New Commercial Oil Discovery at Rovesti Structure in South Adriatic and its Importance for Croatian Part of Adriatic Basin

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REVIEW

This paper has been inspired by the newest data on successful petroleum-geological exploration and the discovery of commercial reservoir in southwestern part of the offshore Adriatic Basin in the vicinity of towns Bari and Brindisi. On several occasions in presentations in Nafta journal, the authors have pointed out that oil discovery could be expected in the Croatian part of Adriatic offshore if the seismic data reinterpretation and exploration drilling results were addressed properly. Recent analyses of such data showed that previous studies did not include all paleo-geographic elements, which affected the development of paleo-structures and creation of potential source and reservoir rocks and cap rocks. Special attention shall be put on the above mentioned elements and at the end, the recommendations for further petroleum-geological exploration shall be given.

Key words: Croatian offshore, exploration, new settings, Rovesti, the new commercial oil discovery

1. INTRODUCTION

The commercial oil discovery in Rovesti structure, which occurred last year, was a direct cause for writing this paper. The news is of outmost petroleum-geological significance for the whole Adriatic area including our Croatian offshore (Figure 1). The discovery was made by *Northern Plc.*, company which recognized the commercial oil quantities in Rovesti structure in the offshore area south-east of Bari and Brindisi (Figure 2). Recoverable oil quantities amount to 5 326 074 m^3 (33.5 million bbl) which should be added to previously recognized reserves of 3 116 151 m^3 (19.6 million bbl). However, according to *ENTERPRISE Oil Comp. Chicago*, on six plays in this area there are further 954 million m^3 (6 billion barrels) of possible reserves of light to medium oil (850-900 kg/m^3 or 25-35 °API).

New exploration results from Apulian carbonate platform slope in Brindisi and Bari offshore are going to be described in this paper (Figure 2). Then they are going to be compared with the exploration results of South Adriatic structure (JJ -3) in Prevlaka offshore in the south-east, up to Maja structure (Maja -1) south-west of Lastovo island and further to Istrian offshore in the northwest. Author's intention was to present the possibility of commercial oil discovery in the Croatian offshore.

2. PETROLEUM-GEOLOGICAL RELATIONS OF THE APULIAN PLATFORM SLOPE

During the geological period from Triassic until Upper Lias, Dinarides and Apulian platform formed one consistent unit. Since Upper Lias until the end of Upper Cretaceous, due to paleo-tectonic influence, this consistent platform was separated by Adriatic Basin (in Italian literature called 'Scaglia-Biancone Basin') with pelagic and hemi-pelagic younger Mesozoic deposits and during Tertiary with clastic sediments of flysch and molasse type. Platforms are divided from the basins by steep offshore slopes where periplatform carbonates clastics and turbidites were sedimented. Due to the obvious analogy between Apulian and Dinarides slopes and their petroleum-geological characteristics, they shall be further described in the following chapters. The separation episode on the Italian side is characterized by Rosso Ammonitico stratigraphic horizon which in the Dinarides corresponds to 'Spotted limestone' formation in the top of Lithiotis deposits.[18] The term **Dinarides carbonate platform** shall be used in text and description of figures according to earlier works in which the first author has participated.[10,11,12] However, the term **Adriatic carbonate platform** (e.g. Velić et al.[26], Vlahović et al.[28] and, Vlahović et al.[29]) has been used lately for offshore and onshore part of carbonate sediments (for their current position) which were formed in the period from Triassic to Paleogene. The same term was used for the first time by Cati (Cati et al.[3]), but only for a narrow offshore part south-west of Budva zone all the way to *Friuli* platform in the north.

2.1. The case history of Rovesti structure

The discovery of commercial oil reservoir in **Rovesti structure**[24] in the Italian offshore was the reason for de-

scribing elements that show similarities of petroleum-geological conditions with the ones from Croatian offshore. The characteristics of Rovesti oil field are presented in geo-seismic interpretation of cross -section[6] through Rovesti structure and neighboring Aquila field (Figure 2). In relation to the Apulian slope, Rovesti structure, as well as Aquilla structure, are situated in the lower part of Apulian platform slope, where most probably, mostly horizontal faulting occurred. This regional fault on the western margin of South Adriatic Basin (Figures 1 and 2) most probably forms the south extension of Zampieri 'lithospheric' *Vicenza-Schio*[30] fault which spreads through the entire Adriatic up to Rovesti structure. The mentioned fault has developed probably during the phase of Ladinian magmatic activity and continental crust extension process and also during the formation of depressions with euxinic sedimentation of potential source rocks taking place there. Depositional areas were situated close to geothermal anomalies[21,22] which enabled higher thermal maturity of deposits and also of organic material. This would enable the possibly generated oil and gas to migrate later into various stratigraphic and structural traps.[2]

Spreading of sedimentary areas presented in Figure 1[13,16] indicates the mentioned 'lithospheric' fault with its outmost petroleum-geological significance as due to horizontal faulting, flower structures like Rovesti and

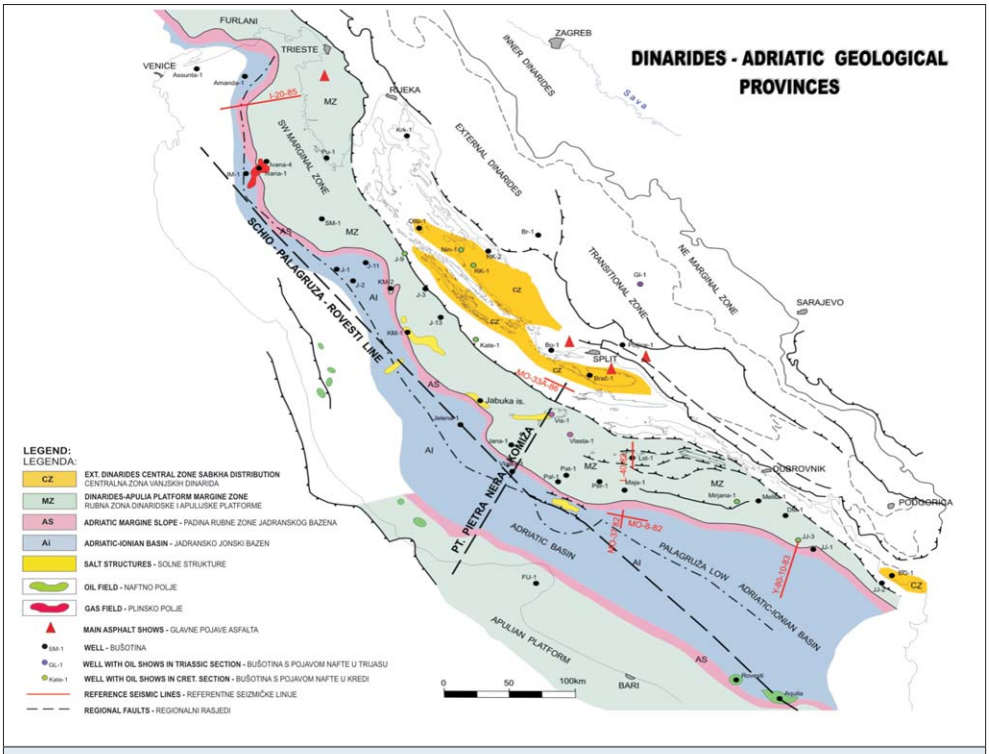

Fig. 1. This map shows Adriatic pelagic and hemipelagic basin (dark blue) and periplatform clastics belt of circum Adriatic area as regional reservoir rocks (pink). Deep regional faults are also presented.[8,16]
Sl. 1. Na ovoj karti prikazan je jadranski pelagički i hemipelagički bazen (tamno plavo) i pojas periplatformskih klastita cirkum jadranskog prostora kao regionalnih ležišnih stijena (ružičasto). Prikazani su i duboki regionalni rasjedi.[8,16]

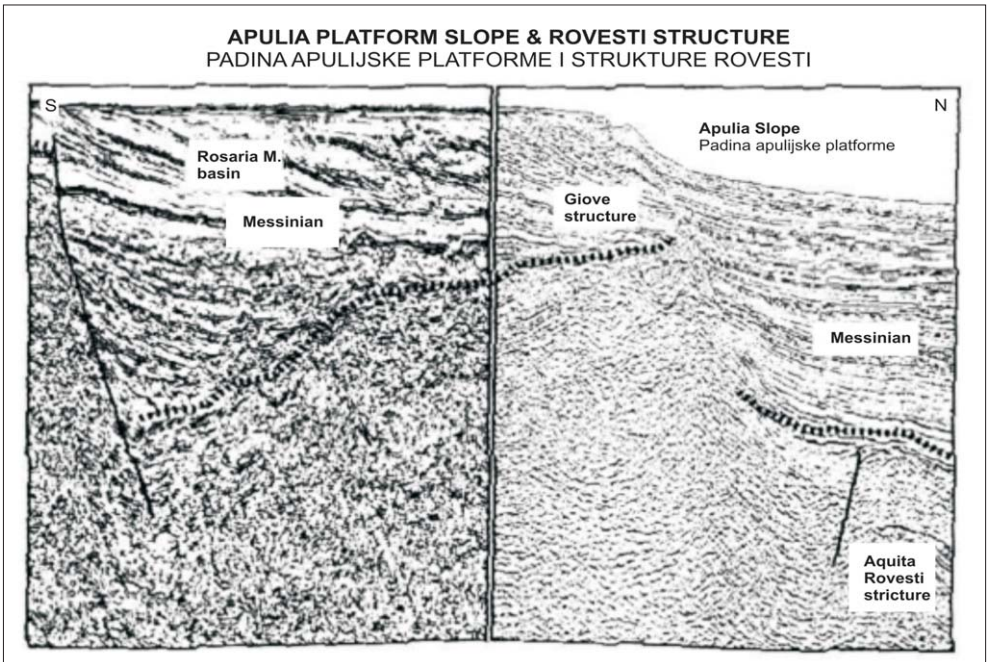

Fig. 2. Seismic cross-section through Apulian slope presents more precisely the structural position of Aquila and Rovesti structure where, in 2007 significant quantity of oil of quality >20 °API was discovered.[22]
Sl. 2. Seizmički profil kroz Apulijski pregib-padinu prikazuje detaljnije strukturni položaj Aquila i Rovesti strukture na kojoj je 2007. ponovno otkrivena veća količina nafte kvalitete >20 °API.[22]

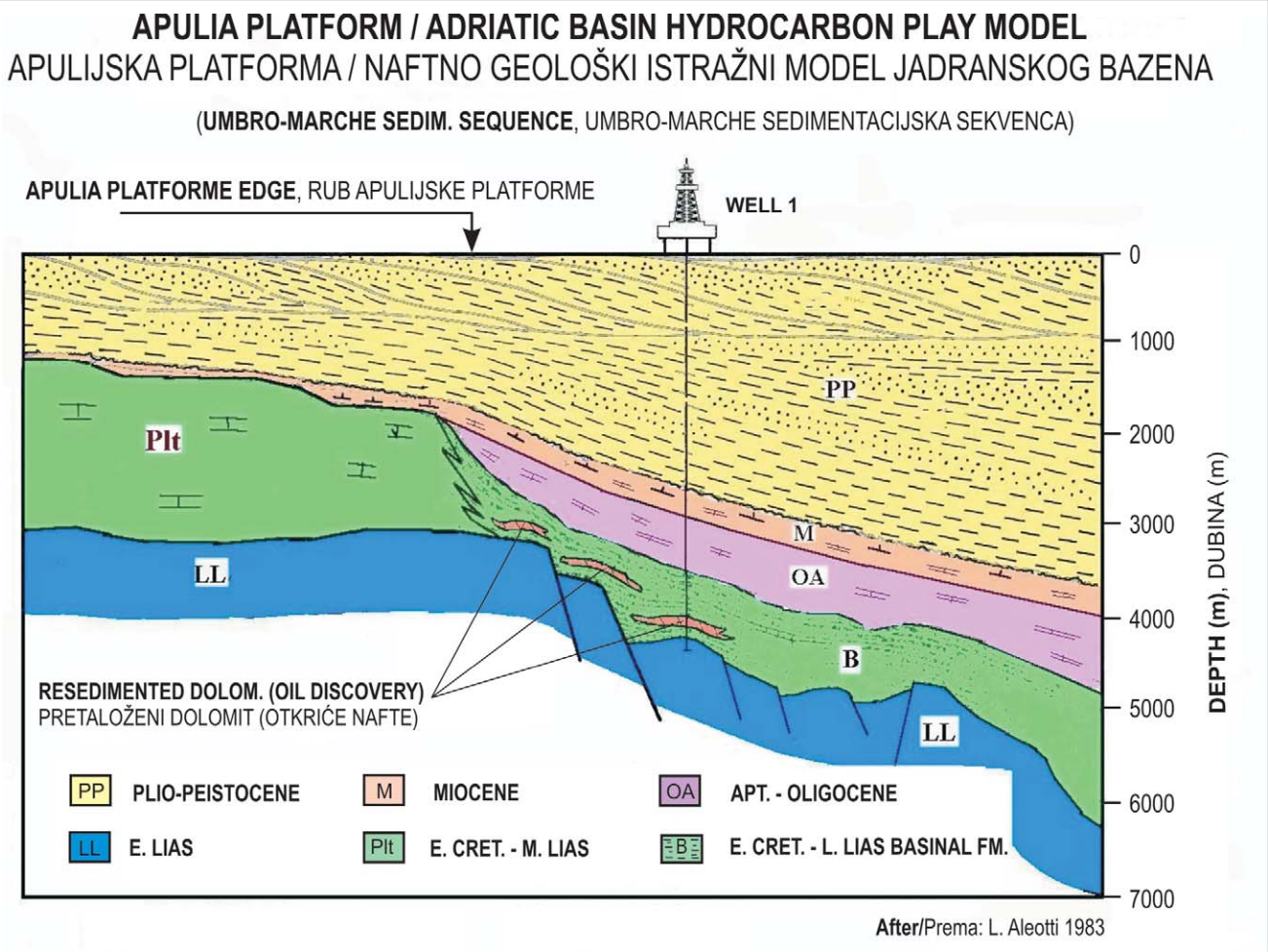

Fig. 3. Geological model of the Apulian carbonate platform slope with periplatform clastics in which oil was recognized in Well-1 well southeast of Gargano in resedimented dolomites.[1]
Sl. 3. Geološki model pregiba Apulijske karbonatne platforme s periplatformskim klastitima u kojima je u bušotini Well-1 jugoistočno od Gargana u pretaloženim dolomitima utvrđena nafta.[1]

Aquila were created and were later elevated toward surface and transformed into 'popup' structures and have become good traps for hydrocarbon accumulation. Oil on Rovesti structure was acquired from the interval from Malm (*Calcari ad Aptici*) to Aptian deposits in Scaglia facies from 2 360 m to 2 554 m (7 743 ft to 8 379 ft).

Reservoir rocks in this structure are represented by periplatform clastics which have developed during relative uplifting of the platform and weathering of its margin marked by three unconformities. Obvious example is Well-1 well diagram southeast of Gargano peninsula where the oil was recovered from dedolomitized limestone of good porosity (Figure 3). The area around the mentioned well was tested by "apparent porosity" mapping being calculated from frequency and amplitude attributes, Aleotti, 1993.[1]

3. PETROLEUM-GEOLOGICAL RELATIONS ALONG THE MARGIN AND SLOPE OF CARBONATE PLATFORM

There are several structures with great petroleum-geological potential at the margin of Dinarides carbonate platform. Several of those are chosen in this chapter by their entire spreading along this margin, from southeast toward northwest. Those structures are: South Adriatic, Maja, PalagruŽa and Lastovo offshore and Istrian slope zone.

3.1. Example of South Adriatic Structure

Exceptionally good example of margins analogy of Dinarides and Apulia platforms is given by seismic cross section through Rovesti structure and South Adriatic structure (defined by JJ-3 well) southwest of offshore Prevlaka peninsula. Big throw between Eocene and Up-

per Cretaceous carbonates on top of structure, over 4.5 km in size is highlighted in Figure 4.

Similar situation is recognized between the top of Apulian platform and Aquila and Rovesti carbonate structures at its base. However, there is also big difference in oil characteristics. Oil from JJ-3 well is heavy and biodegradated while on Italian structures, the oil is of better quality.

This comparison brings us to conclusion that in case of South Adriatic structure, better conditions should be expected at its base which is partly confirmed by drilling results on JJ-1. Detailed analysis of seismic cross-sections on carbonate platform slope resulted in conclusion that periplatform clastics represent regional reservoir rocks not enough explored yet. Such petroleum-geological conditions are indicated by drilling results from the lower part of carbonate platform 'slope' especially in South Adriatic area where significant gas quantities were recognized in sediments at the depth of 3 522 m - 3 610 m (11 654 ft - 11 844 ft) in JJ-1 well. This indicates that the shallower parts of the slope, where coarse clastics were sedimented, probably have more favorable reservoir characteristics for hydrocarbon accumulation.

3.2. Example of Maja Structure

Seismic cross-section (Figure 5) and geological model of Maja-1 well provide very good illustration of complexity required for the exploration of marginal zone (symbol **MZc** and **V.Cr** in Figure 5).

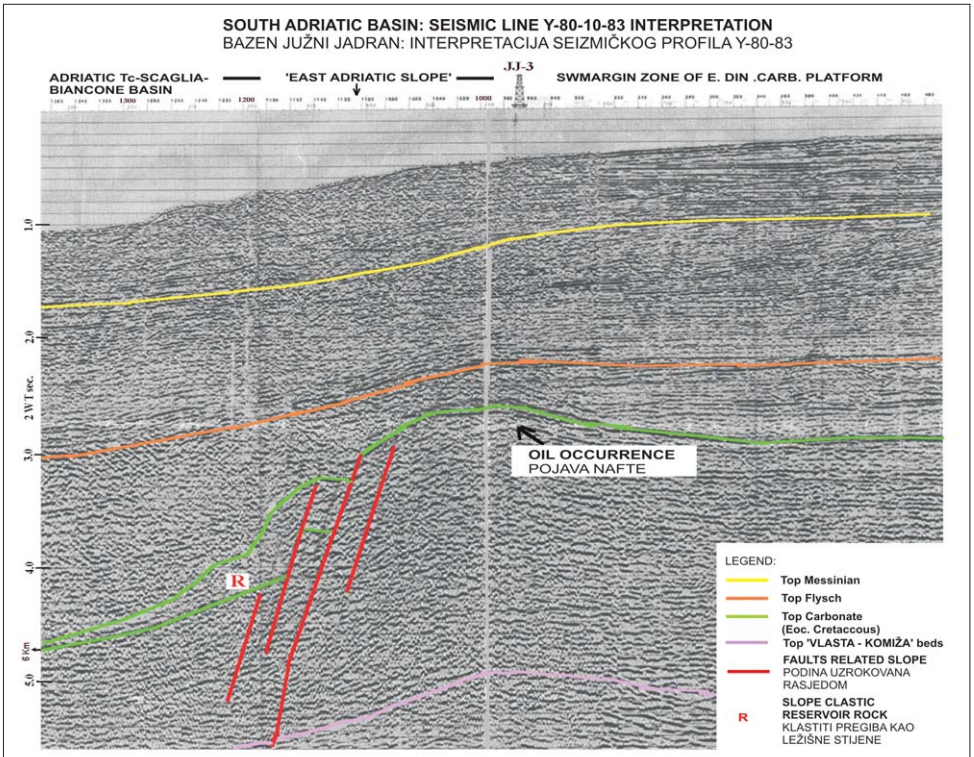

Fig. 4. Seismic cross-section through South Adriatic structure at the margin of Dinarides carbonate platform and its transition into the South Adriatic Basin. The characteristics of transition are clearly visible.
Sl. 4. Seizmički profil kroz strukturu Južni Jadran na rubu Dinarske karbonatne platforme i njenom prijelazu u Južnojadranski bazen. Jasno je vidljiv karakter prijelaza.

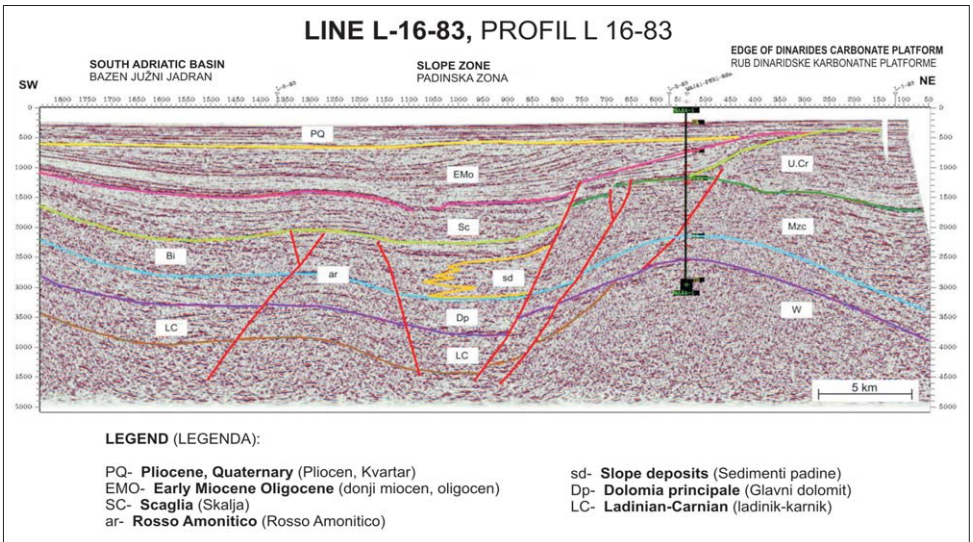

Fig. 5. Margin of Dinarides carbonate platform at its transition into South Adriatic Basin. Intensely eroded margin of Dinarides platform is clearly visible on seismic cross-section northeast of Maja-1 well. Upper Cretaceous rudist limestone deposits, around 1 500 m thick were affected by erosion. At the same time, possible oil reservoirs were eroded. This oil has most probably migrated from neighboring depocenters like Palagruža SE.[16]
Sl. 5. Rub dinaridske karbonatne platforme na prijelazu u Južnojadranski bazen. Na seizmičkom profilu sjeveroistočno od bušotine Maja-1 jasno se ističe intenzivno erodirani rub Dinarske platforme. Erozija je zahvatila naslage gornjokrednih rudistnih vapnenaca debljine oko 1 500 m. Istovremeno su erodirana moguća ležišta nafte koja je najvjerojatnije migrirala iz obližnjih depocentara poput Palagruža JI.[16]

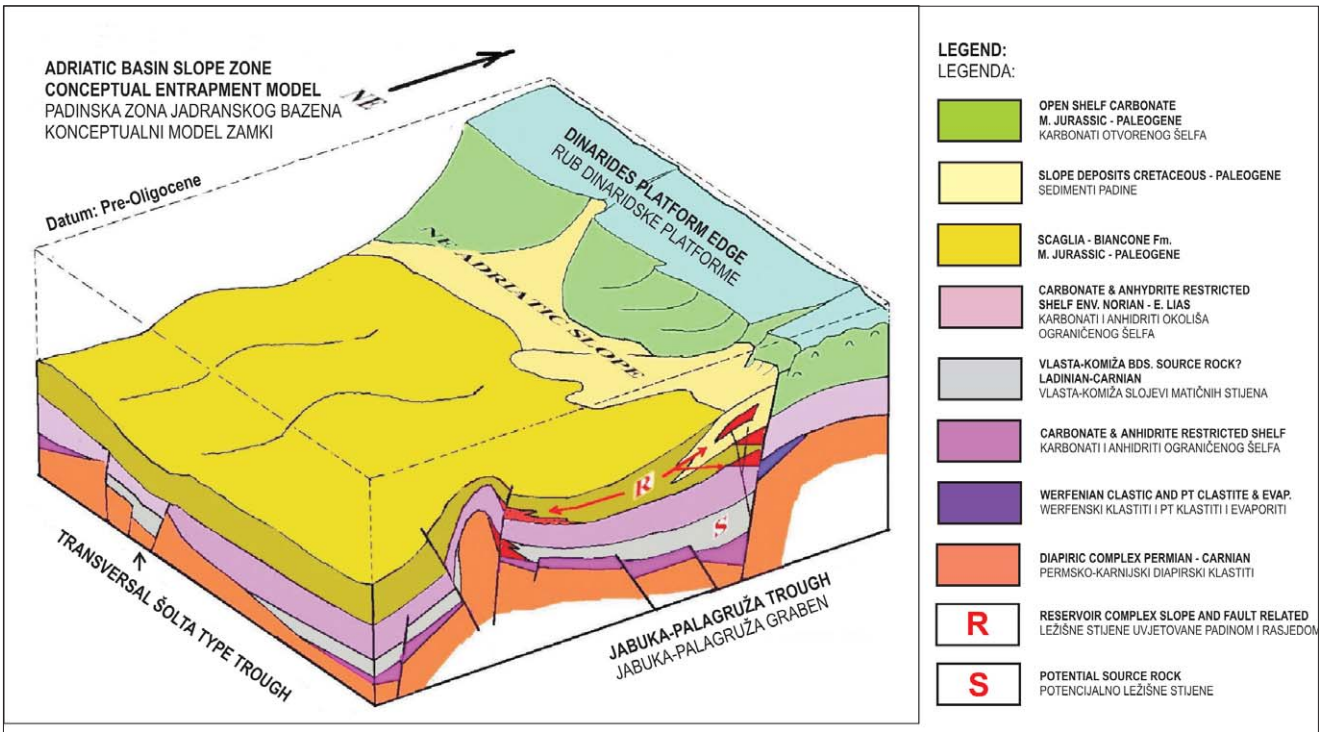

Fig. 6. Conceptual model clearly shows the relation platform/basin and the position of periplatform clastics (R) as reservoir rocks and hydrocarbon trap which originated from source rocks (S).
Sl. 6. Konceptualni model zorno prikazuje odnos platforma/bazen i položaj periplatformskih klastita (R) kao ležišnih stijena te zamku za ugljikovodike podrijetlom iz matičnih stijena (S).

The initial concept of exploring spacious structural closing bigger than 40 km² in this area was based on the assumption of hydrocarbons accumulation in anticline below Tertiary cap rock clastics. However, the fact is that this carbonate structure is composed of Lower Cretaceous carbonates and that it was exposed to long term weathering during post - Cenomanian emersion. Due to this emersion, northeast of Maja-1 well, almost 1 500 m (4 921 ft) of Upper Cretaceous sediments are missing; their remains being sedimented in the platform slope zone. That lead to assumption that possible structural traps have also been degraded. Maja-1 well results confirmed that Upper Triassic lies directly on Werfenian deposits while the Ladinian-Carnian deposits of the same type as those in Vlasta-1 well (as potential source rocks) are entirely missing.

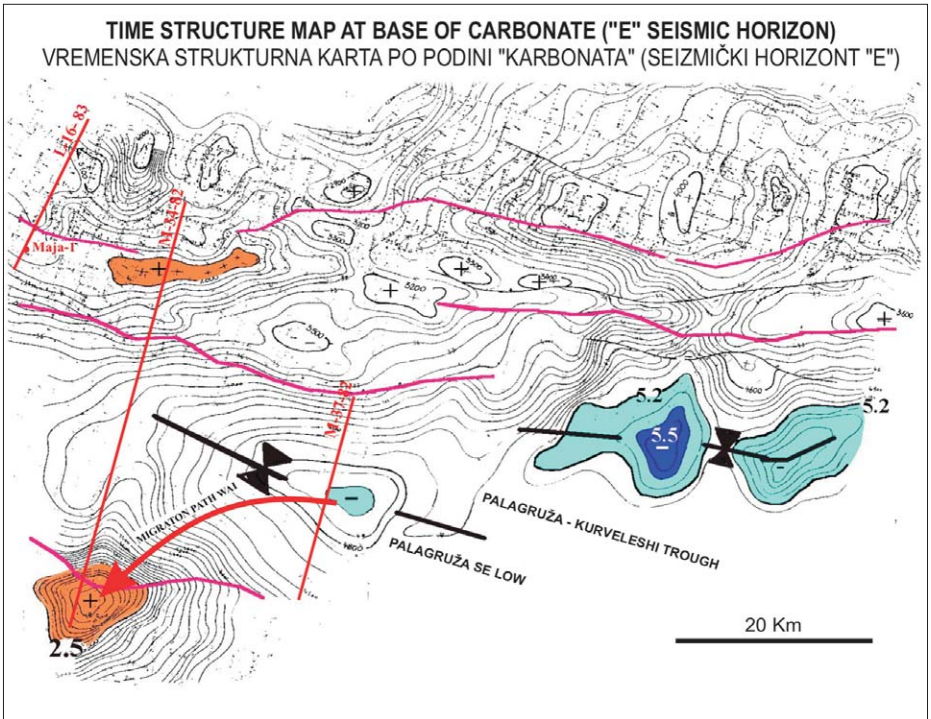

Fig. 7. Structural map of the base of Carbonates, i.e. along 'E' horizon reflects deep graben in the area of Palagruža Southeast structural uplift.[13]
Sl. 7. Strukturna karta po podini Karbonata odnosno po horizontu 'E' odražava duboki graben u predjelu strukturnog uzvišenja Palagruža jugoistok.[13]

The conclusion is that only periplatform clastics form potential reservoir rocks to which hydrocarbons could have migrated from neighboring depocenters situated in e.g. PalagruŽa southeast depocenter. Possible traps in this area are presented in conceptual model in Figure 6.

3.3. Example of petroleum-geological relations of wider Lastovo and Palagruža areas

Generalized structural map along carbonate base, i.e. Upper Triassic dolomites, shows the special distribution of structural uplifts and intra-basinal sedimentary depressions described hereinafter. Structural uplift called PalagruŽa Southeast stands out with the neighboring depression (graben) which probably continues on Kurveleshi zone of Ionian Basin in Albania, containing several source rocks series of Triassic up to Cretaceous age (Figure 7).

Prognosed geological column **JJ-A** illustrates the thicknesses of sedimentary sequences on PalagruŽa South-East uplift structure and intervals of possible source rocks, reservoir rocks and cap rocks shows at the margin of PalagruŽa Southeast depression (Figure 8).

PalagruŽa Southeast structure (Figure 9) represents one of the promising petroleum - geological plays. Authors of this paper recommend this structure as a play worth further exploration. The structure is well covered by Tertiary clastics and argillaceous *Scaglia* deposits while the presented upward clinoforms on structures margins represent favorable structural-stratigraphic traps. It is supposed that the structure is situated in Zampieri fault zone[30] along which the strike-slip movement and formation of pop-up structures were possible, which could represent possible equivalents of Rovesti structure in the Croatian part.

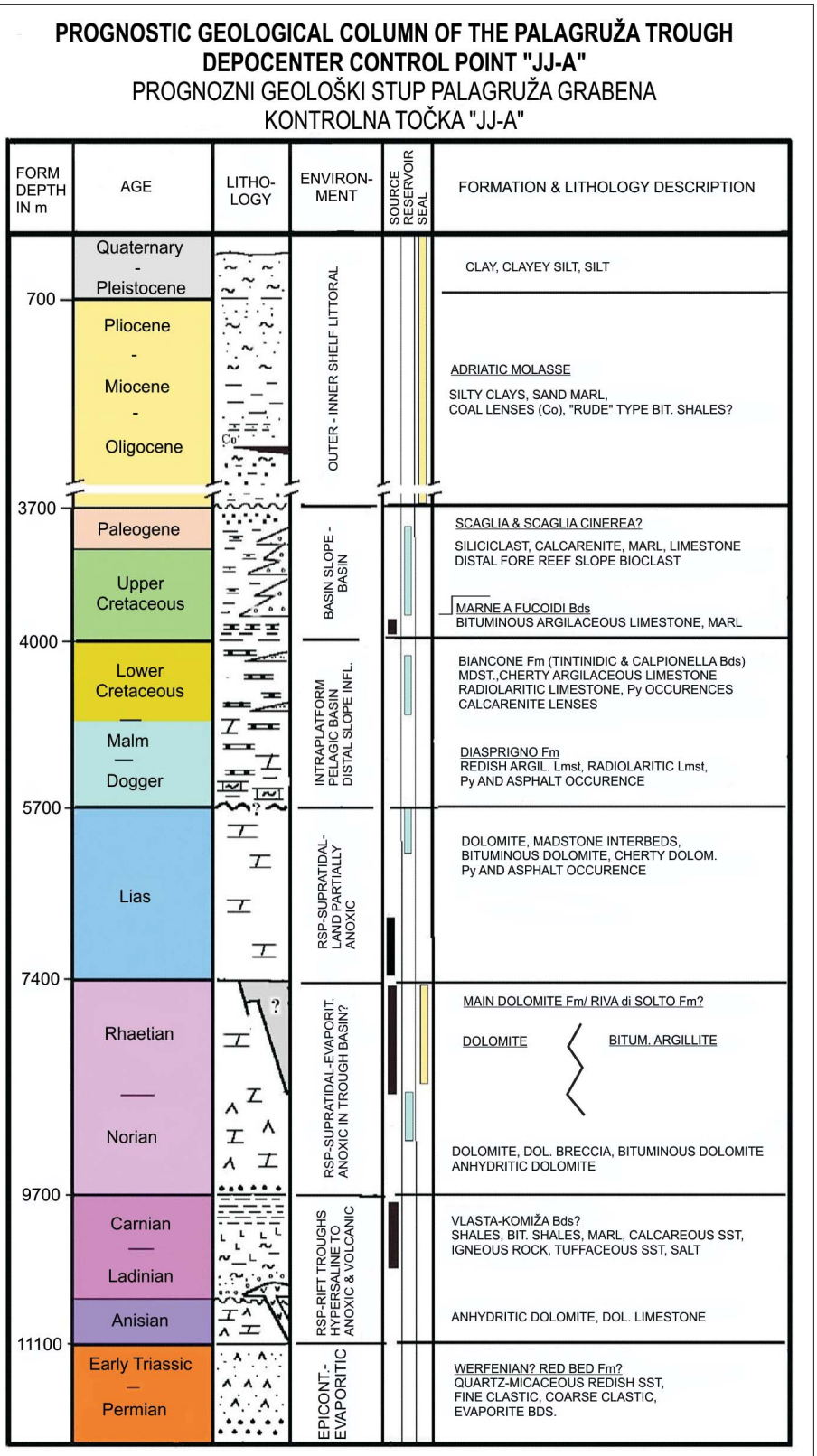

Fig. 8. The prognostic geological column shows the thicknesses of certain lithological sequences and sedimentary environment and intervals of potential source rocks and reservoir rocks.
Sl. 8. Prognozni geološki stup prikazuje debljine pojedinih litoloških sekvenci i ambijenata –okoliša sedimentacije te intervale potencijalno matičnih i ležišnih stijena.

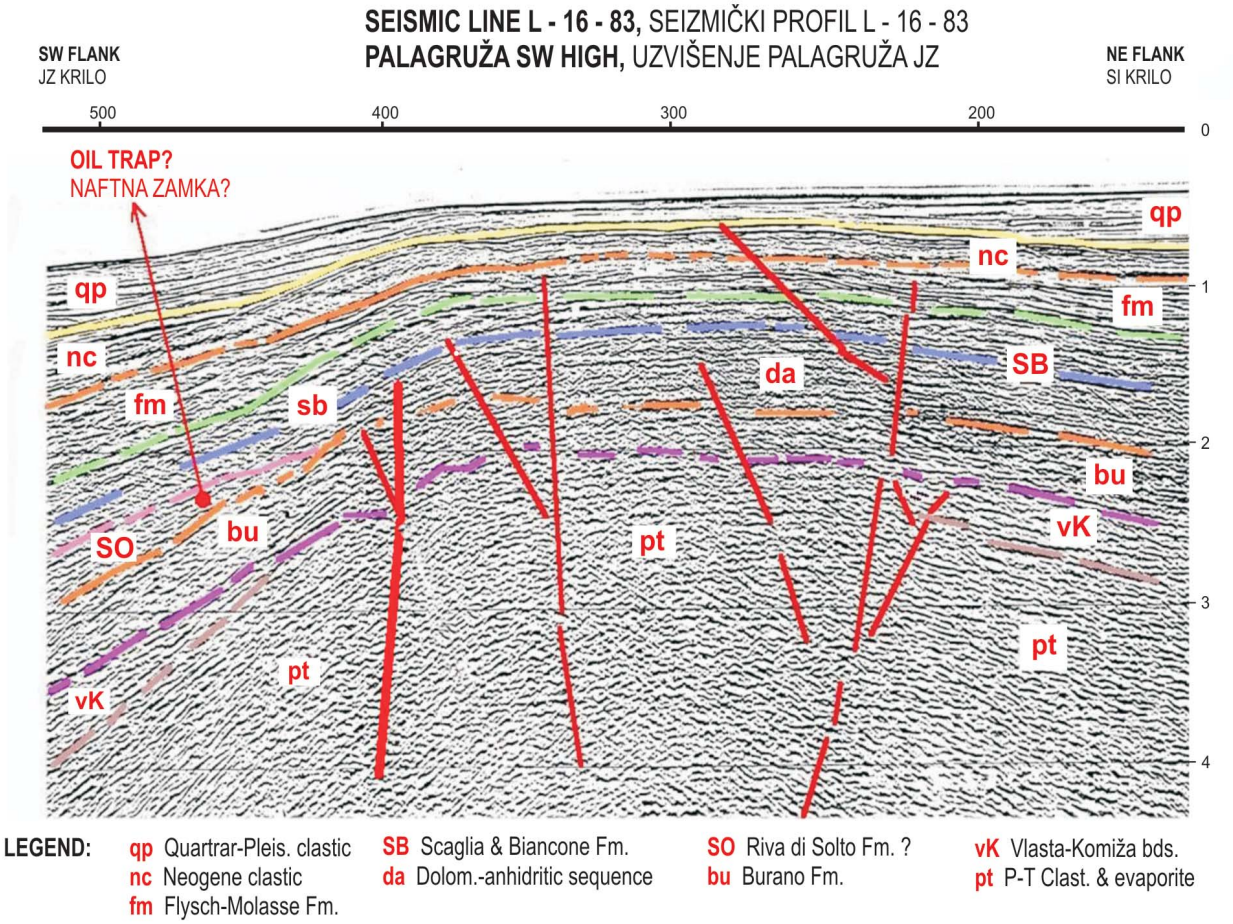

Fig. 9. Presentation of Palagruža structure as intra-basinal uplift is based on interpretation of seismic line L-16-83. 'Upward clinoform trap' is pointed out at the southwestern margin of the structure.
Sl. 9. Prikaz strukture Palagruža kao interbazenskog uzdignuća temelji se na interpretaciji seizmičke linije L-16-83. Istaknuta je 'uzlazna klinoformna zamka' na jugozapadnom boku strukture.

This structure is situated at relatively shallow depth and does not require too high drilling costs.

Seismic cross-sections M-8-82 and M-37-82 (Figures 10 and 11) are chosen to present morphology of PalagruŽa South-East depocenter as possibly oil-gener ating unit from which expulsion and lateral migration of hydrocarbons is supposed into the surrounding traps and structural uplifts.

In the considered area of the southern part of Adriatic Basin from PalagruŽa depocenter to paleo-uplifting in Velebit structure, there was a considerable difference in thickness and facies of sedimentary sequences during the period until the end of Carnian (Figure 12). According to seismic and well data, the greatest thickness of Ladinian-Carnian deposits exceeding 2 000 m (6 561 ft) was sedimented in depressions like the one of Ravni Kotari. The thickness of the mentioned deposits in Vlasta-1 well is 1 360 m (4 462 ft) which is a very important information considering that more than 2 m^3 of medium light oil were determined in Ladinian-Carnian sequence by testing at the depth of 5 545 m (18 192 ft). As relatively heavy Baroid mud was used with density of 1.8 g/cm^3, under different drilling circumstances, the quantity of recovered oil might have been greater.

In Paklenica, near Starigrad in Velebit area, the hiatus of Ladinian-Carnian deposits is marked by regional show of diaspore and oolitic bauxite. Well known are silicate bauxites of Grguri Brijeg in Gračac area and in Lika near Bruvno which lie immediately on Anisian diplopora limestone ('Klimenta limestone') at the base of Upper Triassic dolomites.

3.4. Lastovo Structure

This structure with well expressed anticlinal shape was the subject of exploration drilling which started in Jurassic and ended in Upper Triassic dolomites at the depth of 4 005 m (13 140 ft). At this depth at the bottom of well, bauxite reddish clays were drilled and the well was stuck and the drilling was stopped. There are some indications

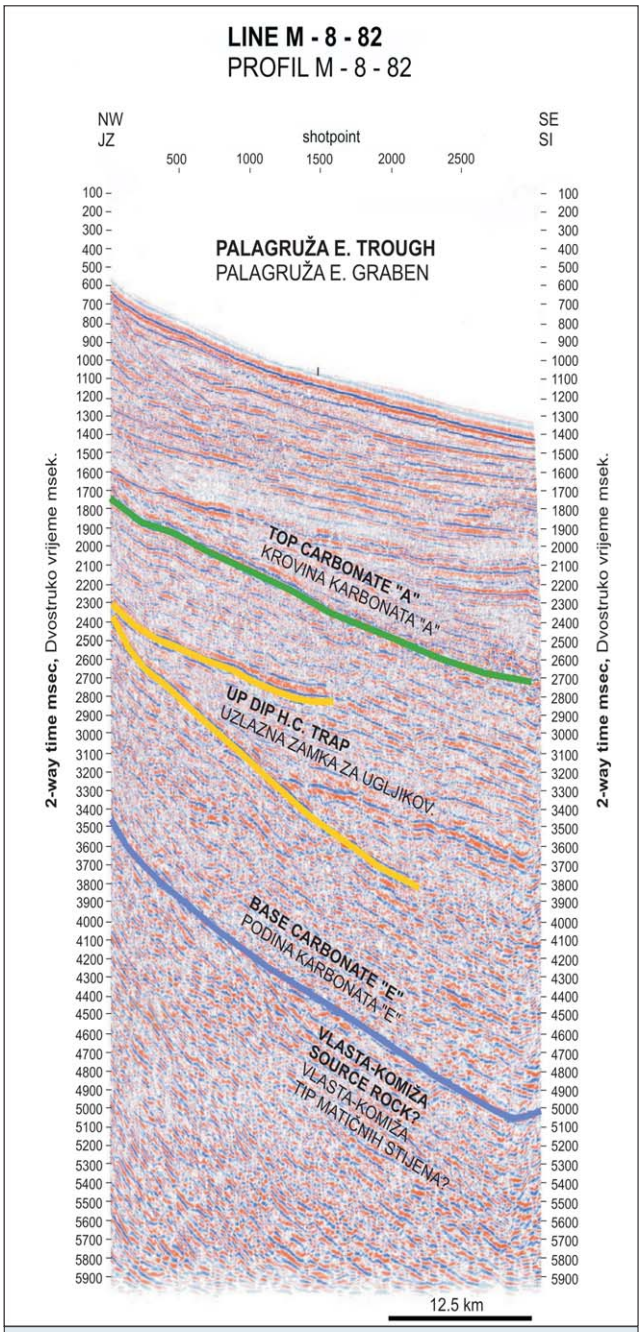

Fig. 10. Interpretational longitudinal cross section M-8-82 delineates in more detail possible trap in the northwestern margin of Palagruža Southeast structure developed in the zone of deep Zampieri fault; possible transcurrent fault.
Sl. 10. Interpretativni uzdužni seizmički profil M-8-82 detaljnije ocrtava moguću zamku na sjeverozapadnom boku Palagruža jugoistok strukture nastale u zoni dubokog 'Zampierovog' rasjeda, mogućeg transkurentnog karaktera.

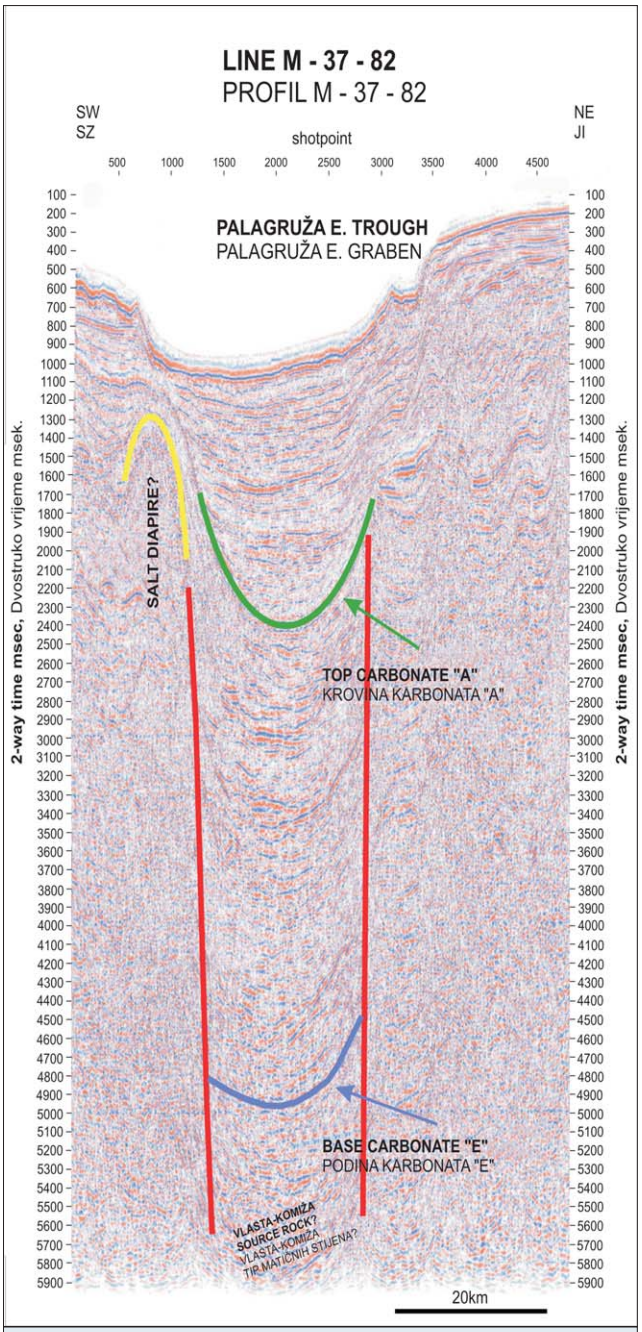

Fig. 11. Transversal) seismic cross-section M-37-82, through Palagruža Southeast depocenter, points out steep flanks of depression and salt diapir show on the south western flank of depression caused by deep fault.
Sl. 11. Poprečni seizmički profil M-37-82, kroz depocentar Palagruža jugoistok, ističe strme bokove depresije i pojavu solnog dijapira na jugozapadnom boku depresije uvjetovanog dubokim rasjedom.

that those clays correspond to well known red "Rabelj clays" which regularly occur in Dinarides at "Haupt Dolomite" formation base well known in Italian literature as "Dolomia Principale". North wing of Lastovo anticline with well developed clinoforms has been proposed in earlier works as favorable play for oil exploration drilling.[14] Very important is northeastern flank of Lastovo structure where stratigraphic-structural trap is visible in clinoform features. These features are situated in the top of Ladinian-Carnian euxinic deposits ('Vlasta – KomiŽa' beds) as well as clasts at the very peak of the structure (Figure 14) marked by symbol '**lk**'.

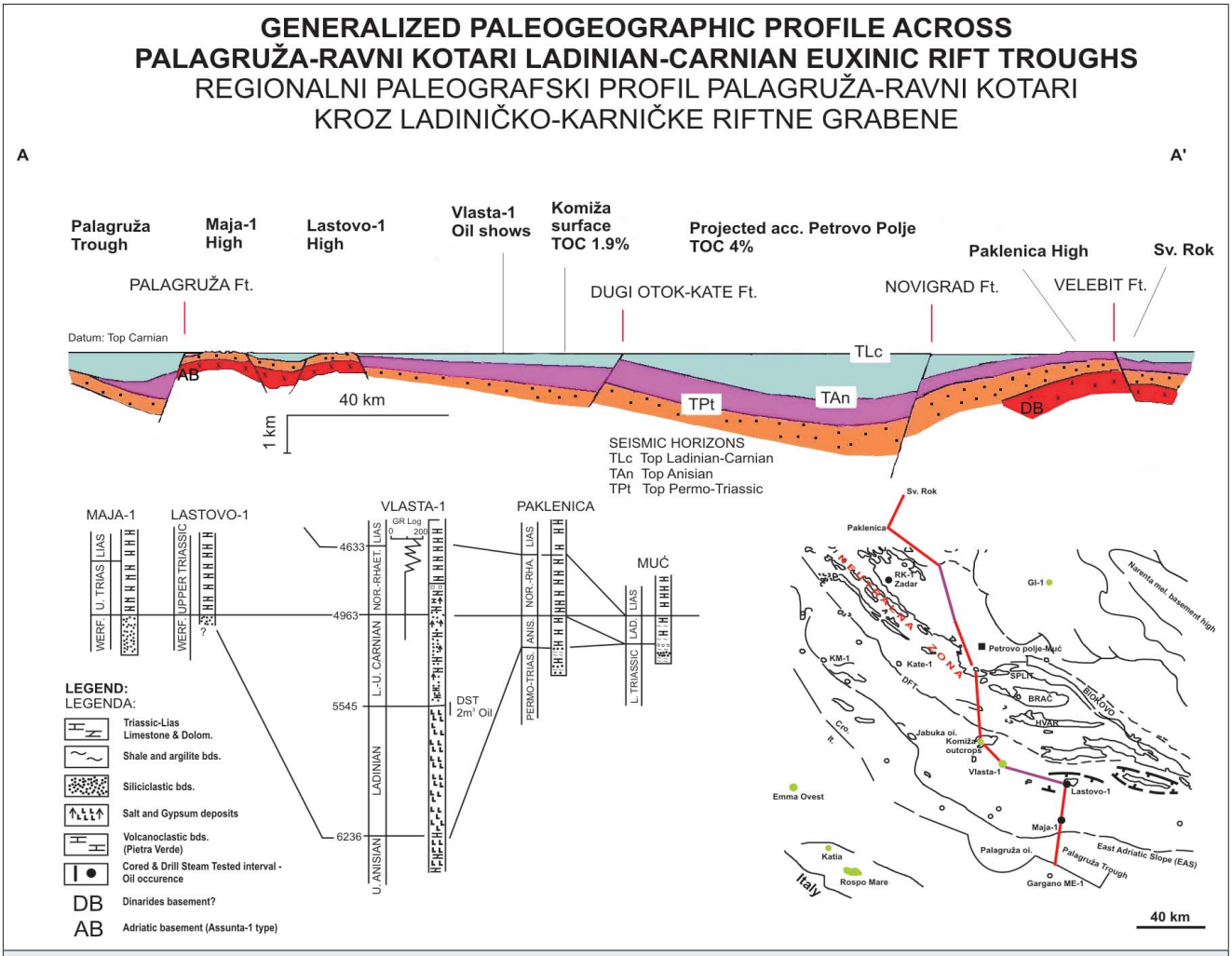

Fig. 12. 'A.A' cross-section shows paleo-morphologic and structural-sedimentary relations on the line from Palagruža and Lastovo structure, Vlasta-1 well to Paklenica in Velebit where Ladinian-Carnian sediments entirely pinch out.
Sl. 12. Profil 'A.A' prikazuje paleomorfološke i strukturno sedimentacijske odnose na potezu od Palagruže preko Lastovo strukture, bušotine Vlasta-1 i do Paklenice u Velebitu gdje ladiničko-karnijski sedimenti u cijelosti isklinjuju.

West of the considered PalagruŽa and Vlasta area, structural-sedimentary relation defines the influence of 'Pt.Pietra Nera–KomiŽa-Šolta' transcurrent fault which is transversal to Dinarides spreading direction. Salt evaporite structures shows were recognized (Dekanić I. et al.) along this fault, which was especially elaborated on the Italian side by Finetti I.R.[8,9] Several of those shows were oil-bearing. Bituminous rocks with 1.5% of carbon TOC (Total Organic Carbon) were recognized along with clastics and evaporites, near KomiŽa. Deep depression of northsouth spreading direction, covered by MO-33A-86 seismic cross-section has been gravimetrically and seismically recognized near Šolta.

Seismic cross-section **M0-33A-86** clearly delineates steep morphology of flanks of this depression (Figure 15) which was most probably developed during the Ladinian extension phase. The mentioned Finetti's transcurrent fault with partly inversed character was most probably followed by magmatic intrusions, the remains of which can be seen on Jabuka island.[23]

It is supposed that asphalt shows on the island of Brač near Škrip, in porous calcarenites originate from Šolta graben. According to Van Krevelen maturity diagram made on samples from the neighboring Brač-1 well from Jurassic anhydrite-dolomite deposits interval below 5 500 m (18 045 ft), mature organic matter with 0 to 5% of vitrinite reflection was recognized in the samples.

3.5. Slope zone of the Istrian part of Dinarides carbonate platform

According to interpretation of IM-1, Ivana-4 and Ivana 4A wells and seismic cross-section **I-20-85** we have come to the conclusion that periplatform clastics of the reach represent favorable stratigraphic-structural traps. Subsea methane shows (*brombole*) are known in this area. Only in the neighboring well Amanda-1 bis, bituminous deposits of Forni formation were deposited in Up-

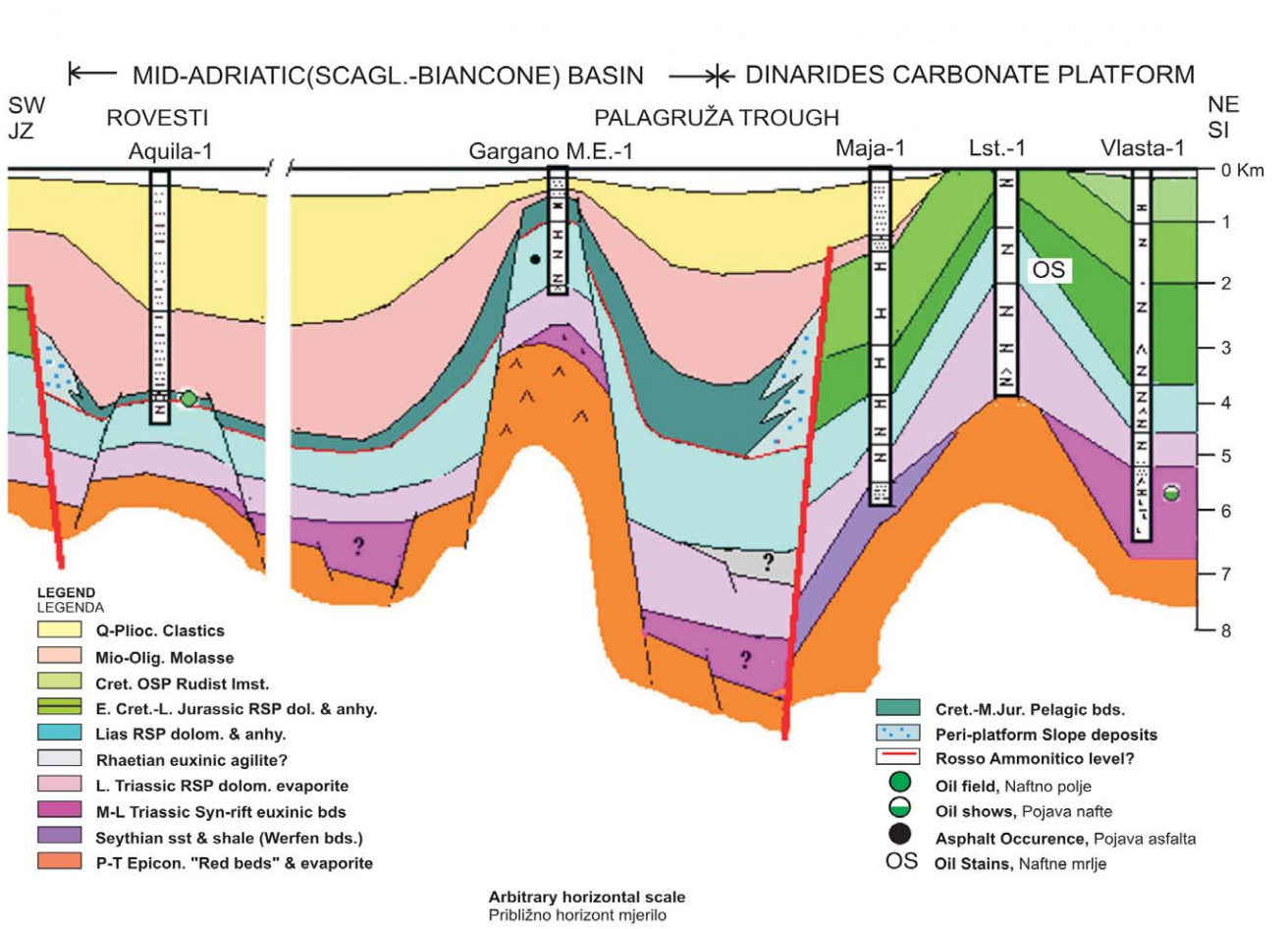

Fig. 13. Paleogeographic relations in the wider stratigraphic range from Ladinian to Tertiary are presented also by correlation table through Adriatic Basin all the way to Vlasta-1 well. Potential source rocks and evaporites intervals are marked along with the interval with oil show marked by symbol (OS). It was clearly indicated that the data from Lastovo-1 well were not sufficient for interpretation of Upper Triassic dolomites base. Thus, it was only supposed that "flower" structure Lastovo as well as neighboring structure Gargano Mare E.-1 were developed by evaporites halokinesis.
Sl. 13. Paleogeografske odnose u širem stratigrafskom rasponu od ladinika do tercijara prikazuje i korelacijska tablica kroz Jadranski bazen do bušotine Vlasta -1. Označeni su intervali potencijalnih matičnih i evaporitnih stijena te interval s pojavom nafte što je označeno simbolom (OS). Jasno je ukazano na okolnost da podaci iz bušotine Lastovo-1 nisu dovoljni za interpretaciju podine gornjotrijaskih dolomita. Zato je samo pretpostavljeno da su "cvjetna" struktura Lastovo kao i obližnja struktura Gargano Mare E.-1 prouzročene halokinezom evaporita.

per Triassic sequence. Forni formation is well known by its exceptionally high TOC of over 45% in the onshore part of Julian Alps. Unfortunately, significant euxinic sedimentary areas as possible oil generating units with potential source rocks of Ladinian-Carnian age were not discovered in this part of platform (Figure 17).

Furthermore, regarding the reservoir characteristics, high porosity was determined in coarse clastic biocalcarenites in IM-1 well at the depth of 3 088 m (10 131 ft) (Figure 18).[27] On the remaining part of the periplatform clastics spreading belts, presented in Figure 1 there are no well data to correlate the results from the other parts of regional zone of periplatform potential reservoir rocks. It is important to mention that along the margin of Friuli platform, where 5 wells were drilled, no testing on periplatform clastics was performed, like the ones recorded in the cross-section between Cesarolo-1 and Ada-1 wells.

4. EUXINIC BASINS SOURCE ROCKS OF SOUTH ADRIATIC OFFSHORE AND THE ISSUE OF THEIR MATURATION

It is supposed that PalagruŽa SE depression follows *Kurveleshi* zone, known for numerous post-Ladinian horizons of Albanian Ionian Basin source rocks which were significant in creating numerous oil fields. It is highly probable that this zone represents also the source of oil that migrated in the direction of Rovesti field and PalagruŽa Southeast high. According to the geothermal relations map (Figure 18) and maturity diagram (Figure 19), in this area the belt of elevated geothermal anomaly

(Kolbah[20, 21]) corresponds greatly to the depression zone (basin) of South Adriatic southeast of PalagruŽa island. The presented map shows that in the area of southeastern extension of PalagruŽa zone, the formation temperature at 3 000 m (9 843 ft) is 60 do 80 °C. Maturity diagram made for point (JJ-A) within the mentioned zone also indicates good maturation conditions of Upper Triassic deposits of Carnian to Norian age.[4]

Measuring of heat flow[5] proves that South Adriatic Basin is characterized by relatively high geothermal values which relates to the fact that it belongs to the extension type of structure developed during Mesozoic. The first one who studied heat flows in this basin was McKenzie[19] who supposed the steady extension of continental crust and the process of its thinning. Although the data on sedimentation history were not available, seismic survey suggested the continental crust reduction from 30 to 20 km over 150 million years. However McKeznie's model of steady extension can not explain the density of heat flow from 65 to 90 mWm^{-2} with the extension of 30 km over 150 million years.[19]

At the depth of 4 510 m (14 797 ft) in JJ-3 well, the temperature of 105 °C was measured which confirms that in the Adriatic offshore there are spaces that may be considered favorable for geothermal maturation of potential source rocks.

Euxinic basins are highly important in determining petroleum-geological potential. Seismic data, i.e. thickness maps of those deposits are basis for determining most probable directions of migrations of hydrocarbons from Carnian sediments into structural-stratigraphic traps. Lateral and vertical hydrocarbon migration in South Adriatic Basin occurred in the direction of Apulian and Dinarides carbonate platform slope. As the margins of these platforms, i.e. their slopes were places where periplatform carbonate clasts of good reservoir quality were deposited, those were also the most favorable places for hydrocarbon accumula-

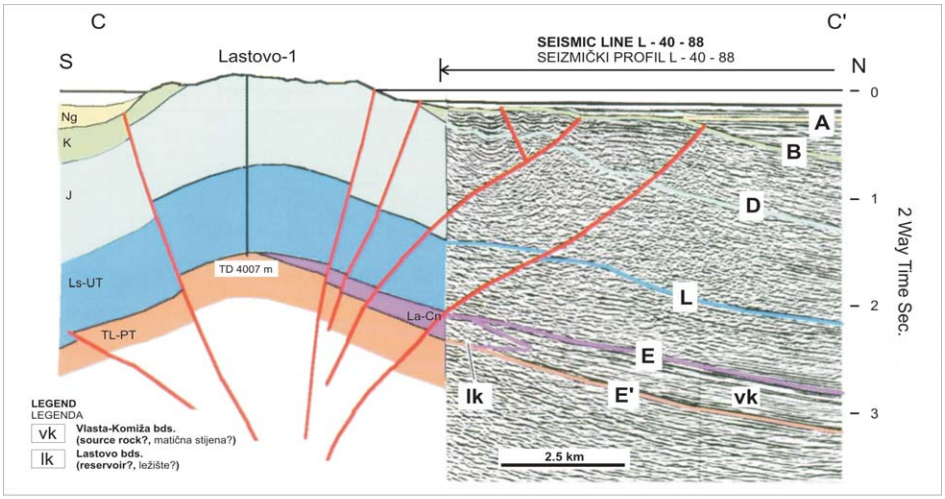

Fig. 14. Combined onshore – offshore cross-section through Lastovo island and its offshore area on the northeastern and southwestern side clearly emphasizes a sequence of potential source rocks marked by 'vk' symbol which are pinching out at the top of paloestructure.
Sl. 14. Kopneno-morski profil kroz otok Lastovo i njegovo podmorje na sjeveroistočnoj i jugozapadnoj strani vrlo dobro ističe sekvencu potencijalno matičnih stijena označenih simbolom 'vk' koji prema vrhu paleostrukture isklinjavaju.

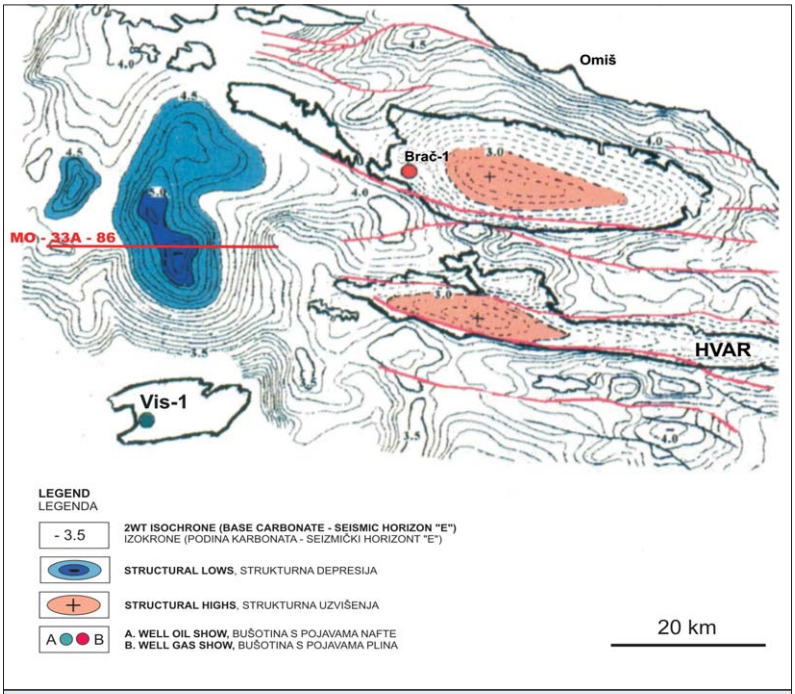

Fig. 15. Seismic cross-section MO-33A-86 crosses the 'Šolta' depression. The depression represents possible maturation center for organic matter in the deposits like the ones discovered and drilled near Komiža on the island of Vis. Hydrocarbon traces in Triassic sequence were recognized in the mentioned Vis-1 well.
Sl. 15. Depresiju 'Šolta' presijeca seizmički profil M0-33A-86. Depresija predstavlja mogući centar za sazrijevanje organske tvari u naslagama kakve su otkrivene i nabušene kod Komiže na otoku Visu. U spomenutoj bušotini Vis-1 utvrđene su tragovi ugljikovodika u trijaskoj sekvenciji.

tion. Thus we have especially emphasized the possibility of migration toward structural uplifts in Croatian offshore, i.e. toward the Dinarides carbonate platform margin.

5. DISCUSSION AND CONCLUSION

As already stated in the introduction of this paper, the incentive for this work was the newest discovery of commercial oil quantities on Rovesti structure which, by its structural and stratigraphic characteristics, relates to the parts of Dinarides platform slope. Especially described are the parts that show most similarities to the Italian oil reservoirs in the Apulian carbonate platform slope zone and its transition into the Adriatic Basin. Analysis of the area in part of Croatian offshore, where exploration drilling was performed, shows that often negative influence of emersions was not taken in consideration, and somewhere like in Kate-1 well also rotation and structure inclination. Also not enough attention was given to whether the structures were in favorable position in relation to anoxic basins, i.e. within the reach of possible migration.

The considered area represents promising petroleum-geological area. Especially significant are slope zones of Apulian and Dinarides platform where peri-platform carbonate clastics were created as favorable reservoir rocks of regional significance. Belt of these clastics, which in Croatian area spreads over approximately 550 km and even more in the Italian side, represents the zone of petroleum-geological traps formation. Especially promising are those parts of belt which are in favorable flank position toward depocenters from where there was a possibility of hydrocarbon lateral migration.

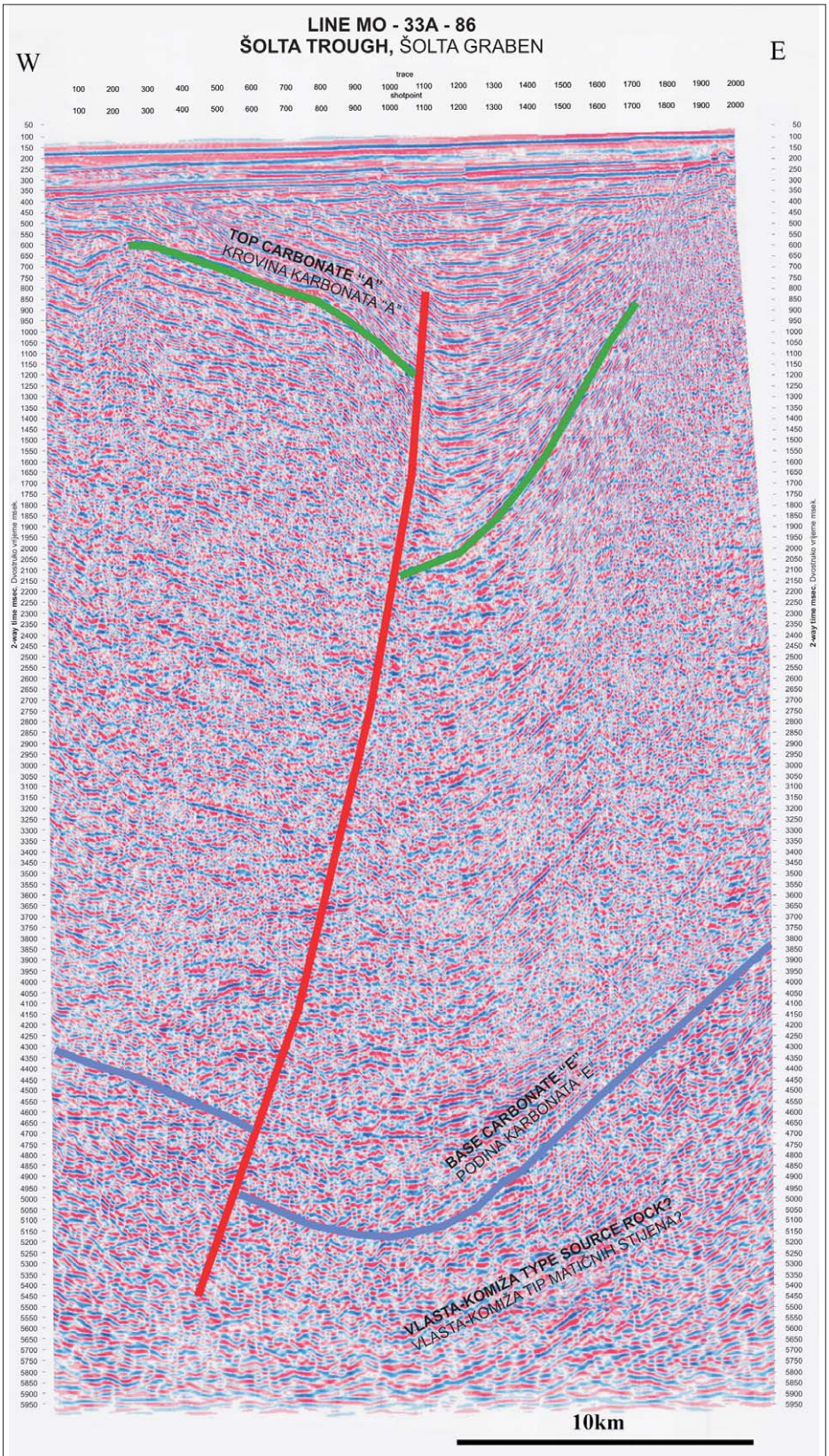

Fig. 16. Transcurrent fault Punta Pietra Nera – Komiža – Šolta (depression) shows some characteristics of reversed fault.
Sl. 16. Transkurentni rasjed Punta Pietra Nera – Komiža – Šolta (depresija) pokazuje djelomično reverzne karakteristike.

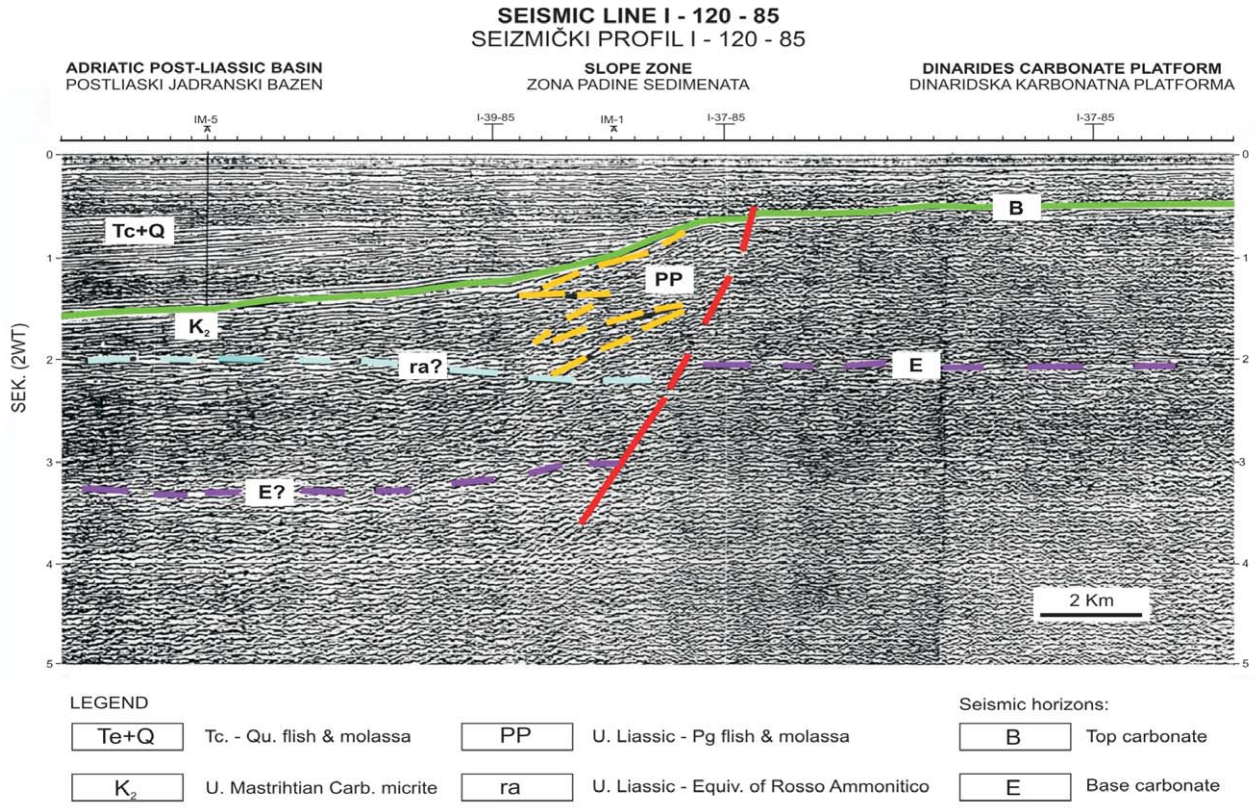

Fig. 17. The presented cross-section clearly shows identical development of periplatform carbonate clastics and previously described periplatform carbonate clastics of line/well JJ-3 of South Adriatic basin. Unfortunately, IM-5 well did not reach this potential reservoir rocks slope.
Sl. 17. Profil jasno ukazuje na istovjetnost razvoja periplatformskih karbonatnih klastita s ranije opisanim klastitima na profilu/bušotini JJ-3 na jugoistoku Jadranskog bazena. Na žalost bušotina IM-5 nije dosegla potencijalno rezervoar stijene padine.

This promising belt is almost unexplored and is recommended for further systematic seismic survey and exploration drilling. The exploration should be aimed to Ladinian-Carnian deposits where the high percentage of carbon total organic content was determined, as well as oil shows as e.g. in Vlasta-1 well.

It is possible to consider the entire sedimentation basin of South Adriatic as favorable geothermal zone separated by the slopes of Apulian and Dinarides carbonate platform as presented in Figures 18 and 19. The following geological units in the southern part of Middle Adriatic Basin and in South Adriatic Basin can be stated as the most promising ones:

1. Lower part of Dinarides platform reach southwest of South Adriatic structure similar to Rovesti structure (where commercial oil quantities were discovered), considering that favorable structures and stratigraphic traps are defined.
2. Parts of Dinarides platform slope southwest of Maja-1, in the belt of periplatform carbonate clastics as good reservoir rocks with favorable structural position toward depocenters near PalagruŽa.

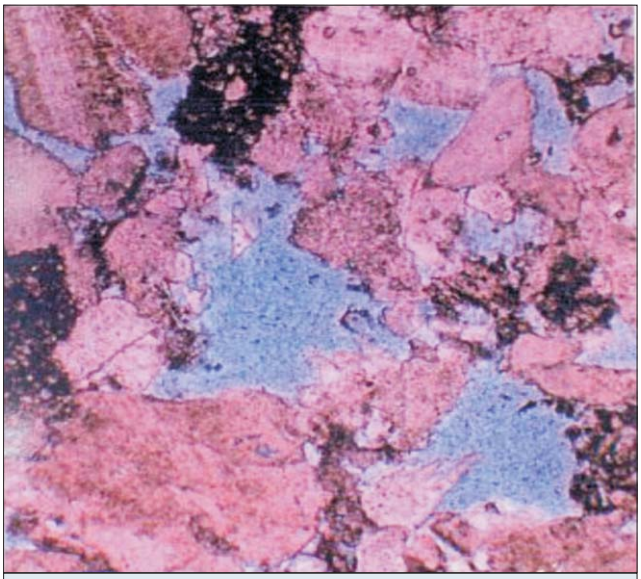

Fig. 18. This figure shows microscope slide of biocalcarenite sample from IM-1 well which is characterized by good intergranular porosity (blue color).[27]
Sl. 18. Slika prikazuje mikroskopski snimak uzorka biokalkarenita iz bušotine IM-1 koji se odlikuje dobrim intergranuralnim porozitetom (plava boja).[27]

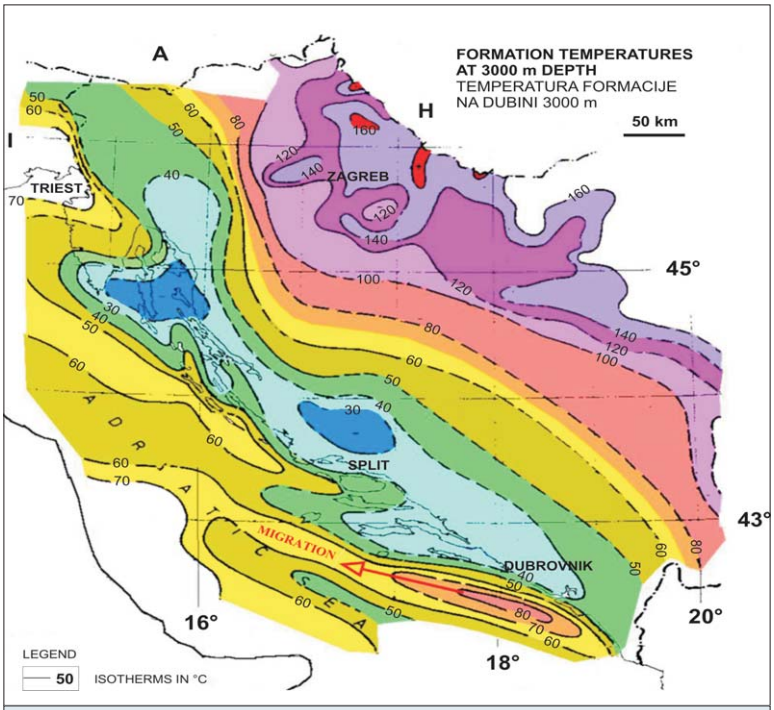

Fig. 19. Regional map shows geothermal anomaly in Dubrovnik offshore of 70° C elongated in the direction of Palagruža southeast depression. The possible hydrocarbon migration is supposed in the same direction.
Sl. 19. Regionalna karta prikazuje geotermalnu anomaliju u dubrovačkom podmorju od 70 °C izduženu u smjeru depresije Palagruža jugoistok. U istom smjeru pretpostavlja se potencijalna migracija ugljikovodika.

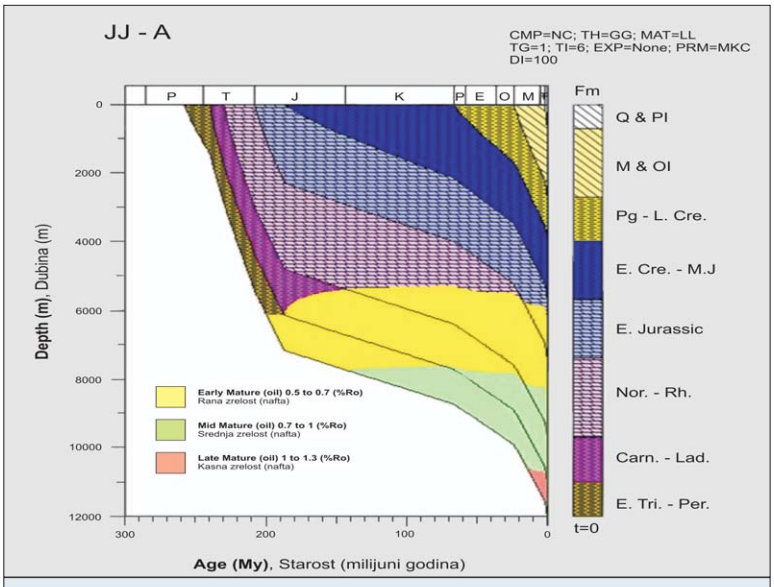

Fig. 20. Diagram of thermal maturation made for point JJ-A (Figure 7) is based on prognosed geological column of 'Palagruža Southeast Depression'. According to the mentioned diagram, pre-Liassic sediments below 6 000 m (19 685 ft) enter the zone of early maturity with the value of Ro=0,7–1%, where also oil can be generated.
Sl. 20. Dijagram termalnog sazrijevanja izrađen za točku JJ-A (slika 7) temelji se na prognoznom geološkom stupu 'depresije Palagruža jugoistok'. Prema spomenutom dijagramu pred-lijaski sedimenti ispod 6 000 m (19 685 ft) ulaze u zonu rane do srednje zrelosti s vrijednošću Ro=0,7–1%, gdje može biti generirana i nafta.

3. Northeastern and southwestern flank of the offshore part of Lastovo structure with clearly expressed 'upward clinoforms' which are in favorable position toward potential source rocks of 'Vlasta-KomiŽa' formation type and southeastern part of PalagruŽa depocenter.
4. In the area of Adriatic Basin, the authors are emphasizing as a very promising one the PalagruŽa southeast zone uplift with favorable relations in the wings of this structure as very good position in relation to PalagruŽa depocenter as favorable oil-generating unit with well developed cap rocks.

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