

## **Does volcanism promote or suppress paleoproductivity?**

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Volcanism is thought to be associated with the formation of organic matter after most shale oil and gas production layers worldwide are discovered to be accompanied by volcanic ash layers. Some volcanism promotes paleoproductivity, and the volcanic ash carries large amounts of nutrients (P, Si, Ca, Mg) and trace metal elements (Fe, Zn, Mn, Ni, V), resulting in algal and bacterial blooms. The thickness of volcanic ash deposition is directly proportional to the concentration of released nutrients, and the moderate amount of deposited ash can promote algal blooms. The magmatic and hydrothermal activities associated with volcanism also directly input nutrients into the water column, promoting the increase of primary productivity in oceans and lakes. Moreover, volcanism contributes to the effective preservation of organic matter due to the anoxic environment at the bottom of the water column triggered by the release of H<sub>2</sub>S and SO<sub>2</sub>, stratification of the water, and oxygen depletion by algae and bacteria. Hydrothermal fluids carry trace catalytic elements such as Se, Zr, Ti, V, Co, Mn, Ni, Mo, and U, which promote the evolution of organic matter. However, it seems that not all volcanism promotes productivity, as recent studies have found that the five mass extinctions in Earth's history were likely triggered by large igneous provinces. Volcanism has led to global warming, cooling, calcification crises, ocean hypoxia, ocean acidification, sea-level fluctuations, toxic metal inputs, and a complex set of catastrophic environmental effects. This has caused a sharp drop in productivity in the ocean and lake, even as a mass of organisms have been buried. The effects of volcanism on different depositional environments in the ocean and land are different, and the effects of different types and scales of volcanism should be distinguished and quantified to disclose the mechanisms of volcanism on productivity.