Exploring long-term climate-driven changes to the Lower Geyser Basin hydrothermal geo-ecosystem

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ABSTRACT

***Background*—**Understanding the resilience of ecosystems to environmental change requires information on how those ecosystems responded to past changes in climate and geology. The thermal basins of Yellowstone National Park are especially dynamic ecosystems, as research from the past five years reveals how long-term changes in climate have shaped both hydrothermal systems and their surrounding ecosystems. Lake sediments have emerged as a useful archive for understanding a thermal area's ecological development, preserving information on changes in vegetation, fire, and hydrothermal activity over millennia.

***Methods*—**Seven lakes (E. Twin Buttes, Goose, Feather, Rush, Lower Basin, Harlequin, and Nez Perce Creek pond) were cored between 2018 and 2023 within and near Lower Geyser Basin, the largest thermal area in Yellowstone National Park. The origins of the lakes are diverse, including those that formed during glacial ice retreat, as hot springs, and in hydrothermal explosion craters. Sediment enriched in sulfur, arsenic, and antimony is used as evidence of past hydrothermal

activity near or within a lake basin in the past. Fossil pollen and charcoal records reconstruct vegetation and fire history through time.

Results/Conclusions—The length of recovered sediment cores varies from 54 to 700 cm, and the sites are <1000 to >14,000 years in age, based on tephrochronology and radiocarbon age dating. Preliminary geochemical results suggest that Goose, Feather, and Lower Basin lakes experienced significant shifts in hydrothermal activity in the last 4000 years. Goose Lake abruptly stopped receiving hydrothermal input after *ca.* 3800 years ago, while Feather Lake shows an increase in trace elements indicative of increased hydrothermal activity during the same period. Associated pollen and charcoal records indicate that these geochemical changes were associated with an opening of basin vegetation from forest to thermal grassland and a decrease in fire activity. Lower Basin Lake underwent a dramatic increase in water level in recent millennia and transformed from a wetland to an open-water lake. Rush Lake currently contains dozens of sublacustrine thermal vents and the geochemical data indicate that hydrothermal input to the lake has been stable since *ca.* 14,500 years ago. Pollen data from Rush Lake suggest that little vegetation change occurred following the development of *Pinus contorta* (lodgepole pine) forest *ca.* 12,000 years ago. Harlequin Lake, situated in the Madison Canyon, had some hydrothermal input in the past, despite being hydrothermally inactive at present. Taken together, the lake-sediment records, while seldom synchronous, show that hydrothermal activity has shifted significantly in and around Lower Geyser Basin over the past 14,500 years. Although the underlying drivers of these shifts and associated ecological changes remain under study, it is likely that millennial-scale variations in hydroclimate coupled with seismic events triggered abrupt reorganization of the hydrothermal plumbing system since deglaciation.

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SESSION TOPIC PREFERENCES

(10) Greater Yellowstone's Dynamic Geology; (4) Wildland Fire, Drought, and Climate Change Adaptation