# Magma Modification in the central Sierra Nevada batholith

INSTRUCTOR'S NOTES:

This multi-week lab is designed to be presented toward the end of the igneous petrology section of the course. I use John Winter's book, *An Introduction to Igneous and Metamorphic Petrology* (2001). By the time we get to this lab, we have covered the following subjects (and chapters in Winter's book):

| Topic | Chapter |
|---|---|
| Introduction – fundamental concepts of petrology | 1 |
| **Nomenclature and textural terms** | ***2-3*** |
| Introduction to thermodynamics | *5* |
| Equilibrium, the phase rule and review of two component phase diagrams | *6.1-6.5.1* |
| Review of two-component phase diagrams | *6.5.2-6.5.3* |
| More two component systems | *6.5.4-7.1.1* |
| Three component systems | *7.1.2-7.1.4* |
| Multi-component systems and pressure/fluid effects on melting | *7.2-7.5* |
| Chemical Petrology: Major and Minor Elements | *8* |
| Chemical Petrology: Trace elements | *9.1-9.6* |
| Chemical Petrology: Isotopes | *9.7* |
| Generation of basaltic magmas | *10* |
| Generation and modification of magmas –melting and fractionation | *11.1-11.2, 12.3* |
| Modification of magmas: mixing and assimilation | *11.3-11.7* |

## Important skills:

I see experience with the microscope as a skill that is necessary to complete this exercise. My students have had at least 7 weeks of experience interpreting the textures of igneous rocks and they have seen many of the textures that I expect them to interpret for this assignment. If students have less experience, or have not seen mixing textures before, it is important to lead the class toward the interpretation of these textures by asking pointed questions. This is where M.J. Hibbard's book, *Petrography to Petrogenesis* (1995) comes in handy. I keep one in the lab for the students.

Students should understand the concepts behind major element diagrams and REE diagrams. We have gone over these in class and the students have completed a slightly shorter (than this one) exercise in the previous two weeks in which they used major elemental data from volcanic rocks to calculate normative mineralogy and generate Harker diagrams.

They need to have been exposed to how isotope systematics work (i.e., the fact that mixing of old crust with new mantle melts generates a hyperbolic curve, and why). Otherwise, they won't know how to interpret the isotope plot.

Students should also have access to nomenclature and textural terms (I give them a list at the beginning of the term and have them define them in the back of their lab notebooks) so that they can complete the petrographic portion of the assignment.

I also make sure that they know that I am available to discuss their findings with me (either in person or via e-mail). Sometimes they just need to know that they are on the right track. I encourage them to work together and depending on the size of the class, I often try to pair them up so that they have another "consultant" to work with.

**Possible adaptations:**

The main goal of this exercise is the integration of a number of different types of data into a coherent story. This makes this exercise highly adaptable – all that is needed to develop a lab of your own is a suite of related hand samples and thin sections, major, trace and isotope data and a map.

I have toyed with the idea of making this a semester- (or at least half a semester-) long project in which I use these samples to illustrate things that we have been doing in class. The students would become intimately familiar with the samples and would do a bit of library research on the possible sources of these magmas. Maybe that is the next step – these could be used to talk about crystallization of magmas (phase diagrams), elemental concentrations (geochemistry) and magma modification. Anyway, I'll let you know if I try it.

If your students do not have the experience that my upper level students have, I would recommend writing some leading questions (some specific and some that are open ended) that will help the students learn the types of things they need to be asking themselves when they look at thin sections. I would be happy to help write these questions if you feel that you need them – don't hesitate to contact me at wenner@uwosh.edu if you need help.