Geochemical Behaviors of Chemical Elements during Subduction-Zone Metamorphism and Geodynamic Significance: A Review

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Table A.3 Compiled bulk-rock compositional data for global HP-UHP metamorphic rocks

Protolith	N-MORB												
Locality	Raspas Complex, SW Ecuador, Andes (John et al., 2010)								New Caledonia (Spandler et al., 2004)		Cabo Ortegal, Spain (Halama et al., 2010)		
Sample	SEC 42-6*	SEC 43-1	SEC 43-3	SEC 44-1	SEC 46-1	SEC 46-2	SEC 47-1	SEC 50-1	803	805	SCO 1-1	SCO 9-2	SCO 12-4
Grade	Ec	Ec	Ec	Ec	Ec	Ec	Ec	Ec	Ec	Ec	Ec	Ec	Ec
major elements in wt. %													
SiO ₂	45.61	47.92	50.17	48.67	44.08	44.88	47.49	49.57	50.36	50	48.72	48.42	49.62
TiO ₂	2.26	1.79	1.86	1.91	1.87	2	1.94	1.88	1.9	1.88	1.24	1.19	1.5
Al ₂ O ₃	14.54	14.67	13.89	14.84	14.71	13.49	15.07	13.62	13.59	13.48	15.73	15.22	14.27
TFe ₂ O ₃	15.14	13.04	13.3	13.75	15.48	13.77	13.87	13.3	14	14.26	11.61	11.82	12.77
MnO	0.28	0.19	0.23	0.19	0.24	0.21	0.23	0.19	0.21	0.23	0.19	0.2	0.18
MgO	6.16	6.46	6.65	6	10.09	8.72	6.01	6.72	7.13	6.72	8.34	7.84	7.81
CaO	11.84	11.1	10.67	10.84	10.87	13.41	11.15	10.48	9.23	10.13	12.15	12.83	12.2
Na ₂ O	3.26	3.09	3.02	3.02	1.69	2.3	2.77	3.04	3.5	2.89	1.55	2.08	1.97
K ₂ O	0.15	0.53	0.07	0.48	0.16	0.11	0.51	0.07	0.02	0.04	0.04	0.02	0.01
P ₂ O ₅	0.2	0.13	0.17	0.16	0.11	0.74	0.17	0.17	0.14	0.14	0.12	0.08	0.12
LOI	0.27	0.57	0.42	0	0.45	0	0.37	0.81	0.51	0.43	0.39	0.63	0
Total	99.71	99.49	100.45	99.86	99.75	99.63	99.58	99.85	100.75	100.42	100.08	100.33	100.45
trace elements in ppm													
Ba	77.8	98.8	21.2	79.4	6.76	21.1	60.9	121	2.48	19.94	5.86	3.05	2.06
Rb	4.38	15.3	1.06	13.1	0.53	0.42	12.7	0.54	0.09	0.56	1.02	0.04	0.43
Cs	0.144	0.837	0.019	0.777	0.011	0.008	0.632	0.019	0.01	0.03	0.13	0.037	0.019
Th	0.424	0.206	0.208	0.146	0.131	0.17	0.138	0.137	0.18	0.17	0.21	0.074	0.13
Nb	3.64	2.04	2.4	2.03	2.19	4.26	2.09	1.91	2.63	2.63	2.68	0.96	1.78
U	0.328	0.212	0.069	0.184	0.175	0.54	0.194	0.054	0.08	0.06	0.082	0.056	0.041
Ta	0.239	0.126	0.141	0.129	0.14	0.183	0.146	0.142	0.15	0.16	0.16	0.063	0.11
La	5.73	4.09	3.75	3.7	4.08	4.4	3.71	3.72	3.3	3.07	3.34	1.9	2.64
Ce	16.1	11.8	12.7	11.6	13.6	14.1	11.7	12.4	10.23	10	9.33	6.27	8.56
Pr	2.9	2.14	2.28	2.17	2.53	2.46	2.18	2.32	1.92	1.8	1.57	1.19	1.57
Pb	2.97	3.81	1.5	4.06	0.646	0.566	2.9	0.738			0.34	0.71	0.28
Sr	76.7	92.5	77	66.8	31.6	36.8	103	84.9	83.2	89.2	91.4	145	72.9
Nd	15.5	11.5	12.6	11.9	13.9	12.9	12.4	12.7	11	10.46	8.43	6.94	8.91
Zr	131	116	109	110	102	104	109	119	117	117	65.3	57.9	66.2
Hf	3.68	3.01	2.85	2.89	2.86	2.91	3.13	3.25	3.2	3.13	1.79	1.68	1.98
P									609	685			
Sm	5.36	4.03	4.38	4.23	5.11	4.28	4.54	4.62	4.26	4	2.91	2.64	3.38
Ti	13545	10728	11148	11448	11208	11987	11627	11268	10420	10580	7432	7132	8990
Eu	1.82	1.43	1.57	1.57	1.71	1.51	1.57	1.59	1.4	1.36	1.03	1	1.23
Gd	6.94	5.47	5.9	5.7	6.74	5.6	6.12	6.34	6.15	5.64	3.9	3.62	4.55
Tb	1.31	1	1.08	1.07	1.18	1	1.17	1.17	1.14	1.06	0.722	0.689	0.862
Dy	8.84	6.95	7.33	7.35	7.89	6.96	7.92	8.01	7.92	7.43	4.83	4.7	5.87
Y	52.6	43.1	46.1	45.1	49.1	46.4	48	50.5	51.5	46.9	29.9	27.8	35.8
Ho	1.89	1.49	1.58	1.56	1.66	1.55	1.69	1.71	1.73	1.6	1.06	1.03	1.28
Er	5.4	4.26	4.59	4.48	4.74	4.52	4.83	4.89	5.27	4.87	2.97	2.91	3.67
Tm	0.8	0.628	0.688	0.668	0.713	0.679	0.712	0.727	0.75	0.68	0.44	0.439	0.544
Yb	5.36	4.16	4.6	4.49	4.83	4.54	4.8	4.89	5.05	4.83	2.91	2.92	3.61
Lu	0.788	0.6	0.674	0.654	0.723	0.678	0.709	0.73	0.79	0.73	0.432	0.434	0.524
Li	35.2	48.5	13.8	51.4	11	13.3	67.3	20.3	–	–	2.02	2.72	1.56
Be									0.44	0.48			
B									5.44	5.51			
Ba/Nb	21.37	48.43	8.83	39.11	3.09	4.95	29.14	63.35	0.94	7.58	2.19	3.18	1.16
U/Nb	0.09	0.10	0.03	0.09	0.08	0.13	0.09	0.03	0.03	0.02	0.03	0.06	0.02
Rb/Sr	0.06	0.17	0.01	0.20	0.02	0.01	0.12	0.01	0.00	0.01	0.01	0.00	0.01
Sm/Nd	0.35	0.35	0.35	0.36	0.37	0.33	0.37	0.36	0.39	0.38	0.35	0.38	0.38
Lu/Hf	0.21	0.20	0.24	0.23	0.25	0.23	0.23	0.22	0.25	0.23	0.24	0.26	0.26

Amp: Amphibolite; Bs: blueschist; Ca: carbonate; Ec: eclogite; Ep: epidosite; Ep: epidosite; G: greenschist; Grt: garnet; Omp: omphacite; Retro.: retrograde.

* Rock sample names and relevant data in bold represent those highly eclogitized rocks with less retrograde metamorphic overprints based on petrological descriptions in literatures, and plotted in Fig. 10.

† Total Fe is expressed as FeO.

Table A.3 Continued

Protolith	N-MORB												
Locality	Cabo Ortegal, Spain (Halama et al., 2010)				Western Tianshan (Ai et al., 2006)			Western Tianshan (Gao and Klemd, 2003)			Western Tianshan (Xiao et al., 2012)		
Sample	SCO 15-1	SCO 16-1	SCO 18-1	SCO 23-1	1082	1083	1085	GC4-1	CG5-1	CG8-2/2	117-1	TS02-16	TS02-17b
Grade	Ec	Ec	Ec	Ec	Bs	Bs	Bs	Ec	Ep	Ec	Ca Ec	Bs	Ec
major elements in wt.%													
SiO ₂	49.75	49.22	50.21	48.45	48.04	46.39	50.35	47.38	39.23	48.11	48.13	47.49	52.98
TiO ₂	1.19	1.26	2.44	1.15	1.36	1.31	1.42	1.13	1.19	1.38	0.8	2.27	1.58
Al ₂ O ₃	14.74	15.04	12.72	15.97	14.1	14.23	13.39	14.32	15.93	13.66	10.78	11.24	11.71
TFe ₂ O ₃	12.87	12.94	16.94	11.27	15.08	14.9	13.34	13.71	14.38	14.17	11.76	22.62	15.34
MnO	0.21	0.21	0.22	0.18	0.34	0.29	0.23	0.31	0.21	0.21	0.14	0.31	0.2
MgO	8.58	8.25	7.29	8.04	6.32	5.58	6.69	6.40	3.91	6.75	5.99	4.84	4.93
CaO	12.13	11.96	8.24	13.31	10.56	10.36	10.94	13.95	17.81	9.87	14.8	9.82	9.65
Na ₂ O	1.68	1.97	2.39	2.02	1.78	2.84	2.87	2.08	1.37	2.09	3.38	1.7	3.06
K ₂ O	0.02	0.06	0.09	0.04	0.27	0.09	0.08	0.08	0.02	0.19	0.06	0.07	0.06
P ₂ O ₅	0.09	0.08	0.21	0.09	0.09	0.11	0.11	0.01	0.04	0.10	0.07	0.16	0.12
LOI	0	0	0	0.41	1.78	3.5	0.71	0.44	5.82	3.08	4.13	0.23	0.69
Total	101.26	100.99	100.75	100.93	99.72	99.6	100.13	99.80	99.91	99.61	100.04	100.75	100.32
trace elements in ppm													
Ba	3.45	5.11	5.47	4.93	90.13	24.4	17.85	31	38	57	5.10	8.80	1.60
Rb	0.48	1.3	n.d.	0.59	8.15	2.28	1.44	5	< 5	< 5	0.60	1.10	0.30
Cs	0.015	0.023	0.034	0.043							0.10	0.30	0.00
Th	0.074	0.075	0.22	0.1	0.14	0.14	0.16	5	<5	<5	0.06	0.13	0.10
Nb	0.81	0.96	3.7	1.48	1.25	1.25	1.35	< 5	< 5	< 5	0.49	1.17	0.91
U	0.053	0.023	0.48	0.058	0.07	0.05	0.05	5	< 5	< 5	0.02	0.04	0.03
Ta	0.05	0.06	0.25	0.088	0.09	0.09	0.09				0.03	0.09	0.07
La	1.5	2.04	4.99	2.16	1.97	2.07	2.57	3.03	4.66	2.71	1.16	2.19	2.13
Ce	5.34	6.25	15.8	7.07	6.61	6.86	8.39	7.18	10.29	10.13	4.04	8.17	8.18
Pr	1.05	1.3	2.75	1.3	1.19	1.23	1.49		1.23	1.25	0.80	1.63	1.64
Pb	0.56	0.67	0.37	0.7	4.67	3.79	1.46	5	6	< 5	1.40	0.80	0.30
Sr	60.7	70.1	65.5	132	133.84	143.84	93.1	172	685	116	87.00	60.60	36.80
Nd	6.25	7.51	15.2	7.37	7.19	7.25	8.57	7.56	7.55	7.78	4.62	9.46	9.47
Zr	46.8	49.8	153	46.1	78.65	74.44	79.97	55	77	72	42.40	102.90	86.50
Hf	1.48	1.56	4.01	1.4	2.13	2.01	2.1				1.25	2.74	2.33
P											305.63	698.59	523.94
Sm	2.46	2.83	5.32	2.79	2.89	2.81	3.22	2.99	2.75	4.29	1.96	4.15	3.78
Ti	7132	7552	14624	6893	8151	7851	8511	6773	7132	8271	4800	13620	9480
Eu	0.887	1.03	1.87	1.07	1.05	1.01	1.15	1.48	0.96	1.08	0.89	1.58	1.34
Gd	3.41	3.93	7.2	3.82	4.06	3.92	4.04		2.79	5.69	2.81	5.98	4.9
Tb	0.676	0.77	1.35	0.732	0.91	0.9	0.83	0.81	0.51	0.97	0.59	1.23	0.95
Dy	4.82	5.43	9.05	4.88	6.11	5.91	5.4		3.35	6.49	4.23	8.53	6.55
Y	29.3	34.3	53.4	28.7	42.67	41.42	36.14	34	28	38	26.41	57.61	43.89
Ho	1.06	1.19	1.93	1.02	1.46	1.42	1.23		0.68	1.45	0.92	1.83	1.41
Er	3.06	3.42	5.41	2.92	3.99	3.89	3.43		1.75	4.14	2.58	5.05	3.89
Tm	0.452	0.502	0.812	0.427	0.65	0.63	0.55		0.22	0.57	0.42	0.81	0.62
Yb	3.01	3.31	5.43	2.85	4.35	4.14	3.6	2.62	1.39	3.90	3.01	5.57	4.25
Lu	0.449	0.497	0.801	0.423	0.72	0.67	0.57	0.41	0.22	0.60	0.5	0.89	0.68
Li	2.62	3.15	3.68	1.88									
Be													
B													
Ba/Nb	4.26	5.32	1.48	3.33	72.10	19.52	13.22	n.d.	n.d.	n.d.	10.41	7.52	1.76
U/Nb	0.07	0.02	0.13	0.04	0.06	0.04	0.04	n.d.	n.d.	n.d.	0.04	0.03	0.03
Rb/Sr	0.01	0.02	n.d.	0.00	0.06	0.02	0.02	0.03	n.d.	n.d.	0.01	0.02	0.01
Sm/Nd	0.39	0.38	0.35	0.38	0.40	0.39	0.38	0.40	0.36	0.55	0.42	0.44	0.40
Lu/Hf	0.30	0.32	0.20	0.30	0.34	0.33	0.27	n.d.	n.d.	n.d.	0.40	0.32	0.29

Table A.3 Continued

Protolith	N-MORB			E-MORB									
Locality	Western Tianshan (Xiao et al., 2012)			New Caledonia (Spandler et al., 2004)					Western Tianshan (Gao and Klemf, 2003)				
Sample	TS02-20	TS02-32A	TS02-33	1001	703	704	705	3106	9754-9	9756-1	CG4-4	CG5-3	8-27-2
Grade	Ec	Ec	Ec	Grt Amp	Grt Amp	Grt Amp	Ec	Grt Amp	Ec	Omp-bearing Bs	Ep (pillow)	Bs	Omp-bearing Bs
major elements in wt.%													
SiO ₂	46.55	46.44	51.32	50.46	46.07	46.6	48.74	49.31	39.37	51.87	45.53	45.13	51.69
TiO ₂	1.56	1.71	1.34	1.46	1.33	1.5	1.66	1.6	1.66	1.61	2.37	1.58	1.44
Al ₂ O ₃	14.07	13.6	12.68	14.15	14.9	15.12	14.45	14.54	14.12	15.30	17.41	14.49	14.12
TFe ₂ O ₃	18.15	16.68	14.1	12	12.51	12.54	12.56	12.32	12.56	9.78	17.17	11.96	11.84
MnO	0.3	0.26	0.22	0.2	0.22	0.2	0.2	0.18	0.21	0.08	0.33	0.17	0.15
MgO	6.02	6.62	5.62	6.81	9.16	7.5	7.31	8.47	6.37	7.60	3.50	6.80	6.42
CaO	10.87	11.33	10.1	10.55	12.46	12.95	10.92	11.13	15.26	6.15	6.38	12.67	7.78
Na ₂ O	2.19	2.6	2.95	2.44	2.17	2.5	2.71	2.16	2.41	4.59	2.97	1.46	4.05
K ₂ O	0.2	0.08	0.27	0.11	0.12	0.11	0.19	0.16	0.76	0.60	2.42	0.49	0.71
P ₂ O ₅	0.13	0.1	0.11	0.16	0.22	0.18	0.14	0.15	0.18	0.12	0.20	0.18	0.18
LOI	0.34	0.19	0.39	1.44	1.21	0.75	1.02	1.23	6.85	2.14	1.33	4.74	1.04
Total	100.4	99.6	99.09	99.78	100.37	99.95	99.9	101.26	99.75	99.84	99.67	99.67	99.51
trace elements in ppm													
Ba	51.40	10.80	76.20	8.82	8.09	6.12	30.2	28.9	253	195	261	149	187
Rb	11.60	0.40	5.00	1.56	0.91	0.7	2.57	1.4	19	11	66	13	10
Cs	0.70	0.10	0.20	0.02	0.03	0.01	0.05	0.01					
Th	0.10	0.08	0.11	0.36	0.33	0.4	0.42	0.46	< 5	<5	<5	< 5	< 5
Nb	1.09	0.74	0.94	4.78	4.52	4.7	4.93	5.46	11	10	13	10	11
U	0.03	0.03	0.05	0.13	0.19	0.13	0.12	0.14	< 5	< 5	< 5	< 5	< 5
Ta	0.07	0.05	0.07	0.29	0.3	0.29	0.32	0.42					
La	2.08	1.79	2.38	4.29	4.91	5.02	7.07	5.54	11.82	19.05	13.26	11.35	18.61
Ce	7.62	6.23	8.33	11.11	12.72	13.05	16.07	14.44	28.12	33.25	25.67	21.21	36.24
Pr	1.51	1.22	1.62	1.75	1.96	2.01	2.6	2.28	3.79	3.80	3.33	2.63	4.22
Pb	0.80	1.20	0.60						14	10	10	6	< 5
Sr	128.3	125.2	122.7	237	153	202	119	185	260	260	194	342	81
Nd	8.74	7.10	9.29	9.01	10.24	10.4	13.16	11.67	18.09	19.45	17.34	13.07	20.54
Zr	79.30	79.30	84.20	80.4	76.5	97.3	99.7	104.3	132	139	153	128	113
Hf	2.03	2.29	2.30	2.05	2.05	2.44	2.62	2.73					
P	567.61	436.62	480.28	731	960	814	580	883					
Sm	3.60	2.84	3.66	2.87	3.59	3.26	4.07	3.79	4.59	4.78	5.19	4.01	6.05
Ti	9360	10260	8040	7986	7440	8773	9268	11798	9949	9650	14205	9470	8631
Eu	1.41	1.11	1.33	1.13	1.32	1.23	1.46	1.4	2.11	1.59	1.79	1.22	1.82
Gd	5.2	4.49	4.81	3.86	4.55	4.07	5.12	4.92	5.75	4.91	6.11	4.52	5.12
Tb	1.09	0.94	0.99	0.64	0.85	0.71	0.92	0.84	0.90	0.61	0.84	0.55	0.55
Dy	7.85	6.47	6.89	4.4	5.64	4.6	5.82	5.38	5.38	3.80	4.82	3.96	3.68
Y	54.97	43.01	45.89	26.3	31.9	26.9	37.9	31.3	28	20	53	30	23
Ho	1.71	1.45	1.57	0.9	1.19	0.96	1.25	1.12	0.97	0.72	0.96	0.89	0.74
Er	4.85	4.17	4.45	2.66	3.19	2.74	3.61	3.17	2.78	1.73	2.67	2.31	1.88
Tm	0.77	0.68	0.7	0.36	0.44	0.39	0.51	0.43	0.34	0.23	0.36	0.33	0.25
Yb	5.42	4.18	4.67	2.49	3.2	2.62	3.29	2.88	2.83	1.34	2.39	2.10	1.42
Lu	0.86	0.64	0.71	0.38	0.45	0.38	0.5	0.45	0.34	0.22	0.36	0.31	0.20
Li				14.2	5.61	9.74	14.31	6.27					
Be				1.11	0.67	0.62	0.51	0.45					
B				5.74	–	6.01	6.08	4.94					
Ba/Nb	47.16	14.59	81.06	1.85	1.79	1.30	6.13	5.29	23.00	19.50	20.08	14.90	17.00
U/Nb	0.03	0.04	0.05	0.03	0.04	0.03	0.02	0.03	n.d.	n.d.	n.d.	n.d.	n.d.
Rb/Sr	0.09	0.00	0.04	0.01	0.01	0.00	0.02	0.01	0.07	0.04	0.34	0.04	0.12
Sm/Nd	0.41	0.40	0.39	0.32	0.35	0.31	0.31	0.32	0.25	0.25	0.30	0.31	0.29
Lu/Hf	0.42	0.28	0.31	0.19	0.22	0.16	0.19	0.16	n.d.	n.d.	n.d.	n.d.	n.d.

Table A.3 Continued

Protolith	E-MORB				OIB								
Locality	Western Tianshan (John et al., 2008)		Western Tianshan (Xiao et al., 2012)	Western Tianshan (van der Straaten et al., 2008)	New Caledonia (Spandler et al., 2004)				Western Tianshan (van der Straaten et al., 2008)				
Sample	r3-1	r3-1	TS02-36	4-1.3	1005	1101	2810	2818	4-1.3	4-1.4	4-1.5	4-2.4	4-2.5
Grade	Bs	Bs	Bs	Ec	Grt Bs	Grt Bs	Grt Bs	Grt	Ec	Ec	Ec	Ec	Ec
major elements in wt.%													
SiO ₂	45.68	46.98	48.01	49.67	47.74	49.6	49.95	50.16	49.48	44.64	49.75	49.07	43.1
TiO ₂	15.6	16.38	2.6	0.8	1.87	2.89	2.36	2	1.65	1.95	1.65	1.97	2.16
Al ₂ O ₃	2.01	1.97	18.5	10.24	16.18	15.01	15.62	14.52	12.89	12.81	13.31	14.45	15.4
TF ₂ O ₃	13.48	9.99	14.42	11.01 [†]	10.48	10.64	11.27	11.88	10.29 [†]	10.54 [†]	9.29 [†]	10.18 [†]	12.41 [†]
MnO	6.36	5.77	0.13	0.1	0.21	0.37	0.42	0.36	0.09	0.12	0.06	0.06	0.14
MgO	0.13	0.04	4.7	5.33	8.71	7.25	7.59	7.63	4.51	6.13	5.23	4.97	4.31
CaO	7.01	10.46	5.71	15.29	7.7	5.61	6.91	6.78	14.45	13.97	12.7	10.78	14.65
Na ₂ O	2.8	2.97	2.99	4.49	2.58	3.75	1.79	4.47	3.19	3.08	2.82	3.5	2.78
K ₂ O	2.03	1.14	2.33	0.04	2.13	2.29	2.17	0.29	0.31	1.11	1.51	2.34	0.85
P ₂ O ₅	0.23	0.17	0.16	1.93	0.33	0.85	0.51	0.44	0.52	0.23	0.58	0.29	0.25
LOI	4.57	4.01	1.89	1.62	2.29	2.07	2.46	2.07	2.13	5.72	3.37	2.33	3.86
Total C	1.21	1.21		1.24					1.7	4.95	2.29	1.13	3.26
Total	99.9	99.88	101.45	100.52	100.23	100.33	101.05	100.6	99.51	100.3	100.27	99.94	99.91
trace elements in ppm													
Ba	467	257	704.80	16.2	163	691	670	51.6	112	370	481	681	268
Rb	56	37.4	59.90	0.948	28.83	74.1	66.9	7.39	6.22	22	29.8	46.4	17.7
Cs	1.36	0.797	1.70	0.07	0.77	0.87	0.72	0.26	0.36	0.87	1.24	1.81	0.73
Th	n.d.	1.02	0.74	0.51	2.13	4.13	3.33	3.46	1.02	1.27	1.27	1.27	1.34
Nb	9.05	9.01	11.21	6.2	29.28	50.67	40.52	34.72	12.5	14	12.2	15.2	16
U	0.19	0.246	0.19	0.51	0.7	1.67	1.04	1.14	0.46	0.38	0.41	0.49	0.41
Ta	0.57	0.64	0.72	0.37	1.75	3.36	2.55	2.4	0.77	0.93	0.79	0.94	1.02
La	12.2	21.3	11.36	12.1	17.33	40.96	28.1	26.82	17.6	15.7	20.5	20.7	17.7
Ce	27.2	47.4	29.09	26.7	36.14	82.2	54.38	51.33	39.9	36.8	48	45	39
Pr	3.82	7.23	4.36	3.79	4.54	10.02	6.85	6.39	5.51	4.91	6.35	6.19	5.73
Pb	1.9	4.06	1.50	1.54					2.35	1.92	2.97	2.42	3.2
Sr	210	527	248.00	222	229	303	200	284	361	254	356	251	412
Nd	18.5	32.8	19.96	17.6	20.06	42.04	29.12	27.03	24.6	21.6	28.4	27.3	25.6
Zr	114	166	181.50	64.7	162	268	229	253	131	155	134	160	174
Hf	2.93	3.81	4.18	1.58	3.59	5.8	5.16	5.55	3.08	3.83	3.13	3.71	4.09
P	1004	753	698.59		1458	3603	3127	2764					
Sm	4.95	11	5.66	4.35	4.97	9.51	7.12	6.73	5.83	5.07	6.88	6.55	6.21
Ti	12050	12428	15600	4795	10580	17250	16990	14540	9889	11687	9889	11807	12946
Eu	1.73	3.75	2.08	1.63	1.63	3.18	3.29	2.23	1.97	1.76	2.35	2.06	1.98
Gd	4.85	9.56	6.16	5.08	5.43	9.01	7.27	7.01	6.22	5.04	7.23	6.42	6.59
Tb	0.73	1.28	1.11	0.79	0.98	1.3	1.11	1.13	0.94	0.7	0.98	0.85	1
Dy	4.63	6.31	7.18	5.07	6.51	7.33	6.08	6.5	5.83	3.97	5.4	4.65	5.84
Y	24.1	30.6	42.18	30	36.9	41.1	32.6	35.7	33.2	20.1	28.8	22.6	31.1
Ho	0.92	1.18	1.49	1.08	1.36	1.37	1.13	1.28	1.21	0.8	1.11	0.89	1.17
Er	2.58	2.93	4.05	2.95	3.72	3.77	2.91	3.39	3.29	2.15	2.97	2.37	3.08
Tm	0.35	0.357	0.62	0.43	0.54	0.5	0.37	0.45	0.48	0.32	0.43	0.34	0.44
Yb	2.5	1.93	4.01	2.62	3.66	3.09	2.33	2.93	2.99	2.09	2.75	2.19	2.77
Lu	0.41	0.248	0.61	0.38	0.55	0.46	0.34	0.42	0.43	0.31	0.4	0.32	0.41
Li	n.d.	24		50.5	12.32	18.02	10.37	40.34	37.2	37.8	37.8	41.6	29.7
Be					1.08	0.81	0.8	0.99					
B					7.17	9.13	7.74	6.24					
Ba/Nb	51.60	28.52	62.87	2.61	5.57	13.64	16.54	1.49	8.96	26.43	39.43	44.80	16.75
U/Nb	0.02	0.03	0.02	0.08	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03
Rb/Sr	0.27	0.07	0.24	0.00	0.13	0.24	0.33	0.03	0.02	0.09	0.08	0.18	0.04
Sm/Nd	0.27	0.34	0.28	0.25	0.25	0.23	0.24	0.25	0.24	0.23	0.24	0.24	0.24
Lu/Hf	0.14	0.07	0.15	0.24	0.15	0.08	0.07	0.08	0.14	0.08	0.13	0.09	0.10

Table A.3 Continued

Protolith	OIB															
Locality	Western Tianshan (van der Straaten et al., 2008)					Western Tianshan (Ai et al., 2006)									Western Tianshan (Beinlich, 2010)	
Sample	4-3.1	4-3.2	4-3.3	4-3.4	4-3.5	1051	1054	10610	10512	10512C	10513	10516	10611	1068	JTS-A	JTS-B
Grade	Ec	Ec	Ec	Ec	Ec	Bs	Bs	Bs	Ec	Ec	Ec	Ec	Ec	Ec	Bs	Bs
	major elements in wt.%															
SiO ₂	52.33	47.67	43.87	40.56	49.82	48.23	47.28	54.1	49.86	46.28	47.63	48.86	45.32	45.91	47.66	48.71
TiO ₂	1.57	1.53	1.96	1.79	1.49	2.67	2.72	1.79	2.77	2.8	2.86	2.76	2.09	2.13	15.44	14.4
Al ₂ O ₃	12.18	12.01	14.36	13.12	11.83	17.06	16.31	14.6	14.8	15.41	12.8	15.16	15.41	15.58	3.76	3.55
TFe ₂ O ₃	7.83 [†]	11.23 [†]	11.84 [†]	12.2 [†]	10.26 [†]	13.94	13.41	12.51	11.43	11.81	14.2	15.5	14.27	12.97	5.53	5.31
MnO	0.02	0.1	0.13	0.19	0.06	0.14	0.18	0.15	0.13	0.15	0.09	0.15	0.16	0.06	13.52	12.99
MgO	5.99	6.87	5.44	5.2	5.96	3.89	5.81	5.78	6.9	5.37	4.25	3.38	3.68	5.82	6.04	6.83
CaO	12.37	12.1	15.17	17.02	14.07	6.15	8.82	2.18	7.48	8.88	7.36	8.58	7.52	8.74	0.7	0.67
Na ₂ O	4.74	3.88	3.14	1.58	4.64	2.58	3.05	3.37	3.57	4.52	5.08	2.29	3.97	3.46	3.25	3.01
K ₂ O	1.12	0.48	0.35	0.43	0.24	2.2	0.6	3.14	0.9	1.02	2.44	1.26	3.07	1.38	2.07	1.93
P ₂ O ₅	0.37	0.34	0.25	0.35	0.39	0.66	0.36	0.22	0.45	0.48	0.22	0.56	0.23	0.16	0.19	0.2
LOI	1.83	4.29	4.22	8.57	1.94	2.03	1.1	2.19	1.51	3.22	3.32	1.17	3.79	3.57	1.01	1.84
Total C	0.61	3.61	3.82	8.56	1.43											
Total	100.35	100.5	100.73	101.01	100.7	99.55	99.64	100.03	99.8	99.94	100.25	99.67	99.51	99.78	99.17	99.44
	trace elements in ppm															
Ba	356	150	109	132	75.2	787.1	227.12	374.85	659.17	171.84	442.88	299.7	392.02	286.06	603	574
Rb	24.8	10.3	7.23	9.09	4.97	46.76	11.38	66.71	13.89	19.8	57.79	28.9	88.67	38.92	36	33.6
Cs	0.83	0.38	0.27	0.32	0.23										0.79	0.755
Th	1.13	1.03	1.29	1.17	1.11	3.15	2.46	2.2	3.09	3.73	3.89	3.6	1.49	0.75	3.57	2.95
Nb	12.6	11.9	14.5	12.7	11.7	27.95	28.66	16.39	29.26	38.16	39.06	40.32	17.63	9.62	29.9	24.7
U	0.24	0.21	0.33	0.26	0.27	0.55	0.66	0.38	0.72	0.86	0.65	0.7	0.25	0.15	0.88	0.751
Ta	0.73	0.73	0.93	0.8	0.72	1.76	1.8	0.99	1.81	2.47	2.34	2.46	1.09	0.62	1.43	1.33
La	13.3	14.6	14.7	14.4	13.4	25.61	24.81	17.66	26.93	31.66	26.57	26	13.57	11.74	33.1	26.2
Ce	32	33.4	34.9	33	30.5	56.99	56.04	40.37	58.88	66.62	56.7	54.23	32.99	30.07	76.7	60.9
Pr	4.26	4.61	4.87	4.51	4.23	7.16	7.19	5.35	7.57	8.7	7.12	6.71	4.29	4.44	10.4	8.27
Pb	1.52	1.63	3.34	4.67	2.53	2.56	3.19	1.58	2.89	2.17	1.83	2.14	1.98	1.96	2.28	2.75
Sr	183	195	402	514	246	259.52	464.12	55.53	281.41	219.84	117.43	182.14	143.79	212.89	205	278
Nd	18.7	20.4	21.6	19.8	18.7	30.06	31.7	23.77	32.74	37.09	29.95	27.65	19.29	21.87	46.3	36.8
Zr	121	123	154	140	123	242.71	236.62	141.13	244.82	216.42	238.73	250.99	174.69	149.39	382	333
Hf	2.88	2.95	3.78	3.35	2.82	5.47	5.44	3.28	5.45	5.66	5.18	5.52	3.8	3.3	8.52	7.56
P																
Sm	4.45	4.87	5.24	4.66	4.58	6.65	7.48	5.9	7.58	8.14	6.64	6.04	4.73	6.2	11.3	9.18
Ti	9410	9170	11747	10728	8930	16003	16302	10728	16602	16782	17141	16542	12526	12766	92539	86306
Eu	1.45	1.62	1.8	1.57	1.53	2.08	2.24	1.74	2.18	2.5	1.96	1.97	1.49	2.11	3.4	2.91
Gd	4.35	5.12	5.73	5.09	4.76	7.02	7.46	5.76	6.64	7.99	5.91	7.11	4.69	5.99	11.2	9.93
Tb	0.56	0.79	0.93	0.81	0.73	1.21	1.24	0.98	1.02	1.18	0.82	1.31	0.85	0.89	1.73	1.62
Dy	2.84	4.93	5.74	4.99	4.52	6.98	6.85	5.67	5.43	6.33	4.17	7.34	5.28	4.51	9.85	9.51
Y	13.3	28.1	29.8	29.6	23.5	40.16	38.85	32.09	29.47	34.74	21.55	45.54	33.53	24.75	49	47.7
Ho	0.51	1	1.16	1.03	0.92	1.43	1.37	1.2	1.04	1.23	0.76	1.52	1.17	0.87	1.88	1.82
Er	1.17	2.53	3.12	2.69	2.43	3.6	3.41	3.12	2.61	3.17	1.93	3.78	3.36	2.32	4.79	4.68
Tm	0.16	0.38	0.46	0.42	0.35	0.52	0.48	0.47	0.38	0.46	0.27	0.57	0.55	0.36	0.657	0.661
Yb	1	2.43	2.93	2.75	2.18	3.19	2.98	2.84	2.36	2.93	1.79	3.66	3.6	2.38	4.13	4.12
Lu	0.15	0.36	0.42	0.41	0.3	0.48	0.45	0.41	0.35	0.45	0.27	0.57	0.55	0.37	0.594	0.571
Li	57.5	43.5	37.6	18.7	56.7										20.4	18.8
Be																
B																
Ba/Nb	28.25	12.61	7.52	10.39	6.43	28.16	7.92	22.87	22.53	4.50	11.34	7.43	22.24	29.74	20.17	23.24
U/Nb	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.03	0.03
Rb/Sr	0.14	0.05	0.02	0.02	0.02	0.18	0.02	1.20	0.05	0.09	0.49	0.16	0.62	0.18	0.18	0.12
Sm/Nd	0.24	0.24	0.24	0.24	0.24	0.22	0.24	0.25	0.23	0.22	0.22	0.22	0.25	0.28	0.24	0.25
Lu/Hf	0.05	0.12	0.11	0.12	0.11	0.09	0.08	0.13	0.06	0.08	0.05	0.10	0.14	0.11	0.07	0.08

Table A.3 Continued

Protolith	OIB													
	Western Tianshan (Gao and Klemm, 2003)								Western Tianshan (Xiao et al., 2012)					
Locality														
Sample	GC7-1	GC7-2	GC8-1	97495-1	97495-5	9754-1	9754-2	CG6-1	TS02-01	TS02-02	TS02-03A	TS02-03B	TS02-04	TS02-05
Grade	Ep	Ompacitite	Retro. Ec	Ompacitite (pillow)	Ep (pillow)	Ompacitite	Ompacitite	Ompacitite	Bs	Bs	Bs	Ec	Ec	Bs
major elements in wt. %														
SiO ₂	45.97	47.26	45.23	45.85	45.04	43.80	44.14	45.21	48.57	52.63	44.17	51.29	46.54	47.19
TiO ₂	2.26	2.43	2.55	2.03	2.57	2.29	2.33	2.53	2.45	2.83	3.72	2.15	3.52	2.38
Al ₂ O ₃	15.93	14.79	15.37	14.07	16.94	14.06	14.70	16.68	14.84	13.13	13.91	9.38	14.38	14.9
TF ₂ O ₃	16.29	12.03	13.05	11.31	9.24	10.80	9.97	11.07	14.6	14.47	14.93	11.63	14.47	11.04
MnO	0.20	0.10	0.18	0.13	0.09	0.09	0.08	0.14	0.08	0.24	0.15	0.11	0.18	0.14
MgO	3.49	4.32	3.69	4.52	3.12	5.06	5.24	4.91	6.81	5.36	6.06	5.47	4.05	8.03
CaO	11.77	11.37	9.86	10.96	12.66	10.64	11.71	6.33	6.85	7.24	7.25	11.9	9.44	6.06
Na ₂ O	2.39	3.70	1.74	2.43	1.80	3.92	3.54	2.44	3.5	3.29	2.72	3.55	3.14	3.66
K ₂ O	0.39	1.12	1.40	2.15	2.60	2.68	2.59	4.79	1.34	0.74	1.4	0.08	1.41	1.18
P ₂ O ₅	0.13	0.32	0.14	0.27	0.38	0.34	0.23	0.15	0.39	0.55	0.64	0.44	0.59	0.5
LOI	0.98	2.15	6.46	4.88	6.69	5.86	5.16	5.50	1.56	0.78	3.68	3.59	1.78	3.5
Total	99.80	99.69	99.67	99.84	99.61	99.55	99.69	99.75	100.99	101.27	98.63	99.59	99.5	98.58
trace elements in ppm														
Ba	89	193	282	538	625	377	533	1259	204.70	189.80	351	9.20	358	250
Rb	9	27	35	47	55	56	53	98	40.20	17.60	27.10	0.90	28.20	23.10
Cs									1.00	0.80	0.80	0.00	1.60	0.80
Th	5	5	5	<5	<5	6	<5	<5	2.24	3.14	2.78	1.69	3.19	3.58
Nb	24	25	23	26	35	26	25	28	18.18	31.63	35.09	14.85	37.63	37.32
U	5	5	5	<5	<5	<5	<5	<5	0.54	0.83	0.76	0.48	0.85	0.84
Ta									1.17	1.99	2.22	1.02	2.15	2.28
La	28.10	32.00	22.50	26.12	23.15	33.77	25.64	17.59	23.85	32.52	31.62	19.72	33.51	34.19
Ce	50.70	60.20	39.70	57.24	56.99	75.49	58.72	41.08	52.88	71.73	69.44	43.26	74.16	71.79
Pr				6.97	6.84	8.75	6.96	3.54	7.08	9.47	9.80	6.12	10.02	9.49
Pb	9	5	7	<5	9	<5	6	<5	3.50	3.50	4.70	3.40	2.70	nd
Sr	356	255	273	244	444	155	282	79	366	209	268	316	129	406
Nd	26.20	37.70	22.70	29.30	28.56	38.55	28.67	17.17	30.62	40.26	41.95	26.59	43.51	37.76
Zr	225	232	258	201	260	224	223	244	191	271	180	152	296	157
Hf									4.49	5.96	4.55	3.86	6.40	3.31
P									1701	2401	2794	1921	2576	2183
Sm	7.17	8.27	6.17	6.25	6.65	7.84	5.79	3.80	7.51	9.41	10.25	6.94	10.30	8.05
Ti	13545	14564	15283	12167	15403	13725	13965	15164	14700	16980	22320	12900	21120	14280
Eu	2.57	2.99	1.88	1.94	2.29	2.91	2.68	1.14	2.52	2.98	3.09	2.28	3.11	2.54
Gd				6.38	7.58	8.60	6.69	3.25	7.96	9.79	10.06	6.69	10.48	7.56
Tb	1.55	1.28	0.99	0.88	1.02	1.30	0.95	0.52	1.27	1.55	1.53	1.12	1.66	1.16
Dy				4.48	5.59	6.12	6.41	3.00	7.32	8.8	8.24	6.66	9.22	6.33
Y	60	34	35	28	28	22	20	17	40.15	49.92	36.62	34.66	52.01	31.48
Ho				0.64	0.93	1.05	1.23	0.62	1.39	1.71	1.52	1.33	1.77	1.19
Er				1.64	2.28	3.01	2.96	1.52	3.50	4.52	3.79	3.37	4.64	3.04
Tm				0.18	0.33	0.46	0.54	0.21	0.48	0.67	0.53	0.49	0.69	0.45
Yb	5.67	3.18	3.31	1.34	1.83	2.24	3.21	1.33	2.54	3.91	3.16	2.87	4.03	2.71
Lu	0.82	0.35	0.43	0.19	0.22	0.33	0.47	0.19	0.36	0.56	0.5	0.4	0.58	0.4
Li														
Be														
B														
Ba/Nb	3.71	7.72	12.26	20.69	17.86	14.50	21.32	44.96	11.26	6.00	10.01	0.62	9.53	6.70
U/Nb	0.21	0.20	0.22	n.d.	n.d.	n.d.	n.d.	n.d.	0.03	0.03	0.02	0.03	0.02	0.02
Rb/Sr	0.03	0.11	0.13	0.19	0.12	0.36	0.19	1.24	0.11	0.08	0.10	0.00	0.22	0.06
Sm/Nd	0.27	0.22	0.27	0.21	0.23	0.20	0.20	0.22	0.25	0.23	0.24	0.26	0.24	0.21
Lu/Hf	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	0.09	0.11	0.10	0.09	0.12

Table A.3 Continued

Protolith	OIB															
Locality	Western Tianshan (Xiao et al., 2012)															
Sample	TS02-06	TS02-08	TS02-09	TS02-11	TS02-35	TS02-38	TS02-41	TS02-42	TS02-47	TS02-48	TS02-99	105-1	105-12	106-14	106-3A	110-3
Grade	Ca Ec	G	G	G	Highly Ec Bs	Bs	Ec	Ec	Omph acitite	Omph acitite	Bs	Highly Ec Bs	Ec	Bs	Bs	Bs
major elements in wt.%																
SiO ₂	40.96	47.49	52.35	48.46	49.07	49.53	46.9	47.82	46.99	47.54	47.08	47.54	47.49	47.84	41.17	49.75
TiO ₂	2.48	3.85	1.76	1.82	2.8	2.25	3.8	3.31	2.4	1.62	2.21	3.02	2.86	2.44	2.4	1.76
Al ₂ O ₃	14.96	19.04	14.21	14.06	17.44	14.04	14.06	13.38	14.82	18.44	12.89	17.88	15.51	14.53	15.27	16.22
TFe ₂ O ₃	13.18	15.06	9.81	11.48	13.01	12.95	13.3	12.99	8.56	10.16	9.83	14.57	12.2	12.23	11.16	11.33
MnO	0.14	0.05	0.1	0.14	0.09	0.17	0.16	0.19	0.07	0.18	0.11	0.19	0.16	0.16	0.21	0.18
MgO	4.29	1.61	6.9	6.59	4.63	4.91	3.31	6.79	4.18	3.71	5.73	3.94	6.71	5.56	3.19	3.93
CaO	8.93	4.02	9.67	8.62	7.71	8.91	8.31	8.77	15.11	10.04	14.35	7.11	8.48	9.98	15.7	11.15
Na ₂ O	2.99	1.95	3.72	3.04	3.81	3.33	3.22	2.88	3.28	3.82	3.51	2.54	3.23	1.83	0.41	3.05
K ₂ O	3.63	2.12	0.11	1.05	1.05	1.15	2.26	1.04	0.12	0.36	0.32	1.92	0.93	1.24	0.07	1.63
P ₂ O ₅	0.35	0.44	0.27	0.22	0.36	0.26	0.7	0.49	0.33	0.24	0.25	0.56	0.42	0.19	0.56	0.47
LOI	8.13	3.84	1.2	3.69	1.2	2.29	3.87	1.16	2.8	2.9	2.9	1.37	1.21	4.16	10.14	1.3
Total	100.04	99.47	100.1	99.17	101.17	99.79	99.89	98.83	98.66	99.01	99.17	100.64	99.2	100.17	100.28	100.76
trace elements in ppm																
Ba	771	924	35.4	141	253	300	545	261	32.9	68.8	87.0	819	799	32.3	570	240
Rb	104	71.2	1.80	23.60	22.50	30.40	52.60	22.80	1.90	6.80	7.10	37.10	16.50	1.00	24.40	40.70
Cs	3.00	2.40	0.10	0.90	0.60	0.80	1.40	0.50	0.10	0.30	0.20	1.00	0.70	0.10	0.90	0.90
Th	2.72	3.20	2.59	1.58	2.57	1.84	4.65	2.87	2.11	1.20	2.07	2.65	3.31	3.20	4.64	1.46
Nb	26.93	35.01	14.85	15.87	24.96	16.25	41.25	25.49	19.94	13.76	24.28	27.40	29.40	22.58	26.77	13.91
U	0.70	0.83	0.46	0.39	0.60	0.54	1.30	0.79	0.65	0.43	0.52	0.60	0.82	1.07	0.84	0.17
Ta	1.66	2.17	0.92	0.99	1.58	1.02	2.56	1.62	1.27	0.86	1.65	1.66	1.83	1.60	1.60	0.83
La	27.60	28.53	22.81	16.74	27.89	20.15	43.66	28.80	24.44	13.22	20.26	27.83	29.21	27.09	32.03	16.23
Ce	60.62	66.44	47.75	36.75	65.53	45.19	98.03	64.67	53.96	29.41	42.89	62.78	63.62	61.45	69.37	33.60
Pr	8.40	9.13	6.37	5.16	8.65	6.05	13.00	8.85	7.14	3.96	5.66	8.40	8.40	7.99	8.94	4.61
Pb	2.30	9.10	3.40	2.60	3.90	2.50	2.90	4.90	4.10	2.50	3.60	3.40	3.30	17.20	3.50	2.50
Sr	138	164	195	215	398	233	134	465	656	343	342	390	326	1763	509	191
Nd	34.68	39.36	25.97	22.00	36.34	25.40	54.19	38.14	29.69	16.86	22.60	34.83	34.17	32.94	35.60	18.88
Zr	172	231	158	132	207	198	245	196	169	147	243	175	259	190	218	139
Hf	3.45	5.19	3.74	3.56	4.45	4.50	5.23	4.27	3.85	3.40	5.29	3.72	5.98	4.34	4.96	3.72
P	1528	1921	1179	961	1572	1135	3056	2139	1441	1048	1091	2445	1833.8	2445	830	2052
Sm	7.79	9.79	5.95	5.49	8.94	6.41	13.14	9.62	7.07	4.30	4.83	8.31	8.01	7.93	7.89	4.45
Ti	14880	23100	10560	10920	16800	13500	22800	19860	14400	9720	13260	18120	17160	14400	14640	10560
Eu	2.49	3.11	1.97	1.86	2.74	2.11	3.93	2.92	2.42	1.50	1.55	2.78	2.64	2.52	2.61	1.45
Gd	7.56	9.46	5.75	5.48	8.59	6.92	13.27	9.4	6.89	4.6	4.91	8.59	8.18	7.38	7.99	4.39
Tb	1.23	1.52	0.85	0.87	1.27	1.14	2.09	1.52	1.02	0.8	0.73	1.46	1.24	1.18	1.3	0.74
Dy	7.17	8.73	4.44	4.89	7.19	6.76	11.55	8.76	5.71	4.92	4	8.83	6.72	6.7	7.62	4.61
Y	37.09	44.71	22.06	22.00	39.01	38.26	61.17	49.90	30.12	28.31	22.83	50.92	36.47	34.93	45.06	28.98
Ho	1.39	1.73	0.8	0.94	1.39	1.31	2.1	1.68	1.08	0.97	0.76	1.73	1.29	1.22	1.55	0.93
Er	3.54	4.53	2.00	2.37	3.71	3.41	5.26	4.46	2.76	2.58	1.95	4.41	3.17	3.02	4.02	2.51
Tm	0.52	0.68	0.3	0.34	0.54	0.49	0.74	0.64	0.39	0.36	0.26	0.62	0.45	0.44	0.57	0.36
Yb	3.16	4.23	1.82	2.03	3.42	3.09	4.52	3.87	2.39	2.35	1.70	3.95	2.74	2.86	3.37	2.29
Lu	0.46	0.61	0.28	0.29	0.49	0.47	0.67	0.56	0.36	0.35	0.26	0.57	0.42	0.43	0.49	0.34
Li																
Be																
B																
Ba/Nb	28.61	26.38	2.38	8.90	10.12	18.43	13.20	10.22	1.65	5.00	3.58	29.88	27.19	1.43	21.30	17.25
U/Nb	0.03	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.05	0.03	0.01
Rb/Sr	0.76	0.43	0.01	0.11	0.06	0.13	0.39	0.05	0.00	0.02	0.02	0.10	0.05	0.00	0.05	0.21
Sn/Nd	0.22	0.25	0.23	0.25	0.25	0.25	0.24	0.25	0.24	0.26	0.21	0.24	0.23	0.24	0.22	0.24
Lu/Hf	0.13	0.12	0.07	0.08	0.11	0.10	0.13	0.13	0.09	0.10	0.05	0.15	0.07	0.10	0.10	0.09