EGU General Assembly 2023

EGU23-5113
EGU General Assembly 2023

Speleothem organic biomarkers trace last millennium fire history at near-annual resolution in northwestern Australia

Elena Argiriadis[1,2], Rhawn F. Denniston[3], Stefania Ondei[4], and David Bowman[4]
[1]National Research Council of Italy, Institute of Polar Sciences CNR-ISP, Venice, Italy (elena.argi@unive.it)
[2]Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Venice, Italy (elena.argi@unive.it)
[3]Department of Geology, Cornell College, Mount Vernon, Iowa, USA (rdenniston@cornellcollege.edu)
[4]School of Natural Sciences, University of Tasmania, Sandy Bay, Tasmania (david.bowman@utas.edu.au)

Recent developments in speleothem science are showing their potential for paleofire reconstruction through a variety of inorganic and organic proxies including trace metals (*s*) and the pyrogenic organic compound levoglucosan (*A*). Previous work by Argiriadis et al. (2019) presented a method for the analysis of trace polycyclic aromatic hydrocarbons (PAHs) and -alkanes in stalagmites (*N*). These compounds reflect biogeochemical processes occurring at the land surface, in the soil, and in the cave. PAHs are primarily related to combustion of biomass while -alkanes, with their potential for vegetation reconstruction (*u*), provide information on fuel availability and composition, as well as fire activity. These organic molecules are carried downward by infiltrating water and incorporated into speleothems (*p*), thereby creating the potential to serve as novel paleofire archives.

Using this approach, we developed a high-resolution stalagmite record of paleofire activity from cave KNI-51 in tropical northwestern Australia. This site is well suited for high resolution paleofire reconstruction as bushfire activity in this tropical savanna is some of the highest on the continent, the cave is shallow and overlain by extremely thin soils, and the stalagmites are fast-growing (1-2 mm yr^{-1}) and precisely dated. We analyzed three stalagmites which grew continuously in different time intervals through the last millennium - KNI-51-F (CE ~1100-1620), KNI-51-G (CE ~1320-1640), and KNI-51-11 (CE ~1750-2009). Samples were drilled continuously at 1-3 mm resolution from stalagmite slabs, processed in a stainless-steel cleanroom to prevent contamination.

Despite a difference in resolution between stalagmites KNI-51-F and -G, peaks in the target compounds show good replication in the overlapping time interval of the two stalagmites, and PAH abundances in a portion of stalagmite KNI-51-11 that grew from CE 2000-2009 are well correlated with satellite-mapped fires occurring proximally to the cave.

Our results suggest an increase in the frequency of low intensity fire in the 20^{th} century relative to much of the previous millennium. The timing of this shift is broadly coincident with the arrival of European pastoralists in the late 19^{th} century and the subsequent displacement of Aboriginal peoples from the land. Aboriginal peoples had previously utilized “fire stick farming”, a method of prescribed, low intensity burning, that was an important influence of ecology, biomass, and fire.

Prior to the late 1800s, the period with the most frequent low intensity fire activity was the 13th century, the wettest interval of the entire record. Peak high intensity fire activity occurred during the 12th century.

Controlled burn and irrigation experiments capable of examining the transmission of pyrogenic compounds from the land surface to cave dripwater represent the next step in this analysis. Given that karst is present in many fire-prone environments, and that stalagmites can be precisely dated and grow continuously for millennia, the potential utility of a stalagmite-based paleofire proxy is high.

(1) L.K. McDonough □□*n*□*l*, □ □□□□□□ *in*□□□□ □□□□□ *in*□ □□□. 325, 258–277 (2022).

(2) J. Homann □□*n*□*l*, □ □□*in*□□□ □ □□*i*, 13:7175 (2022).

(3) E. Argiriadis □□*n*□*l*, □□□□*in*□□□□ *i* 91, 7007–7011 (2019).

(4) R.T. Bush, F. A. McInerney, □ □□□□□□ *in*□□□□ □□□□□ *in*□ □□□. 117, 161–179 (2013).

(5) Y. Sun □□*n*□*l*, □□□□ □□□□□□□. 230, 616–627 (2019).