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High-frequency environmental variability restored by geochemistry of lake sediments

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Recent investigations of environmental dynamics are more and more focusing on high resolution - annual and seasonal time series [IPCC 2007; Ljungqvist 2008]. At the same time annual quantitative reconstructions by lake deposits are scarce. The new approach to study sediment records appeared due to automatic technique for scanning microanalysis of cores in situ. X-ray fluorescence analysis on synchrotron radiation (XRF SR) in the Institute of Nuclear Physics, Novosibirsk was adapted.

Sub-millimeter layered structures (including varves) of bottom sediments from Siberian and Mongolian lakes as well as tree ring series in surrounded areas are studied. On this base fundamental environmental parameters – air temperature, precipitation and lake level are restored on annual scale for Central Asia region. Elements composing organic component of sediments (Br, I, U) usually respond to temperature. And elements from clastic mineral part (Rb, Sr, Ti, Y, Zr etc.) reflect annual precipitation and runoff. Carbonate matter presented by Ca, Mg and Sr evidences salinity fluctuation. Different impact of organic and mineral matter is evaluated in equations of multiple regression describing climate dependence on geochemistry of sediments. So, coefficients near organofillic elements are higher than clastofillic ones in temperature equations, contrary to that are observed in the equations for precipitation and lake level. Time series of lithological-geochemical indicators of climate change based on counting of annual layers and dating by 14C, 137Cs, and 210Pb, are calibrated by instrumental hydrometeorological data to obtain the functions as environmental reconstructions

Availability of several basic series of geochemical indices extends the scope for quantitative reconstructions of sought quantity. That becomes in the line of extrapolation, interpolation (detailed elaboration) and combination. Geochemical time series allowed estimating regression equations for tree ring width and extrapolating these short chronologies. Specifically, aridization trend is revealed in Transbaikalia for the last 2000 yrs (Arachlei Lake) by tree ring growth index, reflecting alternation of cold-wet warm-dry conditions. Discovered centennial and multi-decadal arid periods are not conflict with palinological data. Also rare sampled palinological series, transferred to biomes, are worked out in detail to annual chronologies by training transfer function on element content in the same samples (Teletskoe Lake, Altai). As it was found out, taiga and step biomes have negative correlation, but both verify aridization trend for the last millennia, enhanced during century. Shira lake sedimentary records demonstrate decreasing of annual precipitation in Khakasia region for the last two millennia.

Combined reconstruction of summer temperature is made for Altai mountain region using several geochemical parameters of lake sediments together with independent biological series in multiple regression estimations. The result is more universal than separate reconstructions by sediment geochemistry and tree rings, although the total length is limited by tree ring chronology (1200 yrs). Actually climate response of tree ring series and lake sediments depends on both air temperature and precipitation, at least for Siberian mountain areas.