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Surface ocean iron fertilization: The role of airborne volcanic ash and iron-flux into the Pacific Ocean

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Iron is a limiting micro-nutrient for marine primary production (MPP) in vast areas in the surface ocean. Hence, atmospheric supply of iron to the surface ocean can affect marine biogeochemical cycles, associated ocean-atmosphere exchange of CO2 and eventually climate development. Airborne volcanic ash from volcanic eruptions can be an important atmospheric iron-source in the surface ocean by releasing bio-available iron while settling through in the surface ocean. Here we present new data from time-dependent geochemical experiments with pristine (unhydrated) volcanic ash samples and natural seawater by means of Cathodic Stripping Voltammetry. Our results demonstrate that volcanic ash mobilizes significant amounts of soluble Fe within 60 minutes of contact with natural seawater. Depending on the amount of volcanic ash deposited offshore during major volcanic eruptions and the amount of iron that ash can release on contact with seawater, the calculated increase in the surface ocean Fe levels range from several nanomolar up to several hundred nanomolar (nM). Only 2 nM increase in iron concentrations can stimulate massive diatom blooms in the oceanic regions in which MPP is limited by the availability of iron (the iron-limited oceanic areas) (Wells, 2003). Therefore volcanic ash should be able to significantly affect marine phytoplankton growth in an ash fall area, acting as an iron fertilizer. Based on our new iron-release data and marine sediment core data we provide the first estimate of the flux of Fe from volcanic ash into the Pacific Ocean that covers more than 60 percent of the iron-limited oceanic regions. Our calculations show that the flux of Fe from volcanic ash is comparable to the order of magnitude of the flux of Fe from aeolian dust. Our study shows that volcanic ash is a major and so far underestimated atmospheric iron-source for the oceans and therefore an important component in marine biogeochemical iron cycles.

Wells, M.L.: The level of iron enrichment required to initiate diatom blooms in HNLC waters, Marine Chemistry, 82, 101-114, 2003.