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East Greenland flood basalt volcanism: duration, volatile flux and correlation to the Paleocene-Eocene thermal maximum

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Massive flood basalt volcanism in the NE Atlantic 56 million years ago can be related to the initial manifestation of the Iceland plume and ensuing continental rifting, and has been correlated with a short (c. 200,000 years) global warming period, the Paleocene-Eocene thermal maximum (PETM). A hypothesis is that magmatic sills emplaced into organic-rich sediments on the Norwegian margin triggered rapid release of greenhouse gases. However, the largest exposed volcanic succession in the region, the E Greenland flood basalts provide additional details.

The alkaline Ash-17 provides regional correlation of continental volcanism and pertubation of the oceanic environment. In E Greenland Ash-17 is interbedded with the uppermost part of the flood basalt succession. In the marine sections of Denmark, Ash-17 postdates PETM, most likely by 3-400,000 years. While radiometric ages bracket the duration of the main flood basalt event to less than a million years, the subsidence history of the Skaergaard intrusion due to flood basalt emplacement indicates it took less than 300,000 years. It is therefore possible that the main flood basalts in E Greenland postdates PETM. This is supported by a scarcity of ash layers within the PETM interval.

Continental flood basalt provinces represent some of the highest sustained volcanic outputs preserved within the geologic record. Recent studies have focused on estimating the atmospheric loading of volatile elements and have led to the suggestion that they may be associated with significant global climate changes and mass extinctions. Estimates suggest that c. 400,000 km3 of basaltic lava erupted in E Greenland and the Faeroe islands. Based on measurements of melt inclusions and solubility models, approximately 3000 Gt of SO_2 and 220 Gt of HCl were released by these basalts. Calculated yearly fluxes approach 10 Mt/y SO_2 and 0.7 Mt/y HCl. Refinements of these estimates, based largely on further melt inclusion measurements, are proceeding.

Our estimates for volatile fluxes can also be considered as minima, as we have only considered the volume of the E Greenland and Faeroe lavas. If volcanism associated with continental breakup in the remainder of the North Atlantic occurred over a similarly short duration, then fluxes will be considerably higher. For example, if the 4 x 106 km3 volume estimated for the southern portion of the Northeast Atlantic Igneous Province erupted over 300,000 years then our flux estimates would be an order of magnitude higher. These fluxes approach those associated with much shorter duration historic basaltic eruptions, such as Laki (190 Gt SO_2 over $\sim$9 months), which had markedly deleterious effects in Iceland and throughout northern Europe. The climatic effects of the release of S and Cl in these amounts, and for periods extending for several hundred thousand years, remain unclear, but are likely to be significant. One consequence of East Greenland and related flood basalt volcanism may have been initiation of global cooling to end the Palaeocene-Eocene thermal maximum.