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Supplementary information

Analytical methods

SIMS zircon oxygen isotopic analysis

Measurement of oxygen isotopes in zircon was conducted using the Cameca IMS-1280 ion microprobe at IGGCAS. The Cs^+ primary ion beam was accelerated at 10 kV with an intensity of ca. 2-3 nA. The spot size was 10-15 μm. The isotopes ^{16}O and ^{18}O were measured simultaneously using the multi-collection mode on two off-axis Faraday cups, and the mass resolution used was 2500 during the analyses. Thirty-six measurements were conducted on thirty-six zircon grains of one nepheline-bearing syenite sample (05FW50) from the Hekanzi intrusion in the first session. The instrumental mass fractionation factor (IMF) was corrected using standard zircon TEMORA 2 with a $\delta^{18}O$ value of 8.20 ‰ (Black et al., 2004), and measured $^{18}O/^{16}O$ ratios were normalized by using the Vienna Standard Mean Ocean Water composition (VSMOW, $^{18}O/^{16}O$ = 0.0020052). The second session comprised 28 measurements of 28 zircon grains from two Saima syenite samples (09JH58 and 09JH65). The IMF was corrected using standard zircon Penglai with a $\delta^{18}O$ value of 5.31 ‰ (Li et al., 2010). During this session, the standard zircon 91500 was measured as an unknown. Eight measurements of 91500

zircon yielded a weighted mean of $\delta^{18}O$ = 10.4 ± 0.5 ‰ (2SD), which is consistent within error with the reported value of 9.9 ‰ (Wiedenbeck et al., 2004). Detailed analytical techniques and data processing procedures were similar to those described by Li et al. (2009).

LA-MC-ICPMS zircon Hf isotopic analysis

Zircon Hf isotope analyses were conducted using a Neptune multi-collector (MC)-ICP-MS with an attached 193 nm excimer ArF laser-ablation system. Lu-Hf isotopic measurements were made on the same zircon grains previously analyzed for U-Pb and O isotopes. During Hf analysis, a laser repetition rate of 8 Hz and 15 J/cm^2 was used, and the spot size was 60 μm. Raw count rates for ^{172}Yb, ^{173}Yb, ^{175}Lu, ^{176}(Hf + Yb + Lu), ^{177}Hf, ^{178}Hf, ^{179}Hf, ^{180}Hf and ^{182}W were collected, and isobaric interference corrections for ^{176}Lu and ^{176}Yb on ^{176}Hf were determined precisely. The detailed analytical procedure and correction for interferences followed that described by Wu et al. (2006). During analysis, the ^{176}Hf/^{177}Hf ratios of the standard zircon Mud Tank were 0.282511 ± 16 (2SD, n=13), similar to the commonly accepted ^{176}Hf/^{177}Hf ratio of 0.282507 ± 6 measured using the solution method (Woodhead et al., 2004). The ^{176}Hf/^{177}Hf ratio of the standard zircon GJ-1 was 0.282029 ± 36 (2SD, n=22), similar to the commonly accepted ^{176}Hf/^{177}Hf ratio of 0.282015 ± 19 (2δ, n=25) (Elhlou et al., 2006 GCA).

Selection and screening of zircons from Saima and Hekanzi alkaline

rocks

Zircons from Saima alkaline rocks can be subdivided into primary zircons and altered zircons. No inherited zircon cores or zircon crystals from country rocks were found during our analyses. The altered zircons display subhedral to anhedral shapes with a rough surface. These zircons show chaotic zoning (Fig. DR1). Typical magmatic oscillatory zonation is absent for most of these zircons. Instead, the development of irregular, relatively light domains cutting discordantly across growth zoned domains is commonly observed. These zircons are similar to grains modified by late magmatic hydrothermal fluids (Corfu et al., 2003). The primary zircons, represented by zircons from sample 09JH58 and 09JH65, are euhedral to subhedral with smooth surfaces. They display high luminescence and magmatic zoning, different from the altered zircons (Fig. DR1). In situ U-Pb dating of the primary zircons yielded consistent ages within error (Zhu et al., 2016), which means that late alteration did not significantly affect their U-Pb isotopic system. However, there are large differences in Hf and O isotopes and U-Th concentrations between primary and altered zircons (Table DR1). The altered zircons have very high Th concentrations (up to 15350 ppm) and a large range of U concentrations (61 to 766 ppm). They have $\delta^{18}O$ values of +0.6 to +3.9 ‰, significantly lower than primary zircons as well as normal mantle values (5.3 ± 0.3 ‰; Valley et al., 1998). Furthermore, these $\delta^{18}O$ values also generally show a negative relationship with increasing Th concentration (Fig. DR5c). Their $\varepsilon_{Hf}(t)$ values

vary from -9.0 to -12.4. These features indicate that the Hf-O isotopic data of altered zircons have been modified and thus were not used in this paper to discuss the petrogenesis of the Saima alkaline rocks. The primary zircons have low Th concentrations (124 to 434 ppm, except for 09JH79@12) and a limited range of U concentrations (137 to 589 ppm). They have homogeneous $\delta^{18}O$ (+7.1 to +8.4 ‰) and $\varepsilon_{Hf}(t)$ (-11.2 to -14.0) values, showing no correlation with their apparent ages (Figs. DR5a and b). Accordingly, the Hf and O isotopic data of primary zircon grains were considered to represent the Hf and O isotopes of their parental magma. In contrast, zircons from the Hekanzi alkaline rocks are relatively simple. Most of these zircons show good magmatic oscillation zones (Fig. DR1) and homogeneous $\delta^{18}O$ and $\varepsilon_{Hf}(t)$ values (Figs.DR5a and b).

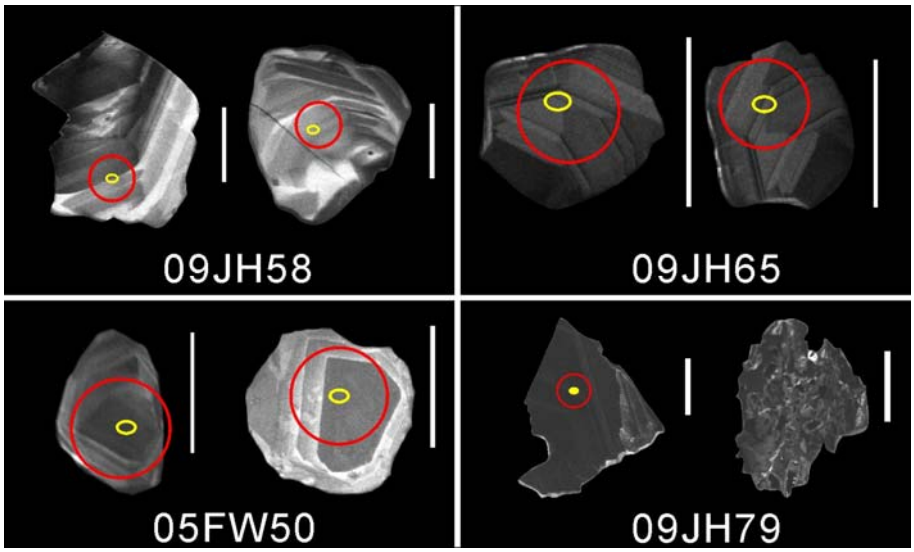

Fig. DR1 Cathodoluminescene (CL) images of zircons from the Hekanzi (05FW50) and Saima (09JH58, 09JH65, 09JH79) alkaline rocks. The red and yellow circles indicate the location of Hf and O isotope analyses, respectively.

All scale bars are 100 μm.

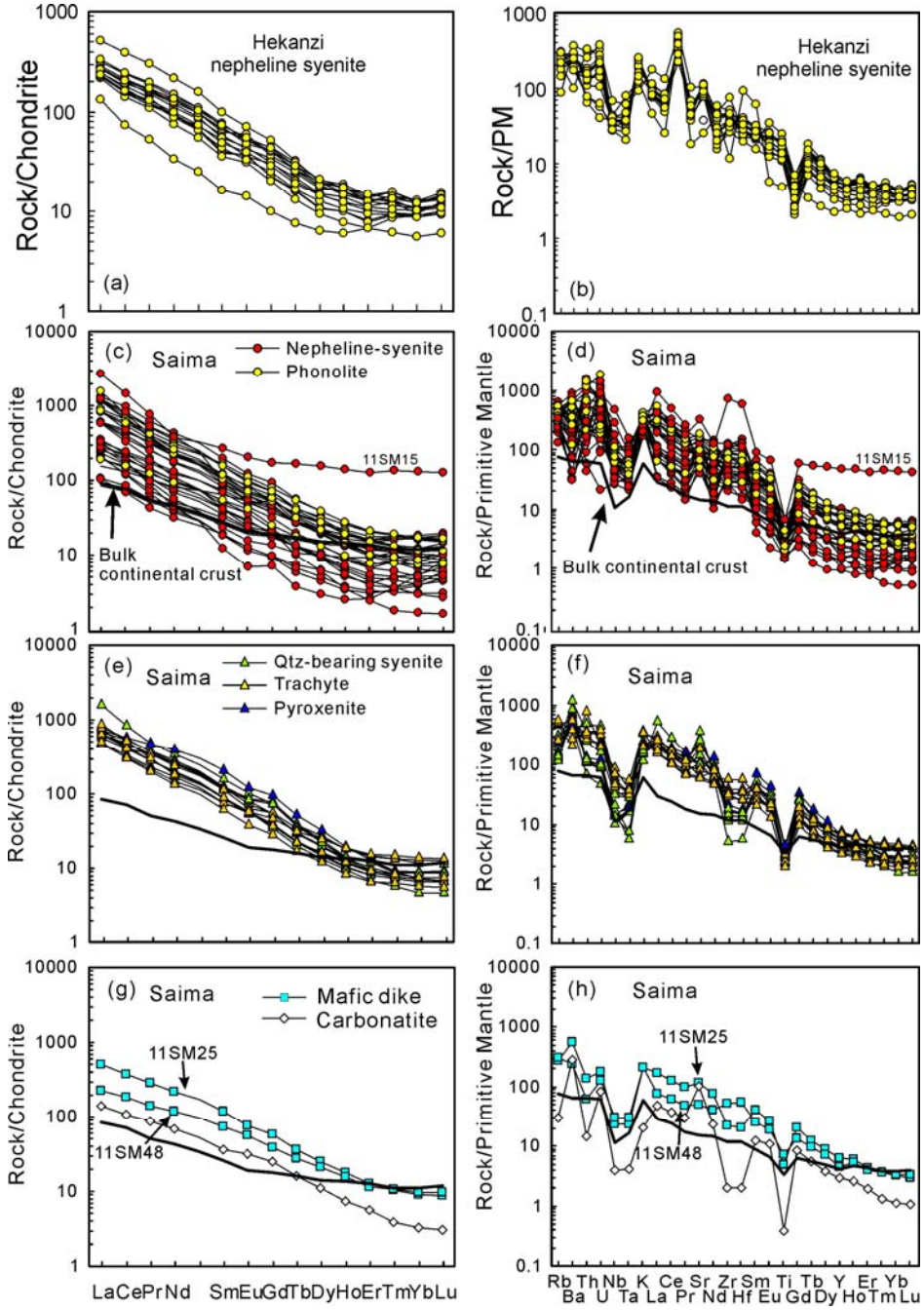

Fig. DR2 Chondrite-normalized REE patterns and primitive mantle normalized incompatible trace element diagrams for alkaline rocks of the Saima and Hekanzi complexes. Data are from Yang et al. (2012) and Zhu et al. (2016). The chondrite and primitive mantle values are from Sun and McDonough

(1989).

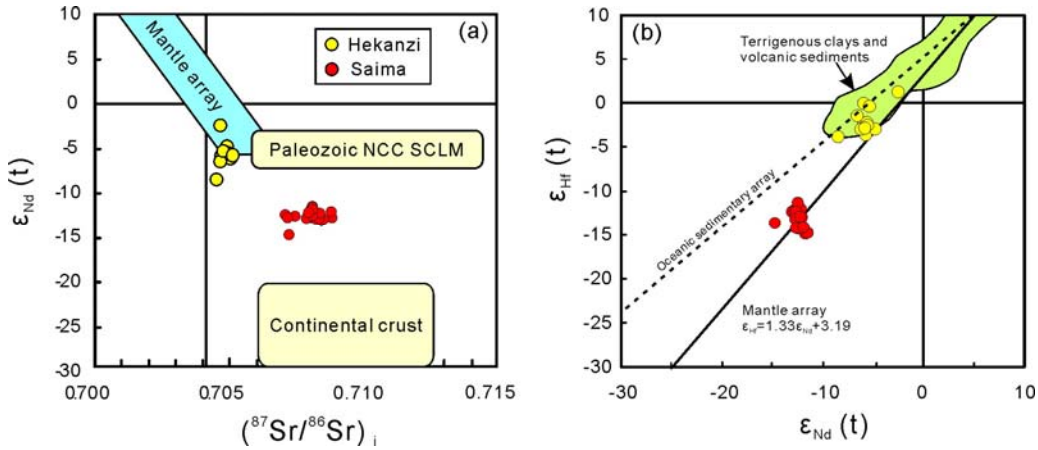

Fig. DR3 (a) Initial $^{87}Sr/^{86}Sr$ vs $\varepsilon_{Nd}(t)$ diagram for the Saima and Hekanzi alkaline rocks. The areas of the Paleozoic SCLM (sub-continental lithospheric mantle) of the NCC and Continental crust are from Jahn et al. (1987,1999) and Zheng (1999). (b) $\varepsilon_{Nd}(t)$ vs $\varepsilon_{Hf}(t)$ diagram for the Saima and Hekanzi alkaline rocks. The areas of terrigneous clays and volcanic sediments and oceanic sedimentary array are from Vervoort et al. (2011). The mantle array line (ε_{Hf}=1.33ε_{Nd+}3.19) is from Vervoort et al. (1999).

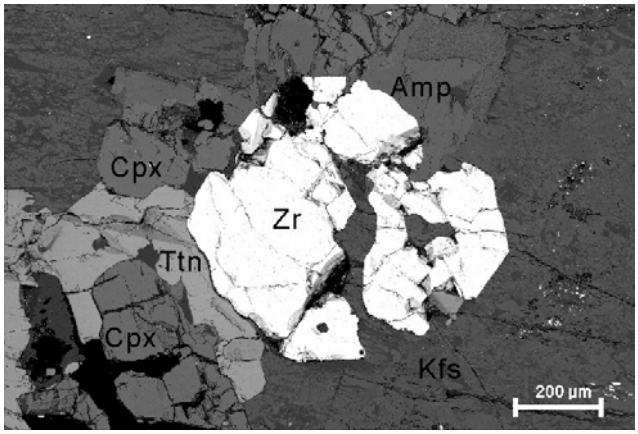

Fig. DR4 Backscattered electron (BSE) images for the Saima alkaline rock (09JH58), showing the occurrence of zircon crystals. Zr-zircon, Cpx-clinopyroxene, Amp-amphibole, Ttn-titanite, Kfs-potassium alkali feldspar.

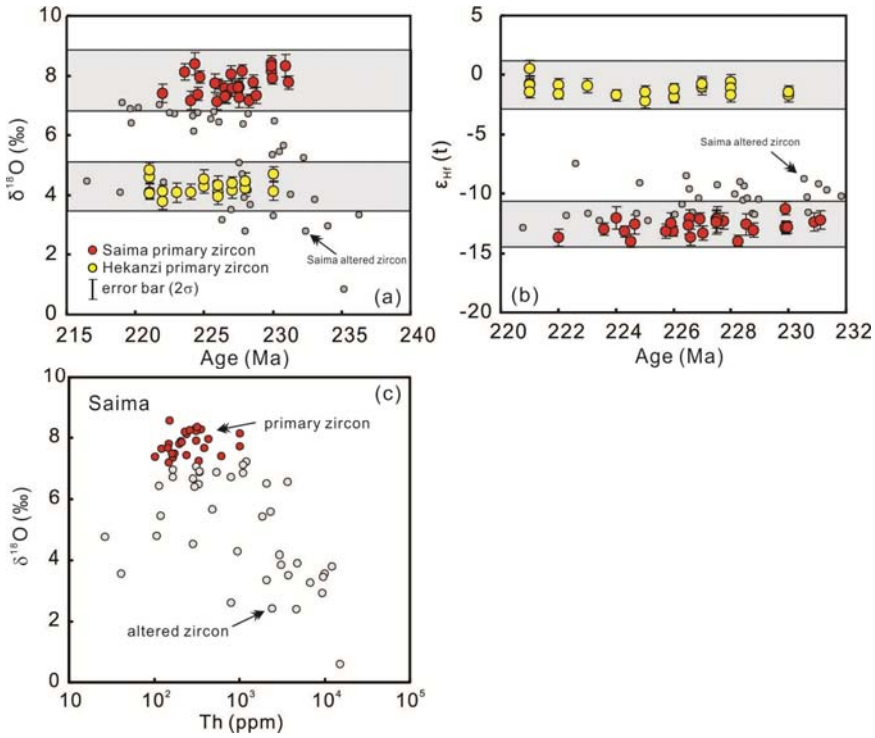

Fig. DR5 Zircon ε_{Hf}(t) (a) and $\delta^{18}O$ (b) values vs zircon apparent ages. (c) Zircon $\delta^{18}O$ values vs Th concentrations for Saima alkaline rocks.

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Table DR1. Zircon Hf-O data and ages for Saima and Hekanzi alkaline rocks

Sample	$^{176}Yb/^{177}Hf$	$^{176}Lu/^{177}Hf$	$^{176}Hf/^{177}Hf$	2σ	$\varepsilon_{Hf}(t)$	2SE	$f_{Lu/Hf}$	T_{DM} (Ma)	$^{18}O/^{16}O_m$	1SE(%)	$\delta^{18}O$ (‰)	2SE (‰)	U (ppm)	Th (ppm)	Pb (ppm)	Age (Ma)	1σ
Hekanzi																	
05FW50	**Nepheline-bearing syentie; N 40°39'9.5"; E 119°23'27.6"**																
	SiO_2=58.24 wt.%; MgO=1.29 wt.%; Na_2O=4.92 wt.%; K_2O=6.89 wt.%; Mg#=37;（Na+K)/Al=0.80; $\varepsilon_{Hf}(t)_{whole\text{-}rock}$=-2.6.																
05FW050 01	0.0279	0.0009	0.282592	13	-1.6	0.5	-0.97	932	0.0020057	0.013	4.7	0.3	-	-	-	-	-
05FW050 02	0.0181	0.0005	0.282583	13	-1.8	0.5	-0.98	935	0.0020044	0.009	4.1	0.2	119	112	5.7	226	3
05FW050 03	0.0575	0.0016	0.282616	15	-0.8	0.5	-0.95	914	0.0020044	0.010	4.1	0.2	226	268	11	222	3
05FW050 04	0.0439	0.0012	0.282589	13	-1.7	0.5	-0.96	944	0.0020044	0.013	4.1	0.3	445	661	24	224	3
05FW050 06	0.0699	0.0019	0.282625	15	-0.5	0.5	-0.94	908	0.0020051	0.016	4.4	0.3	576	542	28	228	3
05FW050 07	0.0671	0.0019	0.282614	17	-0.9	0.6	-0.94	924	0.0020041	0.014	4.0	0.3	-	-	-	-	-
05FW050 08	0.0422	0.0012	0.282584	13	-1.9	0.4	-0.96	951	0.0020049	0.015	4.3	0.3	50	28	2.2	226	4
05FW050 09	0.0286	0.0008	0.282605	14	-1.1	0.5	-0.98	912	0.0020047	0.013	4.2	0.3	181	133	8.4	228	3
05FW050 10	0.0740	0.0021	0.282620	17	-0.7	0.6	-0.94	921	0.0020044	0.013	4.1	0.3	516	265	22	221	3
05FW050 11	0.0669	0.0019	0.282616	16	-0.9	0.6	-0.94	922	0.0020043	0.009	4.1	0.2	183	129	8.1	221	3
05FW050 12	0.0481	0.0014	0.282610	19	-1.0	0.7	-0.96	919	0.0020045	0.014	4.2	0.3	680	992	37	227	3
05FW050 13	0.0600	0.0018	0.282591	17	-1.7	0.6	-0.95	954	0.0020051	0.015	4.5	0.3	182	55	7.5	228	3
05FW050 14	0.0182	0.0006	0.282587	16	-1.7	0.6	-0.98	931	0.0020045	0.017	4.1	0.3	507	465	25	230	3
05FW050 15	0.0989	0.0028	0.282582	17	-2.2	0.6	-0.91	997	0.0020048	0.012	4.3	0.2	156	152	7.5	225	3
05FW050 16	0.0119	0.0003	0.282612	18	-0.8	0.6	-0.99	890	0.0020050	0.010	4.4	0.2	1358	2107	73	227	3
05FW050 17	0.0390	0.0012	0.282590	17	-1.7	0.6	-0.96	942	0.0020053	0.009	4.5	0.2	-	-	-	-	-
05FW050 18	0.0376	0.0011	0.282596	16	-1.5	0.5	-0.97	932	0.0020053	0.016	4.5	0.3	168	169	8.1	225	4
05FW050 19	0.0265	0.0008	0.282598	13	-1.3	0.5	-0.98	921	0.0020056	0.016	4.7	0.3	-	-	-	-	-
05FW050 20	0.0348	0.0010	0.282593	14	-1.6	0.5	-0.97	934	0.0020037	0.013	3.8	0.3	876	924	43	222	4
05FW050 21	0.0255	0.0008	0.282619	15	-0.6	0.5	-0.98	892	0.0020065	0.020	5.2	0.4	-	-	-	-	-
05FW050 22	0.0180	0.0006	0.282594	15	-1.5	0.5	-0.98	922	0.0020054	0.009	4.6	0.2	660	850	34	221	3
05FW050 23	0.0148	0.0005	0.282594	14	-1.4	0.5	-0.99	920	0.0020056	0.013	4.7	0.3	251	301	13	230	3
05FW050 24	0.0155	0.0005	0.282600	12	-1.2	0.4	-0.99	910	0.0020059	0.013	4.9	0.3	-	-	-	-	-
05FW050 25	0.0225	0.0007	0.282601	12	-1.2	0.4	-0.98	913	0.0020041	0.014	4.0	0.3	558	844	30	226	3
05FW050 26	0.0064	0.0002	0.282649	18	0.6	0.6	-0.99	836	0.0020059	0.012	4.8	0.2	314	387	16	221	4
05FW050 27	0.0503	0.0015	0.282614	17	-0.9	0.6	-0.95	917	0.0020044	0.016	4.1	0.3	102	46	4.3	223	3
05FW050 28	0.0139	0.0005	0.282590	14	-1.6	0.5	-0.99	924	0.0020069	0.015	5.4	0.3	-	-	-	-	-
05FW050 29	0.0666	0.0020	0.282597	13	-1.5	0.5	-0.94	952	0.0020049	0.012	4.4	0.2	-	-	-	-	-
05FW050 30	0.0387	0.0012	0.282606	15	-1.1	0.5	-0.96	918	0.0020058	0.013	4.8	0.3	-	-	-	-	-
05FW050 31	0.0484	0.0016	0.282598	17	-1.4	0.6	-0.95	940	0.0020060	0.014	4.9	0.3	-	-	-	-	-
05FW050 32	0.0765	0.0023	0.282579	15	-2.2	0.5	-0.93	985	0.0020043	0.013	4.0	0.3	-	-	-	-	-
05FW050 33	0.0475	0.0014	0.282591	12	-1.7	0.4	-0.96	946	0.0020038	0.013	3.8	0.3	-	-	-	-	-
05FW050 34	0.0330	0.0009	0.282564	17	-2.5	0.6	-0.97	971	0.0020048	0.014	4.3	0.3	-	-	-	-	-
05FW050 35	0.0436	0.0013	0.282614	19	-0.9	0.7	-0.96	912	0.0020049	0.014	4.4	0.3	-	-	-	-	-

05FW050 36	0.0616	0.0017	0.282579	16	-2.1	0.6	-0.95	970	0.0020045	0.011	4.2	0.2	-	-	-	-	-
05FW050 37	0.0714	0.0020	0.282595	15	-1.6	0.5	-0.94	957	0.0020060	0.012	4.9	0.2	-	-	-	-	-

* The $^{176}Hf/^{177}Hf$ and $^{176}Lu/^{177}Hf$ ratios of chondrite and depleted mantle at the present are 0.282772 and 0 0332, and 0.28325 and 0.0384, respectively (Blichert-Toft and Albarede, 1997; Griffin et al., 2000). $\lambda = 1.867\times10^{-11}$ a-1 (Söderlund et al., 2004).

Table DR1. Continued

Sample	$^{176}Yb/^{177}Hf$	$^{176}Lu/^{177}Hf$	$^{176}Hf/^{177}Hf$	2σ	$\varepsilon_{Hf}(t)$	2SE	$f_{Lu/Hf}$	T_{DM} (Ma)	$^{18}O/^{16}O_m$	1SE(%)	$\delta^{18}O$ (‰)	2SE (‰)	U (ppm)	Th (ppm)	Pb (ppm)	Age (Ma)	1σ
Saima																	
09JH58	**Quartz-bearing syenite; N 40°54'47.7"；E 124°36'47.0"**																
	SiO_2=58.70 wt.%; MgO=3.72 wt.%; Na_2O=3.49 wt.%; K_2O=7.15 wt.%;（Na+K)/Al=0.93; Mg#=66; Zr=217 ppm; $\varepsilon_{Hf}(t)_{whole\text{-}rock}$=-13.0.																
09JH58@1	0.0137	0.0005	0.282289	19	-12.3	0.7	-0.98	1342	0.0020146	0.014	7.6	0.3	175	206	8.8	228	3
09JH58@2	0.0057	0.0002	0.282283	22	-12.4	0.8	-0.99	1339	0.0020160	0.019	8.3	0.4	137	153	6.9	231	3
09JH58@3	0.0043	0.0002	0.282262	13	-13.1	0.5	-0.99	1366	0.0020148	0.008	7.7	0.2	383	434	19	226	3
09JH58@4	0.0059	0.0002	0.282290	16	-12.2	0.6	-0.99	1330	0.0020155	0.012	8.1	0.2	226	356	12	227	4
09JH58@5	0.0089	0.0004	0.282267	14	-13.0	0.5	-0.99	1366	0.0020156	0.014	8.1	0.3	353	309	16	224	3
09JH58@6	0.0060	0.0002	0.282278	23	-12.6	0.8	-0.99	1347	0.0020152	0.011	7.9	0.2	273	242	13	225	3
09JH58@7	0.0064	0.0003	0.282291	21	-12.1	0.7	-0.99	1331	0.0020145	0.009	7.6	0.2	483	388	23	227	3
09JH58@8	0.0065	0.0002	0.282287	19	-12.3	0.7	-0.99	1335	0.0020157	0.011	8.2	0.2	246	313	13	228	3
09JH58@9	0.0044	0.0002	0.282294	18	-12.0	0.7	-0.99	1324	0.0020145	0.011	7.6	0.2	268	124	11	227	3
09JH58@10	0.0033	0.0001	0.282288	21	-12.2	0.8	-1.00	1329	0.0020149	0.011	7.8	0.2	141	197	7.7	231	3
09JH58@12	0.0240	0.0009	0.282319	16	-11.2	0.6	-0.97	1313	0.0020157	0.019	8.2	0.4	589	1032	34	230	3
09JH58@13	0.0062	0.0002	0.282269	14	-12.9	0.5	-0.99	1359	0.0020162	0.011	8.4	0.2	258	323	13	230	3
09JH58@14	0.0052	0.0002	0.282271	15	-12.8	0.5	-0.99	1355	0.0020160	0.017	8.3	0.3	207	233	10	230	3
09JH58@15	0.0048	0.0002	0.282271	14	-12.8	0.5	-0.99	1355	0.0020152	0.009	7.9	0.2	149	148	7.2	230	3
09JH58@16	0.0096	0.0003	0.282262	14	-13.2	0.5	-0.99	1373	0.0020161	0.019	8.4	0.4	220	266	11	224	3
09JH65	**Quartz-bearing syenite; N 40°54'39.5"；E 124°32'56.8"**																
	SiO_2=51.76 wt.%; MgO=4.18 wt.%; Na_2O=2.48 wt.%; K_2O=5.59 wt.%;（Na+K)/Al=0.79; Mg#=59; Zr=137 ppm; $\varepsilon_{Hf}(t)_{whole\text{-}rock}$=-14.6.																
09JH65@1	0.0119	0.0005	0.282291	30	-12.2	1.0	-0.99	1338	0.0020150	0.017	7.3	0.3	282	167	12	228	3
09JH65@2	0.0113	0.0005	0.282279	26	-12.6	0.9	-0.99	1354	0.0020161	0.011	7.8	0.2	845	314	36	229	3
09JH65@3	0.0087	0.0003	0.282257	17	-13.3	0.6	-0.99	1380	0.0020156	0.015	7.6	0.3	301	145	13	227	3
09JH65@4	0.0163	0.0007	0.282264	17	-13.2	0.6	-0.98	1382	0.0020160	0.016	7.8	0.3	310	213	14	226	3
09JH65@5	0.0490	0.0019	0.282246	13	-14.0	0.5	-0.94	1453	0.0020148	0.011	7.2	0.2	2719	5484	162	228	3
09JH65@6	0.0124	0.0005	0.282295	27	-12.0	1.0	-0.98	1333	0.0020148	0.015	7.2	0.3	302	338	15	224	3
09JH65@7	0.0143	0.0006	0.282283	24	-12.5	0.9	-0.98	1353	0.0020147	0.012	7.1	0.2	337	150	14	226	3
09JH65@8	0.0169	0.0007	0.282250	20	-13.7	0.7	-0.98	1402	0.0020152	0.015	7.3	0.3	285	243	13	227	3
09JH65@9	0.0075	0.0003	0.282276	20	-12.7	0.7	-0.99	1352	0.0020151	0.011	7.3	0.2	174	104	7.7	227	3

09JH65@10	0.0255	0.0010	0.282268	17	-13.1	0.6	-0.97	1388	0.0020151	0.013	7.3	0.3	848	614	39	229	3
09JH65@11	0.0104	0.0004	0.282247	20	-13.7	0.7	-0.99	1396	0.0020153	0.015	7.4	0.3	207	175	9.5	222	3
09JH65@12	0.0061	0.0002	0.282239	16	-14.0	0.6	-0.99	1401	0.0020152	0.011	7.4	0.2	555	163	22	225	3
09JH65@15	0.0382	0.0014	0.282289	28	-12.4	1.0	-0.96	1375	0.0020157	0.010	7.6	0.2	1041	1028	51	227	3
09JH67	**Trachyte; N 40°58'15.7"；E 124°32'52.3"**																
	SiO_2=62.71 wt.%; MgO=2.12 wt.%; Na_2O=3.40 wt.%; K_2O=6.52 wt.%;（Na+K)/Al=0.80; Mg#=52; Zr=353 ppm; $\varepsilon_{Hf}(t)_{whole\text{-}rock}$=-14.0.																
09JH67@1	0.0208	0.0008	0.282272	19	-12.9	0.7	-0.97	1376	0.0020130	0.017	6.7	0.3	208	288	11	225	3
09JH67@2	0.0087	0.0004	0.282288	20	-12.2	0.7	-0.99	1337	0.0020125	0.014	6.5	0.3	106	116	5.3	226	3
09JH67@3	0.0109	0.0005	0.282268	18	-13.0	0.6	-0.99	1368	0.0020133	0.012	6.9	0.2	126	167	6.5	220	3
09JH67@4	0.0201	0.0008	0.282290	19	-12.3	0.7	-0.98	1349	0.0020128	0.012	6.6	0.2	342	810	22	224	3
09JH67@5	0.0394	0.0014	0.282291	18	-12.3	0.6	-0.96	1372	0.0020130	0.009	6.7	0.2	513	1125	32	228	3
09JH67@6	0.0237	0.0009	0.282271	21	-12.9	0.7	-0.97	1379	0.0020130	0.011	6.7	0.2	176	344	10	223	3
09JH67@7	0.0096	0.0004	0.282285	19	-12.4	0.7	-0.99	1343	0.0020127	0.021	6.6	0.4	190	166	9.0	225	3
09JH67@8	0.0113	0.0004	0.282287	19	-12.3	0.7	-0.99	1342	0.0020130	0.010	6.7	0.2	240	539	15	222	3
09JH67@9	0.0243	0.0009	0.282256	15	-13.5	0.5	-0.97	1402	0.0020134	0.011	6.9	0.2	207	314	11	220	3
09JH67@10	0.0122	0.0005	0.282324	22	-11.0	0.8	-0.99	1291	0.0020137	0.016	7.1	0.3	381	1221	27	219	3
09JH67@12	0.0133	0.0005	0.282310	19	-11.5	0.7	-0.99	1312	0.0020131	0.013	6.8	0.3	240	345	13	226	3
09JH67@13	0.0186	0.0007	0.282290	16	-12.2	0.5	-0.98	1347	0.0020125	0.013	6.5	0.3	1548	3711	101	230	3
09JH67@14	0.0074	0.0003	0.282275	16	-12.7	0.6	-0.99	1354	0.0020123	0.016	6.4	0.3	315	334	15	220	3
09JH67@16	0.0223	0.0009	0.282285	15	-12.4	0.5	-0.97	1359	0.0020136	0.010	7.0	0.2	399	1124	27	222	3
09JH67@17	0.0215	0.0008	0.282321	24	-11.1	0.9	-0.98	1308	0.0020123	0.015	6.4	0.3	759	2081	52	228	3

Table DR1. Continued

Sample	$^{176}Yb/^{177}Hf$	$^{176}Lu/^{177}Hf$	$^{176}Hf/^{177}Hf$	2σ	$\varepsilon_{Hf}(t)$	2SE	$f_{Lu/Hf}$	T_{DM} (Ma)	$^{18}O/^{16}O_m$	1SE(%)	$\delta^{18}O$ (‰)	2SE (‰)	U (ppm)	Th (ppm)	Pb (ppm)	Age (Ma)	1σ
09JH79	**Nepheline syenite; N 40°59'41.6"；E 124°23'26.5"**																
	SiO_2=54.92 wt.%; MgO=2.26 wt.%; Na_2O=4.72 wt.%; K_2O=10.51 wt.%;（Na+K)/Al=1.14; Mg#=43; Zr=553 ppm; $\varepsilon_{Hf}(t)_{whole\text{-}rock}$=-12.0.																
09JH79@1	0.0975	0.0028	0.282348	13	-10.4	0.5	-0.91	1341	0.0020076	0.009	4.1	0.2	72	4764	56	-	-
09JH79@2	0.0747	0.0021	0.282358	14	-9.9	0.5	-0.94	1301	0.0020064	0.012	3.5	0.2	125	6775	79	227	3
09JH79@3	0.0510	0.0017	0.282325	15	-11.0	0.5	-0.95	1335	0.0020057	0.009	3.2	0.2	271	9423	113	226	3
09JH79@4	0.1213	0.0033	0.282388	26	-9.0	0.9	-0.90	1300	0.0020010	0.011	0.9	0.2	544	15350	195	235	3
09JH79@5	0.0817	0.0025	0.282382	19	-9.1	0.7	-0.92	1280	0.0020075	0.010	4.1	0.2	756	12212	157	219	3
09JH79@6	0.0782	0.0023	0.282289	19	-12.4	0.7	-0.93	1406	0.0020076	0.013	4.1	0.3	154	3105	41	228	4
09JH79@7	0.0832	0.0024	0.282355	19	-10.1	0.7	-0.93	1315	0.0020071	0.010	3.9	0.2	61	10196	116	233	3
09JH79@8	0.0299	0.0009	0.282319	22	-11.1	0.8	-0.97	1316	0.0020067	0.013	3.7	0.3	118	2108	29	228	3
09JH79@10	0.1547	0.0057	0.282378	21	-9.7	0.7	-0.83	1408	0.0020053	0.017	3.0	0.3	89	811	12	234	4
09JH79@12	0.0706	0.0020	0.282328	18	-11.0	0.6	-0.94	1341	0.0020049	0.009	2.8	0.2	131	2438	31	228	4
09JH79@13	0.0544	0.0018	0.282356	18	-10.0	0.6	-0.95	1292	0.0020071	0.013	3.9	0.3	106	3784	45	228	4

09JH79@15	0.0441	0.0015	0.282339	21	-10.5	0.8	-0.95	1306	0.0020049	0.009	2.8	0.2	143	4736	58	232	3
09JH79@16	0.0896	0.0024	0.282367	18	-9.7	0.6	-0.93	1300	0.0020071	0.011	3.3	0.2	766	9776	140	236	3
09JH81	**Nepheline syenite; N 40°59'41.6"；E 124°23'26.5"**																
	SiO_2=54.05 wt.%; MgO=0.27 wt.%; Na_2O=8.06 wt.%; K_2O=9.06 wt.%; （Na+K)/Al=1.03; Mg#=8; Zr=532 ppm; $\varepsilon_{Hf}(t)_{whole\text{-}rock}$=-12.0.																
09JH81@1	0.0133	0.0004	0.282325	17	-10.9	0.6	-0.99	1288	0.0020085	0.013	4.0	0.3	531	2997	55	231	3
09JH81@2	0.0304	0.0010	0.282346	23	-10.2	0.8	-0.97	1279	0.0020087	0.013	4.1	0.3	298	947	22	226	3
09JH81@6	0.0069	0.0003	0.282379	22	-8.9	0.8	-0.99	1209	0.0020109	0.009	5.2	0.2	161	120	7.7	232	3
09JH81@7	0.0332	0.0010	0.282369	23	-9.4	0.8	-0.97	1248	0.0020112	0.012	5.4	0.2	515	2344	47	230	3
09JH81@8	0.0166	0.0006	0.282376	27	-9.1	0.9	-0.98	1225	0.0020093	0.017	4.4	0.3	31	5.6	1.2	226	4
09JH81@9	0.0031	0.0001	0.282321	20	-11.0	0.7	-1.00	1284	0.0020071	0.012	3.3	0.2	21	41	1.3	230	4
09JH81@10	0.0050	0.0002	0.282356	23	-9.7	0.8	-0.99	1239	0.0020127	0.010	6.1	0.2	130	304	8.1	224	3
09JH81@11	0.0273	0.0010	0.282362	26	-9.6	0.9	-0.97	1258	0.0020094	0.011	4.5	0.2	56	27	2.3	217	3
09JH81@12	0.0073	0.0002	0.282330	25	-10.7	0.9	-0.99	1276	0.0020106	0.013	5.1	0.3	367	1895	35	228	3
09JH81@14	0.0339	0.0011	0.282344	25	-10.3	0.9	-0.97	1285	0.0020109	0.015	5.7	0.3	29	6.8	1.2	231	4
09JH81@15	0.0298	0.0010	0.282362	24	-9.7	0.8	-0.97	1258	0.0020089	0.018	4.7	0.4	193	108	8.1	228	3
09JH81@16	0.0031	0.0001	0.282403	33	-8.1	1.2	-1.00	1173	0.0020084	0.015	4.4	0.3	118	289	7.5	222	3
09JH81@18	0.0120	0.0004	0.282355	20	-9.8	0.7	-0.99	1246	0.0020105	0.012	5.5	0.2	255	489	15	230	3

Table DR2. Zircon Hf and O data for standard materials during analysis

Sample	$^{18}O/^{16}O_m$	1SE(%)	$\delta^{18}O$ (‰)	2SE (‰)
Temora 2				
TEM@20	0.0020122	0.014	7.99	0.29
TEM@21	0.0020127	0.015	8.22	0.30
TEM@22	0.0020116	0.015	7.70	0.31
TEM@23	0.0020133	0.018	8.52	0.35
TEM@24	0.0020126	0.013	8.19	0.26
TEM@25	0.0020126	0.010	8.17	0.21
TEM@26	0.0020127	0.015	8.22	0.29
TEM@27	0.0020127	0.011	8.24	0.23
TEM@28	0.0020134	0.010	8.57	0.19
TEM@29	0.0020131	0.016	8.44	0.32
TEM@30	0.0020120	0.014	7.90	0.27
TEM@31	0.0020124	0.018	8.09	0.36
TEM@32	0.0020129	0.012	8.34	0.23
			8.20	**0.03**
Penglai				
Penglai@1	0.0020090	0.007	4.9	0.1
Penglai@2	0.0020089	0.011	4.8	0.2
Penglai@3	0.0020095	0.010	5.1	0.2
Penglai@4	0.0020098	0.015	5.2	0.3
Penglai@5	0.0020103	0.012	5.5	0.2
Penglai@6	0.0020104	0.012	5.5	0.2
Penglai@7	0.0020102	0.010	5.4	0.2
Penglai@8	0.0020098	0.014	5.2	0.3
Penglai@9	0.0020098	0.018	5.2	0.4
Penglai@10	0.0020101	0.012	5.4	0.2
Penglai@11	0.0020102	0.014	5.5	0.3
Penglai@12	0.0020118	0.016	5.7	0.3
Penglai@13	0.0020105	0.010	5.0	0.2
Penglai@14	0.0020114	0.008	5.5	0.2
Penglai@15	0.0020106	0.008	5.1	0.2
Penglai@16	0.0020115	0.011	5.5	0.2
Penglai@17	0.0020100	0.013	4.8	0.3
Penglai@18	0.0020104	0.013	5.0	0.3
Penglai@19	0.0020114	0.016	5.5	0.3
Penglai@20	0.0020104	0.013	5.0	0.3
Penglai@21	0.0020113	0.012	5.4	0.2
Penglai@22	0.0020116	0.012	5.6	0.2
Penglai@23	0.0020104	0.017	5.0	0.3
Penglai3@1	0.0020108	0.016	5.7	0.3
Penglai3@2	0.0020100	0.009	5.2	0.2
Penglai3@3	0.0020097	0.010	5.1	0.2
Penglai3@4	0.0020103	0.013	5.4	0.3
Penglai3@5	0.0020098	0.018	5.1	0.4
Penglai3@6	0.0020097	0.009	5.1	0.2
Penglai4@1	0.0020109	0.014	5.7	0.3
Penglai4@2	0.0020101	0.012	5.3	0.2
Penglai4@3	0.0020100	0.019	5.3	0.4
Penglai4@4	0.0020098	0.008	5.2	0.2
Penglai4@5	0.0020101	0.011	5.3	0.2
Penglai4@6	0.0020097	0.011	5.1	0.2
Penglai4@7	0.0020101	0.011	5.3	0.2
Penglai4@8	0.0020093	0.020	4.9	0.4
			5.3	**0.1**
91500				
91500@1	0.0020194	0.007	10.0	0.1
91500@2	0.0020195	0.017	10.1	0.3

Sample	$^{176}Yb/^{177}Hf$	$^{176}Lu/^{177}Hf$	$^{176}Hf/^{177}Hf$	2SE
GJ-1				
GJ-1 55	0.0059	0.0002	0.282002	0.000023
GJ-1 56	0.0057	0.0002	0.281999	0.000020
GJ-1 57	0.0058	0.0002	0.282015	0.000014
GJ-1 58	0.0059	0.0002	0.282024	0.000014
GJ-1 59	0.0059	0.0002	0.282047	0.000015
GJ-1 60	0.0060	0.0002	0.282038	0.000016
GJ-1 61	0.0058	0.0002	0.282041	0.000021
GJ-1 62	0.0057	0.0002	0.282056	0.000022
GJ-1 63	0.0057	0.0002	0.282043	0.000022
GJ-1 64	0.0058	0.0002	0.282029	0.000014
GJ-1 65	0.0058	0.0002	0.282058	0.000013
GJ-1 66	0.0058	0.0002	0.282018	0.000011
GJ-1 67	0.0059	0.0003	0.282051	0.000014
GJ-1 68	0.0058	0.0002	0.282049	0.000013
GJ-1 69	0.0057	0.0002	0.282038	0.000013
GJ-1 70	0.0058	0.0002	0.282022	0.000013
GJ-1 49	0.0058	0.0002	0.282000	0.000015
GJ-1 50	0.0058	0.0002	0.282030	0.000014
GJ-1 51	0.0058	0.0002	0.282013	0.000014
GJ-1 52	0.0057	0.0002	0.282024	0.000014
GJ-1 53	0.0059	0.0002	0.282028	0.000015
GJ-1 54	0.0058	0.0002	0.282013	0.000015
			0.282029	**0.000008**
Mud Tank				
Mud Tank 19	0.0014	0.0000	0.282527	0.000011
Mud Tank 20	0.0015	0.0001	0.282511	0.000011
Mud Tank 21	0.0015	0.0001	0.282513	0.000011
Mud Tank 22	0.0012	0.0000	0.282498	0.000011
Mud Tank 23	0.0011	0.0000	0.282500	0.000010
Mud Tank 24	0.0014	0.0000	0.282513	0.000011
Mud Tank 25	0.0016	0.0001	0.282511	0.000016
Mud Tank 26	0.0015	0.0001	0.282507	0.000011
Mud Tank 27	0.0010	0.0000	0.282511	0.000011
Mud Tank 28	0.0009	0.0000	0.282519	0.000018
Mud Tank 29	0.0011	0.0000	0.282519	0.000011
Mud Tank 30	0.0011	0.0000	0.282512	0.000009
Mud Tank 31	0.0012	0.0000	0.282506	0.000011
			0.282511	**0.000004**
91500				
91500 01	0.0098	0.0003	0.282297	0.000013
91500 02	0.0096	0.0003	0.282285	0.000012
91500 03	0.0095	0.0003	0.282324	0.000012
91500 04	0.0094	0.0003	0.282280	0.000016
91500 05	0.0094	0.0003	0.282276	0.000014
91500 06	0.0091	0.0003	0.282279	0.000016
91500 07	0.0094	0.0003	0.282314	0.000014
91500 08	0.0096	0.0003	0.282287	0.000013
91500 09	0.0098	0.0003	0.282294	0.000016
91500 10	0.0095	0.0003	0.282287	0.000016
91500 11	0.0092	0.0003	0.282285	0.000013
91500 12	0.0094	0.0003	0.282269	0.000013
			0.282290	**0.000004**

91500@3	0.0020205	0.012	10.6	0.2
91500@4	0.0020208	0.015	10.7	0.3
91500@5	0.0020214	0.014	10.5	0.3
91500@6	0.0020206	0.009	10.6	0.2
91500@7	0.0020201	0.017	10.3	0.3
91500@8	0.0020202	0.017	10.3	0.3
			10.4	**0.5**