" block. / Foto 4. Gresie cu *Austrotrillina* sp., *Lepidocyclina* sp. şi *Pseudocyclamina sphaeroidea* (resedimentate) (X60). Oligocen inferior, blocul "Reza e Kanalit" (original).

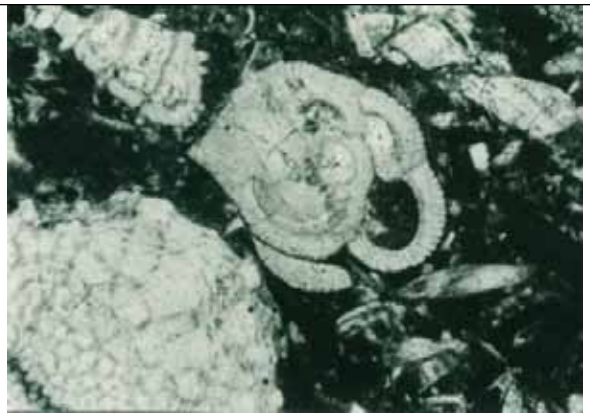

Photo 5. Packstone with *Victoriella* sp. and *Lepidocyclina* sp. (X20), Lower Oligocene, "Reza e Kanalit" block. / Foto 5. Packestone cu *Victoriella* sp. and *Lepidocyclina* sp. (X20), Oligocen inferior, Blocul "Reza e Kanalit" (original).

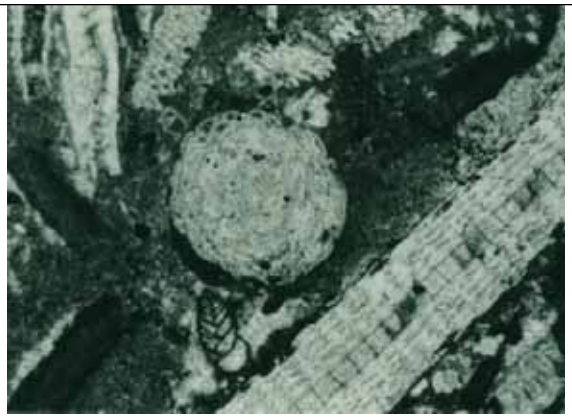

Photo 6. Packstone with *Phaerogypsina* sp., *Lepidocyclina* sp. and Textularidae (X20), Lower Oligocene, "Reza e Kanalit" block. / Foto 6. Packestone cu *Phaerogypsina* sp., *Lepidocyclina* sp. şi Textularidae (X20),Oligocen inferior, blocul "Reza e Kanalit" (original).

PLATE II / PLANŞA II

Photo 7. Packstone with Peneroplidae (X20) Lower Oligocene, "Reza e Kanalit" block. / Foto 7. Packstone cu Peneroplidae (X20) Oligocen inferior, blocul "Reza e Kanalit" (original).

Photo 8. Packstone with *Amphistegina* sp. and *Lepidocyclina* sp. (X40) Lower Oligocene, Gjuza Cape. / Foto 8. Packstone *Amphistegina* sp. şi *Lepidocyclina* sp. (X40) Oligocen inferior, Gjuza Cape (original).

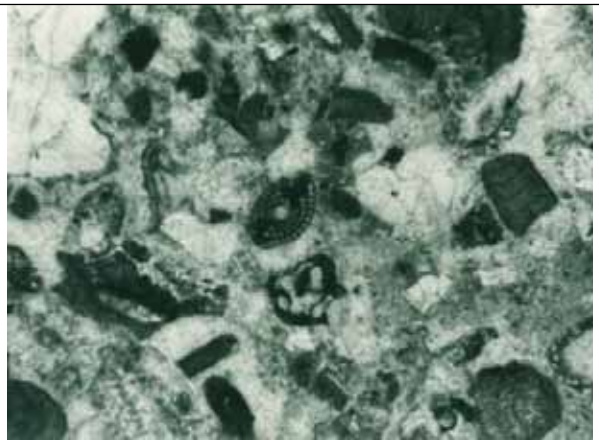

Photo 9. Packstone with *Borelis* sp., Melobesidae and *Subteranyphyllum thomasi* ELLIOT (X40), Lower Oligocene, "Reza e Kanalit" block. / Foto 9. Packstone cu *Borelis* sp., Melobesidae şi *Subteranyphyllum thomasi* ELLIOT (X40), Oligocen inferior, blocul "Reza e Kanalit" (original).

Photo 10. Packstone with *Eulepidina* sp. (X40), Upper Oligocene, Gjuza Cape. / Foto 10. Packstone cu *Eulepidina* sp. (X40), Oligocen inferior, Gjuza Cape (original).

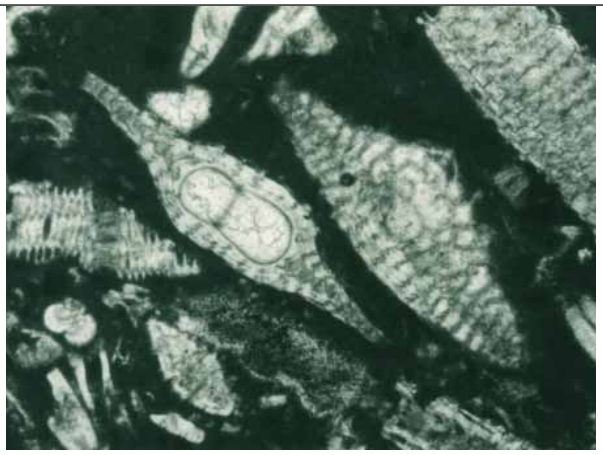

Photo 11. Packstone with *Lepidocyclina* sp. and *Globigerina* (X60), Lower Oligocene, "Reza e Kanalit' block. / Foto 11. Packstone cu *Lepidocyclina* sp. şi *Globigerina* (X60), Oligocen inferior, blocul "Reza e Kanalit" (original).

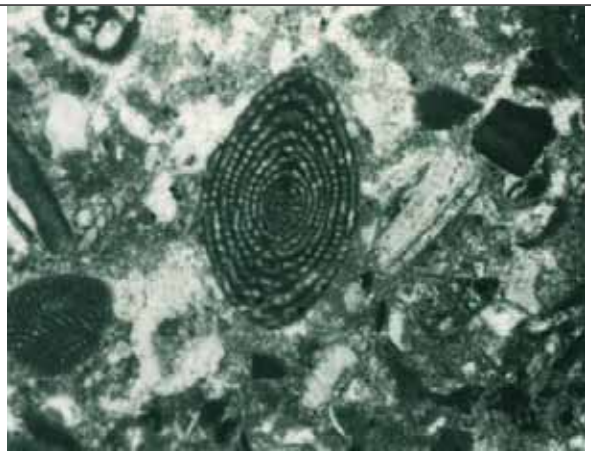

Photo 12. Packstone with *Alveolina* sp. (X40), Lower Oligocene, "Reza e Kanalit' block. / Foto 12. Packstone cu *Alveolina* sp. (X40), Oligocen inferior, blocul "Reza e Kanalit (original).

PLATE III / PLANŞA III

Photo 13. Bioclastic mudstone with *Pararotalia* sp., *Heterostegina* sp., *Amphistegina* sp. and Melobesidae (X60) Lower Oligocene "Reza e Kanalit" block. / Foto 13. Calcar micritic bioclastic cu *Pararotalia* sp., *Heterostegina* sp., *Amphistegina* sp. şi Melobesidae (X60), Oligocen inferior, blocul "Reza e Kanalit" (original).

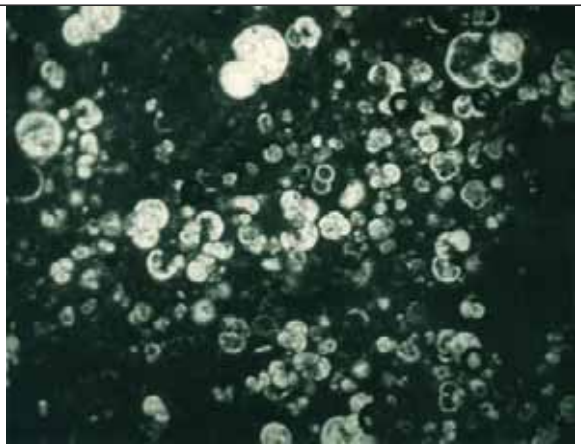

Photo 14. Marls with *Globigerinoides trilobus* REUSS, *Globigerinoides* sp. and Globigerinidae (X60), Burdigalian, Llogara. / Foto 14. Marne cu *Globigerinoides trilobus* REUSS, *Globigerinoides* sp. şi Globigerinidae (60X), Burdigalian, Llogara (original).

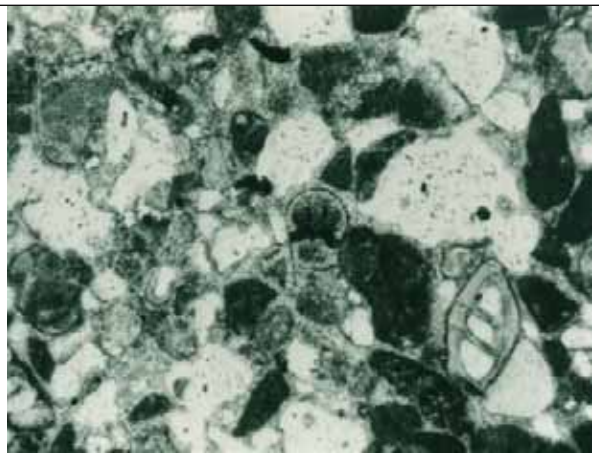

Photo 15. Grainstone with *Globigerinoides trilobus* REUSS, *Globigerinoides* (X40), Burdigalian, Gjuza Cape. / Foto 15. Gresie cu *Globigerinoides trilobus* REUSS, *Globigerinoides* (X40), Burdigalian, Gjuza Cape (original).

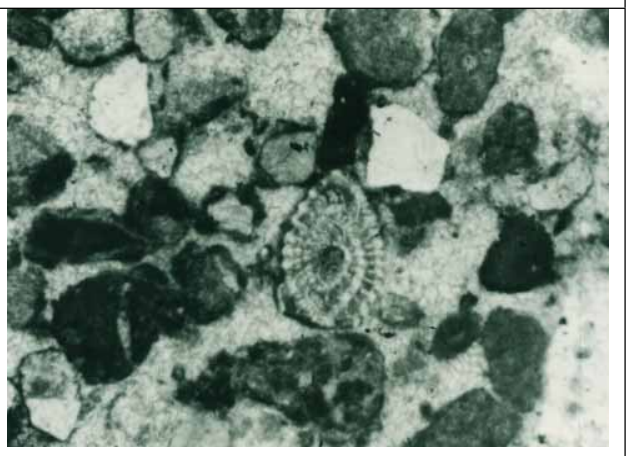

Photo 16. Sandstone with *Elphidium* sp. (X40), Burdigalian, Gjuza Cape. / Foto 16. Gresie cu *Elphidium* sp. (X40), Burdigalian, Gjuza Cape (original).

PLATE IV / PLANŞA IV

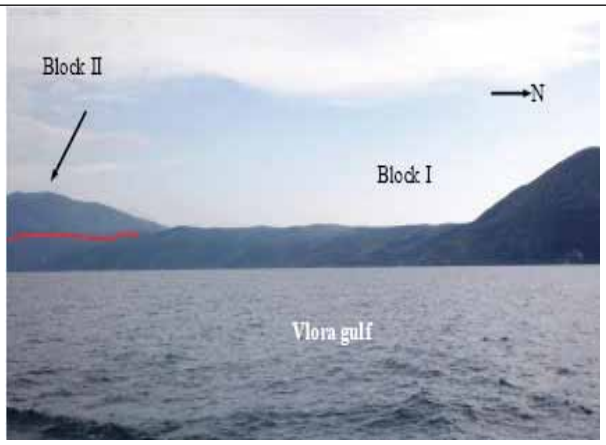

Photo 17. Two blocks of Sazani Zone placed on Karaburuni Peninsula - eastern side. / Foto 17. Peninsula Karaburuni – Două blocuri aparţinând zonei Sazani - partea estică (original).

Photo 18. Late Cretaceous limestones - Gjuza Cape. / Foto 18. Calcare Cretacic superioare - Gjuza Cape (original).

Photo 19. Early Cretaceous-Late Cretaceous bioclastic mudstones from “Mali e Kanalit” - western side. / Foto 19. Calcare aparţinând Cretacicului inferior - Cretacic superior - Mali e Kanalit - partea vestică (original).

Photo 20. Lower Oligocene bioclastic mudstonepackestones eroded by the waves of Ionian Sea. / Foto 20. Calcar micritic -packestone bioclastice Oligocen inferioare erodate de apele marii Ioniene (original).

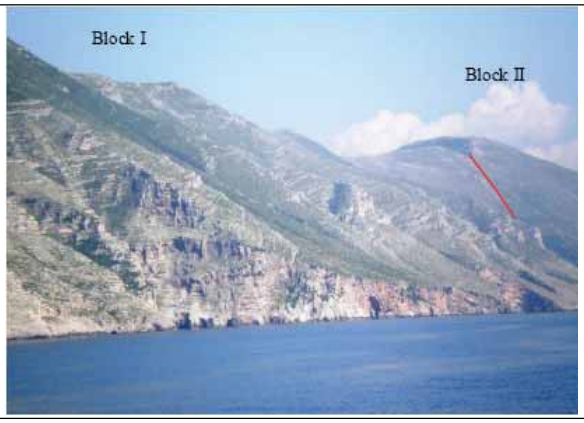

Photo 21. Lower Oligocene bioclastic mudstonepackestones to west of “Reza e Kanalit” block - toward the north. / Foto 21. Calcar micritic-packestone bioclastice Oligocen inferioare la vest de blocul “Reza e Kanalit” - vedere spre nord (original).

Photo 22. Lower Oligocene bioclastic mudstonepackestones to west of “Reza e Kanalit” block - toward the south. / Foto 22. Calcar micritic-packestone bioclastice Oligocen inferioare la vest de blocul “Reza e Kanalit” - vedere spre sud (original).