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A high-resolution diatom-inferred palaeoconductivity and lake level record of the Aral Sea for the last 1600 yr

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Abstract

Formerly the world's fourth largest lake by area, the Aral Sea is presently undergoing extreme desiccation due to large-scale irrigation strategies implemented in the Soviet era. As part of the INTAS-funded CLIMAN project into Holocene climatic variability and the evolution of human settlement in the Aral Sea basin, fossil diatom assemblages contained within a sediment core obtained from the Aral Sea have been applied to a diatom-based inference model of conductivity (r^2=0.767, RMSEP=0.469 $\log_{10}$ µS cm^{-1}). This has provided a high-resolution record of conductivity and lake level change over the last ca. 1600 yr. Three severe episodes of lake level regression are indicated at ca. AD 400, AD 1195–1355 and ca. AD 1780 to the present day. The first two regressions may be linked to the natural diversion of the Amu Darya away from the Aral Sea and the failure of cyclones formed in the Mediterranean to penetrate more continental regions. Human activity, however, and in particular the destruction of irrigation facilities are synchronous with these early regressions and contributed to the severity of the observed low stands.
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Keywords: Aral Sea; Diatoms; Transfer Function; Late Holocene; Anthropogenic activity; Natural climate variability

Introduction

The last 2000 yr are a particularly important time frame during which anthropogenic activity has radically altered the physical environment. Such changes may be a consequence of increased population growth and the need to further exploit natural resources, or a response to climatic fluctuations, notably that of moisture availability. This is particularly important in arid and semi-arid regions where the establishment and development of civilizations and societies are dependent upon the successful management of freshwater resources. The Aral Sea basin, where early human occupation is known from the Palaeolithic (Boroffka et al., 2005), provides an excellent location from which to increase knowledge of the interactions between human activity, climate and environmental processes, currently a major focus of the IGBP-PAGES programme (Dearing et al., 2006).

Closed or terminal lakes in arid and semi-arid regions, such as the Aral Sea, provide excellent archives of detailed palaeoenvironmental data due to their rapid response to changing hydrological inputs caused by natural climatic variability and/or anthropogenic activity. Responses are primarily in the form of changes in water level and chemistry, particularly ionic concentration or conductivity, and ionic composition which may impact upon the species composition of the lake's biota. Diatoms are especially sensitive to changes in lake water chemistry and in particular conductivity, which varies inversely with depth. When preserved in lake sediments, diatoms may then provide quantitative information on former salinity through the development of transfer functions that enable a record of lake-level fluctuations to be established. These have been developed on a regional scale for Africa (Gasse et al., 1995), North America (e.g., Fritz et al., 1993; Wilson et al., 1996), Spain (Reed, 1998) and South America (Servant-Vildary and Roux, 1990), while the

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