Paleoclimate and Vegetation Dynamics at the Forest-Steppe Ecotone of the Lesser Caucasus: A Late Holocene Record from Lake Zaligol, Azerbaijan.

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Résumé

The Caucasus region, situated at the intersection of Mediterranean and arid Central Asian phytogeographic and climatic zones, is a key area for studying ecological transitions over time. In particular, the responses of vegetation to climatic and anthropogenic forcings remain poorly understood, especially in zones where lowland arid ecosystems meet wetter mountain environments. While Armenia and Georgia have yielded some paleoenvironmental reconstructions, such studies are lacking for Azerbaijan. Here, we present the first Late Holocene multi-proxy study from Azerbaijan, based on a 6-meter sediment core retrieved from Lake Zaligol, located in the Lesser Caucasus at 1736 m a.s.l. This site lies at a critical ecotone between Quercus macranthera-Carpinus betulus forests and Poaceae-Artemisia dominated mountain grasslands, just 25 km from the Kura Valley, characterized by arid steppe and halophytic vegetation including Amaranthaceae and Artemisia spp.. The core spans 1700 years and was analysed for lipid biomarkers (GDGTs), pollen, and non-pollen palynomorphs to reconstruct climate, vegetation, and human impact. Sediment analyses (XRF, magnetic susceptibility, spectrocolorimetry) and climate/human impact models (HYDE, TraCE-21K) provided additional context.

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The record includes two major sediment slumps, interpreted as nearly instantaneous deposits related to large earthquakes documented in both historical chronicles and geological records around 800 and 1500 cal yr BP. Quantitative reconstructions of temperature and precipitation from GDGTs and pollen show strong agreement. A warm period from 1200 to 900 cal yr BP, corresponding to the Medieval Warm Period, is followed by a cooler Little Ice Age. The current warm period, from 50 cal yr BP, is attributed to anthropogenic greenhouse gas emissions and is associated with aridification at the forest-steppe ecotone. This modern warming exceeds the magnitude of earlier temperature fluctuations recorded in the sequence. Non-arboreal taxa appear more responsive to precipitation changes (consistent with Artemisia/Amaranthaceae ratio), while arboreal pollen more clearly tracks temperature trends. Dung fungal spores indicate increased grazing pressure during both warm periods.

Further research is needed, particularly in the Kura Valley lowlands, to trace the development of xero-halophytic vegetation, its link to Caspian Sea level fluctuations, and the rise and decline of the Kura-Araxes Bronze Age civilization.

Mots-Clés: Pollen, brGDGT, Azerbaijan, Late Holocene, Climate reconstructions, Vegetation