[PS]Geological Structure and Hydrocarbon Potential of the North of the Barents Sea*

Sergey Pavlov[1], Valentina Shlykova[1], and Bozhena Velichko[1]

Search and Discovery Article #30302 (2013)**
Posted December 9, 2013

*Adapted from a poster presentation given at AAPG 3P Arctic Polar Petroleum Potential Conference & Exhibition, Stavanger, Norway, October 15-18, 2013

[1]Marine Arctic Geological Expedition, Murmansk, Russian Federation (info@mage.ru)

Abstract

Main tectonic elements of the northern part of the Barents Sea are the Alexandrovskaya high zone located in the west, the North Barents depression - in the central part and the Prednovozemelskaya zone of folded dislocations - in the east, which are detected according to the thickness of the sedimentary cover and succession of its seismic geological sequences. There is no common opinion of the tectonics position of the North Barents depression. Many researchers define it as a part of the Barents shelf plate; others consider it as a part of the separate Barents-North-Kara megatrough. There is no clear understanding about the tectonics of the western and eastern parts of the upwarping of Franz Josef Land. Within the Alexandrovskaya high zone the basement occurs at the depths of 400-3,000 m generally subsiding along the monocline towards the central part of the North Barents depression in concession to faults of the northeastern strike. According to Nagurskaya-1 well data, the basement is presented by strongly metamorphosed Vendian – Riphean formations. Seismic data do not allow tracking the basement in the central part of the North Barents depression. Within the Prednovozemelskaya zone of folded dislocations, the consolidated base is located at the depths from six to 17 km showing a graben-horst relief and the following rather gradual subsiding to the center of the North Barents depression. The sedimentary cover is divided into two structural – tectonic stages. The lower one consists of the Lower-Middle Paleozoic seismic geological sequence. Its thickness is caused by the block relief of the basement at the foot and considerably smoother forms of the regional surface of the Pre-Frasnian erosion III2 at the roof. The upper one is made of geological sequences from the Upper Devonian to the Upper Cretaceous deposits. The Cenozoic uplift is more brightly presented in the Alexandrovskaya high zone and in the Prednovozemelskaya zone of folded dislocations where the Jurassic – Cretaceous and, partly, the Triassic deposits are eroded and the erosion depth increases 2 km. The Triassic deposits had rather consistent thickness. The Triassic formations are broken by numerous magma bodies – dykes and sills. As for the formation mechanism of the North Barents depression there should be mentioned that rifting features are absent in the sedimentary cover of the Late Devonian – Cretaceous period.

GEOLOGICAL STRUCTURE AND HYDROCARBON POTENTIAL OF THE NORTH OF THE BARENTS SEA

Sergey Pavlov, Valentina Shlykova, Bozhena Velichko (JSC MAGE)

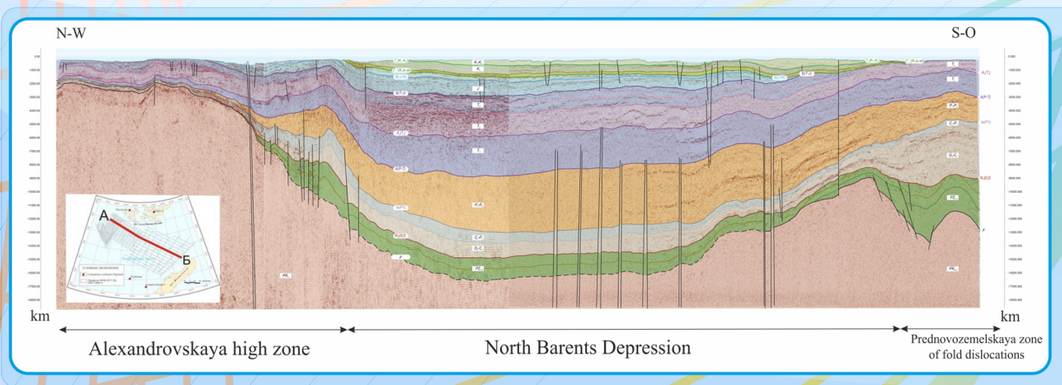

Fig.1. Depth section

At present, the regional geological studies of the northern part of the Barents Sea have almost been completed as the seismic grid interval is more than 0.2 line km/sq km .

Acquired data allowed to prepare generalized structural maps on five main unconformities of the sedimentary cover. That is an erosion surface (III2), subsurface interface of the Permian-Triassic (A), the top of Triassic formations (Б), the top of Jurassic formations (B) and the surface of Early Cretaceous washing out (Гп) upwards. All the mentioned surfaces are connected with breaks in sedimentation - III2, Б, Гп, or change of sedimentation mode – A, B (Fig. 1).

Within the limits of Alexandrovskaya high zone the basement occurs at depths from 400 to 7000 m, subsiding towards the central part of the North Barents Depression by faults of the north-eastern strike. According to Nagurskaya-1 well data the basement is represented by highly metamorphized Vendian-Riphean formations. The basement can't be tracked using seismic data in the central part of the North Barents depression. The consolidated foundation occurs at depths from 6 to 17 km in Prednovozemelskaya zone of fold dislocations showing a graben-horst relief and the subsequent smooth subsiding towards the center of the North Barents Depression.

Surface III2 (Fig. 2) defines a tectonic stabilization and a break in sedimentation for the whole area under consideration in the Middle Devonian. It divides the Lower Devonian and Upper Devonian deposits in Prednovozemelskaya zone of fold dislocations and, apparently, in the North Barents Depression. Surface III2 is identified with an acoustic basement in the area of Alexandrovskaya high zone, and it is the border dividing metamorphized Vendian and Early Carboniferous carbonates on the analogy of Nagurskaya well. At that, the presence of thin Permian deposits can't be excluded.

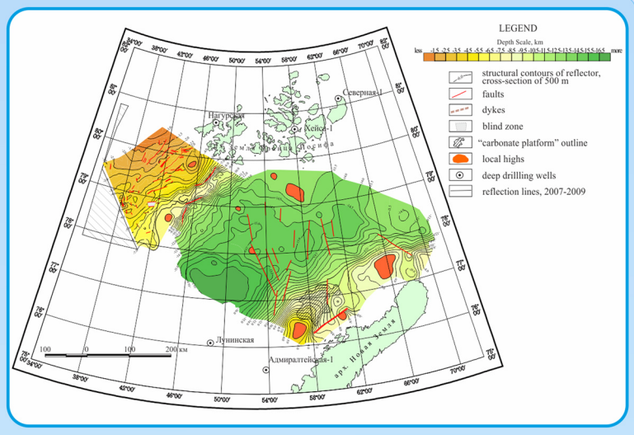

Fig. 2. Structural Map of Reflector $III_2 (P_{1+2} - D_3)$

Alexandrovskaya structural area is subdivided into three structural elements by gradient: Pineginskaya structure terrace wedging out northeastward, Vilchekovskaya monocline where the maximum dip angle of 3.5 degrees can be observed, and the high of Bely Island where the dips do not exceed 2 degrees (Fig. 3). In addition to structural parameters Alexandrovskaya high zone differs from the adjacent North Barents Depression in a set of seismic geological sequences of the sedimentary cover, namely, in the absence of Cretaceous and Jurassic deposits, and partly Upper Triassic ones. Besides, the stratigraphic range of the Paleozoic is limited to the Carboniferous interval and, probably, the Permian one.

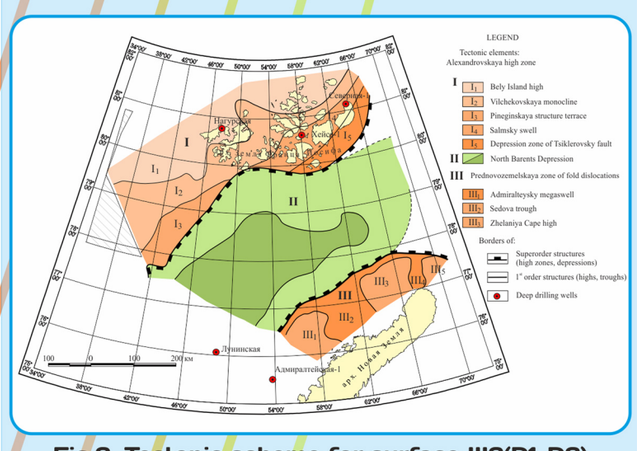

Fig.3. Tectonic scheme for surface III2(D1-D3)

On the basis of structural and seismic geological total criteria of zoning Alexandrovskaya high zone combines with Alexandrovskaya structural formation zone of Franz Josef Land into one tectonic element. The trough belonging to Franz Victoria trough system which was defined before and which separated the water area from Franz Josef Land can't be structurally tracked at surface III2.

The North Barents Depression has a pronounced north-east strike along surface III2, the thickness of sediments increases 16.5 km. Sides of the depression have dips of 4-6 degrees, at that, the western side is steeper. The sedimentary cover is represented by the Lower – Middle Paleozoic seismic geological sequence where there occur the Middle-Upper Paleozoic deposits with an angular unconformity, represented by the Upper Devonian – Lower Permian and Middle-Upper Permian seismic geological sequences. The Mesozoic formations are represented by the Triassic, Jurassic and Cretaceous seismic geological sequences.

As for the structure of surface III2, the Prednovozemelskaya zone of fold dislocations is characterized by alternation of highs and troughs. The distinctive feature of the sedimentary cover is an increased thickness of the Middle-Upper Paleozoic deposits formed at the side of Late Devonian – Middle Permian paleobasin. As well as in the Alexandrovskaya high zone there are no Jurassic, Cretaceous and partly Triassic deposits in the section of the sedimentary cover.

The Pineginskaya structural terrace is altered into Pineginsky swell (fig. 4, 5) along surface A on the structural map, the submeridional part of the North Barents Depression is formed. Taking into consideration significant differences in the structure of the Paleozoic part of the sedimentary cover in Alexandrovskaya high zone and Prednovozemelskaya structure area it denotes a structural alteration of the region.

The submeridional part of the North Barents Depression extends towards Franz Josef Land, and it doesn't contradict the geological sections of Franz Josef Land megaplateau made by I.V. Shkola and Bouguer anomaly map. But Franz Josef Land lacks for a solid cover of Jurassic-Cretaceous seismic geological sequences. Besides, Jurassic-Cretaceous deposits detected in Franz Josef Land are of the effusive-volcanogenic nature. These circumstances didn't allow to include a part of Franz Josef Land into the North Barents Depression within the scope of the accepted zoning system. There is located Salmskaya step between the meridional and north-eastern parts of the depression, as an analogue of Salmskaya structural formation zone of Franz Josef Land.

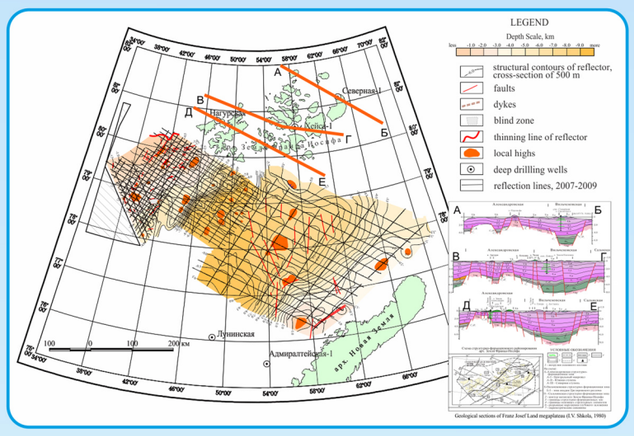

Fig. 4. Structural Map of Reflector A(P-T)

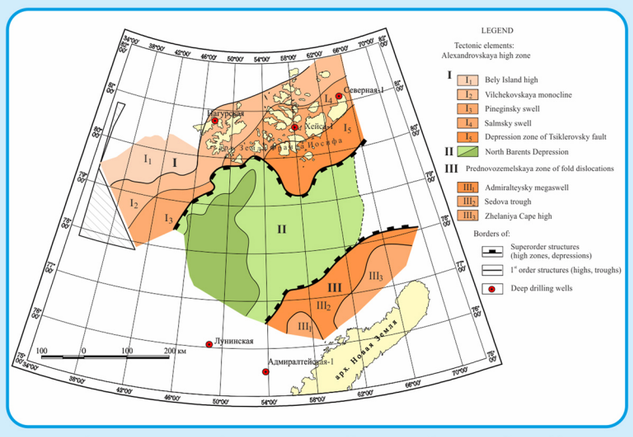

Fig.5. Tectonic scheme for surface A(P-T))

Alexandrovskaya structural area is subdivided into three structural elements by gradient: Pineginskaya structure terrace wedging out northeastward, Vilchekovskaya monocline where the maximum dip angle of 3.5 degrees can be observed, and the high of Bely Island where the dips do not exceed 2 degrees (Fig. 3). In addition to structural parameters Alexandrovskaya high zone differs from the adjacent North Barents Depression in a set of seismic geological sequences of the sedimentary cover, namely, in the absence of Cretaceous and Jurassic deposits, and partly Upper Triassic ones. Besides, the stratigraphic range of the Paleozoic is limited to the Carboniferous interval and, probably, the Permian one.

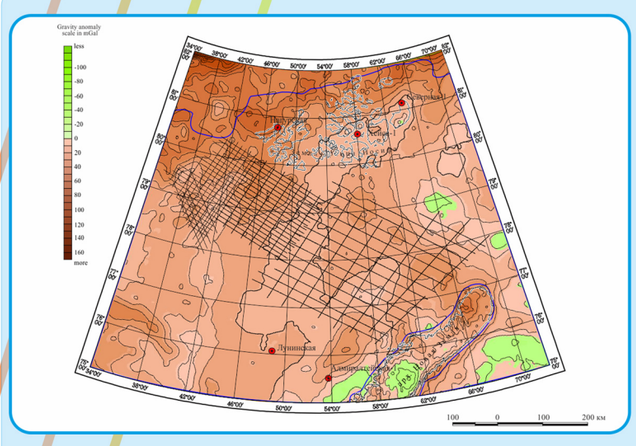

Fig. 6. Bouguer anomaly map with a density of Bouguer plate of 2.30 g/cm³

The northern part of the Barents Sea is characterized by the direct relation of III2 and A interface depth and the intensity of the anomalous Bouguer gravity field, namely, the lowered values of the anomalous gravity field correspond to maximum depths. It more concerns discontinuity A (Fig, 2,4,6). A specific linear anomaly of +20 mGal changes the submeridional direction within the North Barents depression into the north-eastern one within the depression zone of Tsiglerovsky fault. In the east it interfaces with an area of raised values of the field, including Salmskaya step, Albanovsko-Gorbovsky rapid, the high of Zhelaniya Cape and the northern pericline of Admiralteysky megaswell. It corresponds to the structural plan of the Triassic top where there was distinctly seen Albanovsko-Gorbovsky rapid, its southern part was structurally connected with the southern pericline of Admiralteysky megaswell, and its northern part – with Salmskaya step (Fig. 6).

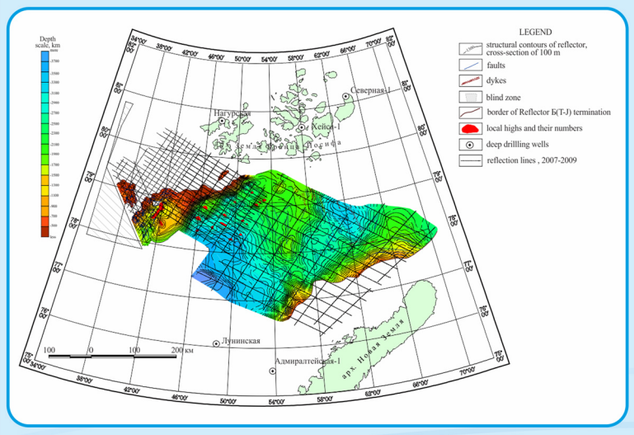

Fig. 7. Structural Map of Reflector Б(T-J)

The structural plans of Jurassic and Cretaceous deposits are analogous on the whole (Fig. 7-9). It shows at synchronous nature of their formation, connected with the Cenozoic uplift which is more distinctly seen in the Alexandrovskaya high zone and in the Prednovozemelskaya zone of fold dislocations, where the Jurassic-Cretaceous and partly Triassic deposits are eroded, at that the depth of erosion increases 2 km.

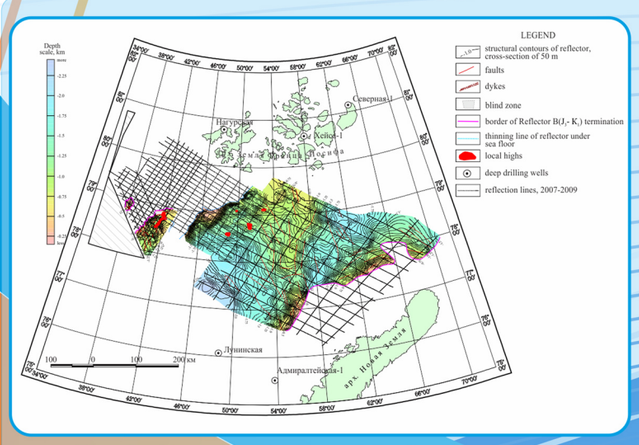

Fig. 8. Structural Map of Reflector $B(J_3 - K_1)$

Conclusions

It seems that the North Barents Depression has a more complicated structure as according to the zonation of structural criterion and, partly, of the stratigraphic one it includes Salmskaya structural formation area and depression zone of Tsiglerovsky fault of Franz Josef Land.

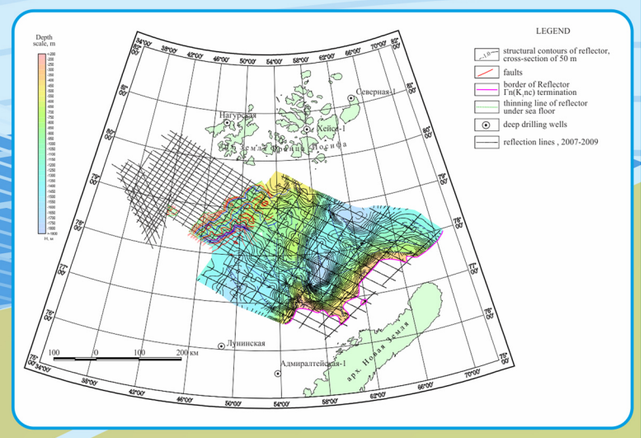

Fig. 9. Structural Map of Reflector Гп(K_1nc)