The main formative material of bay's estuarial abrasion-accumulative jumpers and it's interconnection with the lithological composition of Volgograd reservoir coasts

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Abstract. The article contents results of the data compilation of lithological composition of Volgograd reservoir coasts. The interconnection between the main formative material of bays estuarial abrasion-accumulative jumpers and lithological composition of reservoir coasts was revealed. The principal differences between the material of bays jumpers and lithological composition on the right and the left coasts were determined in this research. An electronic thematic layer "The lithological composition of the coasts of the Volgograd reservoir" was created and the attribute table of this layer was filled. We determined that volumes of bays of the Volgograd reservoir decreased significantly from 1988 to modern time.

1. Introduction
The process of destruction of the coasts of large flat reservoirs including derivative processes of alongshore transport and sedimentation of destruction products remains one of the most actual today. Alongshore transport of sediments initiated a derivative process. It is the complete or partial separation of bays from the main water area of the reservoir. To date, studies devoted to the issues of modern sediment accumulation in the coastal zone of reservoirs, and even more so to the study of abrasive-accumulative jumpers (AAJ) in the entrance gates of the bays, was held relatively little [2-10, 13-15 and etc.]. Their number is significantly inferior to the number of scientific papers on the reshaping of the coasts. However, the question of the time-space features of the movement and accumulation of sediments in the coastal zone of large flat reservoirs today for scientists and practitioners is becoming one of the most discussed. Relatively stable accumulative bodies are formed in the immediate vicinity of the coast as a result of the material transfer process [5].

The process of overlap of bay's entrance gates by abrasion-accumulative jumpers (AAJ) is actively moving on the Volgograd reservoir. The detachment of small bays from the main water area began even when the bowl of the reservoir was filled to the normal retaining level [6, 17] and it is actively continuing at present. Now, more than half (58% of the total) of right and left coast's bays relate to closed bays and bays at the final separation stage.

The Volgograd reservoir is one of the largest flat river channel reservoirs of the world and Russia. It was formed at the same time with the construction of a hydroelectric dam on the Volga River near the Volgograd city in 1958. The geological structure and relief of the coasts of the reservoir create
favorable conditions for the development of processes of their re-formation. The dense rocks (sandstones, opoka) prevail in the structure of the right coast, this rocks is resistant to destruction of the coasts of the reservoir, and there are less dense and younger sedimentary rocks (loams, sandy loams, sands) in the slopes of the left coast [4].

The first information about the formation of abrasion-accumulative jumpers in the entrance gates of bays within this reservoir we find in the works of 1964 [17] and 1976 [6]. Note that the bays within the Volgograd reservoir are numerous. Most of them are the estuarial ravines and beams bring flooded by the waters of the reservoir [5, 6].

The bays are important for the Volgograd reservoir's ecosystem. First of all, it is a part of the feed base, spawning areas, feeding young hydrobionts and the ecological environment of their habitat. Hydrobionts, inhabiting the bays, turn out to be separated from the main their habitat (the channel-valley hollow of the reservoir) as a result of the formation abrasion-accumulative jumpers. The bays lose the opportunity of water exchange with the main water area of the reservoir, water quality indicators are degenerating there. Own limnic type ecosystem with predominance of organogenic siltation and increasing signs of waterlogging begins to form inside the bay. At the same time, the ecosystem of the main part of the reservoir, losing direct aquatic connection with a bay, lose a trophic links and a number of environmental conditions, providing integrity and quality level of the ecosystem.

It should be noted that climatic conditions of the Volgograd reservoir are characterized by small annual amounts of precipitation (on the average 340-380 mm). Spring runoff at the channels of ravines and beams bring in bays some volume of sediments, also contributing to the accumulation it on the already-formed jumpers in the bay's entrance gates of the reservoir. Small rivers on the coasts of the reservoir have a constant drain permanent stock during the whole year. However, the drain module of even permanent watercourses is not sufficient for destruction of the abrasion-accumulative jumpers already formed.

The formation AAJ on the bay's entrance gates depends not only on the speed and way of current, frequency and repeatability of storms, the morphometric parameters of the bays themselves, but also on the lithological composition of the rocks that form the coasts of the Volgograd reservoir. Note that some differences in the mechanism of formation AAJ on the right and the left coasts of reservoir exists. In the present research we analyzed the composition of the main formative material of jumpers and lithological composition of Volgograd reservoir's coasts.

2. Materials and methods
We determined the lithological composition of different parts of the right and left coasts of the Volgograd reservoir, based on studies of the geological structure and lithological composition of the banks of the Volgograd reservoir in the researches of E. Milanovsky [11], A. Baranova [2, 3], F. Zubenko [3, 18], Je Radchenko [3, 16], A. Sidorenko [17]. We compared results of this analysis with natural archive materials of the educational and scientific laboratory of environmental and social researches of the Volzhsky branch of the federal state autonomous educational institution of higher education "Volgograd State University". This material was received in the expeditions of the project "Volzhsky floating university" (2010-2016) and when it was doing research on grants (2008-2009).

Archive data include information about the main formative material of AAJ of some representative bays on the right and the left coasts of reservoir. The composition of formative material was determined visually, according to study in [12], and did not cover sediment particles smaller than a coarse fraction of dusty particles (0,05-0,1 mm). Smaller fractions do not participate in the construction of the coastal shallows. And, presumably, it also does not participate in the construction abrasion-accumulative jumpers. We studied not only formed jumpers, but we also research actively formation AAJ.

The electronic thematic layer "The lithological composition of the coasts of the Volgograd reservoir" was created in the QGIS 2.18 program and the attribute table of this layer was filled.
3. Results and discussion
The table 1 contains results of research of the main formation material of entrance gates AAJ in comparison with the lithological composition of the coasts of the Volgograd reservoir.

Sandstones, including opoka-like and siliceous sandstones, opoka-like clays, dark grey and yellowish gray opoka prevail in the lithological composition of the right coast of the Volgograd reservoir (57.50 % of the length of the studied part of the coast). Loose quartz sands with bands sandstones and thin seams of brown clay come out to the reservoir in some regions of coast. Opoka and quartzite, glauconitic sandstones are located under them (6.67 %; from the south of the Shcherbakovskyj bay to Trubino village, from the north of the Strel'nyj bay to the north of the Rostovyj bay and etc.). The main formative material of jumpers is all fractions of pebble and all fractions of gravel, large dust particles, less often, it is all fractions of a sand.

| Name of the bay | The main formative material of jumper in the entrance gates | The lithological composition of the coast to the north of bay's entrance gates |
|----------------|------------------------------------------------------------|----------------------------------------------------------------------------|
| Bannyj, Korotkij Lipovoj, Dlinnyj Lipovoj, Ternovka, Suhaja Rechka, Verhnij Urakov, Nizhnjaja Dobrinka, Drugalka, Galka, Bol'shoj, Bajdakov ovrag, Mostovoj | All fractions of a pebble (10-100 mm), all fractions of a gravel (1-10 mm) | Sandstones, including opoka-like and siliceous sandstones, opoka-like clays, dark grey and yellowish gray opoka |
| Rostovyj, Shcherbakovskyj, Danilovskij, Bay in 0.3 km to northwest from Danilovskij bay | All fractions of a pebble (10-100 mm), all fractions of a gravel (1-10 mm), less often - all fractions of a sand (0,1-1 mm) | Loose quartz sands with bands sandstones and thin seams of brown clay come out to the reservoir, opoka and quartzitic, glauconitic sandstones are located under them |
| Vodjanaja balka, Krestishhenskaja balka | Sand of all fractions (0,1-1 mm), gravel of all fractions (1-10 mm), small pebble (10-20 mm) | Loose ore weakly compacted sands and sandstones with thin seams of clays |
| Zharkova, Suvodskij Jar | Coatse and medium sand (0,2-1 mm), large dusty particles (0,05-0,1 mm); sometimes it is small and medium gravel (1-5 mm) | Saratov sands with loaves and kamysin beds (below: bluish gray sand-micaceous clay, above: white sands) |
| Borikov, Tomatnyj, Jablonovoj | Sand of all fractions (0,1-1 mm), large dusty particles (just about 0,05-0,1 mm) | Different fractions of sand, sandy loams, clayey sands |
| Mordovskij (Morozovskij) | Clayey particles, dusty fractions (dimension was not determined) | Khvalynskie chocolate clays |
Loose ore weakly compacted sands and sandstones with thin seams of clay are registered in the lithological composition of rocks in some regions of the right coast (6.63 %; from Gornovodjanoe village to Krestishhenskij protrusion and etc.). All fractions of a sand dominates on formed jumpers in bay’s entrance gates, located to south similar regions; small pebble and gravel, large dust fractions also are registered.

The coast is complicated by saratov sands with loaves and kamyshin beds, approximately from the Zharkova draft to south end of Aleksandrovskij fault (1.34 %; below: bluish gray sand-micaceous clay, above: white sands). All fractions of a sand and large dust fractions are dominated in the composition of jumpers in this region; gravel occurs in a less degree.

Khvalynskie chocolate clays, loams, sands sometimes are found in the shorefaces near the bays, (16.74 %; to the south of Nizhnjaja Dobrinka village, to the south of Ternovka village, to the south of Urakov Bugor; on the region: from the nouth of Vihljanceva bay to the north of Kamyshin town). The formative material of jumpers is a large dust fractions: it is a gravel in a less degree.

Prolean beds with light gray and greenish dense quartzitic-glauconitic sands are registered near Antipovka village, but these sands are compacted to loose sandstones in separate regions (7.94 %). Here, the main material in the jumpers will sand, dusty fractions, but this material is gravel in a less degree.

Siliceous white marls, santon siliceous sandstones come out to reservoir on the region of right coast from Trubino village to Morozovka River (2.83 %). The formative material of AAJ will dusty fractions, gravel, pebble.

**Table 2.** The total length of regions of Volgograd reservoir coasts of different lithological composition of the rocks.

| The coast, the lithological composition of the rocks | The total length of regions (km) |
|---------------------------------------------------|---------------------------------|
| The right coast, sandstones, including opoka-like and siliceous sandstones, opoka-like clays, dark grey and yellowish gray opoka | 203.62 |
| The right coast, loose quartz sands with bands sandstones and thin seams of brown clay come out to the reservoir | 23.95 |
| The right coast, loose ore weakly compacted sands and sandstones with thin seams of clays | 23.48 |
| The right coast, fine clayey quartz-glauconitic sands and siliceous-clay sandstones | 28.11 |
| The right coast, saratov sands with loaves and kamyshin beds (below: bluish gray sand-micaceous clay, above: white sands) | 4.74 |
| The right coast, thin-layered chocolate, brown and gray clays, there are seams of sands, loams opoka in some regions | 59.28 |
| The right coast, green senomanic sands | 0.91 |
| The right coast, siliceous white marls, siliceous sandstones | 10.02 |
| The left coast, sands | 48.66 |
| The left coast, sandy loams, loams, sometimes sands and outcrops of khvalynskie chocolate clays are registered here | 182.92 |
| The left coast, khvalynskie chocolate clays | 106.59 |

The left coast of reservoir is folded by sandy loams (54.02 % of the length of the studied part of the coast) of the length of the studied part of the coast), different sand fractions (medium and fine sand, 14.39 %), the coast is folded by loams to a much lesser extent. Outcrops of khvalynskie chocolate clays are registered on a considerable length of left coast (31.52 %; regions from the south of Tomatnyj bay to entrance gate of Eruslan bay; from Bykovo village to Molchanovka village; from the north Peschanij bay to Jablonovvj bay and ect.). The main formative material of AAJ is sand, dusty
fractions; sometimes, it is clayey particles (on jumpers of bays, located to the south of outcrop of khvalynskie chocolate clays).

Figure 1. A fragment of the attribute table of an electronic thematic layer "The lithological composition of the coasts of the Volgograd reservoir".

Table 3. The volume changing of the some representative bays of the Volgograd reservoir.

| Name of the bay (bay’s separation year) | The material of jumper (in the entrance gates) | Bay’s separation year | The volume is calculated by the Atlas of 1988, (m$^3$) | The modern volume (m$^3$) (year of research) | Volume change (number of times) |
|----------------------------------------|-----------------------------------------------|-----------------------|------------------------------------------------------|-------------------------------------------|-------------------------------|
| Dlinnyj Lipovyi                         | Coarse pebble, gravel of all fractions, ultigino us fractions of sediments from the side of the bay | 2006                  | 40287.6                                             | 15167.9 (2016)                           | 2.7                           |
| Korotkij Lipovyi                        | Medium pebble, gravel                          | 1991                  | 21545.2                                             | 2080.76 (2016)                          | 10.4                          |
| Zharkova                                | Sand of all fractions, large dusty particles   | until 1986            | 6617.7                                              | 2080.07 (2016)                          | 3.2                           |
| Rostovyi                                | Pebble, gravel                                 | 1995                  | 20855.1                                             | 17597.07 (2013)                         | 1.2                           |
| Drugalka                                | Coarse pebble, gravel                          | 2017                  | 76188.8                                             | 55460.28 (2015)                         | 1.4                           |
| Bol’shoj                                | Pebble, gravel, sand of all fractions. Outside flange of jumper is folded of coarse pebble | 2006                  | 343405.8                                            | 124467.46 (2014)                        | 2.8                           |
| Mostovoj                                | Pebble of all fractions, gravel                | 1991                  | 10901.6                                             | 2464.17 (2014)                          | 4.4                           |

The total length of regions of Volgograd reservoir coasts of different lithological composition of the rocks are contained in table 2.
An electronic thematic layer "The lithological composition of the coasts of the Volgograd reservoir" was created after the conducted research. The created layer allows to visualize the lithological composition of the coast on the map. A fragment of the attribute table of the resulting layer is shown in figure 1.

The volume of some representative bays was calculated in this research in the geoinformation system. We used maps from "Atlas of a single deep water system of the European part of the RSFSR. The Volga River. From Saratov waterworks to Astrahan", 1988 [1] and data of our natural researches for 2013-2016. The analysis introduce a decrease in the volumes of closed bays by 1.2 times (Rostovyy bay) and even by 10.4 times (Korotkij Lipovyj bay). The results are led in table 3. These bays were separated after 1988 (except the Zharkova bay).

4. Conclusion
1. As a result of performed researches was found, that there is a relationship between the composition of the material of the abrasion-accumulative jumpers and the lithological composition of the rocks of the coasts of the Volgograd reservoir.

2. The right coast of the reservoir, mainly folded by sandstones (including opoka-like and siliceous sandstones), opoka-like clays, dark grey and yellowish gray opoka, supplies pebble and gravel of all fractions, large dusty fractions to the estuarial AAJ. Presence of sand on the jumpers is determined by loose ore weakly compacted sands and sandstones with thin seams of clays in the composition of the coast. The number of fine particles on the bay's jumpers of right coast is very slightly (according to visual observation).

3. The left coast of the reservoir is composed by sandy loams, different fractions of sand, and, it is composed by loams to a much lesser extent; outcrops of khvalynskie chocolate clays are registered on a considerable length of left coast. The left coast supplies on the AAJ, basically, dusty particles (with a prevalence of small fraction); it is sand of all fractions, in a less degree, sometimes it is clayey particles.

4. The revealed relationship between material composition of abrasion-accumulative jumpers and the lithological composition of rocks of the Volgograd reservoir coasts will allow to proceed to the classification of the estuarial bay's jumpers according to the mechanism of their formation and composition of the main formative material.

5. As a result of present research was determined, that volumes of bays of the Volgograd reservoir decreased significantly from 1988 to modern time.

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