ISSN 1028-334X, Doklady Earth Sciences, 2009, Vol. 426, No. 4, pp. 556–558. © Pleiades Publishing, Ltd., 2009.
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GEOLOGY

New Data on the Geology of the Northeastern Sea of Azov

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Presented by Academician A.N. Dmitrievskii July 14, 2008

Received July 15, 2008

DOI: 10.1134/S1028334X09040102

By now, it has been established that the Sea of Azov hosts mostly small and insignificant gas fields. Similar gas fields have also been discovered along the Sea of Azov coast in Rostov and Krasnodar oblasts and the Crimean steppe and Kherson oblast of Ukraine, in the Taman and Kerch peninsulas. Most of these fields associate with Neogene and Maikop sequences, although Paleogene, Cretaceous, and Triassic formations, as well as the Precambrian basement, are locally productive as well. At the same time, medium, large, and unique fields, the Anastasievka–Troitsk field included, have been discovered in the structural–tectonic zones of Krasnodar oblast. They are traceable offshore in the Sea of Azov. Therefore, it is quite possible that similar fields may be discovered also beneath the sea bottom.

Based on the analysis of mobile zones belonging to different-age platforms (West European or Middle German, East European, Scythian–Turan) [1], it was inferred that these geological structures represent suture zones. Additional crustal blocks were accreted along these zones to the nucleus of the East European Platform gradually increasing the latter over the long geological history. Such a mechanism, likely characteristic also of the West Siberian and Siberian platforms, was eventually responsible for the formation of the spacious Eurasian continent.

The southern margin of the East European Platform that was formed after amalgamation of the Ukrainian Shield and Voronezh Massif along the European–Turan Lineament subsequently became such a suture zone, along which other crustal massifs were accreted to the Eurasian continent. This suture zone is the sole genetic feature in common for the Pripyat–Dnieper–Donets Trough, the system of Manych troughs, and the Karkinitskii–North Crimean–North Azov riftoid structure. The northwestern Black Sea region, Crimea, and Black and Azov seas host several riftoid structures, which appeared along Paleozoic, Triassic, Cretaceous, and Cenozoic subduction/obduction zones. Thus, the region under consideration is underlain by crust characterized by high geodynamic activity for 200 Ma (or longer).

If this is true, it is reasonable to believe that hydrocarbons migrate largely from deep Mesozoic (and Paleozoic, where lithologic–facies conditions are favorable) formations along the system of steep thrust-type fractures. Therefore, one can expect the discovery of large hydrocarbon fields in deep formations beneath the bottom of the Sea of Azov. Recent works provide grounds for such an assumption.

It was established that seismic records along many profiles contain below the horizon F (previously identified with the crystalline and, subsequently, acoustic basement) extended relatively readily recognizable sequences with high summing velocities (3600–5200 m/s) attributed to the Paleozoic–Lower Mesozoic (Fig. 1). This seismic complex encloses large anticlinal structures and wave anomalies interpreted as reefogenic bodies.

The previously assumed Paleozoic–Lower Mesozoic North Kuban Trough [2], which most likely represents the marginal structure of the East European Platform, was traced in the easterly direction.

Analysis of the available materials reveals the complex structure of the southern margin of the platform, which consists of the consolidated crust that avoided any significant transformation during the platform development stage and crust reworked (activated) by subsequent (Hercynian) folding. In our opinion, at the recent development stage this reworked margin with the North Kuban Trough is an element of the northern Scythian Plate. The trough most likely represents a complex system of alternating smaller troughs and uplifted blocks (relicts of the Precambrian basement). Such a structure of the suture zone is determined, on the one hand, by the heterogeneous composition of the deep crust and, on the other, by repeated intense hori-

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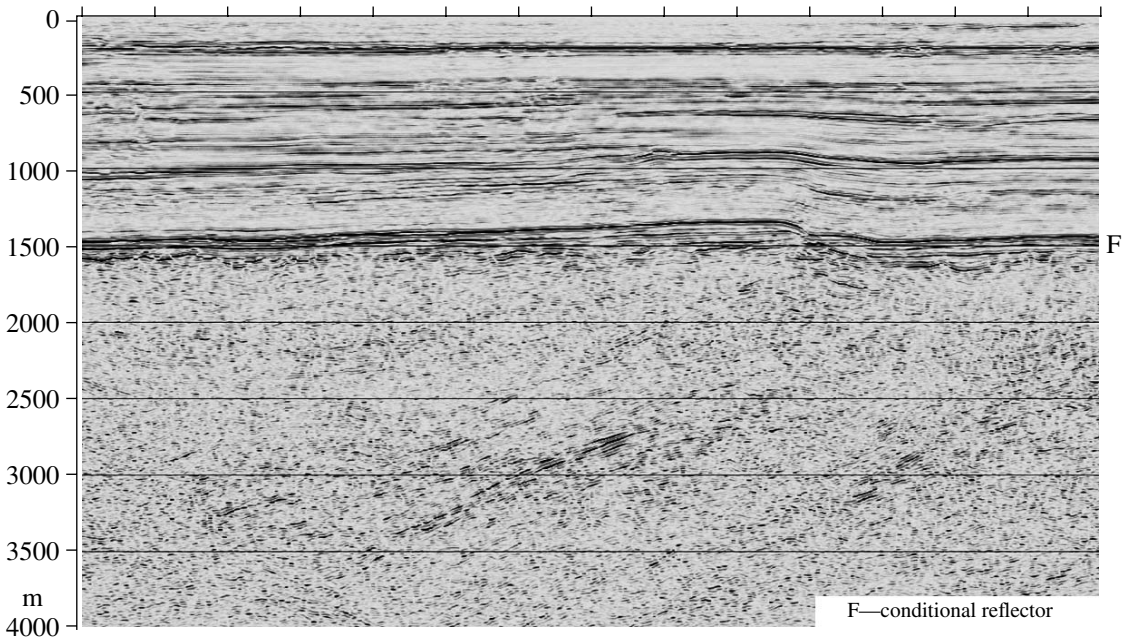

An example of the interpreted promising objects in Paleozoic–Lower Mesozoic sediments beneath the Sea of Azov bottom.

zontal movements. The troughs are filled with Paleozoic and Lower Mesozoic sedimentary and sedimentary–volcanogenic sequences. They accumulated in platform settings and are undoubtedly of interest with respect to oil and gas prospecting. Moreover, they enclose relatively large anticlinal uplifts with presumably high hydrocarbon reserves.

In such a situation, the northern part of the Scythian Plate should have two basements: Precambrian and Paleozoic. The latter is represented by slightly metamorphosed to unmetamorphosed sedimentary rocks locally intruded, probably by magmatic bodies. Strictly speaking, the Paleozoic sequences cannot be considered as representing the real basement, since they retain their initial appearance of platform sedimentary rocks. Inasmuch as the present-day structure of this complex, which includes, in our opinion, partly also Lower Mesozoic rocks reworked by Variscian movements, is unknown, it is reasonable to call it an intermediate one. From this standpoint, we can expect a relatively high petroleum resource potential of Lower Mesozoic (Triassic, Jurassic) and Paleozoic formations in the southern margin of the East European Platform, particularly in the northern part of the Scythian Plate.

The obtained data allow the assumption that the northern part of the Scythian Plate represents, in fact, the activated margin of the East European Platform with the Archean crystalline basement. Its complex structure is determined by repeated activation of lateral compression, owing to which sediments filling the North Kuban Trough are thrust along the Archean basement over the East European Platform.

The main significance of this discovery consists in establishing the fact that Paleozoic–Lower Mesozoic sediments were deposited in platform settings (i.e., under calm tectonic conditions) and should retain all the properties favorable for hydrocarbon generation, accumulation, and preservation.

Thus, it is established that this reworked part of the former southern margin of the East European Platform was structurally included into the Scythian Plate, which increases the petroleum resource potential of the latter as a whole. Previously, researchers considered the Paleozoic and Triassic formation as nonproductive. In contrast, we consider this complex as hydrocarbon-promising and believe that the southern margin of the East European Platform may enclose large (both in size and amplitude) anticlinal uplifts with associated large and medium oil and gas fields.

The following formations may be productive at least in the activated (reworked) margin of the East European Platform: Paleozoic (productive in the Dnieper–Donets Depression, Dobrudja region, and in some Ciscaucasia areas), Mesozoic (productive in the Crimean steppe region, where even the Albian terrigenous–volcanogenic sequence contains hydrocarbon pools, and fields of the Rostov Inlier and Kanev–Berezan Swell), Paleogene (Rostov Inlier), Maikopian (Strelkovoe and Beisug fields in the Sea of Azov and Dzhankoi field in the Crimean steppe region), and Upper Neogene (Morskoe, Nebol'shoe, and Severo-Kerchenskoe fields in the Sea of Azov and Priazovskoe field in the Kherson region). The accumulated sediments were subjected only to the local influence of tectonic processes and retained their capacity and filtration properties practi-

cally unchanged. Therefore, the reworked margin of the East European Platform may contain multistratal hydrocarbon fields with pools enclosed in Paleozoic to Upper Neogene formations developed in relatively large structures such as the assumed Mesozoic and Paleozoic (in opinion of some researchers) reefal build-ups as well in antitethical (reversely stepped) blocks similar to well-known fields in the Norwegian segment of the North Sea.

Unfortunately, these formations are practically unstudied by both offshore and onshore drilling. In boreholes, which recovered these formations for insignificant thickness, their lithology is unfavorable for the formation of hydrocarbon pools. At the same time, some boreholes (for example, Armavirskaya-40) provided economic hydrocarbon yields from these sediments. In any event, the study of these formations requires long-term (and expensive) works aimed at outlining potential development zones of Paleozoic–Lower Mesozoic sediments with suitable reservoir properties, including the drilling of several (two—three) parametric (estimating) boreholes.

In addition, records obtained along several profiles demonstrate vertical ("herring-bone") and horizontal wave-field heterogeneities (anomalous seismic bodies), which correspond most likely to fracturing, thinning, and foliation zones in crystalline rocks. Significant oil and gas pools associate with such zones in many world regions: the White Tiger field in Vietnam, Alberta Province in Canada, the Dnieper–Donets Depression in Ukraine, and others.

Gases from bottom sediments sampled near these anomalous seismic bodies show a wide spectrum of methane homologues (hexane included), which is presumably indicative of both gas and oil fields beneath the Sea of Azov bottom. This assumption is confirmed by studies conducted by scientists from the All-Russia Research Institute of Geology and Petroleum (VNIGNI), who registered traces of relatively mature oils in some samples.

Thus, new geological data on the northeastern Sea of Azov indicate its high petroleum resource potential and provide grounds for expecting significant oil and gas fields in this region.

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