

Supplementary material 1: Pb isotope analytical setting by IMS 1280-HR at the Kochi Institute for Core Sample Research, JAMSTEC

Lead three-isotope analysis ($^{207}\text{Pb}/^{206}\text{Pb}$, $^{208}\text{Pb}/^{206}\text{Pb}$) of one olivine-hosted melt inclusion from Rarotonga Island, rtg41-mi1, was also performed by an ion microprobe, CAMECA IMS 1280-HR at the Kochi Institute for Core Sample Research, JAMSTEC.

A Köhler illumination O_2^- primary beam of 3 nA and $25 \times 15 \mu\text{m}$ in size with a 23 kV total accelerating voltage was used. Secondary ions were accelerated at 10 kV. The transfer optics were set at $\times 200$ magnification and the field aperture size was set at $3 \times 3 \text{ mm}$ corresponding to the $15 \times 15 \mu\text{m}$ of the field of view of the secondary ion image. A mass resolving power ($M/\Delta M$) of ~ 6000 was applied. The energy slit width was set at 50 eV and no energy offset voltage was applied. Positive secondary ions of lead three-isotopes ($^{206}\text{Pb}^+$, $^{207}\text{Pb}^+$, and $^{208}\text{Pb}^+$) and an ion signal at 205.7 amu were detected by an axial electron multiplier (EM) detector using a magnetic peak switching method. The counting time and waiting time for each signal of the single cycle were 1 second (s) and 2 s for 205.7 amu, 5 s and 1 s for ^{206}Pb and ^{207}Pb , 2 s and 1 s for ^{208}Pb , respectively. Each analysis consisted of 200 s for presputtering with a $20 \times 20\text{-}\mu\text{m}$ primary beam raster, 210 s for auto-centering of secondary ions to the field aperture (X- and Y-directions) and the contrast aperture (X-direction), and 100 cycles for measurements. The auto-adjustment of the secondary ion accelerating voltage was also applied before measurements of the first and 50th cycles. The total time for each analysis was about 42 minutes.

The count rates of the $^{208}\text{Pb}^+$ ion of the sample (rtg41-mi1) and the running standard (BCR-2G, 11 ppm Pb) were ~ 100 counts per second (cps) and ~ 420 cps,

respectively. The yield of $^{208}\text{Pb}^+$ ion was 13 cps/ppm/nA based on analysis of BCR-2G. The background noise level of the EM detector was less than 0.01 cps (no signal/100 s at 205.7 amu). The lead isotope ratios ($^{207}\text{Pb}/^{206}\text{Pb}$, $^{208}\text{Pb}/^{206}\text{Pb}$) were calculated based on the integrated mean count rates of the individual ion signals of each analysis. No correction of the instrumental bias for lead isotope ratios was applied and the statistical errors (2σ) based on the total counts of signals were employed as the analytical uncertainty because the measured lead isotope ratios and their reproducibilities (2SD) of multiple test analyses of the USGS standard glasses (BCR-2G, BIR-1G, and BHVO-2G) were consistent with the values in the literature (Elburg *et al.*, 2005) and the 2σ values of the statistical errors, respectively (Fig. S1).

Reference:

Elburg, M., Vroon, P., van der Wagt, B. and Tchalikian, A. (2005) Sr and Pb isotopic composition of five USGS glasses (BHVO-2G, BIR-1G, BCR-2G TB-1G, NKT-1G). *Chem. Geol.* **223**, 196-207.

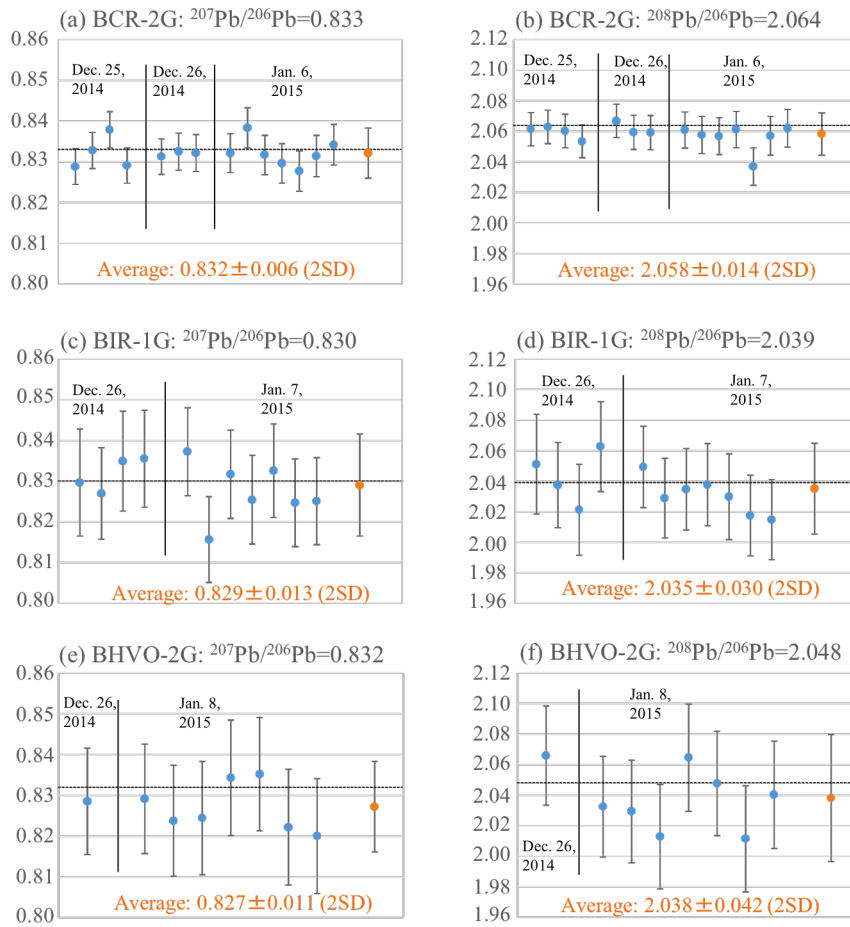


Fig. S1 Results of test lead three-isotope ($^{207}\text{Pb}/^{206}\text{Pb}$, $^{208}\text{Pb}/^{206}\text{Pb}$) measurements of USGS standard glasses, BCR-2G, BIR-1G, and BHVO-2G by SIMS. Individual measurement data (blue) and the average values of multiple measurement sessions (orange) are shown. The horizontal broken lines indicate reference values (Elburg *et al.*, 2005). Errors of individual data are 2σ values of the statistical errors and those of the average values are 2SD of the individual data.

**Supplementary material 2: Time resolving profiles during Pb isotope analysis by
FsLA-MC-ICP-MS**

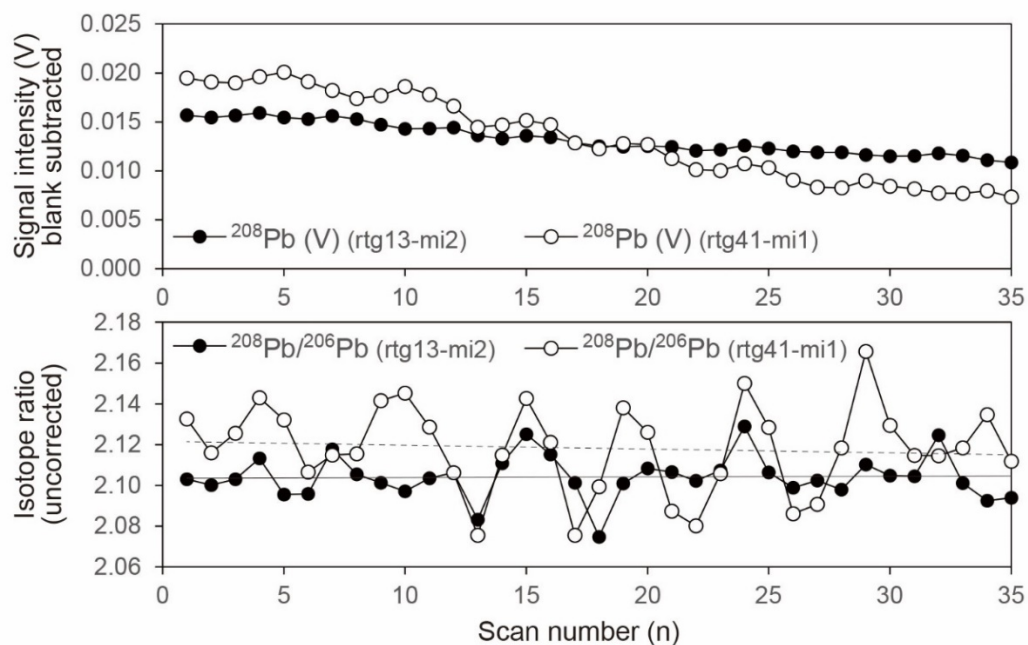


Fig. S2 Pb signal intensities (^{208}Pb) and isotope ratios ($^{208}\text{Pb}/^{206}\text{Pb}$) measured from two melt inclusions. The signal intensities are given by net intensity (blank subtracted). The isotope ratios are the uncorrected values before standard bracketing. Thin dotted and solid lines are regression lines for rtg13-mi2 and rtg41-mi1 samples, respectively.

Supplementary material 3: Comparison between results of Independent Component Analysis (ICA) based on Pb isotopic compositions and those based on Sr, Nd and Pb isotopic compositions

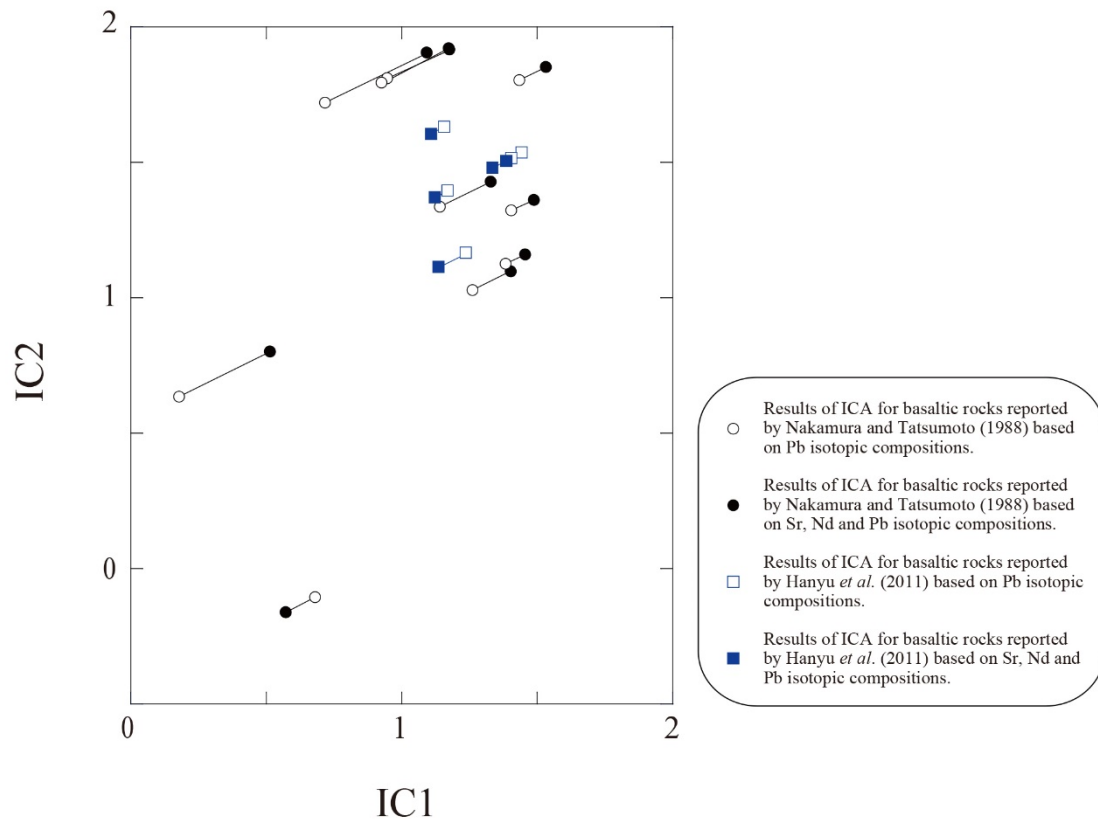


Fig. S3 Comparison between ICA results for basaltic rocks from Rarotonga Island based on Pb isotopic compositions ($^{207}\text{Pb}/^{206}\text{Pb}$ and $^{208}\text{Pb}/^{206}\text{Pb}$) and those based on Sr, Nd and Pb isotopic compositions ($^{204}\text{Pb}/^{206}\text{Pb}$, $^{207}\text{Pb}/^{206}\text{Pb}$, $^{208}\text{Pb}/^{206}\text{Pb}$, $^{87}\text{Sr}/^{86}\text{Sr}$ and $^{143}\text{Nd}/^{144}\text{Nd}$). Pairs of ICA results of identical rocks are connected by lines. Data sources: Nakamura and Tatsumoto (1988) and Hanyu *et al.* (2011).

Table S1 The repeatability and the laboratory bias measured during the analysis.

Sample	$^{208}\text{Pb}/^{206}\text{Pb}$	2SE	$^{207}\text{Pb}/^{206}\text{Pb}$	2SE
BCR-2G-1	2.0658	0.0024	0.8326	0.0016
BCR-2G-2	2.0650	0.0027	0.8330	0.0017
BCR-2G-3	2.0630	0.0026	0.8324	0.0018
BCR-2G-4	2.0629	0.0027	0.8321	0.0020
BCR-2G-5	2.0653	0.0022	0.8335	0.0020
Average / 2SD	2.0644	0.0027	0.8327	0.0012
Laboratory bias / Repeatability	RD‰	2SD‰	RD‰	2SD‰
	0.63	1.31	-0.11	1.38
Reference	2.0631	0.0014	0.8328	0.0005

Note: Reference value from solution ICP-MS by Elburg et al. (2005)

RD‰: relative deviation in permill from the reference value

2SD‰: two-standard deviation in permill

2SE: two-standard error given from single spot data

Table S2 Analyzed major and trace elements and Pb isotope compositions of melt inclusions. Bulk-rock compositions of the host basaltic rocks (Hanyu *et al.*, 2011) are also listed for comparison.

	Melt inclusion rtg13-mi2 (This study)	Host rock RTG301-1 (Hanyu <i>et al.</i> 2011)	Melt inclusion rtg41-mi1 (This study)	Host rock RTG305 (Hanyu <i>et al.</i> 2011)	
Latitude (South)		21° 13.1'		21° 14.9'	
Longitude (West)		159° 47.7'		159° 45.6'	
[Major elements (wt.%)]	(FsLA-ICP-MS)	(XRF)	(FsLA-ICP-MS)	(XRF)	
SiO ₂	54.2	45.74	48.3	45.07	
TiO ₂	2.46	3.57	3.67	3.42	
Al ₂ O ₃	18.04	13.69	16.74	12.98	
FeO	4.26	11.96	8.26	11.89	
MnO	0.07	0.17	0.13	0.17	
MgO	1.32	8.88	1.97	9.59	
CaO	8.99	11.30	11.31	11.76	
Na ₂ O	7.08	2.46	5.45	2.55	
K ₂ O	2.50	1.62	3.38	1.95	
P ₂ O ₅	1.09	0.61	0.79	0.61	
Total	100	100	100	100	
[Trace elements (ppm)]	(FsLA-ICP-MS)	(ICP-MS)	(FsLA-ICP-MS)	(ICP-MS)	
Rb	50.07	41.5	78.31	41.8	
Sr	1493	852	1300	888	
Y	44.49	24.4	31.91	23.4	
Zr	450	298	385	279	
Nb	106	58.3	84.92	63.3	
Ba	462	564	987	640	
La	83.18	46.1	76.35	52.6	
Ce	187.4	94.1	157.72	105	
Pr	21.55	11.3	16.76	12.5	
Nd	89.49	46.1	66.44	49.3	
Sm	19.4	9.26	13.00	9.58	
Eu	6.26	2.91	4.20	3.00	
Gd	14.97	8.09	10.92	8.22	
Tb	2.00	1.15	1.43	1.15	
Dy	11.22	5.78	7.3	5.64	
Ho	1.88	0.993	1.24	0.966	
Er	4.32	2.56	2.5	2.43	
Tm	0.53	0.306	0.32	0.286	
Yb	3.17	1.840	1.78	1.710	
Lu	0.330	0.253	0.27	0.225	
Hf	10.31	6.87	9.38	6.35	
Ta	5.00	3.52	4.67	3.77	
Pb	4.47	4.21	11.55	5.10	
Th	8.43	5.64	9.60	7.06	
U	2.27	1.39	2.38	1.57	
La/Yb	26.2	25.1	42.9	30.8	
[Pb isotopic compositions]	(FsLA-ICP-MS)	(TIMS)	(FsLA-ICP-MS)	(SIMS)	(TIMS)
²⁰⁷ Pb/ ²⁰⁶ Pb	0.8355	0.83613	0.8504	0.8564	0.84287
2SE	0.0015	0.00006	0.0029	0.0162	0.00005
²⁰⁸ Pb/ ²⁰⁶ Pb	2.0888	2.09368	2.1078	2.121	2.10369
2SE	0.0026	0.00016	0.0035	0.040	0.00014
[Mineral mode (%)]					
Olivine		10.2			8.2
Clinopyroxene		22.3			15.1
Plagioclase					0.1
Oxide		0.1			0.9
Groundmass		67.4			75.8

FsLA-ICP-MS: femtosecond laser ablation-inductively coupled plasma-mass spectrometry

ICP-MS: inductively coupled plasma-mass spectrometry

TIMS: thermal ionization mass spectrometry

XRF: X-ray fluorescence spectrometry

2SE: two-standard error given from single spot data