

2002 FARM WORKSHOP REPORT

Workshop on Constitutive Relations for Coseismic Slip

PI's: Terry E. Tullis, Brown University,
Ruth Harris, USGS

SUMMARY

This was a workshop to assess the status of our understanding of the frictional resistance of faults during coseismic slip from the perspective of laboratory experiments and of seismic observations and modeling. As the agenda below shows, presentations were given both by modelers who addressed the question of what can be determined about frictional properties during earthquakes by modeling dynamic ruptures and comparing the model results with data from earthquakes as well as from the perspectives of laboratory rock deformation studies. It is clear that more work is needed from both perspectives. The workshop was very successful in bringing each of these communities up to date with each other's thinking and data.

AGENDA, FARM/ESP WORKSHOP, 2003 CONSTITUTIVE RELATIONS FOR COSEISMIC SLIP

Wednesday, September 10

Afternoon session – The Influence of Constitutive Laws on Dynamic Rupture Models

- 13:30 Welcome and Introduction – Terry Tullis and Ruth Harris
- 13:45 Dynamic rupture models with various constitutive laws – Kim Olsen
- 14:30 Q&D (Questions and discussion)
- 15:15 Coffee Break (around posters)
- 15:45 Thoughts on constitutive laws and dynamic rupture models – Steve Day
- 16:30 Q&D
- 17:15 Session End
- 18:15 Cocktails
- 19:00 Dinner
- 20:00 Poster session

Thursday, September 11

Morning Session – Lab and Theoretical Studies of High Velocity Constitutive Laws

- 8:30 Recent Lab and Theoretical Results for High Speed Friction – Terry Tullis
- 9:15 Q&D
- 10:00 Coffee Break (around posters)
- 10:30 Dynamic interface separation: Experiments and theory – Jim Brune, Rasool Anoooshehpour, and Matt Purvance
- 11:15 Q&D
- 12:00 Lunch

Afternoon session – Observations Bearing on Coseismic Constitutive Laws

- 13:30 Observations from the Chi-Chi earthquake: An example of elastohydrodynamic lubrication? – Emily Brodsky
14:00 Q&D
14:45 Wrap up – Terry Tullis and Ruth Harris
15:00 Adjourn

INVITATION LETTER

In order to allow one to see how we advertised and envisioned the workshop, we reproduce here the letter of invitation to the workshop we sent to about 60 selected scientists.

Dear Colleagues,

We invite you to attend a joint FARM/ESP (Fault and Rock Mechanics / Earthquake Source Physics) workshop right after the SCEC Annual Meeting. The workshop's purpose is described in the announcement attached and below. Most of you will already be attending the SCEC annual meeting, and the incremental additional expenses involved in the additional day will be covered by SCEC Workshop funds. For those on this invitation list not funded through a SCEC grant to attend the Annual Meeting, we can pay for the costs associated with the workshop as well as food at the Annual Meeting, but may not be able to pay for lodging during the annual meeting. USGS employees should have their expenses paid for by the USGS.

The workshop will be held in Oxnard, CA, the same location as the Annual Meeting. The workshop will begin after lunch on Wednesday, Sept. 10 and end by 3 PM on Sept. 11. The annual meeting begins Sunday evening Sept. 7 and ends at noon on Sept. 10.

If you are aware of others who ought to attend this workshop, please pass this information along to them. They are welcome to attend, and after we see what response we get to this invitation we will decide if we can provide them funding.

Regardless of your decision, please hit reply to this email (to Gloria_Correra@brown.edu) as soon as possible so we will know how many to expect, thus allowing us to respond to others who may be interested. Also go to the SCEC web site (<http://www.scec.org/aboutscec/meetings/2003am/>) to register for the SCEC annual meeting which we hope you will also attend. There you should enter "I will also attend the FARM/ESP Workshop after the meeting" into the "Additional meetings comments" box. If you find that your travel plans require you to stay over Thursday night, please enter that into this box as well. (You may return to the web site and add this later.) Try to keep your travel expenses to a minimum. You may wish to contact Sally Henyey at the SCEC office (213-740-5843, shenyey@usc.edu) to see if you can arrange cheaper air fares through the USC travel office; if you use them, your air fare may be able to be charged directly to SCEC.

We hope to see you at our workshop.

Terry E. Tullis, SCEC FARM Disciplinary Committee
 Ruth A. Harris, SCEC ESP Focus Area

Workshop on Constitutive Relations for Coseismic Slip Organizers:
 Terry E. Tullis, Brown University
 Ruth Harris, USGS, Menlo Park

This will be a one-day workshop to bring together and foster collaboration between the Fault and Rock Mechanics (FARM) community and those who have historically identified themselves with the Earthquake Source Physics Focus Area. The purpose is to focus on a particularly important subject for both groups, the constitutive description of fault resistance that is used in dynamic rupture models. This is the principal product that FARM hopes to provide for understanding fault and earthquake mechanics and it is a fundamental input needed to construct dynamic rather than kinematic models of rupture. Such rupture models would ideally be the input for wave propagation models used to predict strong ground motions, but at present kinematic models are typically used. Part of the workshop's goal is to consider how much difference the details of the constitutive description make to dynamic rupture behavior. If the details are unimportant, then their determination by the FARM community is not necessary for SCEC and current codes for dynamic rupture models may be adequate. However, if the details are important then both groups have much work to do. Attendees at the workshop should be scientists working in the disciplines of seismology, fault mechanics and rock mechanics with an interest in earthquake source physics and rupture modeling. The agenda will involve considerable time for in-depth discussion and very few speakers. Attendees are welcome to bring posters, but it is not required.

PARTICIPANTS

Below is a list of most of the participants, together with their email addresses and approximate field of specialization. A few others who accompanied those listed below also attended.

First name	Last name	Organization	email
Brad	Aagaard	United States Geological Survey	baagaard@usgs.gov
Dudley Joe	Andrews	United States Geological Survey	jandrews@usgs.gov
Jennifer	Anthony	Pennsylvania State University	jla213@psu.edu
Maureen	Barley	CSUSB	mbarley81@yahoo.com
Harsha	Bhat	Harvard University	bhat@esag.harvard.edu
Ronald	Biegel	Northern Illinois University	rbiegel@niu.edu
Margaret	Boettcher	Massachusetts Institute of Technology	margaret@quake.mit.edu
Jim	Brune	University of Nevada, Reno	brune@seismo.unr.edu
Jean	Carlson	University of California, Santa Barbara	carlson@physics.ucsb.edu
Judith	Chester	Texas A&M University	chesterj@geo.tamu.edu
Michele	Cooke	University of Massachusetts	cooke@geo.umass.edu

Steve	Day	San Diego State University	day@moho.sdsu.edu
Renata	Dmowska	Harvard University	dmowska@seismology.harvard.edu
Ory	Dor	University of Southern California	dor@usc.edu
Benchun	Duan	University of California, Riverside	benchun@namazu.ucr.edu
James P.	Evans	Utah State University	jpevans@cc.usu.edu
Yuri	Fialko	University of California, San Diego	fialko@radar.ucsd.edu
Jon	Fletcher	United States Geological Survey	jfletcher@usgs.gov
David	Goldsby	Brown University	David_Goldsby@brown.edu
Mariagiovanna	Guatterri	Swiss Reinsurance	mariagiovanna_guatterri@swissre.com
Yonggui	Guo	Rice University	yonggui@rice.edu
Ruth	Harris	United States Geological Survey	harris@usgs.gov
Changrong	He	Institute of Geology, China Seismological Bureau	rmlab@public.bta.net.cn
Debi	Kilb	University of California, San Diego	dkilb@epicenter.ucsd.edu
Nadia	Lapusta	Harvard University	lapusta@caltech.edu
David	Lockner	United States Geological Survey	dlockner@usgs.gov
Shuo	Ma	University of California, Santa Barbara	sma@crystal.ucsb.edu
Isabelle	Manighetti	Institut de Physique du Globe de Paris	manig@ipgp.jussieu.fr
Chris J.	Marone	Pennsylvania State University	cjm38@psu.edu
Sally	McGill	California State University, San Bernardino	smcgill@csusb.edu
Hiroe	Miyake	Stanford University	mhiroe@pangea.stanford.edu
Julia	Morgan	Rice University	morganj@rice.edu
Hiroyuki	Noda	Graduate School of Sciences, Kyoto University	nodahiroyuki@kueps.kyoto-u.ac.jp
David	Oglesby	University of California, Riverside	david.oglesby@ucr.edu
Kim	Olsen	University of California, Santa Barbara	kbolsen@crystal.ucsb.edu
Morgan	Page	University of California, Santa Barbara	pagem@physics.ucsb.edu
Aasha	Pancha	University of Nevada, Reno	pancha@seismo.unr.edu
Zhigang	Peng	University of Southern California	zpeng@terra.usc.edu
Vikas	Prakash	Case Western Reserve University	prakash@mac.cwru.edu
Matthew	Purvance	University of Nevada, Reno	mdp@seismo.unr.edu
James	Rice	Harvard University	rice@esag.harvard.edu
Mousumi	Roy	University of New Mexico	mroy@unm.edu
Heather	Savage	Pennsylvania State University	hsavage@geosc.psu.edu
Bruce	Shaw	Columbia University	shaw@ldeo.columbia.edu
Deborah Elaine	Smith	California Institute of Technology	desmith@gps.caltech.edu
Teh-Ru	Song	Caltech	alex@gps.caltech.edu
Julie	Trotta	Brown University	Julie_Trotta@brown.edu
Terry	Tullis	Brown University	Terry_Tullis@brown.edu
Jan	Vermilye	Whittier College	jvermilye@whittier.edu
Michael	Vredevoogd	University of California, Riverside	m_vredevoogd@yahoo.com
Brenton	Wilson	University of Oklahoma	brentwilson@ou.edu

Teng-Fong	Wong	SUNY Stony Brook	Teng-fong.Wong@stonybrook.edu
Guanshui	Xu	University of California, Riverside	gxu@engr.ucr.edu
Yuehua	Zeng	University of Nevada, Reno	zeng@seismo.unr.edu

RESULTS

In addition to the presentations listed on the agenda, there were short presentations given on Thursday morning both by Jim Rice and by Jenni Junger on the subject of what changes in pore pressure might accompany dynamic slip and thus what effect this might have on the coseismic strength. The number of interesting points made by all the participants in the active discussion is difficult to summarize, but some random points that come to mind include these: Whether there will be a reduction in dynamic shear strength due to an increase in fluid pressure depends not only on the permeability and thermal properties, but on whether dilatancy will accompany slip. Dilatancy is usually neglected in calculations of the increase in pore pressure, but the fact that fault surfaces are well mated prior to slip and that their roughness in the slip direction is significant even for mature faults suggests that it may be hard for them to slip without a significant increase in dilatancy. It was pointed out that whether faults slip via self-healing slip pulses or as a standard crack may depend on the time constant of the healing process following any dynamic weakening. If healing is instantaneous, then self healing pulses are favored, but slow healing would prevent them. Discussions made it clear that D_c has different meaning to different workers in this subject and that it is important to be clear about what one means with using this term. Different ways of trying to determine D_c for a slip weakening model from seismic data were discussed and progress is being made, but uncertainties exist in its determination for all the methods. It is clear that in the Chi-Chi earthquake there are some very interesting differences in the frequency content of the wave forms for the northern and southern parts of the event, but the exact meaning of these for coseismic resistance or its mechanism is still not clear.

SUMMARY

The participants were enthusiastic about what they learned about what everyone with interests in coseismic fault resistance is presently doing and finding out. The opportunity to discuss the state of progress and for everyone to get ideas on what needs to be done next from all perspectives made for a productive workshop. The two communities were brought closer as a result of the interactions.