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Impact processes, permafrost dynamics, and climate and environmental variability in the terrestrial Arctic as inferred from the unique 3.6 Myr record of Lake El'gygytgyn, Far East Russia – A review

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ABSTRACT

Lake El'gygytgyn in Far East Russia is a 3.6 Myr old impact crater lake. Located in an area that has never been affected by Cenozoic glaciations nor desiccation, the unique sediment record of the lake represents the longest continuous sediment archive of the terrestrial Arctic. The surrounding crater is the only impact structure on Earth developed in mostly acid volcanic rocks. Recent studies on the impactite, permafrost, and sediment sequences recovered within the framework of the ICDP "El'gygytgyn Drilling Project" and multiple pre-site surveys yielded new insight into the bedrock origin and cratering processes as well as permafrost dynamics and the climate and environmental history of the terrestrial Arctic back to the mid-Pliocene.

Results from the impact rock section recovered during the deep drilling clearly confirm the impact genesis of the El'gygytgyn crater, but indicate an only very reduced fallback impactite sequence without larger coherent melt bodies. Isotope and element data of impact melt samples indicate a F-type asteroid of mixed composition or an ordinary chondrite as the likely impactor. The impact event caused a long-lasting hydrothermal activity in the crater that is assumed to have persisted for c. 300 kyr.

Geochemical and microbial analyses of the permafrost core indicate a subaquatic formation of the lower part during lake-level highstand, but a subaerial genesis of the upper part after a lake-level drop after the Allerød. The isotope signal and ion compositions of ground ice is overprinted by several thaw-freeze cycles due to variations in the talik underneath the lake. Modeling results suggest a modern permafrost thickness in the crater of c. 340 m, and further confirm a pervasive character of the talik below Lake El'gygytgyn.

The lake sediment sequences shed new leight into the Pliocene and Pleistocene climate and environmental evolution of the Arctic. During the mid-Pliocene, significantly warmer and wetter climatic conditions in western Beringia than today enabled dense boreal forests to grow around Lake El'gygytgyn and, in combination with a higher nutrient flux into the lake, promoted primary production. The

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