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The Paleoproterozoic Francevillian succession of Gabon and the Lomagundi-Jatuli event

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Bakakas Mayika et al. (2020) inferred δ13C heterogeneity in Paleoproterozoic oceans based on the chem stratigraphic and sedimentologic study of a single drillcore of the Francevillian Group (FG) of Gabon, considered to record the end of the ca. 2.22–2.06 Ga Lomagundi carbon isotope excursion (LCIE). The authors concluded that while the shallow-marine carbonates with highly positive δ13C values reflect enhanced primary productivity or evaporative conditions, the deep-water facies reflect steady-state operation of the global carbon cycle with ~0‰ δ13C values. If this interpretation is valid, there was no LCIE, and the end of the “event” was merely a facies shift toward deeper-water settings recognized in Gabon and elsewhere at the end of the LCIE. However, this interpretation relies on a suite of assumptions about the depositional setting and geochemical data that are open to question. We outline several lines of evidence suggesting that all available data are consistent with the basin-scale and global nature of the chem stratigraphic signals recorded by the FG.

Bakakas Mayika et al. studied the FC Formation of the FG, which consists of dolostone and shale overlying black shale and sandstone of the FB Formation. They divided the studied drillcore succession into six units, regarded to reflect a transgressive sequence. While we agree that the depositional setting was upward deepening overall, we recognize three, stacked, transgressive cycles, each made of two units. This is important since the transition from unit IV (black shale with planar-laminated dark-gray dolomarl/shale) to unit V (light to dark-gray doloryhthrite and dololaminate) reflects a sea-level fall. Presence of crinkly, microbial lamination, cross-bedding, and intraclastic beds in unit V indicates shallowing to an environment well above the storm wave-base (Ossa Ossa et al., 2018). Dolomitization resulted in the replacement of dark-gray dolostone by beige diageneric dolomite truncating lamination. Therefore, these are not deeper-water, interlayered dolostones and shales.

While Bakakas Mayika et al. linked the fall in δ13C values in the middle part of the succession to a transgression at the unit III and IV boundary, the gradual decrease in δ13C values in carbonates started ~6 m below the transgressive surface and there is no stepwise change at this boundary. Furthermore, there is another shift from ~4 to 0‰ at the boundary between units IV and V, which corresponds to abrupt shallowing rather than deepening. Importantly, the δ18O trend is coupled to that of δ13C with a gradual increase toward the transgressive surface and a stepwise fall at the regressive surface. This trend is opposite of the one expected in evaporitic settings that are marked by highly positive δ18O values, increasing with the degree of evaporation. Finally, thin carbonates developed in the underlying deep-water (outer-shelf) black shales of the FB formation in the Francevillian sub-basin record highly positive δ13C values, typical for the LCIE. Similar values are observed in other open-marine, deeper-water successions deposited during the LCIE (e.g., Bekker et al., 2008).

Bakakas Mayika et al. also argued that δ13C values of marine carbonates in the Franceville sub-basin reflect a basal stratification with an ~10‰ vertical gradient. However, such an extreme gradient between shallow and deep shelf waters, ultimately driven by nutrient supply, is not observed in modern or ancient open-marine settings and is unlikely given the high ρCO2 of the Paleoproterozoic atmosphere (Hotinski et al., 2004). It would also require oceans with a phosphate reservoir several times the modern size? (Meyer et al., 2016), which is seemingly inconsistent with the estimates for the Paleoproterozoic (Planavsky et al., 2010). Bakakas Mayika et al. related highly positive δ13C values in shallow-water carbonates to either a high degree of evaporation or high primary productivity. However, the FC formation does not show extensive development of evaporites (Ossa Ossa et al., 2019); neither does it show any evidence for nitrogen fixation observed in modern-ocean highly productive upwelling zones (Kipp et al., 2018). Furthermore, mid-Proterozoic and Phanerozoic (excluding intervals with δ13C excursions) carbonate successions with a strong evaporative signal or marked by high primary productivity do not show 13C-enrichment. Ossa Ossa et al. (2018) argued that the end of the LCIE coincided with a sea-level rise and deposition of organic-rich shales as well as a two-step ocean deoxygenation. The sea-level rise has been linked to tectonic reorganization (Bekker and Eriksson, 2003). While we acknowledge that it is important to consider facies-dependent patterns when interpreting carbon-isotope trends, we remain convinced that the FC formation reflects global sedimentologic and chem stratigraphic trends corresponding to the end of the LCIE at ca. 2.11–2.06 Ga, rather than carbon isotope heterogeneity in the oceans.

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