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Subaerial volcanism broke mid-Proterozoic environmental stasis

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The mid-Proterozoic (1.8–0.8 Ga) is recognized as a phase of marine anoxia, low marine primary productivity, and constrained eukaryotic biodiversity. This lull in environmental and biological evolution has been attributed to subdued orogenic activity, which could be linked to the long-term existence of the Columbia supercontinent. However, emergence of extensive organic-rich black shales from mid-Proterozoic signals sporadic surges in marine primary productivity. Geochemical measurements of these shales and associated strata unveil enrichments in redox-sensitive elements (e.g., chromium and molybdenum) along with prominent isotopic fractionations. These results point to oscillations in atmospheric and oceanic oxygenation levels, while the mechanisms behind are still not fully understood. Here, we present a study detailing volcanic activity and its impact on terrestrial weathering through examination of the 1.41–1.35 Ga Xiamaling Formation in North China. Our investigation, leveraging precise mercury and lithium isotopic analyses, reveals the introduction of fresh rock substrates by subaerial volcanism. This geological event initiated a transformative process, shifting the initial regolith-dominated condition in tropical lowland to a regime of enhanced chemical weathering and denudation efficiency. The resultant large amounts of nutrient-rich volcanic derivatives, such as phosphorus and other nutrients, could have spurred marine primary productivity and heightened organic carbon burial. Notably, the identified volcanic activity coincides with the onset of a well-documented mid-Proterozoic oxygenation event. It is likely that the volcanism-induced elevation of primary productivity led to widespread oxygenation via the net burial of organic carbon. Such a scenario is in line with the high organic carbon concentrations and a positive excursion of organic carbon isotopes. Nevertheless, our results emphasize that subaerial volcanism and its corresponding effect on weathering can break the long-term stasis of the mid-Proterozoic.