Future Research Opportunities

- **Fault mechanics**

Current and Recent Research

- **Gulf of California**
- **Western Salton Trough**
- **Arabia-Eurasia collision**
- **Thermochronology**

Future Research Opportunities

**Fault mechanics:** A raging controversy exists in geology and geophysics over the strength of natural faults relative to laboratory friction measurements—are they strong or weak?? Various lines of evidence suggest that faults are weak relative to lab friction, but the cause for this is unclear. This controversy centers on the San Andreas fault, but only very limited samples will be returned from the **SAFOD drill site**.

I plan to initiate a multidisciplinary research project into the formation of the various fault rocks found around the mechanically enigmatic low-angle normal fault (or detachment faults). Detachment faults are the “weak end-member” of all natural faults: they form at high angles to the maximum principal stress as well as under low differential stress (relative to thrusts or strike-slip faults). This project will aim to characterize the mechanical evolution of two or three low-angle normal faults (including the west Salton detachment fault—see below). Specific methods will include (1) detailed field structural geology to constrain the paleo-stress field around the detachments, (2) structural petrology to characterize the mechanisms of formation of...
associated fault rocks, (3) stable-isotope and fluid-inclusion analyses to constrain the source and temperature of the fluids that passed through the fault rocks, and (4) coupled structural, chemical, and hydrological modeling to constrain the reasonable fluid fluxes and pressures. Planned collaborators are Jane Selverstone (UNM), Andy Campbell (NMT), and Brian McPherson (NMT).

Current and Recent Research

Extensional tectonics

**Gulf of California.** My current work in extensional tectonics is mainly in the Gulf of California-Salton Trough rift, which was chosen as one of two "focus sites" for the Rupturing Continental Lithosphere (RCL) initiative of the NSF MARGINS Program (the Red Sea is the other site). The gulf rift is strongly oblique, with the extension direction only about 20°-30° different from the rift-axis trend.

We finished the premier three-year seismic/geologic experiment that combined onshore and marine seismology across the gulf, with structural field studies in eastern Baja California. We imaged the whole-crustal architecture of the rift in three main transects across the gulf, and three of my students mapped key areas on the Baja California extended margin. Publications are in preparation. Collaborators include Dan Lizarralde (WHOI), Steve Holbrook ( U WY ), Alistair Harding and Graham Kent (Scripps), Paul Umhoeffer (NAU), and John Fletcher and Antonio González-Fernández (CICESE). Students were Rob Givler (M.S., now at Lettis & Assoc.), Natanya Black (M.S., now UCLA Ph.D. student), and Sara DiFiori (finishing her M.S.)

**Western Salton Trough.** This collaborative research project documented the evolution of the west Salton detachment system: low-angle normal faults that bound the west edge of the Salton Trough and controlled sedimentary basin evolution there. Detailed structural mapping, sedimentology, magnetostratigraphy, and thermochemistry ([U-Th]/He and 40Ar/ 39Ar) were combined to decipher the history of this fault system and its relationships to the evolution of the southern San Andreas fault system and to the plate boundary evolution. Collaborators include Becky Dorsey (U OR), Susanne Janecke (UT State), Bernie Housen ( W. WA ), Danny Stockli (U KS ), and Marty Grove (UCLA). Students were Mary Kairouz (M.S., now at Leighton Consulting), and Catherine Shirvell (M.S., starting Ph.D. at U KS in 2007).

**Arabia-Eurasia collision.** Iran contains the youngest continental collision on Earth—the oblique Arabia-Eurasia collision—so provides exciting opportunities to study early orogenic processes that are overprinted and obscured in other, older parts of the Alpine-Himalayan chain. In 1998 I began research into the continent-continent collision between the Saudi Arabian
and Eurasian plates in Iran. Iran had recently "opened up" to western Earth scientists, and we worked in northern Iran, in the transpressional Alborz Mountains immediately south of the Caspian Sea. We combined detailed and reconnaissance mapping with geo- and thermochronology. Collaborators were Jamshid Hassanzadeh and Abdol Hossein Amini (U Tehran), Marty Grove (UCLA), Danny Stockli (U KS), and Ken Farley (CalTech). Students were Pat Lam (M.S., now at ENGEIO Inc.) and Bernard Guest (Ph.D., now at U. Hannover, Germany).

Subsequently, we began work in the Zagros Mountains, which comprise the suture zone, the fold and thrust belt, and a major dextral fault zone, all of which developed during the Arabia-Eurasia collision. We combine structural mapping, sedimentology, magnetostratigraphy, thermochronology, and detrital zircon chronology to constrain the age of various major structures and to characterize the evolution of this oblique collision zone. Collaborators are Brian Horton and Marty Grove (UCLA), Jamshid Hassanzadeh and Abdol Hossein Amini (U Tehran), Mohammad Fakhari (retired from the National Iranian Oil Company), Danny Stockli (U KS), and Bernard Guest (U Hannover). The student is Yann Gavillot (M.S. in progress, UCLA).

**Thermochronology**

The footwalls of low-angle normal faults offer unique opportunities to advance thermochronologic techniques because of their simple, rapid cooling histories. Two projects have aimed to use these histories to improve thermochronologic methods. In the first project, we used the 40Ar/39Ar method to date pseudotachylyte (frictional fault melt and ultracataclasite) and the independently determined cooling history to constrain the interpretation that most pseudotachylyte ages are simple cooling ages, but not necessarily age of formation of the fault rocks. In the second (ongoing) project, we are attempting to extend the 40Ar/39Ar multidomain diffusion model currently applied to K-feldspars to lower temperatures by integrating (U-Th)/He data from zircon and apatite into the modeling routine. These projects include collaborators Marty Grove (UCLA), Oscar Lovera (UCLA), and Danny Stockli (U KS), and students Garrett Hazelton (UCLA Ph.D.) and Mary Kairouz (UCLA M.S.).