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Formation of a New Delta-Like Object in the Kapchagai Reservoir on the Ili River

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Abstract—The formation processes of a new delta-like object with a hydromorphic landscape in the upper part of the Kapchagai Reservoir on the Ili R.—an internal delta—are considered. The quantitative characteristics of the development of this delta are evaluated using data of Landsat-2, 5, and 7 space images over period 1975–2012. These processes were found to accelerate considerably in the wet year of 2012, and intense underflooding and salinization of nearby lands were revealed in the Chilikskii alluvial fan on the southern wing of the Kapchagai delta. A consequence of this accumulative process was found to be the development of planar channel deformations of the Ili R. 30 km upstream the Kapchagai delta.

Keywords: delta, reservoir, landscapes, space images, channel deformations
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PROBLEM FORMULATION

The environmental effect of reservoirs has been a subject of comprehensive studies [1, 4, 8, 9, 11]. However, the formation of delta-like landscapes at the river inflow into a water body has not receive sufficient attention, especially, when the river sediment runoff is high. Previously, this process was mostly considered from the viewpoint of water body silting and a decrease in its capacity [1, 2, 5, 10]. However, it proved to be much more diverse, complex, and important for nature development, increasing the biodiversity, and preservation of the environment. In the majority of large reservoirs in the world, especially in arid, subarid, and subhumid regions, new (internal) deltas with peculiar vegetation and soil cover and with rich fauna form during the period after their construction [9]. This is due to the conditions typical of delta-formation processes that develop at the site of river inflow into a large reservoir [3]. The result is the formation of new relief forms because of the presence of hydrophilous plants and the accumulation of organic matter; that is, hydrological–morphological processes are taking place, leading to the formation of delta-like objects, which the author (conventionally) called "new (internal) river deltas." The author has studied such large-scale processes in the water bodies of the Dnieper chain [5, 7], in the Kapchagai Reservoir on the Ili R. [6] (Kazakhstan), and in many reservoirs in the Central Asia.

MATERIALS AND METHODS

The object of the study is the large (28.1 km^3) Kapchagai Reservoir [4] in the Ili R., which originates in China and empties into Balkhash L. in Kazakhstan [8]. Ground studies of the environmental effect of the water body were carried out in 1976–1990 [4], after which Landsat space images with 30-m resolution over 1975–2012 from NASA open archives were analyzed with the use of special software. The images were interpreted with the use of ISODATA algorithm, and the combination of channels 7–5–3 was used to visualize the images. The chosen images were made in July and August, when the reservoir was filled.

RESULTS AND DISCUSSION

Studies [6, 7] showed that about 11 million t river sediments [4] and the products of shore abrasion and organic sediments accumulated every year in the upper part of the reservoir. They formed islands with peculiar hydromorphic landscapes. Increasing and merging, experiencing transformations, and overgrowing with plants, these islands started forming delta-like land, which the author called "Kapchagaiskaya delta." This process was not uniform and depended on the river runoff variations, reservoir level oscillations, and other factors. The mean increase rate of Kapchagaiskaya delta area until 2009 was ~200 ha/year (Table). Landsat space images were used to analyze the formation of this delta over time and space (Fig. 1). The further studies showed that the area increase rate of the delta-like objects increased in the

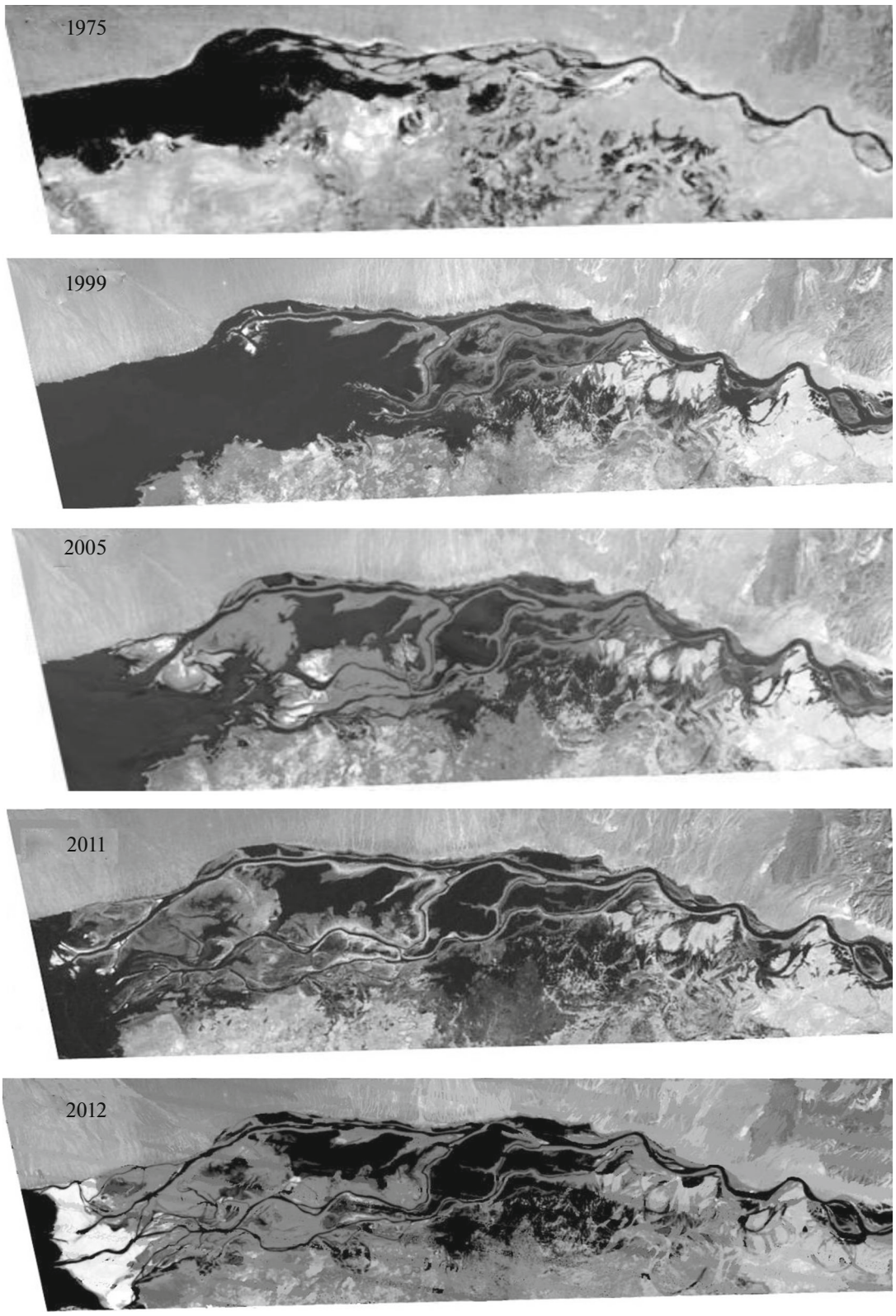

Fig. 1. Formation dynamics of the Kapchagai delta over 1975–2012.

Rate of area increase in the Kapchagaiskaya delta over 1979–2012

Image date	Area of delta hydromorphic landscapes, ha	Area increment, ha	Increase rate, ha/year	Examined reservoir area
1979	436.1	–	–	11775.9
July 31, 1999	2836.1	+2400.0	120.0	11775.9
June 21, 2005	5782.9	+2946.8	491.1	11775.9
Aug. 27, 2009	6497.3	+714.4	178.6	11775.9
Aug. 27, 2012	8165.8	+1668.5	556.2	11775.9
Entire period (1979–2012)	8165.8	7729.7	234.2	11775.9

recent, relatively wet years (2010–2012) and reached 556.2 ha/year. The mean rate of Kapchagaiskaya delta formation all over the observation period (1979–2012) was 234.2 ha/year. In addition, an earlier Landsat-2 image was found in NASA archive for 1975 (Fig. 1).

The forming objects generally follow the regularities of the lithogenesis, morphogenesis, and soil formation in deltas. Bog and meadow-bog soils under reed and cattail overgrowths dominate in the soil cover [6]. Aquatic plants cover considerable shallow areas. Meadow–gray soil and meadow saline soils can be seen only on islands remained not inundated during reservoir filling (Fig. 1, 1975).

An important consequences of delta formation in the upper part of the Kaphcagai Reservoir is the rise of land elevation and an appreciable underflooding and inundation of lands on the periphery of the alluvial fan of the Chilik R., which is adjacent to the southeastern part of the coast, as can be seen in Fig. 1. The result is the swamp formation and salinization of lands that were used in agriculture.

Even more dramatic changes have taken place in recent years in the Ili R. channel upstream of the Kapchagaiskaya Delta because of the development of planar (horizontal) channel deformations [2]. Over a distance of up to 30 km, river banks suffer erosion and large water bodies form in relief depressions (Fig. 2). This process, hazardous for the entire riverine infrastructure, have manifested itself at a distance of 10–13 km.

CONCLUSIONS

A delta-like object (Kapchagaiskaya Delta) is forming in the upper part of the Kapchagai Reservoir at a rate of 234.2 ha/year, and this rate started increasing in recent years.

The formation of this object causes land underflooding in the southern coast (Chilikskii alluvial fan).

Horizontal deformations of the river channel develop upstream of the Kapchagaiskaya Delta, with the formation of new water bodies in relief depression within a distance of up to 30 km.

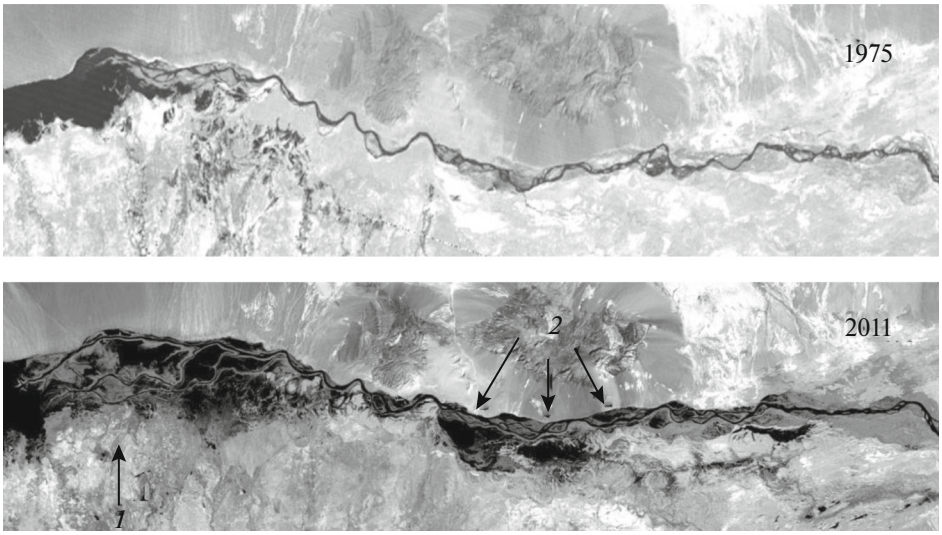

Fig. 2. Horizontal deformation of the Ili R. channel ((*1*) Kapchagaiskaya delta, (*2*) newly formed water bodies along river channel).

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