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Variations of fire events and vegetation in the western Sierra Nevada archived in speleothems during Dansgaard–Oeschger (D–O) cycles

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Dansgaard-Oeschger (D-O) cycles had profound impacts on climates of the northern hemisphere in the last glacial period. However, knowledge of terrestrial climatic responses in western North America and consequently vegetation responses to climatic extremes (e.g., highly variable paleohydroclimate and wildfire events) remains limited. Analysis of organic molecular traces (i.e., plant lipids and fire markers) in speleothems is one of the most promising ways to investigate feedbacks between climatic extremes and vegetation changes. Fire-derived markers, such as polyaromatic hydrocarbons (PAHs) and levoglucosan (LG), a derivative of plant cellulose burning, are increasingly applied as proxies of paleofires in speleothem records. Here, we present a new record of plant lipids, LG, and PAHs from a precisely dated and well-studied stalagmite (~55-67 ka) collected from McLean's Cave (ML-2) in the Sierra Nevada foothills, CA (Oster et al. 2014). The variation of PAHs over the interval 62 to 67 ka corresponds with variations in stalagmite $\delta^{13}C$ during the D-O stadials and interstadials 15-18. The highest concentration of low (≤ 4 rings) and high (≥ 5 rings) molecular weight PAHs as well as LG is found between ~64.25-63.75 ka, suggesting elevated wildfire events during D-O interstadial 18. Dehydroabietic acid (abietane-type acid) is predominantly produced from conifers, and its highest concentration occurs at 63.75 ka and then decreases from 63.5 to 62 ka. The study of modern plants (e.g., Kozłowska et al., 2022) shows that abietane-type acid accumulates at lower radiation and cooler climates and declines in heat and drought due to its antioxidative role in protecting cell membranes from stress-induced damage. The variation of dehydroabietic acid followed the changes in stalagmite $\delta^{13}C$ between 64 and 62 ka (Oster et al., 2014), implying changes in coniferous input affected by the wet and dry cycles (D-O stadials and interstadial 18). This highlights the ability of organic molecular records archived in stalagmites to capture the links between wildfire activity, vegetation, and hydroclimate in central California during D-O cycles.

Reference:

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