Syllabus – GEOL 533: Continental Margin Arcs (Fall 2019)

"We are now fully assured that granite has been made to break, displace and invade the Alpine schistus or primary strata having been previously forced to flow in the bowels of the earth, and reduced into a state of fusion." James Hutton: "Observations on Granite" (1794).

Continental arcs can be viewed as (a) tectonic elements reflecting plate boundary processes, (b) large "differentiation factories" leading to both the formation and removal of continental crust, and (3) living/breathing systems with complex temporal histories. In this class we will examine the mechanical, thermal, and geochemical spatial and temporal evolution of continental arcs and associated orogenic belts, so called "hot orogens".

The construction and evolution of arcs represents one of the most dynamic geologic processes on earth. Mantle, crustal, and surface processes all play important roles. And in contrast to many other geologic settings, magma-host rock systems in hot orogens experience highly variable conditions (e.g., changing P, T, effective viscosities, bulk compositions) during their lifetime resulting in highly variable behavior. Magmatic systems and their host rocks in arcs are open, linked systems: heat, mass, and mechanical energy are all transported across the pluton-host rock contact. Thus to understand the evolution of these systems we need to examine the internal structure and petrology of magmatic bodies, the nature of their contact aureoles, as well as the surrounding regional tectonics.

In lecture we will review and discuss the theoretical aspects of the behavior of both arcs and magma-host rock systems: labs will consist of practical exercises designed to quantitatively evaluate natural systems. I wish to emphasize that although I've done the general organization for this class, I view this class as a collaborative effort. How successful and fun this class will be, in large part, depends on your involvement. If you are working on an arc or pluton, or know of other good papers about topics not in my reading list, or have maps, thin sections, datasets or photos, please share your resources with us.

General Course Information

Lecture (ZHS-118): W 8-11(?), some "distance learning" involved
Lab (B65): M 8-10 (lab always available in room 127)
Field Trip: Depending on class interest, a field trip to the Sierras will be offered.
Office Hours (Rm ZHS 307): MW-11 or anytime through email/Skype
Phone 213-740-6103; email Paterson@usc.edu

Grading:	Class Participation, Weekly Readings	20%
	Weekly Labs	30%
	Class Project (paper/ppt)	30%
	Final Exam	20%

As part of this class we will do a project on an arc or pluton of your choice. Projects in the past have led to a class publication and/or to a new major research direction.

Lecture Topics:

Reviews (I will post the following review lectures online and assume you know the material): (1) Igneous rocks, (2) Plutonic bodies, (3) Volcanic landforms, (4) Stress, (5) Introduction to rock mechanics, (6) Topographic and geologic maps, (7) Geologic mapping.

Lecture 1: Intro to lithospheric magmatic systems (hot orogens) from source to surface
Lecture 2: Geophysical imaging of arcs and overall architecture (Guest lecture: Sylvain Barbot)
Lecture 3: Dynamic arcs: migrations, flare-ups, focusing, tectonics, tempos
Lecture 4: Melting: subduction inputs, mantle processes + melting, MASH zones (Guest lecture: Emily Cooperdock)
Lecture 5: Magma ascent mechanisms and resulting structures
Lecture 6: Magma reservoir growth and recharge
Lecture 7: Emplacement: Host rock displacement during reservoir growth; contact aureoles
Lecture 8: Crustal responses to magmatism: (isostacy, sizes/shapes/crustal patterns)
Lecture 9: Physical and chemical processes during crystallization of magma
Lecture 10: Magma contamination and internal recycling
Lecture 11: Magmatic structures: Local flow and crystal accumulations in chambers
Lecture 12: Fabrics: Strain and mineral preferred orientation in magma chambers
Lecture 13: Testing coupled reservoir growth and host rock displacement models
Lecture 14: Isotopic studies of arcs and single magmatic systems
Lecture 15: Tectonics of hot orogens
Lecture 16: Student Presentations

LABS

Week 1: Answer questions about review lectures.
Week 2: Arc sections, geophysical images, and physical properties.
Week 3: Arc processes: rates.
Week 4: Calculating magma properties (density, viscosity).
Week 5: Fluxes and incremental reservoir growth.
Week 6: Evaluating “emplacement” models.
Week 7: Arc responses to magmatism: isostacy, transcrustal magma architecture
Week 8: Magmatic microstructures, orders of crystallization, crystallization processes.
Week 9: Testing source vs fractionation vs mixing vs assimilation.
Week 10: Chemical and physical processes forming magmatic structures.
Week 11: Submagmatic to solid-state microstructures and deformation mechanisms.
Week 12: Interpretation of structural patterns in plutons.
Week 13: Testing coupled reservoir growth-host rock displacement models
Week 14: Isotopic studies of arcs: testing magma sources
Week 15: Final presentations and reports due.
Week 16: Final exam