Global and Planetary Change 134 (2015) 41–54

Contents lists available at ScienceDirect

Global and Planetary Change

journal homepage: www.elsevier.com/locate/gloplacha

Holocene climate and environmental change in north-eastern Kamchatka (Russian Far East), inferred from a multi-proxy study of lake sediments

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ARTICLE INFO

Article history:
Received 30 October 2014
Received in revised form 18 February 2015
Accepted 27 February 2015
Available online 10 June 2015

Keywords:
Pollen
Diatoms
Chironomids
Geochemistry
Climate change
Tephras

ABSTRACT

A sediment record from a small lake in the north-eastern part of the Kamchatka Peninsula has been investigated in a multi-proxy study to gain knowledge of Holocene climatic and environmental change. Pollen, diatoms, chironomids and selected geochemical parameters were analysed and the sediment record was dated with radiocarbon. The study shows Holocene changes in the terrestrial vegetation as well as responses of the lake ecosystem to catchment maturity and multiple stressors, such as climate change and volcanic eruptions. Climate change is the major driving force resulting in the recorded environmental changes in the lake, although recurrent tephra deposition events also contributed. The sediment record has an age at the base of about 10,000 cal yrs BP, and during the first 400 years the climate was cold and the lake exhibited extensive ice-cover during winter and relatively low primary production. Soils in the catchment were poor with shrub alder and birches dominating the vegetation surrounding the lake. At about 9600–8900 cal yrs BP the climate was cold and moist, and strong seasonal wind stress resulted in reduced ice-cover and increased primary production. After ca. 8900 cal yrs BP the forest density increased around the lake, runoff decreased in a generally drier climate resulting in decreased primary production in the lake until ca. 7000 cal yrs BP. This generally dry climate was interrupted by a brief climatic perturbation, possibly attributed to the 8.2 ka event, indicating increasingly windy conditions with thick snow cover, reduced ice-cover and slightly elevated primary production in the lake. The diatom record shows maximum thermal stratification at ca. 6300–5800 cal yrs BP and indicates together with the geochemical proxies a dry and slightly warmer climate resulting in a high productive lake. The most remarkably change in the catchment vegetation occurred at ca. 4200 cal yrs BP in the form of a conspicuous increase in Siberian dwarf pine (*Pinus pumila*), indicating a shift to a cooler climate with a thicker and more long-lasting snow cover. This vegetational change was accompanied by marked shifts in the diatom and chironomid stratigraphies, which are also indicative of colder climate and more extensive ice-cover.

1. Introduction

To trace and reconstruct long-term environmental changes in aquatic as well as terrestrial ecosystems multi-proxy stratigraphic analysis of lake sediments is a widely used and successful approach (Lotter et al., 1995). Aquatic ecosystems at high latitudes are susceptible to, and commonly respond promptly to climate change. In particular there is a straightforward relationship between climate and aquatic environment in lakes situated near ecotonal boundaries (Smol et al., 2005; Lotter et al., 2010). Many physical properties of lakes, e.g., the duration of ice-cover and thermal stratification, are crucially linked to algal dynamics and community structure as these factors affect the light availability, available habitats and nutrient cycle (Smol et al., 2005; Rühland et al., 2008). Warming trends decrease the length of

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http://dx.doi.org/10.1016/j.gloplacha.2015.02.013