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Paleoclimate and morphological studies of semi-permanent ice patches from the Northern Rocky Mountains

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Glacial ice cores preserve detailed records of atmospheric aerosols and other chemical proxies that can be used to reconstruct past environmental change. In western North America, however, ice core records are rare and existing records from mountain glaciers span only recent centuries. Thus, paleoclimate reconstructions spanning the Holocene are limited to lake sediment core and speleothem records. High-elevation, semi-permanent ice patches provide the opportunity to develop accurately dated, ice-derived records from these alpine regions to develop a better understanding of Holocene climate variability. While these ice patches have been recognized as valuable archeological archives for decades, they remain relatively unexplored as paleoclimate archives. Here we investigate alpine ice patches as paleoclimate indicators using stable water isotope and ice accretion records developed from ice cores recovered from ice patches in northern Wyoming. Additionally, we examine the morphology and internal structure of these ice patches using detailed aerial imagery and ground penetrating radar.

Two ~5.6-m deep ice cores, along with several shorter ice cores, were recovered from two ice patches on the Beartooth Plateau. The ice cores consisted of clean ice units intersected by organic-rich layers that were radiocarbon dated to develop accurate chronologies, with the oldest layers dating to 10,400 and 1,250 cal yr BP. Unlike alpine glaciers, the ice patches show no evidence of internal flow, thus the oldest, deepest ice is preserved. Comparisons to nearby lake sediment and speleothem records suggest that these ice patch water isotope and ice accretion records document Holocene wintertime climate, including a sustained era of relatively mild winter conditions centered at 4,100 cal yr BP followed by an era of cooler and wetter conditions.

High-resolution, drone-based aerial imagery and elevation data, combined with surface-based ground penetrating radar surveys, were used to map the ice patch extent and thickness as well as understand the spatial variability of early- and late-season snow cover. These datasets indicate that the ice patches are up to 12 m thick and covered by over 10 m of seasonal snow. Temperature measurements from a thermistor string placed down one of the 5.6 m boreholes will be used to better understand the process of ice accretion and the role of seasonal snow in insulating the ice patches from summer warmth.

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