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Perovskite geochemistry: Clues to kimberlite and lamproite melt evolution in the Wajrakarur Kimberlite Field (WKF), India.

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Kimberlites and lamproites are deep mantle-derived (>150km), volatile-rich (CO_2, H_2O, and F) igneous rocks that host natural diamonds and provide unique insight into the composition of subcontinental lithospheric mantle. The reconstruction of the primary melt composition as well as the melt evolution of kimberlites/lamproites are complex due to wall rock assimilation, fractionation, and volatile loss. Perovskite is an important but less studied robust phase that fractionates from the kimberlitic/ lamproitic melt over an extended period during progressive crystallization and helps us to understand how the primary melt evolves during ascent. It serves as a major host for incompatible trace elements (i.e., La, Ce, Sr, Nb, Ta), Th, and U, and therefore a valuable tool for U-Pb geochronology. Here we present trace element and U-Pb geochronological data, using in-situ LA-ICPMS, from perovskite in two kimberlites (P3 and CC3) and four lamproites (CC1, CC2, P4, P13) from Wajrakarur kimberlite field, India. The Perovskite $^{206}Pb/^{238}U$ ages indicate an emplacement range of ~1110–1150 Ma. The studied perovskites show a decreasing trend in the Th/U ratio, as well as in Na, REE, Th, and Ta contents, along with an increasing Nb/Ta ratio toward the rim. High Th/U fractionation from the perovskite core provides a clue to the nature of the precursor melt composition as more primitive carbonated silicate melts. The restricted Th/U but higher Nb/Ta ratio with high Zr and Hf content in P13 rims and CC3 likely results from the interaction with modified carbonate-rich melt pockets during ascent. The super-chondritic Zr/Hf ratio (35-40) and a sub-chondritic Nb/Ta ratio (14-16) in bulk rock coincide with the global OIBs dataset and suggest the influence of metasomatic SCLM on the primary melt composition. The negative Pb anomaly indicates minimum effect of crustal contamination. The $^{206}Pb/^{238}U$ ages, along with trace element compositions of perovskite and bulk rock geochemistry, provide strong evidence for a common magma source and similar emplacement timeframe for both kimberlites and lamproites. The partition behaviour of Th-U, Nb-Ta, and Zr-Hf in perovskite suggests that most kimberlites and lamproites follow a carbonated-silicate melt evolution trend, whereas CC3 and P13 indicate carbonate-rich melt enrichment during ascent.