Eruption dynamics and volatile release in flood basalt eruptions

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Flood basalt province formation is distinguished from other basaltic magmatism by the repeated effusion of huge batches of magma, in the order of 103 km3, over a short stretches of geologic time (characteristically < 1 Ma). Such a scenario does not, apparently, occur at any other times in Earth history. Vast flood basalt lava flow fields were formed by activity on fissures 10s-100s of kilometer long. Our recent work on Columbia River basalt flows suggests that eruptions of this magnitude lasted at least 5 and 15 years. Estimated mean eruption rates would have been 103-104 m3/s DRE, or 3x107-1x108 kg/s. To put this into perspective, about 10 years of activity at the AD1783 Laki peak eruption rate (1.2 x 107 kg/s) would produce a lava flow field of flood basalt dimensions. Mass eruption rates would vary depending on the duration of effusion and the length of active fissure at any one time; ~3.5x 103 kg/s/m (m = meter length of fissure) for a 2-km-long active fissure, down to ~100 kg/s/m for a 75-km-long active fissure. The occurrence of deposits of spatter, spatter-fed lava, and scoria mounds along eruptive fissures suggest that there was violent fire fountaining during flood basalt eruptions. Calculations show that fountain heights during periods of peak output may have exceeded 1.5 km for magma with volatile contents of 1-1.5 wt%. Model estimates for the convective plumes rising above the fountains indicate heights in excess of 15 km. Based on a Laki analog and determination of volatile contents of flood basalt lavas we estimate that ~70% of the volatiles were released at the vents and then lofted to upper tropospheric - lower stratospheric heights by the eruption columns. Our measurements indicate that individual flood basalt eruptions are capable of releasing >10,000 Mt of SO2, which amounts to a loading of 1000 Mt per year for a 10-year-long event, a huge amount compared to historic releases such as Mt. Pinatubo, 1991 (20 Mt). Thus, the atmospheric perturbations associated with SO2 emissions from flood lava eruptions are likely to have been of the magnitude predicted for a severe nuclear or volcanic winter, and would have lasted up to decade or longer.