



DEPARTMENT OF
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Report on Snake River Plain Spinel

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Samples of volcanic rock were collected in the summer of 1992 in order to investigate the role of chromite and magnetite in the crystallization of basalt from the Snake River Plain. Samples were collected from the Craters of the Moon National Monument, Hell's Half Acre, Wapi, Shoshone, McKinney flow and from various locations overlooking the Snake River. Polished thin sections were cut from these samples and those samples that contained primary chromite were chosen for analysis by the electron microprobe. Unfortunately no samples that I collected from the Craters of the Moon were found to contain primary chromite. Chemical analyses of 136 chromite and magnetite were made and a table of these analyses is included with this report. A graph of these analyses is also included with this report. These results confirm earlier studies that the Snake River Plain chromite are distinctive because they are relatively rich in iron considering the high chromium content of the chromite. Further work needs to be done in order to publish a paper on the implications of the distinctive nature of the Snake River Plain chromite. The electron microprobe analyses of the Snake River Plain chromite and magnetite have been included in a database of about 20,000 spinel analyses which I have made available free of charge to interested researchers. These analyses are included and described in the review paper which was delivered as the Presidential Address for the Mineralogical Association of Canada and published in The Canadian Mineralogist (Vol. 32, pg. 729-746, 1994). I wish to thank the National Park Service for allowing me access to samples within the National Park.

Peter L. Roeder

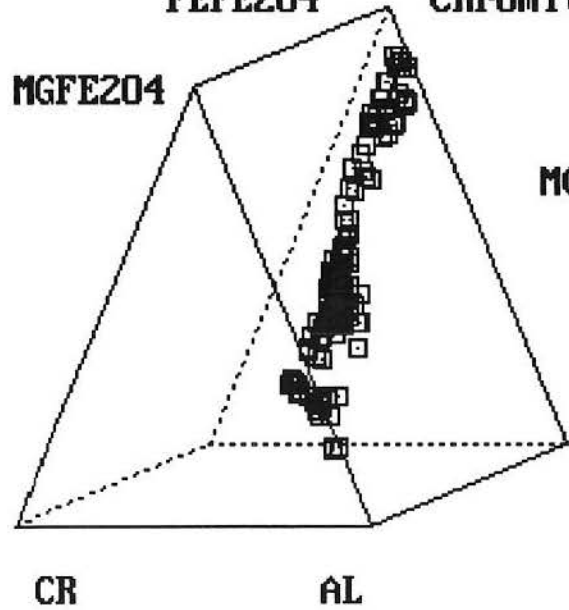
July 11, 1996

FEFE204

Chromite and Magnetite from Snake River Plain

MGFE204

136 ANALYSES OUT OF 136 07-11-1996

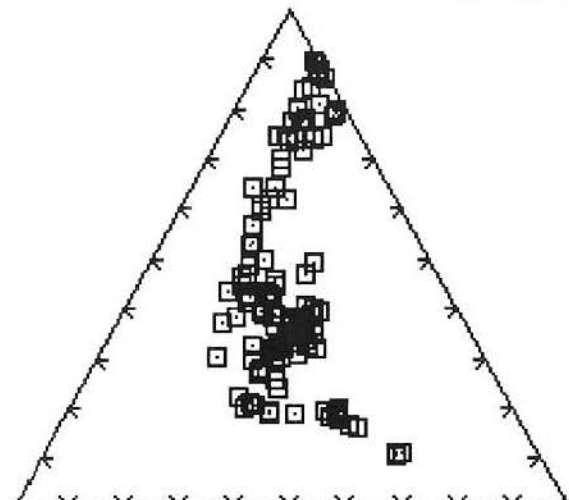
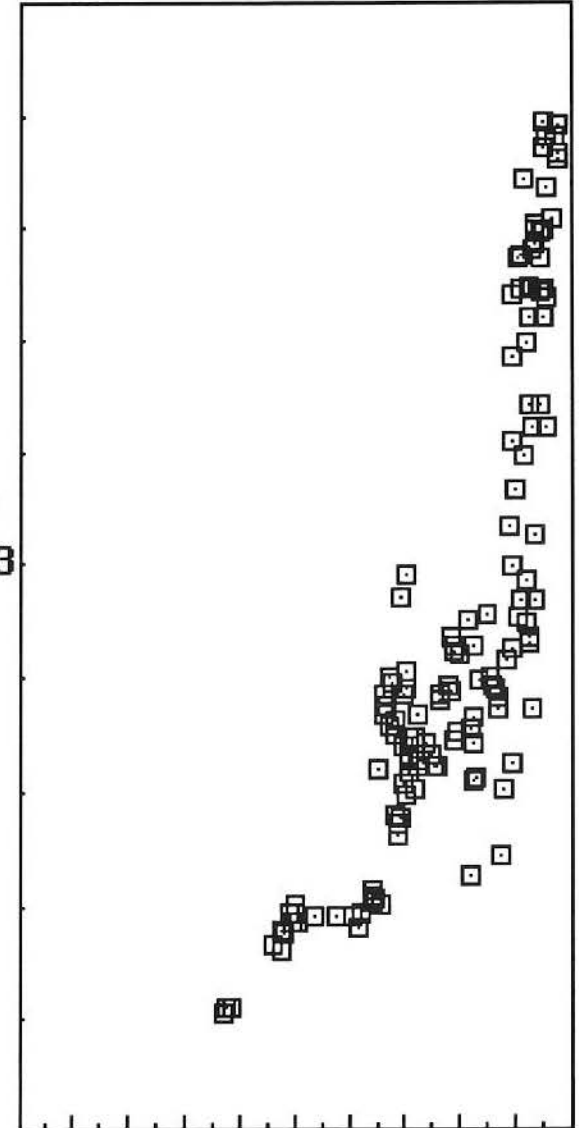
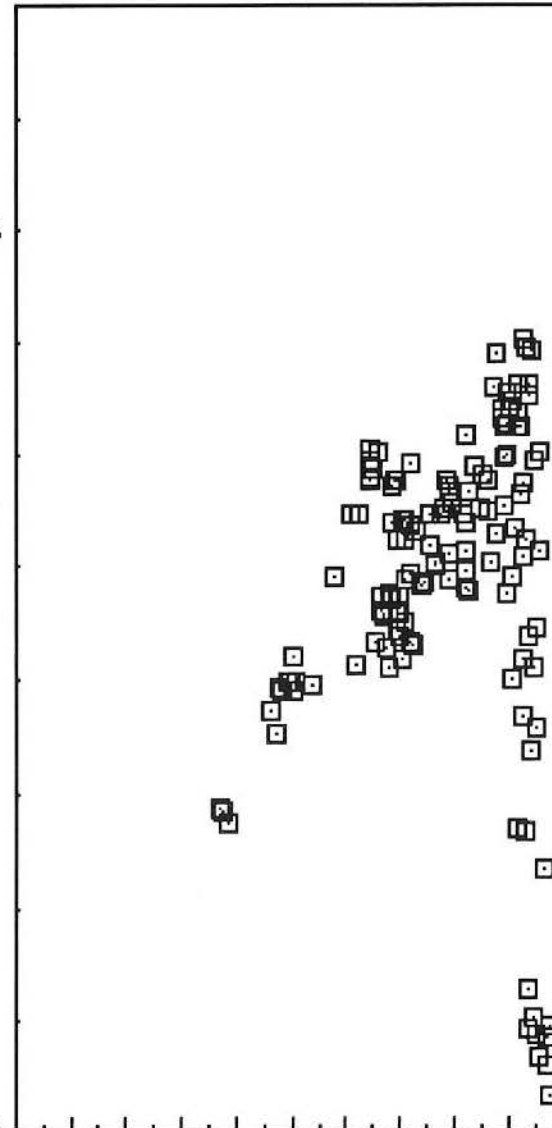


MG

FE2+

MG

FE2+



↑
CR
CR+AL

↑
FE3

SAMPLE	SYMBOL	IDENT.	DESCRIP.	REFERENCE
1	1	SPOL 6225 SMALL	WAPI	T=470
2	1	SPOL 6225 SMALL SAME OL	WAPI	T=470
3	1	SPOL 6225 SMALL SAME OL	WAPI	T=470
4	1	SPOL 6225 SMALL	WAPI	T=470
5	1	SPOL 6225 MED NEAR GM	WAPI	T=470
6	1	SPOL 6223 #19 MED	SNAKE OVERLOOK	T=470
7	1	SPOL 6223 #20 SMALL	SNAKE OVERLOOK	T=470
8	1	SPOL 6223 #21 LARGE NEAR LAST	SNAKE OVERLOOK	T=470
9	1	SPOL 6223 #23 EU SMALL	SNAKE OVERLOOK	T=470
10	1	SPOL 6223 #25 MED EUSNAKE	OVERLOOK	T=470
11	1	SPOL 6223 #26 MED LARGE NEAR LAST	SNAKE OVERLOOK	T=470
12	1	SPOL 6222 #28 SMALL	MCKINNEY	T=470
13	1	SPOL 6222 #29 MED IN SAME OL	MCKINNEY	T=470
14	1	SPOL 6222 #30 SMALL EU	MCKINNEY	T=470
15	1	SPGMOL 6222 #31 MATRIX EXSOLVED	MCKINNEY	T=470
16	1	SPOL 6222 #32 PATCHYMCKINNEY		T=470
17	1	SPOL 6222 #33 PATCHY LIGHT	MCKINNEY	T=470
18	1	SPOL 6222 #37 ANHEDRAL	MCKINNEY	T=470
19	1	SPOL 6226 #39 EU IN EU OL	HELLS HALF ACRE	T=470
20	1	SPOL 6221 #40 LARGE IN LARGE OL	MCKINNEY	T=470
21	1	SPOL 6221 #42 MED ANMCKINNEY		T=470
22	1	SPOL 6221 #44 SMALL	MCKINNEY	T=470
23	1	SPOL 6221 #45 MED IN LARGE OL	MCKINNEY	T=470
24	1	SPOL 6221 #46 MED IN LARGE OL	MCKINNEY	T=470
25	1	SPOL 6221 #48 IN LARGE MELT INCL	MCKINNEY	T=470
26	1	SPOL 6221 #49 LARGE IN LARGE OL	MCKINNEY	T=470
27	1	SPOL 6220 LARGE	MCKINNEY	T=470
28	1	SPOL 6220 MED	MCKINNEY	T=470
29	1	SPOLMX 6220 CLOSE TO OL	MCKINNEY	T=470
30	1	SPOLMX 6220 CLOSE TO MX	MCKINNEY	T=470
31	1	SPOL 6220 SMALL	MCKINNEY	T=470
32	1	SPOL 6220 SMALL	MCKINNEY	T=470
33	1	SPOLMX 6220 LARGE GROUP	MCKINNEY	T=470
34	1	SPOLMX 6220 2ND OF LARGE GROUP	MCKINNEY	T=470
35	1	SPOL 6220 LARGE IN GROUP	MCKINNEY	T=470

36	1	SPMX 6220 MED EU	MCKINNEY	T=470
37	1	SPMX 6220 LARGE EU	MCKINNEY	T=470
38	1	SPOL 6220 NEAR MX LARGE EU	MCKINNEY	T=470
39	1	SPOL 6220 NEAR MX LARGE AN	MCKINNEY	T=470
40	1	SPOLMX 6220 LARGE AN	MCKINNEY	T=470
41	1	SPOLMX 6220 MED AN	MCKINNEY	T=470
42	1	SPMX 6220 LARGE EU CORE&CORE&	MCKINNEY	T=470
43	1	SPMX 6220 LARGE EU RIM&42 RIM&	MCKINNEY	T=470
44	1	SPOL 6219 SQR OL	SHOSHONE	T=470
45	1	SPOL 6219 2ND SQR OL	SHOSHONE	T=470
46	1	SPOL 6219 MED	SHOSHONE	T=470
47	1	SPOL 6219 MED IN SAME OL	SHOSHONE	T=470
48	1	SPOL 6219 SMALL	SHOSHONE	T=470
49	1	SPOL 6219 MED	SHOSHONE	T=470
50	1	SPOL 6219 SMALL	SHOSHONE	T=470
51	1	SPOL 6219 SMALL IN SMALL OL	SHOSHONE	T=470
52	1	SPOL 6219 MED PARALLEL	LAGRAM	T=470
53	1	SPOLMX 6219 CLOSER TO OL&CORE&	SHOSHONE	T=470
54	1	SPOLMX 6219 CLOSER TO MX&53 RIM&	SHOSHONE	T=470
55	1	SPOLMXPL 6219 EU SQR SMALL	SHOSHONE	T=470
56	1	SPOLMX 6219 SMALL EU	SHOSHONE	T=470
57	1	SPOLMX? 6219 SMALL	SHOSHONE	T=470
58	1	SPMX 6219 SMALL EU	SHOSHONE	T=470
59	1	SPMX 6219 SMALL EU	SHOSHONE	T=470
60	1	SPMX 6219 LARGE AN	SHOSHONE	T=470
61	1	SPMX 6219 MED AN	SHOSHONE	T=470
62	1	SPGM 6222 LARGE&CORE&	MCKINNEY	T=470
63	1	SPGM 6222 LARGE&62 MIDWAY&	MCKINNEY	T=470
64	1	SPGM 6222 LARGE&63 RIM&	MCKINNEY	T=470
65	1	SPOLGM 6222&NEAR OL&	MCKINNEY	T=470
66	1	SPOLGM 6222&65 NEAR GM&	MCKINNEY	T=470
67	1	SPGM 6222 LARGE&CORE&	MCKINNEY	T=470
68	1	SPGM 6222 LARGE &67 MIDWAY&	MCKINNEY	T=470
69	1	SPGM 6222 LARGE &68 RIM&	MCKINNEY	T=470
70	1	SPOLGM &NEAR OL&	MCKINNEY	T=470
71	1	SPOLGM 6222 &70 NEAR GM&	MCKINNEY	T=470
72	1	SPOLPL 6226 SPOLPL MED-SMALL	HELLS HALF ACRE	T=470
73	1	SPOLPL 6226MED-SMALL	HELLS HALF ACRE	T=470
74	1	SPOLPL 6226 MED-SMALL	HELLS HALF ACRE	T=470
75	1	SPOLPL 6226 LARGE&CORE&		

		HELLS HALF ACRE	T=470
76	1	SPOLPL 6226 LARGE&75 RIM&	
		HELLS HALF ACRE	T=470
77	1	SPOL 6226 REPEAT OF NO.19	
		HELLS HALF ACRE	T=470
78	1	SPOLGM 6226	T=470
79	1	SPGM 6226 MED&CORE&	T=470
80	1	SPGM 6226 MED& 79 CORNER&	
		HELLS HALF ACRE	T=470
81	1	SPGM 6226 LARGE IRREG&CORE&	
		HELLS HALF ACRE	T=470
82	1	SPGM 6226 LARGE IRREG&81 RIM&	
		HELLS HALF ACRE	T=470
83	1	SPOL 6226 LARGE	T=470
84	1	SPOL 6226 EU MED IN EU OL	
		HELLS HALF ACRE	T=470
85	1	SPOLGM 6226 MED	T=470
86	1	SPGM 6226 MED	T=470
87	1	SPGM 6226 SMALL KITE-LIKE	
		HELLS HALF ACRE	T=470
88	1	SPOLGM 6226 MED ANHED &NEAR OL&	
		HELLS HALF ACRE	T=470
89	1	SPOLGM 6226 MED ANHED &88 NEAR GM&	
		HELLS HALF ACRE	T=470
90	1	SPOLGM 6220 MED&CORE&	
		MCKINNEY	T=470
91	1	SPOLGM 6220 MED&90 RIM&	
		MCKINNEY	T=470
92	1	SPOLGM 6220 MED&91 &MCKINNEY	T=470
93	1	SPGM 6220 LARGE EU&CORE&	
		MCKINNEY	T=470
94	1	SPGM 6220 LARGE EU&93 MIDWAY&	
		MCKINNEY	T=470
95	1	SPGM 6220 LARGE EU&94 &	
		MCKINNEY	T=470
96	1	SPGM 6220 LARGE EU&95 CORNER&	
		MCKINNEY	T=470
97	1	SPGM LARGE EU& 96 EDGE&	
		MCKINNEY	T=470
98	1	SPGM 6220 LARGE&CORE&	
		MCKINNEY	T=470
99	1	SPGM 6220 LARGE&98 EDGE&	
		MCKINNEY	T=470
100	1	SPGM 6220 VERY SMALLMCKINNEY	T=470
101	1	SPGM 6225 EU SMALL&CORE&	
		WAPI	T=470
102	1	SPGM EU SMALL&101 RIM&	
		WAPI	T=470
103	1	SPOLGM 6225 EU MED RIM	
		WAPI	T=470
104	1	SPOLGM 6225 EU MED&CORE&	
		WAPI	T=470
105	1	SPOLGM 6225 EU MED&104 NEAR EDGE&	
		WAPI	T=470
106	1	SPOLGM EU MED& 105 EDGE&	
		WAPI	T=470
107	1	SPOLGM EU EDGE	T=470
108	1	SPPLGM 6225 EU CORNER	
		WAPI	T=470
109	1	SPOLGM 6225 EU LARGEWAPI	T=470

110	1	SPOLGM 6225 AN LARGE&WAPI	T=470
111	1	SPGM 6221 AN LARGE&CORE& MCKINNEY	T=470
112	1	SPGM 6221 AN LARGE&111& MCKINNEY	T=470
113	1	SPGM 6221 AN LARGE&112 NEAR EDGE& MCKINNEY	T=470
114	1	SPGM 6221 AN LARGE&113 EDGE& MCKINNEY	T=470
115	1	SPGM 6221 AN MED&CORE& MCKINNEY	T=470
116	1	SPGM 6221 AN MED&115 EDGE& MCKINNEY	T=470
117	1	SPOLGM 6221 AN MED &CORE& MCKINNEY	T=470
118	1	SPOLGM 6221 AN MED&117 MIDWAY& MCKINNEY	T=470
119	1	SPOLGM 6221 AN MED&118 PROTUB& MCKINNEY	T=470
120	1	SPGM 6223 SM EU SNAKE OVERLOOK	T=470
121	1	SPOLGM 6223 MED EU&NEAR OL& SNAKE OVERLOOK	T=470
122	1	SPOLGM 6223 MED EU&121 CENTRAL& SNAKE OVERLOOK	T=470
123	1	SPOLGM 6223 MED EU&122 MAIN& SNAKE OVERLOOK	T=470
124	1	SPOLGM 6223 MED EU&123 BASE& SNAKE OVERLOOK	T=470
125	1	SPOLGM 6223 MED EU&124 MID& SNAKE OVERLOOK	T=470
126	1	SPOLGM 6223 MED EU&125 NEAR GM& SNAKE OVERLOOK	T=470
127	1	SPOLGM 6223 SQR &NEAR OL& SNAKE OVERLOOK	T=470
128	1	SPOLGM 6223 SQR&127 MAIN& SNAKE OVERLOOK	T=470
129	1	SPOLGM 6223 SQR&128 BASE& SNAKE OVERLOOK	T=470
130	1	SPOLGM 6223 SQR&129 ARM& SNAKE OVERLOOK	T=470
131	1	SPGM 6223 LARGE CUBE CORE SNAKE OVERLOOK	T=470
132	1	SPGM 6223 LARGE EU CORE SNAKE OVERLOOK	T=470
133	1	SPGM 6223 LARGE EU&CORE& SNAKE OVERLOOK	T=470
134	1	SPGM LARGE EU&133 HALFWAY& SNAKE OVERLOOK	T=470
135	1	SPGM 6223 LARGE EU&134 INSIDE RIM& SNAKE OVERLOOK	T=470
136	1	SPGM 6223 LARGE EU&135 RIM& SNAKE OVERLOOK	T=470

Chromite and Magnetite from Snake River Plain

Chromite and Magnetite from Snake River Plain. Collected by P. Roeder 1992

NO.	1	2	3	4	5	6	7
WT %	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622
SIO2	0.39	0.41	0.39	0.48	0.36	0.42	0.40
TIO2	0.89	1.08	1.02	4.02	6.26	10.94	8.73
AL2O3	36.96	37.11	36.57	19.51	13.85	11.08	12.40
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	22.22	20.86	21.63	28.10	30.07	19.92	21.82
FEO	24.29	25.13	24.63	36.23	39.62	50.26	48.43
MNO	0.14	0.10	0.29	0.20	0.29	0.30	0.41
MGO	15.00	14.62	14.78	9.60	8.30	6.17	7.03
CAO	0.11	0.00	0.03	0.09	0.15	0.08	0.05
NA2O	0.00	0.00	0.00	0.00	0.00	0.00	0.07
K2O	0.00	0.00	0.00	0.00	0.00	0.03	0.00
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	100.00	99.31	99.34	98.23	98.90	99.20	99.34

IONS / 24 OXYGEN + ANIONS

SI 4	0.067	0.071	0.068	0.093	0.072	0.085	0.080
TI 4	0.115	0.141	0.133	0.582	0.931	1.663	1.308
AL 3	7.461	7.545	7.441	4.423	3.227	2.640	2.912
FE 3	1.244	1.283	1.294	2.068	2.146	2.779	2.958
CR 3	3.009	2.846	2.953	4.274	4.699	3.184	3.438
FE 2	2.237	2.343	2.263	3.760	4.403	5.717	5.113
MN 2	0.021	0.015	0.043	0.033	0.049	0.052	0.070
MG 2	3.830	3.760	3.804	2.753	2.445	1.859	2.088
CA 2	0.021	0.000	0.006	0.019	0.032	0.018	0.011
NA 1	0.000	0.000	0.000	0.000	0.000	0.000	0.028
K 1	0.000	0.000	0.000	0.000	0.000	0.008	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

WAPI	WAPI	WAPI	WAPI	WAPI	WAPI	SNAKE OV	SNAKE OV
T=470	T=470	T=470	T=470	T=470	T=470	T=470	T=470

Mg/Mg+Fe	0.631	0.616	0.627	0.423	0.357	0.245	0.290
Cr/Cr+Al	0.287	0.274	0.284	0.491	0.593	0.547	0.541

NO.	8	9	10	11	12	13	14
WT %	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622
SIO2	0.39	0.42	0.43	0.48	0.42	0.45	0.28
TIO2	8.06	9.31	8.87	8.92	16.62	11.20	12.42
AL2O3	13.64	12.18	12.66	12.34	9.31	10.53	8.56
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	22.42	20.64	20.82	21.19	15.49	15.96	15.53
FEO	47.99	49.69	49.28	48.84	50.60	55.48	54.94
MNO	0.38	0.31	0.44	0.43	0.60	0.55	0.29
MGO	7.39	6.67	7.09	6.76	3.34	3.23	3.40
CAO	0.06	0.08	0.14	0.06	0.07	0.12	0.10
NA2O	0.06	0.00	0.00	0.00	0.00	0.08	0.00
K2O	0.03	0.03	0.00	0.00	0.00	0.00	0.00
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	100.42	99.33	99.73	99.02	96.45	97.60	95.52

IONS / 24 OXYGEN + ANIONS

SI 4	0.077	0.085	0.086	0.097	0.090	0.095	0.061
TI 4	1.187	1.401	1.323	1.345	2.678	1.766	2.017
AL 3	3.148	2.872	2.959	2.915	2.351	2.602	2.179
FE 3	2.930	2.991	3.057	2.969	1.600	3.120	3.081
CR 3	3.471	3.265	3.264	3.357	2.624	2.646	2.652
FE 2	4.928	5.323	5.116	5.216	7.467	6.608	6.842
MN 2	0.064	0.053	0.074	0.073	0.109	0.098	0.054
MG 2	2.157	1.989	2.096	2.019	1.067	1.010	1.095
CA 2	0.013	0.018	0.030	0.013	0.017	0.027	0.024
NA 1	0.023	0.000	0.000	0.000	0.000	0.033	0.000
K 1	0.008	0.008	0.000	0.000	0.000	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SNAKE OV	SNAKE OV	SNAKE OV	SNAKE OV	MCKINNEY	MCKINNEY	MCKINNEY
T=470	T=470	T=470	T=470	T=470	T=470	T=470

Mg/Mg+Fe	0.304	0.272	0.291	0.279	0.125	0.133	0.138
Cr/Cr+Al	0.524	0.532	0.525	0.535	0.527	0.504	0.549

NO.	15	16	17	18	19	20	21
WT %	SPGMOL 6	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622
SiO2	0.45	0.30	0.28	0.38	0.44	0.44	0.35
TiO2	13.76	12.82	12.97	10.79	13.15	9.72	8.18
Al2O3	2.85	9.20	9.15	9.98	10.43	12.63	13.08
Fe2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr2O3	0.27	16.83	16.46	17.38	15.77	15.85	17.54
FeO	77.22	54.46	54.28	52.95	54.24	53.62	50.39
MnO	0.45	0.33	0.55	0.34	0.31	0.38	0.41
MgO	0.66	5.66	5.81	4.32	6.23	7.49	8.10
CaO	0.12	0.05	0.06	0.10	0.08	0.12	0.07
Na2O	0.20	0.00	0.00	0.00	0.10	0.07	0.00
K2O	0.04	0.00	0.00	0.00	0.05	0.00	0.00
ZnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	96.02	99.65	99.56	96.24	100.80	100.32	98.12

IONS / 24 OXYGEN + ANIONS

SI 4	0.101	0.062	0.058	0.081	0.088	0.087	0.070
TI 4	2.303	1.963	1.986	1.716	1.971	1.434	1.225
AL 3	0.748	2.208	2.196	2.488	2.450	2.921	3.069
FE 3	6.449	3.110	3.138	3.106	3.022	3.662	3.666
CR 3	0.048	2.710	2.650	2.907	2.485	2.459	2.761
FE 2	7.924	6.165	6.105	6.260	6.016	5.135	4.724
MN 2	0.085	0.057	0.095	0.061	0.053	0.064	0.070
MG 2	0.219	1.718	1.764	1.362	1.851	2.190	2.404
CA 2	0.029	0.011	0.014	0.023	0.018	0.026	0.015
NA 1	0.087	0.000	0.000	0.000	0.039	0.027	0.000
K 1	0.012	0.000	0.000	0.000	0.013	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

MCKINNEY	MCKINNEY	MCKINNEY	MCKINNEY	HELLS HA	MCKINNEY	MCKINNEY
T=470	T=470	T=470	T=470	T=470	T=470	T=470

Mg/Mg+Fe	0.027	0.218	0.224	0.179	0.235	0.299	0.337
Cr/Cr+Al	0.060	0.551	0.547	0.539	0.504	0.457	0.474

NO.	22	23	24	25	26	27	28
WT %	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622	SPOL 622
SIO2	0.46	0.37	0.40	0.40	0.44	0.44	0.53
TIO2	8.46	11.79	11.34	10.47	8.62	8.53	8.27
AL2O3	14.97	10.39	10.74	12.45	13.54	13.92	14.39
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	18.27	11.14	12.76	17.42	17.15	17.78	17.94
FEO	49.64	56.41	56.07	50.39	50.24	50.29	49.79
MNO	0.24	0.39	0.24	0.41	0.49	0.34	0.49
MGO	7.10	7.55	7.92	6.46	8.04	8.24	8.03
CAO	0.12	0.09	0.06	0.15	0.05	0.07	0.09
NA2O	0.11	0.00	0.00	0.08	0.00	0.00	0.00
K2O	0.00	0.00	0.04	0.00	0.00	0.00	0.00
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	99.37	98.13	99.57	98.23	98.57	99.61	99.53

IONS / 24 OXYGEN + ANIONS

SI 4	0.091	0.075	0.080	0.081	0.088	0.087	0.104
TI 4	1.251	1.791	1.693	1.590	1.284	1.255	1.217
AL 3	3.469	2.473	2.513	2.963	3.160	3.210	3.318
FE 3	3.085	4.106	4.032	2.981	3.524	3.465	3.393
CR 3	2.841	1.779	2.003	2.781	2.685	2.750	2.775
FE 2	5.078	5.420	5.276	5.528	4.796	4.763	4.754
MN 2	0.040	0.067	0.041	0.071	0.083	0.057	0.082
MG 2	2.081	2.273	2.344	1.945	2.373	2.403	2.342
CA 2	0.026	0.020	0.013	0.033	0.011	0.015	0.019
NA 1	0.042	0.000	0.000	0.032	0.000	0.000	0.000
K 1	0.000	0.000	0.011	0.000	0.000	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.291	0.295	0.308	0.260	0.331	0.335	0.330
Cr/Cr+Al	0.450	0.418	0.444	0.484	0.459	0.461	0.455

NO.	29	30	31	32	33	34	35
WT %	SPOLMX 6	SPOLMX 6	SPOL 622	SPOL 622	SPOLMX 6	SPOLMX 6	SPOL 622
SIO2	0.52	0.62	0.58	0.49	0.44	0.43	0.26
TIO2	8.41	12.68	8.36	9.85	9.74	9.59	8.84
AL2O3	12.79	8.02	13.55	13.66	13.17	13.38	13.52
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	17.07	16.53	18.01	14.11	15.38	14.99	18.23
FEO	51.09	56.12	50.01	51.30	52.31	51.83	49.14
MNO	0.36	0.37	0.22	0.35	0.25	0.41	0.45
MGO	7.20	3.71	7.63	8.03	7.46	8.10	7.78
CAO	0.14	0.15	0.07	0.07	0.14	0.05	0.08
NA2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.03	0.00	0.00	0.00	0.00	0.00
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	97.58	98.23	98.43	97.86	98.89	98.78	98.30

IONS / 24 OXYGEN + ANIONS

SI 4	0.105	0.131	0.116	0.098	0.088	0.085	0.052
TI 4	1.275	2.004	1.250	1.475	1.455	1.426	1.324
AL 3	3.038	1.987	3.176	3.206	3.082	3.117	3.173
FE 3	3.605	3.145	3.408	3.548	3.519	3.628	3.266
CR 3	2.720	2.747	2.832	2.222	2.414	2.343	2.870
FE 2	5.006	6.719	4.909	4.996	5.166	4.939	4.917
MN 2	0.062	0.066	0.038	0.060	0.043	0.069	0.076
MG 2	2.163	1.163	2.262	2.384	2.208	2.386	2.309
CA 2	0.031	0.034	0.015	0.015	0.030	0.011	0.018
NA 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K 1	0.000	0.009	0.000	0.000	0.000	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.302	0.147	0.315	0.323	0.299	0.326	0.320
Cr/Cr+Al	0.472	0.580	0.471	0.409	0.439	0.429	0.475

NO.	36	37	38	39	40	41	42
WT %	SPMX 622	SPMX 622	SPOL 622	SPOL 622	SPOLMX 6	SPOLMX 6	SPMX 622
SIO2	0.49	0.57	0.54	0.64	0.50	0.62	0.41
TIO2	7.24	14.98	9.66	6.56	17.34	10.80	8.09
AL2O3	3.42	3.08	12.69	16.91	4.22	11.58	14.69
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	0.49	0.44	18.08	19.23	11.11	18.21	18.69
FEO	79.53	74.55	49.71	47.23	61.69	53.95	49.68
MNO	0.44	0.59	0.36	0.52	0.63	0.44	0.41
MGO	1.04	1.26	7.16	8.18	3.05	4.44	7.38
CAO	0.26	0.35	0.05	0.13	0.08	0.14	0.11
NA2O	0.12	0.16	0.00	0.00	0.09	0.00	0.00
K2O	0.08	0.05	0.04	0.07	0.00	0.00	0.00
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	93.11	96.03	98.29	99.47	98.71	100.18	99.46

IONS / 24 OXYGEN + ANIONS

SI 4	0.112	0.127	0.109	0.124	0.107	0.126	0.081
TI 4	1.235	2.495	1.458	0.955	2.787	1.642	1.196
AL 3	0.914	0.804	3.001	3.855	1.063	2.759	3.403
FE 3	8.364	5.936	3.130	3.185	3.379	2.944	3.234
CR 3	0.088	0.078	2.869	2.941	1.878	2.911	2.904
FE 2	6.716	7.871	5.212	4.455	7.647	6.177	4.932
MN 2	0.085	0.111	0.062	0.086	0.115	0.076	0.069
MG 2	0.352	0.416	2.142	2.359	0.972	1.338	2.162
CA 2	0.064	0.084	0.011	0.027	0.019	0.031	0.024
NA 1	0.053	0.069	0.000	0.000	0.038	0.000	0.000
K 1	0.024	0.015	0.011	0.018	0.000	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.050	0.050	0.291	0.346	0.113	0.178	0.305
Cr/Cr+Al	0.088	0.087	0.489	0.433	0.638	0.513	0.460

NO.	43	44	45	46	47	48	49
WT %	SPMX 622	SPOL 621	SPOL 621	SPOL 621	SPOL 621	SPOL 621	SPOL 621
SIO2	0.52	0.52	0.51	0.50	0.72	0.53	0.50
TIO2	13.91	2.94	2.80	2.52	2.58	2.91	2.42
AL2O3	6.33	25.59	25.51	28.83	27.56	25.15	26.51
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	16.28	25.17	25.22	23.43	24.50	24.66	25.39
FEO	57.32	34.68	34.23	31.86	31.60	34.44	33.09
MNO	0.45	0.39	0.51	0.13	0.24	0.22	0.35
MGO	2.95	11.57	11.64	12.34	12.55	11.80	12.03
CAO	0.20	0.10	0.05	0.14	0.08	0.15	0.14
NA2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.04	0.03	0.00	0.00	0.00	0.05
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	97.96	101.00	100.50	99.75	99.83	99.86	100.48

IONS / 24 OXYGEN + ANIONS

SI 4	0.112	0.095	0.093	0.090	0.130	0.097	0.091
TI 4	2.236	0.400	0.383	0.341	0.350	0.400	0.329
AL 3	1.595	5.455	5.460	6.105	5.851	5.412	5.638
FE 3	3.081	2.065	2.082	1.810	1.865	2.146	1.998
CR 3	2.751	3.600	3.622	3.328	3.490	3.560	3.623
FE 2	7.162	3.181	3.117	2.978	2.896	3.113	2.997
MN 2	0.082	0.060	0.079	0.020	0.037	0.035	0.054
MG 2	0.940	3.119	3.151	3.305	3.370	3.211	3.236
CA 2	0.046	0.020	0.010	0.027	0.016	0.030	0.028
NA 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K 1	0.000	0.010	0.007	0.000	0.000	0.000	0.012
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.116	0.495	0.503	0.526	0.538	0.508	0.519
Cr/Cr+Al	0.633	0.398	0.399	0.353	0.374	0.397	0.391

NO.	50	51	52	53	54	55	56
WT %	SPOL 621	SPOL 621	SPOL 621	SPOLMX 6	SPOLMX 6	SPOLMXPL	SPOLMX 6
SIO2	0.56	0.34	0.34	0.97	0.39	0.41	0.56
TIO2	3.21	2.60	3.17	3.70	23.29	19.44	10.10
AL2O3	23.79	26.18	24.85	23.69	2.50	2.25	12.81
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	25.70	25.31	23.60	24.75	6.18	7.59	22.39
FEO	34.62	32.87	35.32	38.02	62.48	64.66	44.14
MNO	0.32	0.39	0.15	0.26	0.43	0.64	0.56
MGO	11.50	12.15	11.64	8.78	2.48	1.53	7.78
CAO	0.14	0.08	0.06	0.12	0.16	0.14	0.14
NA2O	0.00	0.00	0.00	0.00	0.00	0.13	0.00
K2O	0.00	0.00	0.00	0.00	0.00	0.00	0.03
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	99.84	99.92	99.13	100.29	97.91	96.79	98.51

IONS / 24 OXYGEN + ANIONS

SI 4	0.104	0.062	0.063	0.181	0.086	0.092	0.112
TI 4	0.445	0.355	0.439	0.520	3.835	3.250	1.517
AL 3	5.158	5.601	5.394	5.210	0.646	0.590	3.016
FE 3	2.129	2.007	2.244	1.965	2.535	3.458	2.316
CR 3	3.739	3.632	3.436	3.652	1.070	1.334	3.536
FE 2	3.198	2.983	3.196	3.969	8.905	8.562	5.057
MN 2	0.050	0.060	0.024	0.042	0.080	0.121	0.095
MG 2	3.154	3.287	3.195	2.442	0.810	0.507	2.316
CA 2	0.028	0.016	0.012	0.024	0.038	0.034	0.030
NA 1	0.000	0.000	0.000	0.000	0.000	0.057	0.000
K 1	0.000	0.000	0.000	0.000	0.000	0.000	0.008
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.497	0.524	0.500	0.381	0.083	0.056	0.314
Cr/Cr+Al	0.420	0.393	0.389	0.412	0.624	0.694	0.540

NO.	57	58	59	60	61	62	63
WT %	SPOLMX?	SPMX 621	SPMX 621	SPMX 621	SPMX 621	SPGM 622	SPGM 622
SIO2	0.64	0.62	0.66	0.54	0.80	0.51	0.50
TIO2	3.09	22.21	21.66	22.82	21.51	16.33	17.15
AL2O3	25.06	1.91	2.26	1.72	2.47	5.63	4.59
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	24.45	2.28	3.50	1.43	2.15	14.01	12.04
FEO	35.90	68.05	66.86	68.64	66.83	57.88	60.76
MNO	0.35	0.46	0.50	0.61	0.51	0.37	0.46
MGO	10.75	1.43	2.11	1.39	2.06	2.88	2.19
CAO	0.14	0.32	0.24	0.36	0.36	0.00	0.07
NA2O	0.00	0.12	0.00	0.14	0.00	0.00	0.00
K2O	0.00	0.00	0.00	0.04	0.04	0.00	0.00
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	100.38	97.40	97.79	97.69	96.73	97.61	97.76

IONS / 24 OXYGEN + ANIONS

SI 4	0.118	0.138	0.145	0.120	0.177	0.110	0.109
TI 4	0.426	3.695	3.571	3.788	3.577	2.647	2.802
AL 3	5.408	0.498	0.584	0.448	0.644	1.431	1.176
FE 3	2.107	3.539	3.535	3.545	3.646	2.816	3.072
CR 3	3.539	0.399	0.607	0.250	0.376	2.388	2.068
FE 2	3.390	9.049	8.722	9.125	8.711	7.618	7.967
MN 2	0.055	0.087	0.093	0.115	0.096	0.068	0.085
MG 2	2.934	0.472	0.690	0.458	0.679	0.926	0.710
CA 2	0.028	0.076	0.057	0.086	0.086	0.000	0.017
NA 1	0.000	0.052	0.000	0.060	0.000	0.000	0.000
K 1	0.000	0.000	0.000	0.012	0.012	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.464	0.050	0.073	0.048	0.072	0.108	0.082
Cr/Cr+Al	0.396	0.445	0.510	0.358	0.369	0.625	0.638

NO.	64	65	66	67	68	69	70
WT %	SPGM 622	SPOLGM 6	SPOLGM 6	SPGM 622	SPGM 622	SPGM 622	SPOLGM &
SIO2	0.52	0.54	0.56	0.47	0.35	0.43	0.48
TIO2	20.04	15.25	21.57	15.91	16.28	18.86	18.14
AL2O3	3.31	5.28	3.43	5.49	4.52	2.80	4.06
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	3.43	14.05	11.71	13.59	13.24	2.91	11.82
FEO	67.46	58.53	56.90	58.12	60.08	68.47	57.19
MNO	0.42	0.52	0.56	0.53	0.45	0.48	0.50
MGO	1.45	2.49	1.95	1.98	1.70	1.45	2.18
CAO	0.10	0.10	0.18	0.08	0.05	0.07	0.10
NA2O	0.00	0.00	0.00	0.00	0.07	0.14	0.00
K2O	0.05	0.00	0.00	0.00	0.00	0.00	0.05
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	96.78	96.76	96.86	96.17	96.74	95.61	94.52

IONS / 24 OXYGEN + ANIONS

SI 4	0.116	0.118	0.125	0.104	0.078	0.097	0.109
TI 4	3.337	2.501	3.594	2.635	2.697	3.176	3.073
AL 3	0.864	1.357	0.896	1.425	1.174	0.739	1.078
FE 3	3.762	3.126	1.754	2.859	3.051	4.279	2.576
CR 3	0.601	2.423	2.052	2.367	2.306	0.516	2.105
FE 2	8.729	7.549	8.790	7.846	8.015	8.543	8.197
MN 2	0.079	0.097	0.106	0.099	0.084	0.092	0.096
MG 2	0.479	0.810	0.644	0.650	0.559	0.484	0.732
CA 2	0.024	0.024	0.043	0.019	0.012	0.017	0.025
NA 1	0.000	0.000	0.000	0.000	0.030	0.061	0.000
K 1	0.015	0.000	0.000	0.000	0.000	0.000	0.015
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.052	0.097	0.068	0.077	0.065	0.054	0.082
Cr/Cr+Al	0.410	0.641	0.696	0.624	0.663	0.411	0.661

NO.	71	72	73	74	75	76	77
WT %	SPOLGM 6	SPOLPL 6	SPOLPL 6	SPOLPL 6	SPOLPL 6	SPOLPL 6	SPOL 622
SIO2	0.61	0.54	0.52	0.45	0.53	0.48	0.53
TIO2	10.82	8.86	9.21	9.41	9.63	10.28	12.97
AL2O3	3.47	11.92	11.89	11.70	12.46	10.52	10.24
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	4.02	23.73	24.11	23.64	21.81	22.77	15.34
FEO	74.05	44.74	44.59	44.89	47.07	47.38	53.59
MNO	0.46	0.15	0.37	0.33	0.43	0.28	0.34
MGO	1.47	7.61	7.61	7.47	7.29	7.02	6.19
CAO	0.04	0.23	0.28	0.12	0.07	0.13	0.13
NA2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	94.94	97.78	98.58	98.01	99.29	98.86	99.33

IONS / 24 OXYGEN + ANIONS

SI 4	0.137	0.110	0.105	0.091	0.106	0.097	0.108
TI 4	1.818	1.346	1.389	1.430	1.443	1.563	1.974
AL 3	0.914	2.837	2.810	2.787	2.925	2.506	2.443
FE 3	6.644	2.579	2.481	2.501	2.676	2.649	3.066
CR 3	0.711	3.789	3.823	3.777	3.435	3.638	2.455
FE 2	7.193	4.977	4.997	5.085	5.166	5.359	6.004
MN 2	0.088	0.026	0.063	0.057	0.073	0.048	0.059
MG 2	0.490	2.291	2.275	2.250	2.165	2.115	1.868
CA 2	0.010	0.050	0.061	0.026	0.015	0.029	0.029
NA 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.064	0.315	0.313	0.307	0.295	0.283	0.237
Cr/Cr+Al	0.437	0.572	0.576	0.575	0.540	0.592	0.501

NO.	78	79	80	81	82	83	84
WT %	SPOLGM 6	SPGM 622	SPGM 622	SPGM 622	SPGM 622	SPOL 622	SPOL 622
SIO2	0.55	0.60	0.50	0.52	0.48	0.53	0.54
TIO2	15.71	15.00	16.26	16.28	15.37	9.42	7.98
AL2O3	7.08	7.07	6.71	7.10	7.13	14.71	14.63
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	14.02	14.40	13.09	13.34	13.89	16.76	16.46
FEO	54.90	55.40	55.94	55.07	54.88	51.57	51.78
MNO	0.42	0.39	0.42	0.38	0.37	0.46	0.38
MGO	5.68	5.70	4.68	5.52	5.64	7.02	6.62
CAO	0.11	0.08	0.18	0.14	0.22	0.09	0.10
NA2O	0.00	0.00	0.00	0.00	0.00	0.00	0.08
K2O	0.04	0.00	0.00	0.05	0.00	0.00	0.03
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	98.51	98.64	97.78	98.40	97.98	100.56	98.60

IONS / 24 OXYGEN + ANIONS

SI 4	0.115	0.125	0.106	0.109	0.101	0.104	0.108
TI 4	2.453	2.339	2.581	2.548	2.412	1.382	1.193
AL 3	1.733	1.728	1.669	1.742	1.754	3.382	3.427
FE 3	2.961	3.143	2.889	2.867	3.034	3.189	3.493
CR 3	2.302	2.360	2.185	2.195	2.292	2.585	2.586
FE 2	6.572	6.462	6.985	6.718	6.543	5.225	5.113
MN 2	0.074	0.069	0.076	0.067	0.066	0.076	0.064
MG 2	1.758	1.761	1.473	1.713	1.754	2.041	1.961
CA 2	0.025	0.018	0.041	0.032	0.050	0.019	0.022
NA 1	0.000	0.000	0.000	0.000	0.000	0.000	0.031
K 1	0.011	0.000	0.000	0.014	0.000	0.000	0.008
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.211	0.214	0.174	0.203	0.211	0.281	0.277
Cr/Cr+Al	0.571	0.577	0.567	0.558	0.567	0.433	0.430

NO.	85	86	87	88	89	90	91
WT %	SPOLGM 6	SPGM 622	SPGM 622	SPOLGM 6	SPOLGM 6	SPOLGM 6	SPOLGM 6
SIO2	0.63	0.54	0.62	0.61	0.53	0.42	0.45
TIO2	15.75	16.11	19.55	16.13	17.14	10.73	13.95
AL2O3	5.34	6.72	3.45	6.84	3.71	12.61	4.08
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	11.75	12.29	3.70	12.32	7.48	17.31	10.19
FEO	60.06	58.36	67.30	56.46	65.91	51.52	63.38
MNO	0.46	0.43	0.53	0.41	0.49	0.55	0.64
MGO	2.79	4.10	2.04	5.00	1.97	4.21	2.61
CAO	0.14	0.24	0.32	0.10	0.16	0.12	0.20
NA2O	0.00	0.10	0.00	0.00	0.07	0.00	0.00
K2O	0.07	0.00	0.00	0.00	0.05	0.00	0.03
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	96.99	98.89	97.51	97.87	97.51	97.47	95.53

IONS / 24 OXYGEN + ANIONS

SI 4	0.137	0.113	0.136	0.129	0.116	0.087	0.100
TI 4	2.567	2.535	3.211	2.549	2.811	1.670	2.318
AL 3	1.364	1.658	0.888	1.694	0.954	3.076	1.063
FE 3	3.366	3.102	3.913	3.062	4.005	2.679	4.421
CR 3	2.013	2.034	0.639	2.047	1.290	2.832	1.780
FE 2	7.519	7.111	8.379	6.860	8.015	6.237	7.287
MN 2	0.085	0.077	0.099	0.073	0.091	0.097	0.120
MG 2	0.902	1.279	0.664	1.566	0.641	1.299	0.860
CA 2	0.033	0.054	0.075	0.023	0.038	0.027	0.048
NA 1	0.000	0.041	0.000	0.000	0.030	0.000	0.000
K 1	0.020	0.000	0.000	0.000	0.014	0.000	0.009
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

HELLS HA	HELLS HA	HELLS HA	HELLS HA	HELLS HA	MCKINNEY	MCKINNEY
T=470	T=470	T=470	T=470	T=470	T=470	T=470

Mg/Mg+Fe	0.107	0.152	0.073	0.186	0.074	0.172	0.105
Cr/Cr+Al	0.596	0.551	0.418	0.547	0.575	0.479	0.626

NO.	92	93	94	95	96	97	98
WT %	SPOLGM 6	SPGM 622	SPGM 622	SPGM 622	SPGM 622	SPGM LAR	SPGM 622
SIO2	0.50	0.41	0.42	0.41	0.40	0.50	0.43
TIO2	14.29	9.99	9.42	11.78	18.40	18.22	10.44
AL2O3	3.62	11.52	12.57	8.44	3.19	3.06	12.81
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	3.62	17.99	17.96	17.19	5.91	4.13	17.96
FEO	69.38	52.52	52.39	55.88	65.25	66.37	50.79
MNO	0.48	0.25	0.39	0.47	0.59	0.71	0.28
MGO	2.30	5.06	5.08	3.47	2.90	2.80	6.36
CAO	0.27	0.12	0.08	0.19	0.18	0.22	0.10
NA2O	0.10	0.00	0.00	0.00	0.00	0.00	0.07
K2O	0.00	0.03	0.00	0.00	0.00	0.00	0.00
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	94.56	97.89	98.31	97.83	96.82	96.01	99.24

IONS / 24 OXYGEN + ANIONS

SI 4	0.112	0.085	0.086	0.087	0.088	0.111	0.086
TI 4	2.397	1.545	1.444	1.870	3.029	3.023	1.570
AL 3	0.952	2.791	3.020	2.099	0.823	0.796	3.020
FE 3	5.472	3.118	3.131	3.210	4.013	4.331	2.912
CR 3	0.639	2.924	2.895	2.868	1.023	0.721	2.840
FE 2	7.469	5.911	5.799	6.651	7.930	7.916	5.583
MN 2	0.091	0.044	0.068	0.084	0.110	0.133	0.048
MG 2	0.765	1.551	1.544	1.092	0.946	0.921	1.896
CA 2	0.065	0.027	0.018	0.043	0.043	0.053	0.022
NA 1	0.044	0.000	0.000	0.000	0.000	0.000	0.028
K 1	0.000	0.008	0.000	0.000	0.000	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

MCKINNEY	MCKINNEY	MCKINNEY	MCKINNEY	MCKINNEY	MCKINNEY	MCKINNEY	MCKINNEY
T=470	T=470	T=470	T=470	T=470	T=470	T=470	T=470

Mg/Mg+Fe	0.093	0.208	0.210	0.141	0.107	0.104	0.254
Cr/Cr+Al	0.402	0.512	0.489	0.577	0.554	0.475	0.485

NO.	99	100	101	102	103	104	105
WT %	SPGM 622	SPGM 622	SPGM 622	SPGM EU	SPOLGM 6	SPOLGM 6	SPOLGM 6
SIO2	0.46	0.65	0.52	0.57	0.49	0.50	0.46
TIO2	11.15	20.43	6.74	6.50	5.35	6.81	11.25
AL2O3	11.51	2.03	14.20	13.76	16.50	13.20	7.04
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	18.41	0.22	29.23	29.00	29.55	29.99	23.24
FEO	49.70	69.33	39.50	38.63	36.80	38.42	51.24
MNO	0.46	0.52	0.24	0.35	0.37	0.49	0.44
MGO	6.07	1.24	8.46	8.10	9.02	8.27	2.91
CAO	0.17	0.45	0.15	0.23	0.18	0.29	0.33
NA2O	0.00	0.07	0.00	0.00	0.07	0.00	0.00
K2O	0.00	0.06	0.00	0.00	0.00	0.06	0.06
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	97.93	95.00	99.04	97.14	98.33	98.03	96.97

IONS / 24 OXYGEN + ANIONS

SI 4	0.094	0.148	0.103	0.115	0.096	0.100	0.100
TI 4	1.713	3.477	0.998	0.983	0.786	1.023	1.822
AL 3	2.771	0.542	3.295	3.261	3.798	3.107	1.787
FE 3	2.746	4.264	2.072	2.055	1.964	1.997	2.485
CR 3	2.973	0.040	4.550	4.610	4.562	4.735	3.957
FE 2	5.742	8.858	4.431	4.442	4.046	4.420	6.744
MN 2	0.080	0.100	0.041	0.060	0.062	0.083	0.081
MG 2	1.848	0.419	2.483	2.428	2.626	2.462	0.935
CA 2	0.038	0.110	0.032	0.050	0.038	0.063	0.077
NA 1	0.000	0.031	0.000	0.000	0.027	0.000	0.000
K 1	0.000	0.018	0.000	0.000	0.000	0.016	0.017
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

MCKINNEY	MCKINNEY	WAPI	WAPI	WAPI	WAPI	WAPI
T=470	T=470	T=470	T=470	T=470	T=470	T=470

Mg/Mg+Fe	0.243	0.045	0.359	0.353	0.394	0.358	0.122
Cr/Cr+Al	0.518	0.068	0.580	0.586	0.546	0.604	0.689

NO.	106	107	108	109	110	111	112
WT %	SPOLGM E	SPOLGM E	SPPLGM 6	SPOLGM 6	SPOLGM 6	SPGM 622	SPGM 622
SiO2	0.91	0.61	0.53	0.36	0.57	0.54	0.56
TiO2	22.50	6.81	6.15	5.77	6.19	14.49	18.51
Al2O3	1.67	11.77	13.39	16.02	14.21	6.99	3.27
Fe2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr2O3	3.65	28.13	30.25	28.87	28.96	15.01	9.22
FeO	65.58	45.08	38.64	37.56	38.36	53.94	60.57
MnO	0.69	0.62	0.32	0.33	0.40	0.52	0.57
MgO	1.48	3.97	7.81	8.66	8.12	4.22	2.76
CaO	0.44	0.32	0.31	0.20	0.19	0.24	0.25
Na2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.06	0.00	0.00	0.03	0.00	0.00	0.00
ZnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	96.98	97.31	97.40	97.80	97.00	95.95	95.71

IONS / 24 OXYGEN + ANIONS

Si 4	0.203	0.128	0.107	0.072	0.115	0.117	0.125
Ti 4	3.767	1.068	0.932	0.856	0.936	2.346	3.088
Al 3	0.439	2.893	3.177	3.725	3.365	1.773	0.855
Fe 3	3.171	2.203	2.031	1.982	2.062	2.869	3.230
Cr 3	0.643	4.638	4.815	4.503	4.601	2.554	1.618
Fe 2	9.037	5.659	4.476	4.215	4.384	6.840	8.007
Mn 2	0.131	0.110	0.055	0.056	0.069	0.095	0.108
Mg 2	0.492	1.234	2.344	2.547	2.432	1.354	0.913
Ca 2	0.105	0.072	0.067	0.043	0.041	0.056	0.060
Na 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K 1	0.018	0.000	0.000	0.008	0.000	0.000	0.000
Zn 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ni 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

WAPI	WAPI	WAPI	WAPI	WAPI	MCKINNEY	MCKINNEY
T=470	T=470	T=470	T=470	T=470	T=470	T=470

Mg/Mg+Fe	0.052	0.179	0.344	0.377	0.357	0.165	0.102
Cr/Cr+Al	0.595	0.616	0.602	0.547	0.578	0.590	0.654

NO.	113	114	115	116	117	118	119
WT %	SPGM 622	SPGM 622	SPGM 622	SPGM 622	SPOLGM 6	SPOLGM 6	SPOLGM 6
SIO2	0.68	0.71	0.29	0.33	0.47	0.55	0.52
TIO2	21.92	22.45	11.30	19.62	8.62	10.38	18.16
AL2O3	2.04	1.81	12.39	2.68	12.44	11.37	2.50
FE2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	3.49	0.99	17.16	5.14	18.12	16.60	3.60
FEO	64.59	65.31	51.60	65.08	50.84	52.57	66.54
MNO	0.47	0.49	0.38	0.54	0.28	0.42	0.36
MGO	2.59	2.45	4.42	2.21	6.68	4.32	2.54
CAO	0.35	0.37	0.20	0.14	0.17	0.18	0.24
NA2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.07	0.04	0.03	0.00	0.00	0.04	0.04
ZNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	96.20	94.62	97.77	95.74	97.62	96.43	94.50

IONS / 24 OXYGEN + ANIONS

SI 4	0.151	0.161	0.060	0.074	0.096	0.116	0.117
TI 4	3.661	3.816	1.753	3.294	1.314	1.636	3.073
AL 3	0.534	0.483	3.012	0.706	2.971	2.809	0.663
FE 3	3.364	3.536	2.611	3.730	3.412	3.058	4.429
CR 3	0.613	0.177	2.799	0.908	2.903	2.751	0.641
FE 2	8.630	8.810	6.291	8.421	5.204	6.157	8.090
MN 2	0.089	0.094	0.067	0.103	0.049	0.075	0.069
MG 2	0.858	0.826	1.359	0.736	2.018	1.350	0.852
CA 2	0.084	0.090	0.045	0.034	0.037	0.041	0.058
NA 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K 1	0.020	0.012	0.008	0.000	0.000	0.011	0.012
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.090	0.086	0.178	0.080	0.279	0.180	0.095
Cr/Cr+Al	0.534	0.268	0.482	0.563	0.494	0.495	0.491

NO.	120	121	122	123	124	125	126
WT %	SPGM 622	SPOLGM 6	SPOLGM 6	SPOLGM 6	SPOLGM 6	SPOLGM 6	SPOLGM 6
SiO2	0.47	0.58	0.51	0.47	0.58	0.60	0.56
TiO2	20.46	15.51	18.11	21.79	23.92	24.70	23.85
Al2O3	2.03	5.57	4.39	3.26	2.75	2.56	2.60
Fe2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr2O3	0.28	16.12	11.95	5.34	1.49	0.56	0.40
FeO	70.90	54.40	59.41	63.73	64.92	65.28	65.17
MnO	0.41	0.62	0.58	0.41	0.40	0.47	0.44
MgO	0.80	3.32	2.53	2.04	2.03	1.91	1.87
CaO	0.07	0.04	0.06	0.09	0.08	0.14	0.13
Na2O	0.00	0.00	0.00	0.00	0.07	0.00	0.06
K2O	0.00	0.03	0.00	0.00	0.04	0.00	0.00
ZnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	95.42	96.19	97.54	97.13	96.28	96.22	95.08

IONS / 24 OXYGEN + ANIONS

Si 4	0.107	0.127	0.111	0.104	0.130	0.134	0.127
Ti 4	3.489	2.542	2.962	3.611	4.002	4.147	4.046
Al 3	0.543	1.431	1.126	0.847	0.721	0.674	0.692
Fe 3	4.347	2.613	2.813	2.920	2.888	2.822	3.023
Cr 3	0.051	2.778	2.055	0.931	0.263	0.099	0.072
Fe 2	9.099	7.301	7.994	8.823	9.190	9.367	9.272
Mn 2	0.079	0.115	0.107	0.077	0.076	0.089	0.085
Mg 2	0.271	1.079	0.821	0.670	0.674	0.636	0.629
Ca 2	0.018	0.010	0.014	0.022	0.020	0.034	0.032
Na 1	0.000	0.000	0.000	0.000	0.031	0.000	0.027
K 1	0.000	0.009	0.000	0.000	0.012	0.000	0.000
Zn 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ni 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Snake OV	Snake OV	Snake OV	Snake OV	Snake OV	Snake OV	Snake OV	Snake OV
T=470	T=470	T=470	T=470	T=470	T=470	T=470	T=470

Mg/Mg+Fe	0.029	0.129	0.093	0.071	0.068	0.064	0.064
Cr/Cr+Al	0.085	0.660	0.646	0.524	0.267	0.128	0.094

NO.	127	128	129	130	131	132	133
WT %	SPOLGM 6	SPOLGM 6	SPOLGM 6	SPOLGM 6	SPGM 622	SPGM 622	SPGM 622
SiO2	0.56	0.53	0.57	0.69	0.52	0.60	0.55
TiO2	18.27	19.37	22.10	21.08	21.93	21.36	12.60
Al2O3	3.65	2.99	2.38	2.36	2.04	2.27	8.37
Fe2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr2O3	10.22	6.75	1.09	0.12	0.32	3.59	18.60
FeO	61.58	63.73	67.36	70.21	70.41	66.64	53.47
MnO	0.28	0.42	0.56	0.49	0.40	0.47	0.51
MgO	1.71	1.21	0.97	0.65	0.72	1.26	2.58
CaO	0.13	0.06	0.12	0.21	0.06	0.13	0.12
Na2O	0.09	0.00	0.12	0.00	0.00	0.13	0.00
K2O	0.00	0.00	0.04	0.07	0.00	0.00	0.00
ZnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM =	96.49	95.06	95.31	95.88	96.40	96.45	96.81

IONS / 24 OXYGEN + ANIONS

SI 4	0.125	0.121	0.130	0.156	0.117	0.135	0.119
TI 4	3.043	3.299	3.762	3.575	3.710	3.589	2.038
AL 3	0.953	0.799	0.635	0.628	0.541	0.598	2.121
FE 3	3.044	3.306	3.499	4.053	3.897	3.444	2.546
CR 3	1.790	1.209	0.196	0.022	0.057	0.635	3.162
FE 2	8.362	8.766	9.254	9.187	9.348	9.007	7.069
MN 2	0.053	0.081	0.108	0.094	0.077	0.089	0.093
MG 2	0.565	0.409	0.328	0.219	0.242	0.420	0.827
CA 2	0.031	0.015	0.030	0.051	0.015	0.032	0.028
NA 1	0.039	0.000	0.053	0.000	0.000	0.057	0.000
K 1	0.000	0.000	0.012	0.021	0.000	0.000	0.000
ZN 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NI 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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T=470 T=470 T=470 T=470 T=470 T=470 T=470

Mg/Mg+Fe	0.063	0.045	0.034	0.023	0.025	0.045	0.105
Cr/Cr+Al	0.653	0.602	0.235	0.033	0.095	0.515	0.599

NO.	134	135	136
WT %	SPGM LAR	SPGM 622	SPGM 622
SIO2	0.48	0.61	0.52
TIO2	16.50	22.91	23.37
AL2O3	4.16	2.62	2.65
FE2O3	0.00	0.00	0.00
CR2O3	14.56	1.98	0.46
FEO	58.55	64.58	65.06
MNO	0.27	0.43	0.49
MGO	1.96	1.63	1.57
CAO	0.11	0.09	0.16
NA2O	0.00	0.11	0.00
K2O	0.00	0.00	0.00
ZNO	0.00	0.00	0.00
NIO	0.00	0.00	0.00
V2O3	0.00	0.00	0.00
SUM =	96.59	94.96	94.28

IONS / 24 OXYGEN + ANIONS

SI 4	0.106	0.138	0.119
TI 4	2.740	3.896	4.009
AL 3	1.083	0.699	0.713
FE 3	2.810	3.018	3.083
CR 3	2.542	0.354	0.083
FE 2	8.000	9.195	9.328
MN 2	0.051	0.083	0.095
MG 2	0.645	0.550	0.534
CA 2	0.027	0.022	0.040
NA 1	0.000	0.049	0.000
K 1	0.000	0.000	0.000
ZN 2	0.000	0.000	0.000
NI 2	0.000	0.000	0.000
V 3	0.000	0.000	0.000

SNAKE OV SNAKE OV SNAKE OV

T=470 T=470 T=470

Mg/Mg+Fe	0.075	0.056	0.054
Cr/Cr+Al	0.701	0.336	0.104