

CURRICULUM VITAE

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2. Education:

B.A. Carleton College, 1964
M.S. UCLA, 1967
Ph.D. UCLA, 1971
Dissertation topic: "Experimental Development of Preferred Orientation of Mica During Recrystallization"

3. Professional Appointments:

1964	(June-Sept)	Tectonophysics Summer Field Assistant, Shell Development Co.
1968-69		Research Assistant, Institute of Geophysics, UCLA
1969-70		Acting Instructor, Department of Geology, UCLA
1970-76		Assistant Professor, Brown University, Department of Geological Sciences
1976-89		Associate Professor, Brown University, Department of Geological Sciences
1976-77	(Sept-Jan)	Visiting Fellow, Australian National University, Research School of Earth Sciences
1977	(Jan-June)	Geologist, U.S. Geological Survey, Office of Earthquake Studies
1984	(April-May)	Visiting Professor, Texas A&M University, Center for Tectonophysics
1989-		Professor, Brown University, Department of Geological Sciences
1990	(Sept.-Oct.)	Visiting Professor, Harvard University
1990	(Aug, Oct.-Dec.)	Geophysicist, GS-15, United States Geological Survey Office of Earthquakes, Volcanoes, and Eng. Geol.
1997-1998		Adjunct Professor, South Dakota School of Mines and Technology, Department of Geology and Geological Engineering

4. Completed Research

a. Books authored or edited

Tullis, T. E. (editor) , 1986, *Special Issue on Friction and Faulting*, Pure and Applied Geophysics, 124, 234 p.

b. Chapters in Books

- Sbar, M. L., Engelder, T. and Tullis, T. E., 1978, Near-surface in situ stress measurements along the 1857 break of the San Andreas Fault, in *Stress and Strain Measurements Related to Earthquake Prediction*, USGS Open File Report 79-370, 485-499.
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- Tullis, T. E. and Tullis, J., 1986, Experimental rock deformation techniques, *Am. Geophys. Union Mon.*, 36, 297-324.
- Power, W. L. and Tullis, T. E., A review of the fractal character of natural fault surfaces with implications for friction and the evolution of fault zones, in *Fractals in The Earth Sciences*, Paul Lapointe and Chris Barton, Eds., Plenum, New York, 89-105, 1995.
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- Tullis, T.E. and Worthington, C., Ground-Penetrating Radar Study of the Petra Great Temple, Petra, Jordan, in *Petra Great Temple, Brown University Excavations 1993-1997*, ed. by Martha Sharp Joukowsky, 179-186, 1999.
- Tullis, T.E., Friction of Rock at Earthquake Slip Rates, in *Earthquake Seismology, Vol. 3 of Treatise on Geophysics*, edited by H. Kanamori, pp. in press, Elsevier, 2007.
- Tullis, T.E., R. Bürgmann, M. Cocco, G. Hirth, G. King, O. Oncken, K. Otsuki, J.R. Rice, A. Rubin, P. Segall, S. A. Shapiro, and C.A.J. Wibberley, Rheology of fault rocks and their surroundings, in *Tectonic Faults, Agents of Change on a Dynamic Earth*, edited by M. Handy, G. Hirth, and N. Hovius, MIT Press, Cambridge, MA, USA, 504 p., *in press*, 2007.

c. Refereed Journal Articles

- Tullis, T. E., 1964, Variation in perthitic microcline from a zoned pegmatite: *Jour. Minn. Acad. Sci.*, 32, 47-50.
- Tullis, J. and Tullis, T. E., 1972, Preferred orientation of quartz produced by mechanical Dauphine twinning: thermodynamics and axial experiments in H. Heard et al., eds., *Flow and Fracture of Rocks*, *Am. Geophys. Union Monograph* 16, 67-82.

- Tullis, T. E. and Wood, D. S., 1975, Correlation of finite strain from both reduction bodies and preferred orientation of mica in slate from Wales, *Geol. Sci. Am. Bull.*, 86, 632-638.
- Holeywell, R. C. and Tullis, T. E., 1975, Mineral reorientation and slaty cleavage in the Martinsburg Formation, Lehigh Gap, Pennsylvania, *Geol. Soc. Am. Bull.*, 86, 1296-1304.
- Tullis, T. E., 1976, Experiments on the origin of slaty cleavage and schistosity, *Geol. Soc. Am. Bull.*, 87, 745-753.
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- Tullis, T. E., 1977, Reflections on measurements of residual stress in rock, *Pure and Applied Geophysics*, 115, 57-68.
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- Shelton, G. L., Tullis, J. and Tullis, T. E., 1981, Experimental high temperature and high pressure faults, *Geophys. Res. Lett.*, 8, 55-58.
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- Blanpied, M. L. and Tullis, T. E., 1986, The stability and behavior of a frictional system with a two state variable constitutive law, *Pure Applied Geophys.*, 124, 43-73.
- Tullis, T. E., 1986, Friction and faulting, *Pure Applied Geophys.*, 124, 1-9.
- Tullis, T. E. and Weeks, J. D., 1986, Constitutive behavior and stability of frictional sliding of granite, *Pure Applied Geophys.*, 124, 10-42.
- Power, W. L., Tullis, T. E., Brown, S. R., Boitnott, G. N., and Scholz, C. H., 1987, Roughness of natural fault surfaces, *Geophys. Res. Lett.*, 14, 29-32.
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- Lorenzetti, E. A. and Tullis, T. E., 1989, Geodetic predictions of a strike-slip fault model: implications for intermediate- and short-term earthquake prediction, *J. Geophys. Res.*, 94, 12343-12361.
- Power, W. L. and Tullis, T. E., 1989, The relationship between slickenside surfaces in fine-grained quartz and the seismic cycle, *J. Structural Geology*, 11, 879-893.
- Yund, R. A., Blanpied, M. L., Weeks, J. D., and Tullis, T. E., 1990, Observation and interpretation of microstructures in experimental fault gouges, *J. Geophys. Res.*, 95, 15589-15602.
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- Tullis, T. E., Horowitz, F. G., and Tullis, J., 1991, Flow laws of polyphase aggregates from end-member flow laws, *J. Geophys. Res.*, 96, 8081-8096.
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- Parker, J. A. Donnellan, G. Lyzenga, J. Rundle, and T. Tullis, Performance modeling codes for the QuakeSim problem solving environment, *Computational Science – ICCS 2003*, proc. Int. Conf. Comp. Sci., Part III, 845-862, Springer-Verlag, Berlin, 2003.
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c. Refereed Journal Articles Accepted

e. Book Reviews

- Tullis, T. E., 1976, Review of Structural Geology by Hobbs, Means and Williams, *Earth Science Reviews*, 13, 99-100.

f. and h. Abstracts of Papers Presented at Meetings

- Tullis, T. E., 1968, Experimentally produced preferred orientations in mica aggregates, *Eos Trans. AGU*, 49, 304.
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- Tullis, T. E., 1977, Stress measurements by shallow overcoring on the Palmdale uplift, *Eos Trans. AGU*, 58, 1122.
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- Hobbs, B. E. and Tullis, T. E., 1979, The influence of pressure on hydrolytic weakening of quartz, *Eos Trans. AGU*, 60, 370.

- Tullis, T. E. and Horowitz, F., 1980, The strength of dry olivine, *Eos Trans. AGU*, 61, 375-376.
- Shelton, G. L. and Tullis, T. E., 1980, Faulting at high temperature and pressure, *Eos Trans. AGU*, 61, 376.
- Horowitz, F. G., Tullis, T. E., Kronenberg, A., Tullis, J., and Needleman, A., 1981, Finite element model of polyphase flow, *Eos Trans. AGU*, 62, 396.
- Weeks, J. and Tullis, T. E., 1982, Velocity dependence of rock friction at large displacement, *Eos Trans. AGU*, 63, 441.
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- Bechtel, T. D., Weeks, J. D., and Tullis, T. E., 1983, Observations of experimentally produced fault gouge, *Eos Trans. AGU*, 64, 834.
- Tullis, T. E., Weeks, J. D., and Bechtel, T. D., 1983, Inverse dependence of frictional resistance on sliding velocity at elevated normal stress, *Eos Trans. AGU*, 64, 850.
- Weeks, J. and Tullis, T. E., 1983, Increase in frictional strength of granite during static contact, *Eos Trans. AGU*, 64, 317.
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- Blanpied, M., Tullis, T. E. and Weeks, J. D., 1984, Stability and behavior of frictional sliding with a two state variable constitutive law, *Eos Trans. AGU*, 65, 1077.
- Weeks, J. D. and Tullis, T. E., 1984, Frictional behavior of dolomite, *Eos Trans. AGU*, 65, 1077.
- Blanpied, M. L., Tullis, T. E., and Weeks, J. D., 1986, Frictional behavior of granite at high slip velocity, *Eos Trans. AGU*, 67, 1186.
- Power, W. L. and Tullis, T. E., 1986, The roughness of natural fault surfaces, *Eos Trans. AGU*, 67, 1187.
- Tullis, T. E., 1986, The relation between surface roughness of laboratory samples and decay distances of friction constitutive laws, *Eos Trans. AGU*, 67, 1187.
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- Tullis, T. E. and Weeks, J. D., 1987, Micromechanics of frictional resistance of calcite, *Eos Trans. AGU*, 68, 405.
- Yund, R. A., Tullis, T. E., Weeks, J. D., and Blanpied, M. L., 1987, Microstructures in experimental fault gouges, *Eos Trans. AGU*, 68, 405.
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- Tullis, T. E., 1993, The difficulty of determining whether slip on an ancient fault was seismic or not, *Geol. Soc. America Abstracts with Programs*, 25, A114.
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- Tullis, T. E., Earthquake models using rate and state friction and fast multipoles, *Geophysical Research Abstracts (European Geophysical Society)*, 5, 13211, 2003.
- Donnellan, A., G. Fox, J. Rundle, D. McLeod, T. Tullis, L. Grant, Numerical Simulations for Active Tectonic Processes: Increasing Interoperability and Performance, extended abstract for Summary Symposium on the Solid Earth Simulator Project (1998-2002), March 13, 2003 at Sasagawa Memorial Hall, 3-12-12 Mita, Minato-ku, Tokyo, Japan, sponsored by Research

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- Tullis, T. E., and D. L. Goldsby, Flash melting of crustal rocks at almost seismic slip rates, *Eos. Trans. Am. Geophys. Union*, 84 (46), Fall Meeting Suppl., Abstract S51B-05, 2003.
- Tullis, T.E., N.M. Beeler, J. Salmon, and N. Kato, A parallel computer code for simulation of earthquake cycles using rate and state friction, radiation damping, and fast multipoles, 4th ACES Workshop, Beijing, 2004.
- Trotta, J.E. and T.E. Tullis, How robust is the load/unload response ratio method of earthquake prediction?, 4th ACES Workshop, Beijing, 2004.
- Di Toro, G., D. Goldsby, and T.E. Tullis, In the presence of water silica gel forms on fault surfaces as slip velocity approaches seismic rates, causing friction to fall towards zero, *Rock Deformation Gordon Conference*, 2004.
- Roig Silva, C., D.L. Goldsby, G. Di Toro, and T.E. Tullis, The role of silica content in dynamic fault weakening due to gel lubrication, in *2004 SCEC Annual Meeting Proceedings and Abstracts*, pp. 150, Southern California Earthquake Center, Palm Springs, California, 2004a.
- Hadizadeh, J., D.L. Goldsby, A. Konkachbaev, M. Yazdanpanah, T.E. Tullis, N.M. Beeler, Some mechanical implications of the development and evolution of Y shears in simulated granite gouge, *Eos. Trans. Am. Geophys. Union, Fall Meeting Suppl.*, 85 (47), 2004
- Roig Silva, C., D.L. Goldsby, G.D. Toro, and T.E. Tullis, The role of silica content in dynamic fault weakening due to gel lubrication, *Eos. Trans. Am. Geophys. Union, Fall Meeting Suppl.*, 85 (47), T21D-07, 2004b.
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- Tullis, T.E., Detailed multi-scale earthquake modeling using rate and state friction and the fast multipole method on parallel computers, *Eos. Trans. Am. Geophys. Union, Fall Meeting Suppl.*, 85 (47), NG54A-06, 2004.

Tullis, T.E. and N.M. Beeler, Detailed multi-scale earthquake modeling using rate and state friction and the fast multipole method on parallel computers, *Chapman Conference on Earthquake Energy*, 2005.

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g. Invited Lectures

- February 1980- "Stress Measurements on the Palmdale Uplift", MIT
- November 1982 - "Mechanics and Processes of Deformation" at National Association of Geology Teachers Symposium on Teaching of Structural Geology and Tectonics
- April 1983 - "The History of Experimental Rock Deformation for the Past 50 Years", Carleton College Symposium on Revolution in the Earth Sciences, 1932-1982
- November 1983 - "Rock Friction and Earthquakes", Cornell University
- April 1984 - "Constitutive Behavior of Rock Friction", Texas A&M University
- February 1985 - "Slip and Time Evolution of Laboratory Friction and Fault Instability Mechanics", Harvard University
- May 1985 - "Constitutive Behavior and Stability of Frictional Sliding of Granite", 5th Ewing Symposium on Earthquake Source Mechanics, Arden House, Harriman, NY
- October 1985 - "Rock Friction and Earthquakes", SUNY at StonyBrook
- April 1986 - "Rock Friction and Earthquakes", SUNY Albany
- November 1986 - "Rock Friction Constitutive Behavior from Laboratory Experiments and its Implications for an Earthquake Prediction Field Monitoring Program", U. S. Geological Survey, Conference on Intermediate -Term Earthquake Prediction
- December 1987 - "Progress and Problems in Understanding Rock Friction" at American Geophysical Union Fall Meeting
- February 1989 - "Rock Friction and Earthquake Prediction", Brown Faculty Colloquium
- August 1989 - "The Science of Understanding Earth Processes", New England Association of Chemistry Teachers 51st Summer Conference
- September 1989 - "Rock Friction and Earthquakes", Yale University
- October 1989 - "Rock Friction and Surface Chemistry", Physical Chemistry Group, Brown University
- February 1990 - "Rock Friction and Earthquakes", University of Connecticut
- March 1990 - "Strain and Geodetic Changes Predicted from Fault Models that use Laboratory-based Constitutive Laws", NSF/USGS Workshop on Crustal Deformation Measurement and Earthquake Mechanics
- April 1990 - "Rock Friction and Earthquakes", Dept. of Terrestrial Magnetism, Carnegie Institution of Washington
- May 1990 - "Rock Friction and Surface Chemistry", Tribology group at NASA's Lewis Research Lab, Cleveland, OH.
- June 1990 - "Origin of the Evolution Effect in Rock Friction", Symposium at MIT in honor of Bill Brace.

- November 1990 - Invited to participate as a member of the U.S. delegation to "The 7th Joint Meeting of the U.S.-Japan Panel on Earthquake Prediction Technology" in Tsukuba, Japan and to give a paper there.
- November 1990 - Invitation and transportation to Tokyo, Japan to present a paper, "Three dimensional modeling of strike slip earthquakes using laboratory-based rate- and state-dependent constitutive laws" at the International Symposium on Earthquake Source Physics and Earthquake Precursors.
- January 1991 - Invited to present a keynote lecture on "Mechanics of Distributed Deformation" at a symposium/workshop on "Mechanics of Lithospheric Deformation: Initiation, Evolution and Destruction of Continental Margins", sponsored by Ocean Studies board and Board on Earth Science of the National Academy of Sciences, Irvine, California, Jan 14-17.
- May, 1992 - Lecture on Geology to students at Alternative Learning Project, Providence
- September 1992 - "The Processes Involved in Rock Friction and Earthquakes", Cornell Univ.
- April, 1993- "Saint Andrew meets Jerry Lee Lewis", Review Club.
- June, 1993 - Invited to present a paper, "The Effect of Pore Fluid Chemistry on the Friction of Quartz Gouge," at a meeting on "The Mechanical Involvement of Fluids in Faulting" sponsored by the U. S. Geological Survey, June 6-10, Tenaya Lodge, Fish Camp, California.
- June, 1993- Invited to present a paper, "What Instability Modeling of Parkfield Earthquakes Suggests About Their Predictability," at the Fifth Annual IRIS (Incorporated Research Institutions in Seismology) Workshop, June 10-14, Waikoloa, Hawaii,
- December, 1993- Invited to present a paper, "The beginning of earthquake rupture in Parkfield models," at a special session on "The Beginning of Earthquake Rupture" at the Fall AGU Meeting, December 6-10, 1994, San Francisco, California.
- May, 1994- Invited to present a paper, "What determines the maximum strength of crustal earthquakes and what are the implications of this for the strength of the crust?," at a special session on "What Do We Know About the Strength of the Crust Anyway?" at the Spring AGU Meeting, May 23-27, 1994, Baltimore Maryland.
- February, 1995- Invited to present a paper on the general area of experimental rock mechanics and its implications for earthquake prediction at a colloquium on "Earthquake Prediction: The Scientific Challenge" sponsored by the U. S. National Academy of Sciences, February 10-11, Irvine, California.
- April 14, 1995 - "Rock Friction and Earthquake Mechanics," Department of Earth, Atmospheric and Planetary Sciences Lecture Series, MIT
- April 1980-1997 - Lead annual seminar discussion on Earth Sciences in a chemistry class at Moses Brown School.
- October 3, 1997 "Rock Friction and Earthquakes", Dept. of Geology and Geological Engineering, South Dakota School of Mines and Technology
- March 6, 1998 "The Roughness of Natural Faults", Dept. of Geology and Geological Engineering, South Dakota School of Mines and Technology
- November 8, 1998 "Earthquakes in the Azores", Portuguese American Federation Annual Congress

- February 4, 1999 "The Cassandra of Earthquake Prediction: Is She Attainable or Desirable?"
Brown University 101 Forum
- February 25, 1999 "Rock Friction and Earthquakes", Brown University, Department of
Geological Sciences Colloquium Series
- March 3, 1999 "Rock Friction and Earthquakes", Kyoto University, Kyoto, Japan
- March 4, 1999 "Rock Friction - Observations and Processes", Geological Survey of
Japan, Tsukuba, Japan
- March 5, 1999 "The Implications of Rock Friction for Earthquake Mechanics and
Prediction", Geological Survey of Japan, Tsukuba, Japan
- March 5, 1999 "Measurements and Significance of Fault-Surface Roughness", Geological
Survey of Japan, Tsukuba, Japan
- April 23, 1999 "Rock Friction and Earthquakes", California Institute of Technology
- August 2, 1999 "Using Microsoft FrontPage to Make Web Pages", Sheridan Center
Seminar, Brown University
- August 9, 1999 "What processes cause time-dependent increases in strength of frictional
surfaces?", Third Gordon Conference on Rock Deformation
- Sept. 30, 1999 "Rock Friction and Earthquakes," Pomona College
- May 23, 2000 "The Origin of State Evolution in Friction: Using Normal Displacement
Measurements to Test the Area-Change Explanation," Harvard
University
- May 27, 2002 "Rock Friction and Earthquake Mechanics," University of Padova, Italy.
- July 18, 2002 "Extreme Frictional Weakening of Quartz Rocks at Intermediate slip
Speeds," KECK Workshop on Earthquake Mechanics, University of
California, Santa Barbara
- June, 2004 USGS in Menlo Park
- November, 2005 KITP – two talks
- February 8, 2006 "Rock Friction at Coseismic Slip Rates," California Institute of
Technology
- April 5, 2007 "Rock Friction at Seismic Slip Rates, Fault and Rock Mechanics (FARM),
and the Southern California Earthquake Center (SCEC)"

5. Research in Progress

Papers In Preparation

- Titone, B., K. Sayre, G. Di Toro, D. Goldsby, and T.E. Tullis, The role of water in the frictional
weakening of quartz at rapid slip rates, *Geophys. Res., Lett.*
- Tullis, T.E., Evaluating the origin of the friction evolution effect using fault-normal
displacements, *Geophys. Res., Lett.*
- Scruggs, V. J., and T. E. Tullis, Friction of bare albite surfaces: comparison to granite, *J.*
Geophys. Res.
- Scruggs, V. J., and T. E. Tullis, Frictional behavior of muscovite, talc and biotite: a comparative
study, *Pure Appl. Geophys.*
- Scruggs, V. J., and Tullis, T.E., Evolution of friction and velocity dependence with large
displacement in albite gouge faults: comparison with granite gouge faults, *J. Geophys. Res.*
- Tullis, T. E., The relation between surface roughness of laboratory samples and decay distances
of friction constitutive laws, *J. Geophys. Res.*

Tullis, T. E., Implications of the role of pH for the origin of the evolution effect in rock friction, *Geophys. Res. Lett.*

Tullis, T. E., The process responsible for the direct effect in friction of calcite, *Geophys. Res. Lett.*

Bristol, D., Tullis, J., and Tullis, T. E., Low-grade folding of a conglomerate layer by distributed faulting: strain history deduced from pressure solution fibers, *Tectonophysics*.

Hadizadeh, J., T.E. Tullis, and D. L. Goldsby, Shear localization and development of cataclastic foliation in simulated granite gouge, *J. Geophys. Res.*

Description of my research

My research program studies the mechanics of stable and unstable fault slip, with applications to understanding and helping to predict earthquakes. The principal focus of this research is a combined experimental and theoretical study of the constitutive behavior for rock friction in order to understand both the fundamental operative processes and the mechanics of earthquake instabilities. The program includes field and laboratory study of the surface topography of natural fault surfaces in order to learn how to scale laboratory friction experimental results to natural earthquakes. I am also engaged in numerical modeling of the stress and slip velocity distribution during a characteristic earthquake cycle in the region surrounding a fault with realistic constitutive behavior, in order to determine expected precursory phenomena that could be measured in a field-monitoring program for earthquake prediction. I have finished a project to evaluate a new approach to predict earthquakes that is based on a controversial method of identifying foreshocks. Although we found that the method was invalid and the apparent triggering due to random chance, the work has opened up some new opportunities for following up with a study of other earthquake prediction methods. A graduate student and I are now investigating the validity of a new method that some Chinese have claimed is successful in predicting earthquakes.

The experimental work by my group in the past several years has concerned: 1) testing whether previously proposed constitutive relations adequately describe rock friction in laboratory experiments, 2) experimentally determining the values of the constitutive parameters in these relations, and 3) testing whether theories of instability that employ these constitutive relations agree with observations of stability behavior in the experimental setting. We have found that the stability theories work well and we are able to understand quantitatively the transition from stick-slip to stable sliding in the laboratory. However, the constitutive descriptions only describe the behavior over more limited ranges of velocity than we have studied experimentally or are important in nature, and thus they represent only a partial description of constitutive behavior. Consequently we are attempting to measure the frictional response at intermediate slip velocities with and without pore fluid and are building equipment to slide at higher rates in the future. With pore fluid shear heating can cause the pore pressure to rise and thus the shear resistance to fall. Without pore fluid, shear melting can occur – this is expected during earthquakes, but it does not occur at the rates we can now attain. Both processes could be important in allowing dynamic stress drops during earthquakes to be larger than static stress drops and can be important in affecting the magnitude of accelerations at the earthquake source and consequently the magnitude of the damage-causing strong ground motions.

To do the laboratory friction measurements I have designed and built a unique high-pressure rotary shear gas apparatus – for the past 23 years I have been using and improving this machine. I am now modifying it so that we can slide at seismic slip rates of 1 meter per second. To do this at 100 MPa normal stress requires 80 horsepower, and the current electric motor and hydraulic power supply can only deliver 10 HP – this is what presently limits us to only intermediate slip rates. Consequently, I have purchased a 100 HP motorcycle engine and I am partway through designing a way to adapt this to the rotary shear apparatus so we can slide at seismic slip rates and investigate the new processes that are expected to occur at these more rapid rates. I have also completed the designs for sample assembly parts that incorporate an internal furnace so we can do experiments in rotary shear at both high pressure and elevated ambient temperature – the most complex of the parts have already been constructed by our machinist.

The constitutive relations we presently use to describe the frictional response are primarily derived empirically from experimental data and are not based upon an understanding of the micromechanical processes that operate during frictional sliding. This is an unsatisfactory situation, both from the point of view of gaining a true understanding of the observed phenomena and that of applying laboratory observations to natural faults. One of the principal difficulties is that the processes that cause frictional resistance in rocks are not really known. Various possible processes have been proposed, in part by analogy with friction in metals, but the relative importance of these for rocks is unknown. One of the major continuing efforts I am engaged in is to try to understand the processes that operate and the implications these have for the constitutive behavior, both in the laboratory and on natural faults. This is an important problem, but a difficult one. The difficulties arise in part because it is hard to make observations of the samples on the scale at which the frictional resistance occurs. One of the important processes in frictional resistance is probably adhesion acting across very small areas of contact. In order to understand the role played by adhesion, I have been investigating the effect of chemical environment on frictional behavior, since recent advances in understanding intermolecular and surface forces suggest that different chemical environments should show different tendencies for attraction and repulsion between surfaces. I am also investigating the quantitative role played by small changes in the thickness of the fault zone and whether these may demonstrate that time-dependent indentation creep is responsible for the changes in friction that occur with time and velocity. This part of my planned research involves fundamental materials science and also has important practical applications for understanding the earth.

I have also done a series of indentation experiments on quartz in a variety of chemical environments in order to determine whether the time dependencies observed in rock friction could be due to plastic flow of contact points. More work on this has been conducted by Dr. David Goldsby, a Research Associate, and Jenni Junger one of my graduate students, at Oak Ridge National Laboratory. I am also planning a study of the healing of oxidized surfaces of silicon crystals, using infrared spectroscopy, to try to understand changes in bonding or water content that may accompany healing of silicate surfaces.

In the last few years I have been conducting research on numerical modeling of fault behavior using constitutive descriptions of fault zone materials obtained from laboratory experiments. This is not only interesting in helping to understand the behavior of faults, it can be

of value in determining the extent to which earthquake prediction can be aided by accurate constitutive descriptions. With the availability of increased computer power it is becoming more feasible to study realistic three dimensional models. I have made three dimensional instability models of the series of characteristic earthquakes that occur at Parkfield, California, and have made videos of these models to aid in understanding their complex behavior. I am now in the process of evaluating whether the model Parkfield earthquakes could be predicted by existing arrays of field instruments in the presence of earth noise. I also have begun to model the 1989 Loma Prieta earthquake that damaged the San Francisco Bay area, with the hope that a good model can forecast when and where the next major earthquake in that area will be. This modeling is much more complex, because it involves using triangular dislocations to fit a warped and dipping plane and because there are components of both dip and strike slip, as well as changes in normal stress.

The numerical modeling of earthquakes suggests that although accelerating slip probably occurs at the earthquake hypocenter prior to the main earthquake, its magnitude may be too small to detect from the ground surface by most measurement methods. However, foreshocks are likely to occur as part of the accelerating slip process and, if they can be identified, they could form the basis for predicting the earthquake. I am interested in working with NASA to determine whether the space-based geodetic methods of GPS and INSAR might be able to detect the small displacements of the Earth's surface that we expect will precede some earthquakes.

I have become involved with a group of other scientists who are interested in trying to understand earthquakes through a combination of simulations of earthquakes and analysis of a wide variety of observations made of the earth that are relevant to earthquake occurrence and prediction. This group is called GEM (General Earthquake Models) and I am the cochairman of the GEM Committee on Simulations. As part of this GEM effort I have attended eight workshops and have taken the lead in applying some advanced computation methods (Fast Multipoles) to this earthquake modeling effort so that we should be able to make much more realistic models using parallel processing on large supercomputers. My results so far on using this method suggest that it is possible to make models with enough elements that we can properly represent a continuum and can simulate microearthquakes as well as major ones in the same model. Some of us in the GEM group have received a 3-year, \$2.2 million grant from NASA that will allow us to make some substantial progress solving these problems. As my part of this I have completed the baseline programming and the first code improvement that involves converting the earthquake code to run in parallel using MPI. Documentation on this is publicly available at <http://www.servogrid.org/slide/GEM/PARK/> as one of the computer codes on the web site set up by our group.

I am a participant in the ACES group (APEC Cooperation in Earthquake Simulation), having been invited to become the US Group leader for Working Group 1, Microscopic Simulation. My laboratory experiments provide important constraints on the discrete particle modeling that the people in this group are doing and I am glad to be able to help pull together this international group of scientist who are trying to understand the deformation of granular fault gouge from a fundamental point of view.

I am the first chair of the Fault and Rock Mechanics disciplinary committee in the new Southern California Earthquake Center (SCEC), and as a consequence a member of the SCEC planning committee that defines the research program and reviews proposals. I was also selected as one of the two at-large Board Members of SCEC. This provides a valuable opportunity for interdisciplinary collaboration in trying to understand earthquake processes, but also takes considerable time and effort.

I am also returning to investigate the implications of the measurements that we made 10 years ago of fault surface roughness and the degree to which opposing fault surfaces are mated. The fact that fault surfaces are mated before an earthquake, but have some roughness in the slip direction has two important implications. First, as slip occurs, dilatancy will occur as the surfaces become unmated. This will cause a suction on the pore fluid that will either reduce the pore pressure causing dilatancy hardening or will tend to counteract any increase in the pore pressure caused by shear heating and pore fluid expansion. Thus the dilatancy may make one proposed dynamic weakening mechanism, thermal pressurization, ineffective. Secondly, the differing roughness of natural faults as compared with flat experimental sliding surfaces may mean that the laboratory characterization of friction evolution with slip in terms of an approximately exponential decay of resistance with slip may not hold for natural faults. If this proves to be true, it suggests major modifications in how we simulate earthquakes and could help us understand better how a large range of sizes of earthquakes can exist.

The combination of experimental, field, and modeling studies makes for a program of understanding deformation of the earth that is intellectually stimulating and of practical value. Although the problems are not easy ones and they will not be solved in a short time, they are important research objectives and provide valuable opportunities for training of students.

Although the emphasis of my research in the next several years will remain on understanding the mechanics of fault behavior, there are a variety of other problems that I hope to work on. I designed and built the unique rotary deformation apparatus in my lab because it enables us to conduct experiments on a variety of problems that cannot be approached in any other way. In addition to allowing us to conduct the high displacement friction experiments now underway, the apparatus will allow doing simple shear experiments to large strain on ductile samples by using an internal furnace. Important problems I eventually hope to study in this area include the development of preferred orientations in simple shear and determining flow laws for rocks in simple shear. This will allow testing whether steady-state in fact occurs by doing experiments to very high shear strain. We can also test whether relating the second invariants of strain-rate and deviatoric stress is in fact the proper approach for generalizing flow laws, a frequently used but essentially untested method.

6. Service

University:

1971-73	Committee on Women Faculty (Secretary, 1972-73)
1973-74	Acting MRL representative from Geological Sciences
1978	Faculty Member, Brown University Himalayan Expedition (May-June)

1978-82 Freshman Advisor

1980-81 Alternate Member, Affirmative Acting Monitoring Committee

1980 Lectured in Continuing College courses on September 30 and October 14;
Lectured to Alumni group in Fairfield County, CT on Brown's
Himalayan Expedition

1981 Alternate Member, Affirmative Action Monitoring Committee; Lectured
in Continuing College course series on March 28 in Menlo Park,
California on Earthquakes; Faculty lecturer on Brown Tours Program,
Salmon River Rafting Trip, August 3-9; Member Faculty Policy Group
and Grievance Subcommittee; Scholarship Advisory Committee

1982-83 Member Faculty Policy Group and Chairman of Grievance Subcommittee;
Alternate member, Affirmative Action Monitoring Committee

1984-85 CAP Freshman Advisor

1985-86 Acting Faculty Secretary to Phi Beta Kappa

1987 Faculty lecturer on Brown Travelers Program, Alaska Wilderness and
Glacier Expedition, July 21 - August 2

1987-88 CAP Freshman Advisor

1988-89 Committee on Academic Computing; CAP Freshman Advisor

1989-90 Committee on Academic Computing; CAP Freshman Advisor

1989 Lectured on Teaching Earth Science in Brown's Institute of Secondary
Education

1990 Lectured to Seattle Brown Club

1990 Faculty lecturer on Brown Travelers Program, Alaska's Inside Passage and
Klondike Expedition, June 15-28

1990-91 On sabbatical leave

1991-92 Committee on Academic Computing; CAP Freshman Advisor

1992 Faculty lecturer on Brown Travelers Program, Voyage to Antarctica,
January 5-18

1992-93 Committee on Academic Computing; CAP Freshman Advisor

1992-93 Continuing Education Committee of Board of Governors of the
Associated Alumni of Brown University

1992 Invited to give presentation to Wayland Collegium on how to teach
laboratory science

1992 Invited to give presentation on methods of teaching science to Sheridan
Seminar Series of the Center for the Advancement of College Teaching

1993-94 Committee on Academic Computing; CAP Freshman Advisor

1994-95 CAP Freshman Advisor; Faculty lecturer on Brown Travelers Program,
Mexico's Copper Canyon, October 1- 8; Lecture on "Earthquake
Prediction" to Pembroke Club; Commencement Forum on "Science and
Society: Are Any of Us Ready for Earthquake Prediction"

1995-96 CAP Freshman Advisor; Faculty Library Committee; Volunteer
participant on Brown University's Petra Southern Temple
Archeological Excavation - conducted Ground Penetrating Radar
survey

1996-97 Faculty Library Committee; Materials Research Council

1997-98 On sabbatical leave

1998-99 MacMillan Oversight Committee (appointed by the Provost); Technology

	Review Committee (<i>ad hoc</i> committee appointed by the Provost); Search Committee for Academic Technology Consultant for Academic and User Services division of CIS
1999-2000	MacMillan Oversight Committee (appointed by the Provost); Technology Review Committee (<i>ad hoc</i> committee appointed by the Provost)
2000-01	Chair, Faculty Advisory Committee on Computing Chair, Screening Committee for Vice President for Computing and Information Services Member, Search Committee for Vice President for Computing and Information Services Board Member, Brown Faculty Club CAP Freshman Advisor MacMillan Oversight Committee (appointed by the Provost)
2001-02	Chair, Faculty Advisory Committee on Computing Search Committee for Vice President for Computing and Information Services Board Member, Brown Faculty Club CAP Freshman Advisor MacMillan Oversight Committee (appointed by the Provost) Faculty lecturer on Brown Travelers Program, Iceland and Greenland, July 15-29
2002-03	Faculty Advisory Committee on Alumni Continuing Education Chair, Faculty Advisory Committee on Computing Board Member, Brown Faculty Club CAP Freshman Advisor MacMillan Oversight Committee (appointed by the Provost) Faculty lecturer on Brown Travelers Program, Galapagos, June 27 - July 8
2003-04	Faculty Advisory Committee on Alumni Continuing Education President of the Board of Managers, Brown Faculty Club CAP Freshman Advisor MacMillan Oversight Committee (appointed by the Provost) Faculty Advisory Committee on Alumni Continuing Education

Departmental Committee Assignments:

1970-76	Departmental Library Representative; Thin Section Equipment Representative; Participated in Departmental Fall Field Trip
1971-75	Excess Government Personal Property Representative
1972-73	Undergraduate Program; Graduate Policy; Advisory Committee on Merit Raises
1975-76	Graduate Policy (Chairman); Admissions and Awards

1977-78 Physical Facilities (Chairman); Graduate Program; Capital Funds; Advisory Committee on Merit Raises

1978-79 Capital Funds; Graduate Program; Physical Facilities (Chairman)

1979-80 Capital Funds; Physical Facilities (Chairman)

1980-81 New Building (Chairman); Physical Facilities; Participated in Undergraduate Geology Spring Field Trip to Texas, March 29 - April 2

1981-82 New Building (Chairman); Merit Raises; Participated in Departmental Fall Field Trip

1982-1983 New Building (Chairman); Physical Facilities (Chairman); Committee for Planning NE Section, Geological Society of America Meeting at Brown in Spring of 1984; Participated in Departmental Fall Field Trip

1984-85 Undergraduate Field Trips (Chairman); Physical Facilities; Departmental Technician Supervisor

1985-86 Computer; Chairman's Advisory Committee; Merit Raises; Committee on Committees; Departmental Technician Supervisor

1986-87 Computer (Chairman); Supervisor of Departmental Technician and of Departmental Machinist

1987-88 Computer; Supervisor of Departmental Technician, Departmental Computer Coordinator, and of Departmental Machinist

1988-89 Computer; Supervisor of Departmental Machinist and of Departmental Computer Coordinator; Participated in Departmental Fall Field Trip

1989-90 Computer; Supervisor of Departmental Machinist and of Departmental Computer Coordinator; Seismology Search Committee; Participated in Departmental Fall Field Trip

1990-91 On sabbatical leave

1991-92 Computer (Chairman); Field Trip (Chairman); Supervisor of Departmental Machinist

1992-93 Computer (Chairman); Undergraduate Program; Supervisor of Departmental Machinist; Supervisor of Departmental Computer Coordinator

1993-94 Computer (Chairman); Undergraduate Program; Supervisor of Departmental Machinist; Supervisor of Departmental Computer Coordinator

1994-95 New Building (Chairman); Physical Facilities (Chairman); Supervisor of Departmental Machinist

1995-96 New Building (Chairman); Physical Facilities (Chairman); Supervisor of Departmental Machinist

1996-97 New Building (Chairman); Physical Facilities (Chairman); Supervisor of Departmental Machinist; Outside Lectures (Fall to organize Spring Lectures)

1997-98 On sabbatical leave

1998-99 MacMillan Oversight Committee; Physical Facilities (Chairman); Supervisor of Departmental Machinist; Computer Committee

1999-2000 MacMillan Oversight Committee; Physical Facilities (Chairman); Supervisor of Departmental Machinist; Departmental Field Trip Committee Chairman and sole member

2000-01 MacMillan Oversight Committee; Physical Facilities (Chairman);

2001-02	Supervisor of Departmental Machinist MacMillan Oversight Committee; Physical Facilities (Chairman); Supervisor of Departmental Machinist
2002-03	MacMillan Oversight Committee; Physical Facilities (Chairman); Supervisor of Departmental Machinist
2002-03	MacMillan Oversight Committee; Physical Facilities (Chairman); Supervisor of Departmental Machinist

Profession:

Member: American Association for the Advancement of Science
American Geophysical Union

External Review Committee, Department of Geology, University of Minnesota, Duluth, 1975

American Geophysical Union, Tectonophysics Meeting Chairman, 1977, 1978.

Panel for review of NATO Post-doctoral Fellowship applications, 1978.

American Geophysical Union, Tectonophysics Section Nominating Committee, 1979.

Panel for review of NSF Women in Science Program Grant Applications, 1980.

Review Panel for Research Proposals submitted to U.S. Geological Survey Earthquake Hazards
Reduction Program:

April 21-24, 1982;

April 20-23, 1983;

April 29-May 2, 1984;

May 7-10, 1986;

May 5-8, 1987;

April 30-May 3, 1988;

August 19-20, 1992.

U.S. National Committee for Rock Mechanics, Commission on Physical Sciences, Mathematics,
and Resources, National Research Council, July, 1982-June, 1985; Chairman,
Nominating Committee, 1985.

Review Panel for Proposals Submitted to NSF Science and Technology Centers Program in the
area of Geophysics, April 11-13, 1988

Geological Society of America, Structural Geology Division, Committee on Career Contribution
Award; Chairman, 1988-89.

Chairman of Site Visit Team for Site Visits to two Proposed Science and Technology Centers:
Harvard-MIT Center for Global Earth Structure and Dynamics, July 18-19, 1988
Cal Tech Center for Earthquake Physics and Tectonics, July 21-22, 1988

"Workshop on Continental Margins", Nov. 21-23, 1988, sponsored by the Ocean Studies Board
of the National Research Council; invited participant.

American Geophysical Union Steering Committee on Deformation of Earth Materials

New England Association of Chemistry Teachers 51st Summer Conference: lectured on "The
Science of Understanding Earth Processes", August 1989

Judge at North Kingston Science Fair, January 29, 1990.

Member of planning committee for initiative on Continental Margins, sponsored by the Ocean Studies Board of the National Research Council; committee meetings May 10-11, and Oct. 9, 1990, Washington D.C.

Meeting to evaluate Science Plan for the National Earthquake Hazards Reduction Program, August 7-8, 1990.

Chairman of working group at NRC-NAS Symposium on "Mechanics of Lithospheric Deformation", Jan 14-17, 1991, Irvine, California.

Organize special session at American Geophysical Union Meeting, Dec. 1991, on "Strength of the Earth."

Participate as a U.S. member of "The 7th Joint Meeting of the U.S.-Japan Panel on Earthquake Prediction Technology" in Tsukuba, Japan, November 14-16, 1990.

Invited participant and Chairman of session on modeling, meeting convened by U.S. Geological Survey to review Parkfield Earthquake Prediction Experiment, June 28 - July 1, 1992

Invited to testify before Parkfield Prediction Experiment Working Group Meeting, December 5, 1992.

Member, Steering Committee on Physical Properties of Earth Materials, American Geophysical Union, 1990-1995

Chairman of Federal Budget Panel of the American Geophysical Union, 1991-93

Member, Committee on Public Affairs, American Geophysical Union, 1992-96

Member, Committee on Mineral and Rock Physics, American Geophysical Union, 1993-95

Member, Steering Committee for San Andreas Fault Zone Drilling Project, 1993-

Member, Site Selection Committee for San Andreas Fault Zone Drilling Project, 1993-

Invited participant in meeting on "Continental Scientific Drilling" in Potsdam, Germany, August 30 - September 1, 1993

Editor, Pure and Applied Geophysics, 1993-2002

Chairman, Committee on Public Affairs, American Geophysical Union, 1994-96

Invited Chairman of Panel Discussion on the Parkfield Earthquake Prediction Experiment, Fall AGU Meeting, 5:30 PM, Thursday Dec. 8, 1994.

Organizer and Chairman of first Gordon Conference on "Rock Deformation," Tilton School, NH, August 13-18, 1995.

Invited to participate in planning processes to define the Five-Year Plan, 1997-2002, for the U.S. Geological Survey Earthquake Hazards Program; Meetings in St Louis, MO, Nov. 14-15, 1996 and in San Diego, CA, January 30-31, 1997.

Co-chair of the Simulation Committee of GEM (General Earthquake Models) Group, 1999-

Participant in PBO (Plate Boundary Observatory) workshop, Snowbird, Oct. 3 - 4, 1999.

USA Working Group Leader for the Microscopic Simulation Working Group (WG1) of ACES (APEC Cooperation for Earthquake Simulation - an international effort of Australia, China, Japan, and the USA)

Organizer and chairman of ACES WG1 sessions at Second ACES Workshop, Tokyo and Hakone, Oct. 15-20, 2000.

Participant in PBO (Plate Boundary Observatory) workshop, Palm Springs, Oct. 29 - Nov. 1, 2000.

Participant and speaker at ACES Workshop on Earthquake Mechanics, Maui, July 30 – Aug. 1, 2001.

Participant in 5th Gordon Conference on Rock Deformation, Il Ciocco, Italy, May 18-24, 2002.

Organizer and chairman of ACES WG1 sessions at Third ACES Workshop, Maui, May , 2002.

Participant and speaker at KECK Workshop on Earthquake Mechanics, Santa Barbara, July 17-20, 2002.

Chairman of Disciplinary Committee on Fault and Rock Mechanics of the Southern California Earthquake Center (SCEC) and member of SCEC Planning Committee, Sept. 2001 –

Member at-large of Board of Directors of SCEC, Sept. 2002 –

Organized SCEC Workshop to Plan Collaborative Activities Involving Fault and Rock Mechanics, September 7-8, 2002.

Organized SCEC Workshop on Constitutive Relations for Coseismic Slip, September 10-11, 2003.

General Secretary of the American Geophysical Union, 2001 - July 1, 2002 – June 30, 2006.

Review 10-12 proposals each year for the Geology and the Geophysics Programs of NSF, for the Basic Energy Sciences Program of DOE, and for NASA. I also review a similar number of papers for a variety of journals.

Review 35 proposals per year for the Southern California Earthquake Center.

7. Honors and Grants

Honors

Phi Beta Kappa, 1964

Sigma Xi, 1964

National Science Foundation Graduate Fellowship, 1964-68

Alfred P. Sloan Research Fellowship, 1973-75

U. S. National Committee for Rock Mechanics Annual Award for 1990 for Outstanding Basic Research in Rock Mechanics for the paper "Roughness and Wear During Brittle Faulting," J. Geophys. Res., 93, 15268-15278, by W. L. Power, T. E. Tullis, and J. D. Weeks.

Editors' Citation for Excellence in Refereeing, American Geophysical Union, 1998.

Fellow, American Geophysical Union, 2002

Research Grants

ARPA

1970-71	\$10,000	X-Ray generator and goniometer
1971-72	\$28,000	Experimental and observational study of preferred orientations in deformed micaceous rocks (100% equipment: Hot-creep tester, recorder, x-ray electronics, saw)

MRL/NSF

1972-73	\$5,000	Orienting mechanics in hot worked mica aggregates
1972-74	\$5,000	Solid state processes affecting creep

NSF

1972-76	\$19,900	Relationship between finite strain and preferred orientation in slate
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1976-77	\$20,600	Construction of a modified hot creep tester (with Jan Tullis)
1976-80	\$225,300	Research initiation and support in Tectonophysics
1977-80	\$65,000	Experiments for understanding upper mantle deformation
1978-79	\$14,900	Microcomputer system for rock deformation equipment and related computing (with Jan Tullis)
1981-82	\$85,000	Rock Friction Constitutive Experiments as Related to Theory of Earthquake Instability (with James Rice and John Weeks)
1981-83	\$55,200	Mechanics of Fold-and-Thrust Belts and Accretionary Wedge Investigated Using Rigid-Plastic Numerical Models (extension of grant originally made to William Chapple, extension was jointly with E.M. Parmentier)
1982-84	\$200,000	Rock Friction Constitutive Experiments as Related to Theory of Earthquake Instability (with John Weeks)
1984-87	\$300,000	Rock Friction Constitutive Experiments as Related to Theory of Earthquake Instability (with John Weeks)
1985-86	\$45,000	Quantitative Measurements of Fault Surfaces: Implications for Stability of Fault Slippage and Earthquake Mechanics.
1986-88	\$120,000	Quantitative Measurements of Fault Surfaces: Implications for Stability of Fault Slippage and Earthquake Mechanics.
1988-89	\$117,575	A Departmental Research Computer Network: Shared Resources and Economics of Scale (with E. M. Parmentier, J. Imbrie, and P. H. Schultz)
1988-91	\$241,000	Rock Friction Constitutive Experiments as Related to Theory of Earthquake Instability (with John Weeks)
1991-93	\$91,761	Origin of Aseismic Slip on Oceanic Transform Faults
1992-93	\$39,500	Supplement to Rock Friction Constitutive Experiments as Related to Theory of Earthquake Instability (with John Weeks)
1993-94	\$80,817	Supplement to Rock Friction Constitutive Experiments as Related to Theory of Earthquake Instability (with John Weeks)
1993-97	\$86,973	Development of High Temperature Capability for Rotary Direct Shear Rock Deformation (with John Weeks)
1994-1998	\$310,000	Rock Friction Constitutive Experiments as Related to Theory of Earthquake Instability (with John Weeks)
1998-1999	\$117,000	Understanding Processes of Rock Friction Relevant to Earthquake Mechanics (with David Goldsby)
1999-2001	\$240,000	Laboratory Experiments on Rock Friction Focused on Understanding Earthquake Mechanics (with David Goldsby)
2001-2004	\$390,000	Laboratory Experiments on Rock Friction Focused on Understanding Earthquake Mechanics (with David Goldsby)
2003-2006	\$216,872	Experimental study of the role of pore fluid pressure in earthquake nucleation

USGS-EHRP

1975-76	\$39,068	An experimental study of the rheology of granitic rocks (with Jan Tullis and Richard Yund)
1980-81	\$35,561	An experimental study of the rheology of crustal rocks (with Jan Tullis)
1982-83	\$75,000	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1983-84	\$80,000	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1984-85	\$107,480	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1985-86	\$117,278	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1986-87	\$108,878	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1987-88	\$115,228	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1988-89	\$135,840	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1989-90	\$130,000	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1989-90	\$28,000	Fault Instability Model for the Loma Prieta Earthquake
1990-91	\$168,779	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1991-92	\$148,500	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1992-93	\$183,066	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1993-94	\$133,675	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1994-95	\$147,000	Experiments on Rock Friction Constitutive Laws Applied to Earthquake Instability Analysis (with John Weeks)
1997-98	\$89,000	Laboratory Experiments on Rock Friction Focused on Understanding Earthquakes
1997-98	\$55,000	Identifying Foreshocks by Their Sensitivity to Remote Triggering
1998-1999	\$85,000	Laboratory Experiments on Rock Friction Focused on Understanding Earthquake Mechanics (with David Goldsby)
1999-2000	\$80,000	Laboratory Experiments on Rock Friction Focused on Understanding Earthquake Mechanics (with David Goldsby)
2000-2001	\$80,000	Experiments to Understand Dynamic Friction During Earthquakes (with David Goldsby)
2001-2002	\$80,000	Experiments to Understand Dynamic Friction During Earthquakes (with David Goldsby)

2002-2003	\$80,000	Experiments to Understand Dynamic Friction During Earthquakes (with David Goldsby)
2003-2004	\$85,000	Experiments to Understand Dynamic Friction During Earthquakes (with David Goldsby)
2004-2005	\$92,508	Experiments to Understand Dynamic Friction During Earthquakes (with David Goldsby)
2005-2006	\$90,000	Experiments to Understand Dynamic Friction During Earthquakes (with David Goldsby)
2006-2007	\$60,000	Experiments to Understand Dynamic Friction During Earthquakes (with David Goldsby)
2007-2008	\$80,000	Experiments to Understand Dynamic Friction During Earthquakes (with David Goldsby)

CRDF (U.S Civilian Research & Development Foundation)

2000-2002	\$5,000	Investigation of Impulsive Energy Release During Dilatant Strain of Heterogeneous Solids Exposed to Weak Vibrations (with Batyr Tsebekovich Manzikov, Scientific Station IVTRAN, Russian Academy of Sciences, Bishkek, Kyrgyzstan - \$41,000 total)
2002-2004	\$9,000	Investigation of Vibration Effects and Tidal Wave Asymmetry in Loaded Terrestrial Materials (with Batyr Tsebekovich Manzikov, Scientific Station IVTRAN, Russian Academy of Sciences, Bishkek, Kyrgyzstan - \$121,021 total)

NASA

2002-2004	\$246,000	Numerical Simulations of Active Tectonic Processes: Increasing Interoperability and Performance (Multi-Institutional, total is \$2,208,000)
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Southern California Research Center

2002-2003	\$24,000	D _c and Fracture Energy due to Friction and Shear Melting During Dynamic Earthquake Rupture (with Nick Beeler)
2002-2003	\$20,000	Workshop to Plan Collaborative Activities Involving Fault and Rock Mechanics (with Jim Dieterich and Chris Marone)
2003-2004	\$20,000	Laboratory Experiments on Fault Shear Resistance Relevant to Coseismic Earthquake Slip (with David Goldsby)
2003-2004	\$10,000	Workshop on Constitutive Relations for Coseismic Slip (with Ruth Harris)
2003-2004	\$40,000	Pilot Studies to Determine the Feasibility of Using New Experimental Techniques to Measure Sliding Resistance at Seismic Slip Rates (with Vikas Prakash and David Goldsby)
2004-2005	\$23,000	Laboratory Experiments on Fault Shear Resistance Relevant to Coseismic Earthquake Slip (with David Goldsby)
2004-2005	\$40,000	Pilot Studies to Determine the Feasibility of Using New Experimental Techniques to Measure Sliding Resistance at

2005-2006	\$22,000	Seismic Slip Rates (with Vikas Prakash and David Goldsby) Laboratory Experiments on Fault Shear Resistance Relevant to Coseismic Earthquake Slip (with David Goldsby)
2005-2006	\$40,000	Pilot Studies to Determine the Feasibility of Using New Experimental Techniques to Measure Sliding Resistance at Seismic Slip Rates (with Vikas Prakash and David Goldsby)
2006-2007	\$28,000	Laboratory Experiments on Fault Shear Resistance Relevant to Coseismic Earthquake Slip (with David Goldsby)
2007-2008	\$25,000	Laboratory Experiments on Fault Shear Resistance Relevant to Coseismic Earthquake Slip (with David Goldsby)

8. Teaching

1970-71

Geol. Sci. 45, Sem. I, enrollment 14
Modes of Thought - "Continental Drift", Sem. II, enrollment 20
Geol. Sci. 253, Sem. II, enrollment 4

1971-72

Geol. Sci. 251 (with W. M. Chapple), Sem. I, enrollment 6
Modes of Thought - "Continental Drift", Sem. I, enrollment 20
Independent Study of Ann Craig on Continental Drift, Sem. I
Geol. Sci. 45, Sem. II, enrollment 16
Geol. Sci. 250 (with W. M. Chapple), Sem. II, enrollment 7

1972-73

Geol. Sci. 251 (with W. M. Chapple), Sem. I, enrollment 9
Modes of Thought - "Continental Drift", Sem. I, enrollment 20
Geol. Sci. 45, Sem. II, enrollment 17
Geol. Sci. 252 (with W. M. Chapple), Sem. II, enrollment 4
Geol. Sci. 191-192, Undergraduate Senior research of W. M. Bruner,
"Experimental and Theoretical Study of Residual Stress and Strain in Rocks",
Sem. I and II

1973-74

Geol. Sci. 251 (with W. M. Chapple), Sem. I, enrollment 9
Geol. Sci. 250 (with W. M. Chapple), Sem. II, enrollment 7
Modes of Thought - "Continental Drift", Sem. I, enrollment 20

1974-75

Geol. Sci. 251 (with W. M. Chapple), Sem. I, enrollment 7
Modes of Thought - "Continental Drift", Sem. I, enrollment 20

1975-76

Geol. Sci. 251 (with W. M. Chapple), Sem. I, enrollment 11
Modes of Thought - "Continental Drift", Sem. I, enrollment 17
Geol. Sci. 45, Sem. II, enrollment 22
Geol. Sci. 161 (with W. M. Chapple), Sem. II, enrollment 18

1976-77

On sabbatical leave

1977-78

Geol. Sci. 2, Sem. I, enrollment 35

Geol. Sci. 251 (with E. M. Parmentier), Sem. I, enrollment 8

Geol. Sci. 45 (with E. M. Parmentier), Sem. II, enrollment 20

1978-79

Geol. Sci. 2, Sem. I, enrollment 52

Geol. Sci. 251 (with E. M. Parmentier), Sem. I, enrollment 5

Special Themes ST/OS33 - "Plate Tectonics", Sem. I, enrollment 14

Geol. Sci. 45, Sem. II, enrollment 12

1979-80

Geol. Sci. 2, Sem. I, enrollment 54

Geol. Sci. 251 (with E. M. Parmentier), Sem. I, enrollment 6

Geol. Sci. 45 (with J. A. Tullis), Sem. II, enrollment 26

1980-81

Geol. Sci. 2, Sem. I, enrollment 84

Geol. Sci. 251 (with E. M. Parmentier), Sem. I, enrollment 11

Geol. Sci. 45 (with J. A. Tullis), Sem. II, enrollment 26

Geol. Sci. 285 (with J. R. Rice, E. M. Parmentier, and D. W. Forsyth), Sem. II, enrollment 5

1981-82

Geol. Sci. 2, Sem. I, enrollment 99

Geol. Sci. 251 (with E. M. Parmentier and C. Simpson), Sem. I, enrollment 5

Geol. Sci. 253 (with J. A. Tullis and C. Simpson), Sem. I, enrollment 4

Geol. Sci. 45 (with J. A. Tullis), Sem. II, enrollment 31

Supervised undergraduate research of Ken Conca

1982-83

Geol. Sci. 2, Sem. I, enrollment 110

Geol. Sci. 251 (with E. M. Parmentier), Sem. I, enrollment 7

Geol. Sci. 45 (with J. A. Tullis), Sem. II, enrollment 33

Independent study: Francis A. Brooks, III, "An Experimental Study of the Effects of Various Surfactants on the Relation Between Stress Intensity Factor and Crack Velocity in Quartz"

1983-84

On sabbatical leave

1984-85

Geol. Sci. 2, Sem I, enrollment 77

Geol. Sci. 45, (with T. Byrne and J. Tullis) Sem II, enrollment 30

Geol. Sci. 253, (with J. Tullis and T. Byrne) Sem II, enrollment 10

Independent Study: Deborah Travis, "A Study of the Mechanism of Deformation of the Purgatory Conglomerate, Rhode Island"

1985-86

Geol. Sci. 2, Sem I, enrollment 40

Geol. Sci. 251, (with T. Byrne), Sem I, enrollment 13

Geol. Sci. 45, (with T. Byrne), Sem. II, enrollment 30

1986-87

Geol. Sci. 2, Sem I, enrollment 50
Geol. Sci. 45, Sem II, enrollment 20

1987-88

Geol. Sci. 22, Sem. I (with R. Yund), enrollment 49
Geol. 251, Sem. I (with E. M. Parmentier, J. A. Tullis, and T. Byrne), enrollment
4
Geol. Sci. 145, Sem. II (with J. A. Tullis), enrollment 11

1988-89

Geol. Sci. 22, Sem. I (with R. Yund), enrollment 48
Geol. 251, Sem. I (with E. M. Parmentier, J. A. Tullis, and T. Byrne), enrollment
10
Geol. Sci. 145, Sem. II (with J. A. Tullis)

1989-90

Geol. Sci. 22, Sem. I (with R. Yund), enrollment 47
Geol. Sci. 145, Sem. II, enrollment 18 (with J. A. Tullis)
Independent Study: Paul Ecker, "Experimental Study of Contact Area as a
Function of Normal Stress in Marble"
Independent Study: Padhrig McCarthy, "Modeling Accretionary Wedge
Deformation"

1990-91

On sabbatical leave

1991-92

Geol. Sci. 22, Sem. I (with J. Tullis), enrollment 94
Geol. Sci. 145, Sem. II (with J. Tullis), enrollment 20

1992-93

Geol. Sci. 22, Sem. I (with R. Yund), enrollment 85
Geol. 251, Sem. I (with E. M. Parmentier), enrollment 3
Geol. Sci. 145, Sem. II, enrollment 28

1993-94

Geol. Sci. 22, Sem. I (with R. Yund), enrollment 93
Geol. Sci. 252, Sem I (with J. Tullis), enrollment 5
Geol. Sci. 145, Sem. II (with J. Tullis), enrollment 26

1994-95

Geol. Sci. 22, Sem. I (with R. Yund), enrollment 85
Geol. Sci. 251, Sem I (with E. M. Parmentier and J. Tullis), enrollment 11
Geol. Sci. 145, Sem. II (with J. Tullis), enrollment 20

1995-96

Geol. Sci. 22, Sem. I (with R. Yund), enrollment 94
Geol. Sci. 253, Sem I (with J. Tullis), enrollment 6
Geol. Sci. 1, Sem II (with B. Giletti), enrollment 37
Geol. Sci. 145, Sem. II (with J. Tullis), enrollment 14

1996-97

Geol. Sci. 251, Sem I enrollment 5

Geol. Sci. 1, Sem II, enrollment ~100

Geol. Sci. 145, Sem. II (with J. Tullis), enrollment ~15

Independent Study: Margaret Boettcher, "Design of See-through Apparatus for Observation of Granular Aggregates During Deformation"

1997-98

On sabbatical leave

1998-99

Geol. Sci. 251, Sem I enrollment 6

Geol. Sci. 1, Sem II, enrollment 61

Geol. Sci. 145, Sem. II (with J. Tullis), enrollment 17

Independent Study: Margaret Boettcher, "Design of See-through Apparatus for Observation of Granular Aggregates During Deformation"

1999-2000

Geol Sci. 211, Sem I.: Independent Reading Course for Sarah Zaranek, "Rock Friction and Earthquake Mechanics"

Geol. Sci. 1, Sem II, enrollment 80

Geol. Sci. 145, Sem. II, enrollment 15

2000-2001

Geol. Sci. 251, Sem I, enrollment 5

Geol. Sci. 1, Sem II, enrollment 59

Geol. Sci. 145, Sem. II (with J. Tullis), enrollment 16

Geol. Sci. 253, Sem. II (with J. Tullis), enrollment 3

Independent Study: Timothy Cook, "Paleoenvironment of a Sequence of Fluvial Sediments at Dodgeville, Attleboro, Southeastern Massachusetts"

2001-2002

Geol 291, Sem I: Seminar/reading Course - Earthquake Mechanics, Earthquake Prediction, and Rock Friction, enrollment 2

Geol Sci. 1, Sem II, enrollment 49

2002-2003

Geol 251, Sem I, enrolment 8

Geol Sci. 1, Sem II, enrollment 64

Participant in Wayland Collegium Course, The University in the Digital Age, led by Kathryn Spoehr

2002-2003

Geol 211, Sem I: Independent Reading Course for Lydia Boroughs – "Advanced Structural Geology, Earthquake Mechanics, and Rock Friction"

Geol Sci. 1, Sem II

Masters Thesis Supervision

M.S. Thesis of Roger C. Holeywell, June 1973
M.S. Thesis of Martha J. Withjack, June 1975
M.S. Thesis of Denise M. Nelson, June 1977
M.S. Thesis of Janet H. Hickey, June 1979
M.S. Thesis of Daniel Ela, June 1982
M.S. Thesis of Frank G. Horowitz, June 1982
M.S. Thesis of Z. Zhoa, June 1983
M.S. Thesis of Timothy Bechtel, June 1984
M.S. Thesis of Michael L. Blanpied, June 1985
M.S. Thesis of Elizabeth Lorenzetti, June 1988
M.S. Thesis of Scott W. Costello, June 1999
M.S. Thesis of Julie Trotta, June 2003
M.S. Research of Katharine Sayre

Ph. D. Thesis Supervision

Ph.D. Thesis of Glen S. Stockmal, August 1983
Ph.D. Thesis of Michael L. Blanpied, June 1989
Ph.D. Thesis of William L. Power, June 1989
Ph.D. Thesis of Linda A. Reinen, June 1993
Ph.D. Thesis of Nicholas M. Beeler, October 1994
Ph.D. Thesis of Valerie J. Scruggs, February 1997
Ph.D. Research of Jennifer Junger
Ph.D. Research of Julie Trotta
Ph.D. Research of Lydia Boroughs

Postdoctoral Supervision

Dr. John Weeks, Stanford University, 1980-1994.
Dr. Shuqing Zhang, Australian National University, June 1995-Nov. 1996.
Dr. David Goldsby, Univ. Minnesota, January, 1997-
Dr. Stephane Bouissou, Université Montpellier, France, January 1999-August 1999
Dr. Naoyuki Kato, Geological Survey of Japan, March 1999-March 2001
Dr. Yasin Dursin Sari, SDU EAF Mining Engineering Department, Turkey, August 2001-

9. August 27, 2007.