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Isotopic decoupling of K from Sr and Nd in the Saima alkaline complex, NE China: interactions of cratonic roots and asthenosphere

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Geological Setting

The eastern block of the North China Craton (NCC) is located east of the Trans-North-China Orogen, between the Xing'an-Mongolian orogenic belt in the north and the Dabie-Sulu ultrahigh-pressure collisional belt in the south. Cratonization of the NCC is estimated to have occurred at 1.85 Ga (Lu et al. 2006). Lithospheric destruction and thinning mainly occurred in the eastern part of the NCC during the Mesozoic, corresponding to extensive magmatic activity and a thin (~80 km) lithosphere (Zhang et al. 2007). The Fuxian kimberlites from the Liaodong Peninsula of the northeast NCC formed at ~465 Ma (Zhang & Yang, 2007), representing a thick (~200 km) cratonic lithosphere and showing that the lithospheric mantle of the eastern NCC was modified at approximately 500 Ma.

The Saima alkaline complex is located in the Paleoproterozoic Liao-Ji orogenic belt (LJOB) and the central part of the Mesozoic tectonic magmatic belt in the Liaodong Peninsula. The exposed area is approximately 280 km2 and comprises eastern quartz-bearing syenites, central trachytes, and western nepheline syenites with small bodies of phonolite, mafic dikes, and carbonatitic veins (Wu et al. 2015; Zhu et al. 2016). While the size of the metasomatized lithospheric mantle roots (MLMRs) of the Saima alkaline rocks is set as 0.5 km (height) × 0.5 km (width) × 1 km (length), the density of the MLMR is 3300 kg/m3, and 20 cm/year is adopted for the convective velocity (Weismüller et al. 2015). We report data for 25 fresh nepheline syenite samples from the Saima alkaline rocks on the northeastern margin of the NCC. The apatite U–Pb ages of the samples were determined using laser ablation–inductively coupled plasma–mass spectrometry (LA–ICP–MS). The results showed that the syenites formed at 236 Ma (Table S1 and Fig. S1).

**Supplementary Figures**

**Supplementary Figure S1.** (a) Cathodoluminescence (CL) images of representative apatite grains that were dated. (b) Apatite U–Pb Tera and Wasserburg plots for the nepheline syenites in northeastern China. Thirty analyses in sample GJ11 yield a weighted mean 206Pb/238U age of 236 ± 55 Ma (MSWD = 1.07).

**Supplementary Figure S2.** εNd(230 Ma) versus ISr(230 Ma) of the Saima alkaline complex in northeastern China. The data of depleted mantle (DMM) from (Workman & Hart, 2005). The upper continental crust (UCC) and lower/middle continental crust (LCC/MCC) values of eastern NCC are from (Gao et al. 1998; Jahn et al. 1999).

**Supplementary** **Figure S3.** Chondrite normalized rare earth element (REE) diagrams (a) and primitive mantle normalized trace element spidergrams (Sun & McDonough, 1989) (b) for the Saima nephelite syenites in northeastern China. The depleted mid-ocean ridge basalt (N-MORB), enriched mid-ocean ridge basalt (E-MORB), and oceanic island basalt (OIB) compositions are from (Sun & McDonough, 1989). The upper continental crust (UCC) and lower continental crust (LCC) values are from (Rudnick & Gao, 2014). The subcontinental lithospheric mantle (SCLM) compositions are from (Mcdonough, 1990). All samples of the Saima nephelite syenites are highly enriched in light rare earth elements (LREEs) and large ion lithophile elements (LILEs) compared to OIB and E-MORB (Sun & McDonough, 1989), showing a distribution pattern like that of UCC, which indicates the involvement of crustal material.

**Supplementary Figure S4.** 10000/Sr versus ISr (a) and MgO vs ISr (b) for Saima nephelite syenites in northeastern China. There are no significant correlations between 1/Sr, MgO, and ISr, indicating that crustal contamination is indistinctive during the ascent of the magma.

**Supplementary Figure S5.** Plots of δ41K versus (a) K2O (wt.%), (b) MgO (wt.%), (c) SiO2 (wt.%), and (d) LOI (wt.%) for the Saima alkaline rocks in northeastern China.

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