Testing sources and pathways of pyrogenic chemical markers to caves in tropical Australia for speleothem paleorecord calibration

Pyrogenic compounds, such as polycyclic aromatic hydrocarbons (PAHs), can track the type and intensity of fires and are preserved in many environmental matrices including speleothems. We recently reported on a stalagmite record of PAH abundance distributions from cave KNI-51, located among the eucalypt savanna in the Ningbing range of tropical Western Australia. In order to better understand the manner by which PAHs from local bushfires are deposited on the land surface and transported into caves, we performed a controlled burn and irrigation experiment at cave KNI-140, located near to and in the same bedrock as cave KNI-51. Samples of soil, vegetation, ash, and air were collected prior to and immediately succeeding the prescribed burn. The fire, which burned predominantly grasses, was ignited by matches (no accelerants were used) and covered approximately 30,000 square meters upwind from the cave. The land surface above the cave was irrigated prior to and immediately succeeding the burn with resulting dripwater collected for analysis. Next, ash samples were deposited directly above the cave and then similarly irrigated, with the drip water also collected. The PAHs present in these samples were measured via gas chromatography-mass spectrometry at Ca' Foscari University, Venice.

Our results reveal that low molecular weight PAHs were the most abundant species of PAH in the drip water and heavier PAHs were substantially less abundant. This result is likely due to the low combustion temperature of the burn, with abundances increasing through each of the three stages of sample collection, demonstrating that deposition from smoke and cinders produces identifiable signals in dripwater (and thus stalagmite) PAHs, supporting the contention that KNI-51 stalagmites record fire activity occurring not just above the cave but within km of the cave. On-going analyses of soil, vegetation, and ash samples will further clarify the role of fire on production and transmission of PAHs at this site, and thus how these organic compounds preserved in speleothems can help delineate the fire history in the region.