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# Continuous high-resolution Reconstruction of paleo-Humidity in the catchment Basin of Lake Baikal during the last 100ky.

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**Introduction.** Sediments of Lake Baikal are the longest and the most studied continuous record of paleoclimates of North-East Asia over the last few million years [1-5]. Signals found in this record vary in pace with the changes in global climate. However, the records lacked quantitative calibration. New data [6, 7] on the distribution of uranium isotopes along a sediment core spanning the last 150 ky strongly suggest that Lake Baikal did not receive any riverine water and hence no dissolved silica, during the full glaciations such as MIS 2 (LG) and MIS4.

The aim of paper presented is the development of geochemical and mathematical models for interpretation of uranium isotopes signals in the sediments and quantitative reconstructions of river paleo runoff in Lake Baikal and paleo humidity in North-East Asia.

**The model.** It was proposed earlier [8,9] that there are two sources uranium buried in the sediments of Lake Baikal. One of them is terrigenous particles bearing $\mathbf{U}_{ter}$with A4=A8

(A4 and A8 are activities of $^{234}$U and $^{238}$U). The other is authigenic (initially dissolved) U with A4/A8>1. Dissolved $^{238}$U ($\mathbf{U}_{diss}$) is adsorbed within the lake by sinking terrigenic particles [8,9], but diatoms do not capture U [10]. Adsorption of U is characterized by distribution coefficient **K**, and **K** = $\mathbf{U}_{aut}$/$\mathbf{U}_{diss}$. Here, $\mathbf{U}_{aut}$ is concentration of adsorbed authigenic $^{238}$U per unit terrigenous particles weight.

Variability of A4/A8 in the sediments was assumed [6,8,9] to be a consequence of the

changing contributions of $\mathbf{U}_{aut}$ and $\mathbf{U}_{ter}$.- the former increased at the warm stages, whereas the latter dominated during the cold stages due to terrigenous input from glaciers, which were formed in the mountains around Lake Baikal. This qualitative model was consistent with the facts. We assume that neither the concentration of dissolved U in riverine water $\mathbf{U}_{riv}$, nor A4/A8 of $\mathbf{U}_{riv}$ changed with time. Hence, all changes in the total $^{238}$U content in the sediments are assumed to be due to changing input of riverine waters with $\mathbf{U}_{riv}$ having an A4/A8 = 2 [6,8,9] and changing input of $\mathbf{U}_{ter}$ with A4/A8=1. Secondly, we assume that waters which delivered $\mathbf{U}_{ter}$ from the glaciers did not carry any unequilibrium U. The third assumption is that sediments are a closed system for uranium. River paleo runoff -**Q** have been found from not steady-state budget of $\mathbf{U}_{dis}$ in Lake Baikal. It was represented as the sum of steady-state solution and not steady-state adjustment: $\mathbf{Q} = \varepsilon \cdot \mathbf{j}_{ter} \cdot \mathbf{S} \cdot \mathbf{K} \cdot \mathbf{U}_{aut} / (\mathbf{K} \cdot \mathbf{U}_{riv} - \mathbf{U}_{aut}) + (\mathbf{V} \cdot d\mathbf{U}_{aut}/dt) / (\mathbf{K} \cdot \mathbf{U}_{riv} - \mathbf{U}_{aut})$.

Here, **V** is volume of Lake Baikal (23 000 km$^3$), **S** – area of its surface (31 400 km$^2$), $\mathbf{j}_{ter}$ – flux of terrigenous particles towards the bottom in the location of core investigated, $\mathbf{U}_{riv}$ – weighted mean concentrations of dissolved $^{238}$U in Baikal tributaries. $\varepsilon \equiv \hat{\mathbf{J}}_{ter} / \mathbf{j}_{ter}$ , and $\hat{\mathbf{J}}_{ter}$ is in turn a mean terrigenous flux in the lake.

**The results and discussion**. We found magnitudes of **K** and $\varepsilon$ from our experimental data [6,7] for upper recent 5 cm of the sediment of Akademichesky Ridge and used in our model necessary values from [11] and $\mathbf{U}_{riv}$=1.05 ppb for present day lake [11]. Reconstruction of paleo runoff **Q** during the last 100ky was performed using the high-resolution (200years) records of uranium isotopes in the sediments of core st2 [6, 7], which was dated by direct U-Th method [6,12].

The most important finding is that **Q** is equal to almost zero during MIS 2 and 4. Rivers did not flow practically during these periods because almost all atmosphere moisture was evaporated in the catchment basin. Our water budget for atmosphere moisture in watershed of Lake Baikal shows zero **Q** during the Last Glacial (LG) would be the case if $\mathbf{P}_{LG}/\mathbf{P}_{modern}$ was equal to 0.6, and $\mathbf{E}_{LG}/\mathbf{E}_{modern}$ – to 0.81. According to [13], evaporation (**E**) during the LG was equal to ca. 0.8 of the present value, i.e., $\mathbf{E}_{LG}/\mathbf{E}_{modern}$=0.8. On the other hand, precipitation (**P**) in Siberia during the LG was about half of that of the present [14]. Hence, our model gives a reasonable result. To reconstruct the running values of **E** and **P**, we used linear parameterization of **E**(**P**) and water mass conservation low in the lake watershed for river runoff $\mathbf{Q}=(\mathbf{P}-\mathbf{E})\cdot\mathbf{Sw}$. Thus, the decrease of **Q** from present 59 km$^3$/y to zero during LG can be explained by a decrease in **P** from 400 and **E** from 295 to ca. 220 mm/y.

The reconstruction of river runoff (and precipitation P) during Holocene showed their maximums were achieved at 5-7 ky, where respective values were 1.2-1.4 times higher

the modern ones. The beginning of slow runoff increasing from zero (during LG) took place at ca.17 ky and lead for B/A event. Nevertheless, abrupt increasing of runoff took place at $\sim$ 9 ky, that is ca.2 years later of abrupt Holocene warming.

**Conclusions.** Unlike the earlier data based on studies of on-land geological sites and sections [14], our reconstruction is the first time presents a continuous high-resolved profiles of climate humidity (river runoff, precipitation and evaporation) in North-East Asia for the last 100 ky. We presented evidences for dramatic oscillations of climate aridity-humidity in watershed of Lake Baikal. Before the present study, the possibility of drying out of rivers in the catchment basin of Lake Baikal during the LG was not considered. Therefore, the correlations of the Baikal sedimentary record with the global climate will need re-interpretation. Dramatic oscillations in the abundance of diatoms which occurred during the last 5 My can now be interpreted in terms of changing paleo-humidity: delivery or absence of nutrients in the Lake Baikal. Arid pulses with precipitation in North-East Asia falling below 220mm/y ($\sim$55%) of that of the present time, became pervasive and regular after the onset of the Pleistocene, *ca*. 1.8 My BP.

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