Short communication

ISSN 2658-3518
LIMNOLOGY FRESHWATER BIOLOGY
www.limnolfwbiol.com

The Anthropocene evolution of the Aral Sea ice gouging derived from the bottom topography

Maznev S.V.*

Lomonosov Moscow State University, Leninskie Gory 1, Moscow, 119991, Russia

ABSTRACT. Ice gouging landforms on the exposed bottom of the Aral Sea give a possibility to get a profound knowledge about processes of the ice-bottom interaction during the level fall. We analyzed ice scours in the different parts of the Aral Sea using geomorphological and remote methods and evaluated the paleoreconstruction of ice gouging processes in the Anthropocene.

Keywords: level change, ice scours, ice ridges, geomorphological methods, remote sensing

1. Introduction

The Aral Sea is a partly freezing, drainless lake located in the deserts of Central Asia. Its level fluctuated during the Pleistocene-Holocene history, but in the second part of the XX century it dropped dramatically due to the human impact. Using satellite images, we found landforms of ice-ground interaction on the exposed bottom of the Aral Sea (Maznev et al., 2019). Nevertheless, the age of these landforms is currently unknown. Therefore, the study aimed to reconstruct the evolution of the ice gouging processes and landforms during the second part of the XX – beginning of the XXI centuries.

2. Materials and methods

To study the exposed topography on the vast territory of the former bottom, we used satellite images of ultra-high resolution from public sources Yandex.Maps (https://yandex.ru/maps), Google Maps (https://www.google.ru/maps), Bing Maps (https://www.bing.com/maps), ESRI World Imagery (https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9)) derived from satellites WorldView, QuickBird, IKONOS and GeoEye of Maxar Technologies Company.

We estimated the age of the scours, compared ice gouging conditions and defined factors influencing the localization of different intensities of effects in this work. We used a complex of analytical approaches including the historical-genetic method, comparative geographical analysis and others. We supposed that the zone of the most intensive ice gouging was located at a depth of 2-5 m by the analogy with the Caspian Sea (Ogorodov et al., 2020). For reconstruction of ice-gouging topography evolution, we examined the intersections of certain scours with paleocoastlines. The ancient coastlines are known from satellite images deciphering (Kravtsova and Tarasenko, 2010). In this way, we have a depth of the ice gouging event that happened in a year(s) when the Aral Sea level was 2-5 m higher. We analyzed many such intersections in different parts of the Aral Sea to reconstruct events for several time intervals.

3. Results and discussion

We suppose that exposed ice-gouging topography was formed at the last stage of the bottom evolution, immediately before and during the degradation of the Aral Sea. A similar topography was formed during the Pleistocene-Holocene in epochs with similar climatic conditions. Under various conditions, from the Arctic to the subtropics, the ice-gouging microrelief can persist for different times depending on local conditions (Maznev and Ogorodov, 2020). At the Aral seabed due to sedimentation and other lithodynamic processes such a topography could not be preserved at the bottom for a long time. Thus, these landforms refer to the second half of the 20th century when the level of the Aral Sea began to fall.

In 1960, before the level dropped, the ice ridges affected most intensively the coastal parts of the Aral Sea and the area of the central rise. Now, we see the most significant number of the scours are located at depths of 15–25 m relative to the 1960 level. Probably, they were formed when the sea depth was 2–5 m in these areas. By that time, the sea level had fallen by 10-20 m and was about 33-43 m a.s.l. Such a level in

*Corresponding author.
E-mail address: maznev@geogr.msu.ru (S.V. Maznev)

Received: May 25, 2022; ***Accepted:*** July 28, 2022;
Available online: September 02, 2022

the South Aral Sea was observed from the early 1980s to the early 2000s.

During the level drop, the zone of the most intense ice impacts and, accordingly, ice scours formation shifted along with the coastline. These zones gradually moved to the middle of the Eastern and Western Aral and then merged in the central part of the basin.

The scours concentrate mainly not in the central and deepest part of the water area but near the 1996-2002 coastline. The most intense ice gouging zone came here from the east coast in the late 1980s – mid-1990s.

Thus, we assume the following reconstruction of the ice-gouging topography formation at the Aral seabed. Until the early 1970s, the level fall was not fast enough to change ice processes. The scours did not preserve for several years; they were washed out and covered with sediment. Scours of this age are almost not present in modern topography. From the beginning of the 1970s, the level drop rate increased, and the newly formed scours did not fill with sediments. As a result, areas with a relatively high concentration of ice scours were formed. Since the mid-1980s, the shrinking of the water area and the decrease in the heat content made the ice conditions severer. At this time, the main mass of ice scours formed. In the 1980s – 1990s, ice scours formed in areas framing the central part of the Eastern Aral from all sides. By the end of the 1980s – mid-1990s, the zone of the most intense ice effect, shifting from the eastern and western shores of the Eastern Aral, reached its central part. At that moment, the conditions for the formation and preservation of the ice-gouging topography on the seabed were the most favorable. The ice scours were forming on vast areas of the flat bottom of the central Aral Sea basin with 10 m depths (at the beginning of the period). Ice conditions during that period were still relatively severe, while weak hydrodynamic activity in the shallow water area led to the good preservation of landforms. From the mid-1990s to the mid-2000s, the intensity of ice impacts decreased. In the late 2000s, the waters of the Eastern Aral became hypersaline, ice formation became fragmented, the reduced area of the reservoir prevented ice ridging, and the gouging almost stopped.

The period of the 1980s-1990s is highlighted by the highest intensity of ice impacts when drifting ice could affect the most extensive areas of the bottom. Conversely, the period of the 1960s is characterized by the least intensity when stable fast ice protected the coastal zone from effects. Such a timescale of impacts reflects the age distribution of ice-gouging landforms at the Aral seabed.

4. Conclusions

The ice scours on the former bottom of the Aral Sea are a geomorphological relic due to the unique conditions in the disappearing sea. The level drop led to ice impacts acting almost overall former water area. At the same time, the reworking of the upper part of the sediments over a large area of the former bottom shows that such processes should be considered in paleolimnological studies in lakes with fluctuating levels. In all freezing water bodies at shallow depths, sedimentary layering can be disturbed, sediments can be mixed, which complicates the reconstruction of paleolimnological events.

Conflict of interest

The author declares no conflict of interest.

References

Kravtsova V.I., Tarasenko T.V. 2010. Space monitoring of Aral Sea degradation. Water Resourses 37 (3): 285-296. DOI: 10.1134/S0097807810030036

Maznev S.V., Ogorodov S.A. 2020. Impact of ice formations on the shore and bottom areas of shallow seas and large lakes of middle and subarctic latitudes. Led i Sneg [Ice and Snow] 60(4): 578-591. DOI: 10.31857/S2076673420040062 (in Russian)

Maznev S.V., Ogorodov S.A., Baranskaya A.V. et al. 2019. Ice-gouging topography of the exposed Aral Sea bed. Remote Sensing 11(2): 1-25. DOI: 10.3390/rs11020113

Ogorodov S.A., Magaeva A.A., Maznev S.V. et al. 2020. Ice features of the Northern Caspian under sea level fluctuations and ice coverage variations. Geography, Environment, Sustainability 13(3): 129-138. DOI: 10.24057/2071-9388-2020-77