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Geological Structure and Petroleum Potential of the Chukchi Sea Shelf

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SUMMARY

The eastern part of the Russian Arctic Shelfs represents one of the most unexplored part of the regions, where the significant oil and gas prospects could be discovered. Seismic, magnetic, gravimetric data and geological survey data from surrounding continent and islands were gathered and obtained in current research. As a result, the main tectonic events that took a place during Paleozoic, Mesozoic and Cenozoic time in the Chukchi margin were determined. Seismic stratigraphy analyses were exploit to achieve a stratigraphic model. Five and Six seismic complexes were indicated in North and South Chukchi correspondently. The main tectonic events were associated to regional unconformities traced by seismic. Paleogeographic maps for main tectonic events in Mesozoic were compiled. This information enable to gain more detailed geological model of studied area. The main oil and gas potential related to Triassic, Jurassic and Cretaceous source rocks. The perspective reservoirs connected with Cretaceous analogs occurred in North Slope.
Introduction

The Chukchi Sea Shelf placed in the East Arctic offshore of Russia between East Siberian Sea Shelf and North Slope Alaska (fig.1). The Chukchi margin is considered as high petroleum potential play. The major problem is absence of core material from drilling wells in Russian part of Chukchi Shelf, hence strong complex geological and geophysical analyses such as seismic stratigraphy interpretation should be provided. In addition, similarity to North Slope and Beaufort Basins (North Chukchi) and Hope Basin (South Chukchi) allow to infer the resembling sedimentary succession and petroleum systems.

Figure 1 The Geological map of Chukchi Sea (USGS, 2005). In the picture the red lines are seismic profiles and the green triangle are drilling wells. Seismic surveys were conducted by DMNG and Halliburton in 1900-1991.

The Chukchi Sea Shelf include North and South Chukchi Basins, which are separated by Wrangel-Herald Arch and characterized by different opening time. The North Chukchi basin is formed as a part as a general part of Canada Basin opened in Early Cretaceous. The mechanism of opening is “clockwise” rotation. Rifting probably started in Kimmerigian (Embry, 1993). A foreland basin occurred between the East Siberian Platform and North Chukchi Basin. Rock samples from surrounded continent and islands suggest: Paleozoic (marine carbonates), Mesozoic (open shelf deposits) and Cenozoic (pelagic) sedimentary succession. The deepest part of North Chukchi Basin could contain 18 km of sediments. The South Chukchi Basin is characterized by a transtensional origin of the basin, this deformation related to motion on the Kobuk Fault (Verzhbitsky et.al, 2012). It was a shallow marine basin with a Cretaceous-Cenozoic succession, the depth of the South Chukchi Basin is in average 3-4 km and it locally could exceed 5-6 km.

Seismic Interpretation

Seismic stratigraphic method was involved in the interpretation of seismic data. Because seismic reflections follow chronostratigraphic correlations, it is possible to achieve stratigraphic interpretation. The main seismic horizons were indicated as: F, PU, JU, LCU, BU, mBU marking each
regional unconformities. The seismic complexes were divided by geometry of seismic reflection correlation pattern: Carboniferous-Upper Permian, Triassic, Jurassic, Cretaceous, Paleogene and Neogene seismic stratigraphy complexes. Strata terminations were provided to define syndepositional shoreline shifts and implicitly to reconstruct the history of base-level changes at the shoreline. The Downlap type of strata terminations in Cretaceous and Cenozoic complexes confirms to clinoform structures and cause significant interest. Truncation surfaces indicate erosion processes and onlap is a diagnostic for transgression.

Petroleum systems

Reconstruction of main tectonic events of basin is important for building correct geological model. The published data combined with seismic interpretation enable to gain tectonostratigraphic events chart (fig.2). Since there are no drilling wells in the North and South Chukchi basins, source rocks could not be proven. Referring to the North Chukchi basin, source rocks equivalents of Lower Cretaceous Pebble Shale Formation, Lower Jurassic Kingdak shales and Upper Triassic Shublik Formation (North Slope) is possible exhibited (Peters, 2006). Older source rocks (Jurassic and Triassic) are based probably on Wrangel Island (Kos’ko et.al, 1993). In the South Chukchi, it is possible that Cretaceous source rocks could be mature for hydrocarbon generation. All reservoirs in the area are proposed based on regional extrapolation. Seals are intraformational, predominantly in the Jurassic and Cretaceous. Erosions and uplifts that could effect on hydrocarbon preservation was substantially in Lower Jurassic and Early Cretaceous periods.

Lithology:
- Sandstones
- Shales
- Carbonates
- Source rock

Tectonic event symbols:
- Regional Uplift and erosion
- Extension
- Compression

Proven reservoirs:
- Carbonate reservoirs
- Terrigenous clastics
- Shallow marine clastics
- Deep marine clastics

Figure 2 North Chukchi basin tectonostratigraphic chart.
Perspective traps

The perspective structures were allocated by seismic cross section study and comparing them with explored analogs. Most of the structures may be connected with fault and stratigraphy traps. The structure formed at Wrangel-Herald Arch to North-Chukchi through similar to well-known structure in Norwegian part of Barents Sea – Loppa High (fig.3). Moreover clinoforms which thickness could attain 1.5 sec found in North-Chukchi Basin, this structures resemble high oil saturated clinoforms structures in West Siberia province. In South Chukchi basin, the seismic wave shows interesting structures akin to diaper fold. Because of sedimentary basin age, it is hardly has salt origin but we could assume the shale diapirism. Inversion-related anticlines and stratigraphic pinch-outs traps could presence in Cretaceous-Cenozoic cross section.

Figure 3  (A)Seismic cross section with interpretation through the Wrangel-Herald Arch to North Chukchi through.(B) Loppa High – analog in Norwegian part of Barents Sea (Sattar et. al,2012).
Conclusions

This work is involved in a large project of Arctic petroleum systems research conducting by oil and gas department of the Moscow State University. The complex approach allow to improve our understanding related to unexplored East Arctic petroleum plays. As a result, we gathered and analyzed source rocks and reservoir analogs and gained improved sedimentary models in Eastern Russian Shelves (Laptev, East Siberian and Chukchi Seas). The primarily perspective structures were developed from the analysis of seismic data. Also “bright spot” seismic attributes were marked on 2D seismic lines, which imply on hydrocarbon perceptivity in the Chukchi Sea Basins. Next step is to evaluate hydrocarbon saturation in certain structures by basin modeling. According to the research, the productive oil and gas are expected in Jurassic, Cretaceous and Cenozoic reservoirs. Appropriate tectonic conditions, proven by well testing source rocks in North Slope and high thickness of basins suggest a success of hydrocarbon exploration in Russian part of Chukchi Sea Shelf.

References


