Replication of Three Centuries of Polycyclic Aromatic Hydrocarbon Distributions between Two Aragonite Stalagmites from Tropical Western Australia

Rhawn Denniston, Elena Argiriadis, Andrei Munteanu, Emma Rowe

Because traditional paleofire archives (e.g., burn scars on trees, charcoal in lake sediments) are not available in all settings, new ways of reconstructing past fire activity are needed. We focus here on polycyclic aromatic hydrocarbons (PAHs) in stalagmites. PAHs are organic molecules composed of two or more fused aromatic rings formed through incomplete combustion of organic matter, and vary in molecular weight depending on combustion conditions. Because the use of PAHs in stalagmites as a paleofire indicator is still in its infancy and because the production, deposition, and transport of PAHs into a cave is a complex and multi-faceted system, we tested the reproducibility of PAHs in two coeval and precisely-dated aragonite stalagmites – KNI-51-F and KNI-51-G - from KNI-51 (15.3°S, 128.6°E), a shallow cave located in the Kimberley region of tropical Western Australia.

KNI-51-F and KNI-51-G span 1110-1620 CE and 1310-1630 CE, respectively. Each was hand-milled for analysis in continuous sections spanning approx. 2 mm-tall intervals at Ca' Foscari University. Owing to differences in growth rate, temporal resolutions for KNI-51-F and KNI-51-G were 3±2 and 1±0.4 yr/sample, respectively. Chemical preparations and analysis methods follow those of Argiriadis et al. (2019) Analytical Chemistry, volume 91. In order to assess replication between the two stalagmites, we compared total abundances of low molecular weight (LMW: Napthalene, Acenaphthylene, Acenaphthene, Fluorene), medium molecular weight (MMW: Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)Anthracene, Chrysene, Retene), and high molecular weight (HHM: Benzo(b)Fluoranthene, Benzo(k)Fluoranthene, Benzo(e)Pyrene, Benzo(a)Pyrene, Perylene, Benzo(ghi)Perylene, Indeno(1,2,3-c,d)Pyrene, Dibenzo(A,H)Anthracene) PAHs. Total abundances of LMW, MMW, and HMW PAHs are similar (<10 ng/g) except for HMW PAHs in KNI-51-G, which are generally <1 ng/g. Total LMW and MMW abundance time series replicate well, with multiple synchronous multidecadal periods characterized by consistently low PAH abundances, suggestive of reduced bushfire activity, punctuated by intervals of high PAH abundances, likely reflecting frequent bushfire. Less coherence exists between HMW PAHs.