In-situ chemical, isotopic and geochronological investigation of the Shaxiongdong carbonatite complex, China

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Abstract: The Shaxiongdong (SXD) carbonatite complex is one of the rare earth element (REE) deposits located in the southern margin of the South Qinling orogeny, central China. It is mainly composed of carbonatite and associated silicate rocks (syenite and pyroxenite). The dominant calcite and apatite within carbonatite are thought to control the REE budget. However, the minority REE minerals (e.g., burbankite) might play a significant role in the REE distribution. Calcite from SXD carbonatite are characterized with highly varied REEs (133–1895ppm), and display flat to weakly light REE (LREE) enriched chondrite-normalized patterns (La/Yb_N=1.34–31.97; La/Nd_N=0.71–2.78). Fluorapatite is enriched in REEs (2895–24543ppm) with negatively sloped distribution patterns. Similar to calcite, apatite show a huge LREE variation (La/Yb_N=4.01–226.12; La/Nd_N=0.51–2.09) as well. Monazite-(Ce), burbankite, strontianite-(Ce), ancylite-(Ce) and allanite have been identified within carbonatite samples that contain calcite and apatite with the most depleted LREE contents. These are LREE abundant minerals, e.g., ancylite is composed of 39.21–54.06% $LREE_2O_3$. The highly varied REE (especially LREE) compositions observed for both calcite and apatite might result from a differentiation sequence controlled by an earlier or co-crystallization of the REE minerals (e.g., burbankite, monazite). These calcite and apatite represent cumulates from a highly fractionated carbonatite magma.

Carbon and oxygen isotopes analyzed for calcite from both carbonatite and syenite are plotted within the ‘mantle carbon box’. These are characterized with similar initial $^{87}Sr/^{86}Sr$ ratios (0.70317-0.70335 for carbonatite; 0.70324-0.70336 for syenite). Sr isotope ratios obtained for apatite (0.70313 to 0.70329) from carbonatite overlap the range for the surounding calcite. These U-depleted apatite are further analyzed by LA-ICP-MS with an Th–Pb age at 433.1±6.4 Ma, which coincides with the zircon U-Pb age (441.8±2.2 Ma) from the associated syenite given their associated uncertainties. The consistent Sr isotope ratios and U-Th-Pb ages further suggest that the SXD carbonatite and syenite were formed simultaneously from a carbonated silicate melt via liquid immiscibility and fractional crystallization.