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Systematic geochemical variations in the upper Deccan lavas: Implications for the magmatic plumbing system

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The Earth's history is punctuated by massive volcanic events during which large amounts of melt (~10^6 km^3) erupt in relatively short periods of time (<10^6 years). These Large Igneous Provinces (LIPs) are mostly associated with the activity of mantle plumes and eruption rates during their main stages are significantly higher than those of today's largest magmatic systems. However, since no LIP is currently active, the architecture of the associated plumbing systems and the magmatic processes triggering eruptions are poorly understood. We present new major and trace element and Sr-Nd-Pb isotope data for 43 lava flows from a continuous 1,200 m thick stratigraphic section through the upper, most voluminous part of the Deccan LIP (Bushe to Mahabaleshwar Formations). The use of geochemical data provides information about magmatic processes such as fractional crystallization, magma mixing and assimilation of mantle and/or crustal components. Together with published paleomagnetic directions and absolute U-Pb ages for zircons separated from weathered flow tops exposed in the section, it allows conclusions to be drawn about the sizes, emplacement mechanisms and eruption rates of the associated magma reservoirs. We find four magmatic sequences each lasting ~10^4 to ~10^5 years during which major and trace element compositions change systematically, followed by an abrupt change in geochemistry at the start of a new sequence. Within each sequence, the MgO content and proportion of crustal contamination decrease progressively, indicating frequent replenishment of the associated magma reservoirs with less contaminated but more evolved melts. These findings are supported by mineral textures of plagioclase phenocrysts indicating mixing of different recharge batches during melt accumulation. Rapid changes of isotopically different contaminants suggest that the lavas associated with each sequence probably erupted from multiple small- to medium-sized magma reservoirs (10^2 to 10^3 km^3) located at different crustal levels. The results of this multidisciplinary study contribute to a better understanding of the establishment and temporal evolution of the Deccan magmatic plumbing system and may be applicable to other flood basalt provinces worldwide.