## PROJECT OF THE EFFECTIVE DEVELOPMENT OF THE OIL FIELD PRIRAZLOMNOE IN THE CONDITIONS OF MOVING ICE OF ARCTIC SHELF

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Shelf of Pechorskoe sea is a part of Timano-Pechorskaya oil bearing province. Main reserves of this province are accumulated in lower permian layers. It has been created under conditions of further deepening of Pechorskaya plate. It is characterized by presumably carbonate sediments, wide development of reef generated bodies that tend to the upper and lower parts of the province. Only South-Eastern part has deep sea sediments. Lower part of the section along the province is represented by basal shell sandstone layer 10–100 m thick that up to the section is replaced by organic limestones with anhydrites and dolomites. In eastern regions the basal part is represented by argillites.

Total thickness of the rocks is 0,5–1,5 km. Commercial inflows of oil in Yugidsky, Pechorokjzhvinsky and Naulsky fields, oil and gas inflows in South-Shapkinskoe, Usinskoe and other fields have been produced from basal sandstones with porosity 22–30%. As a rule, oil-bearing reservoirs are organic limestones and dolomites with porosity 10–34% and permeability up to 1.5 mcm<sup>2</sup>. Industrial reserves of hydrocarbonates are strictly divided by different areas. Western parts of Shapkino-Yurjakhinsky filed is characterized by gas-condensate deposits (Korovinskoe, Kumzhinskoe, Vasilkovskoe); eastern parts (Kolvinsky field) – by oil and gas-condensate deposits (Khylchujuskoe, Yareiskoe); Sorokin field – by oil deposits (Varandeiskoe, Toraveiskoe, South-Toraveiskoe, Naulskoe, Laboganskoe, Sedjaginskoe). About 90% of all the prospected coastal oil reserves and about 33% of potential hydrocarbonate resources correspond to carbonate rocks.

In Pechorskoe sea the main oil resources are also associated with these type of rocks (Sorokin, Gulyaevskoe, Kolvinskoe, Shapkino-Yurjakhinsky fields). Last discoveries in this area also confirm high perspectives of these deposits. In 1985 in the lower permian limestones of the Pomorskaja structure at the depth 2570–2660 m a gas-condensate deposit has been discovered with total resources about 22,5 milliard m<sup>3</sup>. The gas is hydrogen sulphide (H<sub>2</sub>S content is up to 8,5%). On North-Gulyaevskaja structure in 1986 at the depth 2200–2800 m (lower carbonate and permian deposits) gas deposits have been discovered (H<sub>2</sub>S up to 13%) with resources 51,5 milliard m<sup>3</sup> (recoverable reserves – 12,9 million t).

The largest oil deposits have been established in 1989 on the Prirazlomnoe field (area 18,3?5,1 km). Four exploration wells have found two oil deposits in lower permian layers (depth 2363–2410 m) and permian-carboniferous layers (depth 2431–2486 m) with total resources 75,3 million t. Maximum oil recovery is 678 m<sup>3</sup> per day. Oil is poor of paraffin, rich in tar and sulphur (S up to 2,3%), with density 0,908–0,914 g/cm<sup>3</sup>. Oil bearing horizon made of limestones is represented by

two reservoirs – I and II, with the upper containing 3 layers (1?, 1b, 1c). Total thickness of the reservoir I is 43–85 m, net thickness is 42–85 m; for the reservoir II – these thicknesses are 49,5–63,0 m and 11,1-26,2 m, respectively. Average rock porosity is 15,6-21,7 %, permeability is 0,05-0,4 mcm<sup>2</sup>, oil saturation is 77–90 °/?. The rocks are characterized by vertical fractures in the North part of the field, their oil bearing properties improving in the central and south parts. These features determined the method of the field development. In general the development of such fields depends on the specific geographic and climate conditions of the shelf fields on the North of Russia.

Design of the field development project includes the consideration of several variants that differ by the type of well patterns, EOR methods, exploitation methods and so on. As a rule, these parameters are typical for all the fields. However the main parameter for the sea fields development is the number of sea platforms. The number of wells and terms of development depend on this parameter. Prirazlomnoe field in the South-East part of Pechorskoe sea can serve as an example. The 3-row, I-row, area<sup>1</sup> and complex vertical, inclined and horizontal well patterns have been considered. Due to complex geological structure of the deposit a lot of variants differ by well patterns, types and numbers of wells have been put under consideration. In order to reduce the investigation area the preliminary calculations have been conducted to determine the effect of number and type of wells on final oil recovery (for the 21st year of development). The calculations performed proved that number of wells that provide maximum oil recovery is 42–55. In this variant the horizontal/vertical wells ratio is 1?1,33, producing/injection wells ratio is 1,21?2,09. All the next calculations have been performed for these values. Due to the complex structure of the field the degree of the reservoir involving in the process has been determined, as well as oil recovery for every reservoir. In general the oil recovery factor for different variants varies very much: from 0,213 to 0.353. The distribution of oil recovery level versus the distance from the platform has been considered (less than 3 km and more than 3 km). The zone within the radius less than 3 km is characterized by the highest levels of oil recovery. The use of horizontal wells allows considerably increase this value. Oil recovery within the radius is 55,56 million  $m^3$ , outside – 16,43 million  $m^3$ . The other considered variant produced the other values – 49,382 million m<sup>3</sup> and 21,918 million m<sup>3</sup>, respectively. The first variant shows the most constant recovery for different layers.



3D hydrodynamic model of Prirazlomnoe oil offshore field