PRVE SPOZNAJE O PLIOCENSKO-KVARTARNOM TALOŽENJU U PALEODELTI RIJEKE NERETVE

FIRST INSIGHTS ABOUT PLIOCENE-QUATERNARY SEDIMENTATION IN THE NERETVA RIVER PALAEODELTA

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Ključne riječi: pliocen, kvartar, taloženje, delta, Neretva, seizmička interpretacija.
Key words: *Pliocene, Quaternary, deposition, delta, Neretva, seismic interpretation.*

Sažetak

Pješčenjačko-siltitne taložine pliocena i kvartara zastupljene su duž cijeloga jadranskog podmorja, međutim, njihovo rasprostiranje nije posvuda jednako. Za razliku od pelagičkih taložina gline, lapora i vapnenca, klastiti većih dimenzija vezani su gotovo isključivo za riječni donos materijala s kopna te su istaloženi u paleodeltama. Značajnije, odnosno veće delte nalaze se poglavito uz južnu, talijansku obalu Jadrana. To su delte rijeka Po i Adige koje pripadaju Padskoj depresiji, rijeke Piave u Venecijanskoj depresiji te dijelom delte manjih paleotokova depresije Marche-Abruzzi. Pliokvartarne taložine toga područja koje se odlikuju dobrom poroznošću i propusnošću sadrže velike količine plina dokazane otkrićem brojnih polja.

Na sjevernoj strani Jadranskog mora nalazi se nekoliko većih rijeka: Soča, Raša, Zrmanja, Krka, Cetina, Neretva i Bojana. Međutim, niti jedna od njih duljinom svojeg sadašnjeg ili paleotoka ne dosiže duljinu toka spomenutih rijeka na južnoj, talijanskoj obali, posebno u Padskoj depresiji. Isto tako se prostor njihovih delti zbog paleoreljefa, odnosno izrazite razvedenosti sjeverne obale nije mogao nesmetano širiti desetke kilometara u podmorje. Deltu značajnijeg rasprostiranja ima jedino rijeka Neretva, no zbog pružanja poluotoka Pelješca, te otoka Hvara, Sćedra i Brača mogućnost podmorskog taloženja riječnih nanosa ograničena je isključivo na uske kanale između spomenutih poluotoka i otoka. Zbog znatno manjih debljina i prostiranja pliokvartarnih taložina nego što je to slučaj u depresijama Po, Venecijanskoj i Marche-Abruzzi, može se pretpostaviti da u paleodelti rijeke Neretve nije došlo do pokretanja diferencijalne kompakcije kao glavnog mehanizma za stvaranje strukturnih zamki, niti do nakupljanja kritične količine organske tvari čime bi započeo proces generiranja biogenog metana.

Cilj proučavanja podmorskih pliocensko-kvartarnih taložina uz sjevernu obalu Jadranskog mora nije pronalazak ležišta plina, jer je vjerojatnost za to vrlo mala, već uvid u razvoj podmorskih pješčano-siltoznih taložina uz utjecaj paleoreljefa.

Za razliku od južne, sjevernu jadransku obalu karakterzira znatno veća morfološka razvedenost i pomicanje razine mora, naručito tijekom oledbi u razdoblju kvartara. Istraživanje je načinjeno na temelju interpretacije 10-ak 2D seizmičkih profila. Obuhvaćen je prostor između Pelješca, Šćedra, Hvara i Brača ukupne površine od približno 1500 km^2. Korišteni su stratigrafski reperi 1 bušotine, udaljene približno 90 km od sadašnje delte rijeke Neretve.

Abstract

Sediments of Pliocene and Quaternary sandstones and siltites are discovered in entire Adriatic Sea, but their distribution is irregular. Pelagic deposits of clays, marls and limestones fill entire basin, but sandy and silty clastites are almost always derived from land and transported by rivers in palaeodeltas. The largest deltas are located along south, Italian Adriatic coast. These are deltas of Po and Adige Rivers in Po Depression, Piave in Venetto Depression and deltas of smaller palaeorivers in Marche-Abruzzi Depression. Pliocene and Quaternary sediments in those areas, with favourable porosity and permeability, are saturated with large volumes of gas, what is proven by numerous field discoveries.

On the north coast of the Adriatic Sea several larger rivers is located: Soča, Raša, Zrmanja, Krka, Cetina, Neretva and Bojana. However, they did not reach such river flow lengths as mentioned (palaeo) rivers on the Italian coast, especially in Po Depression. Moreover, palaeodeltas on the northern coast could not spread several tens kilometres in subaqueous environment due to irregular coast line and many islands. Only Neretva River delta is of significant size, but also due to strikes of Pelješac Peninsula and Hvar, Šćedro and Brač Islands, possibility of marine deposition have been restricted only on narrow, submarine channels between mentioned islands and peninsula. It is why there are much less thicknesses and spreading of Pliocene and Quaternary then it is observed in Po, Venetto and Marche-Abruzzi. That is reason for assumption than in Neretva palaeodelta differential compaction had not happened, as the main mechanism for forming of structural traps. Also, organic matter was not deposited in critical volumes necessary for biogenic methane generation.

The goal of study of Pliocene and Quaternary sediments along northern coast of Adriatic Sea had been insight in development of sandy and silty depositional bodies influenced by palaeorelief. But, possibility for discoveries of gas reservoirs is almost zero. Some reasons such appraisal of the north coast sediments are significantly larger irregularity of coast line then on the Italian side, and large influence of sea level changes especially in Quaternary glacial periods.

Exploration had been done based on approx. ten 2D seismic sections, which covered areas among Pelješac, Šćedro, Hvar and Brač, with approximately 1500 km^2. There are also used stratigraphic markers from 1 well, distanced approx. 90 km from present Neretva River delta.

1. Introduction

Sandy, silty and clayey clastic of Pliocene and Quaternary are proven along entire Adriatic Sea basin, however their thickness and composition is not homogeneous. They prevail in several Pliocene and Quaternary depressions, i.e. in Venetto, Po, Middle Adriatic, March-Abruzzi, Bradano and Adriatic-Ionian Depressions (e.g. Velić and Malvić, 2011; Prelogović and Kranjec, 1983). Their origin is connected with delta and prodelta of surrounding inland rivers and pelagic basin sedimentation. The most terrigenous clastics had been transported in the largest palaeodeltas located on the north-western Adriatic coast, i.e. in palaeodelta of the Po, Adige and Piave rivers, i.e. in the Po and Venetto Depressions. The several smaller deltas are developed on the Italian coast, spreading in the Marche-Abruzzi and Bradano Depressions.

Generally, all Pliocene and Quaternary sediments (consolidated and unconsolidated) of such origin are characterised by high porosity and permeability values, and somewhere encompass commercial gas reserves. Such deltas at least existed in the last several million years, both at the western and eastern coasts of the palaeo Adriatic Sea, highly influenced with palaeotopology. However, at the eastern (mostly Croatian) coast are not established any Pliocene-Quaternary depression, like on the western coast, which would be filled with river transported clastics, although there existed several smaller rivers. Here are analysed depth and thickness of sediments visible on seismic sections from one of the largest such rivers – the Neretva River.

2. Palaeogeographical at the eastern (Croatian) Adriatic coast

The main feature of the eastern Adriatic coast is extremely geomorphological diversification, especially in comparison with western coast. It is mostly results of subduction and disintegration (Vlahović et al., 2005) of Adriatic Carbonate Platform (AdCP) in Palaeogene what continued in folding and faulting of Dinarides (as part of AdCP). Many regional fault zones and mountain ranges, especially of dominant Dinaric fault strike (NW-SE), had been formed. Ad result, the main drainage divide between Mediterranean and Black Sea basins is just near the eastern coast of the Adriatic Sea (Figure 1. It is why there had not been developed long and ramified river flows like the Po River that could accumulate and transport large quantities of terrigenous clastics and deposit it with delta and prodelta mechanisms.

The larger river flows at the eastern coast of the Adriatic Sea are (from the north to the south) Soča, Raša, Zrmanja, Krka, Cetina, Neretva and Bojana Rivers.

Figure 1. Drainage divides in Europe
(from http://hr.wikipedia.org/wiki/Datoteka:Europ%C3%A4ische_Wasserscheiden.png)

The most remarkable river is the Neretva River with the length 225 km and delta area approx. 170 km^2, which also can be considered as estuary, due to large influence of tide. However, areal extension of delta is determined with inland relief, i.e. location of the Pelješac Peninsula and Hvar, Šćedro and Brač Islands (Figure 2).

It means that river material could be deposited only in narrow channels among coast, the Pelješac Peninsula and islands. These inland geomorphological units existed in similar positions during Pliocene and Quaternary, and even in Quaternary glacial periods had been part of land.

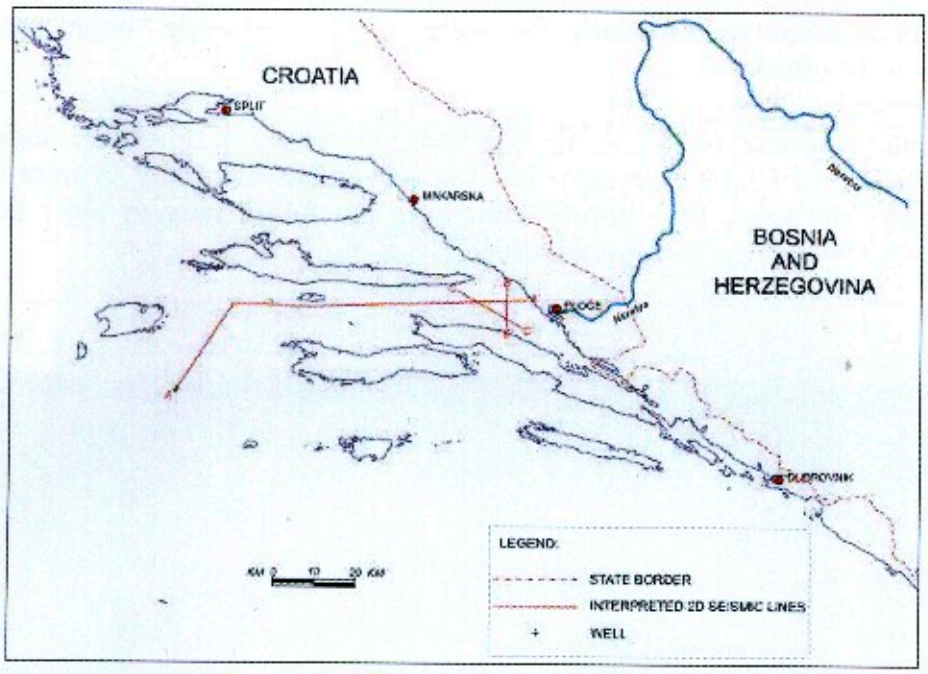

Figure 2. The location of delta of the Neretva River and analysed 2D seismic lines

3. Seismic sections of the Neretva Delta

Pliocene and Quaternary sediments along the eastern coast of the Adriatic Sea have a different portion of hemipelagic deposits compared with such sediments along the western coast, due to smaller transport energy. It depends on palaeostructural evolution, which can be very well estimated from contemporary structural relations, due to analysis of relatively young structures and sediments. So, here is first try of structural analysis of (probably) Pl-Q sequence (but for sure Cenozoic sequence), based on 3 seismic sections selected from the set of 10 available in the wider area of the Neretva Delta (*from the archive of INA-Industry of Oil Plc.*).

Seismic interpretation in the analyzed area (about 1500 km^2) had been uncertain due to lack of well information, and consequently spatially available marker horizons. It means that only the most certain seismic reflection was easily followed regionally. It was border between Mesozoic and Cenozoic. The single available well, with marker horizons, was approx. 90 km on the west from the Neretva Delta (Figure 2).

Moreover, the primary goal of seismic acquisitions in the eastern coast of the Adriatic Sea, until to discoveries of the Northern Adriatic gas field, had been Mesozoic and older rocks, where had been expected hydrocarbon traps. It means that vertical resolution had not been focused on Cenozoic sediments, which are locally very thin, and any correlation of regional markers in this area includes

a lot of assumptions, especially for interpretation of possible "bright spot" or "pull-down" effect.

The longest seismic section A-A' (Figure 3), interpreted in time scale, indicated that thickness of entire Cenozoic sequence in small, especially in intra-island channels. Moreover, the Cenozoic structures are folded only in older part as results forms heritage from palaeorelief.

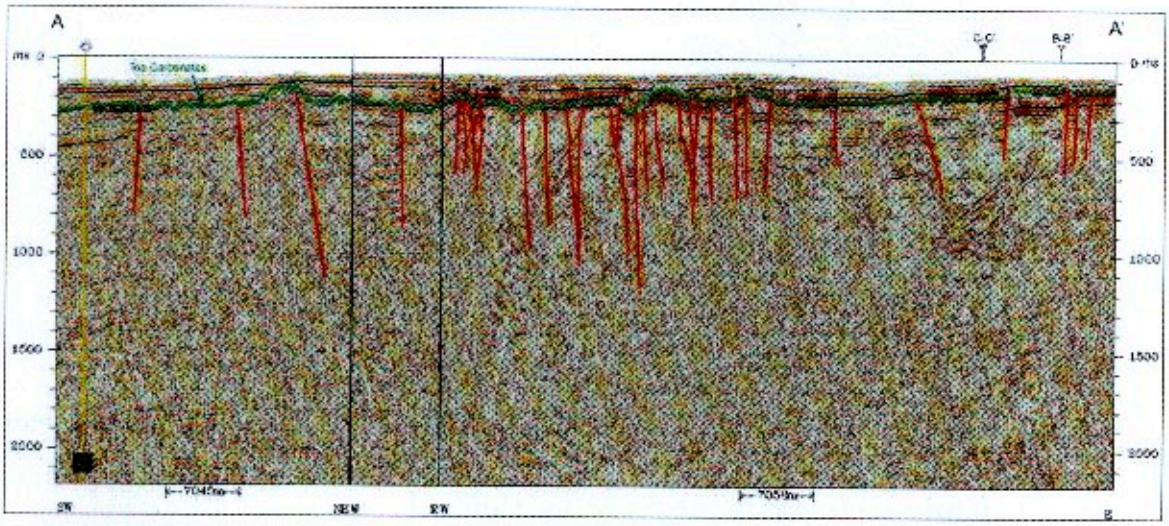

Figure 3. Interpreted seismic section A-A' (time domain)'

Section (A-A') follows transversal direction of sediments, probably in the first 15-20 km mostly deposited in the Neretva River palaeodelta. There are also numerous reverse faults in Mesozoic rocks that shaped basement. Furthermore, palaeo delta and prodelta cannot be distinguished from available dataset, but if Cenozoic sediments are assumed to belong the Neretva deposits, they were probably part of prodelta that extended parallel with top of the Pelješac Peninsula and the Hvar Island. There is easily recognized increasing of thickness (Figure 3) toward the west, i.e. the small Šćedro Island.

The next seismic section B-B' (Figure 4) is located approximately perpendicular (Figure 2) at the contemporary delta of the Neretva River. It is easy to recognize the thickest part (syncline) almost in the middle of the Pelješac Channel.

The last one section C-C' (Figure 5) is located inside (transversal) in the Pelješac Channel (Figure 2) and excellent reveal the thickness increasing toward the Hvar Island. If the eastern part of Cenozoic sediments on the Figure 3 is considered as prodelta, then these on the Figure 5 belonged to delta environment. Here, at Figure 5, is clearly visible the direction of detritus transport, which had been followed in entire Cenozoic sequence. The maximal vertical depth of those clastics is about 150 ms, what is approximately 130 m.

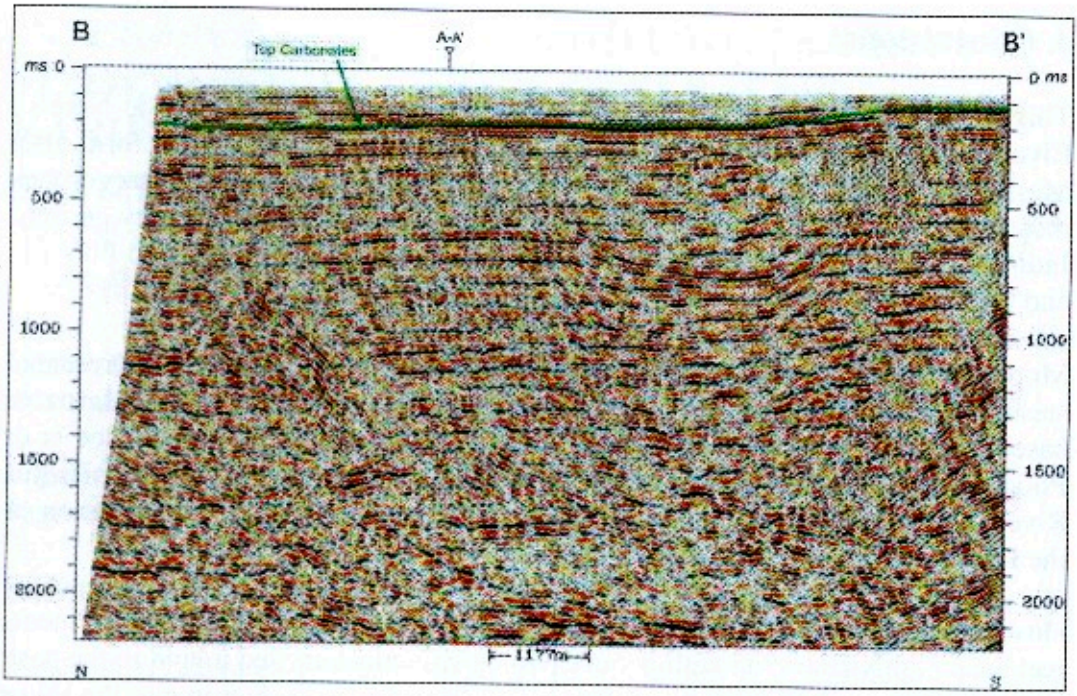

Figure 4. Interpreted seismic section B-B' (time domain)'

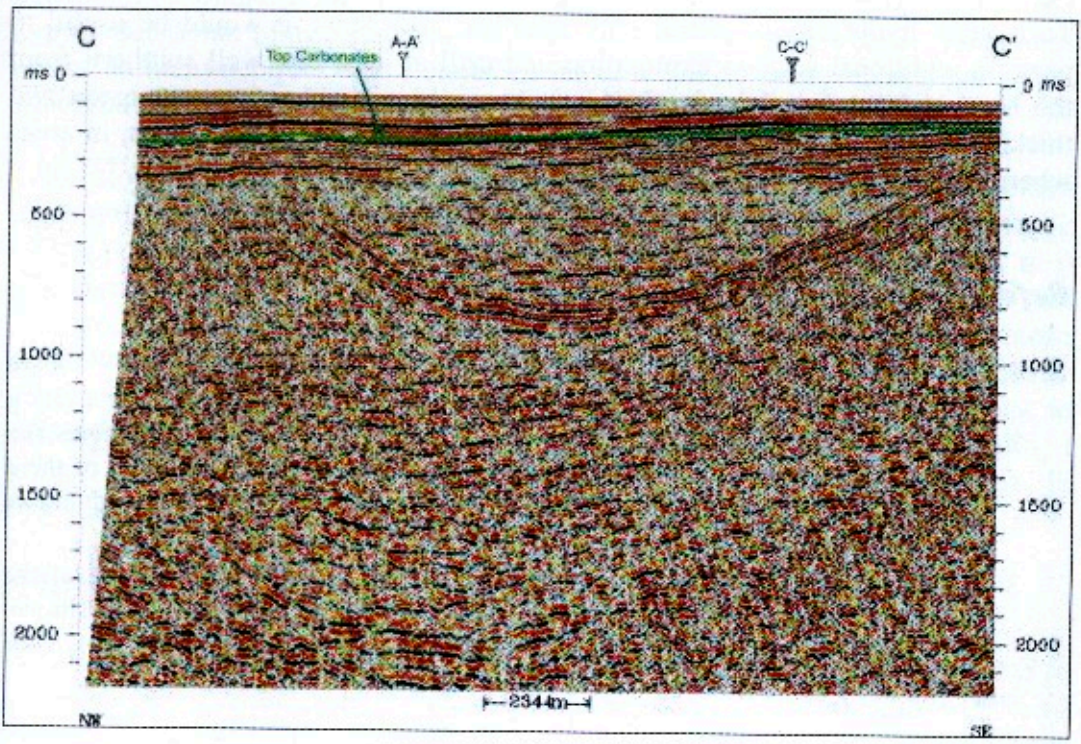

Figure 5. Interpreted seismic section C-C' (time domain)'

4. Conclusions

This is the first seismic analysis of Cenozoic clastic in the area of the Neretva River delta. The contemporary borders of the Adriatic Sea started to form after Messinian salinity crisis. It is why authors assumed that contemporary rivers mostly also existed in the last 5-6 Ma, i.e. in the Pliocene and Quaternary periods. Indirectly, authors supposed that analysed Cenozoic sediments belong to Pliocene and Quaternary periods.

Moreover, the delta and prodelta progradation can be easily followed on presented seismic sections (Figures 3, 4, 5), especially at Figure 5 even to the Mesozoic basement, what is the second indirect prove that entire Cenozoic sequence is of Pliocene and Quaternary age, when is assumed activity of the palaeo Neretva River mouth. Also, the analogy with Pliocene and Quaternary sedimentation in the Po Depression is used.

However, the possible lateral extension of analysed delta and prodelta sediments had been highly restricted with geomorphological units exposed inland in the past. It means that the thickness of clastics is significantly lower than in e.g. the Po or Venetto Depressions. Consequently, the formed anticlines have the very small potential structural closure, smaller than in the northern Adriatic in the sediments of the same age.

To explore hydrocarbon potential of described sediments, it would be useful to perform additional seismic exploration and drill at least one well southern from the Hvar and Korčula Islands. Such results could probably show extension and thickness of possible prodelta sediments deposited in the glacial periods, in areas where the Mesozoic basement had been deeper.

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