Recharge and growth of a deep crustal magma chamber over the lifespan of a flood basalt

XUN YU[1,2], LI-HUI CHEN*[1], CIN-TY A. LEE[2] AND GANG ZENG[1]

[1]State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, China

[2]Department of Earth Science, MS-126 Rice University, 6100 Main St., Houston, TX 77005, United States

Eruptive sequences can be used as windows into the thermal and chemical evolution of magma chambers. We examined a vertical section of the Baichahe basalt flow, one of the youngest magmas associated with the Pliocene Chifeng flood basalt in Inner Mongolia, North China. The section is ~40 m thick and comprised of nine continuous lava flows. From bottom to top, MgO (7.7-8.7 wt. %) and CaO increase, K_2O, SiO_2, LREEs and other incompatible elements decrease, and Nb/La, Ce/Pb and radiogenic Pb isotopic ratios increase. Elemental variations indicate that evolved lavas erupted first and then progressively became more primitive. While the elemental systematics can be readily explained by pure fractional crystallization, such a scenario cannot explain variable incompatible element ratios and Pb isotopes, nor can it physically explain the temporal trend to more primitive compositions. Variable Pb isotope and incompatible element ratios require a component of crustal contamination, most likely of a lower crustal component (unradiogenic Pb, low Ce/Pb and low Nb/La) in the earliest erupted lavas. However, crustal contamination with or without fractional crystallization (e.g., AFC) cannot explain all the elemental systematics. For example, AFC processes should cause more substantial decreases in MgO and Nb than what is observed due to the low Mg and Nb contents of continental crust relative to the primitive basalt endmember. We find instead that continuous recharge by a primitive magma, in combination with AFC type processes, is necessary to simultaneously explain all of the geochemical systematics. In particular, to explain the temporal trend towards more primitive compositions, the proportion of recharging magma to assimilation and fractional crystallization must have increased during the lifespan of the magma chamber. These geochemical trends suggest that the delivery of fresh basalt to the magma chamber may have become more efficient with time, perhaps enabled by thermally induced relaxation of the initially cold crustal wallrock. If so, this could imply that the magma chamber increased in size during the eruptive lifespan of the flood basalt province.