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High-precision Pb-Pb geochronology ties the Great Carbon Cycle Perturbation of the Lomagundi-Jatuli Event to superplume volcanism

JANNE BLICHERT-TOFT[1], KURT O. KONHAUSER[2], BAPTISTE COUTRET[2], MARINE PINTO[3], ARNAUD AGRANIER[4], ABDERRAZAK EL ALBANI[5] AND FRANCIS ALBAREDE[3]

[1]Ecole Normale Supérieure de Lyon & CNRS
[2]University of Alberta
[3]Ecole Normale Superieure de Lyon
[4]University Brest
[5]Université de Poitiers and CNRS, Institut de Chimie des Milieux et Matériaux, 86073 Poitiers, France

We present a high-precision Pb-Pb isochron age of 2194±5 Ma for the archetypal FB section of black shales in the Francevillian basin, Gabon. This sequence hosts abundant centimeter-sized lenticular forms, interpreted by some authors as the earliest known eucaryotes. The FB section is a type locality of the Lomagundi-Jatuli Event (LJE), which occurred at ca. 2.3–2.05 Ga following the Great Oxidation Event (GOE) and is the largest, most prolonged positive carbon isotope excursion in Earth history characterized by elevated $\delta^{13}C$ signatures in carbonates. However, despite extensive study, its timing and underlying mechanism(s) remain debated, largely due to the scarcity of reproducible geochronological data. Dating sedimentary sequences is analytically challenging. Nevertheless, by applying aggressive acid leaching techniques, we have substantially refined both the age of the FB section and its accuracy and precision. Notably, our new Pb-Pb age of 2194±5 Ma precisely coincides with the climax of voluminous flood basalt eruptions at the onset of the Birimian-Eburnean orogeny. This event, which generated over $2x10^6$ km^2 of juvenile crust within < 200 Ma, now extends across vast regions of West Africa and South America. Contrary to models invoking supercontinent assembly, we propose that this massive superplume event—the largest of its kind in Earth history—was a key driver of the LJE. This large-scale volcanic eruption released enormous amounts of mantle-derived CO_2 into the atmosphere, overwhelming the buffering capacity of dissolved marine carbonates and preventing rapid sequestration in the ocean. Consequently, we suggest that the uniquely elevated and bimodal $\delta^{13}C$ values of the LJE reflect episodic bursts of volcanogenic mantle carbon, which intermittently saturated the ocean with isotopically heavy carbon in a low-alkalinity marine environment. Thus, we reinterpret the LJE as the magmatic culmination of the Birimian-Eburnean event that followed the GOE, linking its precise Pb-Pb age to significant carbon isotope anomalies associated with massive volcanism. This perspective provides a novel framework for understanding both the anomalously high and bimodal $\delta^{13}C$ values in 2.4–2.0 Ga carbonates and the broader role of large-scale magmatism in shaping Earth's geochemical history.