Environmental and climate dynamics in northeastern Siberia according to diatom oxygen isotopes

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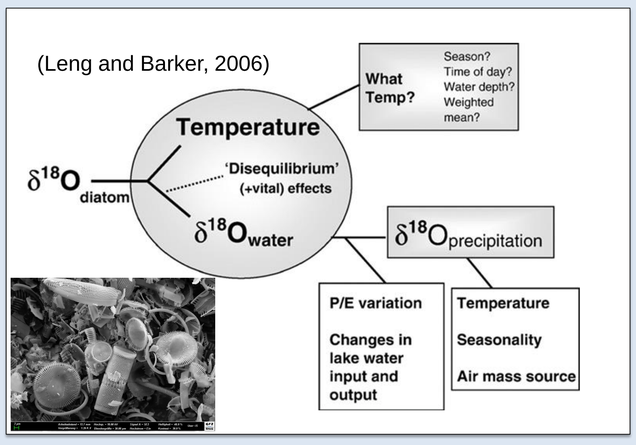
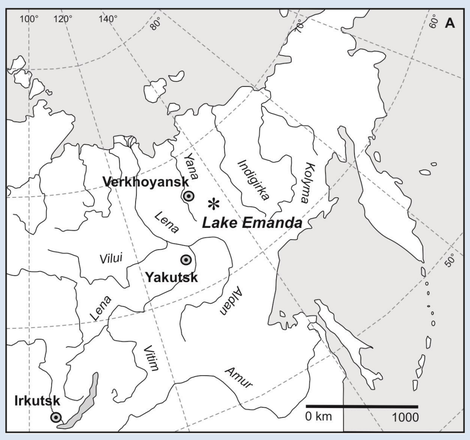
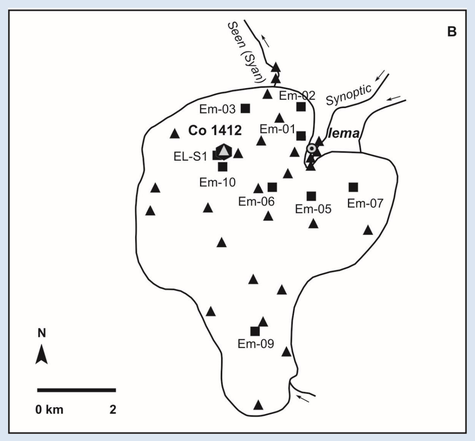
INTRODUCTION

In the last decade, the high potential **of oxygen isotope composition in diatoms** derived from lacustrine sediments for reconstructing past climate, environment and hydrology changes (e.g. Meyer et al., 2015; Chapligin et al., 2016; Kostrova et al., 2019) has been demonstrated.



As part of the German-Russian **'Paleolimnological Transect' (PLOT) project** aiming at investigation the Late Quaternary climate and environmental history along a transect crossing Northern Eurasia, **Lake Emanda**, one large freshwater lake located in the permafrost zone, on the vast plateau of the eastern slope of the Verkhoyansk Mountain Range.

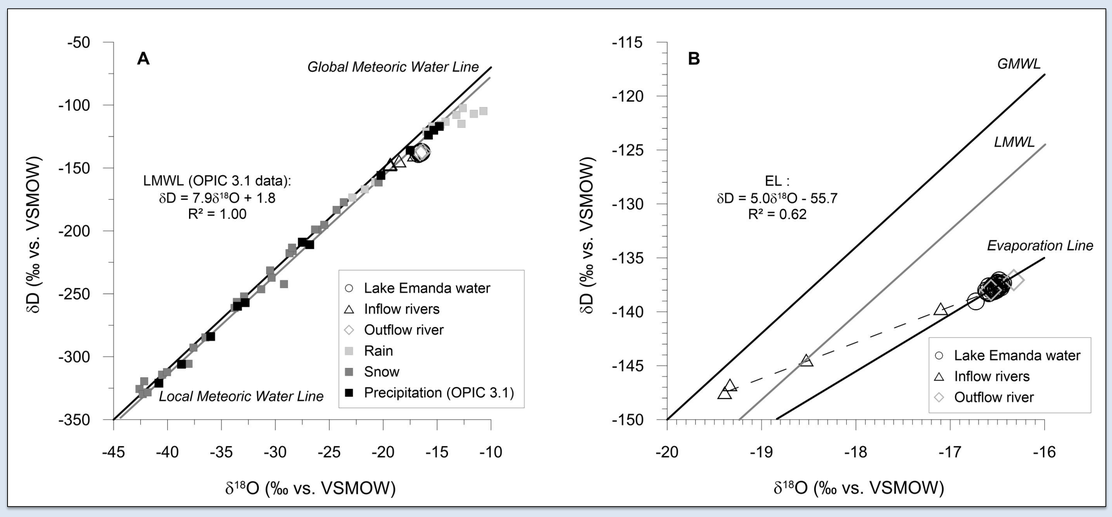




Lake Emanda characteristics:
Area - 33.1 km²
Length - 8.3 km
Width (average) – 3.5 km
Water depth max – 16.8 m
Catchment area – 179 km²
Main inflow: River Synoptic
Outflow: Seen (Syan) River

Mean meteorological data:
Average air temperature:
January −44.7°C
July +13.0°C
Precipitation ~250 mm

ISOTOPE HYDROLOGY



33 Lake Emanda water samples
6 river water samples
40 precipitation samples

LAKE EMANDA:
$\delta^{18}O$ = –16.5‰, δD = –137.8‰
$\delta D = 5.0 \cdot \delta^{18}O - 55.7$; R^2=0.62

INTERCEPTION POINT:
$\delta^{18}O$ = -23.0‰ , δD = -170.0‰

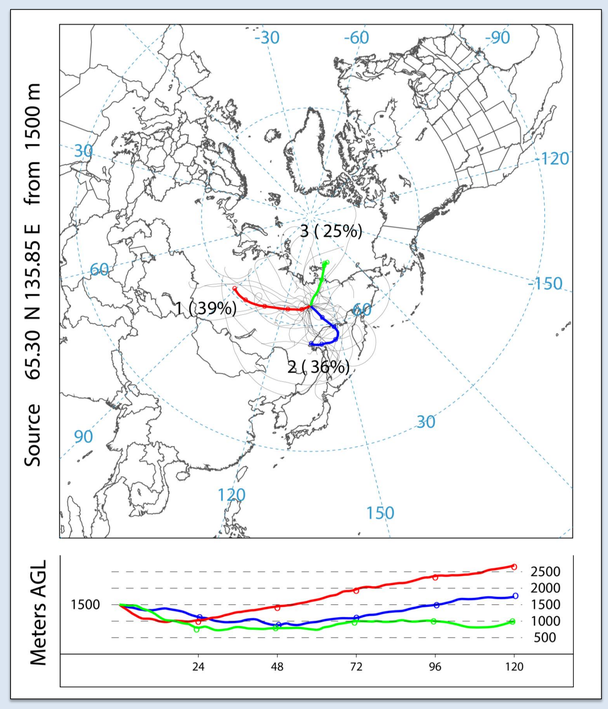
INFLOW (SYNOPTIC RIVE):
$\delta^{18}O$ = -18.6‰ , δD = -144.6‰

OUTFLOW (SEEN RIVER):
$\delta^{18}O$ = -16.4‰ , δD = -137.5‰

RAIN:
$\delta^{18}O$ = -15.9‰, δD = -128.2‰

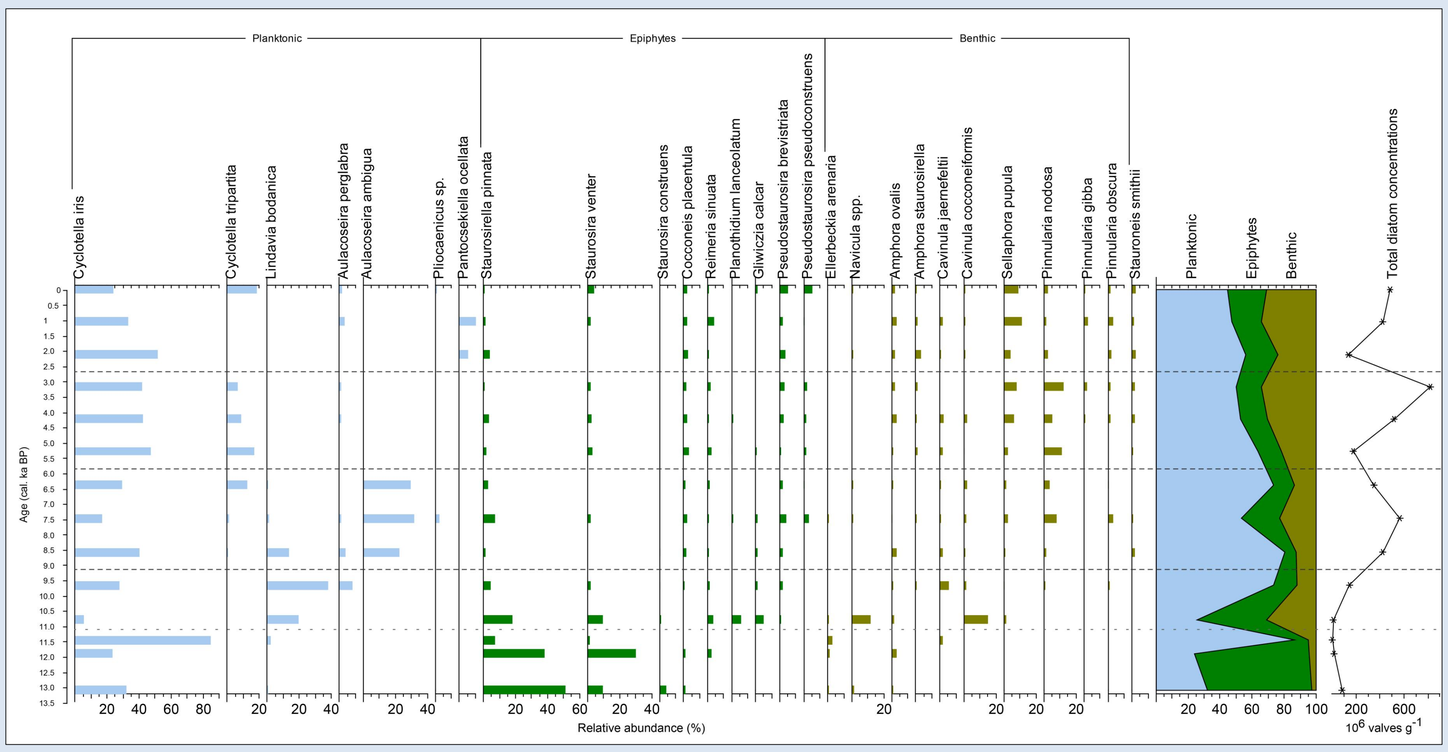
SNOW:
$\delta^{18}O$ = -33.1‰, δD = -256.0‰

MEAN ANNUAL (Bowen, 2020)**:**
$\delta^{18}O$ = -26.6‰, δD = -208.4‰



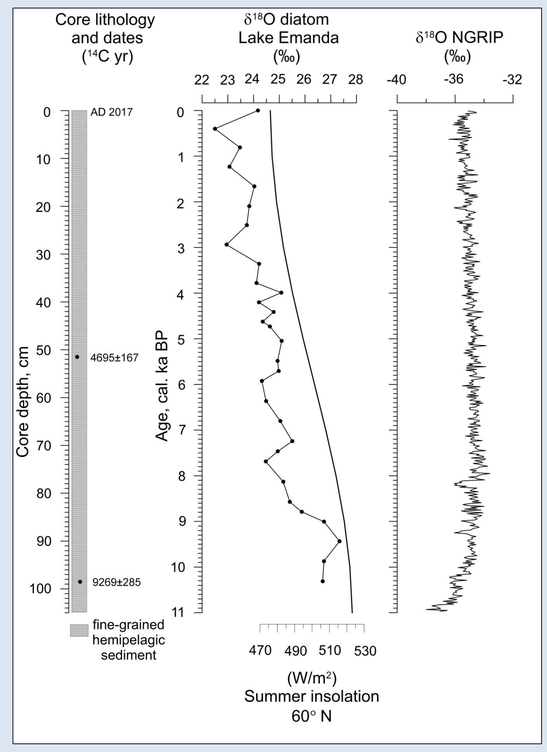
- Lake Emanda is **well-mixed spatially uniform water reservoir**
- $\delta^{18}O_{lake\ water}$ changes are mainly driven by:
  (1) evaporative effect; (2) $\delta^{18}O$ precipitation (T_{air} + moisture source); (3) riverine/meltwater supply.

DIATOM TAXONOMY AND ISOTOPES



Co 1412
65°17' N, 135°45' E;
water depth – 14.6 m

56 clean diatom samples
(0.1–0.9% Al_2O_3; 98.2–99.8% SiO_2)



Cyclotella iris is the **dominant** taxon (up to 84%). The diatom succession is enriched by fragilarioid assemblages in the interval from ca. 11.0 to 13.0 cal. ka BP, while *Lindavia bodanica* is more frequent at ~11−8.5 cal. ka BP and *Aulacoseira ambigua* is second dominant between 8.5 and 6.5 cal. ka BP.

The most recent $\delta^{18}O_{diatom}$ = +24.2‰ correlates well with present-day lake water isotopes (mean $\delta^{18}O_{diatom}$ = -16.5‰), indicating a **reasonable water−silica isotope fractionation** (α = 1.0414) yielding T_{lake} of 12 °C. The diatom isotope variability **reflects changes in water isotope composition** rather than changes in lake temperature, strongly dominated by evaporation. The $\delta^{18}O_{diatom}$ trend follows a decrease **in summer insolation** and in line with **temperature** history in the region and the Northern Hemisphere. **Maximum** values (+26.7 to +27.3‰) at ~10.0−9.0 cal. ka BP reflect **very dry** conditions in **Early Holocene**. The **Holocene Thermal Maximum** at ~8.9−4.5 cal. ka BP (Biskaborn et al., 2016) is characterized by **lower** mean $\delta^{18}O_{diatom}$ = +24.7‰. The **absolute minimum** of +22.5‰ at 0.4 cal. ka BP is visible likely corresponding to **the Little Ice Age**.

CONCLUSION

Changes in the Lake Emanda $\delta^{18}O_{diatom}$ record reflect Late Quaternary variations in $\delta^{18}O_{lake}$ linked with both $\delta^{18}O_{precipitation}$ as well as evaporation effects and, to a lesser degree, riverine/meltwater pulses from the mountainous hinterland.

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