Voluminous Icelandic Basaltic Eruptions Appear To Cause Abrupt Global Warming

Peter L Ward, Teton Tectonics, Jackson, WY 83001

Beginning on June 21, 1783, Laki volcano in southern Iceland erupted 14.7 km^3 basalt, ejecting ~24 Mt SO_2 into the stratosphere where it was blown eastward and northward and ~98 Mt into the troposphere where the jet stream transported it southeastward to Europe. The "dry fog" observed in Europe with an estimated mean concentration of 60 ppbv SO_2, raised daytime temperatures as much as 3.3^oC, causing the warmest July in England from 1659 when measurements began until 1983.

SO_2, tropospheric O_3, NO_2, and fine ash absorb ultraviolet energy from the sun that causes the bonds between and within their atoms to oscillate at ~47 times higher frequency than the bonds in CO_2 absorbing infrared radiation. Temperature is proportional to the kinetic energy of these oscillations, i.e. the frequency squared. Thus these gases are raised to much higher temperatures than greenhouse gases. The Stefan-Boltzmann law says that radiation from these molecules is a constant times temperature raised to the fourth power. As a result, SO_2 and ash radiate far more energy back to earth than CO_2, causing warming. Another way to look at the energy involved shows that 15 ppbv SO_2 in the 0.3-0.42 μm wavelength band absorbs as much solar energy per unit volume as 388,000 ppbv CO_2 absorbs infrared energy in the 12.7-17.5 μm band.

Basaltic volcanoes such as Laki emit 10 to 100 times more SO_2 than more evolved magmas and are less explosive, leaving most of the SO_2 in the troposphere. All 14 Dansgaard-Oeschger (DO) sudden warmings between 46 and 11 ka are contemporaneous with the highest levels of sulfate in the GISP2 drill hole near Summit Greenland. These DO events typically warmed the northern hemisphere out of the ice age within decades, but as volcanism waned, ocean temperatures cooled the world back into an ice age within centuries. The world finally exited the ice age when voluminous volcanism continued from 11.6 to 9.6 ka.

Basaltic table mountains or tuyas in Iceland document major sub-glacial eruptions that occurred during DO 0, A, and 1 (11.6, 13.1, and 14.6 ka) and similar but less well dated activity at least over the past million years. Massive melting of a thick ice sheet by volcanoes would decrease overburden pressure on the magma chambers, potentially increasing volcanism. Continued basaltic eruptions over decades enhanced by such a feedback could explain why the intervals between DO events (1300 to 8800 years) are more random than cyclic and the evidence for sudden influxes of fresh water into the North Atlantic documented during DO events.

Concentrations of sulfate in Greenland were as high from 1928 to 1985 as during the largest DO event. Trace element analysis shows this sulfate came from smoke stacks in northern Russia, Europe, and central North America. Observed levels of SO_2, NO_x, tropospheric O_3 and black carbon are more than sufficient to have been the primary cause of 20th century global warming. Efforts to reduce acid rain by reducing emissions of these pollutants "accidentally" slowed global warming by 1998. Mean global surface temperatures have remained high but have not increased since then.