TABLE DR-1 OXYGEN AND CARBON ITOTOPE RATIOS OF SKARN MINERALS AND WHOLE ROCKS

Empire Mountain: Cupola Zone Skarns

Sample	δ^{18}O (Beige Grt)	δ^{18}O (Red Grt)	δ^{18}O (Other)	Zone, UTM Easting	UTM Northing	Lab	Geographic Area
1	2.4	–0.2	—	11S 358474.16 m E	4037077.92 m N	UT	Massive red garnetite
2	2.5	–1.3	—	11S 358497.93 m E	4037077.33 m N	UT	Massive red garnetite
27	2.9	1.0	—	11S 358470.06 m E	4037078.00 m N	UT	Vein grnt from xenolith; early red, late beige
31	Rim = 2.3	Core = 0.0,–0.5	Qtz = 7.5	11S 358464.80 m E	4037033.37 m N	UT	Large grt in qtz vein, core-rim pair
32	Rim = 2.1, 3.0, 2.3	Core = –0.5, –0.5	Qtz = 5.8	11S 358464.80 m E	4037033.37 m N	UT	Large grt in qtz vein, core-rim pair
do.	Mid. = 2.1, 2.7, 2.4			do.	do.		do.

Empire Mountain: Lower Skarns

Sample	δ^{18}O (Beige Grt)	δ^{18}O (Red Grt)	δ^{18}O (Other)	Zone, UTM Easting	UTM Northing		Geographic Area
35	—	–1.8, –1.7	—	11S 358485.44 m E	4036865.67 m N	UT	Garnet from lower beige garnetite pendants
36A	1.9	—	—	11S 358352.10 m E	4036918.38 m N	UT	Garnet from lower beige garnetite pendants
36B	2.6	—	—	11S 358263.63 m E	4036987.40 m N	UT	Garnet from lower beige garnetite pendants
12	0.6, 0.4	–0.2	Cpx = 2.0	11S 358253.14 m E	4036954.99 m N	UT	Clinopyroxenite with garnet vug fill, late calcite
11MK9B	—	0.8		11S 358199.35 m E	4036150.29 m N	UT	Garnetite from Monarch Canyon
11MK11	—		Cpx = 0.1	11S 358188.20 m E	4036142.74 m N	UT	Clinopyroxenite from Monarch Canyon
11MK13A		-1.3		11S 358197.90 m E	4036078.98 m N	UT	Garnetite from Monarch Canyon
11MK13C	1.3		Cpx = 0.6	11S 358197.90 m E	4036078.98 m N	UT	Garnet-Clinopyroxene Skarn: Monarch Canyon
11MK14B	—	—	Cpx = 1.3	11S 358109.85 m E	4036157.43 m N	UT	Clinopyroxenite from Monarch Canyon

Empire Mountain: Late Epidote Veins

Sample	δ^{18}O (Epidote)	δ^{18}O (Other)		Zone, UTM Easting	UTM Northing		Geographic Area
14	2.7	—		11S 358253.14 m E	4036954.99 m N	UT	Epidote vein with quartz and calcite
3	2.4	—		11S 358474.16 m E	4037077.92 m N	UT	Epidote vein with quartz and calcite
4	2.9	—		11S 358474.42 m E	4037025.28 m N	UT	Epidote vein with large (3 cm) calcite grains

Empire Mountain: Skarn Calcites*

Sample	δ^{18}O (Calcite)	δ^{13}C(Calcite)	Sample	δ^{18}O (Calcite)	δ^{13}C(Calcite)		
12.1	5.3	–5.8	10MD14.1	5.4	–6.8	UR	see above
12.2	5.2	–3.8	10MD14.2	5.2	–7.1	UR	see above
12.3	5.2	–7.2	10MD36.1	5.0	–2.9	UR	see above
4	6.6	–7.4	10MD36.2	5.9	–4.0	UR	see above

Mineral King Pendant Marbles Lacking Skarns

Sample	δ^{18}O (Calcite)	δ^{13}C(Calcite)	Zone, UTM Easting	UTM Northing		Geographic Area
11MK3	17.3	1.6	11S 357353.00 m E	4035052.00 m N	UR	Marble South of Monarch Creek
11MK5	17.8	1.5	11S 358253.14 m E	4036954.99 m N	UR	Marble South of Monarch Creek
11MK6,6A	14.1, 14.3	–10.4,–10.4	11 S 357340.90 m E	4035517.90 m N	UR	Marble Sequence North of Monarch Creek
11MK7,7A	12.9, 13.4	1.7,2.0	11 S 357340.90 m E	4035517.90 m N	UR	Marble Sequence North of Monarch Creek
11MK-8	22.2	2.8	11 S 357340.90 m E	4035517.90 m N	UR	Marble Sequence North of Monarch Creek
11MK-10	15.4	1.6	11 S 357176.80 m E	4035475.28 m N	UR	Marble off Trail on Monarch Creek Hike

Other Empire Mountain Samples

Sample	δ^{18}O	Material	Zone, UTM Easting	UTM Northing		Geographic Area
EMPm	4.7, 4.4	Quartz	11S 357977.22 m E	4036768.92 m N	UT	Empire Mine euhedral vug-filling qtz
17	6.58, 6.75	Zircon	11S 358244.46 m E	4036790.23 m N	UT	Empire quartz diorite, U-Pb dated
17	5.8	Whole Rock	do.	do.	UW	Empire quartz diorite, U-Pb dated
28	4.3	Whole Rock	11S 358501.98 m E	4037029.85 m N	UW	Empire quartz diorite, cupola zone
37	0.6	Whole Rock	11S 358054.30 m E	4036754.17 m N	UW	Calc-silicate rock at contact with pluton
38	0.7	Whole Rock	11S 357995.86 m E	4036707.87 m N	UW	Calc-silicate rock 30m west of contact
10JS04	4.5, 4.4	Whole Rock	11S 357556.12 m E	4036733.74 m N	UW	Metarhyolite 500 m West of Empire Mine
10JS03	5.1	Whole Rock	11S 356108.26 m E	4035471.90 m N	UW	Metarhyolite 2100 m West of Empire Mine

Mount Morrison Pendant: Skarn Garnet δ^{18}O Values from Lackey (2000).

95LV262	Core and Rim = 5.93, 5.83 ± 0.15‰	11 S 336365.16 m E	4154925.24 m N	UW	Scheelore Skarn
98LV471	Bulk: 7.18 ± 0.14‰	11 S 332099.97 m E	4161479.13 m N	UW	Laurel-Convict Fault Skarn
99LV684	Core to Rim = 5.67, 5.57, 5.74 ± 0.12‰	11 S 331970.04 m E	4162278.12 m N	UW	Wollastonite Gulch Skarn
99LV687	Core to Rim = 5.47, 5.65, 5.43, 5.38, 5.43 ± 0.12‰	11 S 331984.76 m E	4162278.74 m N	UW	Wollastonite Gulch Skarn

Note: All δ^{18}O values in ‰ relative to Vienna Standard Mean Ocean Water (VSMOW). Replicate analyses of samples are separated by commas. Calcite vug fill was measured on multiple spots on the same hand sample for three samples (12, 14, 36). Analyses of garnet and epidote at the University of Texas Stable Isotope Lab were standardized to UWG-2 (Valley et al. 1995), adjusting values to an accepted value of UWG-2 of 5.80‰. Quartz was adjusted to Gee Whiz and Lausanne quartz standards. Average δ^{18}O(raw) of UWG-2 at UT lab was 5.98 ± 0.4 (2 S.D., n = 5) analyzed on 4 different days; Gee Whiz (accepted value = 12.6‰) and Lausanne (accepted = 18.1) standards averaged: 12.67 ± 0.15 (n = 3) and 18.00 ± 0.16 (n = 4) for the same sessions. Whole rock powders were analyzed at the University of Wisconsin Stable Isotope lab following the method of Spicuzza et al. (1998). These analyses were standardized to UWG-2 with an average δ^{18}O(raw) of UWG-2 of 5.65 ± 0.18 (2 S.D., n = 7). Values δ^{13}C and δ^{18}O were determined at the University of California, Riverside and reported using the standard δ-notation compared to VSMOW for oxygen and PDB for carbon. Carbonate CO_2 was extracted in a Gas Bench II with 103% phosphoric acid for 1 hour at 70ºC and analyzed by continuous flow in a Delta V Plus. Isotopic values were determined by fitting results to a line anchored to international reference standards NBS-19, LSVEC (δ^{13}C = –46.6‰ PDB) and NBS-18 (δ^{13}C = -5.01‰, VPDB; δ^{18}O = 7.00‰; VSMOW) and external error of standards run with samples was <0.1 ‰ for carbon and <0.2‰ for oxygen. Skarn garnet values compiled in Figure 2A include Sierran skarn garnet values from Lackey (2000), reported here, and Brown et al. (1985). Other skarn garnet δ^{18}O values from the Cordillera of Canada, the U.S., and Mexico include those from Taylor and O'Neil (1977), Bowman et al. (1985), Layne et al. (1991), and Baker and Lang (2003).

TABLE DR-2: SIMS ANALYSES OF GARNET STANDARDS

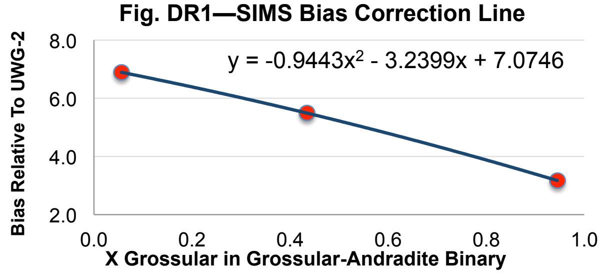
Analysis Number	Spot name	$\delta^{18}O$ VSMOW ‰	Average $\delta^{18}O$ Raw ‰	2SD	Average bias ‰	Average bias rel. UWG-2 ‰	$\delta^{18}O$ Raw ‰	Internal precision ‰
Session #1 Date: 5/31/2011-6/1/2011								
Sample: UW-STD-24								
39	UWG2						9.85	0.18
40	UWG2						9.80	0.20
41	UWG2						9.81	0.18
42	UWG2						9.84	0.17
43	UWG2						9.86	0.20
44	UWG2						9.97	0.19
45	UWG2						9.95	0.18
46	UWG2						10.01	0.21
		5.80	9.89	0.16	4.06	**—**		
47	92 LEW7						9.47	0.12
48	92 LEW7						9.36	0.19
49	92 LEW7						9.49	0.19
50	92 LEW7 13						9.23	0.22
51	92 LEW7 10						9.56	0.15
		-1.60	9.42	0.26	11.04	**6.89**		
52	92 LEW8 G1						8.94	0.20
53	92 LEW8 2						8.59	0.24
54	92 LEW8 2						8.50	0.17
55	92 LEW8 7						8.56	0.18
56	92 LEW8 9						8.88	0.21
		-0.93	8.69	0.40	9.63	**5.49**		
57	beta 114						12.81	0.26
58	beta 114 2						12.72	0.25
59	beta 114 3						12.80	0.24
60	beta 114 4						12.32	0.24
		9.30	12.66	0.46	3.33	**-0.78**		
61	UWG2						10.25	0.22
62	UWG2						10.08	0.19
63	UWG2						10.02	0.17
64	UWG2						9.94	0.14
		5.80	10.07	0.27	4.25	**—**		
Bracket and 2SD			**9.94**	**0.26**	**4.12**			
65	PrpDm g1						8.78	0.18
66	PrpDm g1						8.91	0.22
67	PrpDm g3						8.96	0.20
68	PrpDm g3						9.43	0.24
		5.60	9.02	0.56	3.40	**-0.82**		
69	SpesSE						8.71	0.25
70	SpesSE						8.87	0.09
71	SpesSE						8.46	0.15
72	SpesSE						8.51	0.17
		5.40	8.64	0.38	3.22	**-1.00**		
73	AlmSE						10.91	0.22
74	AlmSE						10.93	0.17
75	AlmSE						10.75	0.13
76	AlmSE						10.83	0.18
		8.30	10.86	0.17	2.53	**-1.68**		
77	GRS SE 1						11.19	0.23
78	GRS SE 1						11.27	0.19
79	GRS SE 1						11.15	0.24
80	GRS SE 1						11.31	0.21
		3.80	11.23	0.15	7.40	**3.17**		
81	UWG2						9.66	0.20
82	UWG2						9.96	0.21
83	UWG2						9.98	0.25
84	UWG2						10.40	0.16
85	UWG2						10.13	0.23
		5.80	10.03	0.54	4.20	**—**		
Bracket and 2SD			**10.05**	**0.42**	**4.22**			
86	Bal509						15.89	0.15
87	Bal509						15.72	0.21
88	Bal509						15.64	0.35
89	~~Bal509~~						~~17.69~~	~~0.27~~
		12.30	15.75	0.25	3.40	**-0.79**		
90	UWG2						10.29	0.15
91	UWG2						10.11	0.22
92	UWG2						10.17	0.41

93	UWG2						10.12	0.20
		5.80	10.17	0.17	4.35	—		
Bracket and 2SD			**10.09**	**0.43**	**4.27**			
Sample: UW-STD-29								
~~94~~	~~R-53~~						~~11.86~~	~~0.233~~
95	UWG2						9.72	0.23
96	UWG2						9.97	0.18
97	UWG2						9.80	0.15
98	UWG2						9.71	0.19
		5.80	9.80	0.24	3.98	—		
99	R53						11.76	0.17
100	R53						11.99	0.17
101	R53						11.88	0.14
102	R53						11.84	0.15
		5.33	11.87	0.19	6.50	**2.51**		
103	UWG2						9.99	0.17
104	UWG2						9.87	0.15
105	UWG2						9.87	0.18
106	UWG2						9.53	0.28
		5.80	9.82	0.40	3.99	—		
Bracket and 2SD			**9.81**	**0.30**	**3.98**			
Sample: UW-STD-23								
107	UWG2						9.95	0.19
108	UWG2						9.46	0.23
109	UWG2						9.81	0.19
110	UWG2						9.80	0.18
		5.80	9.75	0.42	3.93	—		
111	13-63-21						9.76	0.17
112	13-63-21						9.95	0.20
113	13-63-21						9.70	0.17
114	13-63-21						9.42	0.19
		4.55						
115	UWG2						9.98	0.19
116	UWG2						9.55	0.19
117	UWG2						9.62	0.19
118	UWG2						9.93	0.16
		5.80	9.77	0.44	3.94	—		
Bracket and 2SD			**9.76**	**0.40**	**3.94**			

SUMMARY BIAS DATA FOR GARNET STANDARDS

Standard	Mole Fraction Grossular	Bias Relative to UWG-2
92 LEW7	0.05605	6.89
92 LEW8	0.43414	5.49
GrsSE	0.94491	3.17

Fig. DR1—SIMS Bias Correction Line



Note: Oxygen isotopic analyses were performed on the WiscSIMS CAMECA ims-1280 high-resolution, multi-collector ion microprobe at the University of Wisconsin— Madison on two consecutive days. Sample preparation followed the protocol described previously (Kita et al. 2009, Valley and Kita 2009; and Page et al. 2010). These same studies describe the analytical protocol that is summarized as follows: A $^{133}Cs^{+}$ primary ion beam (20 kV total accelerating voltage) was focused to a diameter of 10 µm on the gold-coated sample surface. Primary ion intensities were ca. 2–3 nA. The electron flood gun, with normal incidence, was used to compensate charges. Secondary $^{16}O^{-}$ and $^{18}O^{-}$ ions were accelerated away from the sample by −10 kV and monitored simultaneously on dual Faraday cups. Faraday cups are calibrated in the beginning of the session, using the calibration routine. The intensity of ^{16}O was 2 to $3x10^{9}$ cps depending on the primary intensity (ca. 10^{9} cps/nA). Mass resolving power (MRP, M/ΔM), was set to ca. 2200, enough to separate hydride interferences on ^{18}O. The magnetic field was regulated by a Nuclear Magnetic Resonance (NMR) probe with stability of mass better than 10 ppm/10 h. Each analysis takes ~3.5 minutes, including 10s pre-sputtering and 120s of automated centering of secondary electrons. Mass calibrations are performed every 12 hours. Instrument stability during analytical sessions was documented by repeated analyses of the UWG-2 standard that were used to bracket unknowns (see table above). The 2 S.D. uncertainty on each analysis is calculated as two standard deviations of the two blocks of UWG-2 standards that bracket a series of unknowns. The setting used allows an average reproducibility of ± ~0.25‰ (2 SD) on UWG-2 master standard on the two days of analysis.

Compositional bias correction for garnets was done according to the method of Page et al. (2010), in which a SIMS mount block containing garnet standard chips of known cation composition and $\delta^{18}O$ is analyzed at the start of the analytical session, with standards selected to bracket the range of cation composition of the unknown samples. For the grossular-andradite skarn garnets in this study, compositional bias correlates linearly with grossular composition for three grandite standards (92 LEW7, 92 LEW8, Grossular SE; Page et al., 2010) that span from XGrs = 0.96 to 0.06. Compositional bias corrections for this study range from 7.4 to 11.0‰. Back-scattered electron imaging was used to detect fine-scale zoning in mounted grains (e.g., text Fig. 3) and guide placement of SIMS spots.

Table DR-3: SIMS analysis data

Analysis Number	Spot name	$\delta^{18}O$ ‰ VSMOW	2SD	$\delta^{18}O$ ‰ Raw	Internal precision	X Grs	1+bias/1000	Comment*	
Session #1 Date: 5/31/2011-6/1/2011									
Sample: MD-12									
Calibration curve (y=ax^2+bx+c)									
	a	b	c						
example:	-0.9443	-3.2399	7.0746						
~~343~~	~~UWG-2~~			~~9.838~~	~~0.134~~			Omitted until stable	
~~344~~	~~UWG-2~~			~~9.775~~	~~0.157~~			Omitted until stable	
~~345~~	~~UWG-2~~			~~9.527~~	~~0.156~~			Omitted until stable	
~~346~~	~~UWG-2~~			~~9.612~~	~~0.182~~			Omitted until stable	
347	UWG-2			9.391	0.184				
348	UWG-2			9.329	0.206				
349	UWG-2			9.209	0.151				
350	UWG-2			9.249	0.203				
	average and 2SD			9.491	0.172				
								EMPA Spot	µm
351	MD12-1	1.13	0.36	10.040	0.190	0.49	1.008899	271	99
352	MD12-2	-0.50	0.36	8.956	0.206	0.35	1.009457	279	1386
353	MD12-2	0.76	0.36	9.689	0.262	0.48	1.008923	270	49
354	MD12-4	0.49	0.36	11.200	0.178	0.00	1.010702	274	912
355	MD12-5	0.62	0.36	11.337	0.176	0.00	1.010707	273	584
356	MD12-6	0.24	0.36	10.955	0.169	0.00	1.010711	272	321
357	MD12-7	1.51	0.36	11.057	0.161	0.33	1.009535	275	1014
358	MD12-8	1.58	0.36	11.041	0.168	0.35	1.009448	276	1070
359	MD12-9	1.74	0.36	10.772	0.214	0.46	1.009020	277	1262
360	MD12-10	-0.44	0.36	9.123	0.281	0.32	1.009570	278	1329
361	UWG-2			9.646	0.266				
362	UWG-2			9.465	0.187				
363	UWG-2			9.442	0.151				
364	UWG-2			9.732	0.173				
	average and 2SD			9.571	0.281				
	bracket and 2SD			**9.433**	**0.364**				
Sample: MD-27									
365	MD27-1	3.27	0.28	12.498	0.180	0.45	1.009203	280	
366	MD27-2	2.09	0.28	11.489	0.204	0.40	1.009375	286	
367	MD27-3	2.15	0.28	11.246	0.158	0.48	1.009077	287	
368	MD27-4	3.64	0.28	12.637	0.195	0.50	1.008968	281	
369	MD27-5	3.22	0.28	11.903	0.193	0.57	1.008659	283	
370	MD27-6	3.23	0.28	12.020	0.177	0.55	1.008759	282	
371	MD27-7	2.56	0.28	11.158	0.178	0.59	1.008575	284	
372	MD27-7	2.46	0.28	11.285	0.196	0.54	1.008801	285	
373	MD27-8	3.73	0.28	13.302	0.229	0.36	1.009532	289	
374	MD27-8	3.33	0.28	12.653	0.228	0.42	1.009293	290	
375	MD27-11	3.25	0.28	11.832	0.248	0.60	1.008555	291	
376	MD27-12	3.04	0.28	12.193	0.174	0.46	1.009126	292	
377	MD27-13	4.10	0.28	13.719	0.217	0.35	1.009580	288	
378	UWG-2			9.760	0.225				
379	UWG-2			9.415	0.195				
380	UWG-2			9.430	0.212				
381	UWG-2			9.602	0.162				
382	average and 2SD			9.552	0.325				
383	**bracket and 2SD**			**9.562**	**0.282**				
382	MD27-14	2.83	0.28	11.659	0.207	0.53	1.008802	293	
383	MD27-15	3.26	0.28	12.516	0.263	0.43	1.009224	294	
384	MD27-16	2.61	0.28	11.750	0.220	0.46	1.009120	295	
385	MD27-17	1.80	0.28	11.231	0.180	0.38	1.009418	296	
386	MD27-18	3.95	0.28	13.321	0.199	0.41	1.009331	297	
387	MD27-19	4.38	0.28	13.028	0.168	0.58	1.008614	298	
388	MD27-20	3.67	0.28	12.231	0.243	0.60	1.008526	299	
389	MD27-21	3.15	0.28	11.471	0.131	0.65	1.008296	300	

390	UWG2			9.515	0.211				
391	UWG2			9.484	0.177				
392	UWG2			9.674	0.199				
393	UWG2			9.348	0.164				
	average and 2SD			9.505	0.268				
	bracket and 2SD			**9.529**	**0.280**				
Sample: MD-36									
394	MD-36-1	3.06	0.31	12.178	0.181	0.46	1.009089	307	49
395	MD-36-2	4.13	0.31	14.007	0.192	0.27	1.009838	308	86
396	MD-36-3	4.06	0.31	13.864	0.201	0.29	1.009762	309	112
397	MD-36-4	3.69	0.31	12.302	0.227	0.58	1.008580	310	151
398	MD-36-5	-3.71	0.31	3.842	0.192	0.80	1.007577	321	897
399	MD-36-5	-3.78	0.31	3.765	0.206	0.80	1.007577	321	888
400	MD-36-7	2.65	0.31	10.896	0.193	0.66	1.008226	313	461
401	MD-36-8	2.83	0.31	10.810	0.167	0.72	1.007953	315	681
402	MD-36-9	-0.88	0.31	6.837	0.119	0.77	1.007719	316	792
403	MD-36-10	1.40	0.31	9.412	0.231	0.71	1.007999	325	759
404	MD-36-11	1.89	0.31	10.135	0.207	0.66	1.008226	324	786
405	MD-36-12	-4.04	0.31	3.880	0.136	0.72	1.007953	318	839
406	MD-36-13	-0.79	0.31	7.115	0.130	0.73	1.007906	317	814
407	MD-36-14	-3.53	0.31	4.024	0.193	0.80	1.007577	321	869
408	MD-36-15	2.94	0.31	10.962	0.159	0.71	1.007999	326	532
409	MD-36-16	-0.88	0.31	8.113	0.194	0.48	1.009006	323	921
410	MD-36-16	-1.17	0.31	7.907	0.184	0.46	1.009089	322	921
411	MD-36-17	-0.69	0.31	7.970	0.246	0.56	1.008667	327	937
412	UWG2			9.267	0.173				
413	UWG2			9.691	0.156				
414	UWG2			9.443	0.161				
415	UWG2			9.625	0.175				
	average and 2SD			9.507	0.382				
	bracket and 2SD			**9.506**	**0.305**				
416	MD-36-18	0.88	0.45	9.593	0.215	0.54	1.008707	333	1130
417	MD-36-19	0.85	0.45	9.737	0.208	0.50	1.008880	332	1107
418	MD-36-20	-0.48	0.45	7.694	0.190	0.66	1.008179	329	1017
419	MD-36-21	-0.25	0.45	7.981	0.170	0.65	1.008235	330	1036
420	MD-36-22	-0.56	0.45	7.730	0.185	0.64	1.008290	328	963
421	MD-36-23	-0.25	0.45	8.080	0.150	0.63	1.008328	331	1061
Sample: EMP-2									
422	EMP-2-1	-1.43	0.45	7.205	0.173	0.55	1.008651	244	51
423	EMP-2-2	-0.66	0.45	8.065	0.211	0.54	1.008727	245	188
424	EMP-2-3	-0.32	0.45	8.136	0.176	0.60	1.008454	246	419
425	EMP-2-4	2.05	0.45	10.642	0.220	0.57	1.008572	248	540
426	EMP-2-5	2.40	0.45	10.922	0.157	0.59	1.008500	247	501
427	EMP-2-6	1.51	0.45	9.832	0.141	0.63	1.008311	249	598
428	EMP-2-6	1.76	0.45	10.379	0.168	0.56	1.008602	251	723
429	EMP-2-8	0.99	0.45	9.743	0.202	0.53	1.008741	250	670
430	UWG2			9.590	0.161				
431	UWG2			9.628	0.157				
432	UWG2			9.401	0.129				
433	UWG2			9.032	0.197				
	average and 2SD			9.413	0.545				
	bracket and 2SD			**9.460**	**0.447**				
434	EMP-2-9	2.14	0.43	11.447	0.116	0.41	1.009290	253	810
435	EMP-2-10	2.21	0.43	11.521	0.199	0.41	1.009290	253	771
436	EMP-2-11	0.90	0.43	9.961	0.193	0.47	1.009055	255	834
437	EMP-2-12	1.17	0.43	10.656	0.143	0.36	1.009477	256	906
438	EMP-2-13	1.67	0.43	11.132	0.205	0.37	1.009447	257	911
439	EMP-2-13	2.12	0.43	11.399	0.204	0.42	1.009255	258	1007
440	EMP-2-15	1.00	0.43	9.986	0.163	0.49	1.008980	259	1113
441	EMP-2-15	1.87	0.43	11.066	0.109	0.44	1.009183	260	1234
442	EMP-2-16	2.34	0.43	10.931	0.245	0.58	1.008573	261	1354

443	EMP-2-18	2.31	0.43	11.114	0.189	0.53	1.008779	262	1417
444	EMP-2-19	3.31	0.43	12.563	0.141	0.43	1.009220	264	1581
445	EMP-2-20	3.86	0.43	13.420	0.178	0.35	1.009520	263	1658
446	EMP-2-21	4.22	0.43	13.584	0.213	0.40	1.009328	265	1619
447	EMP-2-22	2.70	0.43	11.816	0.193	0.46	1.009087	266	1716
448	EMP-2-23	3.07	0.43	11.588	0.113	0.60	1.008490	267	1759
449	UWG2			9.705	0.154				
450	UWG2			9.534	0.166				
451	UWG2			9.676	0.147				
452	UWG2			9.517	0.232				
	average and 2SD			9.608	0.192				
	bracket and 2SD			**9.510**	**0.432**				
453	EMP-2-24	2.64	0.33	11.333	0.200	0.56	1.008669	267	1884
454	EMP-2-25	2.20	0.33	10.633	0.211	0.62	1.008410	268	2000
455	EMP-2-26	2.52	0.33	10.598	0.201	0.70	1.008056	269	2072
Sample: EMP-2A									
456	EMP-2A-1	-0.68	0.33	7.810	0.148	0.60	1.008498	334	27
457	EMP-2A-2	1.41	0.33	10.860	0.224	0.37	1.009435	339	476
458	EMP-2A-3	1.40	0.33	10.797	0.268	0.39	1.009383	340	522
459	EMP-2A-4	-0.61	0.33	7.942	0.218	0.59	1.008553	335	163
460	EMP-2A-5	-0.41	0.33	8.151	0.179	0.58	1.008561	336	370
~~461~~	~~EMP-2A-6~~	~~-1.68~~	~~0.33~~	~~7.386~~	~~0.704~~	~~0.46~~	~~1.009086~~	Pit on crack	
462	EMP-2A-6	-0.25	0.33	8.323	0.187	0.58	1.008578	337	389
~~463~~	~~EMP-2A-8~~	~~1.75~~	~~0.33~~	~~10.392~~	~~0.188~~	~~0.57~~	~~1.008630~~	Spot mixes domains	
464	EMP-2A-8	1.37	0.33	10.313	0.150	0.50	1.008928	342	598
465	EMP-2A-10	0.72	0.33	9.506	0.126	0.53	1.008777	346	652
466	EMP-2A-11	0.75	0.33	9.392	0.243	0.57	1.008633	344	709
~~467~~	~~EMP-2A-12~~	~~0.37~~	~~0.33~~	~~9.501~~	~~0.149~~	~~0.45~~	~~1.009127~~	Spot mixes domains	
468	EMP-2A-13	2.00	0.33	11.055	0.146	0.47	1.009037	349	838
469	EMP-2A-14	1.40	0.33	10.981	0.202	0.34	1.009566	350	886
470	EMP-2A-15	0.81	0.33	9.683	0.197	0.51	1.008862	347	762
~~471~~	~~EMP-2A-16~~	~~0.67~~	~~0.33~~	~~9.428~~	~~0.146~~	~~0.54~~	~~1.008751~~	Spot mixes domains	
472	UWG2			9.287	0.212				
473	UWG2			9.529	0.237				
474	UWG2			9.300	0.165				
475	UWG2			8.907	0.186				
	average and 2SD			9.372	0.272				
	bracket and 2SD			**9.507**	**0.327**				
Sample: EMP-36 (Additional Analyses)									
477	UWG2			9.096	0.117				
478	UWG2			9.611	0.242				
479	UWG2			9.379	0.190				
480	UWG2			9.273	0.250				
	average and 2SD			9.340	0.430				
481	MD-36-25	2.76	0.32	11.170	0.163	0.59	1.008386	311	276
482	MD-36-26	2.85	0.32	11.273	0.229	0.59	1.008399	312	353
483	MD-36-27	2.65	0.32	10.598	0.166	0.70	1.007927	314	568
496	UWG-2			9.531	0.178				
497	UWG-2			9.409	0.159				
498	UWG-2			9.266	0.200				
499	UWG-2			9.394	0.228				
	average and 2SD			9.400	0.217				
	bracket and 2SD			**9.370**	**0.322**				

Note: Samples are analyzed together with the UWG-2 master standard to correct the raw $\delta^{18}O$ of unknowns (Table DR-3, "$\delta^{18}O_{Raw}$" column). Following SIMS analysis, garnet composition for each unknown spot is measured by electron microprobe (Table DR4). EMPA analytical spots are offset 10μm from SIMS spots because EMPA analysis directly in pits will produce irregular X-ray emission from interaction volumes that will compromise analyses (Page et al., 2010). Grossular compositions from EMPA data are used to calculate a bias for each analysis relative to UWG-2 and a final $\delta^{18}O$ is calculated ("$\delta^{18}O$ ‰ VSMOW" column). Comment may be any trait that is used to sort or evaluate the data. Here, transect EMPA spot number and transect distances are given, as are indications of irregular pits. Strikethrough indicates incorrect pit placement discovered upon SEM analysis after the SIMS session. These data were excluded from the results of this study.

TABLE DR. 4 EMPA ANALYSES OF EMPIRE MTN. GARNET FOR COMPOSITIONAL BIAS CORRECTION

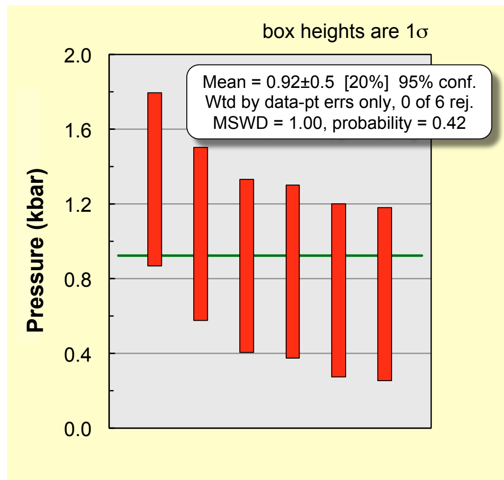
Sample	SIMS spot	SiO2	TiO2	Al2O3	Cr2O3	Fe2O3	FeO	MnO	MgO	CaO	Total	Si	Ti	Al	Cr	Fe3+	Fe2+	Mn	Mg	Ca	% Alm	% Pyp	%Sps	%Ca-Ti	%Grs	%And
12																										
270	353	37.32	0.35	10.67	0.00	16.59	0.00	1.09	0.06	32.03	98.10	3.02	0.02	1.02	0.00	1.01	0.00	0.07	0.01	2.78	0.00	0.25	2.61	1.00	48.25	47.90
271	351	37.45	0.28	10.70	0.00	16.34	0.00	1.13	0.01	31.77	97.67	3.04	0.02	1.02	0.00	1.00	0.00	0.08	0.00	2.77	0.00	0.06	2.74	0.81	48.81	47.58
272	356	34.82	0.00	0.01	0.00	30.88	0.00	0.52	0.00	31.08	97.29	3.02	0.00	0.00	0.00	2.02	0.00	0.04	0.00	2.89	0.00	0.00	1.31	0.00	0.05	98.70
273	355	35.67	0.00	0.03	0.00	30.92	0.00	0.49	0.04	31.09	98.25	3.06	0.00	0.00	0.00	1.99	0.00	0.04	0.01	2.85	0.00	0.18	1.24	0.01	0.16	98.41
274	354	35.44	0.00	0.06	0.00	30.73	0.00	0.45	0.03	31.14	97.85	3.05	0.00	0.01	0.00	1.99	0.00	0.03	0.00	2.87	0.00	0.13	1.13	0.00	0.30	98.45
275	357	36.65	0.99	7.06	0.00	20.61	0.00	0.95	0.02	31.76	98.03	3.02	0.06	0.69	0.00	1.28	0.00	0.07	0.00	2.81	0.00	0.08	2.31	2.96	33.03	61.62
276	358	36.75	0.77	7.74	0.00	20.43	0.00	1.18	0.05	31.96	98.89	3.01	0.05	0.75	0.00	1.26	0.00	0.08	0.01	2.80	0.00	0.22	2.82	2.24	35.26	59.45
277	359	37.36	0.48	9.96	0.00	16.94	0.00	1.18	0.01	31.88	97.80	3.04	0.03	0.96	0.00	1.04	0.00	0.08	0.00	2.78	0.00	0.03	2.85	1.40	45.90	49.82
278	360	36.67	0.28	7.43	0.00	22.52	0.00	1.96	0.02	30.23	99.11	3.01	0.02	0.72	0.00	1.39	0.00	0.14	0.00	2.65	0.00	0.08	4.87	0.78	32.11	62.16
279	352	37.21	0.25	8.09	0.00	21.54	0.00	1.88	0.00	29.58	98.55	3.04	0.02	0.78	0.00	1.33	0.00	0.13	0.00	2.59	0.00	0.00	4.78	0.70	35.02	59.52
27																										
280	365	37.36	0.19	9.60	0.00	17.68	0.00	0.98	0.03	32.79	98.64	3.03	0.01	0.92	0.00	1.08	0.00	0.07	0.00	2.85	0.00	0.14	2.30	0.56	44.58	52.42
281	368	37.02	0.20	10.77	0.00	15.67	0.00	1.02	0.02	32.56	97.26	3.03	0.01	1.04	0.00	0.96	0.00	0.07	0.00	2.85	0.00	0.09	2.41	0.59	50.23	46.67
282	370	37.82	0.26	12.24	0.00	14.20	0.00	1.28	0.04	32.37	98.21	3.04	0.02	1.16	0.00	0.86	0.00	0.09	0.01	2.78	0.00	0.18	3.02	0.76	55.16	40.88
283	369	38.31	0.27	12.80	0.00	13.53	0.00	1.23	0.03	32.92	99.08	3.04	0.02	1.20	0.00	0.81	0.00	0.08	0.00	2.80	0.00	0.14	2.87	0.76	57.47	38.76
284	371	37.92	0.12	13.36	0.00	12.90	0.00	1.54	0.02	32.60	98.44	3.02	0.01	1.26	0.00	0.77	0.00	0.10	0.00	2.79	0.00	0.07	3.60	0.34	59.38	36.61
285	372	38.28	0.21	12.03	0.00	14.62	0.00	1.33	0.01	32.57	99.04	3.05	0.01	1.13	0.00	0.88	0.00	0.09	0.00	2.78	0.00	0.03	3.13	0.60	54.18	42.06
286	366	37.00	0.28	8.51	0.00	18.67	0.00	0.85	0.05	32.08	97.44	3.05	0.02	0.83	0.00	1.16	0.00	0.06	0.01	2.83	0.00	0.22	2.06	0.83	40.34	56.55
287	367	37.42	0.28	10.32	0.00	16.42	0.00	1.24	0.06	32.58	98.31	3.03	0.02	0.99	0.00	1.00	0.00	0.09	0.01	2.83	0.00	0.23	2.92	0.81	47.63	48.40
288	377	36.88	0.37	7.47	0.00	20.33	0.00	0.93	0.08	32.00	98.06	3.04	0.02	0.73	0.00	1.26	0.00	0.07	0.01	2.82	0.00	0.35	2.25	1.10	35.18	61.14
289	373	36.99	0.36	7.67	0.00	19.91	0.00	0.82	0.07	32.24	98.06	3.04	0.02	0.74	0.00	1.23	0.00	0.06	0.01	2.84	0.00	0.28	1.95	1.10	36.39	60.27
290	374	36.85	0.53	9.20	0.00	18.21	0.00	0.95	0.08	32.34	98.16	3.01	0.03	0.89	0.00	1.12	0.00	0.07	0.01	2.83	0.00	0.32	2.27	1.54	42.35	53.51
291	375	38.14	0.20	13.43	0.00	12.66	0.00	1.41	0.06	32.58	98.48	3.03	0.01	1.26	0.00	0.76	0.00	0.10	0.01	2.78	0.00	0.25	3.31	0.57	59.85	36.02
292	376	37.40	0.38	10.06	0.00	16.81	0.00	1.13	0.04	32.24	98.06	3.04	0.02	0.96	0.00	1.03	0.00	0.08	0.01	2.81	0.00	0.19	2.70	1.11	46.44	49.56
293	382	38.13	0.23	12.03	0.00	15.13	0.00	1.21	0.04	31.60	98.37	3.05	0.01	1.13	0.00	0.91	0.00	0.08	0.01	2.71	0.00	0.17	2.94	0.65	53.37	42.87
295	384	37.54	0.20	9.84	0.00	17.19	0.00	1.02	0.03	32.36	98.18	3.05	0.01	0.94	0.00	1.05	0.00	0.07	0.00	2.82	0.00	0.13	2.43	0.59	45.80	51.06
296	385	37.05	0.30	8.15	0.00	19.34	0.00	0.87	0.08	32.24	98.04	3.04	0.02	0.79	0.00	1.19	0.00	0.06	0.01	2.84	0.00	0.36	2.09	0.91	38.43	58.22
297	386	37.09	0.31	8.90	0.00	18.81	0.00	1.41	0.06	31.64	98.23	3.03	0.02	0.86	0.00	1.16	0.00	0.10	0.01	2.77	0.00	0.27	3.40	0.89	40.61	54.82
298	387	37.62	0.26	12.97	0.00	13.55	0.00	1.26	0.01	32.84	98.52	3.01	0.02	1.22	0.00	0.81	0.00	0.09	0.00	2.81	0.00	0.05	2.95	0.75	57.75	38.51
299	388	37.81	0.23	13.57	0.00	12.78	0.00	1.53	0.02	32.70	98.64	3.01	0.01	1.27	0.00	0.77	0.00	0.10	0.00	2.79	0.00	0.10	3.57	0.63	59.76	35.94
300	389	38.24	0.26	14.66	0.00	10.83	0.00	1.54	0.03	32.75	98.31	3.03	0.02	1.37	0.00	0.65	0.00	0.10	0.00	2.78	0.00	0.12	3.59	0.72	64.95	30.62
36																										
307	394	37.50	0.06	9.94	0.00	17.65	0.00	0.95	0.05	32.31	98.47	3.04	0.00	0.95	0.00	1.08	0.00	0.07	0.01	2.81	0.00	0.21	2.26	0.17	45.63	51.72
308	395	36.57	0.00	5.59	0.00	23.28	0.00	0.70	0.03	32.03	98.19	3.04	0.00	0.55	0.00	1.46	0.00	0.05	0.00	2.86	0.00	0.12	1.69	0.00	26.83	71.37
309	396	36.51	0.00	5.97	0.00	21.98	0.00	0.74	0.05	32.07	97.31	3.05	0.00	0.59	0.00	1.38	0.00	0.05	0.01	2.87	0.00	0.19	1.78	0.00	29.26	68.79
310	397	38.05	0.06	12.95	0.00	13.28	0.00	1.30	0.04	32.64	98.32	3.04	0.00	1.22	0.00	0.80	0.00	0.09	0.00	2.79	0.00	0.17	3.04	0.19	58.40	38.22
311	481	38.10	0.66	13.33	0.00	12.68	0.00	1.18	0.00	32.89	98.83	3.02	0.04	1.25	0.00	0.76	0.00	0.08	0.00	2.79	0.00	0.00	2.76	1.88	59.35	36.06
312	482	37.64	0.58	13.07	0.00	12.70	0.00	1.14	0.00	32.94	98.06	3.01	0.03	1.23	0.00	0.77	0.00	0.08	0.00	2.83	0.00	0.00	2.66	1.66	59.05	36.63
313	400	38.60	0.04	15.07	0.00	11.05	0.00	1.28	0.00	33.09	99.13	3.03	0.00	1.39	0.00	0.65	0.00	0.08	0.00	2.78	0.00	0.00	2.96	0.10	66.03	30.92
314	483	38.68	0.14	16.13	0.00	9.63	0.00	1.49	0.00	32.76	98.83	3.03	0.01	1.49	0.00	0.57	0.00	0.10	0.00	2.75	0.00	0.02	3.46	0.38	69.60	26.54
315	401	38.84	0.26	16.73	0.00	8.87	0.00	1.50	0.00	32.70	98.89	3.03	0.02	1.54	0.00	0.52	0.00	0.10	0.00	2.73	0.00	0.00	3.50	0.70	71.61	24.22
316	402	38.77	0.00	18.04	0.00	7.27	0.00	1.37	0.01	33.49	98.91	3.01	0.00	1.65	0.00	0.42	0.00	0.09	0.00	2.78	0.00	0.02	3.13	0.00	77.08	19.83
317	406	39.00	0.04	16.60	0.00	8.55	0.00	1.01	0.00	33.79	99.00	3.04	0.00	1.52	0.00	0.50	0.00	0.07	0.00	2.82	0.00	0.00	2.31	0.12	73.42	24.14
318	405	38.75	0.10	16.10	0.00	9.14	0.00	0.84	0.00	33.47	98.41	3.04	0.01	1.49	0.00	0.54	0.00	0.06	0.00	2.81	0.00	0.00	1.96	0.30	71.74	26.02
319	407	38.53	0.19	16.24	0.00	9.44	0.00	0.83	0.00	33.45	98.65	3.02	0.01	1.50	0.00	0.56	0.00	0.05	0.00	2.81	0.00	0.00	1.92	0.52	71.23	26.44
320	398	37.34	0.07	9.37	0.00	17.60	0.00	0.81	0.04	32.59	97.82	3.05	0.00	0.90	0.00	1.08	0.00	0.06	0.01	2.85	0.00	0.18	1.93	0.20	44.41	53.28
321	399	38.83	0.08	18.47	0.00	6.04	0.00	1.16	0.00	33.31	97.87	3.03	0.00	1.70	0.00	0.35	0.00	0.08	0.00	2.78	0.00	0.00	2.69	0.21	80.38	16.79
322	410	37.40	0.09	9.81	0.00	17.32	0.00	0.84	0.01	32.48	97.96	3.05	0.01	0.94	0.00	1.06	0.00	0.06	0.00	2.83	0.00	0.04	2.01	0.27	45.91	51.77
323	409	37.59	0.08	10.36	0.00	16.85	0.00	1.06	0.03	32.31	98.28	3.04	0.01	0.99	0.00	1.03	0.00	0.07	0.00	2.80	0.00	0.12	2.53	0.24	47.63	49.48
324	404	38.36	0.31	14.70	0.00	10.82	0.00	1.08	0.02	32.94	98.23	3.04	0.02	1.37	0.00	0.64	0.00	0.07	0.00	2.79	0.00	0.08	2.53	0.88	65.65	30.86
325	403	38.54	0.25	16.44	0.00	8.91	0.00	1.47	0.00	33.12	98.70	3.02	0.01	1.52	0.00	0.53	0.00	0.10	0.00	2.78	0.00	0.00	3.39	0.68	71.34	24.69
326	408	38.88	0.24	16.24	0.00	9.18	0.00	1.30	0.01	32.92	98.77	3.04	0.01	1.50	0.00	0.54	0.00	0.09	0.00	2.76	0.00	0.04	3.03	0.67	70.73	25.53
327	411	37.55	0.56	12.57	0.00	13.93	0.00	1.11	0.07	32.55	98.34	3.01	0.03	1.19	0.00	0.84	0.00	0.08	0.01	2.79	0.00	0.27	2.63	1.58	55.93	39.59
328	420	38.27	0.38	14.23	0.00	11.24	0.00	1.37	0.03	32.71	98.23	3.04	0.02	1.33	0.00	0.67	0.00	0.09	0.00	2.78	0.00	0.13	3.19	1.08	63.54	32.06
329	418	38.29	0.26	15.20	0.00	10.64	0.00	1.57	0.01	32.60	98.59	3.02	0.02	1.41	0.00	0.63	0.00	0.11	0.00	2.75	0.00	0.05	3.67	0.73	66.03	29.51
330	419	38.61	0.47	14.82	0.00	10.82	0.00	1.51	0.04	32.38	98.65	3.04	0.03	1.38	0.00	0.64	0.00	0.10	0.01	2.73	0.00	0.18	3.55	1.31	64.78	30.18
331	421	38.06	0.48	14.18	0.00	11.49	0.00	1.46	0.03	32.70	98.39	3.02	0.03	1.33	0.00	0.69	0.00	0.10	0.00	2.78	0.00	0.13	3.40	1.35	62.68	32.43
332	417	37.47	0.03	10.77	0.00	16.04	0.00	1.00	0.04	32.27	97.61	3.05	0.00	1.03	0.00	0.98	0.00	0.07	0.00	2.81	0.00	0.16	2.38	0.09	49.91	47.45
333	416	37.66	0.09	11.82	0.00	14.84	0.00	0.96	0.05	32.38	97.80	3.04	0.01	1.12	0.00	0.90	0.00	0.07	0.01	2.80	0.00	0.22	2.29	0.26	53.98	43.25
2																										
244	422	37.77	0.15	12.90	0.00	14.01	0.00	2.37	0.04	30.59	97.83	3.04	0.01	1.22	0.00	0.85	0.00	0.16	0.00	2.64	0.00	0.17	5.75	0.42	55.30	38.35
245	423	37.82	0.03	12.65	0.00	14.87	0.00	2.50	0.04	30.71	98.62	3.03	0.00	1.19	0.00	0.90	0.00	0.17	0.00	2.63	0.00	0.16	6.05	0.08	53.52	40.19
246	424	37.77	0.15	14.09	0.00	12.52	0.00	2.38	0.01	30.77	97.69	3.03	0.01	1.33	0.00	0.75	0.00	0.16	0.00	2.64	0.00	0.06	5.76	0.41	59.82	33.94
247	426	38.21	0.17	13.90	0.00	12.89	0.00	2.37	0.06	31.05	98.66	3.03	0.01	1.30	0.00	0.77	0.00	0.16	0.01	2.64	0.00	0.27	5.69	0.45	58.79	34.80
248	425	37.88	0.23	13.37	0.00	13.40	0.00	2.29	0.05	31.27	98.50	3.02	0.01	1.26	0.00	0.80	0.00	0.15	0.01	2.67	0.00	0.21	5.46	0.64	57.13	36.55
249	427	38.57	0.08	15.36	0.00	11.55	0.00	2.75	0.00	31.13	99.42	3.02	0.00	1.42	0.00	0.68	0.00	0.18	0.00	2.61	0.00	0.00	6.53	0.20	63.07	30.28
250	429	37.90	0.13	12.84	0.00	13.86	0.00	1.79	0.01	31.89	98.42	3.03	0.01	1.21	0.00	0.83	0.00	0.12	0.00	2.73	0.00	0.04	4.24	0.36	56.44	38.92
251	428	37.84	0.12	11.96	0.00	15.07	0.00	1.56	0.00	31.72	98.26	3.04	0.01	1.13	0.00	0.91	0.00	0.11	0.00	2.73	0.00	0.00	3.74	0.35	53.19	42.76
253	434	36.12	0.19	8.76	0.00	18.46	0.00	1.15	0.02	31.53	96.24	3.02	0.01	0.86	0.00	1.16	0.00	0.08	0.00	2.82	0.00	0.09	2.80	0.58	41.16	55.37
254	436	37.11	0.23	10.00	0.00	16.50	0.00	1.21	0.01	31.91	96.98	3.05	0.01	0.97	0.00	1.02	0.00	0.08	0.00	2.81	0.00	0.06	2.91	0.69	46.92	49.41
255	437	37.42	0.14	7.79	0.00	20.24	0.00	0.98	0.04	31.55	98.16	3.07	0.01	0.75	0.00	1.25	0.00	0.07	0.01	2.77	0.00	0.19	2.39	0.43	36.50	60.50
256	438	37.07	0.15	7.90	0.00	19.81	0.00	1.03	0.03	31.73	97.71	3.06	0.01	0.77	0.00	1.23	0.00	0.07	0.00	2.80	0.00	0.13	2.49	0.46	37.25	59.67
257	439	37.00	0.21	9.07	0.00	18.42	0.00	1.10	0.03	31.78	97.60	3.04	0.01	0.88	0.00	1.14	0.00	0.08	0.00	2.80	0.00	0.13	2.65	0.62	42.04	54.55
258	440	37.59	0.24	10.66	0.00	16.38	0.00	1.12	0.02	32.43	98.44	3.04	0.01	1.01	0.00	1.00	0.00	0.08	0.00	2.81	0.00	0.09	2.67	0.69	48.73	47.82
259	441	37.42	0.09	9.45	0.00	18.01	0.00	1.06	0.01	31.85	97.89	3.05	0.01	0.91	0.00	1.11	0.00	0.07	0.00	2.78	0.00	0.04	2.56	0.26	43.82	53.32
260	442	37.94	0.15	13.18	0.00	13.21	0.00	1.67	0.02	32.06	98.23	3.03	0.01	1.24	0.00	0.79	0.00	0.11	0.00	2.75	0.00	0.08	3.94	0.42	58.27	37.28
261	443	38.04	0.19	11.74	0.00	14.61	0.00	1.43	0.01	32.04	98.07	3.06	0.01	1.11	0.00	0.88	0.00	0.10	0.00	2.76	0.00	0.03	3.42	0.54	53.48	42.52
262	444	37.41	0.14	9.14	0.00	18.17	0.00	0.89	0.02	32.13	97.89	3.06	0.01	0.88	0.00	1.12	0.00	0.06	0.00	2.81	0.00	0.09	2.13	0.41	42.90	54.47
263	446	36.80	0.13	8.61	0.00	19.07	0.00	0.95	0.06	32.32	97.95	3.02	0.01	0.83	0.00	1.18	0.00	0.07	0.01	2.84	0.00	0.24	2.27	0.38	40.23	56.88
264	445	36.58	0.16	7.51	0.00	20.51	0.00	0.90	0.05	31.94	97.66	3.03	0.01	0.73	0.00	1.28	0.00	0.06	0.01	2.83	0.00	0.22	2.18	0.49	35.40	61.71
265	447	37.64	0.10	9.96	0.00	17.07	0.00	1.20	0.05	32.33	98.34	3.05	0.01	0.95	0.00	1.04	0.00	0.08	0.01	2.81	0.00	0.21	2.83	0.30	46.15	50.50
266	448	37.92	0.04	13.49	0.00	12.72	0.00	1.45	0.01	32.34	97.98	3.03	0.00	1.27	0.00	0.77	0.00	0.10	0.00	2.77	0.00	0.05	3.43	0.12	60.17	36.23
267	453	37.20	0.12	12.28	0.00	14.02	0.00	1.16	0.03	32.55	97.36	3.02	0.01	1.17	0.00	0.86	0.00	0.08	0.00	2.83	0.00	0.12	2.74	0.35	55.99	40.81
268	454	38.12	0.44	13.80	0.00	11.97	0.00	1.09	0.00	32.60	98.02	3.04	0.03	1.30	0.00	0.72	0.00	0.07	0.00	2.78	0.00	0.00	2.57	1.26	61.90	34.29
269	455	38.87	0.22	15.90	0.00	9.37	0.00	1.40	0.02	32.57	98.35	3.05	0.01	1.47	0.00	0.55	0.00	0.09	0.00	2.74	0.00	0.08	3.29	0.62	69.76	26.26
2A																										
334	456	37.55	0.25	14.44	0.00	12.67	0.00	2.40	0.04	31.24	98.58	2.99	0.01	1.35	0.00	0.76	0.00	0.16	0.01	2.66	0.00	0.18	5.71	0.65	59.91	33.55
335	459	37.67	0.19	13.72	0.00	12.82	0.00	2.36	0.04	31.02	97.82	3.02	0.01	1.30	0.00	0.77	0.00	0.16	0.00	2.67	0.00	0.16	5.67	0.51	58.66	35.00
336	460	38.13	0.17	13.80	0.00	13.08	0.00	2.31	0.03	30.89	98.40	3.03	0.01	1.29	0.00	0.78	0.00	0.16	0.00	2.63	0.00	0.13	5.57	0.46	58.46	35.38
337	462	37.69	0.21	13.78	0.00	13.07	0.00	2.53	0.03	30.97	98.28	3.01	0.01	1.30	0.00	0.79	0.00	0.17	0.00	2.65	0.00	0.13	6.07	0.57	58.07	35.16
338	461	37.37	0.20	10.45	0.00	17.35	0.00	1.79	0.05	31.31	98.52	3.03	0.01	1.00	0.00	1.06	0.00	0.12	0.01	2.72	0.00	0.20	4.31	0.56	46.10	48.84
339	457	37.08	0.03	8.12	0.00	20.06	0.00	1.32	0.03	31.56	98.20	3.04	0.00	0.79	0.00	1.24	0.00	0.09	0.00	2.78	0.00	0.14	3.21	0.09	37.45	59.11
340	458	37.24	0.26	8.52	0.00	19.45	0.00	1.47	0.10	31.39	98.42	3.04	0.02	0.82	0.00	1.20	0.00	0.10	0.01	2.75	0.00	0.41	3.54	0.75	38.78	56.52
341	463	37.88	0.01	13.10	0.00	13.62	0.00	2.21	0.00	31.12	97.95	3.04	0.00	1.24	0.00	0.82	0.00	0.15	0.00	2.68	0.00	0.00	5.31	0.03	56.88	37.78
342	464	37.41	0.05	10.98	0.00	16.03	0.00	1.40	0.03	31.90	97.80	3.04	0.00	1.05	0.00	0.98	0.00	0.10	0.00	2.78	0.00	0.13	3.35	0.13	49.89	46.49
343	465	37.57	0.10	13.09	0.00	13.32	0.00	1.74	0.00	31.68	97.51	3.03	0.01	1.24	0.00	0.81	0.00	0.12	0.00	2.74	0.00	0.02	4.16	0.29	57.91	37.62
344	466	37.79	0.26	13.01	0.00	13.56	0.00	1.92	0.03	31.76	98.33	3.02	0.02	1.23	0.00	0.82	0.00	0.13	0.00	2.72	0.00	0.13	4.55	0.73	56.80	37.80
345	467	37.43	0.07	9.76	0.00	17.52	0.00	1.30	0.00	31.74	97.79	3.05	0.00	0.94	0.00	1.08	0.00	0.09	0.00	2.77	0.00	0.00	3.13	0.19	45.09	51.68
346	465	37.51	0.09	12.24	0.00	15.06	0.00	1.78	0.01	31.70	98.38	3.02	0.01	1.16	0.00	0.91	0.00	0.12	0.00	2.73	0.00	0.03	4.26	0.24	53.46	42.00
347	470	37.73	0.17	11.54	0.00	15.61	0.00	1.43	0.04	31.77	98.28	3.04	0.01	1.09	0.00	0.95	0.00	0.10	0.00	2.74	0.00	0.16	3.43	0.48	51.46	44.47
348	471	37.87	0.07	12.13	0.00	14.68	0.00	1.64	0.02	31.79	98.20	3.04	0.00	1.15	0.00	0.89	0.00	0.11	0.00	2.74	0.00	0.06	3.92	0.20	54.06	41.75
349	468	37.20	0.38	10.32	0.00	16.52	0.00	1.31	0.02	31.56	97.30	3.04	0.02	0.99	0.00	1.02	0.00	0.09	0.00	2.76	0.00	0.10	3.17	1.11	47.28	48.34
350	469	36.57	0.16	7.22	0.00	20.87	0.00	0.95	0.03	31.51	97.30	3.04	0.01	0.71	0.00	1.31	0.00	0.07	0.00	2.81	0.00	0.12	2.31	0.48	34.13	62.96

Note: Garnet compositions were measured with the University of Wisconsin CAMECA SX50 electron microprobe using wavelength dispersive spectrometry. Analytical conditions were 15 KeV accelerating voltage and 20 nA beam current. Counting times were 10 s on peak, 10 s on background. The instrument was standardized using the following crystalline standards and analyzer crystals: Si (TAP), Ca (PET) = Quebec grossular; Al (TAP), Mg (TAP)= USNM 143968 Kakanui pyrope; Ti (PET) = Miñas Gerais rutile; Fe (LIF) = Cameron Okahandja Hematite; Mn (LIF) = synthetic tephroite. Counting times were 10 s on peak, 10 s on background. Matrix corrections are after the Armstrong-Love/Scott correction of Armstrong (1988). Data were reduced using the *Probe for Windows* software of Donovan et al. (2007). Oxygen was calculated by stoichiometry and Fe^{2+}/Fe^{3+} estimated by charge balance assuming no site vacancies or OH substitution.

TABLE DR-5 HORNBLENDE AND PLAGIOCLASE FOR AL-IN-HORNBLENDE BAROMETRY

	High Al Hornblende Group						Low A lHornblende Group				
Specimen	HB1-A Gr 1	HB1-A Gr 2	HB1-B Gr 1	HB1-B Gr 2	HB1-B Gr 4	HB1-B Gr 5	HB1-A Gr 3	HB1-A Gr 4	HB1-A Gr 5	HB1-A Gr 6	HB1-B Gr 3
SiO2	50.64	50.79	50.49	51.27	50.97	51.50	53.49	52.00	54.37	54.06	52.85
TiO2	0.42	0.33	0.08	0.18	0.13	0.16	0.15	0.17	0.08	0.11	0.18
Al2O3	4.67	4.53	5.20	4.60	5.04	4.66	2.65	3.98	2.35	2.49	3.77
FeO*	13.70	14.01	14.61	13.37	13.99	13.28	12.03	13.31	11.77	11.81	13.03
MgO	13.92	13.98	13.81	14.44	13.74	14.25	15.91	14.88	16.29	15.65	14.82
MnO	0.55	0.61	0.63	0.59	0.66	0.54	0.50	0.47	0.59	0.55	0.54
CaO	11.98	12.17	12.08	12.15	12.20	12.15	12.05	12.04	12.38	12.24	12.21
Na2O	0.54	0.47	0.70	0.52	0.49	0.68	0.30	0.50	0.30	0.32	0.42
K2O	0.39	0.37	0.24	0.25	0.26	0.31	0.09	0.21	0.07	0.13	0.16
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	96.83	96.10	97.84	97.36	97.47	97.53	97.18	97.56	98.18	97.37	97.97
Formula Cations											
T-sites											
Si	7.409	7.402	7.308	7.427	7.402	7.449	7.702	7.507	7.738	7.769	7.590
Al^{IV}	0.591	0.598	0.692	0.573	0.598	0.551	0.298	0.493	0.262	0.231	0.410
Al(total)	0.806	0.778	0.887	0.786	0.863	0.795	0.450	0.677	0.394	0.421	0.639
M1,2,3 sites											
Al^{vi}	0.215	0.180	0.195	0.213	0.266	0.243	0.152	0.184	0.132	0.191	0.228
Ti	0.046	0.036	0.008	0.019	0.014	0.018	0.017	0.019	0.009	0.012	0.019
Fe^{3+}	0.219	0.278	0.433	0.275	0.255	0.246	0.109	0.231	0.110	0.049	0.140
Mg	3.036	3.035	2.979	3.118	2.974	3.073	3.414	3.201	3.454	3.352	3.173
Mn	0.069	0.076	0.078	0.073	0.081	0.067	0.061	0.058	0.071	0.067	0.066
Fe^{2+}	1.415	1.396	1.306	1.302	1.411	1.354	1.247	1.307	1.224	1.329	1.374
Ca	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
M4 site											
Fe	0.042	0.034	0.029	0.043	0.033	0.006	0.092	0.068	0.066	0.041	0.052
Ca	1.878	1.900	1.873	1.885	1.898	1.883	1.859	1.862	1.887	1.886	1.878
Na	0.080	0.066	0.098	0.072	0.068	0.110	0.049	0.069	0.046	0.073	0.070
	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
A -site											
Ca	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Na	0.072	0.067	0.099	0.073	0.069	0.081	0.036	0.070	0.036	0.016	0.046
K	0.072	0.069	0.045	0.046	0.049	0.056	0.017	0.040	0.012	0.023	0.029
Sum A	0.144	0.136	0.144	0.119	0.118	0.137	0.053	0.109	0.048	0.039	0.075
OH site											
O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OH	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cl	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
T (C)	605.1	603.5	634.0	597.7	578.9	613.4	585.4	600.7	590.1	601.1	580.8
P(Kb)	0.87	0.72	1.33	0.74	1.04	0.84	-1.12	0.18	-1.38	-1.15	-0.15
Averaged	X	X	X	X	X	X					
Average P (kb)		0.92									
±2 S.D.		0.50									

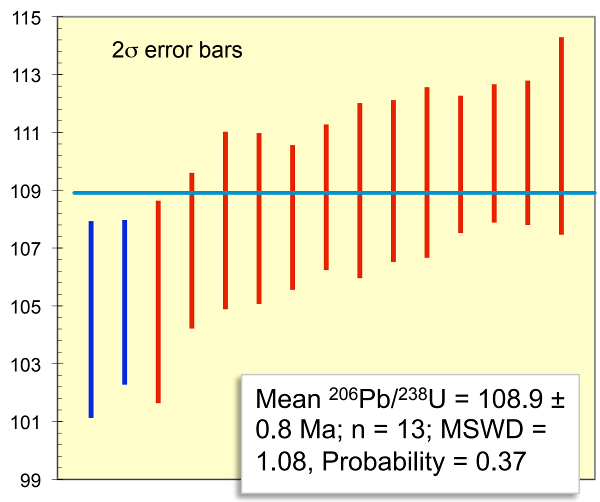
Plagioclase Feldspar Compositions	Pl-1	Pl-2	Pl-3	Pl-4	Pl-5	Pl-6	Pl-7
SiO2	60.42	65.33	62.15	62.63	58.26	58.49	58.38
Al2O3	25.19	22.18	24.18	23.85	26.30	26.52	26.41
FeO	0.12	0.06	0.13	0.11	0.27	0.23	0.25
CaO	6.75	3.14	5.15	5.02	7.89	7.96	7.92
Na2O	8.15	10.41	9.11	9.22	7.20	7.45	7.33
K2O	0.07	0.13	0.07	0.09	0.22	0.11	0.17
BaO	-	-	-	-	-	-	-
TOTAL	100.70	101.25	100.79	100.92	100.15	100.76	100.45
Formula Cations							
Si	2.68	2.85	2.74	2.76	2.61	2.60	2.60
Al	1.32	1.14	1.26	1.24	1.39	1.39	1.39
Fe(ii)	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Ca	0.32	0.15	0.24	0.24	0.38	0.38	0.38
Na	0.70	0.88	0.78	0.79	0.63	0.64	0.63
K	0.00	0.01	0.00	0.01	0.01	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	5.02	5.03	5.03	5.02	5.02	5.03	5.02
T/S	1.00	1.00	1.00	1.00	1.00	0.99	1.00
% An	31.28	14.22	23.71	22.98	37.20	36.90	37.08
% Ab	68.33	85.11	75.90	76.53	61.52	62.51	62.04
% Or	0.39	0.68	0.39	0.49	1.28	0.58	0.88

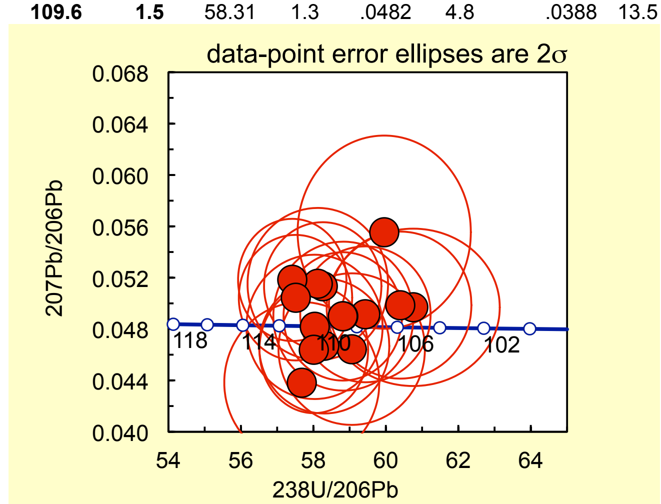


Note: Chemical compositions of hornblende and plagioclase were determined with wavelength dispersive spectrometry using the natural and synthetic crystalline standards as described in Table DR-5. Hornblende analyses are normalized to 23 oxygens following the formula calculation of Blundy and Holland (1990) and Holland and Blundy, (1994), as adopted by Anderson (1996). Plagioclase analyses are normalized to 8 oxygens. Hornblende and plagioclase compositions were used to calculate a temperature-corrected Al-in-hornblende pressure calculation for the sample using rim analyses adjacent to quartz and plagioclase to ensure localized equilibration (Anderson, 1996).

TABLE DR-6 SHRIMP-RG U-PB ANALYSES OF SAMPLE 17

Spot Name	% comm 206	ppm U	ppm Th	232Th /238U	204corr 206Pb /238U Age	1σ err	207corr 206Pb /238U Age	1σ err	Total 238 /206	% err	Total 207 /206	% err	4corr 207r /206r	% err
MD17-1.1C	0.01	208	151	0.75	**108.2**	**1.2**	**108.1**	**1.2**	59.10	1.1	.0490	4.2	.0489	4.2
MD17-1.2R	0.90	176	91	0.54	**108.1**	**1.5**	**109.3**	**1.4**	58.58	1.3	.0467	4.6	.0393	12.3
MD17-2.1C	-0.80	171	132	0.79	**105.6**	**1.7**	**104.5**	**1.7**	61.05	1.6	.0497	5.0	.0562	7.7
MD17-2.2R	1.09	131	71	0.56	**105.0**	**1.8**	**105.2**	**1.7**	60.25	1.6	.0555	5.5	.0467	11.7
MD17-3.1C	0.74	154	104	0.69	**104.6**	**1.4**	**105.1**	**1.4**	60.69	1.3	.0499	4.7	.0438	8.2
MD17-3.2R	1.97	134	70	0.54	**108.1**	**1.9**	**110.9**	**1.7**	57.96	1.5	.0438	5.8	.0274	32.1
MD17-4	0.69	147	90	0.63	**107.4**	**1.5**	**108.0**	**1.5**	59.12	1.3	.0490	4.8	.0433	8.1
MD17-5	0.98	205	112	0.57	**108.1**	**1.3**	**108.8**	**1.3**	58.54	1.1	.0513	4.0	.0433	10.5
MD17-6	1.05	267	118	0.46	**109.6**	**1.3**	**110.3**	**1.2**	57.70	1.1	.0518	3.8	.0432	11.0
MD17-7	0.26	259	140	0.56	**110.3**	**1.2**	**110.3**	**1.2**	57.79	1.1	.0504	4.0	.0483	5.0
MD17-8	0.95	268	136	0.52	**108.6**	**1.3**	**109.9**	**1.2**	58.29	1.1	.0464	4.4	.0385	11.6
MD17-9	0.52	192	114	0.61	**106.5**	**1.3**	**106.9**	**1.3**	59.73	1.2	.0492	4.4	.0449	6.8
MD17-10	1.35	155	80	0.53	**108.0**	**1.6**	**109.0**	**1.5**	58.41	1.4	.0515	4.7	.0404	13.8
MD17-11	0.50	140	76	0.56	**107.2**	**1.6**	**107.9**	**1.5**	59.35	1.4	.0464	5.2	.0423	11.3
MD17-12	1.13	154	81	0.54	**108.4**	**1.5**	**109.6**	**1.5**	58.31	1.3	.0482	4.8	.0388	13.5





Note: Zircon grains were handpicked and purified, mounted on double stick tape on glass slides in 1 x 6 mm rows, cast in 2.54 cm diameter epoxy cylinders and ground and polished to a 1 micron finish. Prior to examination, all grains are imaged with transmitted light and reflected light on a petrographic microscope, and with a cathodoluminescence (CL) detector on a JEOL 5600 scanning electron microscope to determine internal structure, inclusions and physical defects. The mounted grains are washed, rinsed and dried in a vacuum oven, and coated with Au. The probe loading chamber pressure is adjusted to 10^{-7} torr for several hours before being moved into the source chamber of the SHRIMP-RG. The primary O_2^- ion beam generates secondary ions at 4 - 6 nA, which analyzed a spot with the diameter of 20 - 40 microns and a depth of 1 - 2 microns for an analysis time of 9 - 12 minutes. Age data for zircons were standardized against R33 (419 Ma, quartz diorite of Braintree complex, Vermont; Black and others, 2004), which were analyzed repeatedly throughout the duration of the analytical session. The weighted mean average of the oldest 13 of 15 ^{207}Pb-corrected ^{206}Pb/^{238}U zircon ages are interpreted as the crystallization age for the Empire Mountain pluton. All uncertainties and errors of all ages are given in the text as two sigma errors. Data reduction for geochronology follows the methods described by Williams (1997), and Ireland and Williams (2003), and use the MS Excel add-in Squid and Isoplot programs of Ludwig (2001, 2003).

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