

## Supporting information for

# High-temperature and High-pressure Sintering Method to Prepare Magnetite Reference Material for In-situ Microanalysis

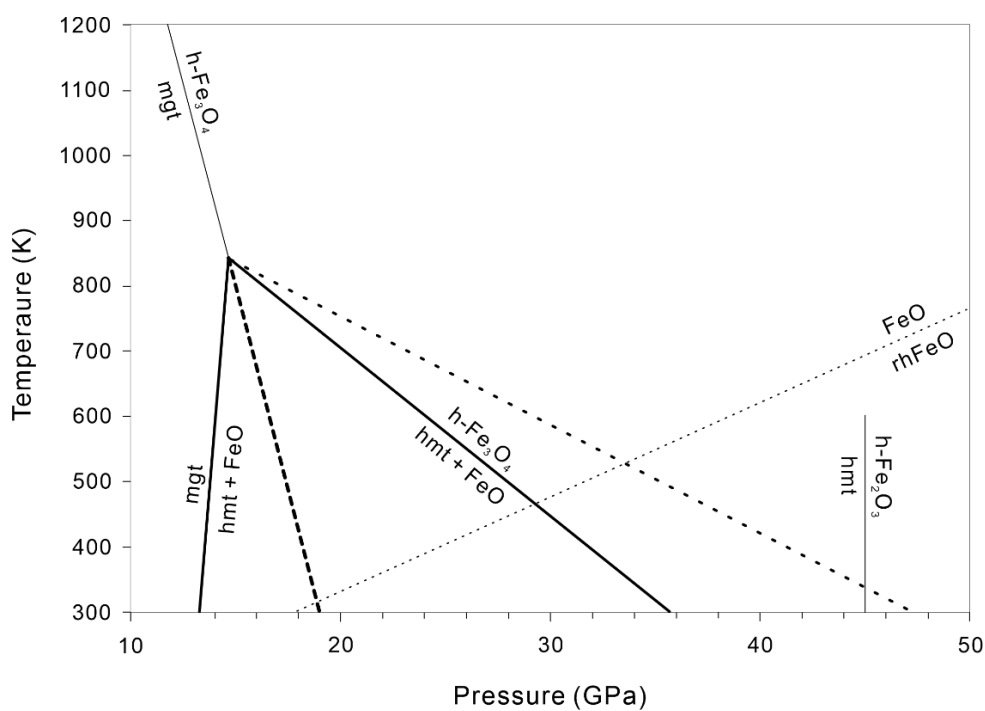
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**Fig. S1** Temperature-pressure phase diagram of Fe-O (modified from Lazor et al. 2004). mgt-magnetite, hmt-hematite.

**Table S1.** Certified values (in wt%) of elements in magnetite reference material, GBW(E)010350

	<b>TFe</b>	<b>FeO</b>	<b>SiO<sub>2</sub></b>	<b>TiO<sub>2</sub></b>	<b>Al<sub>2</sub>O<sub>3</sub></b>	<b>MgO</b>	<b>K<sub>2</sub>O</b>	<b>Na<sub>2</sub>O</b>	<b>CaO</b>	<b>Mn</b>	<b>Cu</b>	<b>Zn</b>	<b>S</b>	<b>P</b>
<b>Certified value</b>	68.29	28.25	2.08	0.057	0.43	1.25	0.060	0.021	0.70	0.061	0.0065	0.0037	0.041	0.0047
<b>Uncertainty</b>	0.07	0.12	0.06	0.003	0.02	0.03	0.003	0.004	0.01	0.002	0.0002	0.0002	0.003	0.0005

**Table S2.** Comparison of obtained values and certified values for the monitoring samples

	Li	Be	B	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	CaO	Sc	TiO <sub>2</sub>	V	Cr	MnO	FeO	Co	Ni	Cu	Zn	Ga	Ge	As	Rb	Sr	Y	Zr	Nb
BC-28			6.35	0.01	1.53	3.74	0.94		0.01		33.40	14.86	10419	1646	0.30	93.14	234	626	23.47	730.77	60.59	1.43	1.32	0.11	0.68	0.26	25.24	1.74
BC-28		0.18			2.80	4.79	0.77	0.01			35.72	15.68	11333	1850	0.29	93.14	368	775	3.00	530.82	60.47	1.52			0.11	0.02	24.67	1.87
BC-28		0.30	21.43	0.02	1.02	4.50	1.49	0.01	0.02		38.91	17.71	12992	1875	0.23	93.14	177	387	99.79	715.53	67.93	1.29	18.56	0.35	3.70	0.42	42.67	2.42
BC-28			16.49	0.00	1.93	4.46	0.48	0.02	0.00		34.68	16.95	12408	1700	0.36	93.14	343	685	13.18	565.90	59.95	1.23	13.57		0.79	0.04	27.79	2.01
BC-28 (average, n=4)		0.24	14.75	0.01	1.82	4.37	0.92	0.01	0.01		35.68	16.30	11788	1768	0.30	93.14	281	618	34.86	635.76	62.24	1.37	11.15	0.23	1.32	0.19	30.09	2.01
Stdev		0.08	7.69	0.01	0.75	0.45	0.42	0.00	0.01		2.36	1.27	1142	112	0.06	0.00	90	166	44.09	102.12	3.81	0.13	8.87	0.17	1.62	0.19	8.50	0.29
RSD%		34.5	52.1	98.8	41.5	10.2	45.7	18.0	103.0		6.6	7.8	9.7	6.3	18.5	0.0	32.2	26.8	126.5	16.1	6.1	9.5	79.6	75.9	122.3	102.5	28.2	14.7
BC-28 (reference value) <sup>a</sup>					1.80	3.67					28.70	13.70	9059	1096	0.26		225.00	536.00	31.00	500.00								
GOR128-G	8.37	0.05	23.76	0.53	22.52	9.02	44.76	0.03	0.04	5.88	31.52	0.26	178.9	2185.9	0.17	9.81	86.79	1053.71	70.91	69.78	8.95	0.91	0.53	0.30	27.42	10.87	9.86	0.09
GOR128-G	11.36	0.12	48.92	0.59	22.75	9.28	46.09	0.04	0.03	5.98	33.56	0.23	182.9	2183.9	0.18	9.81	90.42	1073.68	64.95	68.67	7.75	1.15	12.71	0.41	29.06	12.63	10.45	0.09
GOR128-G (average, n=2)	9.86	0.09	36.34	0.56	22.64	9.15	45.43	0.03	0.03	5.93	32.54	0.24	180.9	2184.9	0.17	9.81	88.60	1063.70	67.93	69.23	8.35	1.03	6.62	0.36	28.24	11.75	10.15	0.09
Stdev	2.11	0.05	17.79	0.04	0.16	0.18	0.94	0.01	0.00	0.07	1.44	0.02	2.81	1.43	0.01	0.00	2.57	14.13	4.21	0.78	0.85	0.17	8.61	0.08	1.15	1.24	0.41	0.00
RSD%	21.4	56.4	48.9	7.8	0.7	2.0	2.1	26.5	5.5		4.4	9.6	1.6	0.1	3.3	0.0	2.9	1.3	6.2	1.1	10.1	16.9	130.1	22.1	4.1	10.6	4.1	4.3
GOR128-G (certified value) <sup>a</sup>	10.40	0.03	23.50	0.57	25.87	9.91	46.11	0.02	0.04	6.24	32.10	0.29	189.00	2272.00	0.18	9.81	92.40	1074.00	63.80	74.70	8.67	0.96	0.10	0.41	30.00	11.80	10.00	0.10

	Mo	Ag	Cd	In	Sn	Cs	Ba	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	W	Bi	Pb	Th	U
BC-28	0.81		0.10	0.14	2.18		0.74	0.11	0.19	0.03			0.01	0.03			0.01		0.02	0.02		0.96	0.12			0.26		0.02
BC-28	0.41			0.16	1.73		0.07	0.03	0.01	0.01					0.01	0.01					0.01	1.08	0.18					
BC-28	0.51			0.12	2.52		4.82	0.28	0.51	0.06	0.21			0.23	0.02	0.07	0.04	0.09		0.17	0.01	1.18	0.14	0.01		0.88	0.12	0.11
BC-28	0.73		0.15	0.12	1.82		0.29	0.03	0.02	0.01	0.04			0.03							0.01	1.04	0.12		0.02	0.28	0.03	
BC-28 (average, n=4)	0.61		0.13	0.13	2.06		1.48	0.11	0.18	0.03	0.12		0.01	0.10	0.01	0.04	0.02	0.09	0.02	0.09	0.01	1.07	0.14	0.01	0.02	0.47	0.07	0.06
Stdev	0.19		0.03	0.02	0.36		2.24	0.12	0.23	0.03	0.12			0.12	0.00	0.04	0.02			0.11	0.00	0.09	0.03			0.35	0.06	0.07

<b>RSD%</b>	30.6	24.4	15.0	17.7		151.8	104.2	127.4	89.5	99.6		117.6	17.7	103.4	82.8	0.0	0.0	117.7	35.5	8.6	19.7		75.0	82.2	104.6			
<b>BC-28 (reference value)<sup>a</sup></b>																												
<b>GOR128-G</b>	0.54		0.07	0.04	0.72	0.25	0.92	0.11	0.38	0.08	0.73	0.51	0.22	1.04	0.24	2.05	0.44	1.45	0.19	1.35	0.22	0.39		14.98		0.01	0.00	
<b>GOR128-G</b>	0.73	0.06		0.03	0.39	0.24	1.24	0.12	0.37	0.09	0.65	0.48	0.23	1.17	0.23	1.91	0.42	1.95	0.18	1.36	0.22	0.39		15.35	0.01	0.31	0.02	
<b>GOR128-G</b>																												
<b>(average, n=2)</b>	0.64	0.06	0.07	0.04	0.55	0.24	1.08	0.12	0.38	0.09	0.69	0.49	0.22	1.11	0.23	1.98	0.43	1.70	0.19	1.35	0.22	0.39		15.17	0.01	0.31	0.01	0.01
<b>Stdev</b>	0.14			0.01	0.23	0.01	0.23	0.01	0.01	0.01	0.06	0.02	0.01	0.09	0.01	0.10	0.01	0.36	0.01	0.00	0.00	0.00		0.26				0.01
<b>RSD%</b>	21.2		0.0	16.4	42.4		21.0	4.4	2.0	6.9	8.2			8.4	5.0	5.2	2.6	20.9	3.8	0.2	0.4	0.4				0.0	0.0	89.7
<b>GOR128-G</b>																												
<b>(certified value)<sup>b</sup></b>	0.71	0.5	0.072	0.067	0.224	0.24	1.06	0.12	0.45	0.1	0.78	0.53	0.26	1.17	0.25	1.98	0.44	1.4	0.2	1.41	0.21	0.35	0.019	15.5		0.008	0.012	

Note: oxides are expressed as wt%, whereas elements are in  $\mu\text{g g}^{-1}$

<sup>a</sup> Dare et al. (2012)

<sup>b</sup> Certified values are from this website: <http://georem.mpch-mainz.gwdg.de/>

**Table S3.** Full EPMA results of the prepared magnetite (MtTR-1)

Analysis no.	FeO wt%	MnO wt%	ZnO wt%	CuO wt%	TiO <sub>2</sub> wt%	SiO <sub>2</sub> wt%	Al <sub>2</sub> O <sub>3</sub> wt%	Na <sub>2</sub> O wt%	MgO wt%	K <sub>2</sub> O wt%	P <sub>2</sub> O <sub>5</sub> wt%	CaO wt%	NiO wt%	Total wt%
1	86.5	0.086	0.059		0.044	2.45	0.236		0.523			0.088		90.0
2	86.5	0.062	0.026	0.041		2.24	0.286	0.075	0.634			0.045		89.9
3	86.2	0.075			0.078	2.33	0.26	0.038	0.565	0.013		0.171	0.022	89.7
4	85.9	0.112				1.95	0.21		0.723	0.01		0.627		89.6
5	86.4	0.076			0.058	2.28	0.206		0.676	0.013		0.19		89.9
6	86.8	0.077				2.12	0.246		0.554	0.01		0.069		90.0
7	86.7	0.049				2.17	0.223	0.03	0.581			0.087		89.9
8	86.5	0.075	0.107			2.29	0.236		0.59	0.016	0.072	0.103		90.1
9	86.9	0.081	0.032		0.06	2.20	0.266	0.038	0.641	0.01		0.069		90.3
10	87.0	0.058			0.058	2.21	0.22	0.075	0.668	0.029		0.094		90.5
11	86.8	0.049				2.21	0.201		0.681	0.014		0.068	0.029	90.0
12	86.9	0.067	0.028		0.065	2.24	0.285	0.06	0.575	0.015		0.075	0.026	90.3
13	86.6	0.051				2.25	0.237		0.502	0.013		0.107		89.8
14	87.7	0.071			0.076	2.25	0.227		0.666			0.101		91.1
15	86.7	0.081			0.047	2.22	0.257		0.63	0.01		0.085		90.1
16	86.8	0.074			0.073	2.19	0.2		0.681	0.017		0.085		90.2
17	86.7	0.073				2.54	0.278		0.667			0.126		90.5
18	86.6	0.047	0.024			2.10	0.214	0.06	0.56			0.099		89.7
19	87.4	0.051				2.16	0.241		0.582		0.039	0.094		90.6
20	86.0	0.1	0.034			2.25	0.278		0.677			0.372		89.7
21	86.8	0.069			0.075	2.25	0.214	0.06	0.608			0.084		90.2
22	86.4	0.063	0.021		0.048	2.06	0.272		0.726	0.018		0.296	0.022	89.9
23	86.4	0.058			0.085	2.25	0.265		0.733	0.017		0.127	0.029	90.0
24	86.7	0.04			0.045	2.28	0.286		0.58	0.016		0.126		90.1
25	86.8	0.061			0.047	2.20	0.21	0.105	0.593	0.015		0.179	0.036	90.3
26	86.9	0.058	0.035			2.09	0.267	0.173	0.611			0.07	0.031	90.3
27	86.2	0.056				2.17	0.201		0.585	0.012		0.135		89.3

28	87.4	0.078	0.022			2.28	0.241			0.708		0.132	0.021	90.9
29	86.9	0.057		0.027		2.29	0.274	0.038	0.623			0.095		90.4
30	85.7	0.07			0.047	2.50	0.296	0.038	0.739			0.292		89.8
31	87.0	0.068	0.04			2.13	0.253	0.038	0.662			0.116	0.033	90.4
32	86.8	0.043	0.035			2.28	0.27	0.143	0.664	0.014		0.063		90.4
33	86.9	0.067		0.03		2.16	0.241		0.599			0.105		90.2
34	86.7	0.065	0.025			2.27	0.277		0.586	0.012		0.061	0.02	90.0
35	87.1	0.063			0.047	2.22	0.273		0.555			0.1		90.4
36	87.4	0.046			0.052	2.23	0.277		0.623			0.083		90.8
37	87.2	0.101			0.039	2.21	0.258		0.593	0.009		0.094		90.5
38	86.9	0.07				2.15	0.239		0.567			0.073		90.1
39	86.3	0.068				2.39	0.288		0.677	0.027		0.144		89.9
40	86.7	0.066	0.029			2.32	0.258		0.648			0.125		90.2
41	87.2	0.069			0.056	2.21	0.235		0.53	0.009		0.068	0.029	90.5
42	86.1	0.071				2.21	0.281		0.547			0.107		89.3
43	86.6	0.075			0.047	2.63	0.224	0.068	0.574			0.064		90.3
44	86.9	0.072			0.073	2.34	0.227	0.18	0.655		0.037	0.155	0.02	90.7
45	87.4	0.05				2.19	0.2		0.55			0.065		90.5
46	87.2	0.075				2.25	0.29	0.113	0.701			0.114		90.8
47	86.7	0.069		0.047	0.041	2.47	0.278		0.742	0.013		0.082		90.5
48	86.9	0.055			0.038	2.13	0.237	0.075	0.595	0.009		0.2		90.2
49	86.3	0.077				2.39	0.259		0.642			0.105		89.8
50	86.7	0.074			0.07	2.36	0.244	0.038	0.585			0.087		90.2
51	87.0	0.075		0.026		2.34	0.288		0.698	0.02	0.049	0.154	0.024	90.8
52	86.2	0.098				2.23	0.277		0.635			0.12		89.6
53	85.9	0.086				2.13	0.197		0.742	0.011		0.642		89.7
54	87.0	0.093	0.044			2.18	0.227		0.636			0.088		90.3
55	87.1	0.087			0.051	2.43	0.241	0.068	0.691	0.009		0.116		90.8
56	86.8	0.102				2.17	0.24		0.616	0.017		0.101		90.1
57	87.5	0.069				2.23	0.272		0.641			0.087		90.9
58	86.7	0.083				2.21	0.247	0.173	0.701			0.076		90.2

59	87.0	0.041			2.42	0.262	0.06	0.615	0.011		0.152	0.031	90.6
60	86.6	0.062		0.024	0.059	2.04	0.222	0.62	0.012		0.393		90.0
61	87.3	0.055				2.24	0.238	0.573			0.12		90.6
62	86.6	0.096	0.028			1.97	0.221	0.754			0.433	0.037	90.2
63	86.9	0.067			0.042	2.19	0.264	0.716			0.162		90.4
64	87.2	0.082		0.021	0.074	2.08	0.254	0.543			0.085		90.4
65	87.4	0.055		0.018	0.049	2.28	0.231	0.053	0.59	0.01	0.162		90.8
66	85.6	0.133		0.019	0.056	2.18	0.212	0.834			0.507		89.6
67	86.5	0.085		0.022		2.22	0.236	0.785			0.321		90.2
68	86.3	0.087	0.021		0.069	2.46	0.254	0.71			0.2		90.1
69	86.8	0.073				2.25	0.244	0.64	0.022		0.138		90.2
70	86.6	0.078			0.054	2.59	0.256	0.098	0.769		0.042	0.234	90.7
71	87.5	0.103			0.052	2.38	0.21	0.55	0.01		0.108		90.9
72	87.8	0.087		0.031		2.25	0.277	0.568			0.106		91.1
73	87.1	0.083			0.057	2.24	0.228	0.578			0.114		90.4
74	86.5	0.095				2.35	0.225	0.06	0.691		0.202		90.2
75	87.4	0.095				2.30	0.274	0.653			0.103		90.9
76	87.1	0.054				2.25	0.238	0.106	0.601	0.018	0.115		90.5
77	87.0	0.073				2.26	0.258	0.673			0.105		90.4
78	87.1	0.079				2.30	0.275	0.585			0.121	0.02	90.6
79	87.0	0.069				2.20	0.205	0.643			0.114		90.3
80	87.1	0.05				2.44	0.237	0.09	0.665		0.12		90.7
81	87.3	0.054				2.24	0.201	0.663			0.14		90.6
82	86.8	0.064				2.42	0.276	0.617			0.13		90.4
83	86.1	0.114		0.036	0.059	2.02	0.231	0.045	0.732		0.698	0.045	90.2
84	87.2	0.037	0.036		0.049	2.28	0.235	0.06	0.593		0.09		90.6
85	86.5	0.079			0.171	2.28	0.255	0.045	0.755	0.017	0.146		90.2
86	87.3	0.081				2.19	0.255	0.571	0.013		0.182		90.7
87	86.6	0.064				2.19	0.279	0.633		0.04	0.143		90.0
88	87.0	0.076			0.039	2.43	0.221	0.075	0.731	0.015	0.165		90.8
89	86.7	0.039			0.072	2.36	0.215	0.595			0.155		90.1

<b>90</b>	87.2	0.058			2.25	0.321	0.12	0.54		0.133		90.7
<b>91</b>	87.1	0.082	0.028		2.32	0.252		0.643	0.009	0.145	0.028	90.6
<b>92</b>	86.9	0.066	0.031	0.066	2.41	0.285	0.053	0.672	0.015	0.134		90.6
<b>93</b>	87.4	0.065			2.15	0.242		0.568	0.019	0.141		90.6
<b>94</b>	86.6	0.07			2.23	0.292		0.698		0.282	0.023	90.2
<b>95</b>	86.9	0.096			2.32	0.226		0.569		0.136		90.3
<b>96</b>	86.7	0.116			2.14	0.319		0.803	0.01	0.354		90.4
<b>97</b>	86.9	0.075	0.019		2.18	0.261		0.557	0.01	0.14		90.2
<b>98</b>	87.1	0.068		0.039	2.25	0.268	0.053	0.59	0.015	0.134		90.6
<b>99</b>	87.2	0.079			2.15	0.235		0.608	0.012	0.16	0.031	90.5
<b>100</b>	87.4	0.08		0.049	2.23	0.205		0.6		0.158		90.7

Notes: data below detection limits are removed from this table. The FeO content represents total iron content calculated as ferrous iron.



**Table S4.** Full LA-ICP-MS results of MtTR-1

Analysis no.	Spot size	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	Rb	Sr	Zr	Mo	Ba	La	Ce	W	Bi	Pb
		wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>
spot8	38μm	0.015	0.718	0.304	2.459	0.028	0.302	0.048	0.091	149.39	39.07	65.10	168.45	41.77	61.80	11.02	2.10	1.19	6.46	1.93	1.27	9.28	1.50	2.39	1.81	34.18	1.38
spot9	38μm	0.014	0.690	0.307	2.382	0.028	0.232	0.049	0.083	149.32	40.42	65.08	166.10	33.36	60.03	10.80	1.66	1.13	5.75	1.80	1.29	8.86	1.41	2.12	2.26	33.12	1.49
spot10	38μm	0.014	0.706	0.308	2.404	0.028	0.257	0.049	0.086	148.82	41.28	63.86	164.13	34.85	61.45	11.28	2.06	1.08	6.10	1.54	1.31	8.33	1.42	2.14	1.94	33.52	1.32
spot11	38μm	0.013	0.696	0.312	2.421	0.026	0.220	0.049	0.083	150.28	58.15	64.52	166.80	37.98	60.76	10.91	2.07	1.00	6.32	2.30	1.61	10.82	1.37	2.04	2.13	34.31	1.30
spot12	38μm	0.012	0.691	0.305	2.353	0.027	0.235	0.049	0.084	150.19	41.91	63.24	162.59	44.12	62.87	10.90	2.13	1.08	6.07	1.47	1.14	8.17	1.30	2.03	1.95	34.49	1.31
spot13	38μm	0.013	0.700	0.309	2.373	0.026	0.260	0.051	0.083	148.78	36.44	63.56	162.75	36.80	58.75	10.78	2.16	0.99	6.26	1.33	1.32	8.55	1.40	2.20	1.85	34.36	1.43
spot14	38μm	0.012	0.695	0.311	2.383	0.027	0.246	0.049	0.082	150.72	43.14	62.72	157.31	38.29	63.18	11.01	2.14	1.10	5.94	1.41	0.99	8.62	1.32	2.08	1.95	35.23	1.28
spot15	38μm	0.013	0.695	0.304	2.400	0.026	0.251	0.049	0.083	150.46	40.03	64.41	158.91	36.06	62.26	10.73	1.87	1.01	5.76	1.34	1.29	8.26	1.32	2.14	1.78	33.60	1.39
spot16	38μm	0.013	0.690	0.310	2.376	0.027	0.245	0.049	0.083	150.95	40.24	62.42	159.24	35.01	62.18	10.18	1.66	1.01	6.04	1.95	1.03	7.97	1.40	2.09	1.64	35.22	1.36
spot17	38μm	0.013	0.699	0.308	2.368	0.027	0.261	0.050	0.085	150.66	37.64	64.75	162.88	36.12	59.96	10.51	1.80	1.20	6.10	1.74	0.94	8.12	1.29	2.18	1.84	34.60	1.79
spot18	38μm	0.013	0.712	0.304	2.333	0.027	0.284	0.048	0.090	146.26	39.92	63.76	161.91	37.34	62.89	10.59	1.75	1.06	6.33	1.71	1.05	8.88	1.48	2.16	2.17	34.58	1.37
spot19	38μm	0.013	0.697	0.313	2.398	0.028	0.225	0.050	0.086	149.98	44.47	65.70	160.71	33.29	61.71	11.18	1.92	1.17	6.06	1.72	0.95	7.39	1.30	2.19	1.68	34.24	1.32
spot20	38μm	0.013	0.696	0.306	2.392	0.027	0.237	0.049	0.082	149.02	45.67	62.09	160.48	37.54	58.62	9.97	1.62	1.18	6.09	1.84	1.11	7.69	1.32	2.10	1.89	34.55	1.28
spot21	38μm	0.013	0.692	0.319	2.352	0.027	0.210	0.050	0.082	149.19	45.85	62.83	163.56	35.08	60.16	10.87	2.20	1.19	6.10	1.64	1.19	9.04	1.36	1.98	1.89	34.85	1.36
spot22	38μm	0.013	0.700	0.305	2.330	0.027	0.277	0.048	0.086	149.95	35.90	62.26	160.63	32.50	63.22	10.70	1.90	1.15	6.16	1.27	1.38	8.70	1.31	2.26	1.87	35.27	1.37
spot23	38μm	0.014	0.704	0.307	2.386	0.028	0.277	0.051	0.084	151.35	38.16	65.12	163.16	34.57	61.28	11.36	1.92	1.15	5.93	2.36	1.04	8.50	1.34	2.19	1.70	35.76	1.28
spot24	38μm	0.013	0.697	0.303	2.347	0.027	0.236	0.049	0.082	149.02	41.13	63.56	161.98	37.92	60.24	10.49	1.55	1.05	6.05	1.81	1.23	8.12	1.34	2.14	1.92	35.06	1.17
spot25	38μm	0.013	0.738	0.301	2.326	0.026	0.283	0.048	0.090	152.01	42.21	64.36	163.54	34.28	65.20	10.69	1.97	1.15	6.11	2.97	1.72	8.56	1.33	2.26	2.04	34.31	1.28
spot26	38μm	0.013	0.672	0.312	2.351	0.028	0.204	0.051	0.079	149.73	34.95	63.28	166.26	38.18	64.32	10.58	1.64	1.06	6.07	1.30	0.87	7.75	1.30	2.03	2.04	35.52	1.33
spot27	38μm	0.014	0.690	0.306	2.345	0.028	0.236	0.050	0.081	150.15	45.43	63.04	161.11	36.94	64.90	10.64	1.91	1.08	5.67	5.50	1.23	8.36	1.25	2.11	1.83	36.61	1.27
mag-1	51μm	0.013	0.642	0.261	2.461	0.024	0.263	0.045	0.083	152.04	44.65	63.44	159.17	34.70	66.60	10.48	1.63	1.22	6.05	2.26	1.16	8.29	1.29	2.08	2.02	32.56	1.23
mag-2	51μm	0.013	0.626	0.257	2.417	0.024	0.237	0.045	0.080	149.22	42.98	62.88	159.89	33.47	64.13	10.50	1.80	1.13	5.53	2.00	1.14	7.50	1.22	2.00	2.00	32.39	0.96
mag-3	51μm	0.014	0.636	0.260	2.426	0.024	0.262	0.045	0.084	151.34	36.89	62.91	159.07	34.16	64.25	11.15	1.87	1.21	5.87	1.48	1.04	7.08	1.31	2.10	2.05	32.61	1.27

mag-4	51µm	0.014	0.627	0.255	2.394	0.025	0.237	0.044	0.080	151.56	42.62	63.32	159.05	34.72	63.23	10.52	2.05	1.07	5.89	1.58	1.13	7.64	1.30	2.18	2.13	32.53	1.37
mag-5	51µm	0.013	0.630	0.255	2.411	0.024	0.229	0.043	0.081	149.70	46.48	63.01	162.97	35.81	63.03	10.54	1.76	1.14	6.00	1.86	1.17	7.38	1.32	2.21	1.99	32.31	1.47
mag-6	51µm	0.013	0.606	0.257	2.354	0.024	0.233	0.043	0.076	150.55	44.72	62.78	154.60	36.08	62.56	10.30	1.89	1.11	5.62	1.37	1.17	7.63	1.42	1.90	2.04	31.64	1.47
mag-7	51µm	0.013	0.615	0.257	2.375	0.024	0.243	0.043	0.079	149.42	31.02	63.03	156.38	34.64	59.79	10.69	1.85	1.10	5.79	1.64	1.32	7.12	1.25	1.97	2.17	31.37	1.23
mag-8	51µm	0.013	0.609	0.259	2.399	0.024	0.228	0.043	0.076	149.40	52.52	63.90	156.24	34.40	60.61	10.78	1.85	1.16	5.62	1.54	1.06	7.88	1.26	2.09	2.03	31.73	1.32
mag-9	51µm	0.013	0.619	0.257	2.395	0.025	0.226	0.042	0.078	146.61	39.55	62.47	155.08	34.10	63.17	10.57	1.95	1.12	5.71	1.23	1.27	7.74	1.26	2.02	1.87	31.34	1.34
mag-10	51µm	0.013	0.616	0.256	2.382	0.024	0.243	0.042	0.077	148.00	35.10	62.90	156.92	33.80	62.15	9.94	1.99	1.13	5.78	2.82	1.18	8.55	1.21	2.06	2.26	31.07	1.16
mag-11	51µm	0.012	0.631	0.254	2.368	0.024	0.263	0.044	0.079	149.18	38.21	63.86	155.66	34.34	60.92	10.18	1.85	1.07	5.73	1.72	1.20	8.03	1.31	2.10	1.91	31.29	1.26
mag-12	51µm	0.012	0.627	0.255	2.383	0.024	0.263	0.041	0.078	152.32	41.19	64.08	154.18	35.86	60.19	10.08	1.96	1.14	5.86	2.29	1.31	8.55	1.26	1.97	2.50	29.68	1.27
mag-13	51µm	0.013	0.619	0.253	2.354	0.024	0.275	0.041	0.080	151.05	42.39	63.36	155.71	33.78	57.63	9.90	2.15	1.19	6.11	1.85	1.32	8.52	1.36	2.26	2.02	30.09	1.61
mag-14	51µm	0.013	0.622	0.258	2.427	0.024	0.237	0.041	0.076	152.09	42.74	65.04	157.41	32.68	60.21	10.38	1.80	1.13	5.97	1.67	1.30	8.43	1.19	2.13	2.25	30.44	1.39
mag-15	51µm	0.012	0.624	0.255	2.365	0.024	0.246	0.041	0.077	149.44	43.77	64.09	153.50	33.78	62.90	10.66	1.75	1.11	5.89	1.25	1.02	7.88	1.29	2.04	2.21	30.49	1.30
mag-16	51µm	0.012	0.629	0.257	2.350	0.023	0.269	0.041	0.077	148.49	39.10	63.36	148.41	33.85	58.93	10.02	1.74	1.03	5.83	1.79	1.06	8.03	1.23	1.98	1.87	29.27	1.30
mag-17	51µm	0.012	0.631	0.253	2.338	0.023	0.272	0.041	0.078	149.71	37.80	61.87	151.89	34.32	58.32	10.09	1.77	1.06	5.85	1.41	1.39	7.85	1.25	1.98	1.91	29.68	1.20
mag-18	51µm	0.012	0.628	0.253	2.332	0.023	0.271	0.041	0.078	148.18	35.47	63.81	149.55	33.91	58.75	9.63	1.74	1.06	5.85	1.70	1.17	7.21	1.38	1.98	2.23	29.19	1.36
mag-19	51µm	0.012	0.628	0.255	2.346	0.023	0.233	0.043	0.074	148.46	37.88	63.39	147.73	33.60	58.12	9.93	1.55	1.00	5.71	1.23	1.11	7.67	1.27	2.01	1.83	30.07	1.34
mag-20	51µm	0.012	0.634	0.256	2.352	0.023	0.275	0.042	0.077	148.75	36.86	63.26	151.22	34.68	58.36	9.82	1.98	1.15	5.87	1.89	1.13	7.88	1.17	1.90	1.94	29.79	1.14
mag-21	51µm	0.012	0.631	0.256	2.308	0.023	0.261	0.042	0.078	149.11	36.23	63.11	149.85	33.57	58.82	10.41	1.91	1.11	5.90	1.89	1.23	8.40	1.28	2.12	1.66	29.76	1.36
mag-22	51µm	0.013	0.641	0.259	2.356	0.023	0.271	0.043	0.078	149.48	43.38	63.04	153.94	35.06	59.60	10.25	1.49	1.14	6.19	1.99	1.46	8.15	1.34	2.22	1.74	30.20	1.19
mag-23	51µm	0.015	0.654	0.259	2.294	0.026	0.277	0.043	0.077	148.67	42.62	63.38	150.66	31.27	57.88	10.06	1.77	1.22	6.91	1.78	1.10	9.06	1.25	1.97	1.98	30.83	1.18
mag-24	51µm	0.015	0.699	0.257	2.362	0.026	0.287	0.044	0.079	148.34	42.63	63.20	153.28	33.36	60.44	10.28	1.90	1.16	7.19	1.64	1.43	8.60	1.26	2.02	1.76	30.56	1.31
mag-25	51µm	0.013	0.626	0.256	2.296	0.023	0.224	0.045	0.078	149.96	49.17	62.54	151.99	33.38	59.05	10.33	2.11	1.11	5.77	1.51	1.23	8.36	1.20	2.14	1.94	30.74	1.19
mag-26	51µm	0.012	0.632	0.256	2.353	0.024	0.258	0.044	0.079	147.88	45.83	63.36	151.79	31.56	61.11	10.86	1.98	1.09	5.69	1.59	1.36	8.22	1.18	1.99	1.70	31.18	1.28
mag-27	51µm	0.013	0.615	0.255	2.321	0.023	0.228	0.043	0.077	147.72	39.06	62.53	150.83	34.22	60.15	10.43	1.95	1.11	5.79	1.88	1.27	8.41	1.21	2.13	1.84	32.64	1.38
mag-28	51µm	0.012	0.627	0.252	2.347	0.024	0.231	0.044	0.078	144.83	33.51	62.96	152.09	33.61	59.14	10.57	1.63	1.08	6.04	2.26	1.20	7.87	1.23	2.00	1.88	32.67	1.39
mag-29	51µm	0.013	0.630	0.251	2.366	0.024	0.250	0.045	0.082	148.82	41.75	63.43	150.96	34.19	59.96	10.77	1.95	1.17	5.91	2.28	1.22	8.23	1.16	1.96	1.99	32.94	1.25
mag-30	51µm	0.012	0.640	0.253	2.368	0.023	0.258	0.045	0.087	148.09	46.01	63.21	151.70	35.32	59.58	10.74	1.82	1.07	6.08	1.59	1.06	8.23	1.31	1.96	2.11	30.54	1.30

Mag1-1	44µm	0.014	0.705	0.281	2.420	0.028	0.323	0.047	0.084	150.48	41.85	66.19	167.34	37.45	55.42	10.56	1.58	1.27	7.39	1.81	1.13	9.09	1.39	2.08	1.79	29.86	1.20
Mag1-2	44µm	0.014	0.711	0.283	2.423	0.027	0.323	0.049	0.085	147.05	38.31	63.19	161.20	36.57	55.46	10.08	1.55	1.21	7.42	1.64	1.69	9.38	1.25	2.06	1.92	31.14	1.35
Mag1-3	44µm	0.013	0.700	0.281	2.354	0.028	0.275	0.050	0.080	147.03	35.74	63.37	157.78	30.33	51.90	10.08	1.59	1.26	6.49	2.73	1.02	8.88	1.07	2.02	2.02	31.17	1.13
Mag1-4	44µm	0.014	0.684	0.280	2.306	0.028	0.308	0.047	0.080	149.15	33.33	64.13	159.39	32.92	51.44	10.21	1.82	1.35	6.60	1.56	1.20	8.32	1.27	1.96	2.19	31.72	1.13
Mag1-5	44µm	0.013	0.688	0.276	2.354	0.027	0.277	0.048	0.080	149.52	38.48	64.12	160.48	35.66	53.83	10.76	1.79	1.11	6.49	1.35	1.21	8.39	1.31	2.08	2.25	30.45	1.41
Mag1-6	44µm	0.014	0.703	0.282	2.470	0.027	0.281	0.051	0.082	151.87	42.99	63.81	163.55	33.06	55.76	10.28	1.71	1.04	6.87	1.67	1.26	8.06	1.24	2.24	2.04	31.27	1.16
Mag1-7	44µm	0.013	0.692	0.274	2.389	0.027	0.280	0.048	0.082	150.78	36.64	63.69	165.39	33.39	54.29	10.57	1.87	1.23	6.59	1.83	1.34	8.58	1.07	2.07	1.80	29.88	1.29
Mag1-8	44µm	0.014	0.704	0.281	2.407	0.029	0.250	0.050	0.079	147.45	39.08	64.07	162.12	32.83	50.39	10.15	1.73	1.12	6.40	1.71	1.07	8.11	1.19	2.18	1.96	32.83	1.27
Mag1-9	44µm	0.014	0.682	0.276	2.342	0.028	0.290	0.050	0.080	147.32	38.59	63.11	161.10	35.41	54.01	10.52	1.82	1.15	6.28	2.64	2.62	9.25	1.19	1.95	2.17	31.92	1.28
Mag1-10	44µm	0.013	0.700	0.269	2.376	0.026	0.335	0.048	0.085	147.80	33.99	63.06	161.29	31.62	49.75	9.89	1.61	1.14	6.84	1.15	2.17	8.57	1.19	2.10	2.03	30.50	1.21
Mag1-11	44µm	0.013	0.707	0.275	2.398	0.027	0.298	0.047	0.087	149.01	45.38	63.39	158.97	34.78	53.07	10.78	1.71	1.16	7.01	1.47	1.17	8.92	1.32	2.26	1.95	30.84	1.12
Mag1-12	44µm	0.013	0.652	0.268	2.315	0.025	0.231	0.048	0.077	145.41	44.94	63.98	159.30	28.67	50.48	10.52	1.78	1.05	6.30	1.32	1.11	8.43	0.98	1.83	1.94	30.73	1.32
Mag1-13	44µm	0.013	0.695	0.270	2.313	0.027	0.251	0.048	0.082	144.81	43.61	62.20	162.01	34.41	54.94	10.30	1.53	1.09	6.58	1.42	1.27	7.99	1.23	2.07	1.94	30.38	1.24
Mag1-14	44µm	0.013	0.688	0.271	2.375	0.026	0.254	0.048	0.080	149.55	40.81	63.38	162.48	35.31	54.42	10.73	1.82	1.23	6.09	1.69	1.37	8.63	1.15	1.91	1.70	30.65	1.22
Mag1-15	44µm	0.013	0.674	0.270	2.406	0.026	0.274	0.047	0.083	143.74	37.23	63.18	163.76	31.56	56.64	10.19	1.95	1.05	6.25	2.65	2.54	8.37	1.15	2.12	1.84	31.18	1.20
Mag1-16	44µm	0.013	0.677	0.271	2.364	0.025	0.292	0.048	0.083	145.17	40.33	62.72	161.61	33.18	58.18	10.81	1.81	1.11	6.37	1.66	1.22	8.14	1.15	1.99	2.45	29.97	1.23
Mag2-1	60µm	0.013	0.678	0.281	2.377	0.026	0.246	0.049	0.081	147.80	38.11	63.02	165.66	35.34	60.62	10.65	1.70	1.20	5.97	1.65	1.29	7.92	1.22	2.11	1.80	33.95	1.35
Mag2-2	60µm	0.013	0.700	0.284	2.327	0.026	0.272	0.049	0.084	150.86	41.20	63.11	161.54	33.37	63.40	10.84	1.95	1.23	6.27	1.39	1.38	8.65	1.29	1.97	2.12	34.02	1.26
Mag2-3	60µm	0.013	0.693	0.291	2.414	0.027	0.249	0.048	0.081	151.36	35.99	63.80	166.02	33.50	59.47	10.74	1.55	1.16	6.17	1.55	1.70	9.00	1.17	2.09	1.80	33.55	1.45
Mag2-4	60µm	0.013	0.696	0.287	2.399	0.026	0.247	0.050	0.081	146.26	36.88	62.09	164.01	33.97	61.81	10.57	1.87	1.12	5.80	1.94	1.26	8.51	1.25	1.97	1.71	33.37	1.17
Mag2-5	60µm	0.013	0.697	0.283	2.362	0.026	0.274	0.049	0.085	150.39	40.61	62.22	163.20	34.82	59.41	10.58	1.76	1.09	6.41	2.18	1.26	9.03	1.40	2.16	1.83	32.34	1.25
Mag2-6	60µm	0.013	0.676	0.285	2.409	0.027	0.217	0.048	0.080	148.83	40.81	63.68	164.34	35.11	63.42	10.79	1.82	1.09	6.18	1.63	1.06	8.85	1.16	1.96	2.14	32.40	1.08
Mag2-7	60µm	0.014	0.687	0.279	2.374	0.027	0.271	0.048	0.085	148.09	39.14	64.69	169.51	35.69	63.86	11.11	1.86	1.18	6.55	1.89	1.17	8.79	1.32	2.38	1.95	32.75	1.31
Mag2-8	60µm	0.013	0.688	0.292	2.422	0.026	0.254	0.049	0.081	147.34	36.18	64.49	166.83	35.74	61.60	11.12	1.76	1.10	6.75	1.82	1.50	8.79	1.16	2.00	2.04	31.02	1.33
Mag2-9	60µm	0.014	0.698	0.292	2.451	0.026	0.251	0.050	0.080	146.80	40.65	63.96	166.96	36.20	62.01	11.14	1.88	1.07	6.88	1.84	1.44	8.03	1.27	2.02	1.96	30.33	1.28
Mag2-10	60µm	0.013	0.683	0.292	2.366	0.025	0.248	0.049	0.081	148.61	39.75	63.37	164.08	33.41	62.20	10.25	1.51	1.07	6.18	1.59	1.30	8.75	1.24	2.00	1.84	31.56	1.33
Mag2-11	60µm	0.013	0.678	0.294	2.388	0.026	0.260	0.049	0.081	147.02	41.92	62.68	164.71	35.75	61.39	10.81	1.69	1.14	6.37	1.54	1.30	8.63	1.25	2.00	2.14	30.94	1.22

<b>Mag2-12</b>	<b>60µm</b>	0.014	0.712	0.298	2.321	0.027	0.426	0.050	0.098	149.07	39.89	63.88	158.83	33.00	65.84	10.74	1.81	1.16	7.48	1.95	1.20	10.38	1.68	2.51	1.90	32.97	1.46
<b>Mag2-13</b>	<b>60µm</b>	0.014	0.699	0.299	2.373	0.028	0.296	0.050	0.083	147.24	37.23	61.84	162.32	34.83	60.75	10.91	1.50	1.22	7.23	1.78	1.18	8.92	1.38	2.26	1.96	31.94	1.27
<b>Mag2-14</b>	<b>60µm</b>	0.014	0.673	0.304	2.335	0.026	0.228	0.050	0.077	148.00	37.65	62.40	157.62	33.57	60.33	10.33	1.62	1.17	6.57	1.74	1.24	8.85	1.36	2.02	1.91	31.87	1.25
<b>Mag2-15</b>	<b>60µm</b>	0.014	0.695	0.304	2.421	0.026	0.247	0.050	0.081	149.17	38.41	64.34	161.98	36.29	62.42	10.98	1.87	1.17	6.60	1.78	1.18	8.73	1.49	2.13	1.83	31.94	1.23
<b>Mag2-16</b>	<b>60µm</b>	0.014	0.688	0.308	2.463	0.026	0.241	0.051	0.078	149.10	38.42	63.71	167.72	34.08	64.58	10.92	1.84	1.13	6.46	2.24	1.27	8.94	1.36	2.24	2.19	31.58	1.25

**Table S5.** Full ICP-MS and ICP-OES results of MtTR-1

Analysis no.	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	V	Cr	Co	Ni	Cu	Zn	Ga	Rb	Sr	Zr	Mo	Ba	La	Ce	W	Bi
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>	µg g <sup>-1</sup>
1	0.004	0.70	0.26	0.006	0.18	0.051	0.169	134	64.2	46.9	133	32.1	100	11.0	1.50	5.96	1.95	0.96	8.8	1.34	2.48	1.97	23.9
2	0.004	0.68	0.24	0.004	0.17	0.047	0.168	146	51.8	49.8	141	34.1	103	11.8	1.74	6.2	4.03	1.03	9.45	1.41	2.68	1.92	25.3
3	0.003	0.68	0.25	0.006	0.17	0.047	0.168	135	46.9	48.7	133	33.3	102	11.4	1.18	5.93	2.03	0.68	9.23	1.19	2.12	1.76	24.7
4	0.017	0.69	0.24	0.012	0.16	0.046	0.169	137	44.3	47.9	132	33.5	103	11.1	1.16	5.75	1.97	0.80	8.62	1.22	2.12	1.97	24.3
5	0.002	0.68	0.29	0.005	0.14	0.045	0.167	145	44.9	50.0	138	34	107	11.5	1.26	6.14	2.07	0.92	9.17	1.31	2.57	1.86	25.2
6	0.002	0.69	0.24	0.004	0.14	0.046	0.167	135	45.2	45.5	127	31.4	97	11.2	1.13	6.24	2.55	1.06	9.19	1.18	2.15	7.28	23.8
7	0.016	0.68	0.25	0.009	0.15	0.048	0.167	143	43.1	45.8	126	31.5	100	10.9	1.11	5.74	2.26	1.39	8.62	1.34	2.66	1.88	24.2
8	0.152	0.68	0.24	0.005	0.20	0.052	0.168	136	44.4	47.2	132	32.4	101	11.1	1.14	6.13	2.36	0.76	8.86	1.22	2.46	1.90	24.3
9	0.003	0.67	0.19	0.006	0.16	0.046	0.165	136	42.5	45.6	125	30.8	102	10.9	1.13	5.64	2.00	0.77	8.52	1.24	2.55	2.14	23.6
10	0.003	0.67	0.26	0.002	0.17	0.045	0.165	138	45.9	48.1	133	33	100	11.0	1.10	6.03	2.10	0.64	9.25	1.24	2.11	1.75	24.7

Notes: Major oxides are determined by ICP-OES, whereas other elements are determined by ICP-MS.