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Mid-Jurassic volcanism at Bokhara River and insights into metasomatism in the lithospheric mantle of the Thomson Orogen, eastern Australia

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Supplemental data

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*Full data in excel workbooks at https://zenodo.org/records/10450582

Table S1. EPMA analytical conditions.

Elements	Channel	Analysing crystal	Peak position (mm)	Lower background position (mm)	Upper background position (mm)	Acquisition time peak (s)	Acquisition time background (s)
Si	1	TAP	77.796	2.500	2.500	20	10
Al	1	TAP	90.931	4.000	4.000	20	10
K	2	PETL	119.914	5.000	5.000	10	5
Ca	2	PETL	107.670	3.000	3.000	15	7
Ti	2	PETL	88.192	2.000	2.000	15	7
P	3	PETL	197.076	5.000	5.000	10	5
Ni	4	LIFL	115.461	3.000	3.000	15	7
Fe	4	LIFL	134.761	3.000	3.000	10	5
Mn	4	LIFL	146.274	5.000	5.000	15	7
Cr	4	LIFL	159.304	5.000	5.000	15	7
Na	5	TAPH	129.407	3.000	3.000	10	5

Table S2. Major element (oxide wt%) and trace element (ppm) results for the magmatic component of the diatreme. Mg# assumes 0.9 FeO in FeO_t. Depth is distance of sample below surface. Due to the downhole major element chemical consistency an average composition is given, and for the same reason only three samples were analysed for trace elements. "Melt" is an estimated melt composition of the magmatic component with 12.8 wt% olivine removed to give a melt composition is in equilibrium with olivine Fo_{90} assuming a $K_{D,Fe-Mg}^{ol/melt}$ of 0.30.

Sample	1201	1202	1203	1204	1205	1206	1207	1208	1209	Avg.	Melt
Depth (m)	315.8	316.2	322.7	324.5	326.9	392.4	345.7	307.9	311.6	–	–
SiO_2	42.56	42.3	42.45	42.05	42.43	42.04	42.06	42.38	41.65	42.21	44.10
TiO_2	2.06	1.93	2.00	2.06	1.97	2.06	2.05	1.98	2.08	2.02	2.37
Al_2O_3	11.77	11.23	11.57	11.38	11.53	11.59	11.68	11.59	11.66	11.56	13.54
FeO_t	10.72	10.56	10.63	10.63	10.3	10.51	10.54	10.33	10.41	10.51	11.06
MnO	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.17	0.17	0.17	0.18
MgO	15.61	16.67	16.37	16.53	16.45	16.12	15.39	16.34	15.6	16.12	12.29
CaO	9.71	9.51	9.44	9.42	9.35	9.55	9.63	9.36	9.64	9.51	11.14
Na_2O	3.11	2.57	2.94	2.87	2.83	3.03	3.06	2.96	2.78	2.91	3.39
K_2O	1.00	1.00	1.01	0.86	1.07	1.05	1.11	0.93	0.80	0.98	1.02
P_2O_5	0.78	0.74	0.74	0.76	0.76	0.79	0.78	0.78	0.78	0.77	0.90
LOI	2.01	2.75	1.99	2.43	2.15	1.47	1.99	2.08	2.77	2.18	–
Total	99.5	99.43	99.3	99.15	99.02	98.39	98.45	98.88	98.34	98.94	99.99
Mg#	76.21	77.65	77.22	77.38	77.85	77.15	76.28	77.68	76.74	77.13	71.00
Li						5.1	5.2		5.3		
Be						2.3	2.2		2.2		
Sc						25.6	27.6		27.8		
Ti						6719	6881		13029		
V						200	206		208		
Cr						491	479		474		
Mn						1311	1358		1330		
Co						59	59		58		
Ni						565	511		525		
Cu						62.1	71.3		68.5		
Zn						83	80		91		
Ga						15.5	15.9		15.8		
Rb						26.9	28.8		14.8		
Sr						881	889		805		
Y						21	24		22		
Zr						110	100		196		
Nb						28	33		65		
Cd						0.08	0.09		0.10		
Cs						0.6	0.6		0.6		
Ba						423	460		469		
La						46	46		46		
Ce						89	88		90		
Pr						10	10		10		
Nd						38	37		37		
Sm						6.68	6.66		6.71		
Eu						2.13	2.14		2.13		
Gd						0.79	0.81		0.79		
Tb						5.59	5.66		5.55		
Gd						3.90	4.18		3.90		
Dy						0.72	0.80		0.72		
Ho						1.88	2.12		1.88		
Er						1.45	1.69		1.46		
Tm						0.20	0.24		0.20		
Yb						1.63	1.44		3.52		
Lu						0.98	1.04		3.19		
Hf						2.24	3.90		1.74		
Ta						2.75	3.18		3.13		
W						6.07	5.92		5.96		
Pb						1.62	1.58		1.57		
Th						5.1	5.2		5.3		
U						2.3	2.2		2.2		

Table S3. Major element (wt% oxide) and trace element (ppm) results for the spinel lherzolite xenoliths. Mg# assumes 0.8 FeO in FeO_t. Depth is distance below surface. *P–T* for each sample is calculated using (BKN90; Brey *et al.,* 1990) for pressure and (Köhler & Brey, 1990) for temperature. An additional xenolith without whole-rock data (1208X1) has a *P* of 1.6 GPa and *T* of 1153 °C.

Sample	1202X1	1204X1	1206X1	1206X2	1207X1
Depth (m)	316.1	324.4	392.2	392.4	345.7
SiO_2	43.73	45.70	44.28	42.34	44.28
TiO_2	0.15	0.14	0.08	0.14	0.08
Al_2O_3	3.11	3.44	3.00	3.83	2.87
FeO_t	9.61	8.39	9.48	11.48	9.74
MnO	0.13	0.13	0.13	0.15	0.14
MgO	37.80	33.62	38.11	37.28	39.10
CaO	3.37	5.90	2.99	2.64	2.78
Na_2O	0.01	0.06	0.01	0.04	0.16
K_2O	0.25	0.25	0.18	0.42	1.33
P_2O_5	0.00	0.01	0.00	0.01	0.02
Total	100.48	100.79	100.92	100.52	101.78
Mg#	89.76	89.93	89.96	87.86	89.95
P (GPa; KB90)	1.2	1.6	2.0	1.6	1.8
T (°C; BKN90)	1155	1119	1098	1166	1139
Li		3.9	2.4	2.4	3.0
Be	< 0.0	< 0.0	< 0.0	0.1	< 0.0
Sc	16.2	22.0	15.3	17.9	14.6
Ti	921	1050	752	1136	776
V	72	95	70	87	72
Cr	1518	2178	1603	3436	1653
Mn	996	936	990	1122	990
Co	97	78	96	104	99
Ni	1928	1539	1953	1766	2050
Cu	29.6	37.2	30.0	4.3	32.0
Zn	48	43	43	63	48
Ga	3.6	3.8	3.3	6.0	3.3
Rb	0.7	1.8	0.9	0.9	1.7
Sr	8	12	3	19	13
Y	3.5	4.1	2.9	2.0	2.7
Zr	5.1	5.1	3.0	6.8	3.4
Nb	0.3	1.4	0.6	0.6	0.9
Cd	0.03	0.03	0.02	0.03	0.03
Cs	< 0.0	< 0.0	< 0.0	< 0.0	< 0.0
Ba	1.7	5.0	0.8	2.1	18.0
La	0.2	0.9	0.3	0.6	0.5
Ce	0.4	1.8	0.7	1.6	1.0
Pr	0.1	0.2	0.1	0.2	0.1
Nd	0.4	1.0	0.4	1.1	0.5
Sm	0.18	0.31	0.15	0.32	0.15
Eu	0.08	0.11	0.06	0.11	0.06
Gd	0.28	0.41	0.23	0.32	0.22
Tb	0.06	0.08	0.05	0.05	0.04
Gd	0.32	0.44	0.26	0.33	0.24
Dy	0.44	0.56	0.36	0.30	0.32
Ho	0.10	0.13	0.08	0.06	0.07
Er	0.30	0.37	0.25	0.17	0.22
Tm	0.17	0.21	0.15	0.09	0.13
Yb	0.29	0.36	0.26	0.17	0.24
Lu	0.04	0.05	0.04	0.02	0.04
Hf	0.14	0.13	0.07	0.16	0.08
Ta	0.03	0.18	0.06	0.06	0.09
W	1.63	3.19	1.81	4.55	3.08
Pb	0.16	0.18	0.09	0.10	0.37
Th	0.02	0.11	0.04	0.05	0.06
U	0.02	0.03	0.01	0.01	0.02

Table S4. Average olivine composition for each spinel lherzolite. 1σ errors are propagated errors from each individual analysis. *n* is the number of analyses of individual grains.

Sample	1202x1	1σ	1204x1	1σ	1206x1	1σ	1206x2	1σ	1207x1	1σ	1208x1	1σ
n	15		15		15		15		15		15	
SiO_2	39.82	0.24	40.41	0.24	39.54	0.24	39.95	0.24	40.38	0.24	40.32	0.24
TiO_2	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02
Al_2O_3	0.03	0.05	0.03	0.05	0.02	0.05	0.03	0.05	0.03	0.05	0.02	0.05
Cr_2O_3	0.01	0.05	0.03	0.05	0.02	0.05	0.02	0.05	0.03	0.05	0.02	0.05
FeO_t	10.48	0.14	10.27	0.14	10.17	0.14	11.70	0.15	10.10	0.14	10.30	0.14
MnO	0.14	0.02	0.14	0.02	0.13	0.02	0.16	0.02	0.14	0.02	0.13	0.02
MgO	48.48	0.20	48.49	0.20	48.42	0.20	47.45	0.20	48.57	0.20	48.65	0.20
CaO	0.10	0.01	0.11	0.01	0.12	0.01	0.11	0.01	0.11	0.01	0.08	0.01
Na_2O	0.02	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04
K_2O	< 0.00	0.02	0.01	0.02	< 0.00	0.02	< 0.00	0.02	< 0.00	0.02	< 0.00	0.02
P_2O_5	0.02	0.08	0.01	0.07	0.01	0.08	0.01	0.08	0.01	0.07	0.01	0.07
NiO	0.37	0.03	0.35	0.03	0.37	0.03	0.34	0.03	0.35	0.03	0.38	0.03
Total	99.88	0.90	99.89	0.89	99.86	0.89	99.92	0.90	99.89	0.89	99.92	0.90
Mg#	89.05	0.52	89.24	0.52	89.34	0.52	87.70	0.52	89.42	0.52	89.26	0.52

Table S5. Average orthopyroxene composition for each spinel lherzolite. 1σ errors are propagated errors from each individual analysis. *n* is the number of analyses of individual grains.

Sample	1202x1	1σ	1204x1	1σ	1206x1	1σ	1206x2	1σ	1207x1	1σ	1208x1	1σ
n	20		20		20		20		20		20	
SiO_2	53.64	0.24	54.31	0.24	53.82	0.24	53.37	0.24	54.14	0.24	54.35	0.24
TiO_2	0.13	0.02	0.10	0.02	0.09	0.02	0.18	0.02	0.10	0.02	0.10	0.02
Al_2O_3	5.46	0.15	5.32	0.14	5.39	1.00	5.36	0.14	5.66	0.15	5.28	0.14
Cr_2O_3	0.42	0.07	0.60	0.08	0.48	0.01	0.56	0.07	0.54	0.07	0.41	0.07
FeO_t	6.51	0.10	6.47	0.09	6.35	0.09	7.57	0.10	6.31	0.09	6.44	0.09
MnO	0.14	0.02	0.14	0.02	0.15	0.02	0.16	0.02	0.14	0.02	0.15	0.02
MgO	32.78	0.14	32.62	0.14	32.90	0.14	31.21	0.14	32.53	0.14	32.17	0.14
CaO	0.97	0.02	1.18	0.02	1.05	0.02	1.19	0.02	1.19	0.02	0.91	0.02
Na_2O	0.14	0.04	0.06	0.04	0.12	0.04	0.09	0.04	0.11	0.04	0.11	0.04
K_2O	0.01	0.01	< 0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.03	< 0.00	0.01
P_2O_5	0.01	0.06	0.01	0.07	0.10	1.39	0.01	0.10	0.01	0.06	0.01	0.05
NiO	0.10	0.02	0.10	0.023	0.01	0.003	0.10	0.026	0.11	0.023	0.11	0.022
Total	100.30	0.88	100.91	0.90	100.45	2.99	99.78	0.94	100.84	0.90	100.04	0.87
Mg#	89.98	0.55	89.99	0.55	90.23	0.55	88.03	0.55	90.19	0.55	89.90	0.55
Wo	1.88	0.03	2.28	0.04	2.03	0.04	2.34	0.04	2.31	0.04	1.79	0.03
En	88.10	0.53	87.74	0.53	88.20	0.54	85.74	0.53	87.91	0.53	88.09	0.54
Fs	10.02	0.15	9.98	0.15	9.77	0.14	11.91	0.16	9.78	0.15	10.12	0.15

Table S6. Average clinopyroxene composition for each spinel lherzolite. 1σ errors are propagated errors from each individual analysis. *n* is the number of analyses of individual grains.

Sample	1202x1	1σ	1204x1	1σ	1206x1	1σ	1206x2	1σ	1207x1	1σ	1208x1	1σ
n	20		20		20		20		20		20	
SiO_2	51.17	0.23	51.60	0.23	51.28	0.23	50.75	0.23	51.61	0.23	51.83	0.23
TiO_2	0.41	0.03	0.27	0.02	0.30	0.02	0.44	0.02	0.30	0.02	0.36	0.02
Al_2O_3	6.84	0.16	5.82	0.14	6.40	0.90	6.28	0.15	6.60	0.15	6.62	0.15
Cr_2O_3	0.70	0.08	0.86	0.09	0.77	0.01	0.86	0.09	0.83	0.09	0.72	0.08
FeO_t	3.36	0.07	3.47	0.07	3.18	0.07	4.41	0.08	3.38	0.07	3.09	0.07
MnO	0.11	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.09	0.02
MgO	17.00	0.10	17.08	0.11	16.57	0.10	16.33	0.11	16.84	0.10	15.78	0.10
CaO	18.27	0.11	20.04	0.07	19.56	0.07	19.22	0.07	19.18	0.07	19.48	0.07
Na_2O	1.39	0.13	0.68	0.07	1.18	0.08	0.86	0.07	1.09	0.08	1.36	0.09
K_2O	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.02
P_2O_5	0.02	0.29	0.01	0.07	0.06	0.23	0.00	0.09	0.02	0.13	0.01	0.10
NiO	0.00	0.03	0.00	0.02	0.00	0.01	0.05	0.02	0.00	0.03	0.00	0.02
Total	99.34	1.27	100.00	0.93	99.43	1.77	99.12	0.96	100.01	1.02	99.39	0.97
Mg#	89.96	0.75	89.87	0.78	90.55	0.81	86.87	0.79	89.91	0.79	90.15	0.81
Wo	41.27	0.30	43.01	0.22	43.30	0.22	40.37	0.21	42.31	0.22	44.36	0.23
En	52.69	0.38	51.01	0.37	51.03	0.37	51.67	0.38	51.69	0.37	49.99	0.36
Fs	6.04	0.13	5.99	0.13	5.66	0.13	7.96	0.15	6.00	0.13	5.65	0.13

Table S7. Average spinel composition for each spinel lherzolite. 1σ errors are propagated errors from each individual analysis. *n* is the number of analyses of individual grains.

Sample	1202x1	1σ	1204x1	1σ	1206x1	1σ	1206x2	1σ	1207x1	1σ	1208x1	1σ
n	15		15		14		15		15		15	
SiO_2	0.08	0.04	0.10	0.04	0.08	0.04	0.10	0.04	0.10	0.03	0.06	0.04
TiO_2	0.16	0.02	0.22	0.02	0.14	0.02	0.51	0.03	0.16	0.02	0.14	0.02
Al_2O_3	57.39	0.50	51.43	0.47	55.99	0.51	48.79	0.46	54.52	0.48	57.29	0.50
Cr_2O_3	9.58	0.28	15.24	0.35	11.25	0.31	15.19	0.34	12.08	0.31	10.25	0.29
FeO_t	10.63	0.13	12.09	0.14	10.66	0.14	16.06	0.16	11.07	0.14	10.70	0.13
MnO	0.11	0.02	0.12	0.02	0.11	0.02	0.14	0.02	0.11	0.02	0.12	0.02
MgO	20.58	0.13	19.22	0.12	20.16	0.13	17.84	0.12	20.13	0.13	20.63	0.13
CaO	0.01	0.07	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.25
Na_2O	0.01	0.07	0.01	0.21	0.01	0.07	< 0.00	0.08	0.01	0.06	0.01	0.82
K_2O	< 0.00	0.09	< 0.00	0.02	0.01	0.06	< 0.00	0.03	< 0.00	0.01	< 0.00	0.01
P_2O_5	0.01	0.06	0.01	0.07	0.01	0.10	0.01	0.15	0.01	0.08	0.01	0.07
NiO	0.38	0.03	0.32	0.03	0.36	0.03	0.33	0.03	0.35	0.03	0.36	0.03
Total	98.40	1.45	98.40	1.52	98.43	1.45	98.40	1.49	98.40	1.33	98.40	2.31
Mg#	79.41	0.52	76.10	0.68	78.50	0.68	70.73	0.68	78.77	0.68	79.36	0.68
Cr#	10.05	0.13	16.55	0.13	11.86	0.13	17.25	0.13	12.92	0.16	10.69	0.13

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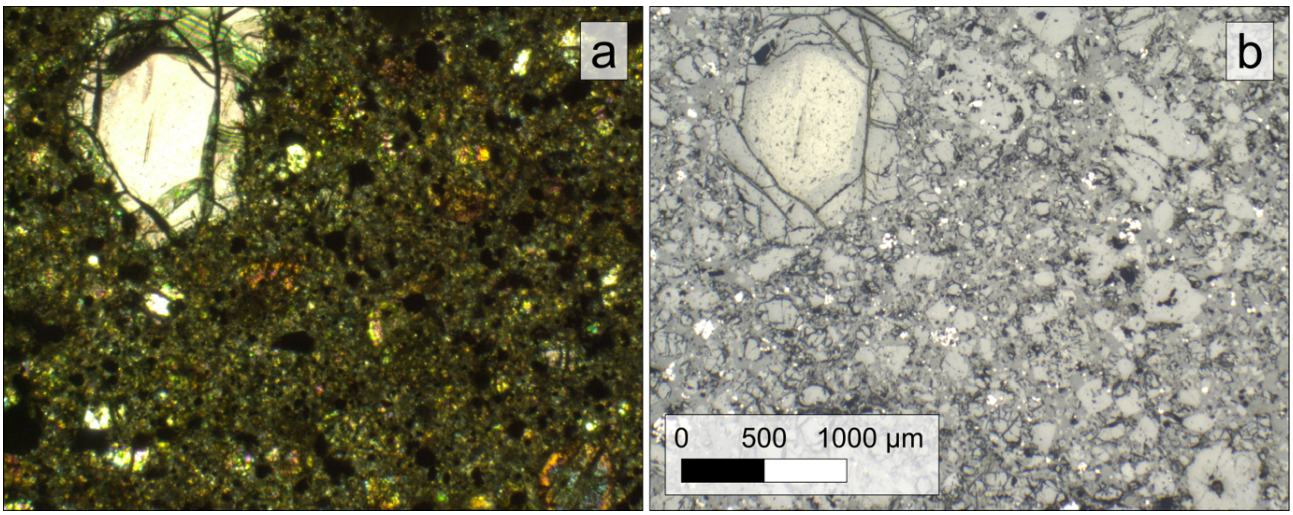

Figure S1. Photomicrographs in (a) cross-polarised and (b) reflected light. This shows the anhedral disaggregated mantle xenocryst cargo, spinel and olivine phenocrysts, along with the fine-grained quench in the groundmass.

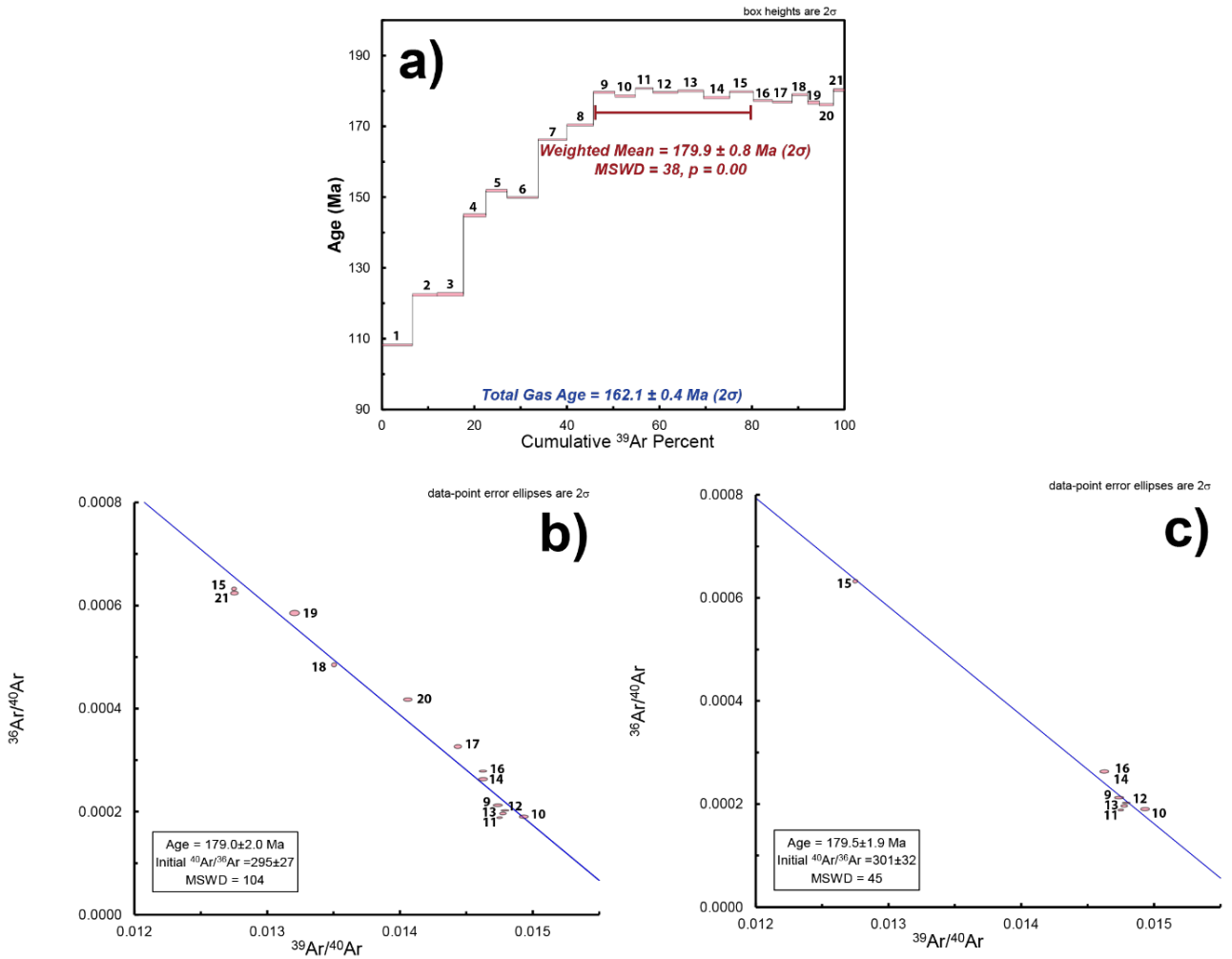

Figure S2. (a) $^{40}Ar/^{39}Ar$ step heating spectra for sample 1201 showing the steps selected for the weighted-mean age and annotated with step numbers; (b) inverse isochron plots calculated from steps 9 to 21, i.e., the flattest part of the spectrum; and (c) inverse isochron plot calculated from the 7 steps included in weighted mean calculation shown in (a). Note all ages overlap within uncertainty. The age spectra and inverse isochrons were generated using ISOPLOT (Ludwig, 2003).