GEOGRAPHY AND TOURISM, Vol. 6, No. 1 (2018), 95-98, Semi-Annual Journal
eISSN 2449-9706, ISSN 2353-4524, DOI: 10.5281/zenodo.1314042


**S.N. Ruleva**
M.V. Lomonosov Moscow State University, Faculty of Geography email: mnks1@yandex.ru

# Channel processes of the Ob River and the use of the river for water transport purposes

**Abstract**: The Ob River is one of the largest rivers in Russia and currently the most important traffic route in Western Siberia. The paper presents the history of water transport on the Ob River against the background of channel processes limiting the navigation on the river. The heterogeneity of the Ob River is determined by specific features of the channel processes and the stability of the riverbed, morphological types of the channel, the nature of deformations, long-term and seasonal changes of riffles and sections of the channel characterized by the presence of riffles. The main measures aimed at improving the navigational conditions of the Ob River include dredging of riffles, construction of dams and bypass channels.

**Keywords**: navigation, water way, channel processes, the Ob River

The Ob River, with the length of 3,662 km and the catchment area of 2,990 km$^2$, is one of the largest rivers in Russia. It ranks first among the river systems of Russia and fifth among the rivers of the world. The Ob is a typical lowland river, but the water regime of some of its tributaries is formed not only in the lowland areas, but also in mountain conditions.

Internal waterways have always played an important role in Russia. In the 18th and 19th centuries, research was carried out on major rivers in Russia. The results of that research were used to prepare hydrographic maps and atlases. Since then, the construction of numerous hydraulic engineering structures, e.g. channels and gateways, has been continued in Russia. The first historical information on the Ob waterways comes from 1797 and refers to the connection between the basins of the Ob and the Yenisei. The first steamship was built in Tyumen and in 1838 it operated on the Ob and the Irtysh. The first passenger steamer sailed on the Ob in 1893 between Biysk and Tomsk.

The Ob River is currently the most important traffic route in Western Siberia and is used for navigation along the entire section from the confluence of the Biya and the Katun to the Gulf of Ob. The guaranteed dimensions for navigation are maintained throughout the section. This route is quite diverse due to the complex navigational conditions, the provision of the guaranteed dimensions, and the volume of dredging necessary to maintain such dimensions. The heterogeneity is determined primarily by several factors: specific features of the channel processes and the stability of the riverbed, morphological types of the channel, the nature of deformations, long-term and seasonal changes of riffles and sections of the channel characterized by the presence of riffles. In addition to natural factors, the development of the channel can be affected by factors related to human activity. In the middle of the 20th century, the volume of transportation in the basin doubled. In the late 1980s, the navigation volume stabilised. In the 1990s, as a result of the economic recession, a sharp decline in the traffic volume was observed, and by 1994 it was at the level of the early 1960s.

Freight transport by water requires the creation and optimal operation of waterways. In 1809, the "X" District of Communications was established, which included all rivers of Western and Eastern Siberia. At the end of the 20th century, waterways were significantly reduced. This was caused by inventory and reorganisation of waterways. Almost all small rivers in the basin and upstream reaches of the main rivers were decommissioned. As a result, the volume of dredging decreased significantly. Thus, while

the volume of river sediments extracted in the navigation period of 1993 amounted to 9,610 thousand $m^3$, in 1994 it was only 1,200 thousand $m^3$.

In the late 20th and the early 21st century, 1,325 km of the main waterways in the Ob basin were used for navigation. Data presented in Table 1 give an overview of the situation on the Ob waterways. The apparent reduction in the guaranteed depths in the river pools results from the reduced volume of dredging and shipping.

**Table 1.** Changes in the guaranteed dimensions of the Ob waterway in different years

| Pools of the Ob | Length | Guaranteed depth, cm | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | km | 1950 | 1960 | 1970 | 1980 | 1985 | 1990 | 1995 |
| Confluence of the Bija and the Katun river – Ust-Charyshskaya Pristan | 114/108 | 75 | 80/100 | 100 | 120 | 135 | 145 | 130 |
| Ust-Charyshskaya Pristan – Barnaul | 132/126 | 105 | 130 | 130 | 130 | 135 | 145 | 130 |
| Barnaul-Kamen-na-Obi | 251 | 130 | 150 | 150 | 165 | 170 | 170 | 140 |
| Kamen-na-Obi-Novosibirsk lock | 182 | 130 | 265 | 265 | 265 | 265 | 265 | 265 |
| Lower approach channel – the Tom river estuary | 302 | 150 | 170 | 230 | 250 | 250 | 250 | 230 |
| The Tom river estuary – Sosnino | 925/950 | 200 | 205 | 230 | 260 | 270 | 270 | 250 |

The Ob river features all known types of channels characteristic of lowland rivers. Each type of channel develops in a unique way. The section of the upper Ob river, from the confluence of the Biya and the Katun to the Charysh estuary (100 km), is characterized by a braided channel along 74% of its length. The number of channels in the cross section ranges from 8 to 10. The first 50 km of this section with a min. width of 2.5 km are characterized by two parallel flows (streams) of similar water volume (the Biya stream with clean water, flowing along the right bank, and the Katun stream containing a large amount of suspended load and running along the left bank). The braid bars (islands) are associated with the area of increased accumulation in the central part of the riverbed, while large riffles and meander bars are formed at the left bank. The channel along this section is very unstable, because of the rapids present in the longitudinal profile of the river channel at the place where the Katun and the Biya leave the foothills and enter the lowlands. This causes a sudden change in the structure of the bedload – from gravel, pebbles and cobbles to sandy bed material. The described section of the Ob river features parallel braided channels – the most complex type of branching. The process of formation of this type of channel began in the 1940s. In the late 19th and the early 20th century, the flow in the right channel (branch) ceased in this section of the river and the main flow was channelled into the left-hand branch. It was then that the upstream Fominsky junction was formed, and two new downstream branches were formed every 20 years. This type of branching is the most difficult to straighten. The survey of the channel helps to identify the trend in the development of river branches and to develop the general direction of the navigation routes, mainly in the right-hand branches. The first such adjustment was carried out at the Fominsky junction, where the navigation route was moved after the improvement works, which consisted mostly in dredging and the construction of a dam and a large bypass channel. At present, this section of the river develops in the form of a single channel, and the bifurcation processes have ceased.

Downstream of the 50th km, groups of braid bars (islands) are located along the opposite banks of the river (a river stretch with alternate unilateral branches). Downstream of the 70th km, the main flow is concentrated in one winding channel, while other channels are shallow and form multiple floodplain branches. This area is characterized by redistribution of the flow between the adjacent branches and stabilization and displacement of meanders of the main stream of the river. Changes of the channel occur with a 20–30 years delay at each downstream point in relation to the upstream one. The erosion rates on steep river banks vary from 5.5 to 11.8 m per year, with the maxi-

mum of 15–25 m. Due to frequent shifting of the stream dynamic axis, intensive erosion is concentrated in particular sections along the main channel and is not observed in secondary channels. The volume of the material entering the river amounts to 40,000 $m^3$ per 1 km of the channel. This section is characterized by a high rate of lateral movement of the channel (200–500 m/year), which results in a high transformation rate of meander bars and braid bars, most of which are less than 30–40 years old. Shortly before the economic crisis, however, it was possible to transform some of the riffles through the extraction of the material and the construction of reinforced dams, so that the former would not be obstacles to navigation. The effect of the channel straightening is visible in this section even after 25-30 years, despite the fact that a large number of dams require repair. Therefore, we can conclude that the method of channel management was correctly chosen for this particular type of riverbed.

Along a 200-km stretch from the Ust-Charyshskaya Pristan (marina) to the village of Buranovo, the channel is also braided (70% of the section length), and the main stream runs along the left bank, which is 80–100 m high. The engineering works in this section were carried out based on the principle of the "main bank" that was introduced by N.I. Makkaveev. According to this principle, the navigation route is calculated in such a way as to be as close to a high bank as possible. This section of the Ob River is characterized by certain features that require special attention during engineering works related to the river channel straightening, i.e. the river bank is composed of loess deposits, which entails frequent landslides that may cause the mainstream to shift to the opposite bank. The width of the channel (0.4–1.4 km) is smaller here compared to the upstream site, and the stability is 1.5–3 times higher. The flow here is channelled in the left arms of the river, islands are formed near the right bank; they are consolidated and usually grow in length. For 15 years, the Shipunovsky island has grown by 3 km and a group of small islands near the village of Vyatkino merged during 20 years into one island of 6×1.5 km. Moreover, a sand dune located on the right bank of the river has been overgrown with vegetation and stabilized. Over the last 20 years, the area of channel forms protruding above the water surface and not covered with vegetation has been reduced. In addition, due to the eolian transport of sand material, the right side of the riverbed become shallower and moved to the left, i.e. towards the high river bank. The average rate of its destruction is 0.3–0.5 m per year; but even at this rate, more than 1.7 million $m^3$ of fine loamy and silty material is delivered to the channel and increases the suspended load transported downstream by 30%.

In the 50 km long section between the village of Buranovo and the city of Barnaul, the 250-400 m wide river channel meanders without any restrictions. Longitudinal and lateral movements of meanders have been observed, with an average rate of bank erosion about 10 m per year and a maximum of 30–90 m per year. In Barnaul and its suburban area, more than 60 industrial facilities (berths, water intakes, power transmission lines, bridges, water areas, dams, settlements, garden plots, drain tunnels) located in the channel and on the river banks were monitored. Most of the facilities were found to be situated in ineffective locations, disregarding the channel evolution. As a result, the sustainable operation of the structures is limited and the facilities have a negative impact on the channel. The construction of a new motorway bridge has intensified horizontal and vertical deformations, which compromised the stability of its piers and led to the activation of landslides on the left bank of the channel. The railway embankment increases the flooding of the village of Zaton and the dockyard; most of the village is flooded, even in years of moderate humidity.

Along a 130 km river section from the Barnaul town to Ilyinsky gorge, the river also flows along the left upper valley side, moving to the right side of the valley near the Gonby village and the mouth of the Chumysh river. This section is dominated by a single channel, sometimes with adjacent branches or a single strait. Active deformations are local.

The 113 km stretch between Ilyinsky gorge and the town of Kamen-na-Obi is part of the backwater zone of the Novosibirsk dam reservoir. The largest range of the backwater zone (up to the village of Sibirka) is observed at the end of a flood event, when the reservoir is filled up to the NWL. The channel is mainly mean-

dering, with steep bends, which in the natural state were characterized by intense lateral displacement – up to 20-50 m per year. Simple branches are rare. After the construction of the reservoir, the rate of bank erosion has been reduced, the channel has become straightened and the high water content has been preserved in old channels. The floodplain on this reach is regularly flooded to a great depth. In the 1990s, changes of the Taradanovskaya meander were studied, as they cause a risk of erosion of the Kamen-na-Obi-Barnaul railroad. The 30-40 m high bank of the sandy terrace retreats at this point at a rate of 50 m per year. At present, the most difficult area for navigation are the Shelabolikhinsky Rifts.

Over the 300 km section of the middle Ob river, between Novosibirsk and the mouth of the Tom river, single and complex branching predominates (64% of the section length), however, a simple, undivided channel dominates over large sections of the river along with unconstrained and constrained bends. The floodplain is well developed and consists of narrow (0.5-2 km) and wide sections (up to 22 km), which is determined by the geological structure of the valley. After the construction of the hydropower station, the degree of the channel branching decreases, a number of secondary channels disappear, the islands are merged into large forms, and the flow is concentrated in the main branches. In some areas, a process of transformation into a meandering channel is observed. Along the 35 km section downstream the dam, the channel has partially transformed into a straight unbranched channel. After the construction of the hydroelectric power plant, the erosion of the banks at the dam site occurred on the right bank and ranged from 100 to 450 m and on the left bank – from 20 to 260 m. The average rate of bank erosion in this section is 3-6 m per year. The maximum erosion rates – up to 15-24 m per year – are recorded on the islands and within the developing branches, along which the mainstream is moving. At the distance of 100 km from Novosibirsk, there is an area referred to as "goose riffles" (19 km), which is a system of adjacent branches, consisting of three islands. The riffles on this section were among the most difficult ones, requiring a large scale of dredging. The section was straightened according to eight river principles and since then the site no longer prevents the navigation. At the same time, a quarry was developed in the upper part of the dividing channel, in the non-navigable right arm, behind the constructed dam. At present, the depth of the quarry is 12 m.

Before the engineering works on the river course had been started, braid bars were the dominant forms of the riverbed. At the present, detached meander bars play an important role; they are located in the wide arms, arranged in a mosaic pattern. They move at a rate of 70-150 m per year.

After the construction of the hydroelectric power station, braid bars have been stabilized by vegetation, including shrubs, developing on the floodplain, especially in the secondary branches.

In the remaining section of the middle Ob (between the mouth of the Tom river and the Irtysh mouth, 1,500 km) and in the downstream section of the Ob (1,160 km), the river channel is mostly meandering. Numerous fragments of the former river channel and its meanders occur over a large part of the floodplain. In the upstream part of this section, riffles requiring regular dredging occur. Significant changes in the channel pattern occur along the main Ob river channel, up to the Chulym river mouth. They are mostly associated with the development of meanders. Branching is rare in this area, except the section from the Tym estuary to Sosnino, where systems of islands and bars are formed.

In the downstream reaches, for 300 km along the right side of the valley (Belogorsky Mainland), the Ob flows in a straight channel with single branches, and further downstream it is divided into two slightly inclined branches (Bolshaya and Malaya Ob), separated by an island of 30-40 km width. A wide floodplain with numerous old channels has also developed in this area. The width of the floodplain varies from 30 to 50 km. In the lower reaches of the Ob, the rates of horizontal deformations are significant: the average rates of erosion of concave banks of meanders are 5-15 m per year, with the maximum of 20-35 m per year. The meanders quickly evolve from gently inclined into meanders with a large radius of curvature, while their straightening is rarely observed.