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Magmatic architecture of continental flood basalts - a Deccan Traps perspective

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Flood basalts represent some of the largest magmatic events in Earth history, with intrusion and eruption of millions of km^3 of basaltic magma over a short time period (~ 1-5 Ma). A typical continental flood basalt (CFB) is emplaced in hundreds of individual eruptive episodes lasting decades to centuries with lava flow volumes of 10^3- 10^4 km^3. These large volumes have logically led to CFB models invoking large magma reservoirs (> 10^5-10^6 km^3) within the crust or at Moho depth. In the last few decades, significant improvements in geochronological, geochemical, paleomagnetic, volcanological, and paleo-proxy measurements have provided high-resolution constraints on CFB eruptive tempo - the volume, duration, and frequency of individual eruptive episodes. Here, we use a new volume-averaged visco-elastic mechanical model for an ellipsoidal magma reservoir coupled to a dike-shaped erodible conduit to calculate how eruptive fluxes (km^3/year) and volumes vary as a function of reservoir geometry and crustal properties for a single magma reservoir, as well as multiple connected reservoirs. We use a 1D thermal model and characteristic timescales for magma reservoir evolution to model how crustal visco-elastic properties evolve over time during the emplacement history of a CFB event, and how they impact magma eruptibility. Using the well-studied Deccan Traps as an archetype for CFB systems (along with datasets from other CFBs), we find that the presence of just a few large crustal magma reservoirs is inconsistent with the observations. We instead propose that CFB eruptions are fed from a number of smaller (~ 10^2 -$10^{3.5}$ km^3) interconnected magma reservoirs present throughout the crust. This magmatic plumbing architecture leads to; (a) large volume efficient eruptive episodes with 10-100s of years duration; (b) relatively short time-periods (1000s of years) separating eruptive episodes since multiple mechanisms can trigger eruptions (e.g., magma recharge or volatile exsolution); (c) lack of large upper-crustal intrusive bodies in geophysical datasets; and (d) marked geochemical changes between and within individual eruptive episodes as observed in various CFB sections. This new model has important implications for the timing and volumes of climate-altering volatile emissions associated with CFBs.