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Petrogenetic Link Between Carbonatite and Silicate rocks: Insights from *In-situ* Geochemical and Isotope Analysis of Trans-magma Minerals

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The petrogenetic link between carbonatite and associated silicate rocks has been debated among igneous petrologists for several decades. Some accessory minerals, such as apatite and calcite, can crystallize throughout magmatic differentiation (termed trans-magma minerals in this study) and record geochemical changes in the crystallizing environment. The compositions of these accessory minerals can, therefore, provide valuable insights into the genesis of carbonatite and associated silicate rocks. The Wajilitage Carbonatite Complex (WCC) in northwest China is a typical carbonatite–alkaline complex composed of calcitic and dolomitic carbonatites, aillikite, nephelinite, and nepheline syenite. In this study, *in-situ* geochemical and C–O isotope analyses on trans-magma minerals (e.g., apatite and calcite) are utilized to investigate their genetic relationships. The Mg content of apatite (Mg_{ap}) is demonstrated to efficiently record the evolutionary history of the carbonatite–alkaline complex. Mg_{ap} values in carbonatite are similar to those in aillikite, but much higher than those in nephelinite and nepheline syenite. This, in combination with the similar $\delta^{13}C$ values of calcite in calcitic carbonatite and carbonated globules in aillikite, we propose that the parental magma of the carbonatite was derived from the aillikite by liquid immiscibility. Subsequent fractional crystallization of calcite and dolomite from the immiscible liquid continued to produce calcitic and dolomitic carbonatites. Trace elements and $\delta^{18}O$ values of apatite suggest that nephelinite evolved to nepheline syenite, while the aillikite mixed with nepheline syenite at an evolved stage. Ultimately, a petrogentic model is proposed to explain the links between carbonatite and associated silicate rocks within the WCC.