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Thermogenic sulfur degassing as a driver of sustained global cooling and extinction

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The emplacement of large igneous provinces (LIPs) may drive catastrophic volatile release through heating of carbon and sulfur-bearing host sediments. In the past twenty years, multiple papers have explored the effect of thermogenic carbon emissions on global climate. Yet, in the geologic community, it is broadly assumed that sulfur injection must reach the stratosphere to drive long-term cooling; thus, these metamorphic sulfur emissions have been almost entirely ignored. However, if the source of sulfur in the troposphere is sustained, the cooling effect may be correspondingly prolonged. Compared to volcanism, metamorphic degassing is an intrinsically slower-yet-steady processes, perfectly positioned to drive sustained sulfur input to the atmosphere. We therefore undertake exploratory modeling of thermogenic/metamorphic carbon and sulfur degassing around a LIP intrusion. Thermodynamic-kinetic modeling is used to estimate carbon and sulfur degassing during basaltic intrusion into a black shale. We find that up to ~25% of the sulfur may be liberated at moderate metamorphic conditions. In addition, the sulfur releasing reaction (requiring reduction of to form H_2S) is directly coupled to organic carbon oxidation. A one-dimensional thermal model predicts temperature-time paths during metamorphism, which in turn drives degassing. The net flux to the atmosphere is estimated based on a conservative area estimate of 10,000 km^2.

These volatile fluxes are then passed to a simple carbon cycle and planetary energy balance models of the climate response. We find that carbon and sulfur emissions from contact metamorphism may be sustained long enough to cause centennial-scale cooling spikes of several Kelvin superimposed on millennial-scale warming from the CO_2 greenhouse effect. Our results suggest that a metamorphic sulfur source should be considered as a driver of sustained global cooling during large igneous province emplacement, with potential implications for Phanerozoic biotic crises such as the End-Triassic Mass Extinction.

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