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PHENOCRYST AND GLASS MICROPROBE ANALYSES
FOR THE 29.5 Ma WAH WAH SPRINGS FORMATION,
NEVADA AND UTAH

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This information should be considered preliminary.
It has not been edited or checked for completeness
or accuracy.

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INTRODUCTION

This manuscript contains microprobe data for Wah Wah Springs Formation samples (Best and Grant, 1987; Nusbaum, 1984; Nusbaum and Grant, 1985; Nusbaum, 1988, Nusbaum and Grant, in prep.) The Wah Wah Springs Formation is a member of the Needles Range Group and is exposed in southern Nevada and Utah (Figure 1).

DATA

These data represent a total of about 800 analyses which were obtained during the summer of 1987 on a fully automated ARL-SEM microprobe housed in the Department of Geological Sciences at Virginia Polytechnic Institute and State University. Phases microprobed include glass, plagioclase, hornblende, biotite, pyroxene, apatite, titanomagnetite, and ilmenite. Each analysis given in the following tables represents a minimum of three determinations on at least two phases. Most analyses were conducted according to the specifications outlined by Solberg and Speer (1982). The exception is the glass analyses which were probed using a broad beam for a total of eight seconds to minimize volatilization of potassium and sodium.

Samples are from sections which have been described (Nusbaum, 1984). Conversion data are listed below.

Sample	Table Code	Figure 1	Section
76-27-05	B	W	Wallaces Peak vitrophyre
74-325	C	SC	Salt Cabin Wash vitrophyre
76-21-06	E	M	Mudspring Hill vitrophyre
82N33	F	N	Needle Range vitrophyre
82N51	G	SE	South Egan vitrophyre
82N49	H	SE	South Egan welded tuff
82N50	I	SE	South Egan welded tuff
82N20	J	W	Wallaces Peak welded tuff
82N45	K	SS	Shingle Spring welded tuff
82N42	L	SS	Shingle Spring welded tuff
82N17	M	W	Wallaces Peak welded tuff
82N17	N	W	Wallaces Peak welded tuff

82N16	O	W	Wallaces Peak welded tuff
82N19	P	W	Wallaces Peak welded tuff
82-4	Q	SS	Shingle Spring welded tuff
82N48	R	SE	South Egan welded tuff
82N38	S	C	Condor Canyon welded tuff
82N39	T	C	Condor Canyon welded tuff
82N41	U	SS	Shingle Spring nonwelded tuff
82N46	V	SE	South Egan welded tuff
82N47	W	SE	South Egan welded tuff
82-1	X	SS	Shingle Spring welded tuff
82N33	Y	N	Neelde Range welded tuff

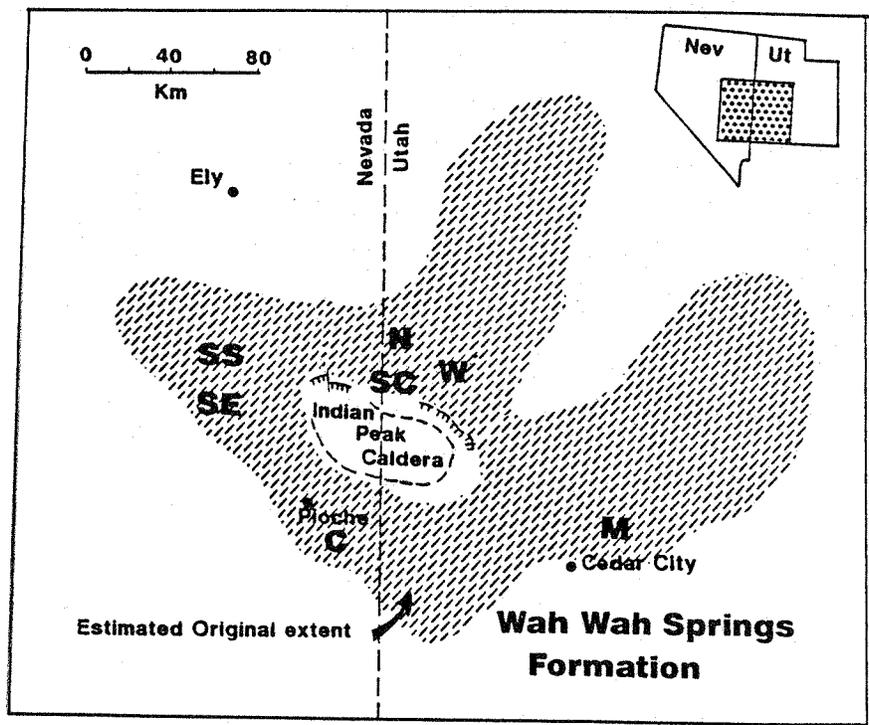


Figure 1. Location of sample sites for the Wah Wah Springs Formation. The geology and figure are modified from Best and Grant (1987). See text for symbols.

TABLE 1
 PLAGIOCLASE MICROPROBE DATA: FORMULA CALCULATIONS BASED ON 8 OXYGENS

	EP1	BP1	CP1-INC	CP1	GP1	HP1	IP1	JP1	KP1	LP1	LP1-TV	LPL-TV
SiO2	56.754	56.193	57.166	57.181	56.914	56.473	57.884	56.671	57.835	56.377	57.152	57.376
Al2O3	26.653	27.697	26.748	26.778	27.392	26.772	26.889	26.779	27.581	27.100	27.253	27.197
Na2O	5.591	5.446	5.904	5.752	5.384	5.651	5.851	5.643	5.580	5.310	5.550	5.347
K2O	0.591	0.513	0.645	0.602	0.546	0.558	0.604	0.575	0.555	0.511	0.545	0.520
CaO	9.355	10.563	9.346	9.429	9.967	9.457	9.304	9.428	9.970	9.667	9.581	9.576
MgO	0.020	0.031	0.042	0.029	0.025	0.084	0.027	0.021	0.050	0.003	0.000	0.000
FeO	0.313	0.321	0.363	0.321	0.305	0.371	0.317	0.331	0.336	0.350	0.305	0.316
MnO	0.007	0.012	0.004	0.000	0.003	0.000	0.003	0.008	0.011	0.033	0.017	0.033
TiO2	0.030	0.014	0.025	0.016	0.018	0.028	0.017	0.015	0.032	0.037	0.053	0.028
BaO	0.047	0.076	0.086	0.065	0.071	0.065	0.054	0.019	0.059	0.090	0.116	0.122
SrO	0.150	0.202	0.171	0.194	0.152	0.159	0.175	0.143	0.133	0.138	0.098	0.086
Total	99.511	101.096	100.578	100.396	100.799	99.644	101.138	99.656	102.181	99.852	100.905	100.821
Si	2.721	2.685	2.717	2.721	2.706	2.710	2.727	2.716	2.710	2.707	2.711	2.719
Al	1.506	1.560	1.499	1.502	1.535	1.514	1.493	1.512	1.523	1.534	1.524	1.519
Na	0.520	0.504	0.544	0.531	0.496	0.526	0.534	0.524	0.507	0.494	0.510	0.491
K	0.036	0.031	0.039	0.037	0.033	0.034	0.036	0.035	0.033	0.031	0.033	0.031
Ca	0.481	0.541	0.476	0.481	0.508	0.486	0.470	0.484	0.501	0.497	0.487	0.486
Mg	0.001	0.002	0.003	0.002	0.002	0.006	0.002	0.002	0.003	.000	0.000	0.000
Fe	0.013	0.013	0.014	0.013	0.012	0.015	0.012	0.013	0.013	0.014	0.012	0.013
Mn	.000	.000	.000	0.000	.000	0.000	.000	.000	.000	0.001	0.001	0.001
Ti	0.001	.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
Ba	0.001	0.001	0.002	0.001	0.001	0.001	0.001	.000	0.001	0.002	0.002	0.002
Sr	0.004	0.006	0.005	0.005	0.004	0.004	0.005	0.004	0.004	0.004	0.003	0.002
XAn	0.464	0.502	0.449	0.459	0.490	0.465	0.451	0.464	0.481	0.486	0.473	0.482
XAb	0.501	0.469	0.514	0.506	0.479	0.503	0.514	0.502	0.487	0.483	0.495	0.487
XOr	0.035	0.029	0.037	0.035	0.032	0.033	0.035	0.034	0.032	0.486	0.032	0.031

	LP1-TV	MP1	OP1	PP1	QP1	RP1							
SiO2	57.029	56.337	56.504	57.241	57.391	57.420	57.254	57.253	56.605	57.811	57.231	57.551	
Al2O3	27.405	28.062	27.582	27.374	27.363	27.328	27.315	27.197	27.466	27.129	27.044	27.303	
Na2O	5.467	5.145	5.251	5.352	5.513	5.400	5.391	5.684	5.696	5.696	5.890	5.696	
K2O	0.529	0.453	0.507	0.509	0.517	0.502	0.510	0.560	0.513	0.589	0.560	0.551	
CaO	9.650	10.292	9.872	9.772	9.783	9.775	9.652	9.690	10.088	9.608	9.457	9.754	
MgO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.040	0.032	0.028	0.025	
FeO	0.301	0.317	0.338	0.307	0.320	0.320	0.309	0.325	0.390	0.353	0.316	0.335	
MnO	0.018	0.029	0.024	0.015	0.036	0.034	0.024	0.009	.000	0.003	0.003	0.012	
TiO2	0.026	0.062	0.037	0.064	0.091	0.000	0.039	0.004	0.019	0.023	0.015	0.027	
BaO	0.098	0.107	0.101	0.305	0.107	0.112	0.098	0.041	0.277	0.059	0.064	0.033	
SrO	0.220	0.114	0.181	0.212	0.091	0.185	0.251	0.185	0.129	0.121	0.141	0.121	
Total	100.956	101.152	100.605	101.394	101.492	101.378	101.108	101.006	101.269	101.453	100.759	101.413	

Si	2.706	2.682	2.696	2.710	2.711	2.716	2.712	2.712	2.692	2.721	2.713	2.713
Al	1.533	1.575	1.551	1.527	1.523	1.523	1.525	1.518	1.540	1.505	1.511	1.517
Na	0.503	0.475	0.486	0.491	0.505	0.495	0.495	0.522	0.525	0.520	0.541	0.521
K	0.032	0.028	0.031	0.031	0.031	0.030	0.031	0.034	0.031	0.035	0.034	0.033
Ca	0.491	0.525	0.505	0.496	0.495	0.495	0.490	0.492	0.514	0.485	0.480	0.493
Mg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.002	0.002	0.002
Fe	0.012	0.013	0.013	0.012	0.013	0.013	0.012	0.013	0.016	0.014	0.013	0.013
Mn	0.001	0.001	0.001	0.001	0.001	0.001	0.001	.000	.000	.000	.000	.000
Ti	0.001	0.002	0.001	0.002	0.003	0.000	0.001	.000	0.001	0.001	0.001	0.001
Ba	0.002	0.002	0.002	0.006	0.002	0.002	0.002	0.001	0.005	0.001	0.001	0.001
Sr	0.006	0.003	0.005	0.006	0.002	0.005	0.007	0.005	0.004	0.003	0.004	0.003
XAn	0.478	0.511	0.494	0.487	0.480	0.485	0.482	0.469	0.480	0.466	0.455	0.471
XAb	0.490	0.462	0.476	0.483	0.490	0.485	0.487	0.498	0.491	0.500	0.513	0.498
XOr	0.031	0.027	0.030	0.030	0.030	0.030	0.030	0.032	0.029	0.034	0.032	0.032

	SP1	TP1	UP1	VP1	WP1	XP1	YP1
SiO2	57.357	56.300	55.120	55.330	56.828	55.458	57.470
Al2O3	26.977	26.903	26.971	26.975	27.156	26.685	27.336
Na2O	5.669	5.503	5.597	5.608	5.580	5.624	5.255
K2O	0.549	0.563	0.527	0.541	0.545	0.559	0.563
CaO	9.578	9.518	9.506	9.504	9.682	9.352	9.957
MgO	0.035	0.017	0.028	0.031	0.027	0.028	0.044
FeO	0.346	0.320	0.331	0.326	0.336	0.325	0.372
MnO	0.001	0.000	0.002	0.011	0.011	0.004	0.006
TiO2	0.017	0.035	0.022	0.021	0.025	0.020	0.026
BaO	0.044	0.029	0.059	0.059	0.078	0.094	0.063
SrO	0.138	0.213	0.193	0.080	0.149	0.153	0.183
Total	100.741	99.456	98.383	98.509	100.494	98.335	101.316

Si	2.720	2.708	2.686	2.690	2.708	2.699	2.716
Al	1.508	1.525	1.549	1.546	1.525	1.531	1.523
Na	0.521	0.513	0.529	0.529	0.515	0.531	0.482
K	0.033	0.035	0.033	0.034	0.033	0.035	0.034
Ca	0.487	0.490	0.496	0.495	0.494	0.488	0.504
Mg	0.002	0.001	0.002	0.002	0.002	0.002	0.003
Fe	0.014	0.013	0.013	0.013	0.013	0.013	0.015
Mn	.000	0.000	.000	.000	.000	.000	.000
Ti	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ba	0.001	0.001	0.001	0.001	0.001	0.002	0.001
Sr	0.004	0.006	0.005	0.002	0.004	0.004	0.005
XAn	0.467	0.472	0.469	0.468	0.474	0.463	0.494
XAb	0.501	0.494	0.500	0.500	0.494	0.504	0.472
XOr	0.032	0.033	0.031	0.032	0.032	0.033	0.033

TABLE 2. HORNBLLENDE MICROPROBE DATA

Tetrahedral and Octahedral Cations Normalized to 13 (Leake, 1978).

H₂O Calculated on the Basis of 2(OH) Per Formula.

	Ehb	Bhb	Chb	Ghb	Ihb	Jhb	Khb	Lhb	Mhb	Ohb	Phb	Qhb
SiO ₂	46.145	47.503	46.217	47.889	48.271	46.846	48.342	46.785	46.661	47.319	48.021	47.419
Al ₂ O ₃	8.154	7.682	8.272	7.249	7.052	7.652	8.013	8.336	8.332	7.648	7.735	7.613
FeO	13.052	12.737	12.783	12.931	12.209	12.496	13.013	13.182	13.201	12.305	12.615	13.128
TiO ₂	1.915	1.516	1.853	1.624	1.548	1.841	1.807	1.875	1.971	1.793	1.758	1.637
MgO	14.557	14.548	14.571	15.104	14.878	14.657	15.005	14.058	14.347	14.979	14.770	14.769
MnO	0.370	0.350	0.380	0.351	0.418	0.359	0.353	0.415	0.335	0.357	0.357	0.385
CaO	11.824	11.773	11.604	11.610	11.772	11.458	11.901	11.607	11.676	11.544	11.636	11.484
BaO	0.094	0.060	0.064	0.628	0.053	0.055	0.090	0.066	0.067	0.050	0.024	0.037
SrO	0.027	0.000	0.050	0.048	0.021	0.026	0.021	0.023	0.011	0.020	0.013	0.007
Na ₂ O	1.322	1.288	1.430	1.177	1.328	1.489	1.358	1.386	1.500	1.458	1.414	1.353
K ₂ O	0.872	0.829	0.854	0.829	0.723	0.778	0.876	0.875	0.901	0.783	0.880	0.839
F	0.280	0.295	0.273	0.335	0.272	0.234	0.248	0.317	0.278	0.263	0.260	0.249
Cl	0.084	0.092	0.083	0.075	0.067	0.059	0.087	0.096	0.070	0.068	0.080	0.078
S	0.017	0.033	0.023	0.021	0.020	0.025	0.024	0.083	0.001	0.011	0.014	0.007
P ₂ O ₅	0.131	0.042	0.036	0.009	0.021	0.011	0.041	0.068	0.030	0.032	0.019	0.022
H ₂ O	1.838	1.814	1.842	1.795	1.821	1.864	1.798	1.805	1.826	1.836	1.815	1.844
Total	100.680	100.563	100.333	101.671	100.472	99.851	102.976	100.978	101.205	100.464	101.406	100.868
Si	6.656	6.836	6.669	6.820	6.935	6.778	6.780	6.731	6.690	6.789	6.835	6.778
Al(IV)	1.344	1.164	1.331	1.180	1.065	1.222	1.220	1.269	1.310	1.211	1.165	1.222
Al(VI)	0.042	0.139	0.076	0.037	0.129	0.083	0.104	0.145	0.098	0.083	0.133	0.061
Fe ³⁺	0.747	0.551	0.765	0.775	0.453	0.651	0.654	0.589	0.631	0.687	0.561	0.868
Fe ²⁺	0.827	0.982	0.777	0.765	1.014	0.861	0.872	0.997	0.952	0.790	0.941	0.701
Ti	0.208	0.164	0.201	0.174	0.167	0.200	0.191	0.203	0.212	0.194	0.188	0.176
Mg	3.130	3.121	3.134	3.207	3.186	3.161	3.137	3.015	3.066	3.204	3.134	3.147
Mn	0.045	0.043	0.046	0.042	0.051	0.044	0.042	0.051	0.041	0.043	0.043	0.047
Ca	1.827	1.815	1.794	1.772	1.812	1.776	1.788	1.789	1.794	1.775	1.775	1.759
Ba	0.005	0.003	0.004	0.035	0.003	0.003	0.005	0.004	0.004	0.003	0.001	0.002
Sr	0.002	0.000	0.004	0.004	0.002	0.002	0.002	0.002	0.001	0.002	0.001	0.001
Na	0.370	0.360	0.400	0.325	0.370	0.418	0.369	0.387	0.417	0.405	0.390	0.375
K	0.160	0.152	0.157	0.151	0.133	0.144	0.157	0.161	0.165	0.143	0.160	0.153
F	0.128	0.134	0.125	0.151	0.123	0.107	0.110	0.144	0.126	0.119	0.117	0.112
Cl	0.020	0.023	0.020	0.018	0.016	0.014	0.021	0.023	0.017	0.017	0.019	0.019
OH	1.852	1.843	1.855	1.831	1.860	1.878	1.869	1.832	1.857	1.864	1.864	1.869
Mg/Fe+Mg	0.791	0.761	0.801	0.807	0.759	0.786	0.782	0.752	0.763	0.802	0.769	0.818

	RHb	SHb	THb	UHb	VHb	WHb	XHb	YHb
SiO2	47.399	47.583	45.958	45.381	45.509	44.678	44.987	44.878
Al2O3	8.124	7.675	8.124	8.218	8.125	8.576	8.247	9.970
FeO	12.722	12.653	12.916	12.320	12.755	12.416	12.919	13.828
TiO2	1.977	1.733	1.961	2.026	1.985	2.286	2.134	1.934
MgO	14.827	14.909	14.096	14.821	14.713	14.320	14.365	13.129
MnO	0.354	0.350	0.402	0.293	0.351	0.309	0.400	0.360
CaO	11.800	11.664	11.484	11.231	11.198	11.104	11.157	11.469
BaO	0.048	0.063	0.073	0.066	0.051	0.054	0.062	0.056
SrO	0.016	0.020	0.010	0.018	0.001	0.013	0.029	0.031
Na2O	1.480	1.392	1.538	1.528	1.495	1.521	1.568	1.536
K2O	0.881	0.817	0.874	0.907	0.893	0.914	0.892	1.082
F	0.261	0.268	0.285	0.230	0.248	0.254	0.243	0.248
Cl	0.067	0.068	0.079	0.065	0.074	0.053	0.060	0.081
S	0.014	0.018	0.016	0.020	0.009	0.023	0.009	0.015
P2O5	0.021	0.029	0.040	0.023	0.035	0.036	0.017	0.037
H2O	1.816	1.826	1.846	1.892	1.883	1.897	1.897	1.859
Total	101.805	101.068	99.703	99.038	99.324	98.449	98.981	100.513

Si	6.734	6.795	6.701	6.611	6.612	6.563	6.581	6.517
Al(IV)	1.266	1.205	1.299	1.389	1.388	1.437	1.419	1.483
Al(VI)	0.094	0.087	0.097	0.022	0.003	0.048	0.003	0.223
Fe3+	0.602	0.677	0.586	0.982	1.094	0.915	0.990	0.637
Fe2+	0.910	0.834	0.989	0.519	0.456	0.611	0.591	1.043
Ti	0.211	0.186	0.215	0.222	0.217	0.252	0.235	0.211
Mg	3.140	3.174	3.064	3.219	3.187	3.136	3.132	2.842
Mn	0.043	0.042	0.050	0.036	0.043	0.038	0.050	0.044
Ca	1.796	1.785	1.794	1.753	1.743	1.748	1.749	1.784
Ba	0.003	0.004	0.004	0.004	0.003	0.003	0.004	0.003
Sr	0.001	0.002	0.001	0.002	0.000	0.001	0.002	0.003
Na	0.408	0.385	0.435	0.432	0.421	0.433	0.445	0.433
K	0.160	0.149	0.163	0.169	0.166	0.171	0.166	0.201
F	0.117	0.121	0.132	0.106	0.114	0.118	0.112	0.114
Cl	0.016	0.017	0.020	0.016	0.018	0.013	0.015	0.020
OH	1.867	1.863	1.849	1.878	1.868	1.869	1.873	1.866
Mg/Fe+Mg	0.775	0.792	0.756	0.861	0.875	0.837	0.841	0.732

TABLE 3. BIOTITE MICROPROBE DATA

Tetrahedral and Octahedral Cations Normalized to Seven.

H₂O Calculated by Assuming 2(OH) Per Formula. Fe³⁺ Calculated by Comparison

to Similar Biotites (Dodge et al., 1969).

	BBi	CBi	EBi	GBi	IBi	JBi	KBi	LBi	MBi	OBi	PBi	QBi
SiO ₂	37.906	37.712	41.014	38.067	38.262	37.357	38.755	38.194	37.466	37.939	38.023	38.196
Al ₂ O ₃	13.783	13.979	13.193	13.555	13.996	13.650	13.596	13.734	13.737	13.744	13.601	13.642
Na ₂ O	0.440	0.383	0.393	0.448	0.498	0.487	0.519	0.522	0.507	0.438	0.430	0.468
K ₂ O	8.609	9.251	8.140	8.661	9.059	8.818	8.790	8.459	8.814	9.029	8.376	8.581
MgO	15.041	15.088	13.278	14.411	14.615	14.270	14.796	14.689	14.422	14.053	14.270	14.307
Cl	0.148	0.135	0.129	0.116	0.129	0.129	0.124	0.124	0.123	0.135	0.132	0.117
FeO	15.051	15.099	13.485	14.913	15.601	15.657	14.826	15.441	15.888	16.501	15.934	15.847
MnO	0.197	0.198	0.196	0.189	0.211	0.183	0.177	0.136	0.196	0.184	0.236	0.184
TiO ₂	4.885	4.995	4.965	5.045	5.114	4.884	4.885	4.823	4.888	4.824	4.768	4.750
BaO	0.578	0.659	0.632	0.710	0.670	0.714	0.584	0.581	0.610	0.932	0.548	0.611
F	0.478	0.707	0.500	0.630	0.905	0.366	0.901	0.408	0.656	0.823	0.380	0.623
CaO	0.116	0.052	0.181	0.297	0.088	0.073	0.223	0.146	0.110	0.121	0.130	0.120
SrO	0.049	0.026	0.010	0.033	0.019	0.021	0.020	0.014	0.023	0.024	0.000	0.015
H ₂ O	3.842	3.435	3.630	3.474	3.295	3.666	3.286	3.684	3.440	3.322	3.681	3.489
O ²⁻ -(F+Cl)	-0.236	-0.625	-0.446	-0.568	-0.765	-0.348	-0.774	-0.371	-0.586	-0.713	-0.353	-0.549
Total	100.886	101.093	99.299	99.978	101.695	99.925	100.708	100.582	100.292	101.355	100.154	100.400
Si	2.853	2.831	3.136	2.898	2.861	2.854	2.915	2.877	2.842	2.866	2.879	2.888
Ti	0.277	0.282	0.286	0.289	0.288	0.281	0.276	0.273	0.279	0.274	0.272	0.270
Al(IV)	1.147	1.169	0.864	1.102	1.139	1.146	1.085	1.123	1.158	1.134	1.121	1.112
Al(VI)	0.076	0.069	0.326	0.114	0.094	0.083	0.121	0.096	0.070	0.089	0.093	0.104
Fe ³⁺	0.189	0.190	0.172	0.190	0.195	0.200	0.187	0.195	0.202	0.208	0.202	0.200
Fe ²⁺	0.758	0.758	0.690	0.760	0.780	0.800	0.746	0.778	0.806	0.834	0.807	0.802
Mn	0.013	0.013	0.013	0.012	0.013	0.012	0.011	0.009	0.013	0.012	0.015	0.012
Mg	1.688	1.689	1.514	1.635	1.629	1.625	1.659	1.649	1.631	1.582	1.611	1.612
Ca	0.009	0.004	0.014	0.023	0.007	0.006	0.017	0.011	0.009	0.009	0.010	0.009
Na	0.062	0.054	0.055	0.063	0.069	0.070	0.072	0.074	0.072	0.061	0.061	0.066
K	0.801	0.854	0.752	0.807	0.827	0.833	0.806	0.788	0.823	0.834	0.786	0.798
Ba	0.017	0.019	0.018	0.020	0.019	0.021	0.016	0.017	0.017	0.026	0.016	0.017
Sr	0.002	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001
F	0.110	0.324	0.229	0.291	0.410	0.171	0.409	0.188	0.304	0.377	0.177	0.287
Cl	0.018	0.017	0.016	0.014	0.016	0.016	0.015	0.015	0.015	0.017	0.016	0.014
OH	1.871	1.660	1.755	1.695	1.574	1.812	1.576	1.796	1.681	1.606	1.807	1.698

	RBi	SBi	TBi	UBi	VBi	WBi	XBi
SiO2	37.653	38.147	36.946	37.713	36.575	35.667	37.980
Al2O3	13.460	13.724	13.724	13.173	12.841	12.172	13.509
Na2O	0.421	0.438	0.456	0.362	0.416	0.442	0.493
K2O	7.631	8.895	8.263	7.481	8.001	7.902	8.744
MgO	15.012	14.162	14.649	13.608	14.193	13.508	13.928
Cl	0.117	0.115	0.117	0.111	0.130	0.107	0.105
FeO	15.526	15.837	15.645	14.532	16.865	18.143	15.599
MnO	0.220	0.176	0.183	0.156	0.166	0.147	0.162
TiO2	4.741	4.885	5.134	6.496	4.667	4.734	5.068
BaO	0.543	0.595	0.745	0.702	0.807	0.557	0.739
F	0.805	0.647	0.486	0.336	1.611	2.289	1.379
CaO	0.277	0.211	0.133	0.278	0.217	0.359	0.115
SrO	0.005	0.005	0.003	0.000	0.039	0.051	0.000
H2O	3.301	3.476	3.563	3.684	2.516	1.860	2.818
O=-(F+Cl)	-0.709	-0.562	-0.433	-0.311	-1.379	-1.997	-1.191
Total	99.001	100.750	99.614	98.320	97.665	95.941	99.448

Si	2.845	2.887	2.809	2.911	2.825	2.805	2.901
Ti	0.269	0.278	0.294	0.377	0.271	0.280	0.291
Al(IV)	1.155	1.113	1.191	1.089	1.175	1.195	1.099
Al(VI)	0.044	0.111	0.039	0.109	-0.006	-0.067	0.117
Fe3+	0.196	0.200	0.199	0.188	0.218	0.239	0.199
Fe2+	0.785	0.802	0.796	0.750	0.872	0.955	0.797
Mn	0.014	0.011	0.012	0.010	0.011	0.010	0.010
Mg	1.691	1.598	1.660	1.566	1.634	1.584	1.586
Ca	0.022	0.016	0.011	0.022	0.017	0.028	0.009
Na	0.060	0.062	0.065	0.052	0.059	0.063	0.069
K	0.712	0.826	0.779	0.709	0.750	0.745	0.805
Ba	0.016	0.017	0.022	0.020	0.023	0.016	0.021
Sr	.000	.000	.000	0.000	0.002	0.002	0.000
F	0.373	0.298	0.227	0.158	0.749	1.069	0.629
Cl	0.015	0.014	0.015	0.014	0.016	0.013	0.013
OH	1.613	1.688	1.758	1.828	1.235	0.917	1.358

TABLE 4. PYROXENE MICROPROBE DATA: FORMULA CALCULATIONS BASED ON 6 OXYGENS
 Fe₂O₃ and Fe³⁺ determined by method described by Robinson (1980).

Oxide	BCpxCore*	BCpx	BOpx	CCpx	ECpx	HCpx	ICpx	JCpx	LCpx	MCpx	OCpx	PCpx
SiO ₂	53.600	53.642	54.321	53.163	52.993	53.307	53.424	52.831	53.917	53.797	53.770	53.460
TiO ₂	0.160	0.247	0.165	0.240	0.284	0.210	0.160	0.214	0.202	0.188	0.191	0.201
Al ₂ O ₃	0.826	1.121	0.548	1.122	1.292	1.064	1.021	1.208	1.065	0.996	1.116	1.134
FeO	7.411	8.259	21.919	7.382	7.102	8.236	7.741	7.903	8.032	7.489	7.852	8.631
Fe ₂ O ₃	1.150	0.619	0.000	1.566	1.261	0.549	1.331	1.215	0.716	1.263	1.142	0.423
MnO	0.567	0.369	1.476	0.473	0.338	0.571	0.588	0.573	0.518	0.558	0.620	0.570
MgO	14.530	14.631	22.301	14.642	15.104	13.879	13.996	13.789	14.268	14.662	14.155	13.609
CaO	22.580	21.843	1.003	21.991	21.651	22.324	22.588	22.210	22.599	22.356	22.599	22.519
Na ₂ O	0.289	0.345	0.034	0.341	0.315	0.366	0.373	0.379	0.347	0.347	0.374	0.372
K ₂ O	0.027	0.021	0.024	0.023	0.017	0.026	0.023	0.029	0.033	0.019	0.022	0.021
Total	101.138	101.098	101.788	100.942	100.358	100.530	101.246	100.351	101.696	101.673	101.841	100.938
Si	1.973	1.973	1.990	1.960	1.958	1.977	1.969	1.965	1.975	1.969	1.969	1.978
Al(IV)	0.027	0.027	0.010	0.040	0.042	0.023	0.031	0.035	0.025	0.031	0.031	0.022
Al(VI)	0.008	0.022	0.013	0.009	0.014	0.024	0.013	0.018	0.021	0.012	0.017	0.027
Ti	0.004	0.007	0.005	0.007	0.008	0.006	0.004	0.006	0.006	0.005	0.005	0.006
Fe ³⁺	0.032	0.017	0.000	0.043	0.035	0.015	0.037	0.034	0.020	0.035	0.031	0.012
Mg	0.797	0.802	1.218	0.805	0.832	0.767	0.769	0.765	0.779	0.800	0.773	0.750
Fe ²⁺	0.228	0.254	0.671	0.228	0.219	0.255	0.239	0.246	0.246	0.229	0.240	0.267
Mn	0.018	0.012	0.046	0.015	0.011	0.018	0.018	0.018	0.016	0.017	0.019	0.018
VI SUM	1.088	1.113	1.953	1.106	1.119	1.085	1.080	1.086	1.087	1.098	1.086	1.080
Ca	0.890	0.861	0.039	0.869	0.857	0.887	0.892	0.885	0.887	0.877	0.887	0.893
Na	0.021	0.025	0.002	0.024	0.023	0.026	0.027	0.027	0.025	0.025	0.027	0.027
K	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
VI-VIII	0.912	0.887	0.043	0.894	0.881	0.915	0.920	0.914	0.913	0.902	0.914	0.920
Wo	0.465	0.449	0.020	0.457	0.449	0.464	0.470	0.467	0.464	0.460	0.467	0.467
En	0.416	0.418	0.631	0.423	0.436	0.402	0.405	0.403	0.407	0.420	0.407	0.393
Fs	0.119	0.133	0.348	0.120	0.115	0.134	0.126	0.130	0.129	0.120	0.127	0.140

* Samples labelled as "core" are resorbed pyroxenes overgrown by either hornblende or pyroxene.

	QCpx	RCpx	SCpx	TCpx	UCpx	VCpxCore	VCpxCore	VCpx	WCpx	XCpx	YCpx
SiO2	53.345	53.163	52.444	53.630	52.312	50.546	51.141	51.545	52.877	51.784	54.072
TiO2	0.207	0.210	0.267	0.175	0.150	0.533	0.475	0.216	0.239	0.210	0.217
Al2O3	1.138	1.060	1.452	0.924	0.833	3.127	2.526	1.239	1.335	1.307	1.054
FeO	8.721	8.670	9.539	8.484	8.550	8.516	8.281	8.676	8.442	9.244	8.786
Fe2O3	0.000	0.000	0.000	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MnO	0.587	0.454	0.608	0.592	0.511	0.318	0.236	0.564	0.487	0.532	0.586
MgO	14.086	14.369	13.355	14.446	13.938	14.578	15.528	13.679	14.272	13.514	14.057
CaO	22.278	22.120	21.900	22.709	21.765	20.068	20.607	21.891	21.890	21.421	22.527
Na2O	0.357	0.307	0.415	0.345	0.365	0.562	0.306	0.369	0.361	0.427	0.364
K2O	0.020	0.019	0.017	0.019	0.020	0.091	0.009	0.021	0.021	0.024	0.025
Total	100.737	100.370	99.996	101.363	98.443	98.338	99.106	98.201	99.923	98.462	101.687
Si	1.975	1.974	1.965	1.974	1.982	1.912	1.916	1.963	1.970	1.968	1.983
Al(IV)	0.025	0.026	0.035	0.026	0.018	0.088	0.084	0.037	0.030	0.032	0.017
Al(VI)	0.025	0.020	0.029	0.014	0.019	0.051	0.028	0.019	0.029	0.026	0.028
Ti	0.006	0.006	0.008	0.005	0.004	0.015	0.013	0.006	0.007	0.006	0.006
Fe3+	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mg	0.778	0.795	0.746	0.793	0.787	0.822	0.867	0.777	0.793	0.765	0.768
Fe2+	0.270	0.269	0.299	0.261	0.271	0.269	0.260	0.276	0.263	0.294	0.269
Mn	0.018	0.014	0.019	0.018	0.016	0.010	0.007	0.018	0.015	0.017	0.018
VI SUM	1.097	1.105	1.101	1.092	1.098	1.168	1.176	1.096	1.106	1.109	1.090
Ca	0.884	0.880	0.879	0.896	0.884	0.813	0.827	0.893	0.874	0.872	0.885
Na	0.026	0.022	0.030	0.025	0.027	0.041	0.022	0.027	0.026	0.031	0.026
K	0.001	0.001	0.001	0.001	0.001	0.004	.000	0.001	0.001	0.001	0.001
VI-VIII	0.910	0.903	0.910	0.921	0.911	0.859	0.850	0.922	0.901	0.905	0.912
Wo	0.458	0.453	0.457	0.459	0.455	0.427	0.423	0.459	0.453	0.452	0.460
En	0.403	0.409	0.388	0.407	0.405	0.432	0.444	0.399	0.411	0.396	0.400
Fs	0.140	0.138	0.155	0.134	0.140	0.141	0.133	0.142	0.136	0.152	0.140

TABLE 5. APATITE MICROPROBE DATA.
 Calculated Formula (P+Ca+Ba+Sr=8). H₂O Calculated by Assuming 1(OH) Per Formula.

	BAp	CAp	GAp	HAp	IAp	JAp	KAp	OPp	PAp	RAp	UAp	YAp
SiO ₂	0.797	0.717	0.916	0.516	0.585	0.680	0.431	0.721	0.498	0.572	1.039	0.914
Na ₂ O	0.234	0.134	0.267	0.136	0.143	0.155	0.102	0.171	0.153	0.134	0.128	0.167
Cl	0.973	1.071	0.966	0.693	0.934	0.928	0.850	0.886	1.029	1.048	0.980	0.929
FeO	2.048	0.756	2.967	1.631	1.976	2.150	1.979	3.116	1.625	1.665	1.791	0.398
MnO	0.183	0.206	0.198	0.143	0.193	0.221	0.139	0.206	0.181	0.179	0.180	0.180
BaO	0.035	0.052	0.027	0.081	0.044	0.063	0.029	0.080	0.056	0.039	0.055	0.049
F	2.248	2.041	1.906	2.357	1.846	2.031	1.975	2.750	2.685	2.929	1.716	1.840
CaO	54.829	54.449	52.203	53.989	53.795	51.897	53.142	52.937	54.405	54.369	51.780	54.673
P ₂ O ₅	38.350	39.837	39.088	38.911	38.708	39.416	40.100	38.327	38.908	39.282	39.378	38.936
SrO	0.146	0.106	0.072	0.043	0.048	0.111	0.113	0.091	0.058	0.085	0.125	0.072
H ₂ O	0.338	0.436	0.496	0.359	0.519	0.450	0.516	0.132	0.143	0.045	0.575	0.532
O ⁻ =(F+Cl)	1.166	1.101	1.021	1.149	0.988	1.065	1.023	1.358	1.363	1.470	0.943	0.984
Total	99.015	98.701	98.083	97.709	97.802	97.037	98.351	98.061	98.378	98.878	96.803	97.704
Si	0.072	0.064	0.083	0.047	0.054	0.062	0.039	0.065	0.044	0.050	0.095	0.084
Ca	5.147	5.065	5.023	5.094	5.098	4.995	5.007	5.084	5.108	5.089	4.992	5.116
Ba	0.001	0.002	0.001	0.003	0.002	0.002	0.001	0.003	0.002	0.001	0.002	0.002
Sr	0.007	0.005	0.004	0.002	0.002	0.006	0.006	0.005	0.003	0.004	0.007	0.004
P	2.845	2.928	2.972	2.901	2.898	2.997	2.986	2.909	2.887	2.905	3.000	2.879
Na	0.041	0.023	0.047	0.024	0.025	0.027	0.018	0.030	0.027	0.023	0.023	0.030
Fe	0.155	0.057	0.226	0.124	0.152	0.163	0.149	0.235	0.121	0.123	0.137	0.030
Mn	0.014	0.016	0.015	0.011	0.015	0.017	0.011	0.016	0.014	0.013	0.014	0.014
F	0.645	0.577	0.549	0.676	0.536	0.584	0.561	0.785	0.759	0.817	0.497	0.532
Cl	0.150	0.162	0.149	0.107	0.145	0.143	0.129	0.136	0.156	0.157	0.152	0.144
OH	0.205	0.260	0.302	0.217	0.318	0.273	0.310	0.080	0.085	0.027	0.351	0.324

TABLE 6. TITANOMAGNETITE AND ILMENITE MICROPROBE DATA
 Fe2O3 vs FeO Calculated by Method of Carmichael (1967).

	BMt	CMt	FMt	GMt	HMt	OMt	VMt	WMt	XMt	YMt
SiO2	0.17	0.15	0.23	0.17	0.07	0.17	0.12	0.34	1.07	0.16
Al2O3	2.13	2.12	1.97	1.88	1.58	1.82	2.01	1.69	2.01	1.87
Na2O	0.00	0.02	0.02	0.02	0.02	0.00	0.01	0.02	0.04	0.01
K2O	0.08	0.09	0.08	0.08	0.08	0.08	0.09	0.09	0.12	0.08
MgO	0.91	1.08	1.01	1.23	1.16	0.71	1.15	1.11	0.50	1.08
CaO	0.16	0.17	0.21	0.27	0.12	0.16	0.20	0.19	0.21	0.21
FeO	43.12	43.94	44.11	43.57	45.00	45.06	43.75	44.15	53.54	53.63
Fe2O3	46.91	44.87	45.38	43.63	44.48	44.01	43.68	43.87	32.16	34.51
MnO	0.60	0.57	0.45	0.59	0.64	0.73	0.70	0.57	0.43	0.63
TiO2	3.40	5.09	4.70	6.21	5.82	5.99	6.14	5.97	5.81	5.09
Total	97.48	98.10	98.16	97.65	98.97	98.73	97.85	98.00	95.89	97.27

	BI1	CI1	FI1	GI1	HI1	QI1	VI1	WI1	XI1	YI1
SiO2	0.06	0.06	0.08	0.15	0.06	0.11	0.31	0.07	0.09	0.09
Al2O3	0.23	0.27	0.16	0.34	0.32	0.30	0.29	0.35	0.27	0.29
Na2O	0.03	0.02	0.00	0.02	0.02	0.03	0.04	0.02	0.03	0.03
K2O	0.08	0.09	0.07	0.07	0.08	0.08	0.09	0.07	0.07	0.07
MgO	2.28	1.74	2.29	1.32	1.80	1.34	2.04	1.57	1.69	1.78
CaO	0.26	0.18	0.21	0.19	0.34	0.32	0.26	0.22	0.19	0.22
FeO	39.61	42.86	43.68	41.08	42.90	38.93	43.77	42.98	42.99	40.03
Fe2O3	16.72	16.38	13.25	21.27	16.82	21.72	12.02	18.03	18.41	19.81
MnO	0.82	0.57	0.77	0.57	0.58	1.99	0.70	0.53	0.51	1.80
TiO2	39.08	35.98	38.53	32.44	36.01	32.05	38.55	35.16	35.08	33.69
Total	99.17	98.15	99.04	97.45	98.93	96.87	98.07	99.00	99.33	97.81

TABLE 7. GLASS MICROPROBE DATA
 Fe2O3 Calculated by Method Described by Kilinc et al. (1983).

Sample	BG1	CG1	EG1	GG1	UG1	YG1
SiO2	74.532	73.538	74.437	73.759	71.940	74.645
Al2O3	11.853	11.840	11.517	11.544	11.596	11.671
Na2O	2.606	4.113	4.456	2.452	2.602	3.006
K2O	5.368	2.751	2.218	5.382	5.056	4.501
MgO	0.138	0.112	0.117	0.149	0.128	0.138
Cl	0.095	0.076	0.083	0.032	0.076	0.089
Fe2O3	0.518	0.424	0.461	0.494	0.451	0.452
FeO	0.246	0.320	0.386	0.403	0.350	0.335
MnO	0.031	0.019	0.012	0.003	0.019	0.005
TiO2	0.153	0.149	0.129	0.178	0.204	0.185
BaO	0.119	0.087	0.102	0.082	0.128	0.121
F	0.004	0.041	0.047	0.002	0.001	0.023
CaO	0.885	0.852	0.674	0.908	0.903	0.915
S	0.003	0.017	0.010	0.005	0.012	0.018
P2O5	0.000	0.017	0.000	0.029	0.008	0.027
SrO	0.037	0.017	0.038	0.033	0.042	0.038
Total	96.590	94.370	94.690	95.450	93.510	96.160

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