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Magnesium isotopic compositions of magnesio- and ferro- carbonatites: insights into the origin and evolution of carbonatite magma

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Carbonatites are unique magmatic rocks with more than 50% carbonate minerals. They are produced by low degree partial melting of CO_2 rich mantle peridotite followed by silicate crystal fractionation or carbonate- silicate liquid immiscibility of the parent magma. Magnesio- carbonatite melts generated by the partial melting of carbonated mantle peridotite are considered direct mantle derivatives. However, scarcity of natural occurrences of pure extrusive Mg-rich carbonatites limits direct testing of this concept. Moreover, most carbonatite suites worldwide are associated with alkaline silicate rocks, suggesting magmatic differentiation through liquid immiscibility. This complicates the determination of parental carbonatite magma composition in a carbonatite suite. Therefore, Mg-rich carbonatites (or characterized by a higher proportion of dolomite) that occur without any associated silicate rocks would provide comprehensive insights into the primary carbonatite melt composition and their evolutionary pathways.

We report major element concentrations and Mg isotopic ratios ($d^{26}Mg$) of carbonatites from the ~1460 Ma old Newania carbonatite complex of India, which is devoid of any associated alkaline silicate rocks. These carbonatites display a wide range in MgO (0.80- 14 wt.%), CaO (25- 42 wt.%), and $FeO_{(T)}$ (11-17 wt.%) concentrations and primarily classified as magnesio and ferro-carbonatites. The $d^{26}Mg$ values of magnesio- carbonatites display constricted variability (-0.35 to -0.41 ‰). By contrast, ferro carbonatites display lower and wider range in $d^{26}Mg$ values (-1.71 to – 2.26‰). A strong positive correlation is observed between the $d^{26}Mg$ values of all carbonatites and their MgO concentrations, MgO/CaO and MgO/FeO_T ratios. Carbonatites were leached with dilute acid and the leachates were further used for their Mg isotopic ratio measurements. Leachates of magnesio- carbonatites exhibit similar $d^{26}Mg$ values to their whole rock compositions, while those from ferro-carbonatites have lower $d^{26}Mg$ values than their corresponding whole rock values. Additionally, the $d^{26}Mg$ values of all leachates display strong positive correlation with their MgO/CaO and MgO/FeO ratios. These findings suggest that the $d^{26}Mg$ values of magnesio-carbonatite samples preserve their source signature, while those of ferro- carbonatites are perhaps influenced by the fractional crystallization process.