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Tectonic Evolution of Gas Traps in the North of West Siberia

E. Surikova* (Novosibirsk State University)

SUMMARY

The article deals with the tectonic aspects of giant gas fields formation in the north of the West Siberian basin. Since fields are confined to the structural traps, the tectonic reason of the traps formation is very important. The research is based on integrated data of interpretation CDP reflection lines and well logging. Five main reflectors (A, B, M, G, C) were allocated and correlated. Structural characteristic shows that Modern reliefs of the reflectors are significantly different from each other. Analysis of tectonic evolution shows that the most important tectonic stages for traps formation were Aptian- Turonian (beginning of the formation of uplifts) and Cenozoic (stage of maximum development of uplifts, formation of modern shape of positive structures and faults formation). By the beginning of the Cenozoic thick Turonian clay of Kuznetsov Formation reached the stage of lithification to impermeable beds. In Cenozoic era system of reservoir+caprock was formed. At that time Aptian source rocks reached gas window, Upper Jurassic source rocks reached oil window, deeper underlining source rocks began producing wet gas. The scale of natural gas generation in Cenozoic was so great that the giant Cenomanian traps were fully or over- filled, and the underlying beds are productive.

Introduction

The study area is located on the north of the West Siberian (WS) Plate, in the area between rivers Nadym and Pur (Fig. 1 -A). WS Plate is the largest young epipaleozoic plate which occupies a vast area (3.5 million km²) of the WS Plain. The plate has two-part structure - different ages (from the Precambrian to the Late Paleozoic) heterogeneous basement and unconformably overlying Mesozoic and Cenozoic sedimentary cover. The world's largest natural gas fields were discovered in the north of the WS Plate.

Figure 1 A- location of the research area, B - oil and gas fields, C - part of tectonic map of West-Siberian basin (A-Medvezh'e-Nuginskii inclined megabar, B-Bol'shaya Kheta megasyncline, 1-Jubilei dome, 2-Yamsovei dome, 3-Pestovii bar, 4-Medvezhii mezobar, 5-Central Urengoy mezobar, 6-South Nyda depression, 7-Maretayakh mesodepression, 8-Yagenetta mesodepression, 9-Nerutinskii megatrough, 10-Upper Tanlov megadepression).

During years 1967-2000 five gas and oil-and-gas fields were struck on the study area (Fig. 1-B). In tectonic terms, these fields are associated with the same name bars and domes (Fig. 1-C). All giant gas pools are concentrated in the Cenomanian massive reservoir consisting of slightly compacted sandstones and siltstones. The caprock for gas deposits are thick clays of Kuznetsov Formation (Turonian). In the study area Cenomanian reservoir have height of 148-188m, associated to high-amplitude structural traps, filled completely or with an excess of dry gas. Besides the basic Cenomanian deposits there are pools and influx of oil, gas-condensate and rich gas in underlying Jurassic, Neocomian and Aptian-Albian deposits. Hydrocarbon fields of the study area are characterized by large reserves, wide stratigraphic interval of productivity (Lower Jurassic - Cretaceous), high-amplitude traps. Later in this article will be considered tectonic aspects of the formation of these fields.

Seismic markers and seismogeological sequences

Five seismic markers controlling basic seismogeological sequences are indicated in sedimentary cover of West Siberia: A - a bottom of Jurassic, B - a bottom of the Bazhenov Formation (Late Jurassic, Tithonian), M - the Koshai shale unit of the Alym formation (Early Cretaceous, Aptian), G - the Kuznetsov Formation (Late Cretaceous, Turonian), C - the Talitskii Formation (Late Cretaceous, Maastricht). Reflectors are associated with transgressive clay beds with stable areal thickness, formed during the era of calm tectonic, have spread over large area of the WS basin, and can be used as peneplanation planes. Construction of structural maps by the reflectors and thickness maps of the basis sequences (Jurassic, Tithonian-Aptian, Aptian-Turonian, Turonian-Maastricht and Cenozoic) has been carried out during the research (Kontorovich, 2009). Fig. 1-B,C show the seismic lines which were used for reconstructions.

Structural characteristics and tectonic evolution

Modern reliefs of the reflectors are significantly different from each other on the study area. In the A reflector relief there are isometric uplift in the south of the Medvezhii area, dome on the Jubilee area, small elongated uplift (bar) on the Yamsovey area. In the B reflector relief Central- Medvezhii and South- Medvezhii domes combine in a single elongated uplift, north of which there are Nyda dome, located slightly above hypsometrically. Yamsovey and Yareyskii uplifts represent separate domes. In the marker M relief we can identify Medvezhii mezobar united South- Medvezhii, Central- Medvezhii and Nyda domes. Similarly we can allocate Yamsovey elongated uplift united in its composition Yamsovey and Yareyskii domes. Up the section there is a "compression" of the structures in sublatitudinal direction and elongation them in submeridional direction, thereby there are positive elongated from south to north structures with axial ratio reaching 1:10 in the reliefs of Upper Cretaceous and Cenozoic reflecting horizons.

In recent work method of thickness is used to reconstruct the history of tectonic evolution of the northern part of the WS Plate in Nadym and Pur interfluvium. The analysis shows that the modern positive tectonic structures did not exist in Tithonian time (time of B reflector formation) in relief of A reflector. It means that the modern uplifts and bars of Nadym-Pur interfluvium, which are associated with the giant gas fields are not structures formed above the basement uplifts. The research area landscape was a monocline with a slope to the north-east with a lot of small domes to the Aptian. At that time ridge of domes tend to increase in Sandibinskii-Nyda-Medvezhii-Pangoda-Yamsovei-Yareyskii local areas. Almost all uplifts of landscape were formed during the Aptian-Turonian time, Medvezhii, Yamsovei and Yareyskii domes developed actively. During late Cretaceous the epicenter of subsidence moved to the south, that tectonic result in the formation Maretayahinskii and Yagenettinskii synclinal bowls. At the same time East Medvezhii dome formed, Yamsovei and Yareyskii anticlines united into one structure, which intensively developed during the Late Cretaceous. Cenozoic tectonic processes have had a significant influence on the almost all modern uplifts formation.

It was Cenozoic tectonic stage that resulted in the formation of elongated from south to north uplifts. Tectonic activation had not only the regional component of uplift of the WS plate northern part, but probably the global component of compression of the WS plate in sublatitudinal direction. As a result there are elongated linear structures on the study area. It should also be noted that this stage of tectonic evolution accompanied by intense faulting. Faults intersecting almost all Mesozoic-Cenozoic sediments could be channels for hydrocarbon migration and possibly predetermined excess filling traps in this region.

Research suggests the following conclusions.

- The most important tectonic stages for traps formation in Nadym -Pur interfluvium area were Aptian-Turonian (beginning of the formation of uplifts) and Cenozoic, when there were maximum growth and formation of modern shape of positive structures, when faults formed.
- In the north of plate source rocks are Triassic - Lower- Middle Jurassic, Upper Jurassic and Aptian sediments enriched in organic matter. Since at least the end of the Late Cretaceous Jurassic source rocks have been able to generate hydrocarbons, but there was no good quality reservoir caprock and uplifts were very small. By the beginning of the Cenozoic thick Turonian clay of Kuznetsov Formation reached the stage of lithification to impermeable beds. In Cenozoic era system of reservoir+ caprock was formed. During Cenozoic Aptian source rocks reached gas window and began to produce dry gas, Upper Jurassic reached oil window, deeper underlining source rocks began producing wet gas. The scale of natural gas generation in the Cenozoic was so great that the giant Cenomanian traps were fully or over- filled, and the underlying beds are productive.

References

- Kontorovich, V.A. [2009] Mesozoic-Cenozoic tectonics and petroleum potential of West Siberia. *Geology and Geophysics*, **50** (4), 461-474.