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GORDON RESEARCH CONFERENCES *frontiers of science*

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Nancy Ryan Gray, Ph.D.
Director

**2012 GORDON RESEARCH CONFERENCE
on ROCK DEFORMATION**

FINAL PROGRESS REPORT
DEPARTMENT OF ENERGY
GRANT NO. DE-SC0008119

The Gordon Research Conference on ROCK DEFORMATION was held at Proctor Academy Andover, New Hampshire, August 19-24, 2012. The Conference was well-attended with 124 participants (attendees list attached). The attendees represented the spectrum of endeavor in this field coming from academia, industry, and government laboratories, both U.S. and foreign scientists, senior researchers, young investigators, and students. Of the 124 attendees, 66 voluntarily responded to a general inquiry regarding ethnicity which appears on our registration forms. Of the 66 respondents, 8% were Minorities – 2% Hispanic, 6% Asian and 0% African American. Approximately 27% of the participants at the 2012 meeting were women.

In designing the formal speakers program, emphasis was placed on current unpublished research and discussion of the future target areas in this field. There was a conscious effort to stimulate lively discussion about the key issues in the field today. Time for formal presentations was limited in the interest of group discussions. In order that more scientists could communicate their most recent results, poster presentation time was scheduled. Attached is a copy of the formal schedule and speaker program and the poster program. In addition to these formal interactions, "free time" was scheduled to allow informal discussions. Such discussions are fostering new collaborations and joint efforts in the field.

Thank you for your support of this Conference. As you know, in the interest of promoting the presentation of unpublished and frontier-breaking research, Gordon Research Conferences does not permit publication of meeting proceedings. If you wish any further details, please feel free to contact me. Thank you.

Sincerely,
Peter Kelemen, Conference Chairperson
COLUMBIA UNIVERSITY

Rock Deformation
Feedback Processes in Rock Deformation
August 19-24, 2012
Proctor Academy
Andover, NH
Chair:
Peter Kelemen

Vice Chair:
Wenlu Zhu

Feedback processes are vitally important in controlling the rates and mechanisms of rock deformation. Positive feedbacks lead to accelerating rates, and commonly to spatial focusing. Localization and acceleration of creep is often associated with stress and/or strain rate dependent grain size reduction, frictional heating, or viscous shear heating. The presence of melt may help to localize and accelerate deformation, and in turn deformation may help to localize melt transport. Volume changes during retrograde metamorphic reactions may, under some circumstances, lead to fractures that maintain or increase permeability and reactive surface area, which in turn accelerates reaction rates. Hydraulic fracture often triggers a widening cascade of frictional failures on adjacent fracture systems. Feedbacks that form or reactivate closely-spaced fractures in the upper crust have relevance for, e.g., geological storage of CO₂, enhanced geothermal power systems, and shale gas extraction. Clustering of earthquakes involves feedbacks in stress distribution on different faults, or segments of fault zones, that focus deformation in both time and space. Negative feedbacks can modulate or prevent accelerating strain. Gravitational instabilities, such as "delamination", "relamination", and diapirism, are affected by both positive and negative feedbacks when material undergoes phase transformations driven by changing pressure and temperature. Changes in pore pressure due to metamorphic reactions and/or shear heating can modulate earthquake behavior. There is increasing understanding of the mechanisms that limit earthquake rupture zones, and cause slow slip rather than seismic events. Crystallization in pore space can randomize previously focused fluid flow, reduce permeability, and bring metamorphic reactions to a halt. All of these feedbacks are related in a rich interplay of geodynamic processes.

Contributors



SUNDAY

2:00 pm - 9:00 pm	Arrival and Check-in (Office Closed 6:00 pm - 7:00 pm)
6:00 pm	Dinner
7:30 pm - 7:40 pm	Welcome / Introductory Comments by GRC Site Staff
7:40 pm - 9:30 pm	Failure At High Confining Pressure I
	Discussion Leader: Peter Kelemen (Columbia University)
7:40 pm - 7:50 pm	Remarks by Discussion Leader
7:50 pm - 8:25 pm	Olga Sergienko (Princeton University) "Viscoelastic behavior of ice during stick/slip cycles"
8:25 pm - 8:40 pm	Discussion
8:40 pm - 9:15 pm	Erland Schulson (Dartmouth College) "Failure in ice at high confining pressure"
9:15 pm - 9:30 pm	Discussion

MONDAY

7:30 am - 8:30 am	Breakfast
9:00 am - 12:30 pm	Failure At High Confining Pressure II
	Discussion Leader: Jessica Warren (Stanford University)
9:00 am - 9:10 am	Remarks by Discussion Leader
9:10 am - 9:40 am	Peter Kelemen (Columbia University)
9:40 am - 9:50 am	Discussion
9:50 am - 10:20 am	Bruno Reynard (Lab. Science de la Terre, ENS Lyons) "Feed-back between metamorphic reactions, creep and seismicity in subduction zones"
10:20 am - 10:35 am	Discussion
10:35 am	Coffee Break
11:00 am - 11:30 am	Michel Bestmann (Inst. Geologie & Mineralogie, Erlangen) "Ultrafine-grained deformation microstructure of quartz in pseudotachylite-bearing faults"
11:30 am - 11:45 am	Discussion
11:45 am - 12:15 pm	Virginia Toy (Geology Dept., University of Otago) "Localized shear zones in peridotite massifs"
12:15 pm - 12:30 pm	Discussion
12:30 pm	Lunch
1:30 pm - 4:00 pm	Free Time
4:00 pm - 6:00 pm	<u>Poster Session I</u>
	Moderator: Wenlu Zhu (University of Maryland)
6:00 pm	Dinner
7:30 pm - 9:30 pm	Fluid-assisted Slip, Earthquakes & Fracture I

	Discussion Leader: Harry Green (UC Riverside)
7:30 pm - 7:40 pm	Remarks by Discussion Leader
7:40 pm - 8:15 pm	Nicholas Brantut (ENS Paris) "Dehydration reactions and slip instabilities in subduction zones"
8:15 pm - 8:35 pm	Discussion
8:35 pm - 9:10 pm	Nadia Lapusta (Caltech) "Shear heating-induced thermal pressurization during earthquakes"
9:10 pm - 9:30 pm	Discussion

TUESDAY

7:30 am - 8:30 am	Breakfast
8:30 am	Group Photo
9:00 am - 12:30 pm	Fluid-assisted Slip, Earthquakes & Fracture II
	Discussion Leader: Greg Hirth (Brown University)
9:00 am - 9:10 am	Remarks by Discussion Leader
9:10 am - 9:40 am	Leonid Germanovich (Georgia Tech) "Natural and induced hydraulic fracture"
9:40 am - 9:55 am	Discussion
9:55 am - 10:25 am	Nick Austin (Esso Canada) "Induced hydraulic fractures in low permeability hydrocarbon reservoirs"
10:25 am - 10:40 am	Discussion
10:40 am	Coffee Break
11:00 am - 11:30 am	François Renard (Université Joseph Fourier, Grenoble) "Fracturing and fracture sealing induced by mineral growth in porous rocks"
11:30 am - 11:45 am	Discussion
11:45 am - 12:15 pm	Scott Johnson & Senthil Vel (University of Maine) "Elastic response of polycrystalline materials to rapid thermal, fluid, and tectonic loads"
12:15 pm - 12:30 pm	Discussion
12:30 pm	Lunch
1:30 pm - 4:00 pm	Free Time
4:00 pm - 6:00 pm	<u>Poster Session I</u> Moderator: Wenlu Zhu (University of Maryland)
6:00 pm	Dinner
7:30 pm - 9:30 pm	Reaction-driven Cracking
	Discussion Leader: Peter Kelemen (Columbia University)
7:30 pm - 7:40 pm	Remarks by Discussion Leader
7:40 pm - 8:15 pm	Bjørn Jamtveit (University of Oslo)

	"Reaction-induced cracking"
8:15 pm - 8:35 pm	Discussion
8:35 pm - 9:10 pm	Ray Fletcher (PGP, Oslo) "Weathering and metamorphic replacement from the point of view of rock mechanics"
9:10 pm - 9:30 pm	Discussion

WEDNESDAY

7:30 am - 8:30 am	Breakfast
9:00 am - 12:30 pm	Fluid Transport, Deformation And Reaction Discussion Leader: Marc Spiegelman (Columbia University)
9:00 am - 9:10 am	Remarks by Discussion Leader
9:10 am - 9:40 am	Russell Detwiler (University of California, Irvine) "Deformation caused by mineral dissolution in fractures"
9:40 am - 9:55 am	Discussion
9:55 am - 10:25 am	Jan Ludvig Vinningland (International Research Inst. of Stavanger, Norway) "Reactive flow of brines in calcite pores using Lattice-Boltzmann"
10:25 am - 10:40 am	Discussion
10:40 am	Coffee Break
11:00 am - 11:30 am	Richard Katz (Oxford University) "Porosity bands in a deforming aggregate with anisotropic viscosity"
11:30 am - 11:45 am	Discussion
11:45 am - 12:15 pm	Laura Hebert (University of Maryland) "Melt permeability barriers at spreading centers"
12:15 pm - 12:30 pm	Discussion
12:30 pm	Lunch
1:30 pm - 4:00 pm	Free Time
4:00 pm - 6:00 pm	<u>Poster Session II</u> Moderator: Wenlu Zhu (University of Maryland)
6:00 pm	Dinner
7:00 pm - 7:30 pm	<u>Business Meeting</u> <i>Nominations for the next Vice Chair; Fill out Conference Evaluation Forms; Discuss future Site & Scheduling preferences; Election of the next Vice Chair</i>
7:30 pm - 9:30 pm	Localized Fluid Transport And Deformation Discussion Leader: Ben Holtzman (Columbia University)
7:30 pm - 7:40 pm	Remarks by Discussion Leader
7:40 pm - 8:15 pm	Erik Rybacki (GFZ Potsdam)

	"Deformation of plagioclase, with and without intergranular melt"
8:15 pm - 8:35 pm	Discussion
8:35 pm - 9:10 pm	Dave Kohlstedt (University of Minnesota) "Stress-driven melt segregation in a plagioclase matrix"
9:10 pm - 9:30 pm	Discussion

THURSDAY

7:30 am - 8:30 am	Breakfast
9:00 am - 12:30 pm	Earthquake Mechanisms
	Discussion Leader: Heather Savage (Columbia University)
9:00 am - 9:10 am	Remarks by Discussion Leader
9:10 am - 9:40 am	Tom Heaton (Caltech) "Strong, scale dependent, rate weakening friction"
9:40 am - 9:55 am	Discussion
9:55 am - 10:25 am	David Shelly (USGS Menlo Park) "Tremor activity on the lower crustal San Andreas fault"
10:25 am - 10:40 am	Discussion
10:40 am	Coffee Break
11:00 am - 11:30 am	Kelin Wang (Geological Survey of Canada) "Geodetic observations of subduction earthquake cycles"
11:30 am - 11:45 am	Discussion
11:45 am - 12:15 pm	Karen Mair (University of Oslo) "Fragmentation processes and strain localisation"
12:15 pm - 12:30 pm	Discussion
12:30 pm	Lunch
1:30 pm - 4:00 pm	Free Time
4:00 pm - 6:00 pm	<u>Poster Session II</u>
	Moderator: Wenlu Zhu (University of Maryland)
6:00 pm	Dinner
7:30 pm - 9:30 pm	Subduction Zone Dynamics And Crustal Growth
	Discussion Leader: Mark Behn (WHOI)
7:30 pm - 7:40 pm	Remarks by Discussion Leader
7:40 pm - 8:15 pm	Clare Warren (Open University) "Continental collision and exhumation of high pressure rocks"
8:15 pm - 8:35 pm	Discussion
8:35 pm - 9:10 pm	Gene Humphreys (University of Oregon) "Tectonic insight into mantle-lithosphere deformation processes"
9:10 pm - 9:30 pm	Discussion

FRIDAY

7:30 am - 8:30 am Breakfast

9:00 am Departure

Rock Deformation (2012)

Name	Organization	Participation	Status
ALPERN, JENNIFER S	PENNSYLVANIA STATE UNIVERSITY	Poster Presenter	Registered
AUSTIN, NICHOLAS J.	IMPERIAL OIL RESOURCES	Speaker	Registered
BANKER, JEREMY S	UNIVERSITY OF MARYLAND	Attendee	Registered
BECKER, THORSTEN W	UNIVERSITY OF SOUTHERN CALIFORNIA	Poster Presenter	Registered
BEHN, MARK D	WOODS HOLE OCEANOGRAPHIC INSTITUTION	Discussion Leader	Registered
BEHR, WHITNEY M	UNIVERSITY OF TEXAS AUSTIN	Poster Presenter	Registered
BENSON, PHILIP M	UNIVERSITY OF PORTSMOUTH	Poster Presenter	Registered
BESTMANN, MICHEL	UNIVERSITY OF ERLANGEN	Speaker	Registered
BOULTON, CAROLYN J	UNIVERSITY OF CANTERBURY	Poster Presenter	Registered
BRANTUT, NICOLAS	UNIVERSITY COLLEGE LONDON	Speaker	Registered
BROWNE, CASSANDRA M	UNIVERSITY OF TEXAS INSTITUTE FOR GEOPHYSICS	Poster Presenter	Registered
CANDELA, THIBAUT	PENNSYLVANIA STATE UNIVERSITY	Poster Presenter	Registered
CARPENTER, BRETT M	ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA	Poster Presenter	Registered
CASWELL, TESS	BROWN UNIVERSITY	Attendee	Registered
COOPER, REID F	BROWN UNIVERSITY	Poster Presenter	Registered
CROSS, ANDREW J	UNIVERSITY OF OTAGO	Poster Presenter	Registered
DE PAOLA, NICOLA	DURHAM UNIVERSITY	Poster Presenter	Registered
DEEMS, NIKOLAUS J	STANFORD UNIVERSITY	Poster Presenter	Registered
DETWILER, RUSSELL L	UNIVERSITY OF CALIFORNIA, IRVINE	Speaker	Registered
DICK, HENRY JB	WOODS HOLE OCEANOGRAPHIC INSTITUTION	Attendee	Registered
DURHAM, WILLIAM B	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	Attendee	Registered
EICHENBAUM-PIKSER, JACOB	COLUMBIA UNIVERSITY	Attendee	Registered
FARLA, ROBERT	YALE UNIVERSITY	Poster Presenter	Registered
FAUL, ULRICH	BOSTON UNIVERSITY	Poster Presenter	Registered
FLETCHER, RAYMOND C	PGP, UNIVERSITY OF OSLO, NORWAY	Speaker	Registered
FRENCH, MELODIE	TEXAS A&M UNIVERSITY	Poster Presenter	Registered
GARAGASH, DMITRY	DALHOUSIE UNIVERSITY	Poster Presenter	Registered
GERMANOVICH, LEONID	GEORGIA TECH	Speaker	Registered
GETSINGER, AMANDA	BROWN UNIVERSITY	Poster Presenter	Registered

GOLDSBY, DAVID L	BROWN UNIVERSITY	Attendee	Registered
GREEN, HARRY W	UNIVERSITY OF CALIFORNIA, RIVERSIDE	Discussion Leader	Registered
GRIMES, CRAIG B	OHIO UNIVERSITY	Attendee	Registered
HADIZADEH, JAFAR	UNIVERSITY OF LOUISVILLE	Poster Presenter	Registered
HANSEN, LARS N	UNIVERSITY OF MINNESOTA	Poster Presenter	Registered
HAVLIN, CHRIS	BROWN UNIVERSITY	Poster Presenter	Registered
HEATON, THOMAS H	CALIFORNIA INSTITUTE OF TECHNOLOGY	Speaker	Registered
HEBERT, LAURA B	UNIVERSITY OF MARYLAND	Speaker	Registered
HIROSE, TAKEHIRO	JAMSTEC	Poster Presenter	Registered
HIRTH, GREG	BROWN UNIVERSITY	Discussion Leader	Registered
HOLTZMAN, BENJAMIN	LDEO COLUMBIA UNIVERSITY	Discussion Leader	Registered
HUMPHREYS, GENE	UNIVERSITY OF OREGON	Speaker	Registered
JAMTVEIT, BJORN	UNIV. OF OSLO	Speaker	Registered
JOHN, BARBARA E	UNIVERSITY OF WYOMING	Attendee	Registered
JOHNSON, SCOTT	UNIVERSITY OF MAINE	Speaker	Registered
KANAYA, TAKA	BROWN UNIVERSITY	Poster Presenter	Registered
KANEKO, YOSHIHIRO	WOODS HOLE OCEANOGRAPHIC INSTITUTION	Poster Presenter	Registered
KAPROTH, BRYAN M	PENN STATE UNIVERSITY	Poster Presenter	Registered
KATZ, RICHARD	UNIVERSITY OF OXFORD	Speaker	Registered
KELEMEN, PETER	COLUMBIA UNIVERSITY	Chair	Registered
KIDDER, STEVEN B	UNIVERSITY OF OTAGO	Poster Presenter	Registered
KILIAN, RUDIGER	UNIVERSITY BASEL	Poster Presenter	Registered
KIRKPATRICK, JAMES	UNIVERSITY OF CALIFORNIA, SANTA CRUZ	Poster Presenter	Registered
KITAJIMA, HIROKO	NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE	Poster Presenter	Registered
KOHLI, ARJUN H	STANFORD UNIVERSITY	Poster Presenter	Registered
KOHLSTEDT, DAVID L	UNIVERSITY OF MINNEOSTA	Speaker	Registered
KRONENBERG, ANDREAS	TEXAS A&M UNIVERSITY	Poster Presenter	Registered
LAFORGE, JUSTIN S	UNIVERSITY OF WYOMING	Attendee	Registered
LAPUSTA, NADIA	CALIFORNIA INSTITUTE OF TECHNOLOGY	Speaker	Registered
LEEMAN, JOHN R	PENN STATE	Attendee	Registered
LI, YANG	UNIVERSITY OF MINNESOTA	Poster Presenter	Registered
LISABETH, HARRISON P	UNIVERISTY OF MARYLAND	Poster Presenter	Registered

LIU, YAJING	MCGILL UNIVERSITY	Poster Presenter	Registered
LOCKNER, DAVID A	USGS	Poster Presenter	Registered
MACDONALD, CODY	OHIO UNIVERSITY	Attendee	Registered
MAIR, KAREN	UNIVERSITY OF OSLO	Speaker	Registered
MARONE, CHRIS J	PENN STATE UNIVERSITY	Attendee	Registered
MCCARTHY, CHRISTINE	LAMONT-DOHERTY EARTH OBSERVATORY OF COLUMBIA	Poster Presenter	Registered
MEYERS, CAMERON D	BROWN UNIVERSITY	Poster Presenter	Registered
MILLER, KEVIN J	UNIVERSITY OF MARYLAND	Poster Presenter	Registered
MITCHELL, THOMAS M	INGV ROME	Poster Presenter	Registered
MITCHELL, ERICA K	U.C. SAN DIEGO	Poster Presenter	Registered
MOORE, DIANE E	U. S. GEOLOGICAL SURVEY	Poster Presenter	Registered
NEVITT, JOHANNA M	STANFORD UNIVERSITY	Poster Presenter	Registered
NODA, HIROYUKI	JAMSTEC	Poster Presenter	Registered
OKAZAKI, KEISHI	HIROSHIMA UNIVERSITY	Poster Presenter	Registered
OLCOTT, KATELYN A	PENNSYLVANIA STATE UNIVERSITY	Poster Presenter	Registered
OUGIER-SIMONIN, AUDREY	UNIVERSITY OF MARYLAND	Poster Presenter	Registered
PEC, MATEJ	UNIVERSITY OF BASEL	Poster Presenter	Registered
PLATT, JOHN D	HARVARD UNIVERSITY	Poster Presenter	Registered
PLUEMPER, OLIVER	UNIVERSITY OF OSLO	Poster Presenter	Registered
PRIOR, DAVID J	UNIVERSITY OF OTAGO	Poster Presenter	Registered
PROCTOR, BROOKS P	BROWN UNIVERSITY	Poster Presenter	Registered
QI, CHAO	UNIVERSITY OF MINNESOTA	Poster Presenter	Registered
QUINTANILLA TERMINEL, ALEJANDRA	MIT	Poster Presenter	Registered
RABINOWITZ, HANNAH	WASHINGTON UNIVERSITY IN ST. LOUIS	Poster Presenter	Registered
RATHBUN, ANDREW P	UNIV. JOSEPH FOURIER, GRENOBLE	Poster Presenter	Registered
REMPE, MARIEKE	UNIVERSITÀ DEGLI STUDI DI PADOVA	Poster Presenter	Registered
RENARD, FRANCOIS	UNIVERSITY GRENOBLE I	Speaker	Registered
REYNARD, BRUNO	ENS - LYON	Speaker	Registered
RYBACKI, ERIK	GFZ POTSDAM	Speaker	Registered

SAVAGE, HEATHER M	COLUMBIA UNIVERSITY	Discussion Leader	Registered
SCHUBNEL, ALEXANDRE L	ECOLE NORMALE SUPÉRIEURE / CNRS	Poster Presenter	Registered
SCHULSON, ERLAND M	DARTMOUTH COLLEGE	Speaker	Registered
SCUDERI, MARCO MARIA	PENN STATE UNIVERSITY	Poster Presenter	Registered
SERGIENKO, OLGA V	PRINCETON UNIVERSITY	Speaker	Registered
SHELLY, DAVID	USGS	Speaker	Registered
SHI, FENG	UNIVERSITY OF CALIFORNIA,RIVERSIDE	Poster Presenter	Registered
SHIMAMOTO, TOSHI	INSTITUTE OF GEOLOGY, CEA	Poster Presenter	Registered
SKEMER, PHILIP A	WASHINGTON UNIVERSITY IN SAINT LOUIS	Poster Presenter	Registered
SONE, HIROKI	GFZ GERMAN RESEARCH CENTRE FOR GEOSCIENCES	Poster Presenter	Registered
SPAGNUOLO, ELENA	INGV	Poster Presenter	Registered
STUNITZ, HOLGER	UNIVERSITY OF TROMSO	Poster Presenter	Registered
TASAKA, MIKI	UNIVERSITY OF MINNESOTA	Poster Presenter	Registered
TIELKE, JACOB A	UNIVERSITY OF MINNESOTA	Poster Presenter	Registered
TOY, VIRGINIA	UNIVERSITY OF OTAGO	Speaker	Registered
TULLIS, TERRY	BROWN UNIVERSITY	Poster Presenter	Registered
ULVEN, OLE IVAR	UNIVERSITY OF OSLO	Poster Presenter	Registered
VALDEZ, ROBERT D.	PENNSYLVANIA STATE UNIVERSITY	Attendee	Registered
Vel, Senthil s	UNIVERSITY OF MAINE	Speaker	Registered
VIESCA, ROBERT C	DALHOUSIE UNIVERSITY	Poster Presenter	Registered
VINCI, CARLO	RUHR-UNIVERSITY BOCHUM	Poster Presenter	Registered
VINCIGUERRA, SERGIO	UNIVERSITY OF TURIN	Poster Presenter	Registered
VINNINGLAND, JAN LUDVIG	INTERNATIONAL RESEARCH INSTITUTE OF STAVANGER	Speaker	Registered
VIOLAY, MARIE	ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA	Poster Presenter	Registered
WANG, KELIN	GEOLOGICAL SURVEY OF CANADA	Speaker	Registered
WARREN, CLARE	THE OPEN UNIVERSITY	Speaker	Registered
WARREN, JESSICA M	STANFORD UNIVERSITY	Discussion Leader	Registered
XIA, GANG	UNIVERSITY OF CALIFORNIA, RIVERSIDE	Poster Presenter	Registered
XU, LILI	UNIVERSITY OF MINNESOTA, CHINA UNIVER. OF GEOSCI.	Poster Presenter	Registered
ZANZERKIA, EVA	NATIONAL SCIENCE FOUNDATION	Attendee	Registered

ZHOU, YONHSHENG	INSTITUTE OF GEOLOGY, CEA	Poster Presenter	Registered
ZHU, WENLU	UNIVERSITY OF MARYLAND	Vice Chair	Registered
ZIMMERMAN, MARK E	UNIVERSITY OF MINNESOTA	Attendee	Registered
ZOET, LUCAS K	PENN STATE UNIVERSITY	Poster Presenter	Registered
124 Attendees			