Carbon isotope fluctuations and Phosphorus accumulation during Late Devonian anoxic events in Erfoud Morocco

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The Late Devonian Frasnian-Famennian biotic crisis marks one of the most intriguing and largest mass extinctions in Earth history. The most severe biotic crises are the lower and upper Kellwasser events (LKWE-UKWE), which occurred at the end of the Frasnian and decimated the reef system, shallow benthos and some pelagic swimmers. These crises were associated with major sea-level rises, warm climate and widespread ocean anoxia.

Environmental and depositional changes across the Late Devonian Kellwassers events in the Anti-Atlas, near Erfoud, Morocco, are examined based on microfacies, mineralogy, $\delta^{13}C$ values and phosphorus (Ptot) analyses. Correlation based on δ^{13}Corg with other sections (e.g. Benner, Germany, Baisha, China) reveals the Erfoud section as stratigraphically complete across the Frasnian-Famennian transition. Microfacies analyses suggest outer shelf to hemipelagic conditions. Both LKWE and UKWE correspond to laminated black shales deposited during a sea-level rise under anoxic conditions and coincide with increased detrital inputs (quartz, feldspars) reflecting intense weathering on land. However, Ptot concentrations are quite different in the two Kellwasser horizons. The LKWE is almost completely depleted in Ptot, contrary to the UKWE, which is characterized by more variable contents, ranging from very high contents (3500 ppm) to background values (<200ppm). This may indicate that the two Kellwasser levels reflect different environmental conditions. The LKWE appears to be more anoxic preventing the effective retention of P into the sediments. In contrast, the UKWE reflects more variable conditions with episodic oxic intervals.

A multilayered ocean in the Ediacaran Yangtze platform? Insights from carbonate and organic matter paired $\delta^{13}C$

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The large carbon isotope fluctuations systematically reported for Ediacaran carbonate rocks are interpreted as evidence of strong environmental variations. New paired $\delta^{13}C$ data on carbonates and their associated organic matter are presented for the Yangjiaping section of the Doushantuo Formation (Hunan, South China), which, integrated with previously reported ones [1, 2], allow the reconstruction of lateral variations of $\delta^{13}C_{carb}$, $\delta^{13}C_{org}$ and $\Delta^{13}C_{carb\text{-}org}$ for a shelf-to-basin cross section of the Yangtze platform. Strong lateral heterogeneities are revealed, with complex variations of $\delta^{13}C_{carb}$ and $\Delta^{13}C_{dol\text{-}org}$ ($\Delta^{13}C_{dol\text{-}org} = \delta^{13}C_{carb} - \delta^{13}C_{org}$) in the inner shelf section, phased variations (positive $\delta^{13}C_{carb}$ and $\Delta^{13}C_{dol\text{-}org}$ close to 29‰) in the shelf margin section, and negative $\delta^{13}C_{carb}$ ($\Delta^{13}C_{dol\text{-}org}$ as low as 20‰) in the basin.

Assuming that carbonate $\delta^{13}C$ is acquired in bottom waters, we show that the spatial and temporal $\delta^{13}C_{carb}$ and $\Delta^{13}C_{dol\text{-}org}$ variations are compatible with a three-layered water column : (i) an oxic surface layer, which dissolved inorganic carbon (DIC) is probably in isotope equilibrium with the atmosphere; (ii) an intermediate euxinic layer with a DIC enriched in ^{12}C due to organic matter oxidation by sulphate reduction; (iii) a deepest euxinic layer that seems to be restricted to the inner shelf lagoonal facies, lacking sulphate, and with a DIC enriched in ^{13}C by methanogenesis. This model implies that some Ediacaran basins may have contained distinct DIC reservoirs, thus complicating our understanding of the global carbon cycle at the time.

[1] Guo *et al.* (2007) *Pal. Pal. Pal.* **254**, 140-157.
[2] McFadden *et al.* (2008) *PNAS* **105**, 3197-3202.