

Laptev Sea: A Frontier Arctic Basin

The Laptev Sea Basin is a frontier Arctic basin explored by regional seismic only. Its thick sedimentary cover is thought to contain numerous potential reservoirs, seals and mature source rocks, and structural traps are probably abundant. The Lena River Delta is of special interest for hydrocarbon entrapment.

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The Laptev Sea Basin – covering an area comparable to the southern part of the Norwegian Barents Sea – lies almost entirely on the continental shelf of Laptev Sea, off the northern coast of Russia. It is situated between the **Taymyr Peninsula** in the west and the islands of the **Novosibirsk** (New Siberian) Archipelago in the east. Its southern border is roughly coincident with the Siberian coast, and it extends from the

mouth of the **Khatanga River** eastward to the **Omoloy River**. It includes part of the Lena River delta, which extends over one hundred kilometres into the sea.

The Laptev Sea Basin's sedimentary fill (including the Precambrian-Cambrian sequence) is estimated to be up to 13 km thick in the basin's deepest parts. The basin's structure includes a series of rift troughs of north-western strike filled with Upper Cretaceous-Miocene sediments overlain by a Pliocene-Quaternary cover.

Water depths in the basin typically are less than 50 m, but along the northern margin of the basin there is a steep continental slope, where water depths increase to over 1,000 m.

No Offshore Wells

The Laptev Sea Basin has been explored by geophysical methods only. Detailed airborne magnetic surveys were carried out over the islands, but at a much smaller scale offshore. The first refraction seismic surveys were run in 1973, and later in 1979 and 1985-1988.

First CDP surveys were run in the mid 1980's. Between 1984-1990, a series of regional lines were shot across the entire offshore. These and subsequent profiles were shot on an irregular and sparse grid. The seismic data were interpreted using correlations with five stratigraphic test wells drilled onshore close to the basin's southern margin.

In 1993, 1994, 1997 and 1998, Germany's Federal Institute for Geosciences and Natural Resources in cooperation with the SevMorNefteGeofizika (SMNG) Trust acquired a large data set of regional seismic

in the basin. In 2004-2006, SMNG and MAGE acquired additional regional datasets.

Geological Setting and Basin Evolution

The basement of the Laptev Sea Basin comprises a number of heterogeneous blocks that were welded together during the mid-Mesozoic (Late Jurassic) "Cimmerian" collision of the Siberian Platform and the pre-existing continent of Arctica (or Hyperborea). These blocks have differing pre-Cimmerian sequences, but their offshore boundaries are not obvious on seismic data, as the area has been tectonically overprinted by Cenozoic rifting.

The most important structural elements comprising the basement include the offshore extension of the Siberian Platform in western Laptev Sea (also known as the Laptev Fold System), and the offshore extension of the Verkhoyansk and the Novosibirsk-Chukotka Mesozoic fold belts in the East Laptev.

From Ordovician to Early Carboniferous time, the northern East Siberian continental margin evolved in a stable tectonic regime. Ordovician-Middle Devonian sequence in the Laptev Sea Basin is thought to be composed largely of shallow marine carbonates. Upper Devonian-Early Carboniferous sequence is represented by shallow marine clastics and carbonates.

Towards the end of the Devonian, the Cherskiy block broke off the eastern margin of the Siberian Platform initiating an oceanic basin east of the Siberian Platform. A major submarine fan sequence known as the Verkhoyansk Complex was deposited in this oceanic basin between the Early Carboniferous and the Early Cretaceous. In Late Jurassic-Early Cretaceous time, it was

Basin Boundaries

The basin's western boundary is formed by the Taymyr Fold Belt. The fold belt is subdivided into two systems, i.e. the North Taymyr with metamorphosed Upper Proterozoic clastic and volcanic formations; and the South Taymyr with Upper Paleozoic-Lower Mesozoic clastics and Permian-Triassic volcanics.

To the south, the Olenek fold zone separates the Laptev Sea Basin from the Lena- Anabar Trough and Yenisey-Khatanga Basin. East of the Lena Delta, the Verkhoyansk Fold Belt forms the basin's eastern margin. Near the coast, the north-south striking fold belt splits into several branches running north-west and east.

To the east, the basin's margin is formed by the Lomonosov-Svyatoy Nos uplift zone. It extends from Cape Svyatoy Nos to the Lya-khovskiye and the Anzhu group of islands on the shelf and then on to the Lomonosov Ridge in the ocean. The Anzhu group of islands are part of the Kotelnicheskii median massif.

The northern boundary of the basin is defined by the shelf edge and continental slope as it opens into the Eurasia basin of the Arctic Ocean.

folded by the collision of Siberia and various exotic terranes (Cimmerian collision).

The initial phase of rifting causing the opening of the Eurasia Basin to the north of the Laptev Sea Basin took place in the Late Paleocene-Eocene. The spreading occurred along the Nansen-Gakkel ridge. A vast marine transgression took place in the Early-Middle Eocene. In the Oligocene-Early Miocene, the plate rotation pole shifted to the southern margin of the Nansen-Gakkel Ridge and a compressional episode took place. Extension resumed in the Middle Miocene-Middle Pleistocene.

Petroleum Geology

Source Rocks

The main potential source rocks in the Laptev Basin are believed to occur in Permian and Triassic formations. As no wells have been drilled in the basin, all rock intervals described are from outcrops or wells on the mainland or from nearby islands, all of which lie outside the basin.

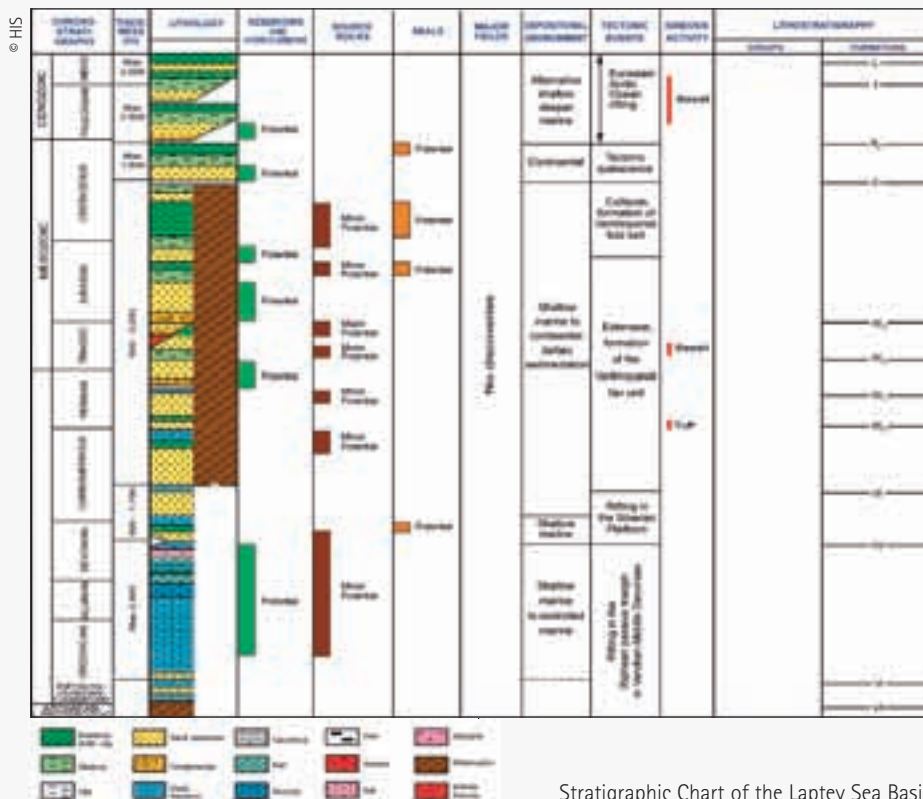
The giant Olenek bitumen deposit in Permian formations is located on the Olenek high onshore northern East Siberia. In the early 1950's, a gas show from a Permian interval was registered in an exploration well drilled near the River Olenek's mouth. Non-commercial flows of heavy oil from Permian-Triassic sediments were registered in wells near the Khatanga Bay.

Triassic rocks from wells in the neighbouring Lena-Anabar Trough are largely shales, with thin algal limestone interbedded. TOC and bitumen A content in Middle and Upper Triassic rocks are considerably higher than in the underlying formations, with TOC values usually exceeding 2%. The kerogen is mixed humic-sapropelic. It is mature which is evidenced by the high carbon content and low heterogeneous element content in bitumen.

Offshore, the Upper Paleozoic-Lower Cretaceous sequence is between 500-3,000 m thick, and its top occurs at 2,000 m or deeper suggesting that potential source rocks in the sequence were able to reach maturity. Generally, Triassic rocks offshore are thought to comprise marine clastics deposited in reducing geochemical environments, while Permian rocks comprise shallow marine clastics and volcanics with minor carbonate interbedded.

Other potential source rocks include Precambrian¹ Cambrian clastics and carbonates, Ordovician-Silurian carbonates





Stratigraphic Chart of the Laptev Sea Basin.

voir/seal combinations.

No large structures/potential traps have so far been identified within the rift troughs. Potential traps here could be represented by drape basement structures. The best trapping potential appears to be associated with the trough flanks and the slopes of the highs separating the troughs. Expected mechanisms are onlaps, pinch-outs and facies changes. These are likely to be combined with structural control as there are numerous normal faults present in Upper Cretaceous-Tertiary sequence.

Potential traps associated with deltaic and fluvial systems could be of major importance in the basin. Five long-living river systems, i.e. Lena, Anabar, Olenek, Khantanga and Yana flow into Laptev Sea. Lena could have been in existence since Jurassic/Cretaceous time, i.e. since the inception of the Verkhoyansk fold belt. The river's channel has migrated, and its fan systems have shifted several times in its history. This could have resulted in accumulation of a large fluvio-deltaic system.

Deep Water Potential

The continental slope of the basin's northern margin could represent an important exploration target as well. Sedimentary cover can be as thick as 6-8 km here, with most of it taken by Cretaceous and Paleogene formations. Syn-rift sediments fill in basement grabens and are overlain by deep-water turbidites. The latter occur in submarine canyons and fans providing for a complex combination of potential structural and stratigraphic traps. The basin is also regarded as having excellent potential for gas generation and hydrate formation, typically in the sandstones of Late Cretaceous to Neogene age. 🌱

Ordovician to Middle Devonian carbonates in the adjacent Lena-Anabar Trough have porosities of up to 20% and permeabilities reaching 180 mD. Equivalent formations in the Laptev Sea Basin are potential reservoirs and could hold hydrocarbons in structural or structural-stratigraphic traps.

Offshore, Precambrian-Paleozoic carbonates are the thickest in the South Laptev trough (up to 7,500 m). The megasequence's top occurs at 3-4 km in this trough. The structure has not been impacted by Cenozoic rifting, and simple structural traps could be expected in its central areas.

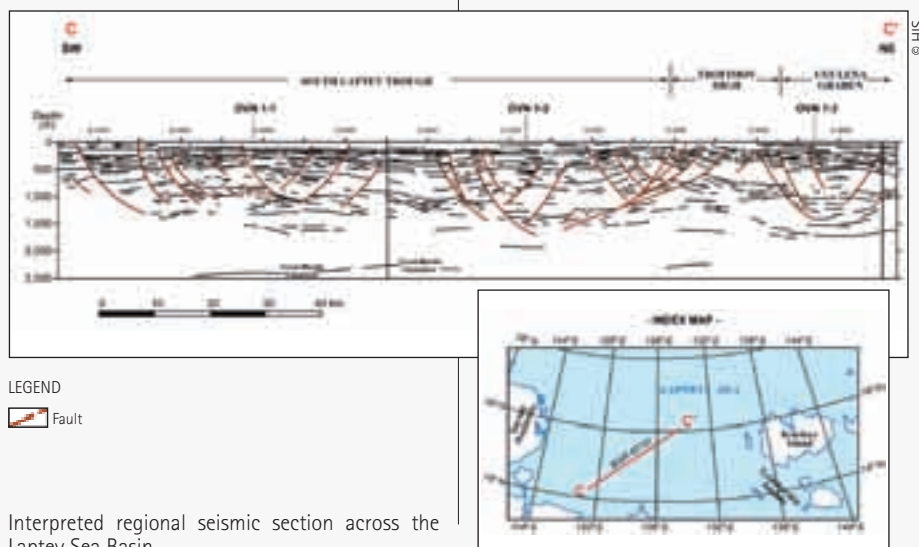
The main prospectivity is thought to be associated with Precambrian-Lower Cretaceous sequence, including oil and gas in Permian and Triassic clastics. This is as suggested by oil shows along the northern margin of the East Siberian Platform. Upper Permian-Lower Triassic sandstones are minor gas reservoirs in the Lena-Anabar Trough where they have porosity values of up to 30% and permeabilities of some 300 mD.

By analogy with the Yenisey-Khatanga Basin (lying to the west of the Laptev Sea, where commercial gas discoveries have been made), Jurassic-Lower Cretaceous sandstones in Laptev Sea Basin have potential in structural traps.

The Upper Cretaceous-Tertiary

Seismic data suggest high-energy environments for Upper Cretaceous-

Tertiary sediments in the Laptev Sea Basin. Clinoforms and cross-bedding have been identified in Upper Cretaceous intervals. Possible deltaic formations can be seen in Cretaceous formations in the basin's east, and in Paleogene formations in the south. According to the data available onshore and in Laptev Sea islands, Upper Cretaceous-Miocene sediments comprise a wide range of sedimentary facies, from continental with coal, to near-shore marine. Marine sediments occur primarily in Eocene, Oligocene and Miocene formations. Clastics are represented by a wide range of fine to coarse rocks, providing for potential reser-



Interpreted regional seismic section across the Laptev Sea Basin.