Peri-Adriatic platforms Proximal Talus reservoir potential (part 2)

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Key words: proximal talus, hydrocarbon generation and expulsion center

9. PESCARA-VINIŠĆE REGIONAL PROFILE

This profile shows regional position of proximal talus along Apulian and Dinarides carbonate platform as potential reservoir rocks. On the Italian side, the indication for hydrocarbon presence in talus is oil on the neighboring Miglianico field whereas on Croatian side it is significant asphalt show in old Roman Vinišće mine. According to Italian data, oil source in Miglianico field is composed of deposits, marked on profile as '*VK*' and those are Vlasta –Komiža layers where oil shows were recognized in Vlasta-1 well.

10. GEOLOGICAL MODEL CORRELATION ON THE EASTERN EDGE OF THE APULIAN CARBONATE PLATFORM AND WESTERN EDGE OF DINARIDES PLATFORM

The presented model clearly shows the Apulian carbonate platform slope. Elsa-1 well position, located in the

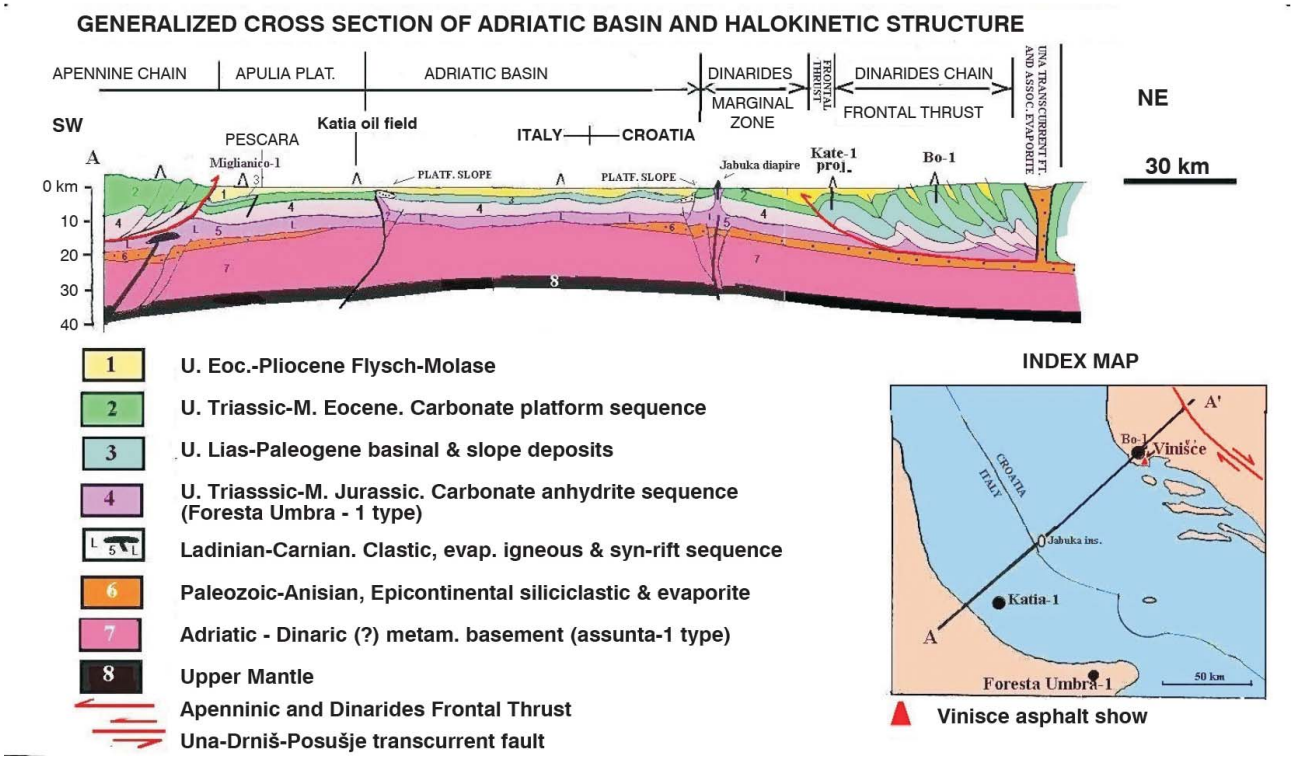

Fig. 23. Slopes on the edge of Apulian and Dinarides carbonate platform are pointed out as places of proximal talus development as possible reservoirs. Miglianico reservoir was discovered near Pescara. It originates from Upper Triassic deposits. Dinarides and Apulian carbonate platform slopes on the edge of Adriatic Basin are pointed out in the profile.

Sl. 23. Ističu se padine na rubu Apulijske i Dinaridske karbonatne platforme kao mjesta stvaranja proksimal talusa kao mogućeg rezervoara. Kod Pescare otkriveno je ležište Miglianico porijeklom iz gornjotrijaskih naslaga. Na profilu su istaknutepadine karbonatnih platformi Dinarida i Apulije na rubu Jadranskog bazena.

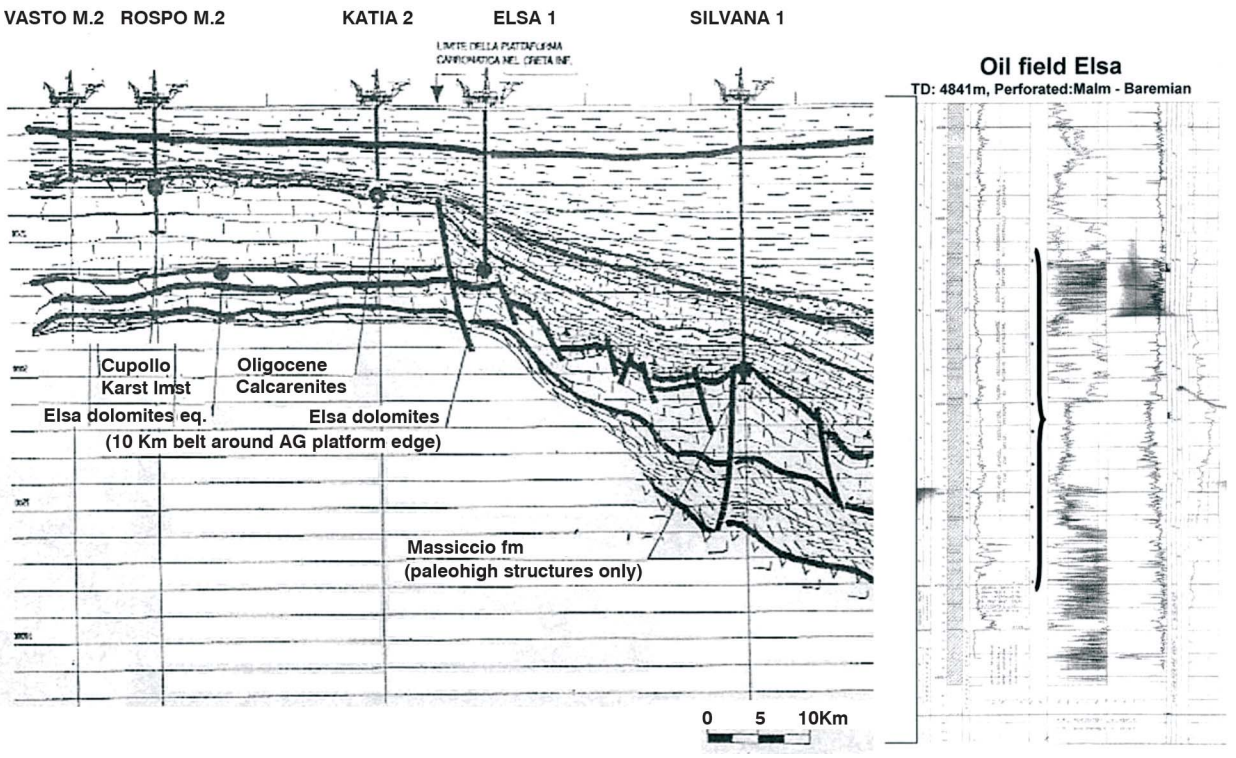

Fig. 24. Along with the above description, an oil interval on Elsa-1 well column marked by curly bracket for 4 250-4 700 m interval needs to be pointed out.

Sl. 24. Pored gornjeg opisa treba istaknuti i interval nafte na stupu bušotine Elsa-1 označen vitičastom zagradom za interval 4 250 - 4 700 m.

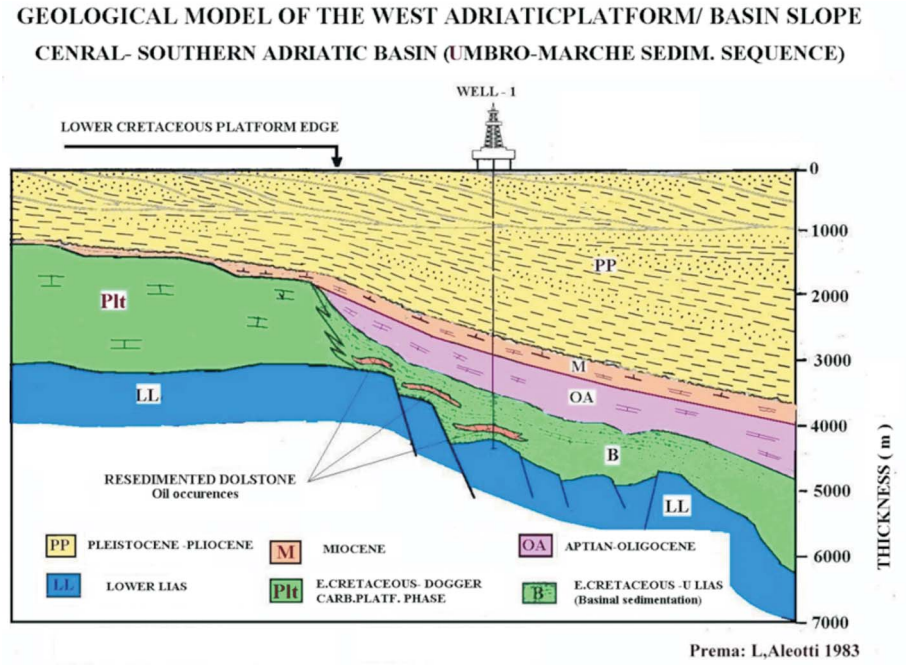

Fig. 25. According to L. Aleotti, oil show was confirmed in the mentioned well, discovered in Aptian-Oligocene resedimented dolomites indicated in brown.

Sl. 25. Na spomenutoj bušotini potvrđena je prema L. Aleotti-u pojava nafte u apt oligocenskim resedimentiranim dolomitima što je označeno na slici smeđom bojom.

very slope – paleo fault is especially pointed out as presented in Fig. 24. The same model shows position of Rospo Mare where Aquitan organization has performed horizontal drilling to reach the oil in lithothamnion limestone caverns.

This model is an analogue of the same models on Dinarides carbonate platform slope. Well-1 well is situated 25 km NE of port of Bari and was drilled 3 km from Apulian platform slope. As presented in the profile, older Mesozoic carbonate deposits and oil bearing horizons of proximal talus from Biancone formation are well covered by younger clastics of Oligocene, Miocene and Pliocene age. After L. Aleotti, oil was recognized in resedimented dolomites. Due to confi-

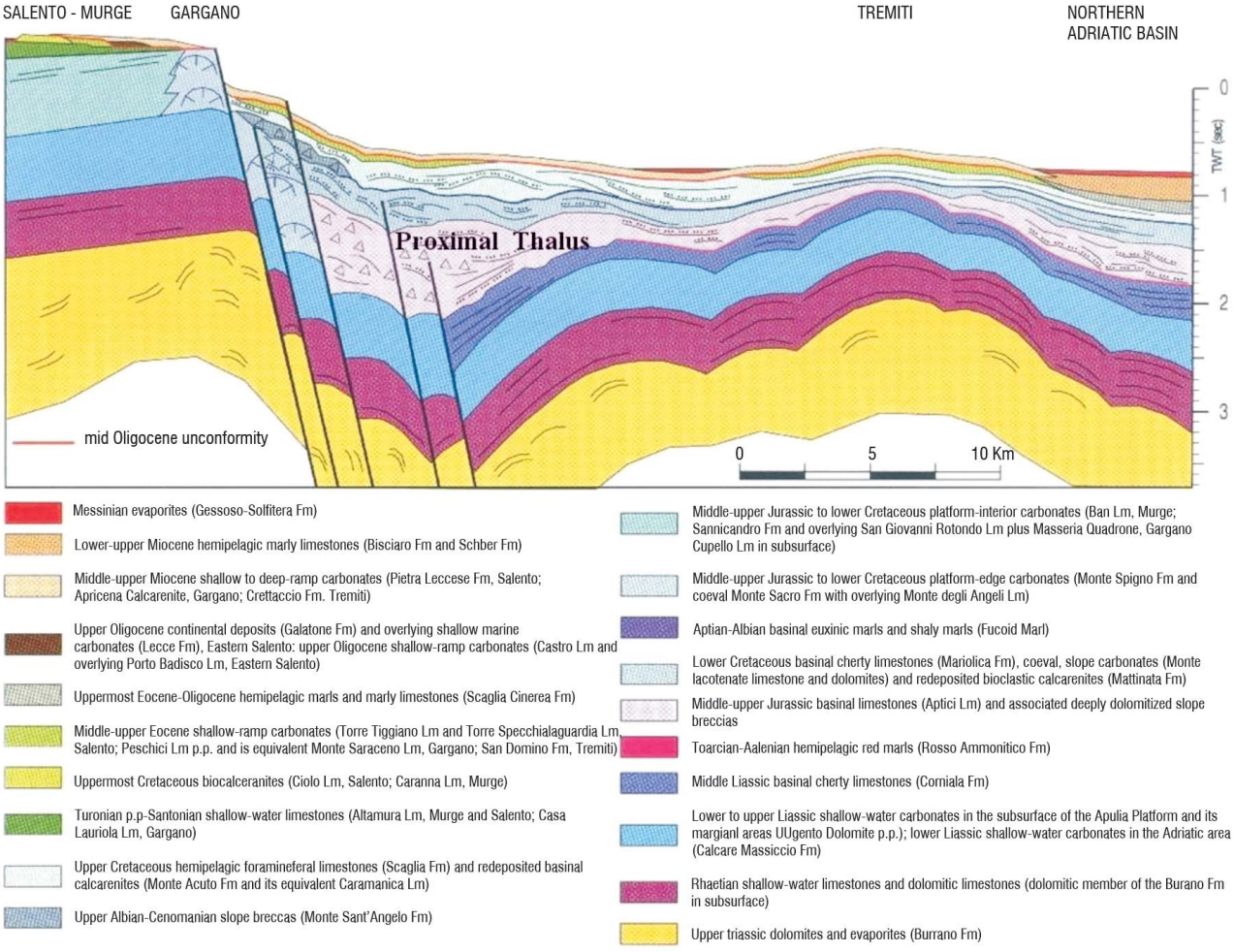

Fig. 26. This geological profile after P.Scandone and E. Patacca[26] very clearly shows proximal talus on Gargano platform slope, which has developed after separation of Dinarides and Apulian platform, i.e. after Upper Liassic.

Sl. 26. Ovaj geološki profil prema P.Scandone i E. Patacca[26] vrlo jasno prikazuje proksimal talus na padini Gargano platforme, koji je nastao nakon razdvajanja Dinaridske i Apulijske platforme tj. nakon gornjeg lijasa.

dentiality, porosity and permeability data were not provided. The presented model is an analogue of the same models on Dinarides carbonate platform slope. As presented on the profile, older Mesozoic carbonate deposits and oil-bearing horizons of Biancone formation proximal talus are well covered by younger clastics of Oligocene, Miocene and Pliocene age.

11. GEOLOGICAL PROFILE ON THE EASTERN EDGE OF GARGANO CARBONATE PLATFORM

Gargano peninsula represents marginal part of carbonate platforms system on the Italian east coast of the Adriatic Basin. Carbonate platform transition is genetically related to post Triassic faults which confirm that Jurassic phase was followed by pelagic sedimentation and creation of proximal talus whereas clastics sedimentation occurred in Tertiary.

12. GEOTHERMAL RELATIONS IN LASTOVO OFFSHORE AREA

See Fig. 27.

CREATING OF SLOPE IN THE ADRIATIC BASIN ON THE EDGE OF APULIAN PLATFORM SUOTH OF BRINDISI

See Fig. 28.

PROXIMAL TALUS IN LASTOVO ISLAND AREA

Palagruža depocenter SE, as possible migration source, is situated relatively close (5-12 km) to proximal talus in Maja-1 well area (Fig. 8). The structural map of Mesozoic carbonates top shows the zone of proximal talus (brown) whereas migration directions from depocenter are indicated in blue.

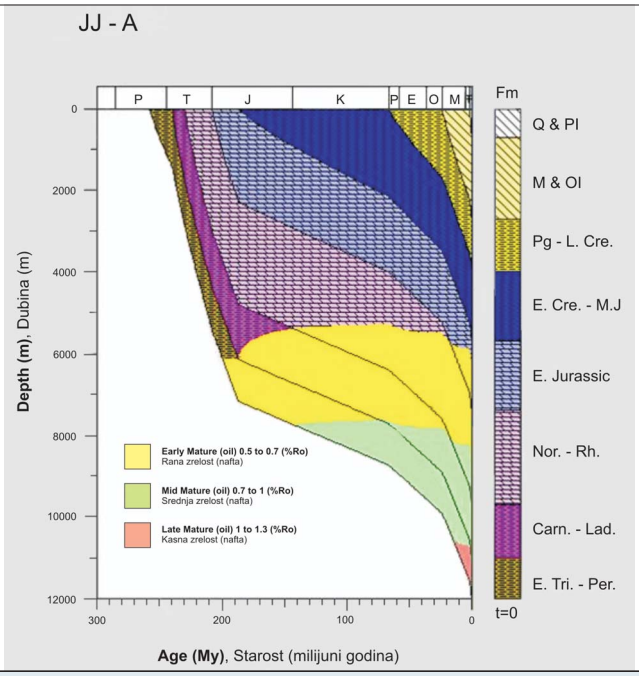

Fig. 27. This maturation diagram, after S. Kolbah, shows that Upper Triassic deposits are situated in "middle maturity" zone (oil) at the depth below 10 km. This maturation diagram shows that possible Upper Triassic source rocks of Vlasta-1 type are buried below 8 000 m and probably here within a belt of the increased geothermal gradient needed for hydrocarbon generation and expulsion.

Sl. 27. Na ovom grafikonu maturacije se, prema S. Kolbahu , može vidjetida se gornjotrijaske naslage nalaze u zoni srednje zrelosti matičnih stijena na dubini ispod 10 km. Isto tako se na ovom grafikonu maturacije vidi da mogućematične stijene gornjeg trijasa tipa Vlasta-1 zaliježu ispod 8 000 m, te se vjerojatno nalaze u pojasu povišenog geotermičkog gradijenta potrebnog za generiranje i ekspulziju ugljikovodika.

PROXIMAL TALUS WEST OF MAJA-1 WELL

According to seismic cross section interpretation of Dinarides carbonate platform edge, significant quantities of proximal talus were sedimented west of Maja-1 well. According to preliminary interpreted line Janica 3D 1120 processed by D. Balić which encompasses proximal talus with developed cllinoforms as potential hydrocarbon traps (Fig.6). The mentioned cross section shows deep and intense erosion and resedimentation into Upper Cretaceous deposits basin. This geological model can be correlated to the geological model of Gargano platform slope at the transition into the Adriatic Basin, after P. Scandone and E. Patacca

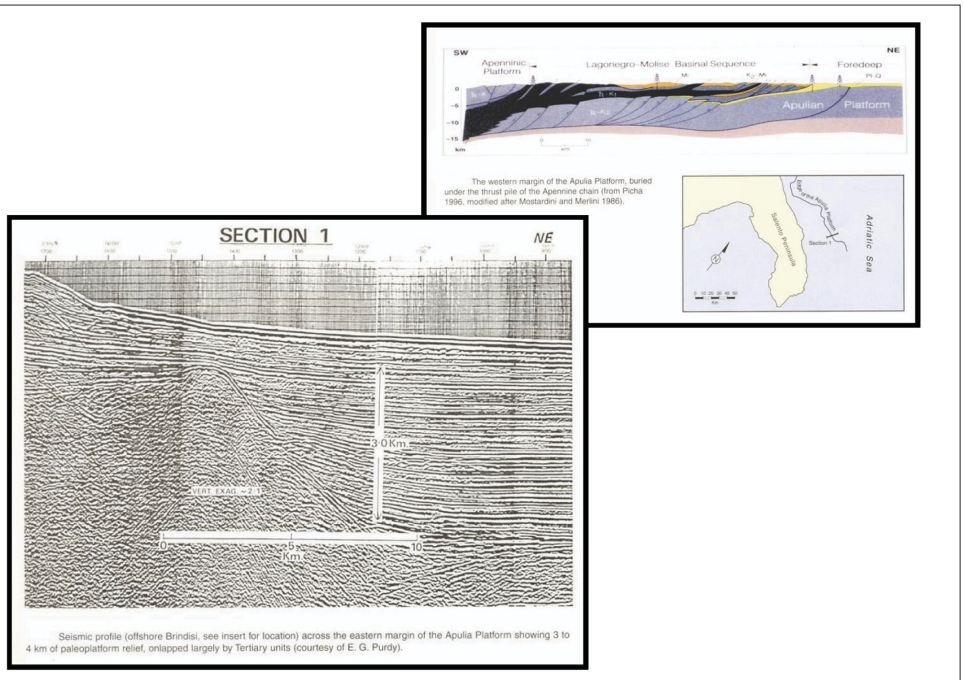

Fig. 28 Seismic profile of the area near Brindisi offshore (38 km NE of the coast) through the eastern edge of the Apulian platform covered by 3-4 km thick Tertiary clastics (after E. G. Prudy).

Sl. 28. Seizmički profil u podmorju kod grada Brindizzia (38 km SI od obale) kroz istočni rub padine Apulija platforme prekrivene naslagama tercijarnih klastita, debljine od 3-4 km. (Prema E.G.Prudy).

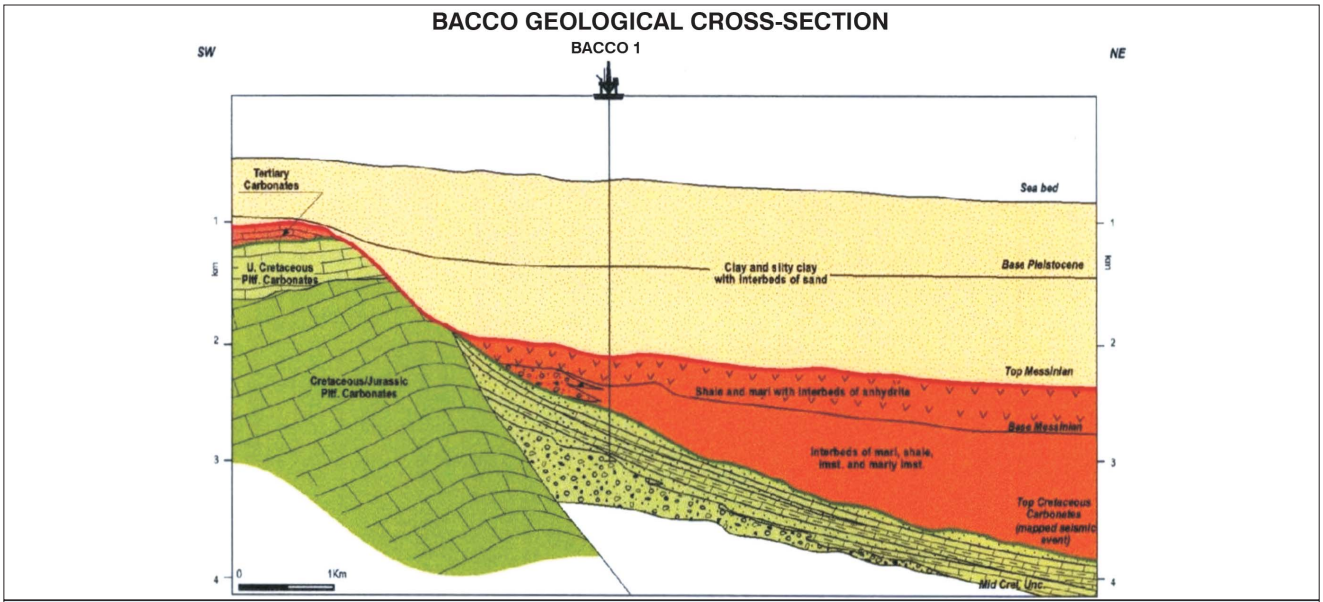

Fig. 29. Sedimetological profile of the Apulian carbonate platform slope of the wider offshore area near Brindisi. The prospect is identical to the prospect south of Mirjana-1 well on the Dinarides platform edge.

Sl. 29. Prikazan je sedimentološki profil padine Apulijske karbonatne platforme na širempodručju podmorja kod Bridizzia. Radi se o prospektu koji je identičan s prospektom južno od bušotine Mirjana-1na rubu Dinaridske platforme sjeverno od Brindizzia .

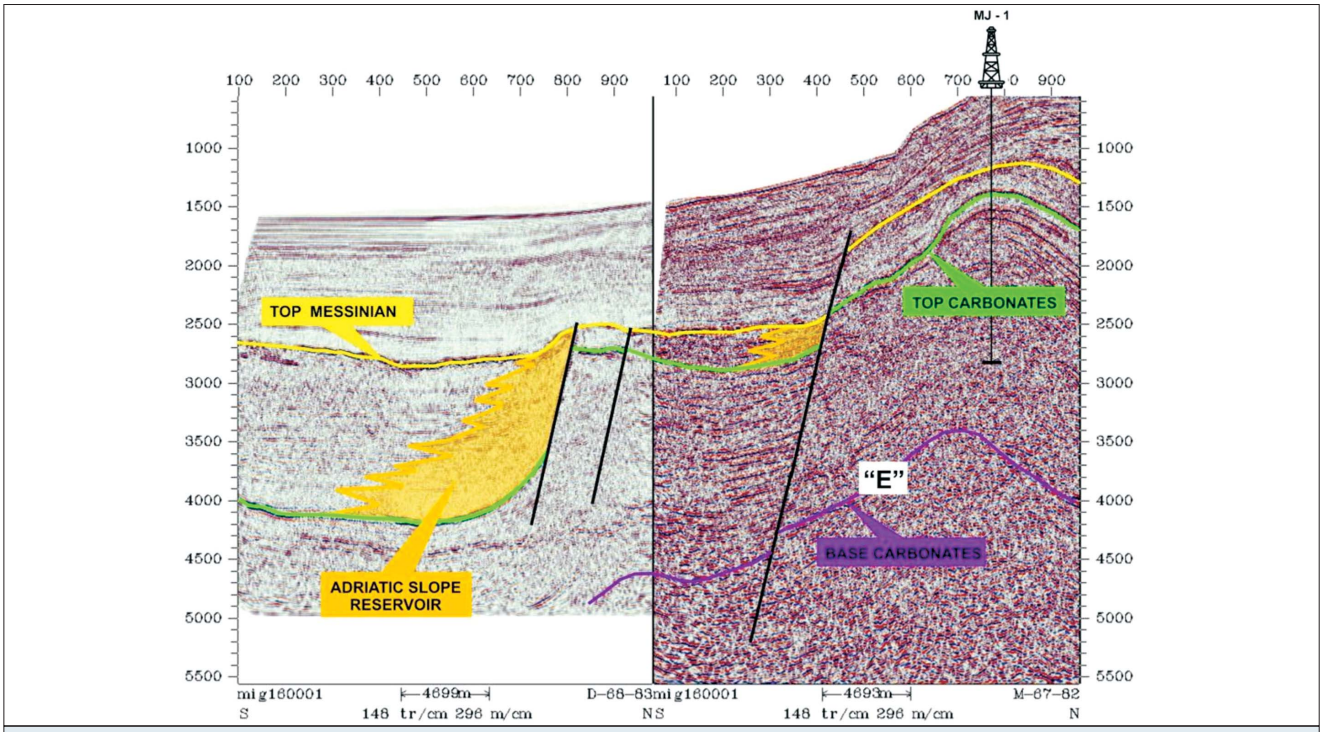

Fig. 30. Proximal talus presented in yellow can be compared to geological model of Gargano platform in Adriatic Basin (Fig. 26). Proximal zone of platform talus SW of Mirjana-1 well as an average lead is 9 400 m wide and its maximal thickness is 1 750 m calculated after D-68-83 seismic cross section. Possible reservoir volume on the stated location, after I. Rusan is 13 365 439 m³ of total calculated recoverable reserves of 454 714 580 m³. Sea depth is 1 350 m which is technically challenging.

Sl. 30. Proksimal talus označen žutom bojom vrlo se dobro može usporediti sanalognim geološkim modelom padine Gargano platforme (Sl. 26). Proksimalna zona platformskog talusa JZ od bušotine Mirjana-1 kao prosječan lid (Lead) ima širinu 9 400 m i maksimalnu debljinu 1 750 m, izračunato prema seizmičkom profilu D-68-83. Mogući rezervoarski volumen na navedenoj lokaciji prema I. Rusanu iznosi 13 365 439 m³ od ukupno izračunatih pridobivih rezervi, od 454 714 580 m³. Dubinamora je 1 350 m što je tehnička nepovoljnost.

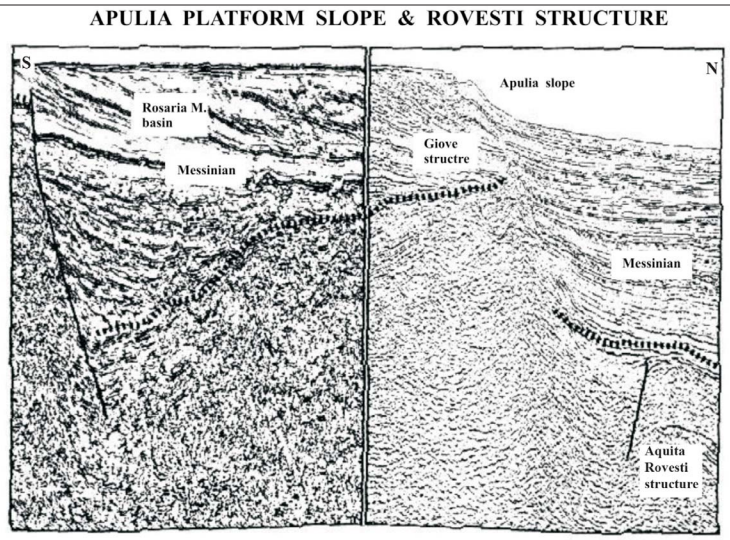

Fig. 31. Slope on the eastern edge of Apulian carbonate platform at transition into South Adriatic Basin where pop up structures were formed and Rovesti and Apuila reservoirs were discovered.
Sl. 31. Prikazana je padina na istočnom rubu Apulijske karbonatne platforme na prijelazu u Južno Jadranski bazen gdje su nastale uzdignute strukture i gdje su otkrivena ležišta Rovesti i Apulia.

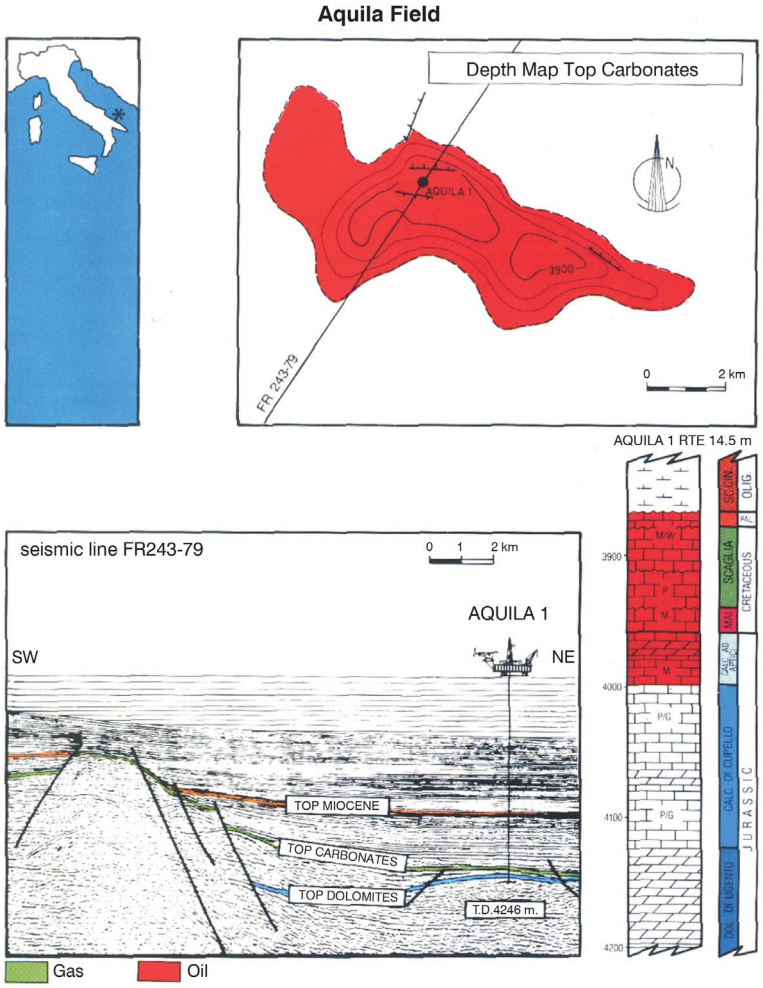

Fig. 32. Aquilla well on intrabasinal pop-up in Scaglia limestones.
Sl. 32. Bušotina Aquila na inter bazenskom ('pop-up') uzvišenju Scaglia vapnenaca.

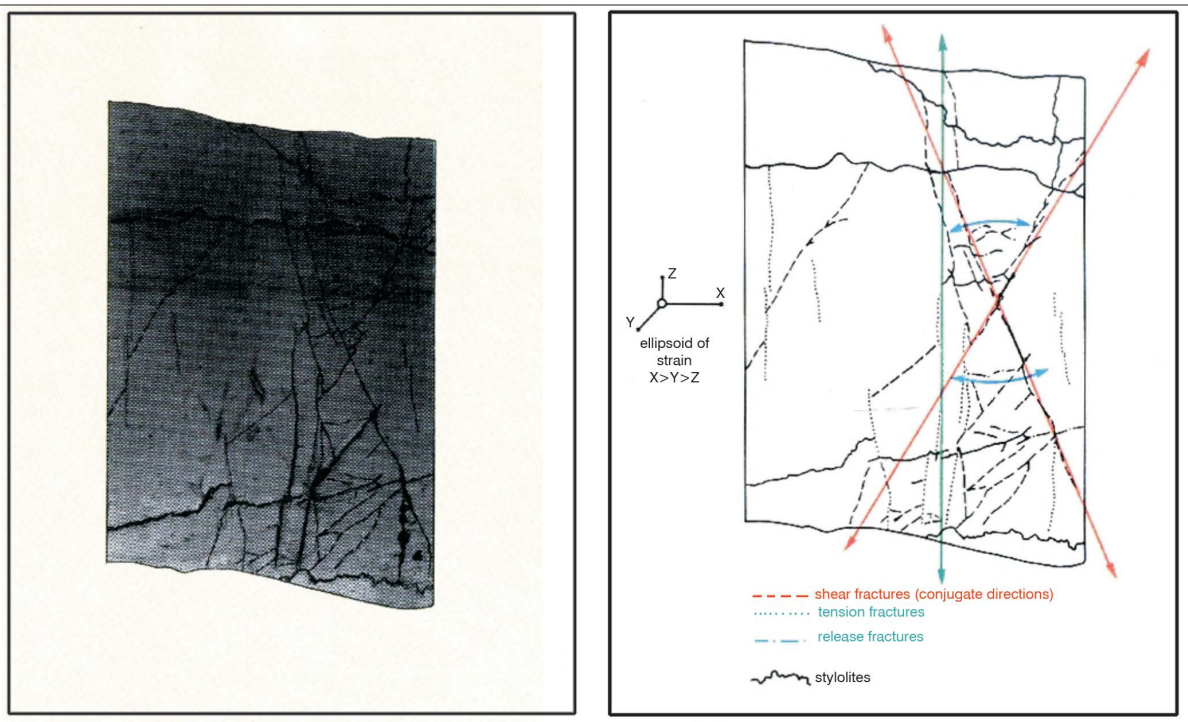

Fig. 33. Fractures system in Aquila-1 well core proves very good secondary porosity as well as in all other fields in the Adriatic Basin area with pelagic Mesozoic deposits.

Sl. 33. Sistem pukotina na jezgri bušotine Aquila -1 dokazuje vrlo dobar sekundarni porozitet kao i na svim poljima u području Jadranskog bazena s pelagičkim mezozojskim naslagama.

26. Well-1 geological model (after L. Aleotti) is known in this part of the Adriatic Basin where hydrocarbon presence was recognized in Aptian-Oligocene clastics of proximal talus originating from Gargano platform.

MAP OF POSSIBLE MIGRATION PATHS FROM GENERATIVE DEPOCENTERS IN THE DIRECTION OF STRUCTURAL TRAPS

The total length of depocenters spreading as possible hydrocarbon generation centers is around 60 km (Fig. 7). The stated centers spread parallel to proximal clastics zone from which they are 10 km far which represents relatively short distance for hydrocarbons migration.

The distance between Dinarides carbonate platform edge and Kurveleshi-Palagruža trough (Fig.7) is around 30 km, which is relatively short distance and represents a possible migration corridor. Recommended optimal spot for exploration drilling is on L-68-83 seismic cross section spreading all the way to Melita-1 well. Oil shows were confirmed in the mentioned well which even more certifies the potential of proximal talus on this seismic line.

PETROLEUM-GEOLOGICAL MODELS IN SOUTH ADRIATIC

Big amount of proximal talus is accumulated on this slope. This can be seen on Y-80-10 cross section which covers the very edge of Dinarides platform 30 km NW of Dubrovnik and 160 km east of port of Bari on the Italian

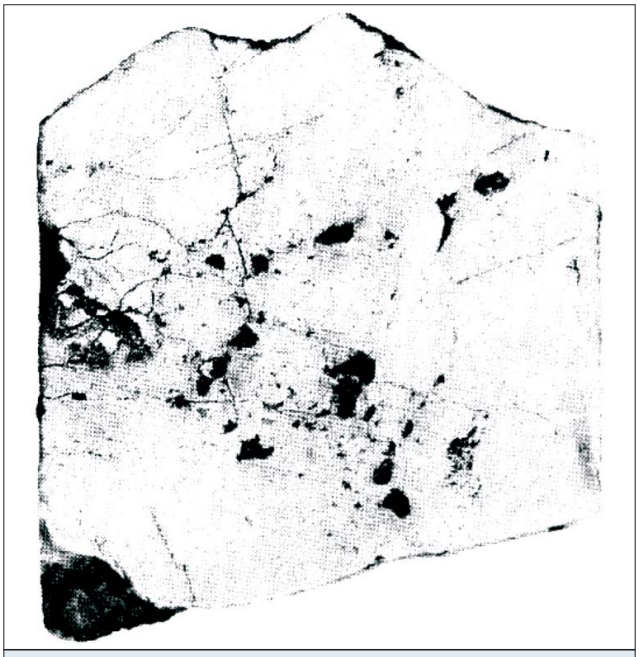

Fig. 34. Typical secondary porosity in Gorishti-1 well core near Dumre diapir in Albania which proves good porosity and permeability of pelagic deposits named in Albania as 'Porcelaneus Fm'.

Sl. 34. Tipičan sekundarni porozitet na jezgri bušotine Gorishti-1 kod dijapira Dumre u Albaniji koji pokazuje povoljnu poroznost i permeabilnost pelagičkih naslaga nazvanih u Albaniji 'Porcelaneus Fm'.

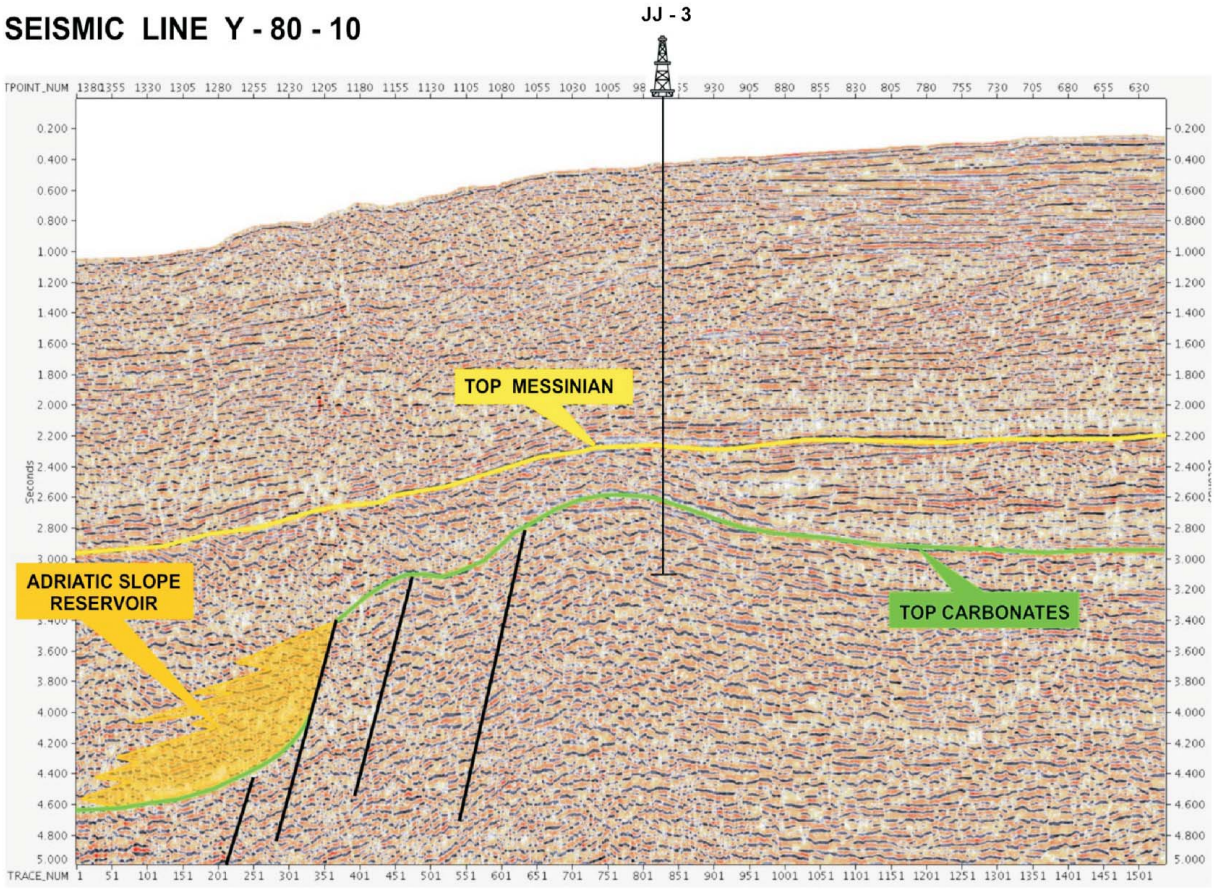

Fig. 35. Unconventional JJ-3 reservoir is characterized by heavy oxidized oil. It is only 10 km away from the slope and indicates the most probable connection with main accumulation in proximal talus zone. Seismic cross section Y-80-10 covers the most eastern part of Dinarides carbonate platform edge and slope.

Sl. 35. Nekonvencijalno ležište JJ-3 karakterizirano je teško pokretnom oksidiranom naftom. Udaljeno je od padine svega 10 km i ukazuje na najvjerojatniju povezanost s glavnom akumulacijom u zoni proksimal talusa. Seizmički profil Y-80-10 zahvaća krajnji rub jugoistočnog dijela i padine karbonatne platforme Dinarida.

coast, where Rovesti commercial field was discovered. The mentioned field and Bacco prospect are considered in this paper as an analogue model where hydrocarbon discovery is foreseen.

Especially important is Melita-1 well where heavy oil was found in chalky limestone in Upper Eocene vuggy porosity interval 2 550-2 565 m and 2 257 to 2 258.5 m interval. Those shows are the proof of hydrocarbon generation centers west of platform edge, most probably from Palagruža SE depocenters with carbonate top at 5.2 sec. of two way time.

GEOLOGICAL MODEL JJ-1α

A fault transversal to the spreading of Dinarides platform can be seen between JJ-3 and JJ-1α wells. Along this fault, Adriatic Basin is moved 30 km toward NE. Thus in the deeper part on D-27/83 seismic line at the depth of around 180 m, JJ-1α well was drilled up to 4 750 m. However, carbonates top in pelagic facies is expected at 6 100 m, which is analogue of ROVESTI commercial oil field, after Švec. Intense secondary porosity and permeability is expected in mentioned limestones of Scaglia and Maiolica type.

Considering the potential of JJ-1α prospect, gas at 3556-3627 in this well is most probably thermogenetic gas. Gas intrusion into potential hydrocarbon reservoir in Oligocene clastics might prevent its oxidation as in JJ-3 well and can maintain high degree of density. The case of Italian reservoir DAVID was taken in consideration where degree of density, unlike in the surrounding oil, was high due to gas intrusion from reservoir cap in older deposits, most probably of Upper Triassic origin.

A fault transversal to Dinarides spreading can be seen in the present cross section. Fault systems of the same trend probably creates JJ-1 prospect – structure where an analogy of Rovesti commercial reservoir is foreseen, south of port of Bari area.

RECOVERABLE RESERVES ESTIMATE IN PROXIMAL TALUS ZONE ON DINARIDES CARBONATE PLATFORM SLOPE

See Fig. 37.

See Fig. 38.

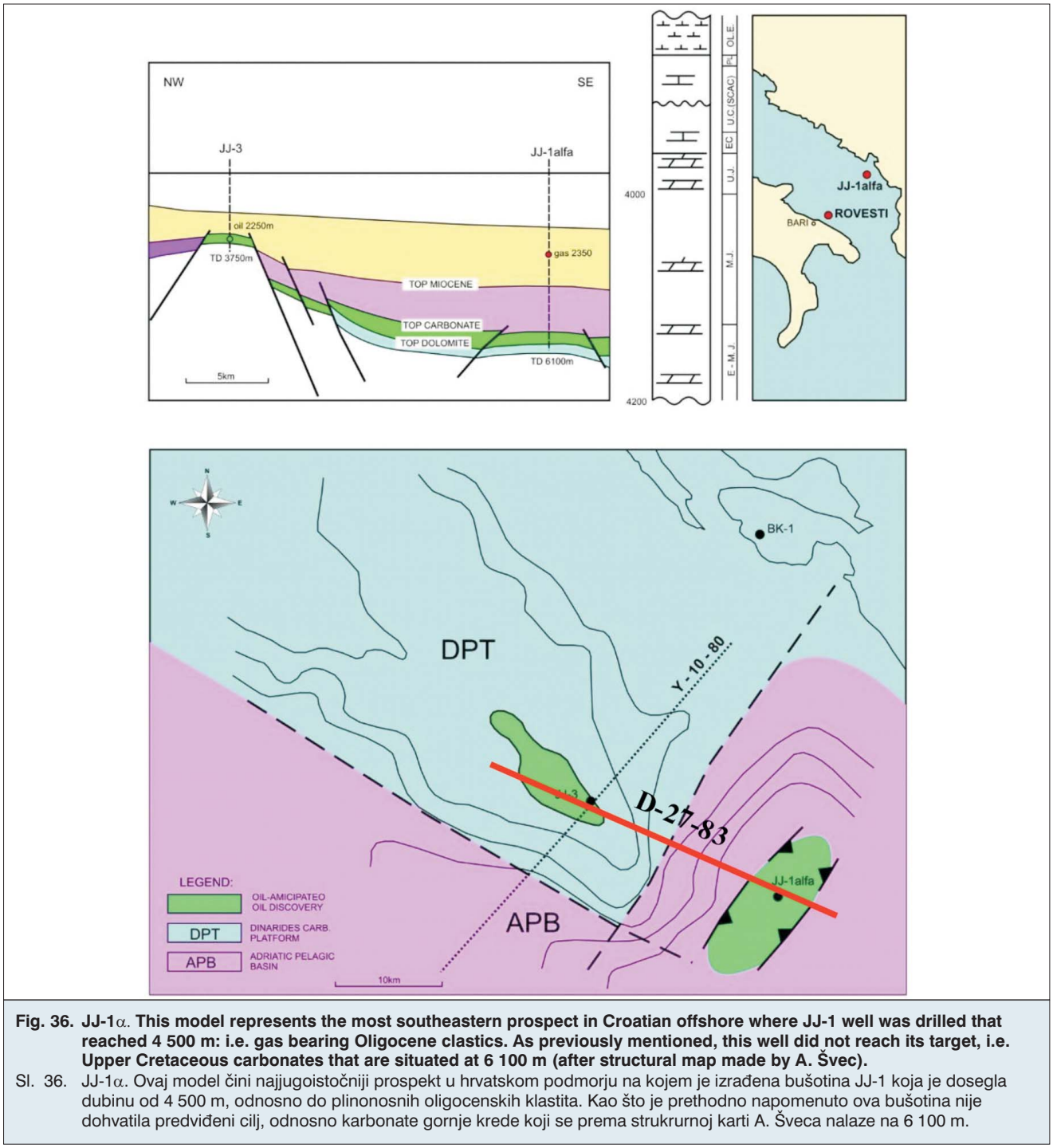

Fig. 36. JJ-1α. This model represents the most southeastern prospect in Croatian offshore where JJ-1 well was drilled that reached 4 500 m: i.e. gas bearing Oligocene clastics. As previously mentioned, this well did not reach its target, i.e. Upper Cretaceous carbonates that are situated at 6 100 m (after structural map made by A. Švec).

Sl. 36. JJ-1α. Ovaj model čini najjugoistočniji prospekt u hrvatskom podmorju na kojem je izrađena bušotina JJ-1 koja je dosegla dubinu od 4 500 m, odnosno do plinonosnih oligocenskih klastita. Kao što je prethodno napomenuto ova bušotina nije dohvatila predviđeni cilj, odnosno karbonate gornje krede koji se prema strukrurnoj karti A. Šveca nalaze na 6 100 m.

RECOVERABLE RESERVES ESTIMATE IN PROXIMAL TALUS ZONE ON DINARIDES CARBONATE PLATFORM SLOPE

Based on the interpretation of 11 seismic cross sections, the estimate of recoverable maximal reserves in m^3 based on reservoir size and vuggy porosity was made. Calculated, it amounts to 457.68 million m^3 (2.87 billion barrels). This is an estimate for the entire proximal talus zone from Savudrija to Oštri Rt at the entrance into Boka Kotorska Bay which should probably be reduced to the most promising part of 55 km – the distance between Palagruža depression and Dubrovnik offshore where Mirjana-1 well was drilled. M. Šušterčić has performed seismic interpretation and determined structural depressions on "E" horizon of 5.5 sec. which means in the belt of deep lowering of Carnian euxinic shales as source rocks where in Vlasta-1 well 2m^3 of oil were recovered by testing. The best fill of proximal talus by hydrocarbons can be expected in this part of the offshore.

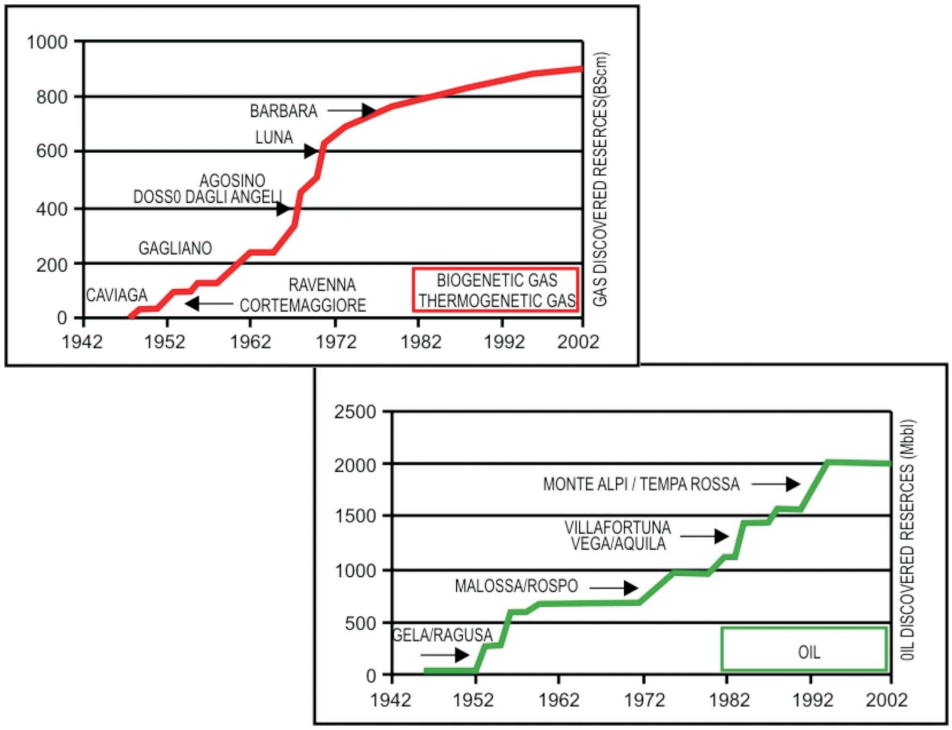

Fig. 37. Tables show cumulatively discovered reserves: a: gas in wedged terrigenous fore-reef deposits, b: oil and thermogenetic gas in Mesozoic basement, After F. Bartollo et al.(2004).

Sl. 37. Na dijagramima su prikazane kumulativno otkrivene rezerve: a. plina u isklinjenim terigenim predgorskim naslagama b. nafte i termogenog plina u mezozojskoj podini, prema F. Bartollo et al.(2004).

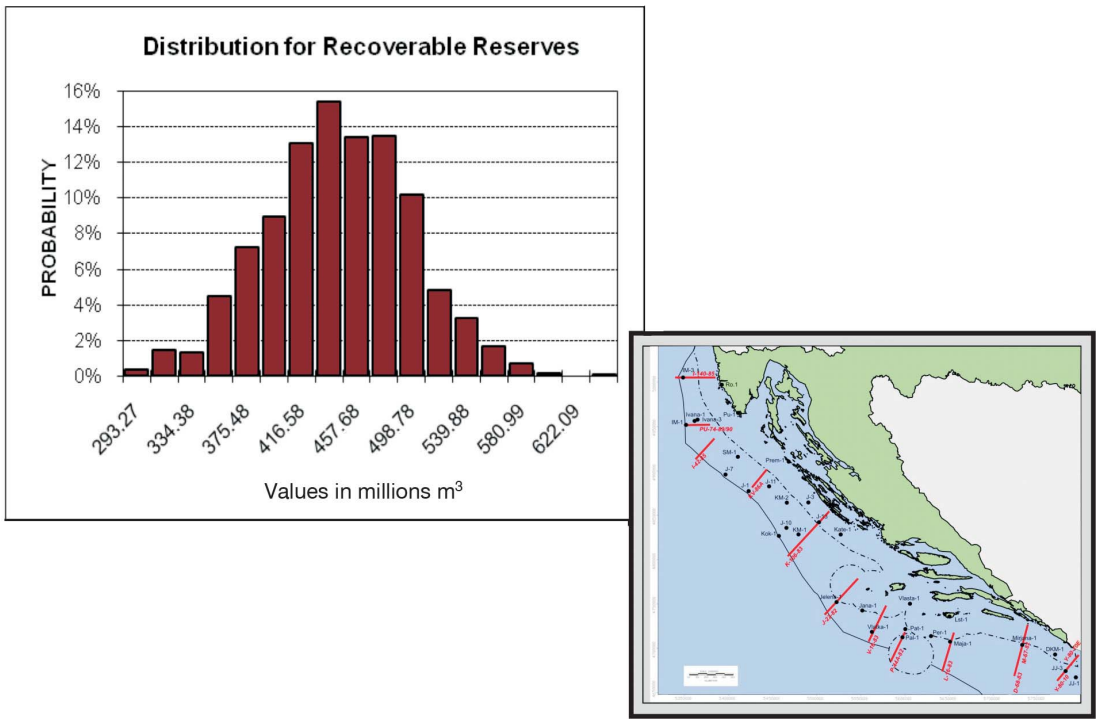

Fig. 38. Based on the interpretation of 11 seismic cross sections, the estimate of recoverable maximal reserves in the amount of 457.68 million m³ (2.87 billion bbl) based on reservoir size and vuggy porosity was made.

Sl. 38. Na temelju interpretacije 11 seizmičkih profila učinjena je procjena pridobivih maksimalnih rezervi u iznosu od 457,68 milijuna m³ (2,87 milijardi bbl) na temelju veličine ležišta i šupljikavosti.

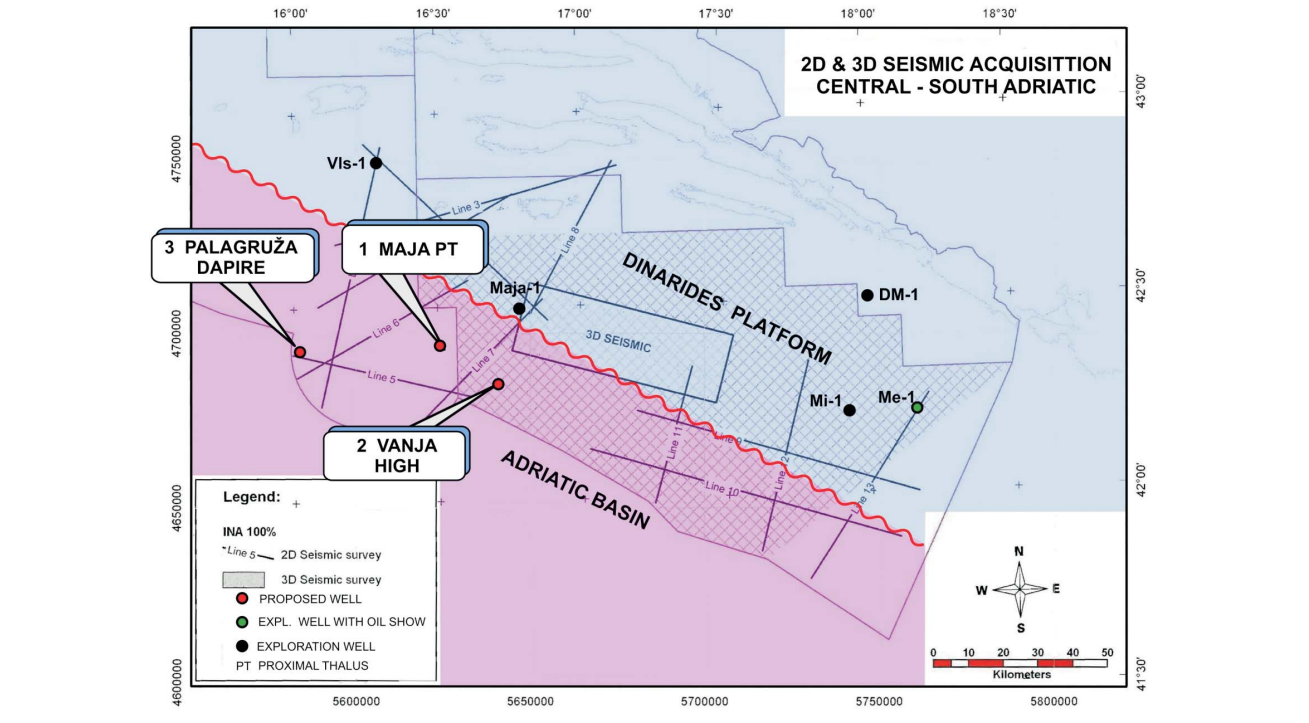

Fig. 39. This prospect map for exploration drilling shows the first prospect named Maja PxT-1 which is targeted to exploration of upward clinoforms. The second prospect is aimed to explore interbasinal high Vanja-1, while the third prospect shall explore halokinetically steepened Carnian deposits as source rocks recognized in Vlasta-1 well.

Sl. 39. Na ovoj karti prospekata za istražno bušnje prvi prospekt nazvan je Maja PxT -1 i usmjeren je na istraživanje uzlazne klinoforme, drugi prospekt ima za cilj istražiti interbazensko uzvišenje Vanja-1, dok treći prospekt ima za cilj zahvatiti halokinetski ustrmljene karničke naslage kao matične stijene dokazane na bušotini Vlasta-1.

SEPARATED PROSPECT PROPOSED FOR TEST DRILLING

As a conclusion test drilling is proposed on three prospects – leads of different petroleum – geological characteristics. Locations are the following:

1. Maja-1 PxT Prospect (Proximal talus). The favorable characteristic of this prospect is that it encompasses "upward clinoforms" as potential traps. This prospect is from 3D seismic cross section 1120 around 20 km from the center of "Palagruža-Kurveleshi trough". According to M. Šušterčić, within the trough there is "E" horizon, i.e. top of Upper Triassic at 5.5 sec of two way time or below 9km calculated by seismic velocity of 3 500 m/sec. Maturation diagram made by S. Kolbah shows Carnian-Ladinian deposits at this depth in mid maturation zone (Mid mature oil) of 0.7 to 1% Ro (Fig. 25). Results from Vlasta-1 well, where oil presence was determined, show that oil might have migrated to the neighboring proximal talus belt. As previously mentioned, proximal talus on this location is of huge width and thickness. Position of this prospect is 8 250 m SW of Maja-1 well.

2. Vanja High Prospect. This prospect is defined around 65 km S (183°) ESE of Lastovo island. The target of exploration is at 1 sec of two way time, i.e. at the depth of around 2 200 m with supposed velocity of 4 400 m/sec. At this depth, promising reservoir rocks are within Lower Cretaceous secondary porous Maiolica limestone (Fig. 21). This prospect is analogous to Rovesti commercial oil field in Brindisi offshore. Sea depth at structure peak is around 150 m.

3. "Palagruža Trap" Prospect Palagruža Diapir presented on P-44A-82 seismic line (Fig. 18) indicates great potential of petroleum geological trap in 'E' horizon, i.e. in Upper Triassic anoxic shales where 2m^3 of oil were recognized in Vlasta-1 well by testing. Those are steep deposits with the dip up to 70° at the sea depth of 150 m, which are in truncation with impermeable anhydrites. Such model is known on numerous oil exploration areas. In potential Upper Triassic oil bearing deposits of Vlasta-1 type, 2 m^3 of oil was acquired while steep deposits dip allows strong hydrostatic lift.

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