Ecosystem response to environmental changes in Lake Baikal

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Ecosystem response

Photosynthetic pigments are being increasingly used to monitor recent and past changes of the phytoplankton composition and productivity that indicate changes of climatic and other environmental conditions. Three main aspects were investigated in Lake Baikal: (1) the distribution of phytoplankton and pigments in the euphotic zone, (2) its sedimentation through the water column, and (3) the variation of sedimentary pigments in the pristine lake during the Holocene and last interglacial.

1) A three year-long intense phytoplankton monitoring programme was carried out. HPLC-aided pigment analyses were combined with microscopic counts, fluorometry, and satellite image analyses. The pigment-based phytoplankton monitoring provided a broad overview on the abundance and composition including the little known picoplankters and even induced the first record of Eustigmatophyceae that must be considered as an important component of the Baikalian eukaryotic picoplankton. Temperature and stratification were found to be of major influence on the phytoplankton composition.

2) Because Lake Baikal is unusual in terms of size and depth, it represents an interesting end-member in investigations of pigment biogeochemistry. The conclusions on how pigments do settle to its sediment surface, considerably contribute to the understanding on the manner in which organic molecules are incorporated into the sediments in cold, deep, oxygenated lakes and marine systems. The manner and extent of degradation was site-specific; however, the main contribution to the settling material was formed at both sites by heavy, non-edible Bacillariophyceae, while strong degradation processes controlled the sedimentation of small, light and edible phytoplankton.

3) Sedimentary pigments were analysed in cores covering the Holocene (since 10,000 years ago) and Kazantsevo Interglacial (129,000-117,000 years ago) taken from three main regions. We have demonstrated that fossil Chl*a*s and pheophorbide *a* in Lake Baikal serve as reliable indicators for global climatic changes. The comparison of the sedimentary pigments with published diatom records indicated that phytoplankton other than diatoms contributed to the buried organic material and fossil Chl*b*s tracked the development of Chlorophyta.

Taken together, pigment-based analyses were shown to accurately reflect phytoplankton variation caused by environmental changes of natural or human origin in Lake Baikal.

In the future, markers for food-web structure and quality (e.g. fatty-acids, sterols) in the recent water column as well as partly in the sediment archives shall be included.
The recent studies should also be extended in view of future threats, such as warming, ice cover reduction and pollution…

Climate and other environmental changes

Climate and related environmental changes are currently assessed using different biomarkers. For example, climate changes are assessed using a novel paleotemperature proxy called TEX86 (Tetraether index of lipids with 86 carbon atoms) based on crenarchaeol membrane lipids. These are relatively stable compounds that occur ubiquitously. First analyses revealed that they can be found in Lake Baikal sediments and first reconstructions have been attempted.

However we still know relatively little about their formation, sedimentation and preservation in Lake Baikal. Some sediment trap material has been used for first calibration studies, but further material especially from sequential sediment traps would be essential.

Besides Tex86-calibration, other proxies for related environmental changes shall be included in the upcoming studies (e.g. terrestrial input, ice cover changes).
All individual proxies shall then be integrated to determine past climate and related environmental changes and the respective response of the ecosystem, especially of the phytoplankton production.

In summary in the future we would like to 1) enhance the study of current changes and their implications for the ecosystem, 2) improve the biomarker calibration and 3) reveal new ideas for the paleo-marker application.