# Forum Comment

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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 $\delta^{13}C$ heterogeneity in Paleoproterozoic oceans based on the chemostratigraphic 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 $\delta^{13}C$ values record enhanced primary productivity or evaporitic conditions, the deep-water facies reflect steady-state operation of the global carbon cycle with ~0‰ $\delta^{13}C$ 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 chemostratigraphic 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 dolorhythmite and dololaminite) 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 diagenetic dolomite truncating lamination. Therefore, these are not deeper-water, interlayered dolostones and shales.

While Bakakas Mayika et al. linked the fall in $\delta^{13}C$ values in the middle part of the succession to a transgression at the unit III and IV boundary, the gradual decrease in $\delta^{13}C$ 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 $\delta^{18}O$ trend is coupled to that of $\delta^{13}C$ 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 $\delta^{18}O$ 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 Franceville sub-basin record highly positive $\delta^{13}C$ 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 $\delta^{13}C$ values of marine carbonates in the Franceville sub-basin reflect a basinal 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 $pCO_2$ 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 $\delta^{13}C$ 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 $\delta^{13}C$ excursions) carbonate successions with a strong evaporative signal or marked by high primary productivity do not show $^{13}C$-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 chemostratigraphic trends corresponding to the end of the LCIE at ca. 2.11–2.06 Ga, rather than carbon isotope heterogeneity in the oceans.

## REFERENCES CITED

Bakakas Mayika, K.B., Moussavou, M., Prave, A.R., Lepland, A., Mbina, M., and Kirsimae, K., 2020, The Paleoproterozoic Francevillian succession of Gabon and the Lomagundi-Jatuli event: Geology, v. 48, p. 1099–1104, https://doi.org/10.1130/G47651.1.

Bekker, A., and Eriksson, K.A., 2003, Paleoproterozoic drowned carbonate platform on the southeastern margin of the Wyoming Craton: A record of the Kenorland breakup: Precambrian Research, v. 120, p. 327–364, https://doi.org/10.1016/S0301-9268(02)00165-1.

Bekker, A., Holmden, C., Beukes, N.J., Kenig, F., Eglington, B., and Patterson, W.P., 2008, Fractionation between inorganic and organic carbon during the Lomagundi (2.22–2.1 Ga) carbon isotope excursion: Earth and Planetary Science Letters, v. 271, p. 278–291, https://doi.org/10.1016/j.epsl.2008.04.021.

Hotinski, R.M., Kump, L.R., and Arthur, M.A., 2004, The effectiveness of the Paleoproterozoic biological pump: A d13C gradient from platform carbonates of the Pethei Group (Great Slave Lake Supergroup, NWT): Geological Society of America Bulletin, v. 116, p. 539–554, https://doi.org/10.1130/B25272.1.

Kipp, M.A., Stüeken, E.E., Yun, M., Bekker, A., and Buick, R., 2018, Pervasive aerobic nitrogen cycling in the surface ocean accross the Paleoproterozoic Era: Earth and Planetary Science Letters, v. 500, p. 117–126, https://doi.org/10.1016/j.epsl.2018.08.007.

Meyer, K.M., Ridgwell, A., and Payne, J.L., 2016, The influence of the biological pump on ocean chemistry: Implications for long-term trends in marine redox chemistry, the global carbon cycle, and marine animal ecosystems: Geobiology, v. 14, p. 207–219, https://doi.org/10.1111/gbi.12176.

Ossa Ossa, F., Eickmann, B., Hofmann, A., Planavsky, N.J., Asael, D., Pambo, F., and Bekker, A., 2018, Two-step deoxygenation at the end of the Paleoproterozoic Lomagundi Event: Earth and Planetary Science Letters, v. 486, p. 70–83, https://doi.org/10.1016/j.epsl.2018.01.009.

Ossa Ossa, F., Eickmann, B., Hofmann, A., Planavsky, N.J., Asael, D., Pambo, F., and Bekker, A., 2019, Two-step deoxygenation at the end of the Paleoproterozoic Lomagundi Event [Reply]: Earth and Planetary Science Letters, v. 511, p. 259–261, https://doi.org/10.1016/j.epsl.2019.01.013.

Planavsky, N.J., Rouxel, O.J., Bekker, A., Lalonde, S.V., Konhauser, K.O., Reinhard, C.R., and Lyons, T.W., 2010, The evolution of the marine phosphate reservoir: Nature, v. 467, p. 1088–1090, https://doi.org/10.1038/nature09485.