

GSA Data Repository Item # 89-13

Title of article "Postmetamorphic unroofing history deduced from petrology,  
fluid inclusions, thermochronometry, and thermal modeling: an example..."

Author(s) Willis E. Hames, Robert J. Tracy and Robert J. Bodnar

see Geology v. 17, p. 727 - 730

**Contents**

14 pgs.

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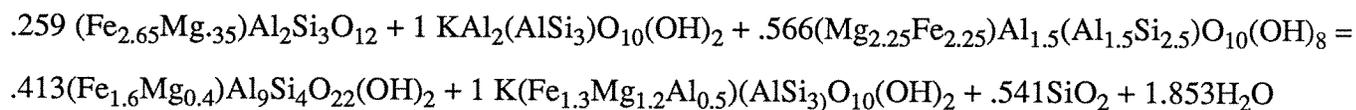
Supplementary data to "Postmetamorphic unroofing history deduced from petrology, fluid inclusions, thermochronometry, and thermal modeling: an example from southwestern New England" by Willis E. Hames, Robert J. Tracy, and Robert J. Bodnar, Department of geological Sciences, Virginia Polytechnic Institute and State University.

We examined several samples from the Roxbury Quadrangle, western Connecticut. Data for two representative samples are given here (field UTM coordinates: 641771 m E, 4596221 m N); this is all of the data used in the publication. Numbers on the thin-section sketches refer to record numbers in the tables.

Data from sample 1 can be used to balance the reaction

Garnet + Muscovite + Chlorite = Staurolite + Biotite + Quartz + Water,

yielding,



The mineral formulas have been simplified for the purposes of calculation; CaO/Na<sub>2</sub>O are not considered for this sample because it lacks observable plagioclase.

AVERAGED COMPOSITIONS FOR SAMPLE 1: USED FOR BALANCING EQUATION 1

Weight %	BIOTITE (1)		MUSCOVITE (1)		GARNET RIM (1)		STAUROLITE RIM (1)		CHLORITE (1)	
	Average	Uncertainty	Average	Uncertainty	Average	Uncertainty	Average	Uncertainty	Average	Uncertainty
SiO2	36.15	1.231	44.94	3.479	38.11	2.198	28.15	0.870	24.75	0.852
TiO2	1.56	0.102	0.50	0.552	0.13	0.057	0.56	0.078	1.32	0.691
Al2O3	19.71	0.652	34.16	6.661	22.51	1.854	54.79	2.243	24.00	0.788
FeO	19.61	1.043	3.85	8.443	35.72	3.081	14.28	0.577	24.91	1.056
MnO	0.03	0.021	0.01	0.028	0.53	0.410	0.03	0.023	0.04	0.043
MgO	9.69	0.817	1.60	3.111	2.58	0.432	1.72	0.130	14.13	0.652
CaO	0.06	0.034	0.05	0.014	2.97	1.983	0.03	0.036	0.05	0.035
BaO	n.d.		n.d.		n.d.		n.d.		n.d.	
Na2O	0.34	0.060	1.50	0.552	0.02	0.044	0.01	0.017	0.00	0.012
K2O	8.14	0.707	8.21	0.042	0.05	0.056	0.01	0.014	0.04	0.061
Σ Wt. %	95.29		94.79		102.62		99.58		89.23	

ATOMS

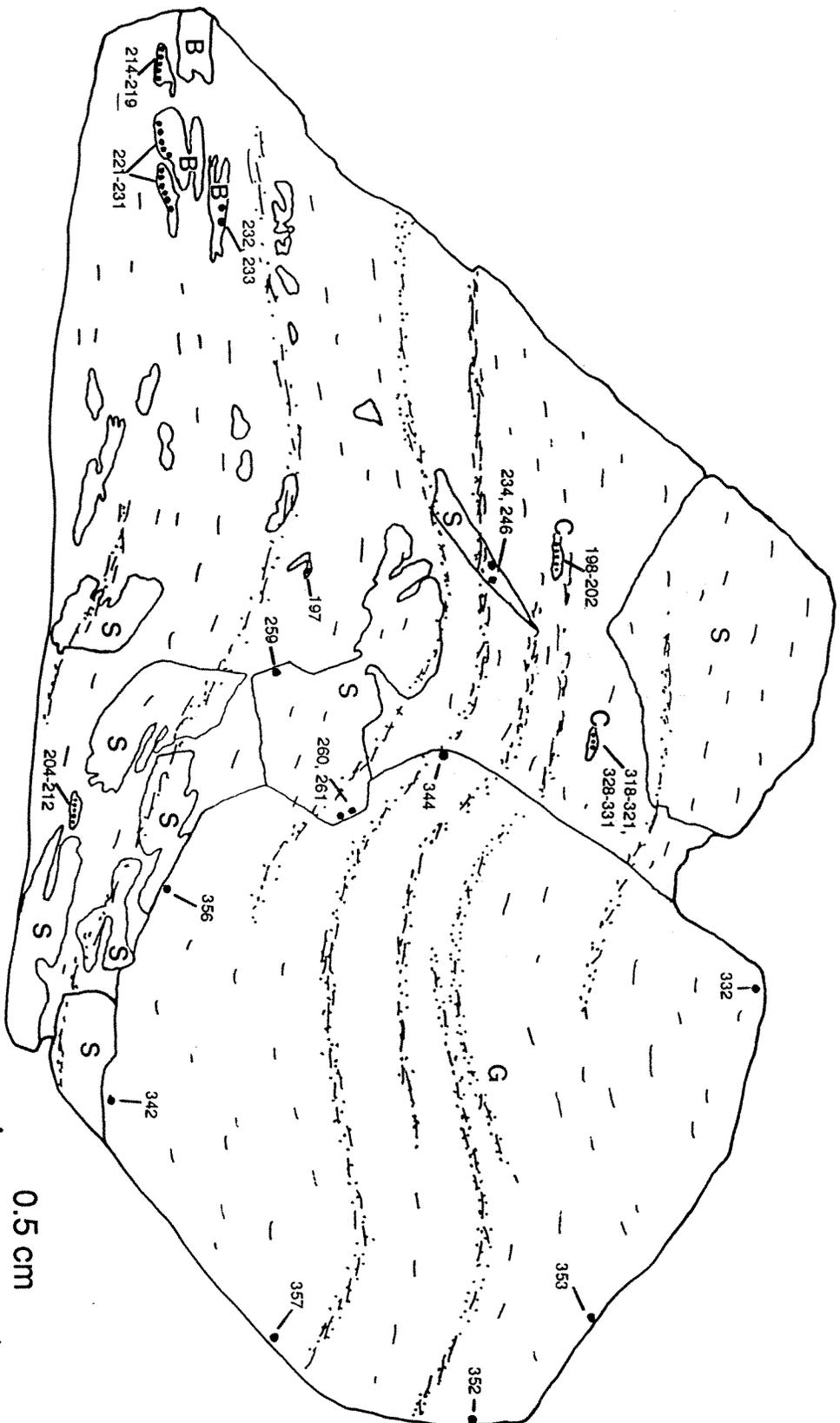
Si	5.45	0.123	6.05	0.220	2.98	0.097	7.84	0.103	5.10	0.100
Ti	0.18	0.012	0.05	0.058	0.01	0.003	0.11	0.014	0.20	0.109
Al	3.50	0.094	5.42	0.835	2.07	0.193	17.99	0.099	5.83	0.112
Fe	2.47	0.152	0.44	0.969	2.33	0.190	3.33	0.084	4.29	0.111
Mn	0.00	0.003	0.00	0.003	0.04	0.043	0.01	0.005	0.01	0.008
Mg	2.18	0.169	0.32	0.638	0.30	0.029	0.71	0.054	4.34	0.106
Ca	0.01	0.005	0.01	0.002	0.25	0.166	0.01	0.011	0.01	0.008
Na	0.10	0.017	0.39	0.128	0.00	0.007	0.00	0.009	0.00	0.005
K	1.57	0.131	1.41	0.065	0.00	0.005	0.00	0.005	0.01	0.016
			(22 oxygen)				(47 oxygen)		(28 oxygen)	
							n=5		n=12	
Al IV	2.55	0.123	Al IV	1.95	0.220	Σ VIII	2.92	0.112		
Al VI	0.95	0.103	Al VI	3.47	1.055	X Alm	0.7998	0.0548		
Σ VI	5.79	0.135	Σ VI	4.28	0.613	X Pyr	0.1029	0.0131		
Σ XII	1.67	0.141	Σ XII	1.81	0.065	X Sp	0.0121	0.0099		
X Ann	0.4270	0.0196	X Al VI	0.8164	0.3632	X Gr	0.0853	0.0568		
X Phl	0.3761	0.0255	X Musc	0.7809	0.064		n=7			
	n=22		X Parag	0.2155	0.0632					
			X Marg	0.0036	0.0009					
				n=2						

AVERAGED COMPOSITIONS FOR SAMPLE 2: USED FOR THERMOBAROMETRIC CALCULATIONS

Weight %	BIOTITE (2)		MUSCOVITE (2)		GARNET RIM (2)		FELDSPAR (2)	
	Average	Uncertainty	Average	Uncertainty	Average	Uncertainty	Average	Uncertainty
SiO2	36.96	0.790	46.51	1.030	39.06	0.481	61.38	0.860
TiO2	1.65	0.177	0.37	0.129	0.09	0.088	24.63	0.806
Al2O3	18.68	0.400	33.63	0.629	19.64	0.651	0.01	0.025
FeO	19.29	0.398	1.07	0.122	33.82	0.686	0.17	0.332
MnO	0.04	0.050	0.01	0.023	0.40	0.424	0.01	0.025
MgO	9.98	0.271	0.61	0.076	2.50	0.267	0.01	0.019
CaO	0.05	0.023	0.03	0.030	5.15	0.916	6.27	0.732
BaO	n.d.		n.d.		n.d.		0.02	0.057
Na2O	0.36	0.123	1.65	0.201	0.02	0.045	8.29	0.936
K2O	8.13	0.358	8.49	0.127	0.03	0.018	0.08	0.076
Σ Wt. %	95.13		92.36		100.70		100.87	

ATOMS

Si	5.57	0.070	6.32	0.092	3.11	0.033	2.71	0.035			
Ti	0.19	0.020	0.04	0.013	0.00	0.005	0.00	0.001			
Al	3.32	0.074	5.39	0.101	1.84	0.053	1.28	0.039			
Fe	2.43	0.049	0.12	0.015	2.25	0.048	0.01	0.012			
Mn	0.01	0.006	0.00	0.003	0.03	0.049	0.00	0.001			
Mg	2.24	0.065	0.12	0.016	0.30	0.018	0.00	0.001			
Ca	0.01	0.004	0.00	0.004	0.44	0.078	0.30	0.035			
Na	0.11	0.036	0.43	0.053	0.00	0.007	0.71	0.078			
K	1.56	0.060	1.47	0.026	0.00	0.003	0.00	0.004			
	(22 oxygen)		(22 oxygen)								
Al IV	2.43	0.070	Al IV	1.68	0.092	Σ VIII	3.01	0.030	Σ IV	3.99	0.015
Al VI	0.88	0.042	Al VI	3.71	0.028	X Alm	0.7470	0.0155	Σ VIII	1.02	0.055
Σ IV	5.75	0.043	Σ IV	3.99	0.023	X Pyr	0.0983	0.0166	X An	0.2919	0.0434
Σ XII	1.67	0.074	Σ XII	1.91	0.059	X Sp	0.0090	0.0059	X Ab	0.6966	0.0477
X Ann	0.4224	0.0082	X Al VI	0.929	0.0066	X Gr	0.1457	0.0257	X Or	0.0046	0.0041
X Phl	0.3894	0.0099	X Mus	0.7706	0.0221		n=6			n=24	
	n=16		X Par	0.2275	0.0214						
			X Mar	0.0019	0.0023						
				n=8							



**SAMPLE 1**

0.5 cm

GARNET RIM COMPOSITIONS, SAMPLE 1

SAMPLE REC#	BGARGA 332	BGARGA 342	BGARGA 344	BGARGA 352	BGARGA 353	BGARGA 356	BGARGA 357	GARNET AVERAGE	STDEV
SiO2	39.27	39.09	36.77	36.87	38.4	39.06	37.32	38.1114	2.19847
TiO2	0.15	0.17	0.12	0.14	0.12	0.08	0.14	0.13143	0.05707
Al2O3	22.30	21.83	22.05	24.51	22.17	21.98	22.72	22.5086	1.85449
FeO	37.57	35.47	36.74	34.23	34.63	37.47	33.92	35.7186	3.0807
MgO	2.94	2.5	2.56	2.37	2.46	2.78	2.45	2.58	0.40972
MnO	0.32	0.57	0.34	0.41	0.73	0.45	0.9	0.53143	0.43165
CaO	2.10	4.06	1.93	2.92	3.95	1.94	3.89	2.97	1.98273
Na2O	0.06	0.00	0	0.02	0.02	0.04	0.01	0.02143	0.04386
K2O	0.11	0.04	0.03	0.04	0.03	0.05	0.04	0.04857	0.05589
Σ Wt. %	104.82	103.73	100.54	101.51	102.51	103.85	101.39	Σ Wt. %	102.621

ATOMS

Si	3.008	3.020	2.949	2.892	2.998	3.022	2.946	2.97634	0.09746
Ti	0.008	0.009	0.007	0.008	0.007	0.004	0.008	0.00714	0.00305
Al	2.013	1.988	2.084	2.266	2.040	2.004	2.114	2.07257	0.19261
Fe	2.407	2.292	2.464	2.245	2.261	2.424	2.239	2.33309	0.19012
Mg	0.336	0.288	0.306	0.277	0.286	0.321	0.288	0.30024	0.04263
Mn	0.021	0.037	0.023	0.027	0.048	0.029	0.060	0.03519	0.02887
Ca	0.172	0.336	0.166	0.245	0.330	0.161	0.329	0.24855	0.16572
Na	0.009	0.000	0.000	0.003	0.003	0.006	0.002	0.00322	0.00652
K	0.011	0.004	0.003	0.004	0.003	0.005	0.004	0.00482	0.00539
Σ VIII	2.935	2.953	2.959	2.795	2.926	2.935	2.916	2.91707	0.11152
X Alm	0.8199	0.7761	0.8327	0.8033	0.7727	0.8259	0.7677	0.79977	0.05482
X Pyr	0.1143	0.0975	0.1034	0.0991	0.0978	0.1092	0.0988	0.1029	0.01309
X Spess.	0.0071	0.0126	0.0078	0.0097	0.0165	0.0100	0.0206	0.01206	0.00986
X Gross.	0.0587	0.1138	0.0560	0.0878	0.1129	0.0548	0.1128	0.08527	0.05676
F/F+M	0.8776	0.8884	0.8895	0.8902	0.8876	0.8832	0.8859	0.88606	0.00881

[Normalized for 12 Oxygens]

SiO2	20.91	20.82	19.58	19.64	20.45	20.80	19.87		
TiO2	0.07	0.08	0.05	0.06	0.05	0.04	0.06		
Al2O3	10.50	10.28	10.38	11.54	10.44	10.35	10.70		
FeO	8.37	7.90	8.18	7.62	7.71	8.34	7.55		
MgO	1.17	0.99	1.02	0.94	0.98	1.10	0.97		
MnO	0.07	0.13	0.08	0.09	0.16	0.10	0.20		
CaO	0.60	1.16	0.55	0.83	1.13	0.55	1.11		
Na2O	0.02	0.00	0.00	0.01	0.01	0.01	0.00		
K2O	0.02	0.01	0.01	0.01	0.01	0.01	0.01		
Σ Wt% O	41.72	41.36	39.85	40.74	40.93	41.31	40.48		
O Const.	4.60	4.64	4.82	4.71	4.69	4.65	4.74		

CHLORITE COMPOSITIONS; SAMPLE 1

SAMPLE CHB1CC CHB1CC CHB1CC CHB1CC CHB1CC CHC7C1 CHC7C1 CHC7C1 CHC7C1 CHC7CB CHC7CB CHC7CB													CHLORITE		
REC #	198	199	200	201	202	318	319	320	321	328	330	331	Wt %	Average	2*Stdev
SiO2	23.97	25.10	24.96	24.53	24.81	24.16	25.30	25.27	25.09	24.47	24.52	24.76	SiO2	24.745	0.8517
TiO2	1.08	1.08	1.08	1.07	0.97	2.14	1.42	1.16	1.15	1.37	1.71	1.57	TiO2	1.3167	0.6906
Al2O3	24.08	24.02	24.43	23.90	24.33	23.87	24.10	24.32	24.48	23.08	23.63	23.77	Al2O3	24.001	0.7877
FeO	24.32	25.52	25.63	25.20	25.28	24.16	24.79	25.31	24.99	24.02	24.68	25.04	FeO	24.912	1.0557
MnO	0.02	0.01	0.04	0.04	0.04	0.09	0.05	0.04	0.05	0.02	0.06	0.06	MnO	0.0433	0.0429
MgO	14.06	14.26	14.35	14.27	14.19	13.88	14.31	14.49	14.36	13.25	13.98	14.17	MgO	14.131	0.6521
CaO	0.03	0.04	0.04	0.03	0.07	0.07	0.08	0.04	0.06	0.04	0.04	0.03	CaO	0.0475	0.0353
Na2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.01	0	0.02	Na2O	0.0025	0.0124
K2O	0.02	0.02	0.02	0.02	0.03	0.03	0.13	0.04	0.02	0.04	0.03	0.03	K2O	0.0358	0.0612
Σ Wt. %	87.58	90.05	90.55	89.06	89.72	88.40	90.18	90.67	90.20	86.30	88.65	89.45	Σ Wt. %	89.234	2.6272

ATOMS													ATOMS		
Si	5.028	5.132	5.077	5.075	5.089	5.018	5.148	5.122	5.105	5.201	5.086	5.094	Si	5.0978	0.0997
Ti	0.170	0.166	0.165	0.166	0.150	0.334	0.217	0.177	0.176	0.219	0.267	0.243	Ti	0.2042	0.1092
Al	5.952	5.788	5.857	5.827	5.881	5.843	5.779	5.809	5.870	5.781	5.777	5.764	Al	5.8274	0.1119
Fe	4.266	4.363	4.360	4.360	4.336	4.197	4.218	4.290	4.252	4.269	4.281	4.308	Fe	4.2917	0.1111
Mn	0.004	0.002	0.007	0.007	0.007	0.016	0.009	0.007	0.009	0.004	0.011	0.010	Mn	0.0076	0.0075
Mg	4.396	4.346	4.351	4.400	4.338	4.297	4.340	4.377	4.355	4.198	4.322	4.345	Mg	4.3387	0.106
Ca	0.007	0.009	0.009	0.007	0.015	0.016	0.017	0.009	0.013	0.009	0.009	0.007	Ca	0.0105	0.0077
Na	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.008	Na	0.001	0.005
K	0.005	0.005	0.005	0.005	0.008	0.008	0.034	0.010	0.005	0.011	0.008	0.008	K	0.0094	0.0158

Wt % O												
SiO2	12.77	13.37	13.29	13.06	13.21	12.87	13.47	13.46	13.36	13.03	13.06	13.19
TiO2	0.43	0.43	0.43	0.43	0.39	0.86	0.57	0.46	0.46	0.55	0.68	0.63
Al2O3	11.34	11.31	11.50	11.25	11.45	11.24	11.35	11.45	11.52	10.87	11.12	11.19
FeO	5.42	5.68	5.71	5.61	5.63	5.38	5.52	5.64	5.57	5.35	5.50	5.58
MnO	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.01	0.01
MgO	5.58	5.66	5.70	5.66	5.63	5.51	5.68	5.75	5.70	5.26	5.55	5.62
CaO	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01
Na2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
K2O	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.00	0.01	0.01	0.01
Σ Wt% C	35.55	36.47	36.65	36.04	36.35	35.90	36.64	36.79	36.64	35.08	35.94	36.24
O Const.	12.60	12.28	12.22	12.43	12.32	12.48	12.23	12.18	12.23	12.77	12.46	12.36

MUSCOVITE COMPOSITIONS, SAMPLE 1

SAMPLE REC #	MUB4BC	BIB1CC	MUSCOVITE Average	2*stdev
216	197		44.94	3.48
SiO2	43.71	46.17	0.50	0.55
TiO2	0.69	0.30	34.16	6.66
Al2O3	31.80	36.51	3.85	8.44
FeO	6.83	0.86	0.01	0.03
MnO	0.02	0.00	1.60	3.11
MgO	2.70	0.50	0.05	0.01
CaO	0.04	0.05	1.50	0.55
Na2O	1.30	1.69	8.21	0.04
K2O	8.22	8.19		
Σ Wt. %	95.31	94.27	94.79	

ATOMS		ATOMS	
Si	5.974	Si	6.05
Ti	0.071	Ti	0.05
Al	5.122	Al	5.42
Fe	0.781	Fe	0.44
Mn	0.002	Mn	0.00
Mg	0.550	Mg	0.32
Ca	0.006	Ca	0.01
Na	0.344	Na	0.39
K	1.433	K	1.41

Al IV	2.0265	Al IV	1.95	0.220
Al VI	3.0954	Al VI	3.47	1.055
Σ VI	4.4992	Σ VI	4.28	0.613
Σ XII	1.7834	Σ XII	1.81	0.065
X Al VI	0.688	X Al VI	0.8164	0.3632
X Musc	0.8036	X Musc	0.7809	0.0640
X Parag	0.1932	X Parag	0.2155	0.0632
X Marg	0.0033	X Marg	0.0036	0.0009

SiO2	23.28	24.59
TiO2	0.28	0.12
Al2O3	14.97	17.19
FeO	1.52	0.19
MnO	0.00	0.00
MgO	1.07	0.20
CaO	0.01	0.01
Na2O	0.34	0.44
K2O	1.40	1.39
Σ Wt% O	42.87	44.13
O Const.	8.21	7.98

VERS. 2/13/88 NORMALIZED TO 22 OXYGEN

## BIOTITE COMPOSITIONS, SAMPLE 1

SAMPLE	BIB3BC	BIB3BC	BIB3BC	BIB3BC	B3BTBI	B3BTBI	B3BTBI	B3BTBI	B3BTBI	B3BTBI	B4BCBI	B5BCBI							
REC #	204	206	207	208	209	210	211	212	214	215	218	219	221	222					
SiO2	36.07	36.61	36.31	35.85	37.7	35.95	35.63	35.55	36.63	36.59	36.5	35.57	36.58	35.65					
TiO2	1.48	1.61	1.56	1.59	1.52	1.6	1.57	1.52	1.60	1.6	1.55	1.65	1.51	1.57					
Al2O3	19.84	19.6	19.59	19.86	19.6	19.02	19.05	19.33	19.41	20.12	20.04	19.93	19.52	20					
FeO	19.48	19.77	19.38	19.06	18.70	19.33	19.56	19.29	19.95	19.86	19.65	19.69	19.99	20.22					
MnO	0.02	0.04	0.04	0.03	0.03	0.02	0.02	0.03	0.03	0.04	0.01	0.03	0.04	0.02					
MgO	10.09	9.72	9.94	9.78	9.03	9.36	9.34	9.34	9.63	9.6	9.97	9.54	10.15	10.57					
CaO	0.04	0.04	0.03	0.03	0.04	0.05	0.07	0.05	0.07	0.06	0.06	0.07	0.06	0.06					
Na2O	0.34	0.31	0.4	0.38	0.35	0.37	0.35	0.37	0.32	0.31	0.38	0.32	0.35	0.31					
K2O	8.40	8.42	8.46	8.41	7.98	8.32	8.02	8.32	8.20	8.12	8.24	8.22	8.21	7.56					
Σ Wt. %	95.76	96.12	95.71	94.99	94.95	94.02	93.61	93.80	95.84	96.30	96.40	95.02	96.41	95.96					
Wt% O																			
SiO2	19.21	19.50	19.34	19.09	20.08	19.15	18.98	18.93	19.51	19.49	19.44	18.94	19.48	18.99					
TiO2	0.59	0.64	0.62	0.64	0.61	0.64	0.63	0.61	0.64	0.64	0.62	0.66	0.60	0.63					
Al2O3	9.34	9.23	9.22	9.35	9.23	8.95	8.97	9.10	9.14	9.47	9.43	9.38	9.19	9.42					
FeO	4.34	4.40	4.32	4.24	4.16	4.30	4.36	4.30	4.44	4.42	4.38	4.39	4.45	4.50					
MnO	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00					
MgO	4.00	3.86	3.95	3.88	3.58	3.71	3.71	3.71	3.82	3.81	3.96	3.79	4.03	4.20					
CaO	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02					
Na2O	0.09	0.08	0.10	0.10	0.09	0.10	0.09	0.10	0.08	0.08	0.10	0.08	0.09	0.08					
K2O	1.43	1.43	1.44	1.43	1.36	1.41	1.36	1.41	1.39	1.38	1.40	1.40	1.39	1.28					
Σ Wt% O	39.02	39.16	39.00	38.75	39.13	38.29	38.11	38.17	39.05	39.32	39.34	38.66	39.27	39.11					
O Const.	9.02	8.99	9.02	9.08	9.00	9.19	9.24	9.22	9.01	8.95	8.95	9.10	8.96	9.00					
ATOMS																			
Si	5.416	5.477	5.454	5.420	5.645	5.500	5.477	5.455	5.495	5.452	5.435	5.389	5.457	5.339					
Ti	0.167	0.181	0.176	0.181	0.171	0.184	0.181	0.175	0.180	0.179	0.174	0.188	0.169	0.177					
Al	3.511	3.456	3.468	3.539	3.459	3.430	3.451	3.496	3.431	3.533	3.517	3.559	3.432	3.530					
Fe	2.446	2.473	2.434	2.410	2.341	2.473	2.514	2.476	2.503	2.475	2.447	2.495	2.494	2.533					
Mn	0.003	0.005	0.005	0.004	0.004	0.003	0.003	0.004	0.004	0.005	0.001	0.004	0.005	0.003					
Mg	2.258	2.167	2.225	2.204	2.015	2.135	2.140	2.136	2.153	2.132	2.213	2.154	2.257	2.360					
Ca	0.006	0.006	0.005	0.005	0.006	0.008	0.012	0.008	0.011	0.010	0.010	0.011	0.010	0.010					
Na	0.099	0.090	0.116	0.111	0.102	0.110	0.104	0.110	0.093	0.090	0.110	0.094	0.101	0.090					
K	1.609	1.607	1.621	1.622	1.524	1.624	1.573	1.629	1.569	1.543	1.565	1.589	1.562	1.444					
Al IV	2.584	2.523	2.546	2.580	2.355	2.500	2.523	2.545	2.505	2.548	2.565	2.611	2.543	2.661					
Al VI	0.927	0.932	0.921	0.959	1.103	0.930	0.927	0.951	0.926	0.985	0.951	0.948	0.889	0.870					
Y-sites*	5.807	5.765	5.767	5.762	5.641	5.733	5.777	5.751	5.777	5.785	5.795	5.801	5.825	5.951					
All Na+K	1.708	1.697	1.737	1.733	1.626	1.734	1.677	1.739	1.662	1.633	1.675	1.683	1.664	1.534					
Na+K(A)#	1.708	1.697	1.737	1.733	1.626	1.734	1.677	1.739	1.662	1.633	1.675	1.683	1.664	1.534					
X Anllite	0.4212	0.4290	0.4221	0.4182	0.4151	0.4314	0.4352	0.4305	0.4332	0.4277	0.4222	0.4301	0.4282	0.4256					
X Phlog.	0.3889	0.3759	0.3859	0.3825	0.3572	0.3723	0.3704	0.3715	0.3727	0.3685	0.3818	0.3714	0.3875	0.3965					
F/FM	0.5200	0.5330	0.5224	0.5223	0.5374	0.5368	0.5402	0.5368	0.5375	0.5372	0.5251	0.5366	0.5249	0.5177					

vers. 2/13/88; NORMALIZED TO 22 OXYGEN

## BIOTITE COMPOSITIONS, SAMPLE 1

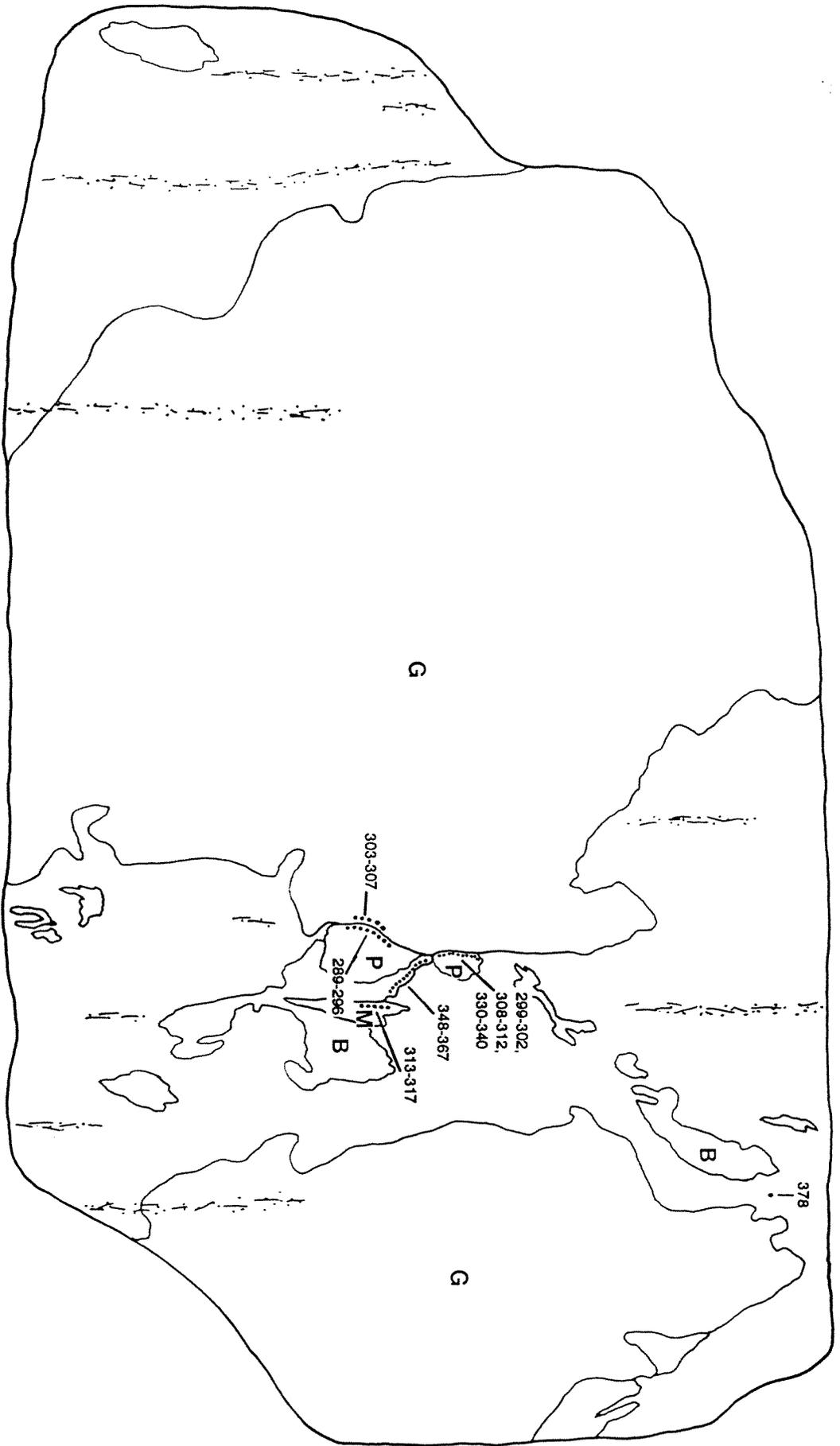
SAMPLE REC#	B5BCBI	B6B BI	BIB1CC	STATISTICS	STATISTICS																
																				AVERAGE	2*STDEV
SiO2	18.83	19.53	19.61	19.55	19.16	18.49	19.33	19.36	19.39	19.14	18.77	19.24	19.24	19.24	19.24	19.24	19.24	19.24	19.24	19.24	19.24
TiO2	0.60	0.61	0.61	0.63	0.63	0.63	0.63	0.63	0.66	0.64	0.58	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Al2O3	9.42	9.22	9.44	9.53	9.14	9.12	9.27	9.30	9.37	9.47	9.37	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20
FeO	4.46	4.23	4.24	4.31	4.33	4.43	4.30	4.44	4.34	4.40	4.77	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28
MnO	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
MgO	4.14	3.97	3.96	3.79	3.90	3.89	3.70	3.88	3.77	3.66	3.47	3.91	3.91	3.91	3.91	3.91	3.91	3.91	3.91	3.91	3.91
CaO	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Na2O	0.08	0.09	0.10	0.09	0.08	0.09	0.09	0.09	0.10	0.09	0.07	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
K2O	1.31	1.42	1.42	1.43	1.42	1.35	1.40	1.39	1.37	1.35	1.15	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
Σ Wt% O	38.85	39.09	39.40	39.35	38.69	38.00	38.71	39.12	39.05	38.79	38.22	38.76	38.76	38.76	38.76	38.76	38.76	38.76	38.76	38.76	38.76
O Const.	9.06	9.00	8.93	8.95	9.10	9.26	9.09	9.00	9.01	9.07	9.21	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08
ATOMS																					
Si	5.330	5.495	5.476	5.464	5.448	5.352	5.493	5.443	5.460	5.428	5.401	5.459	5.459	5.459	5.459	5.459	5.459	5.459	5.459	5.459	5.459
Ti	0.169	0.172	0.170	0.176	0.180	0.182	0.168	0.178	0.186	0.182	0.168	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172
Al	3.556	3.460	3.513	3.553	3.466	3.519	3.514	3.486	3.520	3.581	3.595	3.481	3.481	3.481	3.481	3.481	3.481	3.481	3.481	3.481	3.481
Fe	2.526	2.382	2.370	2.412	2.459	2.563	2.444	2.496	2.446	2.497	2.747	2.431	2.431	2.431	2.431	2.431	2.431	2.431	2.431	2.431	2.431
Mn	0.004	0.004	0.004	0.003	0.003	0.001	0.005	0.004	0.006	0.001	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Mg	2.342	2.231	2.210	2.121	2.216	2.249	2.102	2.181	2.126	2.076	1.999	2.219	2.219	2.219	2.219	2.219	2.219	2.219	2.219	2.219	2.219
Ca	0.010	0.008	0.008	0.008	0.010	0.007	0.008	0.010	0.018	0.013	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
Na	0.088	0.105	0.110	0.095	0.094	0.099	0.103	0.107	0.111	0.105	0.083	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
K	1.487	1.594	1.582	1.599	1.617	1.567	1.589	1.568	1.548	1.536	1.326	1.604	1.604	1.604	1.604	1.604	1.604	1.604	1.604	1.604	1.604
Al IV	2.670	2.505	2.524	2.536	2.552	2.648	2.507	2.557	2.540	2.572	2.599	2.541	2.541	2.541	2.541	2.541	2.541	2.541	2.541	2.541	2.541
Al VI	0.886	0.955	0.989	1.017	0.914	0.871	1.007	0.929	0.980	1.009	0.996	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940
Y-sites*	5.935	5.752	5.751	5.736	5.782	5.873	5.735	5.797	5.763	5.778	5.927	5.776	5.776	5.776	5.776	5.776	5.776	5.776	5.776	5.776	5.776
All Na+K	1.574	1.699	1.691	1.694	1.711	1.666	1.691	1.676	1.659	1.641	1.409	1.704	1.704	1.704	1.704	1.704	1.704	1.704	1.704	1.704	1.704
Na+K(A)#	1.574	1.699	1.691	1.694	1.711	1.666	1.691	1.676	1.659	1.641	1.409	1.704	1.704	1.704	1.704	1.704	1.704	1.704	1.704	1.704	1.704
X Annite	0.4255	0.4141	0.4121	0.4204	0.4253	0.4364	0.4261	0.4305	0.4245	0.4322	0.4634	0.4208	0.4208	0.4208	0.4208	0.4208	0.4208	0.4208	0.4208	0.4208	0.4208
X Phlog.	0.3945	0.3879	0.3842	0.3698	0.3833	0.3830	0.3666	0.3762	0.3690	0.3592	0.3373	0.3842	0.3842	0.3842	0.3842	0.3842	0.3842	0.3842	0.3842	0.3842	0.3842
F/FM	0.5189	0.5164	0.5175	0.5320	0.5260	0.5326	0.5376	0.5337	0.5350	0.5461	0.5788	0.5228	0.5228	0.5228	0.5228	0.5228	0.5228	0.5228	0.5228	0.5228	0.5228

STATISTICS  
AVERAGE 2\*STDEV

vers. 2/13/88; NORMALIZED TO 22 OXYGEN

**SAMPLE 2**

0.5 cm





SAMPLE 2 BIOTITE COMPOSITIONS

SAMPLE REC #	BIOTITE		STATISTICS	
	B18C1	B18C1	AVERAGE	STDEV 2s
365	366	SiO2	36.956	0.79
36.65	37.09	TiO2	1.6475	0.1766
1.74	1.56	Al2O3	18.676	0.4004
18.83	18.36	FeO	19.288	0.3977
19.21	19.8	MnO	0.0444	0.0495
0.03	0.02	MgO	9.9781	0.271
10.08	9.85	CaO	0.045	0.0231
0.05	0.02	Na2O	0.3625	0.1234
0.43	0.37	K2O	8.1313	0.3581
8.18	8.09	Σ Wt. %	95.129	
95.20	95.16	ATOMS		
Si	5.522	Si	5.5671	0.0697
Ti	0.197	Ti	0.1866	0.0201
Al	3.344	Al	3.3159	0.0736
Fe	2.421	Fe	2.43	0.0495
Mn	0.004	Mn	0.0057	0.0063
Mg	2.264	Mg	2.2406	0.0652
Ca	0.008	Ca	0.0073	0.0038
Na	0.126	Na	0.1059	0.0356
K	1.572	K	1.5625	0.0603
Al IV	2.478	Al IV	2.4329	0.0697
Al VI	0.866	Al VI	0.8831	0.0416
Y-sites*	5.759	Y-sites*	5.7532	0.0431
All Na+K	1.698	All Na+K	1.6684	0.0741
X Annite	0.4203	X Annite	0.4224	0.0082
X Phlog.	0.3931	X Phlog.	0.3894	0.0099
F/FM	0.5167	F/FM	0.5203	0.0098
Wt% O				
SiO2	19.52	SiO2	19.75	
TiO2	0.70	TiO2	0.62	
Al2O3	8.86	Al2O3	8.64	
FeO	4.28	FeO	4.41	
MnO	0.01	MnO	0.00	
MgO	4.00	MgO	3.91	
CaO	0.01	CaO	0.01	
Na2O	0.11	Na2O	0.10	
K2O	1.39	K2O	1.37	
Σ Wt% O	38.88	Σ Wt% O	38.82	
O Const.	9.05	O Const.	9.07	



SAMPLE 2 FELDSPAR COMPOSITIONS

SAMPLE RECORD#	FELDSPAR COMPOSITIONS												FELDSPAR STATISTICS	
	FEB82 310	FEB82 311	FEB82 312	FEB81 330	FEB81 331	FEB81 332	FEB81 333	FEB81 334	FEB81 336	FEB81 338	AVERAGE	STDEV/2s		
SiO2	61.48	61.64	61.20	61.04	61.40	61.41	62.12	61.22	60.88	61.85	61.38	0.8598		
Al2O3	24.66	24.42	23.94	24.79	24.63	24.74	24.26	24.38	25.75	24.59	24.63	0.8063		
TiO2	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.0079	0.025		
FeO	0.39	0.31	0.43	0.51	0.14	0.06	0.04	0.02	0.02	0.02	0.1671	0.3321		
MnO	0.00	0.02	0.00	0.03	0.02	0.01	0.02	0.02	0.04	0.00	0.0088	0.0252		
MgO	0.01	0.00	0.02	0.00	0.02	0.03	0.02	0.00	0.00	0.00	0.0075	0.0189		
CaO	6.65	6.63	5.89	6.30	6.69	6.42	5.71	6.59	6.46	6.04	6.2729	0.7325		
BaO	0.03	0.05	0.03	0.02	0.05	0.03	0.00	0.06	0.06	0.00	0.0238	0.0568		
Na2O	8.05	8.00	8.24	7.91	8.19	8.50	8.80	8.17	8.54	8.21	8.2875	0.9359		
K2O	0.05	0.06	0.21	0.06	0.05	0.08	0.06	0.07	0.16	0.06	0.0817	0.0757		
Σ Wt. % ATOMS	101.33	101.14	99.99	100.66	101.19	101.28	101.03	100.53	101.95	100.78	100.87			
Si	2.704	2.715	2.726	2.701	2.704	2.702	2.732	2.712	2.666	2.724	2.7087	0.0348		
Al	1.278	1.267	1.257	1.293	1.278	1.283	1.258	1.273	1.329	1.276	1.281	0.0391		
Ti	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.0003	0.0008		
Fe	0.014	0.011	0.016	0.019	0.005	0.002	0.001	0.001	0.001	0.001	0.0062	0.0123		
Mn	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.0003	0.0009		
Mg	0.001	0.000	0.001	0.000	0.001	0.002	0.001	0.000	0.000	0.000	0.0005	0.0012		
Ca	0.313	0.313	0.281	0.299	0.316	0.303	0.269	0.313	0.303	0.285	0.2966	0.0347		
BaO	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.0004	0.001		
Na	0.687	0.683	0.712	0.679	0.699	0.725	0.750	0.702	0.725	0.701	0.7091	0.0782		
K	0.003	0.003	0.012	0.003	0.003	0.004	0.003	0.004	0.009	0.003	0.0046	0.0043		
Si + Al	3.98	3.98	3.98	3.99	3.98	3.98	3.99	3.98	3.99	4.00	3.9896	0.0152		
Σ VIII	1.018	1.011	1.022	1.001	1.025	1.037	1.026	1.020	1.039	0.990	1.0173	0.055		
% An	30.79	30.93	27.50	29.85	30.80	29.19	26.21	30.67	29.16	28.78	0.2919	0.0434		
% Ab	67.46	67.54	69.63	67.82	68.23	69.94	73.11	68.80	69.77	70.80	0.6966	0.0477		
% Or	0.28	0.33	1.17	0.34	0.27	0.43	0.33	0.39	0.86	0.34	0.0045	0.0041		
Wt% O														

SiO2	32.741	32.827	32.592	32.507	32.699	32.704	33.082	32.603	32.422	32.938
Al2O3	11.609	11.496	11.270	11.670	11.594	11.646	11.420	11.477	12.122	11.576
TiO2	0.004	0.004	0.012	0.000	0.000	0.000	0.000	0.000	0.016	0.004
FeO	0.087	0.069	0.096	0.114	0.031	0.013	0.009	0.004	0.004	0.004
MnO	0.000	0.005	0.000	0.007	0.005	0.002	0.005	0.005	0.009	0.000
MgO	0.004	0.000	0.008	0.000	0.008	0.012	0.008	0.000	0.000	0.000
CaO	1.897	1.892	1.680	1.797	1.909	1.832	1.629	1.880	1.843	1.723
BaO	0.003	0.005	0.003	0.002	0.005	0.003	0.000	0.006	0.006	0.000
Na2O	2.078	2.065	2.127	2.042	2.114	2.194	2.272	2.109	2.205	2.119
K2O	0.008	0.010	0.036	0.010	0.008	0.014	0.010	0.012	0.027	0.010
Σ Wt% O	48.432	48.372	47.824	48.149	48.373	48.420	48.435	48.096	48.654	48.375
O Const	2.643	2.646	2.676	2.658	2.646	2.643	2.643	2.661	2.631	2.646

vers. 2/17/88: NORMALIZED TO 8 OXYGEN

GARNET RIM COMPOSITIONS, SAMPLE 2

SAMPLE	GA8C1	GA8C1	GA8C1	GA8C1						
wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%
Si	3.110	3.114	3.109	3.124	3.109	3.075	3.10685	0.03287		
Ti	0.004	0.008	0.004	0.007	0.001	0.004	0.00471	0.00492		
Al	1.853	1.832	1.832	1.803	1.839	1.883	1.84041	0.05303		
Fe	2.228	2.249	2.233	2.253	2.240	2.295	2.24964	0.04787		
Mg	0.312	0.279	0.278	0.285	0.282	0.339	0.29593	0.04909		
Mn	0.016	0.027	0.036	0.035	0.032	0.016	0.02707	0.01803		
Ca	0.432	0.445	0.473	0.455	0.465	0.365	0.43886	0.07832		
Na	0.003	0.006	0.008	0.000	0.000	0.000	0.00283	0.00688		
K	0.003	0.004	0.002	0.002	0.004	0.000	0.00254	0.00309		
Σ VIII	2.988	3.000	3.020	3.028	3.020	3.014	3.0115	0.02987		
X Alm	0.7457	0.7496	0.7395	0.7441	0.7419	0.7612	0.74702	0.01551		
X Pyr	0.1044	0.0930	0.0921	0.0942	0.0935	0.1124	0.09828	0.01659		
X Spess.	0.0054	0.0090	0.0118	0.0116	0.0107	0.0054	0.00898	0.00593		
X Gross.	0.1445	0.1483	0.1566	0.1501	0.1539	0.1210	0.14572	0.0257		
F/F+M	0.8772	0.8896	0.8893	0.8876	0.8881	0.8713	0.88385	0.01541		

[Normalized for 12 Oxygens]

wt.% O	wt.% O	wt.% O	wt.% O	wt.% O	wt.% O	wt.% O	wt.% O	wt.% O	wt.% O	wt.% O
SiO2	20.97	20.72	20.86	20.87	20.81	20.60	20.87	20.81	20.60	20.60
TiO2	0.04	0.06	0.03	0.06	0.01	0.03	0.06	0.01	0.03	0.03
Al2O3	9.37	9.15	9.22	9.03	9.23	9.46	9.03	9.23	9.46	9.46
FeO	7.51	7.48	7.49	7.53	7.50	7.69	7.53	7.50	7.69	7.69
MgO	1.05	0.93	0.93	0.95	0.94	1.14	0.95	0.94	1.14	1.14
MnO	0.05	0.09	0.12	0.12	0.11	0.05	0.12	0.11	0.05	0.05
CaO	1.46	1.48	1.59	1.52	1.55	1.22	1.52	1.55	1.22	1.22
Na2O	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Σ Wt% O	40.45	39.93	40.26	40.07	40.16	40.19	40.07	40.16	40.19	40.19
O Const.	4.75	4.81	4.77	4.79	4.78	4.78	4.79	4.78	4.78	4.78

vers. 2/13/88 NORMALIZED TO 12 OXYGENS