



Research in structural geology & tectonics at TTU explores questions relating to the nature of magma/melt migration and emplacement in the lithosphere and the structural/tectonic evolution of arcs, oceanic spreading centers, and icy satellites. I combine field geological mapping with microstructural analysis and theoretical models to explain the structural history of these systems. In collaboration with petrologists, geochemists, and geochronologists, I study arc evolution in field settings such as the US Cordillera and central Norway. My passion is to combine a variety of datasets, observations, and collaborators, to optimally inform our understanding of the tectonic evolution of the lithosphere.

This document provides an overview of new, current, and past projects in the realm of structural geology & tectonics, as well as other information for interested students and collaborators.

### **Areas of Research in Structural Geology & Tectonics**

I am currently engaged these four research topics:

- a) structural, petrological and geochronological studies of deformation, migmatization and batholith construction (locations including Caledonides of central Norway, Proterozoic terranes of New Mexico);
- b) evolutionary studies of batholith construction in a variety of locations (Sierra Nevada, CA, Klamath Mountains, CA/OR, Norway, New Mexico) using a variety of tools (field mapping, geochronology, thermal studies, microstructural analysis);
- c) structural and petrologic evolution of ophiolite complexes, with particular emphasis on lower crustal, supersolidus deformation and upper mantle dynamics (Josephine ophiolite); and
- d) microstructural, imaging (SEM-EBSD), and structural studies of supersolidus flow and strain localization at mid-ocean ridges (e.g., Southwest Indian Ridge, ODP Legs 118, 176 & 179 and Cocos Ridge, IODP Leg 335).

My emphasis with students is to combine field studies (detailed mapping at scales from 1:24,000 to 1:300), cross section construction, and field-structural analysis with laboratory work including quantitative microstructural analyses (image analysis, SEM-EBSD analysis, strain analysis, LPO/SPO, etc.) and geochemistry. Geochemical studies are conducted in collaboration with Drs. Cal Barnes and Callum Hetherington, also at Texas Tech. I also collaborate with scientists from a variety of institutions including the University of Wyoming, U.S. Geological Survey, Norwegian Geological Survey, and elsewhere.

Given our emphasis on field-oriented studies of high-temperature deformation, igneous and metamorphic petrology, geochemistry and geochronology, and the intimacy of our program, I think we have defined a successful niche in the realm of studies dealing with structural

petrology. With collaborators both in-house and at various universities and geological surveys, we can provide training at a variety of levels and across a number of disciplines. This type of collaborative work allows students to develop networks with researchers & faculty members at other institutions, thus enabling future collaborations and/or continued graduate training opportunities upon leaving Texas Tech.

In addition to studies on high-temperature structural petrology, I am also interested in more “classical” structural problems including the interaction of folding and fracture development and the geometrical and kinematic evolution of fold and thrust belts. I have on- and off-again field-oriented projects in the Big Bend region of SW Texas as well as the Cordilleran fold and thrust belt in eastern California.

### **Potential New Projects as of January 2012**

Kinematics of high-temperature mantle flow in the Josephine peridotite: Implications to intra-arc rifting in the Jurassic Josephine ophiolite.

Thermal modeling of magma emplacement, host rock deformation & incorporation, & fabric formation fronts.

Unraveling ~1.6 Ga. And ~1.4 Ga. deformation & metamorphism in the Manzano Mountains.

### **On-going Projects**

*“Batholith Tectonics”, Arcs & Collisional Systems*

1. Nature, tempo & emplacement of magmas into a tilted plutonic complex, Klamath Mountains, CA.
2. Xenolith incorporation & assimilation in plutonic systems: Wooley Creek batholith, CA, & Bindal Batholith, central Norway.
3. Structural and geochronologic evolution of the Helgeland Nappe Complex, Norway.

*Oceanic Spreading Centers*

1. Hypersolidus deformation in the oceanic lower crust as exposed in ophiolites.
2. Evaluating magmatic strain in the oceanic lower crust of the Southwest Indian Ridge (ODP Legs 176, 179) and Cocos Ridge (IODP Leg 335).

### **Projects “Near” Completion**

*Kinematic analysis of structures on icy satellites.*

1. Kinematic evidence for active and paleo diapirism on Enceladus.

*Landscape Response to Tectonics & Climate*

1. Surface uplift and bedrock river incision in the Klamath Mountains, CA. *Tim Anderson’s fantastic thesis work that we hope to publish very soon.*
2. Testing models for recent tectonism in the western Sacramento Mountains, NM, using bedrock river longitudinal profiles. *Joe Bauman’s superb thesis work that we also hope to publish very soon!*

### *Oceanic Spreading Centers*

1. Tectonic and magmatic evolution of the Tortuga ophiolite, Tierra del Fuego, southernmost Argentina and Chile. *Finishing the writing.*

### **Pending, Current & Past Contracts and Grants that have funded research at TTU:**

- 2012-2014. Collaborative Research: Hypersolidus strain localization at an oceanic core complex: Constraining the genesis and rheology of "hot" detachment faults at the Southwest Indian Ridge. With Dr. Elena Miranda, CSUN. NSF 2012-2014, submitted.
- 2012-2013. Consortium for Ocean Leadership, US Science Support Program, "Evaluating strain in the lower oceanic crust at super fast spreading rates, IODP Hole U1256D", \$15,000. With Ph.D. candidate Jeremy Deans.
- 2009-2012. Collaborative Research: Nature, tempo and emplacement of magmas into a tilted plutonic complex, Wooley Creek Batholith, Klamath Mountains. PI, \$292,000, with Co-PI's Cal Barnes (TTU) and Kevin Chamberlain (Univ. of Wyo.), NSF – 2009 - 2011.
- 2005-2008. Collaborative Research: Magma-host Rock Interactions Processes of Assimilation in the Mid-Crustal Hortavaer Intrusive Complex, Central Norway", \$229,000. With Cal Barnes (TTU) and Carol Frost (University of Wyoming), NSF – 2005 - 2008.
2005. TTU TLTC: GEOWALL: Accessing and evaluating the spatial and visualization skills in Geoscience students. \$9,600, PI.
2005. Halliburton Corporation: GEOWALL: 3-D imaging of subsurface geometry in petroleum systems, \$20,000, PI.
2003. Texas Tech University, Faculty Research Enhancement Grant, "Plutons & Plate Motions", \$4,680, PI.
- 2001-2004. Contact Aureole Rheology. \$114,000, PI, NSF – 2001 – 2004.
2000. Texas Tech University, Faculty Research Enhancement Grant, '3-D Mapping of a Rifted Margin', \$3,500, PI.
- 1998-2002. Investigating the magmatic and tectonic evolution of oceanic gabbros: Insights from the Tortuga Ophiolite. \$204,000, NSF – 1998 - 2002.
- 1998-1999. Foliation development across the hypersolidus to subsolidus transition: Implications to the rheology of the lower oceanic crust. \$23,000, PI, JOI-USSSP, 1998 – 1999.
- 1998-1999. The Rocas Verdes ophiolites: Mapping the formation of oceanic crust, \$37,000, PI, National Geographic Society Grant for Research and Exploration, 1998 – 1999.

## **My Philosophy of Advising, Teaching and Learning**

While there is a strong focus on research in the Geoscience Department, I equally emphasize the development of mentoring skills, teaching and learning pedagogy, and the notion of multiple learning styles with the students who work with me. Whether students go on to work in industry or academics, my philosophy is that developing multiple methods of communication and interactivity as well as an understanding of the diverse ways in which people learn will allow the student to communicate their science and enthusiasm with the maximum impact. I also recognize that all successful graduate students must be strong oral and written communicators. To this end I emphasize proposal writing and scientific presentation to all of my graduate students.

### **“Best Attributes” & Expectations**

Over the years I have come to appreciate the following attributes that make the ‘best’ graduate students – those that are successful in the graduate program and go on to solid careers and productive lives. These include:

- a passion for geosciences
- avid readers of the geologic literature
- initiative
- independence
- ambition
- collegiality
- a strong work ethic
- curiosity
- “follow-through”
- self-motivation
- constantly challenge me with new ideas, hypotheses and interpretations

In addition to the various mandatory degree requirements as outlined by the Geosciences Department and Graduate School (see the Department website for more details), I have a general list of “expectations” from each graduate student. These include:

- active and vocal participation in seminars and weekly meetings,
- development of a research proposal (or proposals) that is submitted to a society funding source (e.g., GSA, Sigma Xi, etc.)
- at the PhD level, development of and participation in proposal writing to Federal Agencies such as NSF, DOD, etc. (this is critical in your becoming a colleague and a well-trained, thoughtful scientist),
- extensive commitment to field mapping, sampling and structural analysis (often, but not always, in remote, beautiful locations!),
- positive and satisfactory progress on research and teaching goals as evaluated over each semester,
- oral and poster presentation of the state of their research (whether it be undergraduate, Master’s, or PhD level research),
- participation in any industry interviews, outreach programs, conferences and/or short courses in the students area of interest,

- the completion and submittal of at least one (for an M.S.) to three (for a PhD) manuscripts to a refereed journal upon graduation.

### **Outcomes**

Meeting these expectations should place the student in the best possible position for employment or continuing their education upon finishing the program at Texas Tech. As of December 2011, my current and former students have been offered or taken positions at ExxonMobil, Schlumberger, numerous independent petroleum companies, environmental and mining firms in southern California and Wyoming, or entered PhD programs such as the University of Massachusetts, Amherst, the University of Kentucky, and Texas Tech.

### **Current graduate students with whom I work**

Andrew Whitesides, PhD. expected 2015

Jeremy Deans, PhD. expected 2014, Evaluating magmatic strain in the oceanic lower crust.

Paul Gifford, MS. expected 2012, Kinematic evolution of fractures on Enceladus.

Jacob Leader, MS. expected 2012, Shear zone initiation in the Atlantis Bank.

Brendan Hargrove, MS. expected 2012, Emplacement & hypersolidus fabric development in the Wooley Creek batholith, Klamath Mountains, CA.

Nolwenn Coint, PhD., expected 2012, with Cal Barnes.

Wayne Marko, PhD. expected 2012, Crustal melting and emplacement of the Vega batholith, central Norway, with Cal Barnes.

Mike Muncy, MS. Structural analysis of Permian growth strata in Fresno Canyon.

### **Past Students:**

Joe Bauman, MS. 2011, Tectonic geomorphology of the Sacramento Mountains, NM.

Chloe Beddingfield, BS. 2010, Structural evolution of ice streams on Enceladus.

Heather Anderson, MS 2009, Emplacement of the Andalshatten pluton, central Norway.

Tim Anderson, MS 2008, Surface uplift and bed rock river incision in the Klamath Mountains, CA/OR.

Dave Martin, MS 2007, Emplacement of the McKinney Springs laccolith, Big Bend National Park.

Ryan Krueger, MS 2005, Mid-Cretaceous dextral transpression in the central Sierra Nevada batholith.

Nathan Zimmermann, MS 2005, Fracture formation during laccolith emplacement, Big Bend National Park.

Jeannette Wolak, MS 2004, Xenolith incorporation in the Jackass Lakes plutons, Sierra Nevada, CA.

Wayne Marko, MS 2004, Contact aureole rheology of the White Horse plutons.

Mike Salisbury, MS 2004, Kinematics of deformation in the Josephine peridotite.

Greg Dumond, MS 2002, Emplacement of the Sausfjellet pluton, Norway.

### **Financial Support**

Graduate student support in the Geosciences may come as either a Research Assistantship (RA) or a Teaching Assistantship (TA). Assistantships range from ~\$14,000 to \$17,000 per 9 months. Support may be guaranteed for 2 years for the M.S. degree and 3 years for the PhD. Additional support may be offered based on satisfactory progress. For example, support beyond 3 years for

the PhD may be derived from grants, Departmental TA's or other funds. I regularly apply for Federally funded grants (e.g., NSF) and expect to work very hard to acquire funding to support the research group. Except for a brief period during the fall of 2004, I have had continuous NSF support since arriving at Texas Tech in 1999. Students with the best qualifications will be nominated for a Chancellor's Fellowship. This is a very prestigious award at the University level and offers an additional \$3000/year for MS students and \$4000/year for PhD students. Four students that I have advised have been awarded Chancellor's Fellowships.

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