CONTRIBUTIONS TO KNOWING THE DANUBE DELTA: DELTA DEPOSITS STRUCTURE THROUGH HIGH RESOLUTION SEISMIC

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Abstract. The paper presents the results of the seismic studies carried out in the Danube Delta in the last 10 years. With a view of rendering evident some shallow horizons (10-200 m) in the deltaic deposits and establishing the delta formations structure the seismic refraction and reflection methods in the high frequency have been used. The studies evidenced: three-four refracting seismic horizons in the upper part of the section, with limit velocities between 500 and 2,500 m/s, some refracting horizons only sporadically and a characteristic reflecting horizon at the bottom of the Quaternary formations. Seismic sections on representative directions have been carried out and a map with isobaths at the level of the bottom of the Quaternary all over the Danube Delta have been drawn up; the new image of the bottom of the Quaternary deposits correlates much better with the data from the drillings carried out in the Delta region.

Key words: alluvial deposits, high-resolution seismic, geological structure, seismic velocities.

INTRODUCTION

Geological research has shown that the structure of the Danube Delta consists (Liteanu and Pricajean, 1963, Panin, 1989) of a sequence of detritic deposits, few hundred meters thick, built up mainly in the last part of the Quaternary.

The information regarding the thickness, composition, nature and structure of these sediments is due to systematic geological research activity, surface mapping and drilling, as well as to geophysical investigations carried out in 3-4 decenies long period of time.

For studying the sedimentary formations of the first 1-2 hundred meters of the section the only technique which could give some useful data is the high frequency seismometry.

The possibilities of this refraction and reflection seismic technique using frequencies larger than 100 Hz have been tested since 1981 with a portable, multichannel equipment having the possibility of summing up the weak seismic signals and having nonexplosive generating sources (Fig.1).

During the last decade the seismic works spread almost all over the Danube Delta area, the carried out profiles (shown in figure 1 by filled circles) being especially located on steady ground: bank levees, littoral beach-ridges belts, protecting dams etc.

The data obtained by seismometry refer to:

- establishing the succession of 3-4 refraction horizons in the upper 30-40 m of the geological section;

- evidencing and correlating, in certain areas, some reflection-seismic sequences, in between a depth of about 40 and 100 m;

- locating a seismic horizon at the bottom of the Quaternary formation on the basis of a very characteristic reflection.

RESULTS

Refraction limits

The seismic prospecting of the superficial deposits with the refraction method can be successfully applied to the areas where there are important seismic waves velocity contrasts between the different horizons and the geological conditions are relatively simple; in the areas where there are small velocity contrasts (Spânoche et al., 1996), some difficulties in interpreting the data may appear due to generating the seismic waves in weakly consolidated sediments and to the lack of sure correlations between the seismic parameters and the specific types of deposits; to these are added the increase of the errors importance in the seismic investigation at a small scale, as well as the existence of the water bearing formation where a quick increase of the longitudinal waves velocity within the water saturated formations occurs. All these limitations have been present in the Danube Delta area too. On the other hand, the separation of the different refracting layers within the respective Quaternary deposits was more difficult due to the relatively low waves velocity; consequently the velocity contrasts at the level of the refracting formations were very low.

These difficulties have been eliminated partially by generating and recording the high frequency components of the seismic oscillations, by a high precision measuring of travel time (0.1 ms) and by summing the weak signals.

The performances obtained are quite good; thin

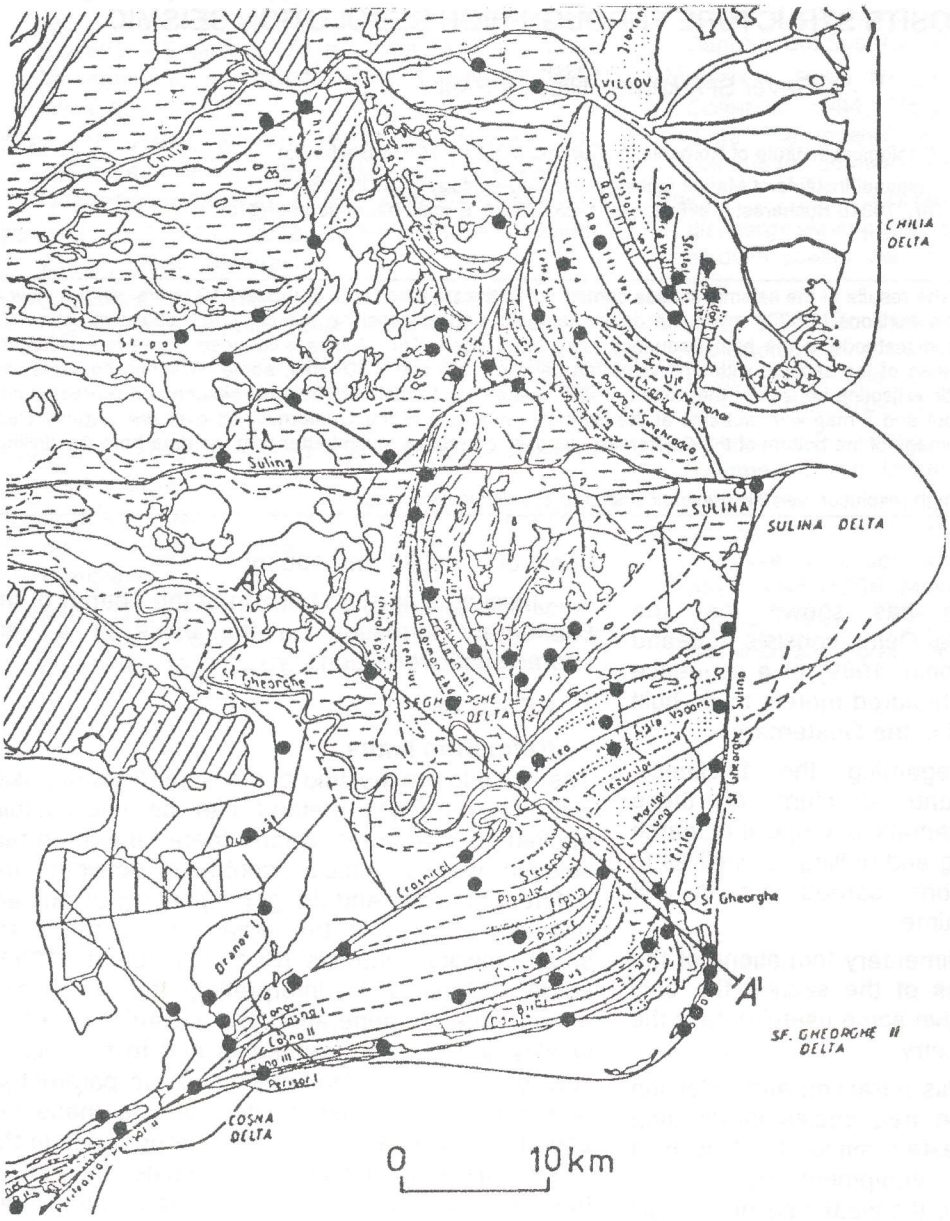

Fig.1 Distribution of the seismic arrays in Danube Delta. A A' – seismic section of Fig.2

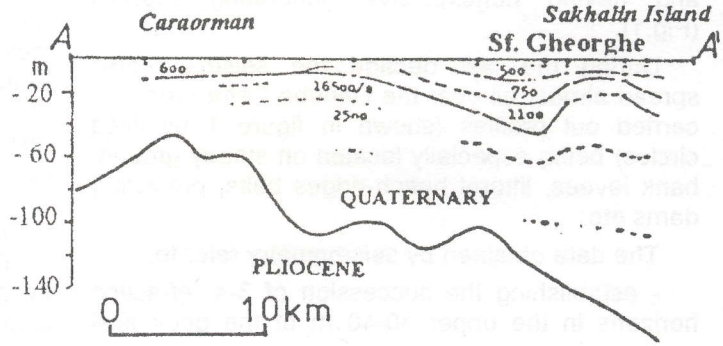

Fig.2 Seismic line between Grindul Caraorman and Sakhalin Island

seismic refracting layers of 10 m to 30 m in thickness; they are characterized by limit velocity having values, mainly of 500, 700, 1.100, 1.650 and 2.000 m/s, and sometimes more than 2,600 m/s. The first three values might characterize horizons represented by sand and dry loam, those of 1,650 m/s correspond to the saturated horizons (sands, clayey sands), and the highest ones to some clayey layers or to wet gravels (2,000-2,700 m/s). In the present case we cannot establish precise correlations between the velocity parameter and the sediment type.

Intermediate reflecting limits

At least 2-3 reflection seismic sequences at an echo period of 0.030s-0.150s and at 60-100Hz, even higher locally, have appeared between the surface refracting layers and the reflecting seismic horizon at the bottom of the Quaternary formations; within the geological section they are in between the levels -40 m and -75 m. These reflections in the central area of the Danube Delta are situated in a narrow period of time, 30 ms, while in the littoral area this gets to 60-66 ms, suggesting a thickening of the deltaic sediments.

On the average, these reflecting horizons are located at the levels -40 m, -58 m and -72 m, and are found, at about the some depths in the marine domain too, where through a continuous seismic reflection profiling, several seismic sequences have been recognized (Wong et al., 1994).

The reflection at the bottom of the Quaternary

As it has already been mentioned before, at the bottom of the Quaternary, where clayey deposits are present, a reflection with well individualized characteristics (signal shape and frequency at about 30-50 Hz) were recorded. These characteristics make it easy to identify and correlate.

The double time of it varies from an area to another, being between 60-80 ms, in the central part of the Danube, 100 and 150 ms in the eastern part and reaching the value of 0.2 sec in the area of the Dranov and Tãrâta channels. Translated into depths and correlated with the results of some drillings in the close neighborhood of the measurement points, the recorded values correspond with some medium positions of the respective horizon at 80-100 m, in the lowest areas reaching the -220 m level.

Taking into account this reflection all over the Danube Delta it was possible to draw up a map with isobaths which shows the morphology of the Quaternary formations bottom and brings about further information on the Quaternary deposits thickness (Fig.2).

Figure 2 shows the seismic section oriented NV-SE, between the Caraorman Formation and Sakhalin Island. The location of this profile is marked in figure 1, between A and A^1. The profile crosses the southern area of the Initial Spit and the Caraorman Formation, takes over the southern part of the Ivancea beach ridge, the northern part of the Palade beach ridge and ends up in SE on the Sakhalin Island, bringing up information progressively from the oldest deltaic formations areas to the most recent ones.

The horizontal (distance) scale is 1:200,000, vertical (depths) scale is about the filled circles represent the locations of the record profiles taken into consideration:

- Belciug lake - Crasnicol beach ridge - western part of the Perisor Formation;
- Ivancea - L.Rosulet channel;
- Sf.Gheorghe-Sakhalin Island area.

The general analysis of the Prequaternary relief forms distribution shows that the most important littoral accumulative formations (Letea, Caraorman) in the Danube Delta are located in the heaving areas of this surface, true relicts (erosion ones) of the predeltaic formations.

The depressionary zones represent, probably, the morphological elements which influenced the orientation of the oldest Quaternary hydrographic network. The most significant of such possible paleo-valleys is located between the southern end of the Initial Spit and Murighiol-Dunavãt Promontory, being oriented towards the present day Dranov-Perisor area.

A last remark may be made regarding another depressionary zone, southward the frame shown in figure 3, namely between Periboina-Gura Portitei in the east and Baia locality in Dobrogea in the west. It might represent the surface effect of a depressionary graben-like structure, at a great depth, where older formations, especially Cretaceous ones from the Babadag basin, are present.

It results that the seismic researches carried out in the Danube Delta, bring some new information, which, corroborated with the previous geological information and with the ones obtained from drillings, complete and change the image regarding the structure of the delta.

So, as to the simple interpretations made on the old drilling data, the image of the delta obtained from interpreting the seismic data, is much more complex and detailed.

The new image of the Quaternary deposits bottom obtained by the corroboration of all the existent data, including seismic ones, correlates much better with the obtained from the newest drillings carried out in the Danube Delta area.

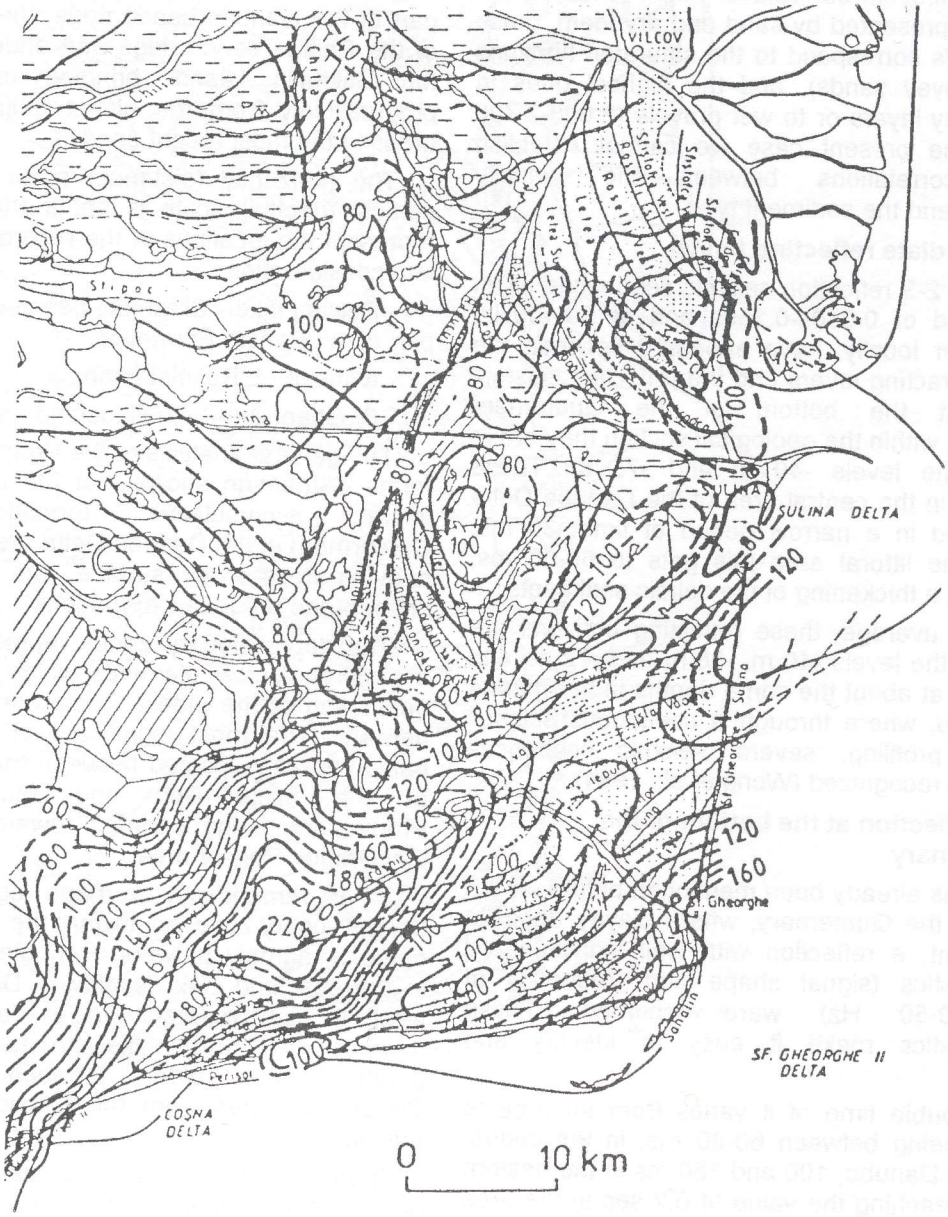

Fig.3 Isopach map of the Quaternary deposits

REFERENCES

LITEANU, E., PRICĂJAN A., 1963, Alcătuirea geologică a Deltei Dunării; Hidrobiologia", IV, 57-81, Bucuresti.

PANIN, N., 1989, Danube Delta, Genesis, evolution and sedimentology. Rev. Roum. Geol. Geophys., Geogr., Ser. Geographie, 33, 25-36, Bucuresti.

SPÂNOCHE, S., RĂDULESCU, FL., CRISTEA, P., 1966-30 Years of Seismic Research in Frame of the Geological Institute of Romania. Annuar IGR, 69, part.II (sub tipar)

WONG, H.K., PANIN, N., DINU, C., GEORGESCU, P., RAHN CORNELIA, 1994-Morphology and post-Chaudian (Late Pleistocene) evolution of the submarine Danube fan complex: Terra Nova, 6, 502-511.