WORKING WITH ELECTRON MICROPROBE DATA FROM A HIGH PRESSURE EXPERIMENT – CALCULATING MINERAL FORMULAS, UNIT CELL CONTENT, AND GEOTHERMOMETRY

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SOLUTION SET

Problem #1

Olivine		$(Mg,Fe)_2SiO_4$ 4 oxy				
OXIDE	**WT%**	**MOL WT**	**Atm. Prop**	**oxide* #O**	**Norm OXY**	***cat:ox**
SiO_2	41.05	60.08	0.683	1.3665113	2.025	1.012
Al_2O_3	0.04	101.96	0.000	0.0011769	0.002	0.001
FeO	7.92	71.85	0.110	0.110	0.163	0.163
MnO	0.14	70.94	0.002	0.002	0.003	0.003
MgO	48.7	40.3	1.208	1.208	1.791	1.791
CaO	0.34	56.08	0.006	0.006	0.009	0.009
Na_2O	0	61.98	0.000	0.000	0.000	0.000
Cr_2O_3	0.26	151.99	0.002	0.005	0.008	0.005
TOTAL	98.45			2.700	4.000	2.984
			normalize	1.482		

Olivine: $Ca_{.01}(Mg_{1.79},Fe_{.16},Mn_{.003},Al_{.001},Cr_{.005})_{1.96}Si_{1.01}O_4$

OPX		$(Mg,Fe)_2Si_2O_6$ 6 oxy				
OXIDE	**WT%**	**MOL WT**	**Atm. Prop**	**oxide* #O**	**Norm OXY**	***cat:ox**
SiO_2	55.68	60.08	0.927	1.8535286	3.814	1.907
Al_2O_3	3.66	101.96	0.036	0.1076893	0.222	0.148
FeO	5.1	71.85	0.071	0.071	0.146	0.146
MnO	0.11	70.94	0.002	0.002	0.003	0.003
MgO	32.54	40.3	0.807	0.807	1.662	1.662
CaO	2.71	56.08	0.048	0.048	0.099	0.099
Na_2O	0.06	61.98	0.001	0.001	0.002	0.004
Cr_2O_3	1.27	151.99	0.008	0.025	0.052	0.034
TOTAL	101.13			2.916	6.000	4.004
			normalize	2.058		

Orthopyroxene: $Na_{.004}Ca_{0.1}(Mg_{1.66},Fe_{.15},Mn_{.003},Cr_{.034},Al_{.058})_{1.905}(Si_{1.91}Al_{.09})_2O_6$

CPX		Ca(Mg,Fe)Si2O6 6 oxy				
OXIDE	WT%	MOL WT	Atm. Prop	oxide* #O	Norm OXY	*cat:ox
SiO_2	53.23	60.08	0.886	1.7719707	3.789	1.894
Al_2O_3	4.49	101.96	0.044	0.1321106	0.282	0.188
FeO	3.74	71.85	0.052	0.052	0.111	0.111
MnO	0.12	70.94	0.002	0.002	0.004	0.004
MgO	22.18	40.3	0.550	0.550	1.177	1.177
CaO	14.61	56.08	0.261	0.261	0.557	0.557
Na_2O	0.21	61.98	0.003	0.003	0.007	0.014
Cr_2O_3	1.72	151.99	0.011	0.034	0.073	0.048
TOTAL	100.3			2.806	6.000	3.994
			normalize	2.138		

Clinopyroxene: $Na_{.014}Ca_{.56}(Mg_{1.18},Fe_{.11},Mn_{.004},Cr_{.048},Al_{.08})_{1.42}(Si_{1.89}Al_{.11})_2O_6$

Spinel		$MgAl_2O_4$-$MgCr_2O_4$ 4 oxygen				
OXIDE	WT%	MOL WT	Atm. Prop	oxide* #O	Norm OXY	*cat:ox
SiO_2	0	60.08	0.000	0	0.000	0.000
Al_2O_3	30.48	101.96	0.299	0.8968223	1.603	1.069
FeO	9.08	71.85	0.126	0.126	0.226	0.226
MnO	0	70.94	0.000	0.000	0.000	0.000
MgO	18.32	40.3	0.455	0.455	0.813	0.813
CaO	0	56.08	0.000	0.000	0.000	0.000
Na_2O	0	61.98	0.000	0.000	0.000	0.000
Cr_2O_3	38.49	151.99	0.253	0.760	1.358	0.905
TOTAL	96.37			2.238	4.000	3.013
			normalize	1.788		

Spinel: $(Mg_{.81},Fe_{.23})_{1.04}(Cr_{.91},Al_{1.07})_{1.98}O_4$

Problem #2

Spinel: $(Mg_{.81},Fe_{.23})_{1.04}(Cr_{.91},Al_{1.07})_{1.98}O_4$

Formula weight = **172.7145 gm/mol**

a = 8.23 Å

unit cell volume = **557.44 Å^3**

density = 4.12 gm/cm^3

formula units = $V\rho N_A$/formula weight

formula units = $(557.44\times10^{-24}cm^3 * 4.12 gm/cm^3 * 6.02\times10^{23} mol^{-1})/172.7145$ gm/mol

formula units = **8**

Problem #3

Olivine: $Ca_{.01}(Mg_{1.79},Fe_{.16},Mn_{.003},Al_{.001},Cr_{.005})_{1.96}Si_{1.01}O_4$

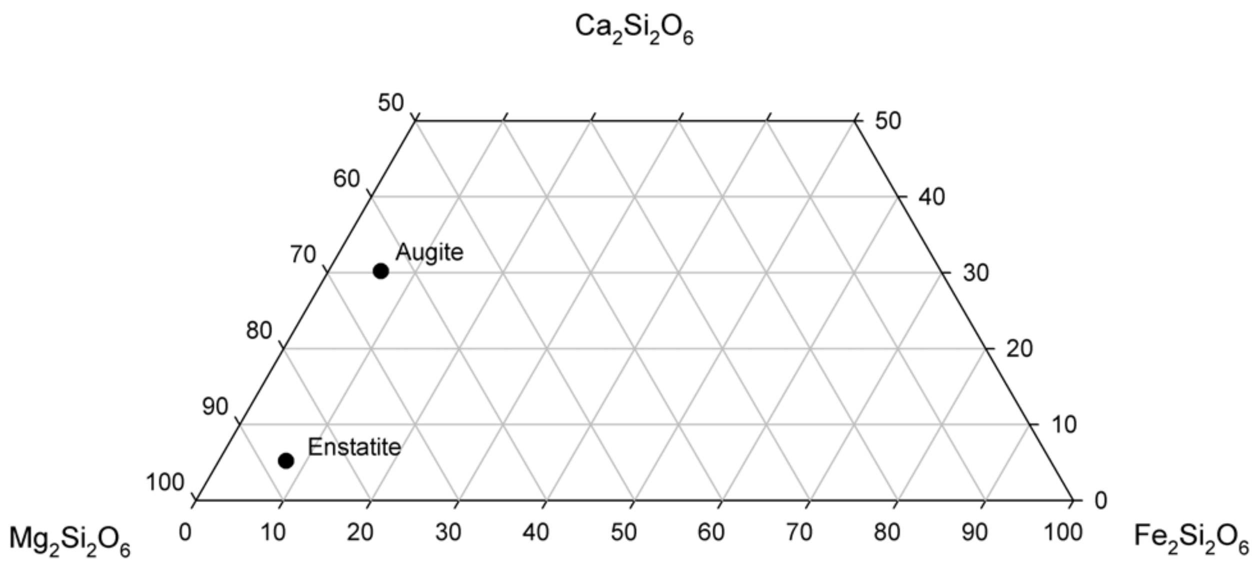
Forsterite content = Mg cations/(Mg cations + Fe cations) x 100%

Fo = 1.79/(1.79+.16) = 91.8%

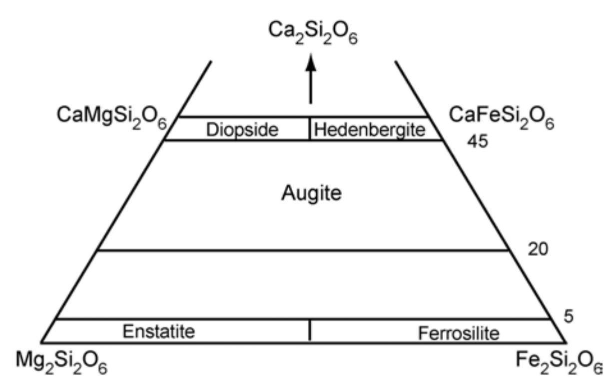
$Fo_{91.8}$

Problem #4

***Plot the two points on the quadrilateral*.**



Compare your plot to Figure 3. ***Provide a mineral name for each pyroxene.***



Are there any other significant chemical components in your pyroxenes? If so, what are they? Would the consideration of other components affect the naming of the minerals?

This question refers to non-quadrilateral pyroxene components of which there are no significant contributions in these pyroxenes. (As expected given the ultramafic composition of the sample.) Students should simply recognize that the ternary components they plotted make up ~95% of the phases and thus characterize well the compositions of the minerals. However, if there were a significant jadeite component, for example, then using the diagram in Figure 3 would be inappropriate. This should serve to remind students that they must be careful to choose appropriate diagrams when working.

Problem #5

Temp (°C) = $-2.0914x^2 + 44.164x + 1131.4$, where x = wt. % CaO

What is the temperature of the experiment?

wt% CaO	Temp
14.61	1330.2

Temp = 1330°C

Give an example and provide a literature or web reference of another "geothermometer." What are the requirements and assumptions that must be made when using this geothermometer?

Many possibilities here.

Assumptions & pitfalls (described in detail by Winter, J.D. 2001, An Introduction to Igneous and Metamorphic Petrology, p554-555, Prentice Hall, New Jersey):

- Minerals are at equilibrium
- Complications due to zoning
- Retrograde effects
- Blocking temperatures
- Calibration of thermometer
- Complication of added components
- Extrapolation in P or T
- Oxidation state (Fe^{2+} vs. Fe^{3+})
- T-P range of applicability
- Polymetamorphic effects