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Mid-late Holocene climate and vegetation in northeastern part of the Altai Mountains recorded in Lake Teletskoye

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We report the first high-resolution (with intervals ca. 20-50 years) late-Holocene (4200 yr BP) pollen record from Lake Teletskoye, Altai Mountains, obtained from the underwater Ridge of Sofia Lepneva in 2006 (core Tel 2006). The study presents (i) the results of palynological analysis of Tel 2006; (ii) the results of spectral analysis of natural cycles based on the periodical fluctuation of taiga-biome curve; and (iii) quantitative reconstructions of the late-Holocene regional vegetation, woody coverage and climate in northern part of the Altai Mountains in order to define place of Northeast Altai on the map of the late-Holocene Central Asian environmental history.

Late Holocene vegetation of the northeastern part of Altai recorded in Tel 2006 core is characterized by spread of dark-coniferous forest with structure similar to modern. Dominant trees, Siberian pine (Pinus sibirica) and Siberian fir (Abies sibirica), are the most ecological sensitive taxa between Siberian conifers (Shumilova, 1962), that as a whole suggests mild and humid climatic conditions during last 4200 years. However, changes of pollen taxa percentages and results of numerical analysis reveal pronounced fluctuation of climate and vegetation.

Relatively cool and dry stage occurred prior to ca. 3500 cal yr BP. Open vegetation was widespread in the region with maximum deforestation and minimal July temperatures between 3800-3500 cal yr BP. Steppe-like communities with Artemisia, Chenopodiaceae and Cyperaceae could grow on the open sites around Lake Teletskoye. Reconstructed woody coverage is very low and varies between 29-35%. After ca. 3500 cal yr BP the area of dark-coniferous mountain taiga has significantly enlarged with maximums of woody coverages and taiga biome scores between ca. 2470-1040 cal yr BP. In the period of ∼3500-2500 cal yr BP the averages July temperatures increased more than 1 0C. Climate became warmer and wetter.

During last millennium (after 1040 cal yr BP) average July temperatures fell to 17.04 0C. Minimums of July temperatures related to AD1560-1650 and may reflect Little Ice Age in the northeastern Altai. This assumption is in an agreement with previous data from Lake Teletskoye (core Tel 2001-02 covered last 1000 years) where the period with relatively cold and dry climate was revealed between AD1560 and 1820 (Andreev et al., 2007). The coldest period in Tuva according to dendrochronological data (Myglan, Oidupaa, Vaganov, 2012) was in 17-19 centuries with minimum of June-July temperatures at AD1778-1819. Pollen records from the Chuya basin (southeastern part of Russian Altai) revealed the onset of LIA around AD1600 (Schluetz&Lehmkuhl, 2007).

Open steppe-like vegetation slightly enlarged after ∼AD1700 with increasing of continentality. Modern Index of Continentality mapping for the Altai Mountains is in range of 50-59 (Grieser et al., 2006). The average Index of Continentality calculated for last 30 years using data from Barnaul meteostation, located 300 km northwest of the lake in forest-steppe zone, is 40.6; the average Index of Continentality for Yailu meteostation (north shore of Lake Teletskoye) is 20. Index of Continentality reconstructed from Tel 2006 varies in limits of 48-58 and obviously shows regional but not local situation.

Throughout the Tel 2006 record woody coverages vary between 29.0% at the 3890 cal yr BP and 50.3% at the AD1830. Woody coverage greater than 65% is associated with the Siberian mid-latitudinal zonal taiga. Areas north and south of the taiga zone have moderate forest coverage (25–45%), suggesting greater landscape openness (Tarasov et al., 2007). Regarding to VCF data, modern woody cover in 20 km around the lake is ca. 55% (http://glcf.umiacs.umd.edu/data/vcf). Reconstructed woody coverage is lower than observed and reflect probably forest development in the whole lake catchment basin.

Spectral analysis of Tel 2006 data demonstrates periodic changes of taiga-biome curve of ∼1050, ∼470 and ∼210 years intervals during the Late Holocene. Kravchinsky et al. (2013) presume that the 1000- and 500-year periodicities recorded in magnetic properties of soil layers correspond to solar activity induced climate changes in Southern Siberia; however, Stuiver&Braziunas (1993) relate the ∼500-yr cycle to flux oscillations in the Atlantic

Ocean thermohaline circulation. The ∼210-year periodicities may reflect the ∼200-year solar de Vries cycle that is commonly believed to be one of the most intense solar cycles (e.g. Wagner G. et al., 2001; Damon&Peristykh, 2000; Stuiver&Braziunas, 1993). Dendrochronlogical data obtained from the Tien Shan and Qinghai-Tibetan Plateau confirm the existence of 200-year climatic cycles associated with solar activity in Central Asia (Raspopov et al., 2008). Absence of 1500-year climatic cycles (Bond events) in Tel 2006 record may be explained by deep intercontinental location of the Lake Teletskoye whereas 1500-year cycles are linked with the North Atlantic oceanic circulation (Bond et al., 2001; Debret et al., 2007).