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Through Layers of Mud and Time: Lacustrine Archives of Quaternary Climate Variation (Hans Oeschger Medal Lecture)

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Lake sediments record climate dynamics and ecosystem response at resolutions ranging from sub-annual to millions of years, dependent upon on the age and depositional characteristics of the basin. Thus, they provide a rich archive for elucidating environmental dynamics at a range of temporal scales. In this lecture, I will discuss a selection of examples from lacustrine sequences in the Americas that provide insight into the magnitude, duration, forcing, and impacts of Quaternary climate variability.

The first set of examples deals with hydroclimate variation during the Holocene in the North American continental interior. In agricultural regions, lake studies documented intervals of drought that were more persistent than any in recorded history, now referred to as “megadroughts". Subsequent tree-ring compilations have shown that these megadroughts were widespread throughout western NA during the last 1000 years. In the central Great Plains during Medieval times ($\sim$900-1300 CE), moisture deficits persisted for multiple decades and were sufficient to drop the water table, kill off native grassland vegetation, and mobilize sand dunes, as demonstrated by coupled lacustrine and geomorphic records. A network of late-Holocene lacustrine records spanning the Great Plains and northern Rocky Mountain regions shows that major climate excursions were synchronous across the northern tier of the continental interior, reflecting large-scale atmospheric dynamics driven by temperature variation in the Pacific and Atlantic Oceans.

Lake records also have been instrumental in documenting tropical moisture variation associated with fluctuations in the South American Summer Monsoon (SASM). High lake levels and wet periods in the tropical Andes are correlated with cold intervals in the North Atlantic region at multiple temporal scales, from orbital to millennial to centennial, reflecting intensification of the SASM. Large changes in moisture availability (P-E) occurred on $\sim$100 ka (eccentricity) cycles, synchronous with global glacial cycles. Both precessional and millennial signals also are evident in Andean lake records, although the relative strength of insolation in pacing moisture variation appears to be reduced during times of high ice volume. Indeed, some of the largest excursions in effective moisture in tropical South America are associated with the Heinrich events.

Finally, lacustrine archives offer the extraordinary potential to evaluate the role of climate in biotic processes, including landscape evolution and patterns of diversification and extinction through time by integration of multiple independent proxies contained in the same samples. Thus, I’ll discuss several examples of the linkages between climate and evolutionary processes at both short and long temporal scales.