Using Data to Teach the Petrology of Igneous Rocks

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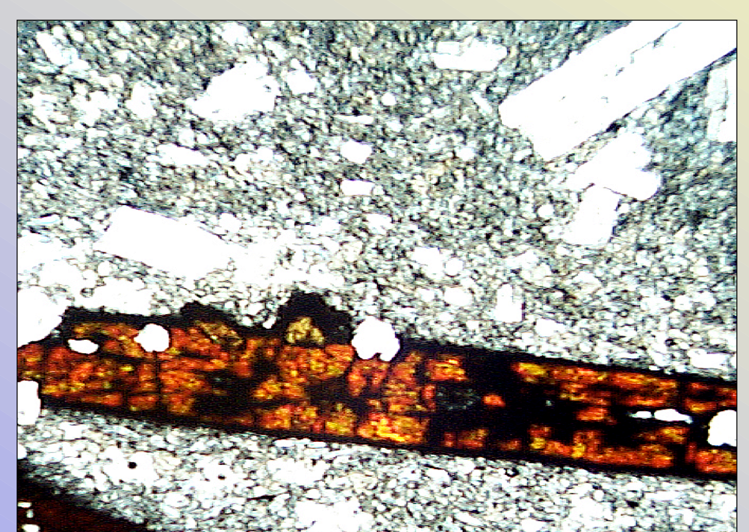
Introduction

At Georgia Southern University, Petrology is taught as a lecture course along with the accompanying laboratory. In order to make connections between the two disparate segments of this course; short exercises using real data accompany each laboratory exercise. Two examples are discussed in this poster.

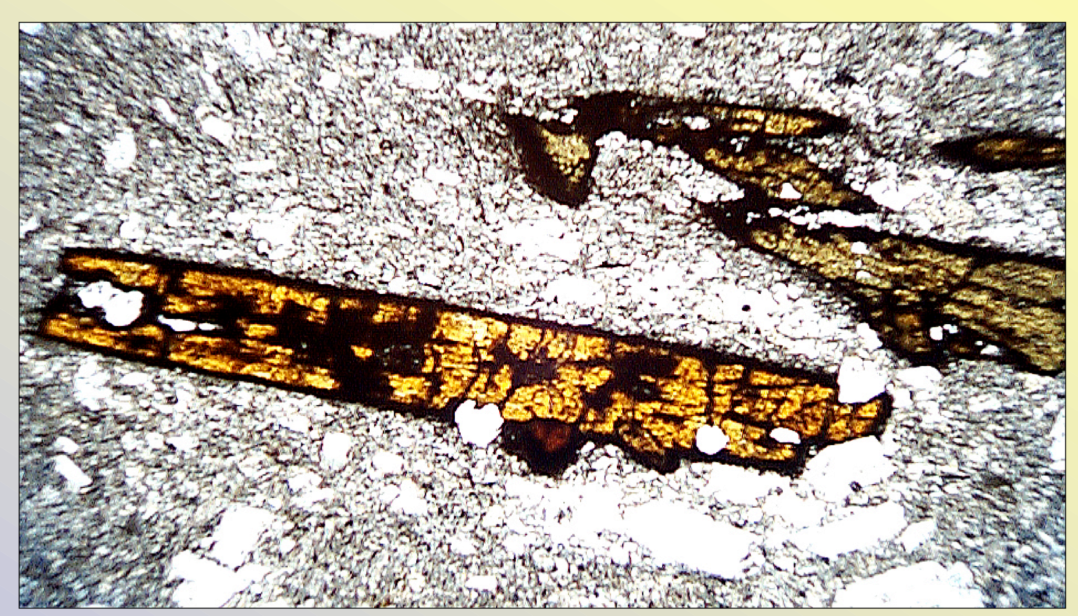
I. Basalts, Andesites, Rhyolites, and Tuffs

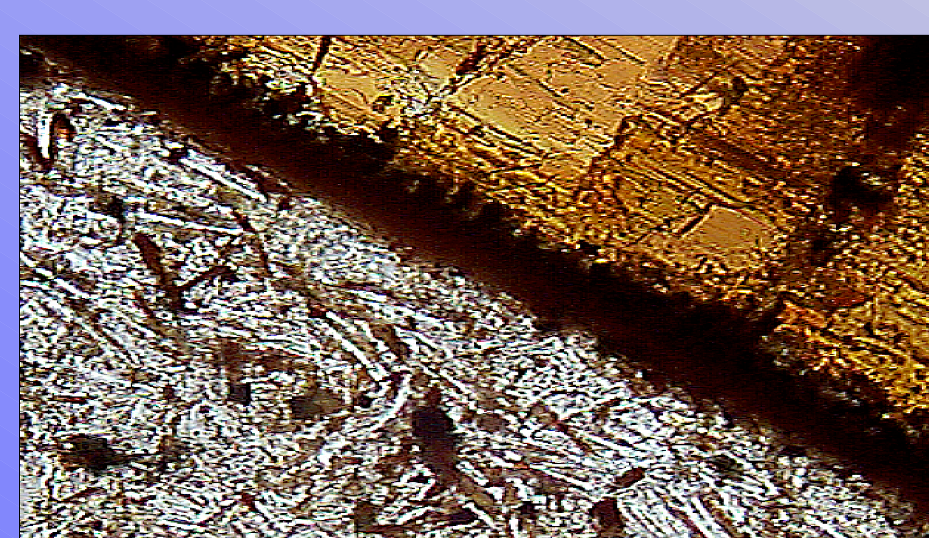
The first example is associated with a laboratory exercise on "Basalts, Andesites, Rhyolites and Tuff." In this laboratory, students examine and describe each of the rocks using hand specimens and thin sections. Once the rock descriptions are complete, the students evaluate the similarities and differences between these rocks (e.g., all the samples are porphyritic and contain plagioclase, anorthite content of plagioclase varies with composition). Students then work in small groups to calculate magma ascent rates from amphibole reaction rim thickness according to methods described by Farver and Brabender (2001). The students collect, appraise, and interpret their own data in the context of a much larger data set and model developed by Rutherford and Hill (1993). This addition to the exercise allows students to make linkages with lecture discussions on magma ascent rates and how they may be determined for recent volcanic eruptions.



Porphyritic texture of Hornblende Andesite (above, Wards sample # 29) from Mt. Shasta, California. Zoned labradorite and hornblende phenocrysts are embedded in a fine-grained matrix of plagioclase and ferromagnesian minerals. Field of view is 4 mm.

Reaction rims on hornblende phenocrysts (below) are visible in plane polarized light. Field of view is 5 mm.

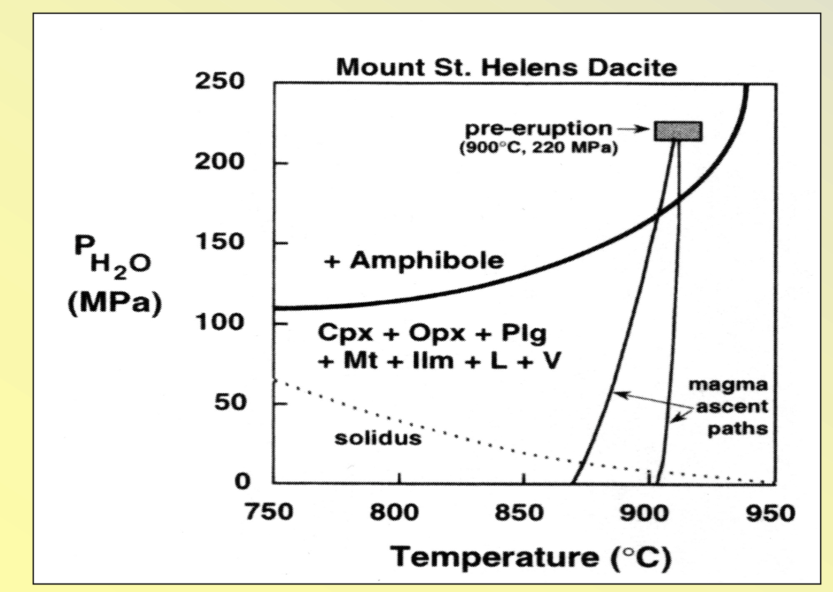




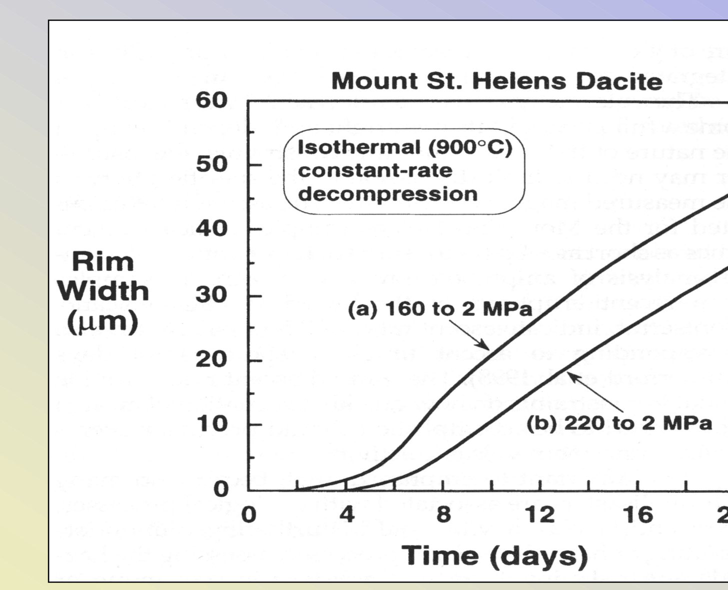
The students determine the thickness of the reaction rim for 5 hornblende phenocrysts (left). For each phenocryst, approximately 10 rim measurements are made around the periphery of the grain. Field of view is 0.5 mm.

Assignment

According to Rutherford and Hill (1993), during ascent amphibole phenocryts in volcanic magmas breakdown to form Orthopyroxene+clinopyroxene+ plagioclase+ magnetite+ ilmenite+liquid+vapor. This pressure-dependant breakdown reaction may manifest itself in the rock as a thick, dark colored reaction rim around the phenocryst with mostly magnetite and/or ilmenite being visible in PPL. Take at least 10 measurements of reaction rim thickness for each amphibole grain (you should use at least 4 or 5 grains). Calculate the mean-rim thickness value for each student group. The average-rim thickness value should be compared to the published values of Rutherford and Hill (1993) showed in the attached graph. Knowing the ascent duration, the ascent rate can be calculated in either m/hr or km/hr for the Mt. Shasta eruption.



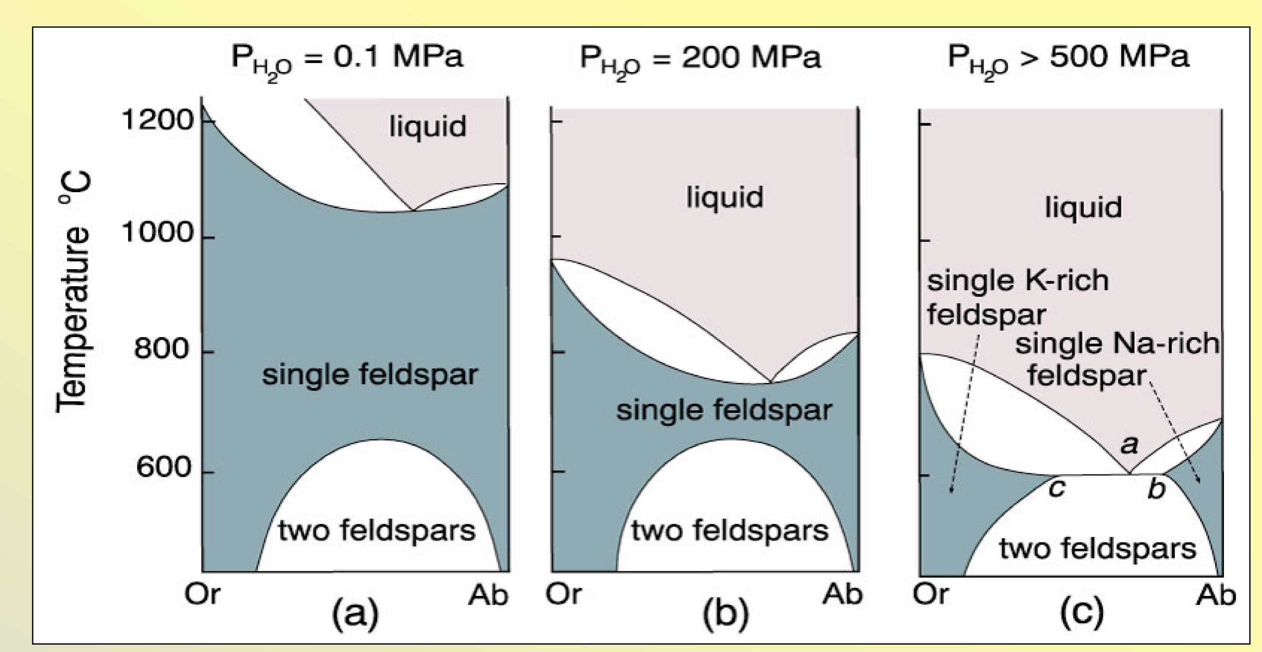
Pressure-temperature diagram showing amphibole stability field for Mount St. Helens dacite (Farver and Brabender, 2001).

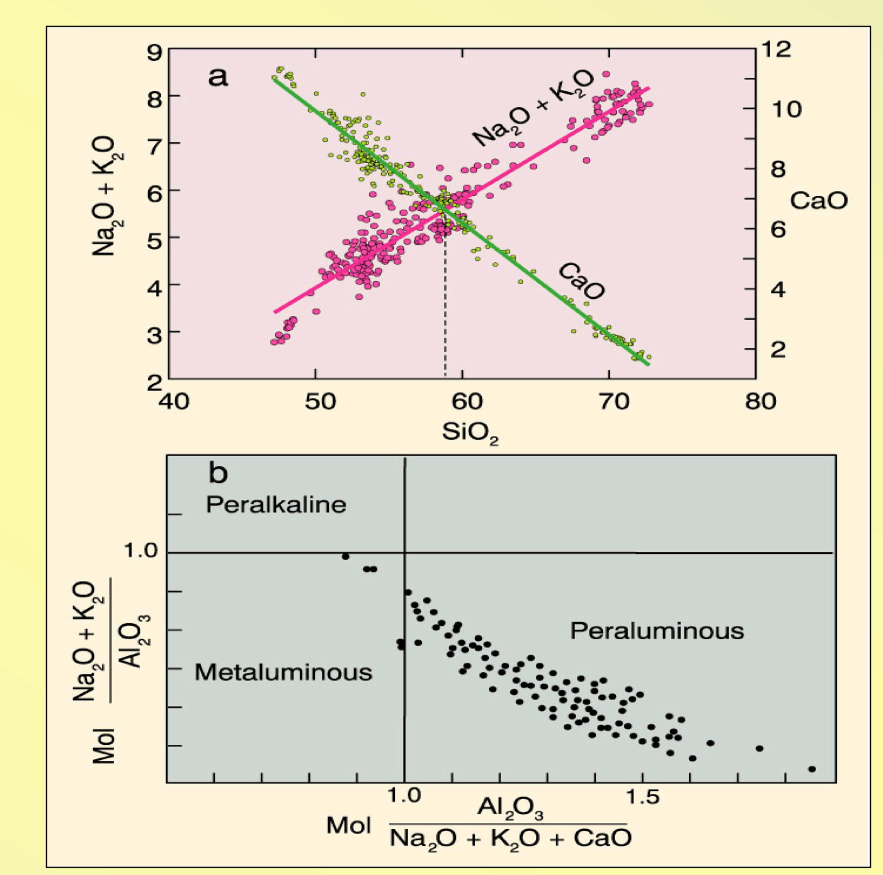


Experimental calibration of amphibole reaction rim thickness as function of time (Farver and Brabender, 2001).

II. Granites

A suite of granites are the subject of another laboratory exercise. Samples from the Sierra Nevada Batholith are used in this exercise. In addition to the usual description of hand samples and petrographic descriptions, the students also classify these rocks according to the sub- or hypersolvus classification. Based on the minerals present in each rock, they are further classified as "S", "I", "A", or "M" type granites. Whole rock and trace element analyses are also provided for classification based on alkali content.



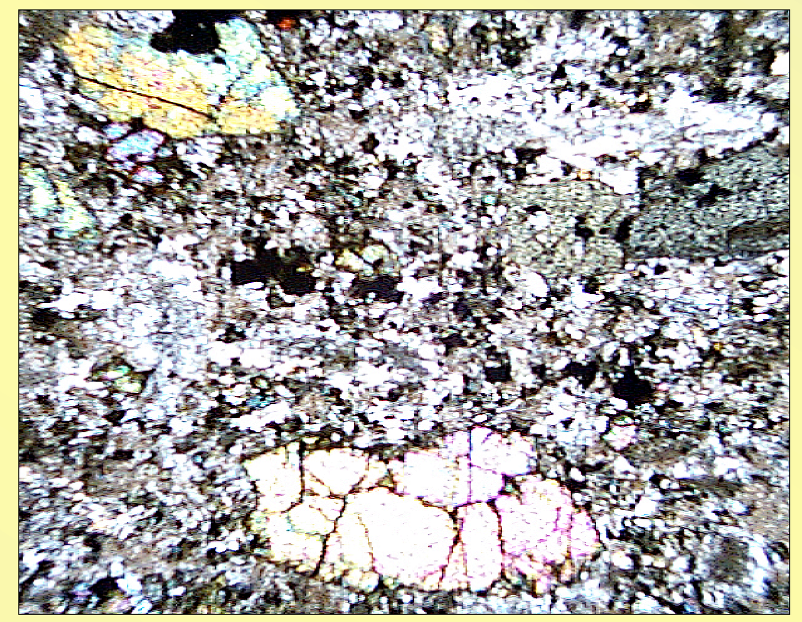


The Albite-Potassium feldspar system at various pressures (above). "Alkali-lime index" and alumina saturation indices (right). Both figures were taken from Winter, 2001.

III. Basalts

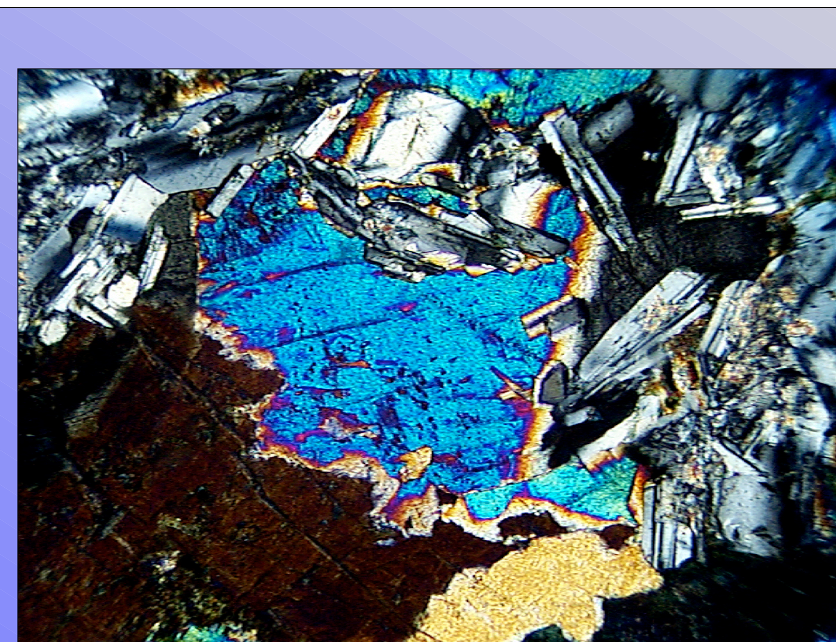
The second example relates to a laboratory exercise on "Basalts." Here, students examine and report descriptions on hand-samples and thin sections of three different basalts: an olivine tholeiite from Hawai`i, an alkali basalt from the Gregory rift in Kenya, and a Mesozoic diabase (quartz-normative tholeiite) from Connecticut. Whole rock and trace element data for these samples are also provided. Students use their rock descriptions and the geochemical data provided to answer questions regarding the degree of saturation of the magma, classification of the type of basalt (requiring normative calculations), and the tectonic setting of each rock (analyzing trace element data). This part of the exercise reinforces lecture materials on phase diagrams and geochemical tools used to decipher tectonic origin of rocks.

Olivine tholeiite from the 1868 Mauna Loa flows, Hawaii. Hand sample on left shows olivine phenocrysts being weathered. The photomicrograph on the right shows an olivine microphenocryst embedded in a finer grained matrix. Field of view is 0.75 mm.



Alkali olivine basalt from Kenya exhibiting porphyritic texture. Phenocrysts of titanaugite, plagioclase, and olivine are common. Field of view is 4 mm.

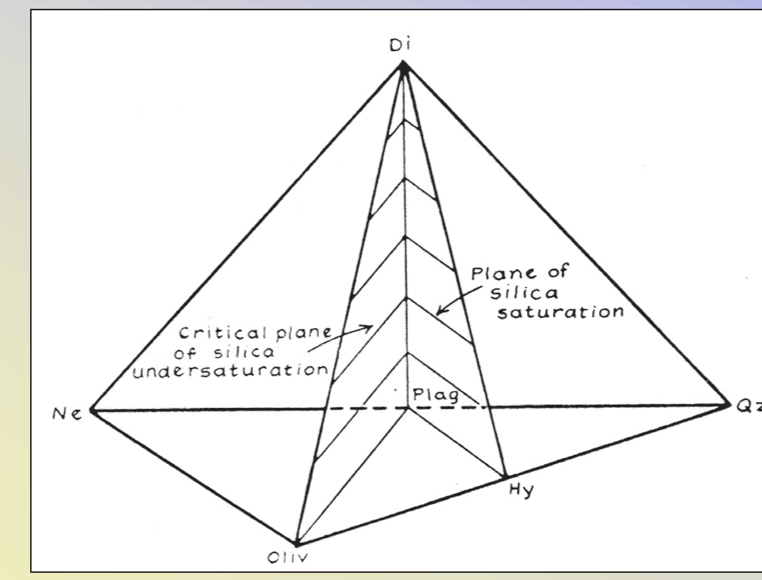
Diabase from Higganum, Connecticut. A solitary orthopyroxene phenocryst with a Fe-rich rim surrounded by fine-grained groundmass. Width of field 3 mm.

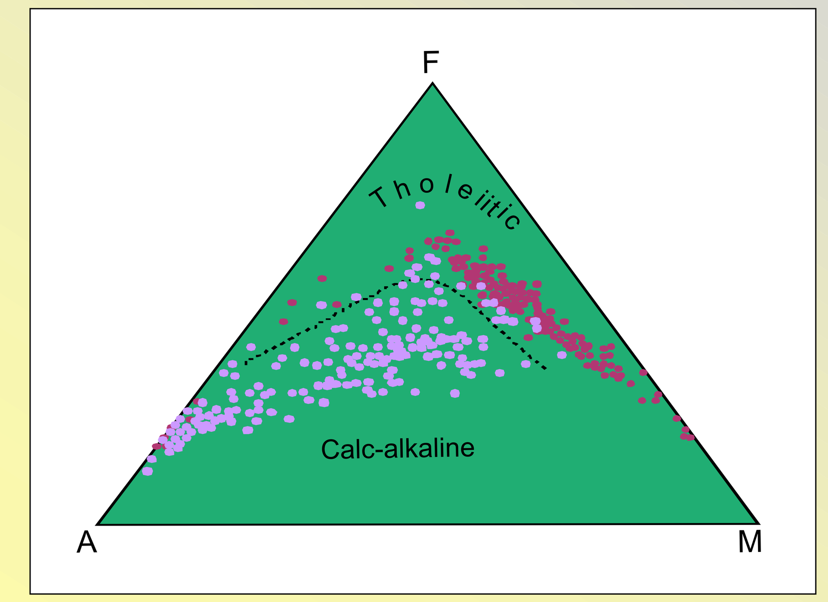


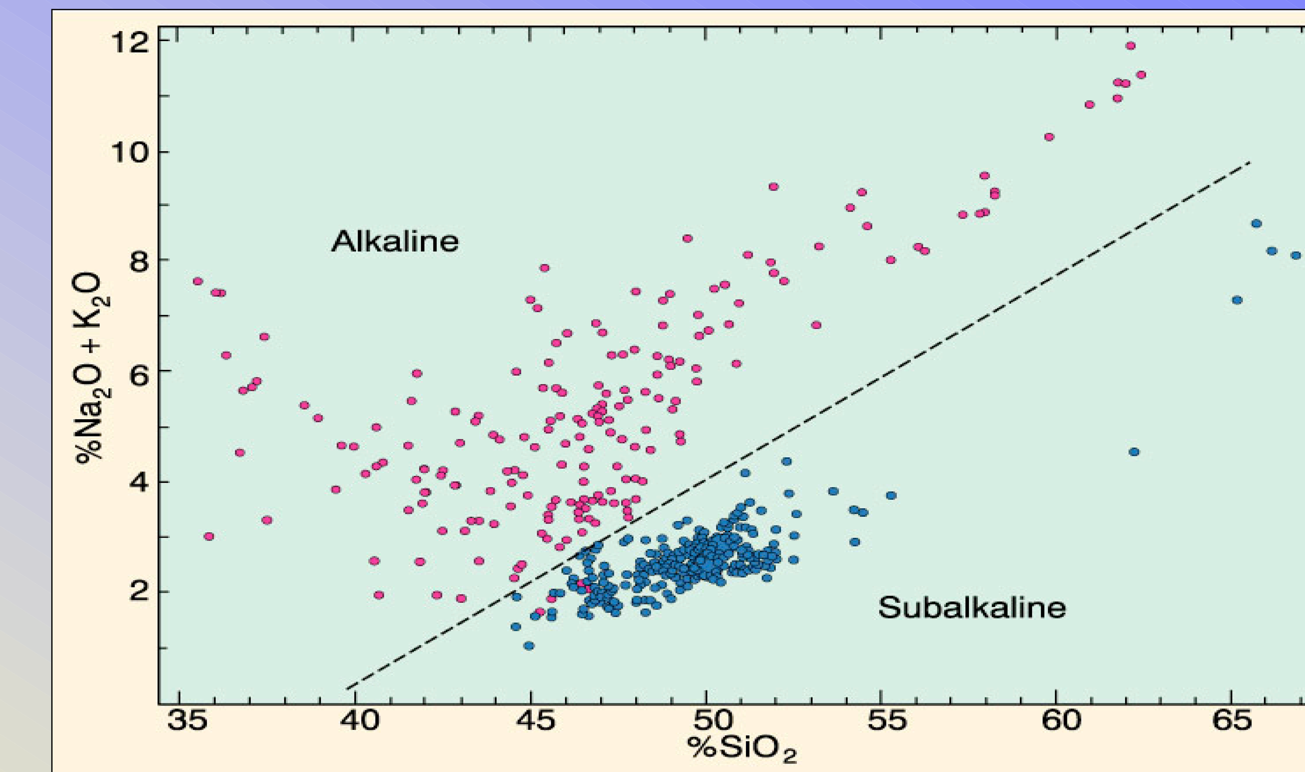
Diabase from Higganum, Connecticut. Rounded glomeroporphyritic cluster of augite. Each augite is intergrown with plagioclase lath(s). Width of field 4 mm.

Data Source	BSVP (1981)	Wilson (1989)	Asher (1995)
Sample location	Hawai'i	Kenya	New England
wt. %			
SiO_2	47.68	47.93	52.77
TiO_2	1.40	2.11	1.21
Al_2O_3	8.95	15.01	17.22
Fe_2O_3	3.67	2.99	1.12
FeO	7.90	8.96	9.56
MnO	0.16	0.20	0.19
MgO	21.02	6.94	7.29
CaO	6.99	12.05	11.08
Na_2O	1.48	2.69	2.08
K_2O	0.27	0.80	0.60
P_2O_5	0.17	0.32	-
Total	100.00	100.00	100.00
Concentrations in ppm			
Sc	21	37	-
Cr	1405	83	264
Co	-	47	67
Ni	-	76	96
Cu	-	-	-
Zn	-	-	-
Rb	4	15	22
Sr	213	428	186
Y	15	24	18
Zr	88	112	119
Nb	8	-	-
Ba	70	300	-
Normative minerals			
Q			2.93
Or	1.54	4.73	3.54
Ab	12.52	22.75	17.59
An	16.6	26.52	27.37
Cpx	12.79	25.39	22.68
Opx	21.4	0.16	21.97
Ol	27.58	11.36	
Mt	1.97	4.34	1.62
Il	2.6	4.01	2.3
Ap	0.42	0.76	

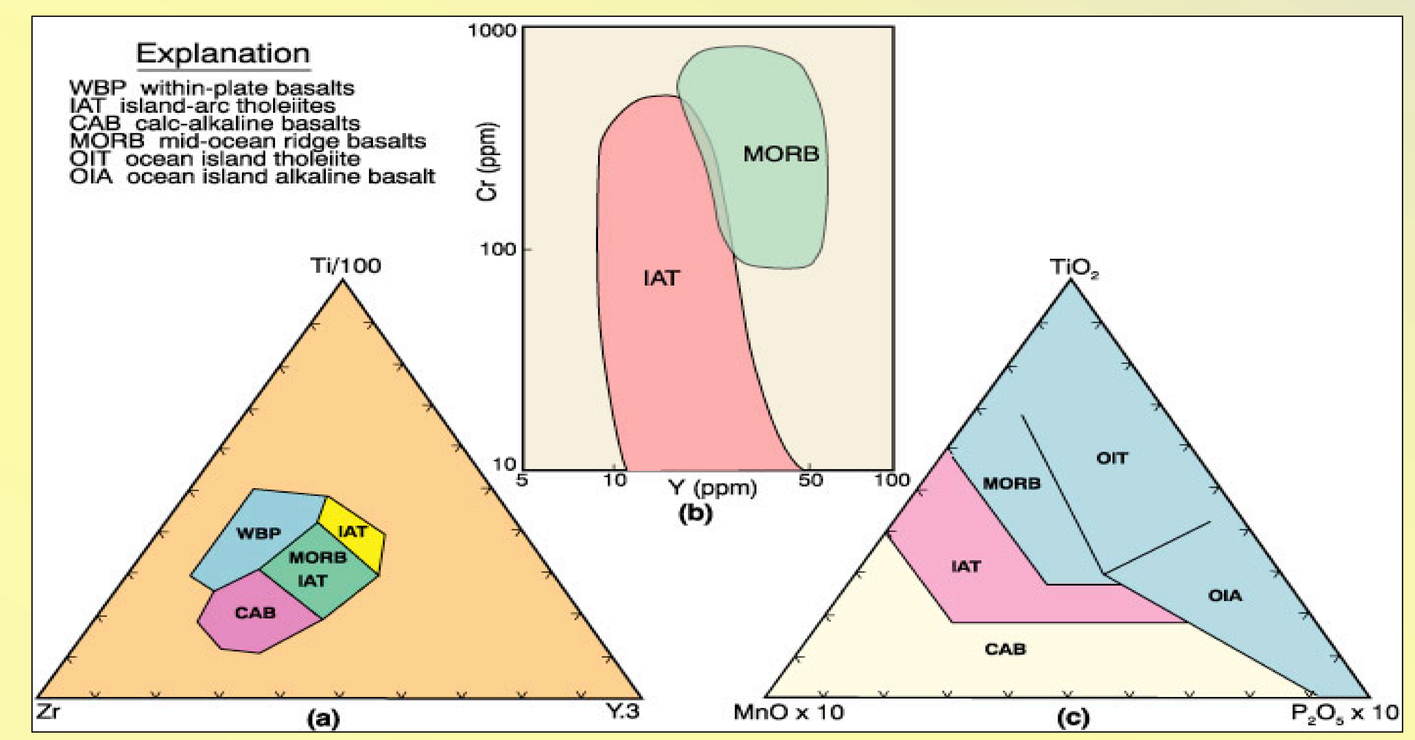
Geochemical data for the samples listed. Students have the option to request additional data from the locality to determine differentiation trends or tectonic setting.



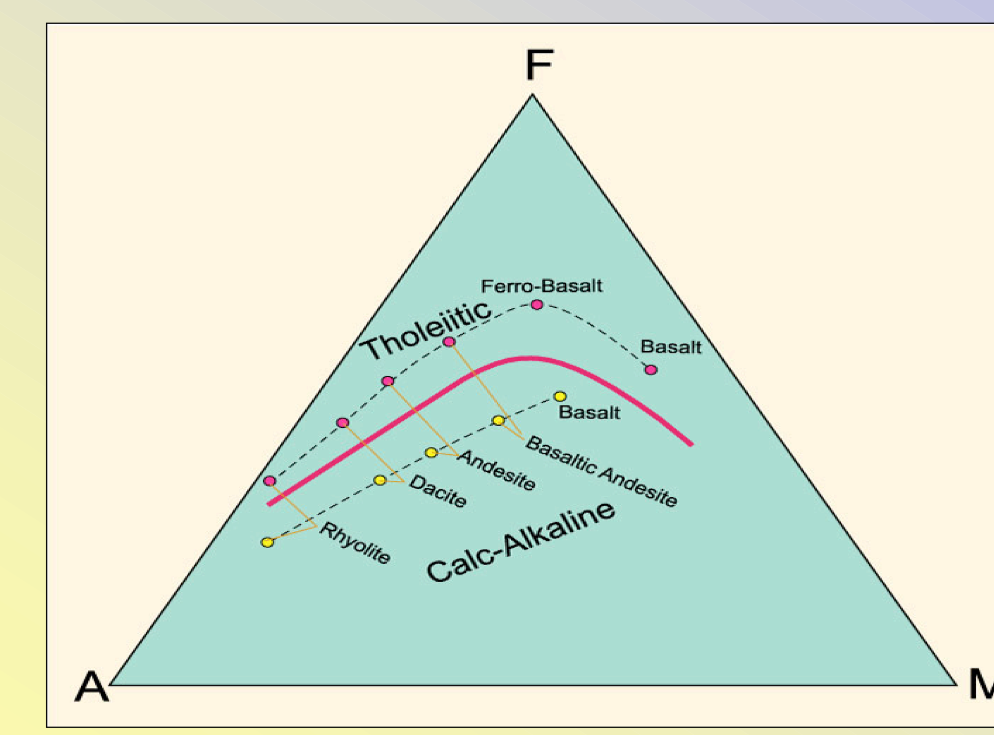




The samples are plotted (above, left) in the basalt tetrahedron to determine the degree of saturation. The Connecticut sample plots in the over-saturated field while the other two fall in the saturated field. Total alkalis vs. silica diagram (above, right). AFM diagram (left) showing the difference between tholeiitic rocks from calc-alkaline rocks. All three figures are taken from Winter (2001).



Examples of discrimination diagrams used to determine the tectonic setting of volcanic rocks. Taken from Winter, 2001.



AFM diagram taken from Winter, 2001 Additional geochemical data were also provided to determine the trends exhibited by the suite from each locality.

Summary

Assigning such activities allows students to retain materials learnt in lecture, have a better understanding of the lecture material, improve their ability to think critically, and gain experience in non-discipline skills such as writing, graphing, and working with peers (Manduca and Mogk, 2002).

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