古新世特提斯北缘前黑海地区盆地的演化与油气远景

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[内容提要] 此文为研究特提斯北缘前黑海地区盆地地质发展史的成果。结论是：携带有北方大陆碎屑物质的河流是其沉积作用中的主要因素。油气远景与古河流扇影响的地带有关，在那些地带出现碎屑储层的斜坡沉积。这已为古顿河—库班河和古多脑河—第聂伯尔河先三角洲的大量野外发现所证实。

关键词　前黑海地区盆地　特提斯北缘　油气远景　古新世

THE EVOLUTION OF THE PRE-BLACK-SEA-AREA BASIN OF THE TETHYS NORTHERN MARGIN IN PALEOGENE AND OIL AND GAS PERSPECTIVES

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Abstract

The results of studying the histoy of geological development of the Pre-Black-Sea-Area basin of the Tethys northern margin are given. It is concluded that the rivers drifting detrital material from the northern mainland were of main importance in sedimentation. Oil and gas perspectives is connected with the zones of influence of paleo-rivers fans where clinoform of psam-

mitic collectors take place. It is confirmed by the discovery of a number of fields belonging to the paleo-Don-Kuban and paleo-Danube-Dnieper avantdeltas.

Key words: Pre-Black-Sea-Area basin, Tethys northern margin, oil and gas perspectives, Paleogene

It is known from the history of the Tethys Ocean[1,2] that during the time of its existence its northern margin was active and its southern one was passive. That caused the gigantic hydrocarbon potential of the southern margin and the less potential of the northern margin.

The ocean opened in Permian and its northern and southern margins began to converge in Cretaceous. In Turonian and Maastrichtian the events of collision took place here and there. The main phase of the ocean closing at the boundary of Oligocene and Miocene was accompanied by folding and piling up the sedimentary masses.

During the time of the Tethys existence the investigated region was situated at the rear of the extensive complicated transitional zone consisting of marginal seas, island arcs and microcontinents. Oil-and-gas-bearingness in the northern marginal basins is regionally connected with the Upper Mesozoic and Maikopian formations. From the ocean of Tethys our region was separated by the Pont-Transcaucasus microcontinent that was situated in the limits of Moesian platform, the Black Sea depression, Transcaucasus and Transcaspian middle massifs.

The geological history of South Ukraine and adjacent aquatories in Late Cretaceous reveals the gradual shortening of the sea basin in Maastrichtian and its regression in the south and south-east directions. The sea was shallow except for the south-east part of Kerch Peninsula where it was relatively deep and spread from the side of the Tethys.

Terrigenous material was brought into the Paleocene basin from relatively lifted parts of dry land of Ukrainian shield and Pre-Azov ledge and, to some extent, from Dobrogea and Mount Crimea as well. On the south of Ukraine the areas adjacent towards the north of the sea were lowlands where the Cretaceous sediments were widely spread. The sea was opened to the Tethys Ocean, was warm and of normal salinity . In M. E. Zubkovick opinion[3] climate was subtropical and very closely approached to tropical in Crimea as well as all over South Ukraine. It is most likely that the sea basin was connected with the seas existing on the west in Carpathians and on the north-east in Dnieper-Donets depression.

Likeness of Paleocene fauna of South Ukraine Dnieper-Donets depression, North Caucasus, Povolzhie and Western Europe testifies about this.

The transition from Cretaceous to Paleogene took place quietly in our region; practically everywhere marl-limestone formations are replaced by marl-clayey ones.

The thickness of Paleocene deposits reaches 285 m. Significant changes in relationship betweem sea and land didn't take place in Early Eocene in comparison with Paleocene. The sea basin was only a little widened thanks to transgression of the sea from the south. On account of this in littoral zone the Lower Eocene sediments lie transgressively mainly on the Cretaceous ones. Clay-marl and carbonate formations (marls, carbonate clays, here and there organic limestones) were accumulated. The sea was shallow, it deepened towards the east to Northern Caucasus where the thickness of the Lower Eocene deposits considerably increases. As well as in Paleocene the sea was warm; abundance of fauna of mollusks, nummulites and foraminifers witnesses about it as well as enlarging of carbonate deposits. Thin carbonate-clay material was brought from lowlands adjacent to the sea on the north. Terrigenous components was brought, as a rule. from mountainous parts of Crimea and Dobrogea. After A. M. Kryshtofovich's data[4] remnants of thin foliage evergreens occur in the sediments; that allows to think that the climate in Early Eocene was subtropical little humid.

Middle Eocene was characterized by subsidence of the southern part of East European platform that caused the continuation of the transgression from the south from the Crimean-Caucasus part of the Tethys. Sandy-clayey formations were deposited in its nearshore zone. The interbeds of marls, clays and sands are observed to the south. Here and there (to the south of Melitopol) the interbeds of limestones occur. On the Tarkhankut peninsula (western Crimea) Middle Eocene complex is represented by bedded or massive limestones. Farther to the south deep-water limestones and marls were deposited. The northern coast of the basin was lowland.

In Late Eocene the transgression of the sea continued in the north-west direction. It was the deepest sea of all Paleogene basins. Ukrainian shield was divided to a number of islands by wide straits, and sea waters of northern Ukraine and Bieloruss were joined with the Tethys waters via the southern sea. The connection with the West European basin existed too, the results of investigations of the fauna witness about that.

Upper Eocene deposits are characterized by essential widening of marls and only in the direction to the coastline they are mainly replaced by sandy-clayey formations or by glau-

conitic sands.

The depth of the sea reached 500 m. Abundance of pelagic foraminifers accompanies thin structures of marls. The finds of palm fruits testify about tropical climate.

The new stage began at the Eocene-Oligocene boundary. Here and there the sharp unconformity is observed between them. The composition of the sediments changes sharply: carbonate-clayey deposits disappear and are replaced by dark-coloured predominantly unlimy clays with sandy-silty beds of Maikopian series.

In Early-Middle Oligocene sea waters spread far to the north having cccupied almost whole territory of Ukrainian shield except its north-western and south-western parts (Fig. 1). The basin was shallow and only on Kerch and Taman peninsulas the deposits are deep-water and the thickness of them is more than 3500 m. In Lower Maikopian oppressed fauna of mollusks and small foraminifers occur. It isn't excluded that the sea was infected with hydrogen sulphide. In Middle Maikopian shortening of the sea basin took place. In Oligocene climate was colder than that in Late Eocene but soft like subtropical. The north-western part of Ukrainian shield and Pre-Azov massif were the high dry land. They were the main areas of drainage. To a small degree Mount Crimea was an area of drainage too. The low dry land also occupied considerable territory.

In the second part of Oligocene the sea began to regress. That was caused by new tectonic movements and processes of folding in the Alpian system. Numerous islands, shallows and bays and gulfs appeared in the shallow sea.

Denudational-accumulative dry land with the areas of predominant scouring or deposition of continental formations occurred in Volyn-Podillia, Ukrainian shield and south-west part of Dnieper-Donets depression. These areas formed great, dry island land that is separated from the mainland on the north by the narrow strait. The area of the dry island land gradually curtailed in time that was conditioned by transgression which was at its maximum in late Eocene[5].

At the adjacent northwards dry land of East European platform in Paleogene the river systems were developed that caused accumulation of the nearshore terrigenous successions in the sea basin. Analysis of the composition, thicknesses and character of the localization of the sediments in paleodeltas allow to distinguish the terrestrial, proximal and distal parts of them.

At the area of Kerch peninsula the Paleogene succession generally represents the part of the deltaic buildup, more precisely, the part of the distal clayey avantdelta, and much


Ural
Volga
KIEV
Desna
Prypjat
Dnister
Prut
Siret
S.Bug
ODESA
Azov Sea
ROSTOV
Don
Kuban
BLACK

Fig. 1 Paleogeographical model of the Pre-Black-Sea-Area basin of the mordern margin of the Tethys in Oligocene

1=isopach of Lower Oligocene formations (in m). Boundaries; 2=of paleoledges; 3=of lithofacies; 4=probable southern alluvial plain with overwater deltas of paleo-rivers during regression, a strait between the mainland and islands during transgression; 5=probable southern undaforms with the proximal parts of paleo-rivers deltas. Directions of terrigenous material drift; 6=plot of possible accumulation of clastic material from southern sources; 7=main; 8=secondary; 9=probable ways of paleo-drift of clastic material; 10=well, thickness of Lower Oligocene formations (in m) in brackets—not full thickness owing to the wash-out of the upper part. Structural-facies zones; 11=denudational paleo-mainland; 12=raised (tectonically active) dry land; 13=probable zone of watershed of paleo-rivers of Dnieper and Don. Undaform; 14=islands. Lithofacies complexes; 15=sandy-clayey rocks with the limestone interbeds; 16=alternation of clayey limestones, marls and limy clays (fondoform); 17=alternation of limy and non-limy clays, marls and clayey limestones; 18=alteration of limy and non-limy clays; 19=limy and sandy clays; 20=alteration of sandy clays, sands and sandstones; 21=sands and sandstones with the interbeds of sandy clays; 22=medium- and fine-grained sands and sandstones and aleurolites

more precisely, the biggest part of its southern and the least part of its northern fans (Fig. 2). The least part of its southern and the biggest part of its northern fans are situated at the adjacent aquatories of Pre-Kerch shelves of the Black and Azov seas respectively[6]. The sediments here represent thick succession of clay rocks among which the sandy-silty interbeds and sets are marked. They belong to the bottom part of Maikopian series, and we interprete them as the terrigenous beds that slid down along the clay mass into the distal fan of paleo-Don-Kuban delta which was unloaded in the deepest bathyal part of the sea.

After the geophysical data, at the north-western shelf of the Black Sea there are large fans of the extensive paleo-Danube and paleo-Dnieper avantdeltas.

We think that terrigenous-clayey deposits of Maikopian series of Northern Pre-Black-Sea-Area, Tarkhankut peninsula and adjacent aquatory of the Black Sea can be connected with the progradation of the paleo-Dnieper delta from the north that is covered with the paleo-South Bug delta on the west.

Thus, the northern margin of the Tethys in Paleogene was in different paleogeographical environments from continental to deep-water. Accumulation of sediments took place on the background of predominent transgression from the south-south-east. In Early and Middle Paleogene sedimentation was terrigenous in the strait between the main-

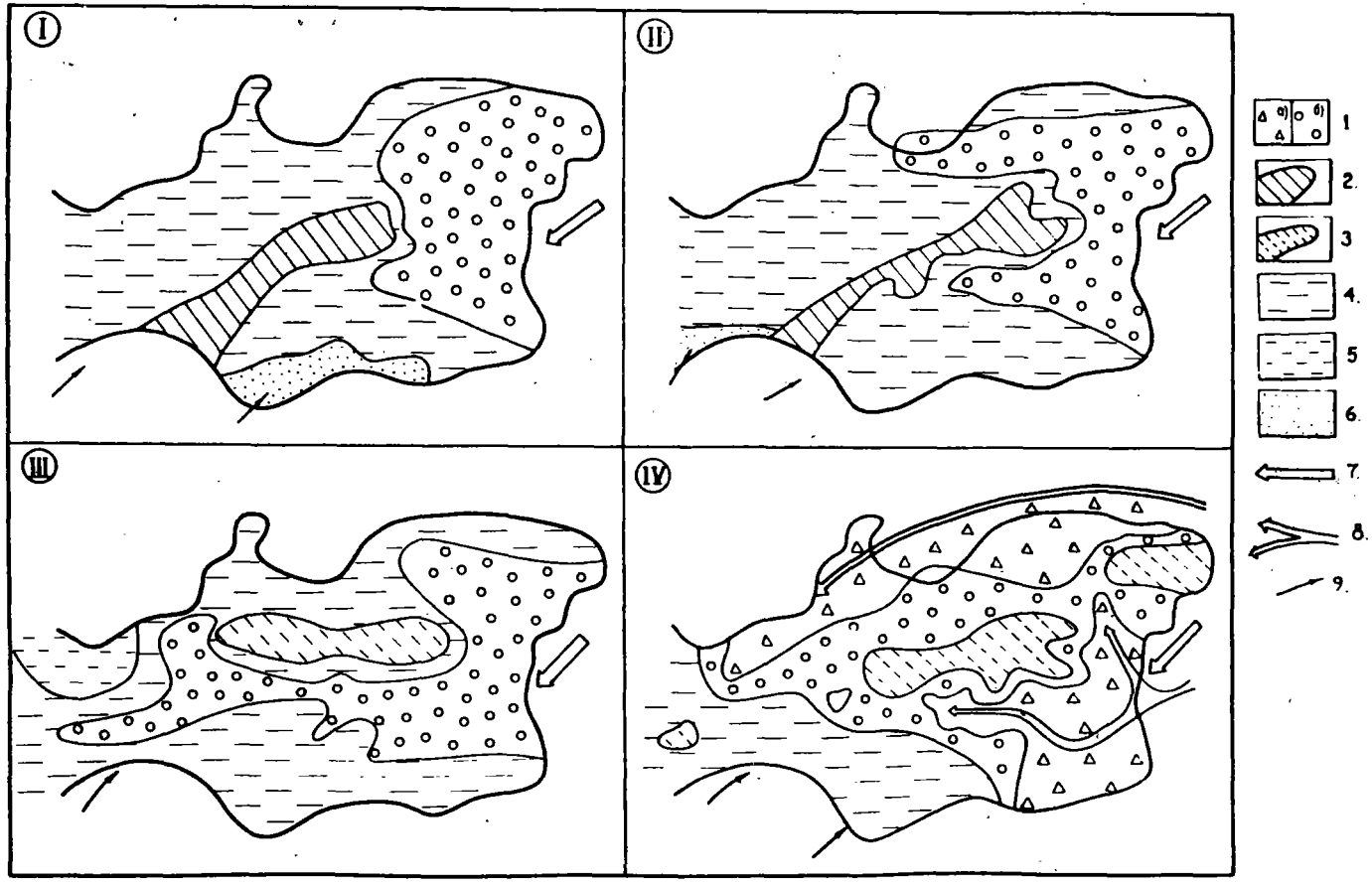

Fig. 2 The scheme of the development of the paleogeographic environments in Paleogene on Kerch peninsula

1=zones of a river activity influence; a=with bigger quantity of detrital material; b=with less amount of detrital material. Uplifts in paleorelief that are marked by: 2=absence of deposits; 3=decreasing the thicknesses of sediments. Fondoform: 4=less deep zone; 5=deeper zone; 6=lots of possible drift of detrital material from southern sources. Directions of detrital material: 7=general; 8=main; 9=secondary; Ⅰ=Early Paleocene: shallow water fondoform influenced by the action of a great river; Ⅱ=Late Paleocene: relatively deep-water fondoform with the distant part of the submarine fan of the paleo-Don-Kuban; Ⅲ=Eocene: deep-water fondoform with the distal fan; Ⅳ=Early Oligocene-clinoform (distal avantdelta). on the southwest deep-water fondoform

land and islands and farther to the south the carbonate deposits prevailed till the end of Eocene that was connected with the general carbonatization of the basin characteristic for that time.

In Oligocene terrigenous sediments were supposed to be connected with the activity of several rivers[7]. On the east (Kerch peninsula) the distal fan of the big river of paleo-Kuban was fixed all Paleogene long. In the central part of the paleo-Dnieper and paleo-South Bug existed and so did the deltas of paleo-Dnister and paleo-Danube on the west[8]. Very much distinctly these submarine fans are manifested in the youngest sedimentary complex-Pleistocene deposits. If their thickness in the Black Sea deep is estimated to be till 1 km in average then in the limits of the above mentioned deltas it increases twice or three times[9,10].

Oil and gas perspectives are connected at first with the zones paleodeltaic fans where conditional reservoir rocks are prognosticated. Seismic works must be oriented onto the delineation of them.

In the limits of the distinguished paleo-Don-Kuban avantdelta six small gas, gas-condensate and oil fields were discovered. They belong mainly to clinoforms formed on the slopes of the local paleo-uplifts. Summary thickness of sandy-silty sets changes in wide range from 0 to 150—200 m. Open porosity is 4.6—30.0%, permeability 0.0001—0.6426 μkm^2。

On the Fontanivka gas-condensate field the influx of gas with condensate was obtained in the well N5 (int. 3336—3360); production was 270×10^3 m^3 through 10 mm diaphragm with buffer pressure 20.0 and annulus one 20.0 MPa. Five tectonically sealed and lithologically limited deposits are distinguished here. Their initial explored recoverable resources are 1517×10^6 m^3 of gas and 493×10^3 tons of condensate.

In the Povorotne gas field the influx of gas was measuned 143.6×10^3 m^3 of production through 8.2 mm diaphragm with buffer pressure 10.0 and annulus one 9.0 MPa. Till now one tectonically screened and lithologically limited deposit with 1756×10^6 m^3 of gas resources. The field is under prospecting.

In the Prydorozhne gas field the influx of gas was obtained from the well NI (int. 4955—4969). Production through the 6 mm diaphragm was 26.8×10^3 m^3 per day with the buffer pressure 5.0 and annulus one 8.7 MPa. Till now one deposit was explored; it is of the same type that is in the preceding fields. The resources are 1008×10^6 m^3 of gas. Gas

of the field is methane (to 95—96%). Sum of heavy hydrocarbons is 3.6—3.7%, that of nitrogen 1.3—1.4%[11].

The chain of gas and gas-condensate fields is also ascribed to the fans of paleo-Danube-Dnieper avantdelta on the north-western shelf of the Black Sea and adjacent land of Tarkhankut peninsula.

Golitsyn gas-condensate field is situated in 70 km west from Grimea. Gas production in well changed from 70 to 305 m^3 per day. Gas-condensate factor is from 23 to 126 cm^3/m^3. Beds of aleurolites, silts and fine-grained serve as a reservoir. The initial explored resources are 11896×10^6 m^3 of gas and 330×10^3 tons of condensate. The field is in exploitation.

Schmidt gas field is situated in 50 km from the Crimean coast. In the well N25 from Maikopian terrigenous deposits (int. 449—700) gas production was 141.2×10^3 m^3 per day. Explored resources are 2729×10^6 m^3 of gas. On the field they provide prospecting the deposit of gas with condensate that belonged to the deeper Upper Cretaceous producing carbonate formations.

Crimean gas field is situated in 70 km from Crimean peninsula. During well testing the Middle Maikopian sandstones in the well NI (int. 868—882) with the 8 mm diaphragm gas production reached 62×10^3 m^3 per day. Explored resources are 650×10^6 m^3.

Gas is dry, and consists of methane (98—99%), ethane (0.1—0.5%) and traces (less than 0.1%) of propans. Of nonhydrocarbon components nitrogen (to 1%) and carbonic acid gas (to 0.3%) are marked.

So, thick sandy buildups of submarine fans of Paleogene paleo-rivers of the Pre-Black-Sea-Area basin of the northern margin of the Tethys are of interest from the point of view of hydrocarbon screened traps develppment. Their sediments are enriched with organic matter that surely generize gas. In the limits of submarine fan of the Danube numerous outlets of gas revealed at the depth from 250 to 1300 m.[12] Crystals of hydrohydrate were found in breccias of submarine mud volcanos. In the eastern part of Don-Kuban fan in the limits of the Black Sea shelf the seismic anomaly BSR was determined. Its area is more than 200 km^2 at the depth about 0.5 km under the bottom[10].

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