Palaeogeography, Palaeoclimatology, Palaeoecology 436 (2015) 167–177

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

The Réunion Subchron vegetation and climate history of the northeastern Russian Arctic inferred from the Lake El'gygytgyn pollen record

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ARTICLE INFO

Article history:
Received 4 February 2015
Received in revised form 24 June 2015
Accepted 30 June 2015
Available online 6 July 2015

Keywords:
Pollen
Early Pleistocene
Biome
Orbital forcing
Northeastern Russian Arctic

ABSTRACT

The 318-m-thick sediment record from Lake El'gygytgyn provides unique opportunities for a detailed examination of environmental changes during the Réunion Subchron polarity reversal event (2.1384–2.1216 Myr BP) in the northeastern Russian Arctic. The paper describes vegetation and climate fluctuations between ~2.15 and 2.10 Myr BP as inferred from palynological data. Biome reconstructions indicate that throughout this interval the tundra (TUND) biome generally has higher affinity scores as compared to cold steppe (STEP) or cold deciduous forest (CLDE). An exception is the climatic optimum between ~2.139 and 2.131 Myr BP, coinciding with Marine Isotope Stage 81 (approximately the Réunion Subchron), when the CLDE biome has the highest scores. Landscape-openness indices suggest that more closed vegetation characterized most of the interval between 2.146 and 2.127 Myr BP, when deciduous forest and shrubs expanded in the regional vegetation and climate was relatively warm and wet. Peaks in green algal colonies (*Botryococcus*) and *Zygnema*-type spores ~2.150–2.146, ~2.131–2.123, and ~2.112–2.102 Myr BP indicate expansions of shallow-water habitats and lowered lake levels. Comparisons with biome reconstructions from other interglacial intervals at Lake El'gygytgyn suggest that precession-related summer insolation intensity and obliquity-related duration of summer daylight are major controls on the onset of interglaciations, whereas obliquity probably plays a more significant role on vegetation succession at northern high latitudes during the Pleistocene.

1. Introduction

Lake El'gygytgyn, located in northeastern Russia (67°30′ N, 172°05′ E; Fig. 1), hosts the oldest continuous terrestrial sediment record from the Arctic (Melles et al., 2012; Brigham-Grette et al., 2013). In spring 2009, a 318-m-thick composite record was recovered in the center of the lake (ICDP Site 5011-1, Fig 1), penetrating the last 3.6 Myr BP, with full recovery down to 2.8 Myr BP (Melles et al., 2011). A suite of multi-disciplinary studies on this record has been reported previously (Melles et al., 2012; Brigham-Grette et al., 2013; special issue of Climate of the Past: http://www.clim-past.net/special_issue48.html), including ones using palynological data to reconstruct past vegetation and climate (Lozhkin et al., 2007; Lozhkin and Anderson, 2013; Tarasov et al., 2013; Andreev et al., 2014). These earlier studies revealed a number of major shifts in vegetation, perhaps none more noteworthy than those of the Late Pliocene to Early Pleistocene (3.575–2.150 Myr BP). Until ~2.93 Myr BP, the vegetation was dominated by taxon-rich, cool-mixed and cool-conifer forests, Pliocene remnants representing climates significantly warmer and wetter than the present. After ~2.725 Myr BP, cold deciduous forests and tundra characterized the El'gygytgyn region. Beginning ~2.6 Myr BP, the cool conifer and cold deciduous forests were gradually replaced by tundra. Despite the onset of glaciation in the northern hemisphere (Brigham-Grette et al., 2013), warmer-than-present Arctic summers persisted at Lake El'gygytgyn until ~2.2 Myr BP, when glacial episodes started to gradually increase in frequency (Melles et al., 2012; Brigham-Grette et al., 2013).

The Lake El'gygytgyn sediments indicate clear polarity zonations and thus provide 12 first-order tie points to pin down the age of the longest paleoclimate record from the continental Arctic (Haltia and Nowaczyk, 2014). The mean sedimentation rate decreases rapidly from ~50 cm kyr^{-1} to 4–5 cm kyr^{-1} at the onset of the Pleistocene, when polarity shifts from the Gauss Chron to the Matuyama Chron. This reversal likely was associated with the reorganization of circumpolar atmospheric circulation through climate changes that have caused variations in sediment deposition (Haltia and Nowaczyk, 2014; Fig. 2). The Réunion Subchron, which is the first polarity reversal within the Quaternary recognized in the Lake El'gygytgyn sediment record,

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http://dx.doi.org/10.1016/j.palaeo.2015.06.047
0031-0182/