Millennial Scale Holocene Climate Variability: Iberian Precipitation Reconstructed from two Speleothems

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Palaeoclimate records from the Northern Iberian Peninsula are ideally suited to provide detailed insight into terrestrial climate change and oceanic variability. However, long duration unaltered palaeoclimate records are rare in this region. Two speleothems from a small cave in Matienzo (Cantabria) have been used in conjunction with cave monitoring to develop a continuous, high resolution isotope and trace element palaeoclimate record, which spans the Holocene and Younger Dryas. This speleothem record is interpreted in terms of changing winter precipitation amount, driven by moisture deliverance from the North Atlantic Ocean [1]. Oxygen isotope maxima occur at 1200, 3100, 4500, 5200, 8000 and 9500 years BP, suggesting significant periods of relative winter aridity throughout the Holocene.

Precipitation minima occur in phase with North Atlantic cold periods marked by IRD and identified by Bond *et al*. 1997 [2]. Concurrent alterations in oceanic and atmospheric circulation are known to cause significant reductions in moisture availability, in this case limiting precipitation in Southern Europe. The high correlation between the timing of North Atlantic cold events and speleothem isotope maxima suggests a rapid atmospheric response to changes in oceanic conditions and strong teleconnections between the northern Atlantic Ocean and mid latitudes. This speleothem offers one of the first high resolution, continuous terrestrial records of North Atlantic Ocean cold SST events. These large-scale oceanic processes appear to have dramatically influenced precipitation in northern Iberia and may have played a decisive role in environmental development in the region.

[1] Drunnond *et al*. (2011) *Climate Res*. **48**,193-201. [2] Bond *et al*. (1997) *Science* **278**, 1257-1266.

Chemostratigraphy of Pennsylvanian Core Shale Cyclothems, Illinois Basin, Southern Indiana

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Major and trace element data from five Late Middle Pennsylvanian cores (Carbondale Group) were determined to investigate sediement sources and chemical conditions in the water column during organic matter deposition. A series of limestone, gray and black shale (including the Excello Shale), siltstone, sandstone and coals from a coal bed methane exploration well that penetrated the Linton and Petersburg Formations, Vanderburgh County, Southern Indiana were sampled to provide 99 core samples used in this study. These sequences were deposited in a near-shore intracratonic basin flooded by shallow epeiric seas.

Exploratory data analyses including principal component analysis (PCA) and hierarchical clustering analysis (Ward's Linkage HCA) were used to analyze the data for significant groupings of elements by lithology and total organic carbon (TOC) content. Principal component 1 (PC1) accounts for 49% of the toal variance in the data and can be used to distinguish between clastic (Si, Al, K, Na, Ti) and carbonte (Ca, Sr) related elements. Principal component 2 (PC2) accounts for 19% of the total variance and is indicative of the presence or absence of redox sensitive trace element proxies for total organic carbon (Mo, U, V, Cr, Ni, Zn and Hg). Clustering analysis of sandstone and siltstones form a largely homogenous grouping for sequences interpreted as marine and non-marine, wheras there is greater heterogeneity in the groupings of both gray and black shales.

The Excello black shale shows the strongest enrichment in redox sensitive trace metal proxies for TOC. Finally, low TOC gray shales exhibit a relative enrichment in rare earth elements relative to the black shales and the North American Shale Composite (NASC), that may also reflect different sediment sources or diagenetic processes.

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