

Mass Balance Constraints on Volcanic Processes

Table 1. Analyses for a simple example of crystal fractionation. Data in weight percent.

Oxide	Melt	Forsterite	Mass in New Melt	Composition of New Melt
SiO ₂	50.0	42.7	32.92	54.87
MgO	25.0	57.3	2.08	3.47
CaO	25.0	0.0	25.00	41.66
Sum	100.0	100.0	60.00	100.00

Table 2. Data for constructing the addition-subtraction diagram described by Bowen (1928, Ch. 6, pp. 74-78).

Oxide	A	T	Subt	Add
SiO ₂	45.0	50.0	41.43	58.33
Al ₂ O ₃	15.0	13.0	16.43	9.67
Fe ₂ O ₃	13.0	13.0	13.00	13.00
MgO	8.0	5.0	10.14	0.00
CaO	9.0	10.0	8.29	11.67
Na ₂ O	2.5	2.8	2.29	3.30
K ₂ O	0.5	1.2	0.00	2.37

Table 2, cont. Possible Mineral Assemblage for Subtracted Composition: Normative Minerals.

Plagioclase	(An ₆₃)	53.0%
Augite	(Wo ₅₁ , En ₂₉ , Fs ₂₀)	7.5%
Olivine	(Fo ₅₉)	27.0%
Magnetite		4.5%

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Table 3. Example data set for constructing Pearce element diagrams and inferring magmatic process.

Analyses in Weight Percent							
Oxide	#1	#2	#3	#4	#5	#6	#7
SiO ₂	50.63	49.10	47.77	50.79	51.10	51.21	51.30
TiO ₂	2.64	2.29	1.98	2.89	3.09	3.25	3.39
Al ₂ O ₃	13.68	11.85	10.26	12.80	11.15	10.68	10.33
FeO	11.27	12.28	13.14	11.78	12.71	13.03	13.28
MgO	7.40	12.03	16.06	7.55	7.84	8.02	8.19
CaO	11.25	9.75	8.44	11.13	10.88	10.56	10.24
Na ₂ O	2.32	2.01	1.74	2.32	2.30	2.28	2.25
K ₂ O	0.52	0.45	0.39	0.55	0.61	0.64	0.67
P ₂ O ₅	0.28	0.24	0.21	0.29	0.32	0.34	0.35
Element Ratios							
Si/K	76.327	85.534	96.020	72.391	65.669	62.726	
Ti/K	2.993	3.000	2.993	3.098	2.986	2.994	2.983
Al/K	24.306	24.330	24.306	21.502	16.888	15.418	
Fe/K	14.209	17.890	22.088	14.042	13.660	13.347	
Mg/K	16.628	31.326	48.116	16.040	15.017	14.642	
Ca/K	18.171	18.198	18.177	16.997	14.981	13.859	
Na/K	6.781	6.789	6.781	6.411	5.731	5.415	5.104
P/K	0.357	0.354	0.357	0.350	0.348	0.353	0.347

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Table 4. Ratios in Minerals

Ideal Cases			
Mineral	Formula	(Fe + Mg)/Si	
Olivine	$(\text{Mg,Fe})_2\text{SiO}_4$	2	
Orthopyroxene	$(\text{Mg,Fe})_2\text{Si}_2\text{O}_6$	1	
Clinopyroxene	$\text{Ca}(\text{Mg,Fe})\text{Si}_2\text{O}_6$	1/2	
Fe-Ti Spinel	$\text{Fe}(\text{Fe,Ti})_2\text{O}_4$	Infinity	
Fe-Ti Rhombohedral	$\text{Fe}(\text{Fe,Ti})\text{O}_3$	Infinity	
Mineral	Formula	(2 Ca + Na)/Al	
Plagioclase	$\text{NaAlSi}_3\text{O}_8$ - $\text{CaAl}_2\text{Si}_2\text{O}_8$	1	
Clinopyroxene	$\text{Ca}(\text{Mg,Fe})\text{Si}_2\text{O}_6$	Infinity	
Measured Mineral Compositions			
Mineral	(Fe + Mg)/Si Slope	Slope in deg	Ideal
Olivine	1.980±0.033	63.2°±0.4°	63.4°
Augite	0.638±0.037	32.4°±1.5°	26.6°
	(2 Ca + Na)/Al Slope	Slope in deg	Ideal
Plagioclase	1.054±0.015	46.4°±0.4°	45.0°
Augite	13.473±3.347	85.8°±1.2°	90.0°
N = 15			

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Table 5. Mineral formula of an augite phenocryst from the 1955 lava flows of Kilauea Volcano, Hawaii. Calculated from data in Ho and Garcia, (1988).

Si	1.894
Al^{iv}	0.106
Al^{vi}	0.029
Ti	0.036
Fe³⁺	0.020
Fe²⁺	0.257
Mg	0.981
Ca	0.663