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Depositional environment for sands from the Galata Formation near the city of Varna

Седиментационна обстановка на формиране на пясъци от Галатската свита край град Варна

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Introduction

Marine environment can be characterized by analyzing various types of sediments but clastic deposits provide significant information about water dynamics and energy. Thus, the grain size analysis is a basic tool in the marine environmental interpretation. Particle distribution depends on hydrodynamics, meteorology, and climate and bottom morphology. Different environmental contexts are characterized by a different distribution of statistical parameters (Romano et al., 2017). The grain size distribution will depend on the source rock. This study aimes to present an attempt at reconstruction of the depositional environment in a part of Varna Balchik Bay of the Euxinian Basin (Kojumdgieva, Popov, 1981) during the middle Miocene time (Karaganian and Konkian).

Geological setting

Neogene deposits in NE Bulgaria represent a thick sequence of shallow marine and beach deposits in Varna-Balchik Bay of the Euxinian Basin. The following formal lithostratigraphic units are distinguished in the area (Popov, Kojumdgieva, 1987): Galata, Euxinograd, Franga, Ogartsi, Topola, and Karvuna Formations. The oldest one is the Galata Formation. It is composed mostly of medium and coarse-grained sand and sandstone, rarely conglomerate, limestone, marl and clay. The formation thickness is 80–260 m. The Galata Formation contains abundant fossil fauna, including mollusks, foraminifers, ostracodes. Chronostratigraphic range is Tarkhanian, Chokrakian, Karaganian, Konkian stages and lower substage of the Sarmatian s.l. – Volhynian. The formation is distributed within an area of the Kamchia River valley, Varna town and its surroundings.

An outcrop at locality Sveti Nikola, SW from the wharf Euxinograd, where sediments of both the Galata and Euxinograd Formations are exposed, is studied. Deposits of the Galata Formation here are represented by alternation of fine clayey sand, fine sand, and coarse gravelly sand.

At the base of the section fine-grained sands crop out with a thickness of more than 10 cm, followed by sands with fine gravel, fine-grained sands with mollusks, fine-grained clayey sands with carbonate nodules and gray-green clays with mollusks with a total thickness of 70 cm. These sediments are covered by fine- and medium-grained sands, gray-yellowish, followed by coarse- to very coarse-grained sands light beige in color. This sequence is followed by an alternation of fine- and medium-grained sands, gray and yellowish in color. They are horizontally layered, with a 3–4 cm thick black clay layer. The section ends with ocher-colored medium-grained sands.

Methods

Grain size analyses using Udden-Wenthwoth scale (Wenthwoth, 1922) were applied to nine samples from the outcrop. The grain-size analysis is conducted by automatic sieving system FRITSCH ANALYSETTE PRO 3 for fractions above 0.063 mm, and pipette analysis – for fractions less than 0.063 mm. Results are plotted on Folk classification triangle diagram (Folk, 1954). Cumulative curves are drawn to calculate grain-size statistical parameters by graphic methods (Folk, Ward, 1957): graphic mean size (Mz), standard deviation (σ1), graphic skewness (Sk) and graphic kurtozis (KG). The discriminate functions proposed by Sahu (1964) were applied to the grain size in attempt to characterize depositional setting. It is possible to distinguish between aeolian, marine, fluvial, and turbidity current mechanisms; and between littoral (beach) and shallow agitated water (down to 300 feet) environments within the spectrum of marine depositional processes (Sahu, 1964). Textural maturity of the sediments was determined in accordance with Folk (1968).

Results and discussion

Results of grain-size analysis and calculated statistical parameters are displayed on Table 1. According to their grain-size composition plotted on triangle diagram, the studied sediments are sand, slightly gravelly sand, gravelly sand, and one sample is silty clay. Sand deposits are with mean size ranging from Mz –0.31 φ to Mz 1.27 φ which puts them in the field of coarse and very coarse sand. They are moderately and poorly sorted with standard deviation σ1 between 0.80 φ (moderately sorted) and 1.61 φ (poorly sorted). The graphic skewness is symmetrical with Sk between 0.1 φ and –0.07 φ and only for the lowermost sample is coarse skewed Sk –0.12 φ. About half of the samples have platykurtic graphic of distribution and the other half are with mesokurtic and leptikurtic graphics.

The mean Mz as an indicator for the transport distance and the energy of the transporting agent (Folk, Ward, 1957) suggests that these sands are deposited under high energy conditions. The relatively high energy conditions of transport and deposition are proved also by presence of nearly sorted sediments. Poorly sorted sediments evidence for variation in energy of the transporting medium and in depositional environment. These two parameters define majority of sediments as poorly sorted coarse sand.

An attempt at determination of the mechanisms and environment of deposition (Sahu, 1964) was made. The following discriminate functions were used: Y1 is for discrimination between aeolian and littoral (intertidal zone) environment; Y2 is for discrimination between beach (back shore) and shallow agitated marine environment (subtidal zone); and Y3 separate the shallow marine from fluvial environments. The studied sediments are deposited on the beach with significant influence of fluvial processes. According to values of Y1 (aeolian or beach environment) these sands are deposited in beach environment, and the same environment is determined by Y 2 (beach or subtidal). Only the sample BM-4 (sandstone) was defined as deposited under subtidal conditions. According to values of Y3, studied sands are product of alternating fluvial (or deltaic) and shallow marine depositional environment. Sands deposited in shallow marine environment (BM-5, BM-7 and BM-4) are nearly sorted, with symmetrical distribution and mesokurtic graphic. The rest are poorly sorted and with symmetrical distribution, too.

Scatter plot of Y1 and Y2 (Fig. 1A) shows that most of the sands fall in Beach/shallow agitated environment except for BM-4 that is deposited in shallow marine – tidal conditions. The scatter plot of Y2 and

Table 1. Grain-size composition, texture maturity and statistical parameters

	Mud %	Sand %	Gravel %	Name	Texture maturity	Mz φ	σ1 φ	Sorting	Sk	Skewness	KG	Kurtosis
BM-1	8.45	90.71	0.84	gravely sand	immature	0.26	1.61	poorly sorted	–0.12	coarse skewed	0.78	Platykurtic
BM-2	1.33	95.36	3.31	slightly gravelly sand	submature	1.27	1.08	poorly sorted	–0.04	symmetrical	1.21	Leptokurtic
BM-3	93.25	6.75	0.00	silty clay	immature	5.8	2.2	very poorly sorted	–0.1	symmetrical	0.71	Platykurtic
BM-5	0.10	99.80	0.10	sand	mature	–0.13	0.80	nearly sorted	0.00	symmetrical	1.15	Leptokurtic
BM-6	0.68	95.47	3.85	slightly gravelly sand	submature	–0.12	1.09	poorly sorted	–0.07	symmetrical	0.87	Platykurtic
BM-7	0.46	89.64	9.90	slightly gravelly sand	mature	–0.26	0.90	nearly sorted	0.05	symmetrical	0.98	Mesokurtic
BM-8	1.13	88.79	10.09	slightly gravelly sand	submature	–0.31	1.34	poorly sorted	–0.03	symmetrical	0.90	Platykurtic
BM-9	2.30	97.67	0.20	sand	submature	0.32	1.00	poorly sorted	0.01	symmetrical	0.60	Very Platykurtic
BM-4	0.36	98.23	1.41	sand	mature	–0.13	0.80	nearly sorted	0.00	symmetrical	1.01	Mesokurtic

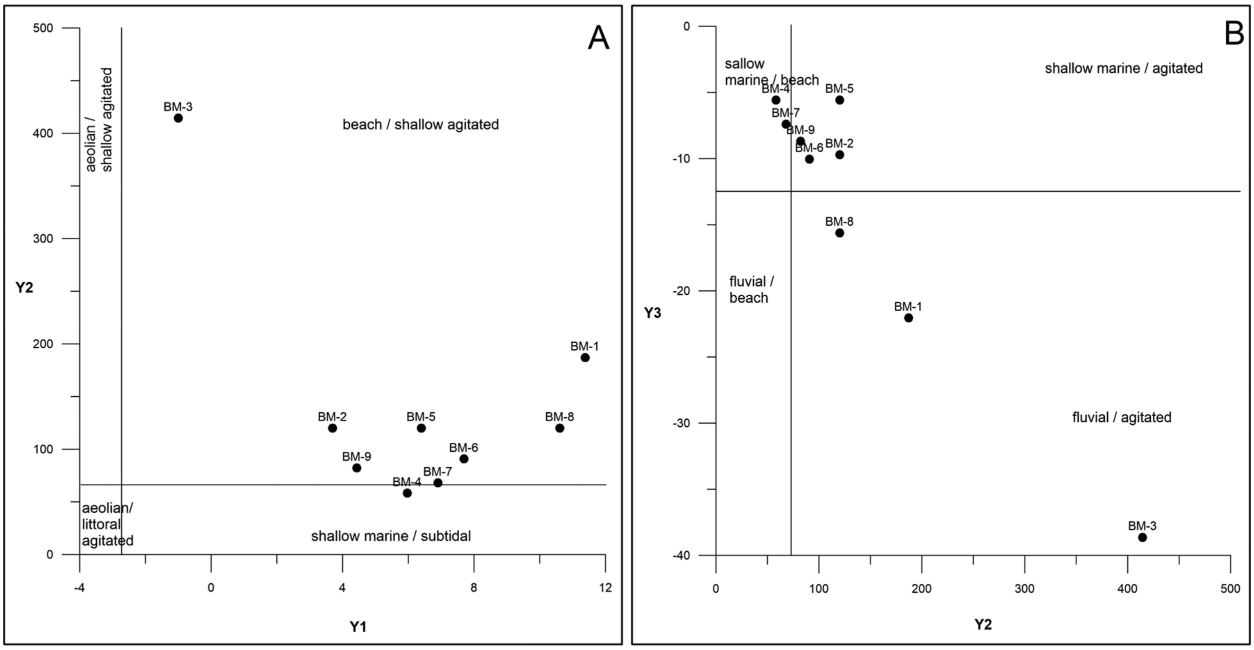

Fig. 1. Relationship between the discriminate functions showing estimated environments: *A*, scatter plot of Y1 and Y2; *B*, scatter plot of Y2 and Y3

Y3 (Fig. 1B) indicates that 4 samples are deposited in shallow marine agitated, 3 are in fluvial agitated, and other 3 are in beach agitated environment.

Textural maturity of the sediments was determined on the basis of clay content, sorting and roundness (Folk, 1968). The maturity reflects the mechanical energy of waves and currents that is applied to the sediment after the end of transportation. Samples BM-5, BM-7 and BM-4 are at mature stage of development, whereas the rest are at submature stage. The mature sediments were deposited in shallow marine environment and were reworked longer by waves. Textural maturity could be accepted as a reflection of the tectonic activity (Folk, 1968). Immature sediments are related to periods of higher activity whereas mature sediments are deposited during more inactive times.

Conclusion

The studied section of the Galata Formation near the city of Varna is composed of sand, slightly gravelly sand, gravelly sand, and one layer of silty clay. Sands are coarse grained, nearly sorted and poorly sorted with symmetrical distribution. They are transported and deposited in high energy environment on the beach with contribution of fluvial/deltaic processes. An alteration of fluvial and shallow marine environment is determined. This leads to the supposition about fluctuation of the sea level and littoral zone during the middle Miocene time.

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