Emplacement of continental flood basalt lava flow fields

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We examine the conditions required to explain the great length (up to 1000 km) and the large volume (perhaps up to 10,000 cu km) of continental flood basalt lava flows. Two simple requirements for a long lava flow are 1: sufficient magma held in a chamber to supply a large volume of lava, and 2: an emplacement system that can transport the liquid lava from vent to flow front without the lava freezing. For the common lava composition in many provinces, including the Columbia River basalt (CRB) flood basalts, this is a cooling range of only approximately 150 plus or minus 50 C. During flow-field emplacement, a combination of cooling and degassing promotes groundmass crystallization that is crucial in determining the resulting flow characteristics. All large lava flows in flood basalt provinces are exclusively pahoehoe, or closely related varieties. This is mandated by the fact that aa lava flows are too thermally inefficient, cooling by approximately 2 to 5 C per km in the feeder channels and rapidly developing groundmass crystals, to attain lengths much in excess of 100 km on Earth. Only the insulated flow model for pahoehoe flow fields, where the dominant lava body is the inflated sheet lobe, fits all the quantitative criteria required to explain the great extent of flood basalt flows: effusion rates are on the order of 1000s cu m per sec, lava travels from the vent to the flow front in days to weeks, heat losses are restricted to as little as 0.001 to 0.1 C per km, and eruption durations are years to centuries. These values dictate that eruptive volumes must be 100s to 1000s of cu km, a condition met by only by lava flow eruptions in flood basalt provinces. Such enormous mean output rates from fissure vents (100s-1000s cu m per s) would feed numerous inflating sheet lobes (each containing 0.05-0.5 cu km of lava), into which most of the lava output is emplaced. However, each lobe need only have local injection rates of a few to 10s of cu m per second in order to thicken within plausible time-frames (months to a few years). Significantly higher mean output rates (equating to much shorter eruption duration rates) do not provide sufficient time to explain the growth of inflated lobes with the observed crustal thicknesses and show that, compared with almost all historic basaltic volcanism, rates at which typical CFB lavas formed were at times spectacularly high, especially for certain parameters. New results explaining the details of internal lava transport within simple flow fields from the CRB suggest that there is only time to emplace the observed number of sheet lobes if several are forming at once. Vent systems for flood basalts are poorly understood, and maps of vents on the 180-km-long CRB Roza fissure system will help us understand the nature of venting and eruption columns, important for assessment of the environmental impact of flood basalt volcanism.