

Table S2 (replicates and reference materials)

# ICPMS Reference Materials

Element	Unit	GeoReM*	Mean n=9	1SD (abs)	1SD (%)	Diff. (%)	GeoReM*	Mean n=9	1SD (abs)	1SD (%)	Diff. (%)
		BHVO-2	BHVO-2				AGV-2	AGV-2			
Li	µg/g	4.5	4.65	0.05	1.1	3.4	10.8	10.7	0.20	1.8	1.2
Sc	µg/g	31.83	31.4	0.78	2.5	1.3	13.11	13.5	0.39	2.9	2.8
V	µg/g	318.2	322	9.39	2.9	1.3	118.5	124	5.53	4.4	5.0
Cr	µg/g	287.2	277	11.72	4.2	3.6	16.22	19.3	0.96	4.9	19.3
Co	µg/g	44.89	45.8	1.33	2.9	2.1	15.46	16.4	0.64	3.9	5.9
Ni	µg/g	119.8	122	3.19	2.6	1.9	18.87	19.0	0.40	2.1	0.5
Cu	µg/g	129.3	130	2.48	1.9	0.6	51.51	53.1	1.18	2.2	3.2
Zn	µg/g	103.9	104	2.62	2.5	0.1	86.7	88.8	3.63	4.1	2.4
Ga	µg/g	21.37	21.5	0.45	2.1	0.6	20.42	20.9	0.60	2.9	2.5
Rb	µg/g	9.261	9.33	0.17	1.8	0.8	67.79	68.6	1.23	1.8	1.2
Sr	µg/g	394.1	397	7.80	2.0	0.8	659.5	663	9.28	1.4	0.5
Y	µg/g	25.91	26.3	0.64	2.4	1.5	19.14	19.9	0.45	2.2	3.8
Zr	µg/g	171.2	177	6.25	3.5	3.4	232	239	7.94	3.3	3.0
Nb	µg/g	18.1	18.1	0.21	1.1	0.0	14.12	13.8	0.21	1.6	2.5
Cs	µg/g	0.0996	0.11	0.00	3.8	7.5	1.173	1.21	0.03	2.1	3.3
Ba	µg/g	130.9	132	2.36	1.8	0.8	1134	1123	23.78	2.1	1.0
La	µg/g	15.2	15.4	0.23	1.5	1.2	38.21	38.2	0.66	1.7	0.0
Ce	µg/g	37.53	38.1	0.33	0.9	1.4	69.43	69.0	1.82	2.6	0.6
Pr	µg/g	5.339	5.34	0.10	1.8	0.1	8.165	8.13	0.14	1.7	0.4
Nd	µg/g	24.27	24.9	0.44	1.8	2.7	30.49	30.9	0.55	1.8	1.4
Sm	µg/g	6.023	6.18	0.12	2.0	2.6	5.509	5.57	0.10	1.8	1.2
Eu	µg/g	2.043	2.10	0.05	2.2	2.7	1.553	1.55	0.03	1.9	0.5
Gd	µg/g	6.207	6.19	0.12	1.9	0.3	4.678	4.68	0.07	1.5	0.1
Tb	µg/g	0.9392	0.94	0.02	1.9	0.1	0.651	0.644	0.01	1.3	1.0
Dy	µg/g	5.28	5.34	0.11	2.0	1.1	3.549	3.50	0.05	1.5	1.3
Ho	µg/g	0.9887	0.98	0.02	1.7	1.0	0.6818	0.660	0.01	1.7	3.2
Er	µg/g	2.511	2.47	0.09	3.6	1.6	1.825	1.78	0.05	3.0	2.5
Tm	µg/g	0.3349	0.33	0.01	1.9	2.2	0.262	0.252	0.00	1.7	4.1
Yb	µg/g	1.994	1.98	0.04	1.8	0.5	1.653	1.63	0.02	1.5	1.5
Lu	µg/g	0.2754	0.28	0.01	1.9	3.0	0.2507	0.254	0.00	1.5	1.2
Hf	µg/g	4.47	4.26	0.15	3.6	4.6	5.137	4.93	0.13	2.6	4.0
Ta	µg/g	1.154	1.14	0.02	2.1	0.9	0.865	0.820	0.02	2.3	5.2
Pb	µg/g	1.653	1.69	0.09	5.4	2.5	13.14	13.7	0.41	3.0	4.4
Th	µg/g	1.224	1.21	0.02	1.3	1.0	6.174	6.10	0.09	1.4	1.2
U	µg/g	0.412	0.42	0.00	1.1	1.0	1.885	1.85	0.02	1.3	1.6

\*Jochum, K. P., Weis, U., Schwager, B., Stoll, B., Wilson, S. A., Haug, G. H., Andreae, M. O., and Enzweiler, J., 2016, Reference Values Following ISO Guidelines for Frequently Requested Rock Reference Materials: *Geostandards and Geoanalytical Research*, v. 40, no. 3, p. 333-350.

**ICPMS Sample Replicates**

Element	Unit	SO255- DR31-3	SO255- DR31-3	Diff. (%)	SO255- DR131-1	SO255- DR131-1	Diff. (%)
		Dup 1	Dup 2		Dup 1	Dup 2	
Li	µg/g	6.29	6.37	1.2	5.31	5.32	0.2
Sc	µg/g	43.6	43.7	0.2	54.2	53.8	0.7
V	µg/g	378	379	0.2	367	366	0.3
Cr	µg/g	149	150	0.6	80.0	80.1	0.2
Co	µg/g	37.3	37.4	0.3	42.4	41.5	2.2
Ni	µg/g	32.9	33.3	1.4	37.6	36.7	2.4
Cu	µg/g	131	132	0.4	130.6	128.6	1.6
Zn	µg/g	82.1	83.0	1.1	82.9	82.5	0.5
Ga	µg/g	16.6	16.7	0.8	15.1	15.3	1.1
Rb	µg/g	9.94	9.93	0.1	5.08	5.02	1.2
Sr	µg/g	321	325	1.5	137	136	0.8
Y	µg/g	18.5	18.6	0.6	16.6	16.5	1.0
Zr	µg/g	54.3	51.7	4.7	30.5	30.2	0.9
Nb	µg/g	0.815	0.816	0.1	0.222	0.221	0.5
Cs	µg/g	0.319	0.320	0.4	0.432	0.424	1.8
Ba	µg/g	320	316	1.4	101	100	0.7
La	µg/g	3.35	3.37	0.6	1.25	1.23	1.2
Ce	µg/g	7.95	8.01	0.7	3.59	3.55	1.2
Pr	µg/g	1.27	1.29	1.5	0.642	0.638	0.5
Nd	µg/g	6.60	6.61	0.1	3.70	3.72	0.4
Sm	µg/g	2.05	2.06	0.8	1.45	1.42	2.0
Eu	µg/g	0.746	0.753	0.8	0.569	0.557	2.1
Gd	µg/g	2.51	2.51	0.1	2.03	1.99	2.2
Tb	µg/g	0.437	0.441	0.8	0.386	0.380	1.5
Dy	µg/g	2.92	2.90	0.6	2.68	2.63	1.9
Ho	µg/g	0.621	0.629	1.3	0.591	0.579	2.0
Er	µg/g	1.87	1.88	0.5	1.79	1.76	1.7
Tm	µg/g	0.273	0.270	1.0	0.264	0.259	2.1
Yb	µg/g	1.83	1.82	0.7	1.77	1.74	1.8
Lu	µg/g	0.286	0.290	1.4	0.278	0.275	1.1
Hf	µg/g	1.35	1.30	3.3	0.886	0.878	0.9
Ta	µg/g	0.053	0.053	0.6	0.022	0.021	5.9
Pb	µg/g	2.61	2.62	0.6	1.77	1.73	2.2
Th	µg/g	0.469	0.472	0.7	0.190	0.188	1.1
U	µg/g	0.188	0.187	0.7	0.083	0.085	2.9

## Sr-Nd-Pb-Hf Reference Materials

Ratio	RM	this study*	2SD (abs)	N	Fourny et al. (2016)	2SD (abs)	Todd et al. (2015)	2SD (abs)	RM	this study	2SD (abs)	N	Instrument	Lab
$^{87}\text{Sr}/^{86}\text{Sr}$	BCR-2	0.705004	0.000013	8	0.705006	0.000007			NBS987	0.710250	0.000008	101	Triton Plus	GEOMAR
$^{143}\text{Nd}/^{144}\text{Nd}$	BCR-2	0.512637	0.000011	8	0.512643	0.000014			La Jolla	0.511850	0.000006	95	Triton Plus	GEOMAR
$^{206}\text{Pb}/^{204}\text{Pb}$	BCR-2	18.8019	0.0012	8	18.7988	0.0027	18.8004	0.0038	NBS981	16.9408	0.0018	173	Triton Plus	GEOMAR
$^{207}\text{Pb}/^{204}\text{Pb}$	BCR-2	15.6232	0.0012	8	15.6235	0.0028	15.6238	0.0016	NBS981	15.4975	0.0018	173	Triton Plus	GEOMAR
$^{208}\text{Pb}/^{204}\text{Pb}$	BCR-2	38.8227	0.0046	8	38.8281	0.0099	38.8287	0.0049	NBS981	36.7207	0.0048	173	Triton Plus	GEOMAR
$^{207}\text{Pb}/^{206}\text{Pb}$	BCR-2	0.830939	0.000050	8					NBS981	0.914803	0.000050	173	Triton Plus	GEOMAR
$^{208}\text{Pb}/^{206}\text{Pb}$	BCR-2	2.064830	0.000167	8					NBS981	2.167584	0.000099	173	Triton Plus	GEOMAR
$^{176}\text{Hf}/^{177}\text{Hf}$	BCR-2	0.282870	0.000005	3	0.282869	0.000014			SPEX	0.282170	0.000006	110	Neptune Plus	GEOMAR
$^{176}\text{Hf}/^{177}\text{Hf}$	AGV-2	0.282979	0.000006	2	0.282973	0.000010								

\* leached in 2 M HCl at 70°C for one hour followed by triple rinsing in 18.2 MΩ H<sub>2</sub>O

Fourny, A., Weis, D., and Scoates, J. S., 2016, Comprehensive Pb-Sr-Nd-Hf isotopic, trace element, and mineralogical characterization of mafic to ultramafic rock reference materials: Geochemistry, Geophysics, Geosystems, v. 17, no. 3, p. 739-773.

Todd, E., Stracke, A., and Scherer, E. E., 2015, Effects of simple acid leaching of crushed and powdered geological materials on high-precision Pb isotope analyses: Geochemistry, Geophysics, Geosystems, v. 16, no. 7, p. 2276-2302.

# Sr-Nd-Pb-Hf Sample Replicates

Sample	Dissolution	<sup>87</sup> Sr/ <sup>86</sup> Sr	2SE	<sup>143</sup> Nd/ <sup>144</sup> Nd	2SE	<sup>206</sup> Pb/ <sup>204</sup> Pb	2SE	<sup>207</sup> Pb/ <sup>204</sup> Pb	2SE	<sup>208</sup> Pb/ <sup>204</sup> Pb	2SE	<sup>207</sup> Pb/ <sup>204</sup> Pb	2SE	<sup>208</sup> Pb/ <sup>206</sup> Pb	2SE	<sup>176</sup> Hf/ <sup>177</sup> Hf	2SE
SO255-DR30-2	#1	0.703995	0.000005	0.513009	0.000005	18.6773	0.0009	15.5794	0.0010	38.6033	0.0033	0.834136	0.000016	2.066855	0.000082		
SO255-DR30-2	#2	0.704004	0.000005	0.513001	0.000006	18.6759	0.0007	15.5774	0.0008	38.5964	0.0022	0.834093	0.000011	2.066646	0.000055		
SO255-DR35-9	#1	0.704389	0.000005	0.512950	0.000004	18.6584	0.0007	15.5828	0.0007	38.5857	0.0022	0.835164	0.000013	2.068003	0.000057		
SO255-DR35-9	#2	0.704410	0.000005	0.512943	0.000004	18.6583	0.0011	15.5824	0.0013	38.5857	0.0043	0.835146	0.000022	2.068014	0.000117		
SO255-DR62-6	#1															0.283132	0.000006
SO255-DR62-6	#2															0.283140	0.000004
SO255-DR78-1A	#1	0.703559	0.000006	0.512966	0.000004	18.7392	0.0040	15.5696	0.0035	38.5483	0.0084	0.830858	0.000039	2.057098	0.000080		
SO255-DR78-1A	#2	0.703543	0.000005	0.512960	0.000004	18.7256	0.0018	15.5753	0.0016	38.5517	0.0044	0.831763	0.000012	2.058766	0.000052		
SO255-DR136-1	#1	0.704367	0.000006	0.512955	0.000006	18.3844	0.0010	15.5279	0.0011	38.5351	0.0034	0.844626	0.000017	2.096076	0.000083		
SO255-DR136-1	#2*	0.704274	0.000005	0.512956	0.000004	18.4013	0.0012	15.5486	0.0014	38.6059	0.0047	0.844971	0.000023	2.098000	0.000120		
SO255-DR139-8	#1	0.706023	0.000005	0.512951	0.000005	18.4758	0.0013	15.5561	0.0014	38.6111	0.0041	0.841974	0.000020	2.089823	0.000097		
SO255-DR139-8	#2*	0.704316	0.000005	n.a		n.a		n.a		n.a		n.a		n.a			
SO255-DR156-1BClastl	#1	0.704640	0.000005	0.512964	0.000005	18.4270	0.0007	15.5464	0.0006	38.5895	0.0017	0.843678	0.000010	2.094189	0.000033		
SO255-DR156-1BClastl	#2*	0.704645	0.000006	0.512964	0.000005	18.4231	0.0006	15.5450	0.0006	38.5850	0.0015	0.843781	0.000008	2.094386	0.000030		
TAN1611-DR01A	#1	0.705011	0.000005	0.513003	0.000005	19.1064	0.0067	15.5789	0.0055	38.6740	0.0135	0.815374	0.000048	2.024137	0.000097		
TAN1611-DR01A	#2	0.704334	0.000006	0.513000	0.000005	19.0963	0.0009	15.5688	0.0008	38.6467	0.0023	0.815279	0.000010	2.023780	0.000044		
TAN1611-DR01A	#3*	0.702869	0.000005	n.a		n.a		n.a		n.a		n.a		n.a			
TAN1611-DR02A	#1	0.702818	0.000005	0.513030	0.000004	19.0218	0.0055	15.5610	0.0045	38.5512	0.0110	0.818064	0.000036	2.026688	0.000057		
TAN1611-DR02A	#2	0.702825	0.000006	0.513020	0.000005	19.0226	0.0010	15.5609	0.0011	38.5544	0.0035	0.818019	0.000018	2.026763	0.000087		

\*leached in 6M

HCl @ 150C for

12 hrs