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Hydrological and climate changes in southeast Siberia over the last 33 kyr

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ABSTRACT

Paleoenvironmental and paleoclimate changes in intracontinental Siberia were reconstructed by continuous, high-resolution records (biogenic silica, U, total organic carbon and N, total S, and grain size) from a sediment core retrieved from the Buguldeika Saddle, Lake Baikal, dating back to the last 33 cal. ka BP. The Holocene climate was wet relative to the last glacial period. The climate became gradually warm and wet from the early to middle Holocene, followed by a shift at ca. 6.5 cal. ka BP toward warm and dry, possibly because of evapotranspiration. This suggests that the climate system transition from the glacial to interglacial state occurred at that time. In the last glacial, the deposition of carbonate mud from the Primorsky Range was associated with Heinrich events (H3 and H1) and the Selenga River inflow during the Last Glacial Maximum was caused by meltwater of mountain glaciers in the Khamar–Daban Range. The anoxic bottom-water during the Allerød-Younger Dryas was probably a result of weakened ventilation associated with reduced Selenga River inflow and microbial decomposition of organic matters originating from moderate input of nutrients from the Primorsky Range. The rapid decline in precipitation during the early Holocene may have been a response to the 8.2 ka cooling event.

1. Introduction

Lake Baikal in southeast Siberia is the most continental setting on Earth that is remote from ocean and ice sheets. Energy balance modeling shows that southeast Siberia is highly sensitive to seasonal changes in solar insolation (Short et al., 1991). Thus, southeast Siberia is a crucial region for understanding how the intracontinental climate system itself has responded in timing and magnitude to changes in global climatic processes. Lake Baikal, formed by the Baikal Rift Zone (BRZ), is an ancient lake that has existed for about 25–40 million years (Williams et al., 2001). The north and south lake shores are surrounded by mountain ranges. The catchment, mainly occupied by the Selenga drainage system, spreads from southeast Siberia to northern Mongolia (Fig. 1A). The strata of bottom sediments in Lake Baikal preserve a continuous record of paleoenvironmental changes representative for a wide area of intracontinental Siberia in both age and area. The history of environmental and biological changes is recorded back to ca. 10 million years by the long sedimentary cores drilled from different sites (Fig. 1B) (Buguldeika Saddle, Academician Ridge, Posolskaya Bank, etc.) (BDP-Members, 1997a, 1997b, 2001, 2005).

Prior works on Lake Baikal have indicated that the bottom sediments record variations at various time-scales in the catchment of the lake and the lake itself, represented by aquatic productivity, hydrological cycle, vegetation evolution, and glacial and fluvial erosion inferred on the basis of the various proxies. The contents of biogenic silica (Si_{bio}), composed of diatom frustule remnant, provide the most important benchmark records in the Baikal region (intracontinental Siberia) since the middle Miocene and reflect glacial–interglacial cycles with higher values in the interglacial periods (Colman et al., 1995; Williams et al., 1997; Kashiwaya et al., 2001). During the last glacial period (marine isotope stage (MIS) 4–2), diatom content gradually decreased in response to the Bond cooling cycles (Prokopenko et al.,

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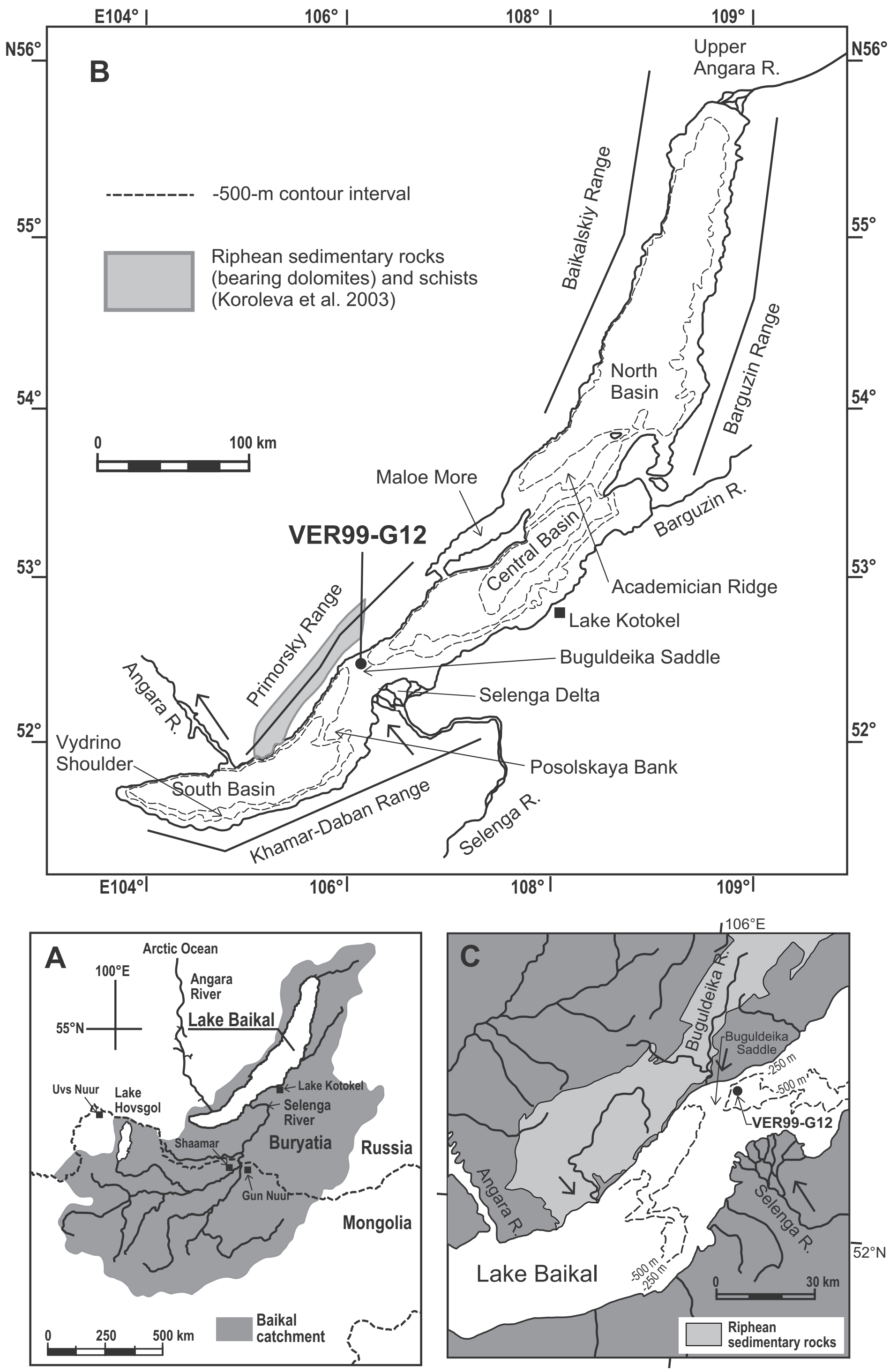

Fig. 1. (A) Map of Lake Baikal and its catchment. (B) Bathymetric map of Lake Baikal and the drill site of the VER99-G12 core. (C) Close-up of the Buguldeika Saddle and its surrounding area (after Ivanov et al., 2016).

2001a, 2001c). In addition, responses of the diatom and Si_{bio} productivities to the Bølling/Allerød interstadial and the Younger Dryas (YD) event are also detected in the Lake Baikal sediments (Colman et al., 1999; Karabanov et al., 2004; Prokopenko et al., 2007). Accumulation in the bottom sediments of diatom and Si_{bio} was extremely low during the Last Glacial Maximum (LGM) (Karabanov et al., 2004). The Holocene short-term variability in the diatom and Si_{bio} contents is related to the climatic optimum as a period of high productivity (Mackay, 2007) and the North Atlantic Bond cooling events (Murakami et al., 2012).

The signals associated with Heinrich events are recorded in the core BDP93-2 from the Buguldeika Saddle across the Selenga Delta (Fig. 1C) as brownish carbonate mud with terrestrial organic carbon (Prokopenko et al., 2001a, 2001c). These episodic depositions are considered to have originated from recurrent runoff-erosion events of the Selenga River into Lake Baikal associated with dramatic changes in atmospheric precipitations in the semi-arid area of the Selenga River drainage. Grygar et al. (2006) report that variations in Fe(II)/Fe(III) ratios in the silicate of sediment core from the Academician Ridge are correlated with Heinrich events H4, H3, and H2. However, vegetation