The role of seafloor-hydrothermal activity as a driver of marine anoxia

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Numerous Paleozoic biotic crises correlate with sedimentological and geochemical evidence for widespread low-O_2 and high-H_2S, shallow-marine conditions (anoxia and euxinia). Hypothesized factors that promoted the recurrent anoxic events range from external (volcanic outgassing, continental configuration) to internal (biogeochemical cycling) [1]. Recent work has suggested that seafloor-hydrothermal activity, recorded by large volcanogenic massive sulfide (VMS) deposits, may have acted as an additional external driver of basinal-to-regional shifts in shallow-marine redox states [2]. Forming during mid-ocean ridge, arc, and back-arc volcanism, these hydrothermal systems potentially sustained significant fluxes of reductants (Fe, Mn, H_2S, H_2) over ~10^5 years, acting as a sink for oxidants and a mechanism for limiting nutrients. Here we provide the first test of ocean redox sensitivity to seafloor-hydrothermal activity using an intermediate-complexity, 3D Earth system model (cGENIE). Across a range of Paleozoic pO_2, climate, and nutrient scenarios, our results demonstrate that benthic reductant fluxes associated with VMS mineralization are capable of driving dysoxia and impacting biogeochemical cycling at a basinal to regional scale. These simulations suggest that VMS systems may act as a lever on local redox states, the strength of which is influenced by O_2 supply from meridional overturning and strength of the biological pump. Although not likely the sole driver, seafloor-hydrothermal activity potentially played a significant role in strengthening positive feedbacks in biogeochemical and nutrient cycling, setting the stage for Paleozoic marine anoxic-euxinic events.

[1] Meyer and Kump (2008) *Annu. Rev. Earth Planet. Sci.* **36**, 251–288. [2] Grenne and Slack (2019) *Miner. Deposita* **54**, 829–848.