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Lake Ohrid: The history of forest biodiversity and hydrological variations from Europe's oldest lake

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The vegetation record of the Quaternary in Europe is characterized by successive loss of tree species due to the repeated migration across E-W oriented mountain chains during glacial-interglacial cycles. Relative to central Europe, tree diversity in refugia in the Mediterranean remained high for much of the Quaternary, although the precise relation between (regional) extinctions, climate variability and local edaphic factors is not known. Lake Ohrid, located at the Albanian / FYROM (Macedonian) border at 693 m asl, is the deepest, largest and oldest tectonic lake in Europe and formed between 1.2 and 1.9 Ma ago. Lake Ohrid is a biodiversity hotspot and a likely glacial forest refugium, containing a continuous sediment infill of glacial-interglacial vegetation cycles since its establishment. Within the International Continental Scientific Drilling Program (ICDP), the lake was drilled in 2013 and a 569-m long sediment core was collected. The palynological record of the DEEP site has now been analyzed down to the base of the continuous lake phase at nearly 1.4 Ma, and is supported by a well-constrained independent age model based on tephrostratigraphy, magnetostratigraphy, and complementary tuning of bio-geochemical proxy data to orbital parameters. Here we report the botanical regional extinction events that are documented in the palynological record and assess the relation between the tree cover and glacial-interglacial climate variability and local palynological richness. There is an excellent correspondence between forested / non-forested periods at Ohrid and interglacial / glacial cycles of the Mediterranean marine isotope stratigraphy, suggesting a regionally relevant vegetation and climate record. The base of the record shows occurrences of typical 'Tertiary elements' that currently occur in SE United States and SE Asia, such as Taxodium-type and Liquidambar and subsequent surprisingly young last occurrences of Tsuga, Cedrus, Pterocarya, Carya. Prior to 1.2 Ma, the Ohrid catchment had a clearly different configuration with shallower water and less pronounced vertical vegetation zonation, and high amounts of relict taxa. Rarefied palynological richness of tree taxa (i.e. corrected for variable count sums) shows relatively low variability in line with the refuge character of the site where, in glacial conditions, vegetation belts were compressed but tree diversity remained largely intact. After 1.2 Ma, lake levels increase and maximum richness is recorded, followed by phases of biodiversity decline around 900 ka, 450 ka, and 150 ka. Precession-scale variability is significant in the record and characterized by rapid alternations between mesophilous and lower montane vegetation that point to humidity variations.