The Effect of Volcanoes on Atmospheric Chemistry and Climate over the Course of Earth History

D C Catling (Dept Atmospheric Sciences, Box 351640, University of Washington, Seattle, WA 98195; ph. 206-543-4576; fax 206-543-0308; e-mail: davidc@atmos.washington.edu)

Over geological time, volcanic and metamorphic volatiles have strongly influenced the chemical and radiative properties of the atmosphere. I will discuss two key elements of the influence of volatile inputs to the atmosphere over the course of Earth history: redox change and climate control. Atmospheric redox chemistry has changed dramatically from an atmosphere with trace levels of oxygen to one that is unique in the solar system by virtue of abundant oxygen. However, carbon isotopes imply that the net production of oxygen from the burial of photosynthetically-fixed carbon was quantitatively similar before and after the rise of atmospheric oxygen. To explain this puzzle, the proportion of reduced volatiles from volcanism and metamorphism must have declined. The oxygen fugacity of volcanic inputs is constrained by redox-sensitive geochemical tracers to have changed no more than a factor of ~3 over geological time. The redox nature of metamorphic (as opposed to volcanic) volatiles is poorly constrained and deserves future research. The changing chemistry of the atmosphere was necessarily linked to changes in greenhouse gases and climate control. A popular view is that temperature-dependent silicate weathering and CO2 removal acts as a thermostat, moderating Earth's climate on geological timescales. However, global glaciations near the beginning (2.4-2.2 Ga) and end (750-540 Ma) of the Proterozoic eon suggest that other biogeochemical factors controlling atmospheric greenhouse gases have been important in the past. Similarly, sudden climate change in more recent times and the near-synchronous correlation of climate tracers (CH4, CO2, isotopes, non-seasalt sulfate particles) over the last 250 k.y. suggest a strong coupling between physical and biological cycles in the climate system. Nevertheless, volcanic activity controls the release of volatiles from the lithosphere - usually the largest reservoir for a given volatile - and this flux sets the steady state of key biogeochemical cycles (C, S, O, N).