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The SCOPSCO Deep Drilling Project: a 1.3 million-year palaeoenvironmental reconstruction from Lake Ohrid using stable isotopes

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Lake Ohrid is a large, ancient lake situated on the Balkan Peninsula in the central northern Mediterranean region. The lake hosts a world-class degree of endemic biodiversity and an extensive sedimentary archive. In 2013, an extremely successful International Continental scientific Drilling Program deep drilling campaign was conducted as part of the transdisciplinary Scientific Collaboration on Past Speciation Conditions in Lake Ohrid (SCOPSCO) project and recovered over 2100 m of sediment from the lake. The main target site in the central basin provided a 584-m composite record covering at least 1.3 million years. Here, we present new oxygen and carbon isotope data (δ^{18}O and δ^{13}C) from carbonate for the entire lacustrine sequence (upper 430 m) of the SCOPSCO cores spanning Marine Isotope Stages (MIS) 41-1, based on chronological information derived from tephrostratigraphy, palaeomagnetic analyses, and orbital tuning of biogeochemical proxies. Contemporary monitoring data suggest variations in δ^{18}O are primarily a function of changes in regional water balance. This is confirmed through the Holocene where the isotope dataset shows a stable transition from wetter conditions in the Early Holocene to a drier climate in the Late Holocene, which is consistent with a regional pattern of aridification. At the onset of deep-water lacustrine conditions around 1.3 Ma, very low δ^{18}O are comparable to measured values for surface inflow today and infer that Lake Ohrid had a greatly reduced residence time and volume. Multiple rapid shifts to higher values in long-term average δ^{18}O are observed in the early lake history, most likely associated with lake ontogeny and the progressive deepening of Lake Ohrid. After MIS 10, the observed variability between glacial and interglacial δ^{18}O increases dramatically concomitant with a lower reconstructed lake level, suggesting a more pronounced sensitivity to hydroclimate change. A trend to higher interglacial δ^{18}O through this time frame traces the development of a warmer and drier Mediterranean climate regime. Low-frequency δ^{18}O oscillations are characterised by an orbital pacing dependent on the phase of eccentricity, where transitions between zones of maximum and minimum eccentricity (400 ka cycle) are associated with tipping points defined by major shifts in δ^{18}O. This sequence represents one of the most extensive and highly-resolved terrestrial isotope records available, and highlights Lake Ohrid sediments as a valuable archive of Quaternary palaeoclimate and palaeoenvironmental information.