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GR focus review

The fluctuating Aral Sea: A multidisciplinary-based history of the last two thousand years

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ABSTRACT

The Aral Sea (an intracontinental saline lake in western Central Asia) is of great interest because of its rapid shrinkage during the last 50 years, which caused catastrophic environmental and socio-economic consequences for the region and its population. Geoscientists established the existence of similar multiple fast and deep lake level fluctuations in the past; however, a comprehensive picture of these changes has been lacking. In this paper, we summarize published and new geomorphological, sedimentological, paleoenvironmental, geoarcheological, and historical data to reconstruct fluctuations in the Aral during the last two thousand years. Two deep regressions are recognized, in addition to the modern human-induced regression. The regressions occurred at ca. 2.1–1.3 and 1.1–0.35 ka cal BP according to the sedimentary and faunal data, and 2.1–1.45 and 1.0 (0.85)–0.45 ka cal BP according to the archeological and historical data. The Aral Sea lake level dropped to ca. 10 m a.s.l. during the first regression and to ca. 29 m a.s.l. during the second one. Transgressions which separated these periods reached elevations of ca. 52 m a.s.l., and 54 m a.s.l., respectively. According to the current data, the regressions lasted longer than the transgressions, or were of equal duration. Reasons considered for past Aral Sea lake level changes include both natural and human-related causes, as the region features more than 2000 years of agricultural activity.

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1. Introduction

The Aral Sea, an intracontinental brackish water basin shared by Kazakhstan and Uzbekistan, western Central Asia (Fig. 1, A), was formerly ranked as the fourth largest lake on Earth. However, its water

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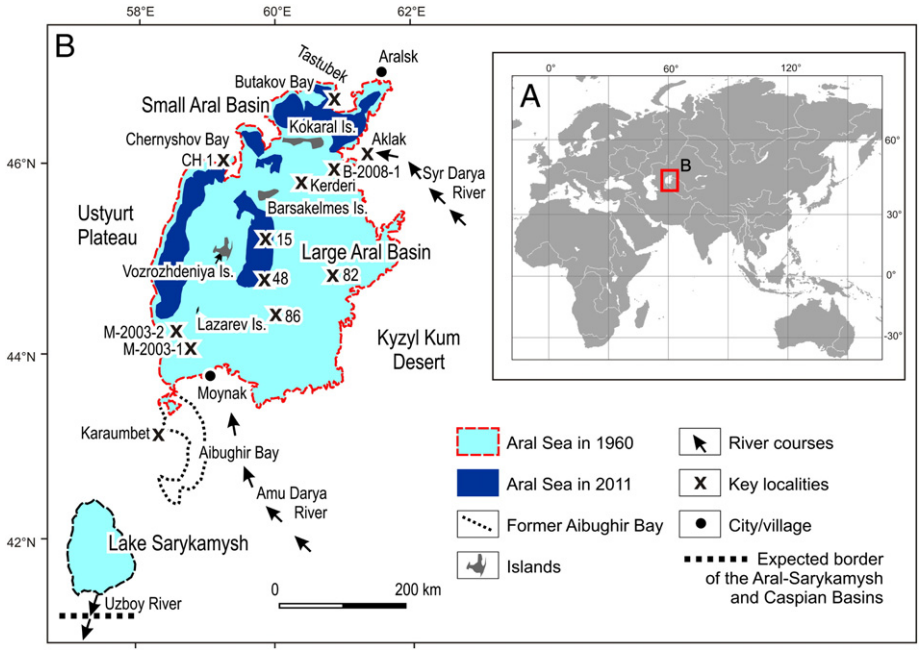

Fig. 1. The position of the Aral Sea: A — overview map; B — location map.

level has dropped precipitously during the last half century (Fig. 2) due to intensive agricultural and industrial water consumption from the Amu Darya and Syr Darya rivers that feed the Aral Sea. Its area and volume are currently ten times smaller than during its recent maximum (Aladin et al., 2009), and they continue to decrease. During this regression, the Aral Sea has become divided into three separate basins: Small Aral, Eastern Large Aral, and Western Large Aral (Fig. 1, B). The drop in Aral Sea lake level has caused persistent catastrophic ecological and social consequences despite numerous international rehabilitation efforts (e.g. Ashirbekov and Zonn, 2003; Micklin and Aladin, 2008; Zonn and Kosarev, 2010).

The modern deep regression is not unique in the Aral's history as early and more recent investigations show. Russian geographer Berg (1908) was the first to show that Aral Sea lake levels varied by 3–3.5 m since AD 1790. Since that study, the Aral Sea maintained a metastable transgressive state until the early 1960s (Fig. 3). Russian philologist Bartold (1902) collected information from historical sources about the Aral Sea from antique times. These data, especially remarks about a Medieval disappearance of the Aral Sea, provide valuable information. Soviet geologists, geomorphologists, and limnologists provided a comprehensive picture of the past Aral Sea changes (e.g., Veinbergs and Stelle, 1980; Kes, 1983; Shnitnikov, 1983; Rubanov et al., 1987), and its progressive desiccation in modern times attracted scientific interest worldwide. These data have been summarized in a series of review papers (Sevastyanov et al., 1991; Aladin and Plotnikov, 1995; Tarasov et al., 1996; Létolle and Mainguet, 1997; Boomer et al., 2000, 2009; Svitoch, 2010; Cretaux et al., 2013). Since then, it has become clear that the Aral Sea is a very young basin, dating to the late Glacial–early Holocene. The Aral Basin was firstly occupied by shallow saline lakes and salt marshes that expanded substantially in the middle Holocene. This change is marked by the appearance of a marine mollusk *Cerastoderma*, which invaded the Aral Sea from the Caspian Sea. During its history, several transgressions and regressions have been recognized (e.g., Boomer et al., 2000). The most prominent regression left peat layers in the central part of the Aral Basin at ca. 1.6 ka ^{14}C BP.

In those studies, determination of sediment ages limited the reliability of paleogeographic reconstructions. Conventional radiocarbon dating of Aral Sea bottom sediments required relatively large amounts of organic and carbonate matters, or mollusk shells. About 70 published ^{14}C dates for the Aral Basin (summarized in Krivonogov et al., 2010b) reveal ambiguities that call into question their reliability (Rubanov et al., 1987; Ferronskii et al., 2003). In 200 boreholes, only dates obtained on plant

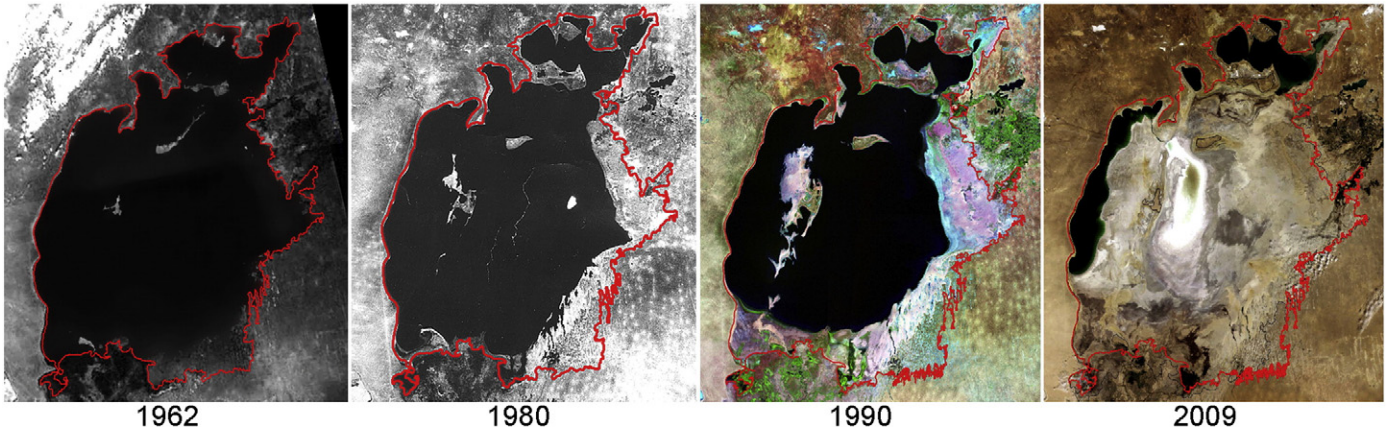

Fig. 2. Desiccation of the Aral Sea illustrated by satellite imagery: 1962 — unknown satellite; 1980 — Meteor; 1990 — Landsat; 2009 — Modis. Red outline is a metastable lake level of the Aral Sea prior to 1960 from a nautical chart.