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NATIONAL RESEARCH COUNCIL  
BOARD ON EARTH SCIENCES AND RESOURCES

**U.S. NATIONAL COMMITTEE FOR ROCK MECHANICS**  
and  
**CONCEPTUAL MODELS OF FLUID INFILTRATION IN FRACTURED MEDIA**

**Project Summary — July 28, 1997 to July 27, 1998**  
Grant No. DE-FG08-97NV12056

**TASK 1: U.S. National Committee for Rock Mechanics**

The U.S. National Committee for Rock Mechanics (USNC/RM) provides for U.S. participation in international activities in rock mechanics, principally through adherence to the International Society for Rock Mechanics (ISRM). It also keeps the U.S. rock mechanics community informed about new programs directed toward major areas of national concern in which rock mechanics problems represent critical or limiting factors, such as energy resources, excavation, underground storage and waste disposal, and reactor siting. The committee also guides or produces advisory studies and reports on problem areas in rock mechanics.

**THE USNC/RM**

The U.S. National Committee for Rock Mechanics, which represents the American rock mechanics community in the United States and internationally, identifies critical issues in rock mechanics that need to be addressed, and reviews the health of the science that serves industry and government. It is an activity of the National Research Council's Board on Earth Sciences and Resources, Commission on Geosciences, Environment, and Resources.

At least three major industries vital to the U.S. and world economies—energy materials production, mineral extraction, and construction—require the knowledge and expertise of rock mechanics because those industries involve the breaking and removal of rock. The science of rock mechanics is essential to these industries in providing insights into bedrock behavior, structure, and properties. In addition, rock mechanics is necessary to plan the activities, strategies, safety procedures, and environmental precautions necessary to carry out their programs economically and safely.

Many current research and engineering developments in rock mechanics have been driven by concerns associated with environmental management, including radioactive and hazardous waste isolation and remediation of waste sites; new and innovative technologies for energy resource



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extraction; continued interest in defense structures in rock; mitigation of natural hazards such as earthquakes; and environmentally sound recovery of natural resources. The technological, economic, social, and political impacts of these issues engage the attention of many government agencies, business corporations, and public interest groups.

The expertise, judgment, and strategic perspective of the USNC/RM serves to define and help initiate sponsored studies and other activities with respect to major areas of national interest or concern in which rock mechanics problems represent critical or limiting factors. The USNC/RM offers a forum for discussions with federal sponsors and other interested organizations to exchange ideas and information on important topics. A committee roster is enclosed.

## USNC/RM Committee Meetings

### Washington, D.C., March 1998

The U.S. National Committee for Rock Mechanics held its winter meeting in Washington, D.C., on March 27-28, 1998. The open session was attended by 22 scientists and engineers, including liaisons from nine federal agencies and professional organizations. The agenda and attendee list are enclosed.

The meeting included presentations about two ongoing NRC studies related to rock mechanics: (1) Mine Seismicity and the Comprehensive Nuclear Test Ban Treaty, and (2) Conceptual Models of Fluid Infiltration in Fractured Media. These studies are described in greater detail below.

Representatives of six federal agencies gave presentations on research related to rock mechanics:

#### Brief Agency Reports

- National Science Foundation *Priscilla Nelson*
- Nuclear Regulatory Commission *Jacob Philip & Thomas Nicholson*
- U.S. Army Topographic Engineering Center *William Roper & Judy Ehlen*
- Air Force Office of Scientific Research *Maj. Michael Chipley*
- DOE/Basic Energy Science *Nicholas Woodward*
- DOE/Geothermal Division *Paul Grabowski*

The committee discussed several potential new studies, including:

- Federal Role in Research and Information Related to Mining and Mineral Processing *Lewis Wade & Jaak Daemen*
- Carbon Sequestration *John Rudnicki*
- Rock Mechanics Issues Related to Penetrator Performance *Catherine Aimone-Martin*
- Scientific Drilling Projects and Rock Mechanics Issues *Bezalel Haimson*

The first presentation on the appropriate federal role in research and information related to mining and mineral processing included a discussion of several topics related to mine health and safety: (1) mine safety and disaster prevention, (2) the next generation of mining technology, which might lead to moving workers to a safer and more secure location, and (3) holistic solutions to safety, environmental, and economic problems in mining. This presentation also included a discussion of research conducted or supported by the former U.S. Bureau of Mines. The committee discussed the current status and future prospects of research related to rock mechanics, including topics that have a direct bearing on health and safety, such as ground control, rock bursts, characterization of rock masses, and slope stability.

The presentation on carbon sequestration has indirect implications for mine health and safety. Increased research on carbon sequestration has been stimulated by several policy developments, including:

- Kyoto Protocol (including international trading of CO<sub>2</sub> emissions permits)
- President's Committee of Advisors on Science and Technology Report on "Federal Energy Research and Development for the Challenges of the Twenty-First Century" (November, 1997)
- DOE's Comprehensive National Energy Strategy (January 30, 1998 draft)

The potential for adsorbing CO<sub>2</sub> in coal beds is a possible mechanism for carbon sequestration, which is emerging as a major topic in the context of the policy developments listed above. Enhanced research on coal-bed methane and adsorption of CO<sub>2</sub> in coal beds has been proposed to advance our understanding of carbon sequestration. These topics have implications for our understanding of health and safety issues related to "coal bumps" and coal-bed methane.

The committee meeting also provided a forum for the USNC/RM to take actions related to its responsibilities as the U.S. adherent to the International Society for Rock Mechanics and the U.S. representative to the organizing committee of the North American Rock Mechanics Symposium.

### **Cancun, Mexico, June 1998**

The U.S. National Committee for Rock Mechanics convened its summer meeting in conjunction with the North American Rock Mechanics Symposium in Cancun, Mexico, on June 2-3. An agenda is enclosed with this document and a list of speakers and discussion topics at the USNC/RM meeting is provided below:

#### **Brief Agency Reports**

- NIOSH  
*Keith Heasley*
- DOE Yucca Mountain Project Office

*William Boyle*

**Potential New Studies**

- Rock Mechanics Issues Related to Penetrator Performance  
*Catherine Aimone-Martin*
- Effect of Regulations on Innovation  
*James Monsees*
- Carbon Sequestration  
*John Rudnicki*

**Status of Ongoing NRC Studies**

- Seismic Signals from Mining Operations and the Comprehensive Test Ban Treaty  
*Catherine Aimone-Martin*
- Conceptual Models of Fluid Infiltration in Fractured Media  
*Craig Schiffries*

**U.S. Rock Mechanics Symposia**

- 36th U.S. Rock Mechanics Symposium, NY Rocks '97—Summary  
*Herbert Einstein*
- 37th U.S. Rock Mechanics Symposium, Vail Rocks '99  
*Peter Smeallie*

**American Rock Mechanics Association Issues**

*Thomas Doe*

**International Society for Rock Mechanics Issues**

*Herbert Einstein*

**Future Meetings**

The U.S. National Committee plans to convene its winter committee meeting in Washington D.C. in the first quarter of 1999. It plans to convene its summer meeting in conjunction with the 38th U.S. Rock Mechanics Symposium (Vail Rocks'99) in Vail, Colorado.

**Appointments to the Committee**

New appointments to the U.S. National Committee for Rock Mechanics were announced in early 1998. The committee has a new chair (Herbert H. Einstein, Massachusetts Institute of Technology) and vice chair (Ronald P. Steiger, Exxon Production Research Company), and three new members (Jaak J. K. Daemen, Mackay School of Mines, University of Nevada, Reno; Richard E. Goodman, Professor emeritus, Department of Civil Engineering, University of

California at Berkeley; and Paul A. Hsieh, U.S. Geological Survey, Menlo Park, California). The vice chair position was created so that the leadership of the committee can include representation from both industry and academia. A complete roster of the USNC/RM is attached to this report. Brief biographies of the new appointees are provided below:

#### *Chairman*

**Herbert H. Einstein** is Professor of Civil and Environmental Engineering at the Massachusetts Institute of Technology. His main areas of interest are rock mechanics, engineering geology, and underground construction. He is teaching, doing research, and consulting in these areas, and at present he is also responsible for the revision of the undergraduate curriculum in his department. Professor Einstein is Vice President for North America and First Vice President of the International Society for Rock Mechanics. He is author or coauthor of over 130 publications.

#### *Vice Chairman*

**Ronald P. Steiger** is Senior Research Associate at Exxon Production Research Company in Houston, Texas. Dr. Steiger leads research projects on oil and gas drilling and completions. He is a leading expert on well-bore stability, an issue in rock mechanics of great interest for the petroleum industry.

**Jaak J. K. Daemen** is Professor of Mining Engineering at the Mackay School of Mines, University of Nevada, Reno. His main research interests are rock mechanics applications in underground mining and construction, rock breakage with explosives, and sealing of nuclear waste repositories. He previously was on the faculty at the University of Arizona, and prior to that was with E. I. du Pont de Nemours. He is a registered professional engineer in civil and mining engineering.

**Richard E. Goodman** is Emeritus Professor of Geological Engineering in the Department of Civil Engineering at Berkeley, where he taught and conducted research in rock mechanics and engineering geology for some thirty years. He is the author of several hundred publications and five books, concerning geological engineering, rock mechanics, engineering geology, and engineering history (a biography of Karl Terzaghi). He serves as consultant to the Bureau of Reclamation, Pacific Gas and Electric Company, Codelco Mines of Chile, and other organizations, mainly on solution of engineering problems with rock excavation and support, and foundations of dams and penstocks. Dr. Goodman is a member of the National Academy of Engineering.

**Paul A. Hsieh** is a Hydrologist at the U.S. Geological Survey in Menlo Park, California. He conducts research on fluid flow and solute transport in fractured rocks. He is also an adjunct professor in the Department of Geological and Environmental Sciences at Stanford University. He was a member of the NRC Panel on Fracture Characterization and Fluid Flow and Chair of the American Society for Civil Engineers Committee on Ground Water Hydrology. He is a member of the American Geophysical Union, American Society of Civil Engineers, and the National Ground Water Association.

## **Rock Mechanics Symposia**

### **36th U.S. Rock Mechanics Symposium**

The U.S. National Committee for Rock Mechanics was the sponsor of the 36th U.S. Rock Mechanics Symposium (NYRocks'97) on June 29-July 2, 1997. The USNC/RM was responsible for choosing the Henry Krumb School of Mines at Columbia University as the convener of the meeting. The USNC/RM worked with the organizing committee to publicize the symposium and to provide advice regarding the technical program and publication of the proceedings. The conference was designated an International Symposium of the ISRM. The USNC/RM represented the United States at the ISRM Board and Council Meetings.

The theme of NYRocks'97 was "Linking Science to Rock Engineering." The meeting was attended by approximately 500 scientists and engineers from more than 30 countries. The symposia included a series of short courses and field trips. Plenary speakers included ISRM Past President Charles Fairhurst ("Rock Mechanics to Rock Engineering: The Exciting Challenge), ISRM President-Elect Marc Panet ("The Channel Tunnel: Geology and Geotechnique -- Evaluation Before and After Construction"), and Prof. Michel Van Sint Jan ("Contributions from Rock Mechanics Research and Practice to the Mining Industry"). The symposium banquet speaker was Dr. Benoit Mandelbrot, author of *The Fractal Geometry of Nature*. Other events held in conjunction with NYRocks'97 include the ISRM board and council meetings, the USNC/RM committee meeting, and the ARMA board and general meeting.

### **3rd North American Rock Mechanics Symposium**

The USNC/RM played an active role at the 3rd North American Rock Mechanics Symposium (NARMS) in Cancun, Mexico, on June 3-5, 1998. The Symposium involved approximately 300 scientists and engineers from more than 20 countries. The USNC/RM (1) convened a USNC/RM meeting in conjunction with the symposium; (2) represented the United States on the NARMS Organizing Committee; (3) represented the United States at the Board and Council meetings of the International Society for Rock Mechanics; (4) conferred the annual USNC/RM Awards for Outstanding Accomplishments in Rock Mechanics; and (5) members conducted a short course, chaired technical sessions, and delivered technical papers. The USNC/RM participated in planning technical aspects of the NARMS'98 program and reviewed abstracts submitted for presentation at the conference.

The theme of NARMS'98 was "Rock Mechanics in Mining, Petroleum, and Civil Works." NARMS'98 included a wide variety of forums with keynote addresses, technical sessions, poster sessions, short courses, field tours, and technical exhibits of goods and services. The Symposium was preceded by two days of short courses, including Rock Blasting; Rock Slope Stability; Hydraulic Fracturing; Joint Network Modeling and Application of Block Theory for Surficial and Underground Excavations; Role of Numerical Models in Rock Mechanics Problem Solving; Applied Rock Mechanics Instrumentation; Rock Grouting; and Thermoporosity.



The technical program included sessions on mine design and ground control; state of stresses; ground support; numerical modeling; fracture discontinuity and mechanical breakage of rocks; storage for disposal; rock mechanics testing; and Yucca Mountain nuclear waste repository.

A major activity of the USNC/RM was to review nearly 200 abstracts submitted for presentation at NARMS'98. This task involved providing recommendations as to whether each paper should be accepted or rejected. A summary of the USNC/RM's recommendations is provided in Table 1 and a list of the title and reviewer of each abstract is attached to this summary. Papers presented at NARMS'98 were compiled and made available on a CD at the symposium and abstracts were published in a printed volume.

### **Rock Mechanics Awards**

The USNC/RM recognizes and confers awards for outstanding contributions to the basic science and engineering applications of rock mechanics. Two awards were presented at the plenary banquet at the 1998 NARMS symposium in Cancun, Mexico:

- **Dr. Neville G.W. Cook Award for the Outstanding Doctoral Dissertation**  
Xiaolin Wu, "Theoretical Analysis of Bump and Airblast Events Associated with Coal Mining Under Strong Roofs," Department of Mining and Minerals Engineering, Virginia Polytechnic Institute and State University.
- **Case History Award**  
Francois E. Heuze (LLNL), Robert P. Swift (LANL), Leslie R. Hill (SNL), and William H. Barrett (SNL), "Behavior of a Steel Liner-and-Bolts System Under Very High Thermal and Mechanical Loading," published in *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr.*, Vol. 32, pp. 643-672, 1995.

**Table 1. Tabulation of NARMS '98 Abstract Reviews**

COUNTRY (Total Number of Abstracts)	Number of Abstracts ACCEPTED	Number of Abstracts REJECTED	Number of Abstracts UNDECIDED
Australia (4)	2		2
Austria (1)	1		
Belgium (1)	1		
Brazil (4)	2	1	1
Canada (31)	22	2	7
Chile (1)	1		
Costa Rica (1)	1		
Czech Republic (1)		1	
Dominican Republic (1)		1	
England (1)	1		
France (8)	7		1
Germany (2)	2		
Hong Kong (1)	1		
Israel (3)	2	1	
Japan (8)	5	1	2
Korea (5)	4		1
Lebanon (1)	1		
Mexico (29)	19	6	4
Norway (3)	2		1
Poland (2)	2		
Puerto Rico (1)	1		
Russia (2)		1	1
South Africa (3)	1	1	1
Spain (1)		1	
Sweden (1)	1		
Turkey (5)	3	1	1
USA (75)	56	8	11

196 Total Reviewed Abstracts

138 Accepted

25 Rejected

33 Undecided

## **International Society for Rock Mechanics**

The USNC/RM provides for U.S. participation in international activities in rock mechanics principally through adherence to the International Society for Rock Mechanics (ISRM). The ISRM recognizes the USNC/RM as the national group representing ISRM members in the United States. The committee strives to provide effective representation through active participation in the business of the international society. The USNC/RM plays a continuing role in national, regional, and international ISRM symposia. The USNC/RM's role is described below:

**1997 U.S. Rock Mechanics Symposium (New York City).** The USNC/RM sponsored the 36th U.S. Rock Mechanics Symposium (NYRocks'97) at Columbia University on June 29 to July 2, 1997. The meeting was attended by approximately 500 scientists and engineers from more than 30 countries. In conjunction with the Symposium, the USNC/RM represented the United States at the ISRM Board and Council meetings, presented the 1997 awards for outstanding contributions in rock mechanics, and convened a committee meeting that featured two mini-workshops on (1) Rock Mechanics Issues Related to Penetrator Performance, and (2) Scientific Drilling Projects and Rock Mechanics Issues. NYRocks'97 was an ISRM international symposium, and the USNC/RM was responsible for selecting Columbia University's proposal to host the meeting. The USNC/RM worked with the organizers of the symposium to publicize the meeting and to provide advice regarding the technical program and publication of the proceedings. The theme of the meeting was "Linking Science to Rock Engineering."

**1998 North American Rock Mechanics Symposium (Cancun, Mexico).** The USNC/RM played an active role at the 3rd North American Rock Mechanics Symposium (NARMS) in Cancun, Mexico, on June 3-5, 1998. The Symposium involved approximately 300 scientists and engineers from more than 20 countries. This meeting was designated as an ISRM International Symposium. The USNC/RM (1) represented the United States on the NARMS Organizing Committee, which is responsible for the overall quality and continuity of the NARM Symposia; (2) represented the United States at the ISRM Board and Council meetings; (3) convened a USNC/RM meeting in conjunction with the symposium; and (4) conferred the annual USNC/RM awards for outstanding accomplishments in rock mechanics. The USNC/RM participated in planning technical aspects of the NARMS'98 program and reviewed nearly 200 abstracts submitted for presentation at the conference.

**1999 U.S. Rock Mechanics Symposium (Vail, Colorado).** The USNC/RM is participating in planning for the 37th U.S. Rock Mechanics Symposium in Vail, Colorado on June 6-9, 1999. It is anticipated that members of the USNC/RM will be appointed to the technical program committee and that the meeting will be designated as an ISRM Regional Symposium. The theme of the meeting is "Rock Mechanics for Industry."

**1999 International Congress on Rock Mechanics (Paris).** The USNC/RM has issued a call for papers for the 9th International Congress on Rock Mechanics to be held in Paris,

France on August 25-28, 1998. The USNC/RM is responsible for reviewing and selecting U.S. abstracts for presentation at the quadrennial Congress. Major sessions at the Congress include (1) Applied Rock Mechanics: Safety and Control of the Environment; (2) Coupling Mechanics Phenomena with Thermal, Hydraulic and Chemical Phenomena; (3) Rock Dynamics and Tectonophysics; (4) Field Tests, Measurements, and Monitoring. The Congress will also include workshops and field trips.

**2003 International Congress on Rock Mechanics (South Africa).** The ISRM Council selected the South African National Group on Rock Mechanics to host the 10th International Congress in Sun City, South Africa in 2003. This will be the first Congress to be held on the African continent and only the second to be held in the Southern hemisphere. The unique conditions and depths of mining in South Africa have led to the creation of a large body of rock mechanics expertise. South Africa's rock mechanics interests extend beyond deep level mining to other fields, such as large civil infrastructure projects as well as surface mining. The theme of the meeting is "Technology Roadmap for Rock Mechanics." Field trips will include visits to ultradeep mining (gold), shallow hard rock mining (platinum), open cast mining (iron ore), and strip mining in environmentally sensitive areas (coal).

### **American Rock Mechanics Association**

The USNC/RM is continuing to transfer appropriate responsibilities to the American Rock Mechanics Association (ARMA), a professional association founded in 1994. Throughout its history, the National Research Council has been willing to provide services for scientific and technical disciplines that did not have their own national scientific or professional society. This is not, however, a role that the National Research Council feels obligated to retain when other organizations are willing and able to serve in an equivalent capacity. The American Rock Mechanics Association was established to fill a gap in the structure of U.S. scientific and professional organizations. ARMA has already assumed responsibility for collecting U.S. individual membership dues for the International Society for Rock Mechanics (ISRM), distributing the *ISRM News Journal* to U.S. members of ISRM, providing other membership services, and sponsoring the biennial U.S. Rock Mechanics Symposia. In June 1998, the North American Rock Mechanics Symposium Committee modified the trilateral agreement with the United States, Mexico, and Canada to transfer U.S. responsibility for future North American Rock Mechanics Symposia to the American Rock Mechanics Association. This transfer becomes effective at the Fourth North American Rock Mechanics Symposium to be held in the United States in 2000.

## USNC/RM Home Page on World Wide Web

The USNC/RM maintains a home page on the World Wide Web. The address of the home page is <http://www2.nas.edu/besr>. It contains information about recent and forthcoming events sponsored by the USNC/RM. It also contains links to other sites of interest to the rock mechanics community.

### Related Activity

#### Seismic Signals from Mining Operations and the Comprehensive Test Ban Treaty

During the past year, the NRC initiated and completed a study on *Seismic Signals from Mining Operations and the Comprehensive Test Ban Treaty*. The report was published by the National Academy Press in July 1998. A copy of the report is enclosed with this document, and the full text of the report is also available at <http://www.nas.edu/readingroom>. A brief description of the study is provided below:

#### ***Seismic Activity from Mining Operations and the Comprehensive Test Ban Treaty: Comments on a Department of Energy Working Group Report***

[National Research Council] — July 1998

The Comprehensive Test Ban Treaty (CTBT) has been signed by 147 nations and bans all nuclear explosions. A global seismic network forms much of the basis of the International Monitoring System being established for treaty compliance. Some mining explosions, mine collapses, and rock failures can have seismic signals similar to those resulting from small or decoupled nuclear explosions. Not only will some mining-related seismic events be visible to the International Monitoring System, but some could potentially be interpreted as a nuclear event and a treaty violation. The NRC study comments on a draft report, *Reducing the Ambiguity and Visibility of Seismic Signals from Mining Activities*, prepared by a Working Group for the Department of Energy. In addition to discussing the validity of the recommendations in the DOE Working Group report, the NRC study also addresses (1) additional measures that could reduce the ambiguity and visibility of seismic signals from mine related events, and (2) how should the information be disseminated to promote their use in the mining community.

At the request of the Department of Energy's Office of Non-Proliferation, the National Research Council conducted a study to review recommendations in a draft DOE-sponsored study entitled *Reducing the Ambiguity and Visibility of Seismic Signals from Mining Activities*. The DOE-sponsored report includes specific recommendations for improving occupational health and safety in the mining industry. According to the DOE Working Group report, "If the mining practices recommended in this report are adopted by the mining companies, they will likely

provided intrinsic safety and economic benefits to mine operators.” For example, the report contains recommendations for decreasing the possibility of generating flyrock that results in occupational injuries, improving highwall stability to reduce dangers to miners working in adjacent areas, and ground motion control in order to reduce damage to structures in the mine or at adjacent facilities.

Monitoring the Comprehensive Test Ban Treaty (CTBT) will require a thorough understanding of worldwide seismicity down to seismic magnitudes of approximately 3.5. This effort will require a significant focus on mine seismicity since it can resemble a nuclear explosion. The report from this National Research Council project assesses recommendations for reducing the ambiguity and intensity of mine seismicity. It also suggests dissemination activities to promote mine engineering practices in support of CTBT monitoring.

The study was conducted under the auspices of the NRC’s Board on Earth Sciences and Resources with input from the U.S. National Committee for Rock Mechanics, the Committee on Seismology, and the Committee on Earth Resources. Dr. Aimone-Martin, who is a member of both the USNC/RM and the Committee on Mine Seismicity and the Comprehensive Test Ban Treaty, provided a briefing about the progress of the study at three meetings of the USNC/RM in 1997-98. These presentations provided an opportunity for other members of the USNC/RM to provide input to the study on *Seismic Signals from Mining Operations and the Comprehensive Test Ban Treaty*.

The members of the Committee on Mine Seismicity and the Comprehensive Test Ban Treaty are listed below and a complete committee roster is attached to this status report.

Thomas J. O’Neil, *Chair*, Vice President, Cleveland-Cliffs, Inc.

Thomas J. Ahrens, Seismological Laboratory, California Institute of Technology

Catherine T. Aimone-Martin, Department of Mineral and Environmental Engineering,  
New Mexico Institute of Mining & Technology

Robert R. Blandford, Air Force Technical Applications Center

Blair M. Gardner, Assistant General Counsel, Arch Coal, Inc.

Michael E. Karmis, Department of Mining and Engineering, Virginia Polytechnic  
Institute and State University

William S. Leith, U.S. Geological Survey

Jean-Michel M. Rendu, Vice President, Newmont Gold Company

John Wiegand, President, Vibronics, Inc.

Zavis M. Zavodni, Manager of Geotechnical Engineering, Kennecott Utah Copper

## TASK 2: Conceptual Models of Fluid Infiltration in Fractured Media

A new panel under the auspices of the U.S. National Committee for Rock Mechanics has been appointed to conduct a study on *Conceptual Models of Fluid Infiltration in Fractured Media*. The study has health and environmental applications related to the underground flow of pollutants through fractured rock in and around mines and waste repositories. Support of the study has been received from the U.S. Nuclear Regulatory Commission and the Department of Energy's Yucca Mountain Project Office. The new study builds on the success of a recent USNC/RM report entitled *Rock Fractures and Fluid Flow: Contemporary Understanding and Applications* (National Academy Press, 1996, 551 pp.). A summary of the new study is provided below:

### ***Conceptual Models of Fluid Infiltration in Fractured Media***

[National Research Council] — In Progress

The development of realistic conceptual models for fluid infiltration in fractured media is a critical research problem for nuclear waste repository siting, enhanced oil recovery, and for addressing subsurface contamination by aqueous and nonaqueous phase liquids. Numerical models developed from inappropriate conceptual models can have large uncertainties that are difficult to quantify, and may lead to results that differ significantly from the physical systems they seek to describe. This study will address the scale, complexity, and site specific conditions and processes that need to be determined in order to develop an appropriate conceptual infiltration model. It will evaluate a variety of conceptual models of fluid infiltration in fractured media, develop a process for determining an appropriate conceptual model to use in computational simulations, and investigate a strategy for discriminating among models.

## Appointments to the Panel

The panel consists of nine people with expertise in (1) fluid and solute transport in the vadose zone, (2) hydrogeochemistry, (3) field hydrological testing, and (4) hydrogeological modeling. These areas of expertise are necessary for the panel to meet its stated objectives. The new panel is chaired by Dr. Paul Hsieh, U.S. Geological Survey, who is also a member of the USNC/RM. A complete roster of the panel is attached to this report. Brief biographies of the members are provided below:

### ***Chairman***

**PAUL A. HSIEH** is a research hydrologist with the U.S. Geological Survey in Menlo Park, California. Dr. Hsieh is also an adjunct professor in the Department of Geological and Environmental Sciences at Stanford University. He currently serves on the U.S. National Committee for Rock Mechanics and was a member of the Committee on Fracture Characterization and Fluid Flow (*Rock Fractures and Fluid Flow: Contemporary Understanding and Applications*, NRC, 1996). He conducts theoretical and field research on fluid flow and

solute transport in fractured rocks, development of computer simulation models, and laboratory investigations of hydraulic properties of low-permeability rocks. He is a member of the American Geophysical Union, American Society of Civil Engineers, and the National Ground Water Association.

**JEAN M. BAHR** is a professor in the Department of Geology and Geophysics at the University of Wisconsin-Madison. Dr. Bahr specializes in field monitoring and tracer studies of the effects of these transport processes in real time, core and outcrop studies to provide data on hydrologic and geochemical properties of aquifer materials, and numerical modeling of groundwater transport systems. She served on several NRC activities: (1) as a member of the Board on Radioactive Waste Management (1992-1997); (2) as vice-chair of the NRC Committee on Yucca Mountain Peer Review: Surface Characteristics, Preclosure Hydrology, and Erosion; and (3) as a member of the Committee on Technical Bases for Yucca Mountain Standards. Her Ph.D. was awarded from Stanford University. She is a member of the American Geophysical Union and an Associate Editor of AGU's journal "Water Resources Research." She is also a member of the American Geological Institute's editorial board of *Geotimes*.

**THOMAS W. DOE** is a principal of Golder Associates, Inc., located in Seattle, Washington. He is manager of the FracMan Technology Group, which develops software for analysis and modeling of heterogeneous and fractured rock masses containing discrete features such as faults, fractures, paleochannels, karsts, and stratigraphic contacts. Dr. Doe is a pioneer in the development of fractional dimension type curve methods for understanding connectivity patterns, permeability, and storativity. He has also worked extensively on interpretation of well tests in fractured rock to determine hydraulic and geometric characteristics of fractures. Dr. Doe earned his Ph.D. from the University of Wisconsin-Madison. He is a member of the American Geophysical Union, and is currently serving as President of the American Rock Mechanics Association.

**ALAN L. FLINT** is a research hydrologist with the U.S. Geological Survey in the California District, Sacramento. Dr. Flint earned his Ph.D. from Oregon State University in soil physics. He has primarily been involved in modeling and field characterization of unsaturated zone infiltration; much of his recent work has been related to hydrological conditions at Yucca Mountain, Nevada. Dr. Flint also collaborates in an international effort to validate flow and transport models in the saturated and unsaturated zone. He is a member of the American Geophysical Union.

**GLENDON GEE** is a Senior Staff Scientist in the Environmental Technology Division of the Batelle Pacific Northwest Laboratories. Dr. Gee specializes in the study of recharge in arid regions and the physical and chemical observations of fluid flow and transport under field conditions.

**LYNN W. GELHAR** is a Professor in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology. Dr. Gelhar investigates the effects of natural heterogeneity in the underground aqueous systems using mathematical theory to stochastically represent the variability of flow and transport properties, and evaluates the applicability of the



theoretical results through controlled field experimentation. He is a fellow of the American Geophysical Union.

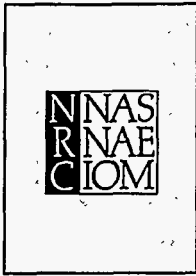
**D. KIP SOLOMON** is a chemical hydrogeologist with the Department of Geology and Geophysics at the University of Utah. He specializes in fluid flow in soils and shallow aquifers, emphasizing the fate and transport of contaminants. Dr. Solomon has also worked on techniques for determining the age of shallow groundwater using tritium and helium isotopes and chlorofluorocarbons and using these tools to examine mass transport in fractured, clay-rich systems. He earned a Ph.D. from the University of Waterloo. He is a member of the American Geophysical Union and the Geological Society of America.

**MARTINUS TH. VAN GENUCHTEN** is a soil scientist and research leader in the Soil Physics and Pesticide Research Unit of the Department of Agriculture's U.S. Salinity Laboratory, Riverside, California. Dr. van Genuchten is also an adjunct professor in the Department of Soil and Environmental Sciences at the University of California, Riverside. He is an expert in water flow and solute transport in the vadose zone, analytical and numerical methods for simulating water and solute movement in the subsurface, preferential flow of water and solutes in structured media, and description and measurement of unsaturated soil hydraulic properties. He is a fellow of both the American Geophysical Union and the Soil Science Society of America. Dr. van Genuchten earned his bachelors and masters degrees from the Agricultural University (Wageningen, The Netherlands) and a Ph.D. in soil physics from New Mexico State University. From 1975 to 1978, he was with the Water Resources Program at Princeton University prior to his career with the U.S. Salinity Laboratory.

**STEPHEN W. WHEATCRAFT** is a Professor in the Department of Geological Sciences and Associate Dean of the Mackay School of Mines at the University of Nevada, Reno. His research ranges from classical problems such, as sea water intrusion, to the use of chaos to describe flow and transport characteristics in unsaturated fracture flow. Most recently, he has used fractional calculus to develop a new transport theory in saturated heterogeneous aquifers. Dr. Wheatcraft earned a Ph.D. from the University of Hawaii. He is a member of the American Geophysical Union, the Association of Groundwater Scientists and Engineers, and a fellow of the Geological Society of America.

### **Panel Meetings**

The Panel on Conceptual Models of Fluid Infiltration in Fractured Media has scheduled its first meeting to be on September 18-19, 1998, in Washington, D.C. It is expected that the panel will be deciding the types of keynote and background papers that might be considered for the workshop, the level of detail needed, the critical points that need to be covered, and who might be enlisted to prepare or deliver them. The date for the workshop will be decided on at the meeting but it is anticipated to be in early 1999.



## U.S. NATIONAL COMMITTEE FOR ROCK MECHANICS

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(All terms expire December 31 of the year indicated)

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# U.S. NATIONAL COMMITTEE FOR ROCK MECHANICS

Board on Earth Sciences and Resources  
National Research Council

Georgetown Facility, Green Building, Room 118  
2001 Wisconsin Avenue, N.W., Washington D.C.  
March 27-28, 1998

## Preliminary Agenda

Friday, March 27, 1998

### OPEN SESSION

- 8:00 a.m. Continental breakfast available in the meeting room
- 8:30 Welcome *Herbert Einstein*
- Introductions
  - Review of Agenda
  - Commemoration of Neville G. Cook
  - Overview of USNC/RM Activities
- 8:45 NRC Study on Mining-Induced Seismicity and the Comprehensive Nuclear Test Ban Treaty *Catherine Aimone-Martin*
- 9:00 Brief Agency Reports *Priscilla Nelson*
- National Science Foundation
  - Nuclear Regulatory Commission *Jacob Philip & Thomas Nicholson*
- 10:00 Break
- 10:15 Brief Agency Reports (cont.) *William Roper & Judy Ehlen*
- U.S. Army Topographic Engineering Center *Capt. Michael Chipley*
  - Air Force Office of Scientific Research *Nicholas Woodward*
  - DOE/Basic Energy Science
- 12:00 p.m. Lunch in Meeting Room

- 1:00 p.m.      NRC Study on Conceptual Models of Fluid Infiltration in Fractured Media      *Paul Hsieh*
- Carbon Sequestration      *John Rudnicki*
- Federal Role in Research and Information Related to Mining and Mineral Processing      *Lewis Wade & Jaak Daemen*
- Follow-up on USNC/RM Mini-Workshops
- Rock Mechanics Issues Related to Penetrator Performance      *Catherine Aimone-Martin*
  - Scientific Drilling Projects and Rock Mechanics Issues      *Bezalel Haimson*
- Potential New Studies in Rock Mechanics      *Roundtable Discussion*
- 3:00      Break
- 3:15      American Rock Mechanics Association Activities      *Thomas Doe & Peter Smeallie*
- 1998 Workshop on Future of Rock Mechanics
  - 1999 U.S. Rock Mechanics Symposium
  - Proposal to Transfer Responsibility for North American Rock Mechanics Symposia
- Roles and Responsibilities of USNC/RM, ARMA, and ISRM      *Roundtable Discussion*
- 5:00      Adjourn for the day
- Group Dinner at a Local Restaurant  
(Committee Members and Guests Invited)

Saturday, March 28, 1998

*CLOSED SESSION*

- 8:00 a.m. Continental breakfast available in the meeting room
- 8:30 Welcome and Review of Agenda *Herbert Einstein*
- New Policies of the National Research Council: FACA *Craig Schiffries*
- Discussion of Bias and Conflict of Interest *Craig Schiffries*
- 9:30 Recommendations for Participants in the Workshop on *Paul Hsieh*  
Conceptual Models of Fluid Infiltration in Fractured Media
- 9:45 ISRM and ARMA *Herbert Einstein*
- Review of Proposal to Transfer Responsibility for Future North American Rock Mechanics Symposia
  - 1997 U.S. Rock Mechanics Symposium (NYRocks'97)
  - 1998 North American Rock Mechanics Symposium (Cancun)
  - International Society for Rock Mechanics Activities
  - Awards for Outstanding Contributions in Rock Mechanics
  - Other Business
- 10:15 Break
- 10:30 Detailed Discussion of New Studies  
(Possible Breakout Sessions for Drafting Prospectuses)
- 12:00 p.m. Other Business
- Plans for NARMS'98 in Cancun
  - Schedule for Future USNC/RM Meetings
- 12:15 p.m. Lunch in Meeting Room
- 1:00 Adjourn

***U.S. NATIONAL COMMITTEE FOR ROCK MECHANICS***

Board on Earth Sciences and Resources  
National Research Council

Georgetown Facility, Green Building, Room 118  
2001 Wisconsin Avenue, N.W., Washington D.C.  
March 27, 1998

**Expected Attendance**

Committee Members

Herbert Einstein, Chair  
Catherine Aimone-Martin  
Jaak Daemen  
Bezalel Haimson  
Paul Hsieh  
James Monsees  
John Rudnicki  
Lewis Wade (former)

Invited Guests

C. I. (Jim) Chang, Air Force Office of Scientific Research  
Capt. Michael Chipley, Air Force Office of Scientific Research  
Thomas Doe, American Rock Mechanics Association  
Judy Ehlen, U.S. Army Topographic Engineering Center  
Paul Grabowski, DOE Geothermal Division  
Priscilla Nelson, National Science Foundation  
Thomas Nicholson, U.S. Nuclear Regulatory Commission  
Jacob Philip, U.S. Nuclear Regulatory Commission  
William Roper, U.S. Army Corps of Engineers  
Peter Smeallie, American Rock Mechanics Association  
Nicholas Woodward, DOE Basic Energy Sciences  
Michael York, DOE Office of Fossil Energy

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Craig Schiffries, Board on Earth Sciences and Resources, USNC/RM  
Thomas Usselman, Board on Earth Sciences and Resources  
Jennifer Estep, Board on Earth Sciences and Resources, USNC/RM

# **U.S. NATIONAL COMMITTEE FOR ROCK MECHANICS**

Board on Earth Sciences and Resources  
National Research Council

Maria Fernanda Room  
Fiesta Americana Condesa Cancún  
Boulevard Kukulcán, Cancún, Mexico  
June 2, 1998

## **Preliminary Agenda**

**Tuesday, June 2, 1998**

### ***CLOSED SESSION***

9:15 a.m.	Welcome and Review of Agenda	<i>Herbert Einstein</i>
	Rock Mechanics Awards	<i>Catherine Aimone-Martin</i>
	ISRM Votes	<i>Herbert Einstein</i>
	Committee Membership	
	Future Meeting Dates	

### ***OPEN SESSION***

10:00	Brief Agency Reports	
	• NIOSH	<i>Keith Heasley</i>
	• DOE Yucca Mountain Project Office	<i>William Boyle</i>
11:00	Potential New Studies	
	• Rock Mechanics Issues Related to Penetrator Performance	<i>Catherine Aimone-Martin</i>
	• Effect of Regulations on Innovation	<i>James Monsees</i>
	• Carbon Sequestration	<i>John Rudnicki</i>
12:00 noon	Working Lunch	



- 1:00 p.m.      Status of Ongoing NRC Studies
- Seismic Signals from Mining Operations and the Comprehensive Test Ban Treaty      *Catherine Aimone-Martin*
  - Conceptual Models of Fluid Infiltration in Fractured Media      *Craig Schiffries*
- 1:30            U.S. Rock Mechanics Symposia
- 36th U.S. Rock Mechanics Symposium, NY Rocks '97—Summary      *TBA*
  - 37th U.S. Rock Mechanics Symposium, Vail Rocks '99      *Peter Smeallie*
- ARMA Issues      *Thomas Doe*
- ISRM Issues      *Herbert Einstein*
- 2:30            Adjourn

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Additional Events of Interest to the USNC/RM

June 2, 1998

2:30 p.m.      ISRM Council Meeting, Fiesta Americana Condesa Cancún

June 3, 1998

5:30 p.m.      ARMA Board Meeting, Maria Luisa Room

7:00 p.m.      USNC/RM Closed Writing Session, Maria Fernanda Room

June 4, 1998

Evening        Presentation of U.S. Rock Mechanics Awards at Banquet

***U.S. NATIONAL COMMITTEE FOR ROCK MECHANICS***

Board on Earth Sciences and Resources  
National Research Council

Maria Fernanda Room  
Fiesta Americana Condesa Cancún  
Boulevard Kukulcán, Cancún, Mexico  
June 2, 1998

**Expected Attendance**

**USNC/RM Members**

Herbert Einstein, Chair  
Catherine Aimone-Martin  
Jaak Daemen  
Richard Goodman  
Bezalel Haimson  
James Monsees  
John Rudnicki

**Guests**

William Boyle, DOE Yucca Mountain Project Office  
Thomas Doe, American Rock Mechanics Association  
Keith Heasley, National Institute for Occupational Safety and Health  
Peter Smeallie, American Rock Mechanics Association

**NRC Staff**

Craig Schiffries

## U.S. REVIEW OF NARMS' 98 ABSTRACTS

Review Results	COUNTRY/ABSTRACT TITLE AND AUTHOR(S)	Reviewer
	<b>AUSTRALIA - 4</b>	
	AUS-330-1 <i>Reinforcement Systems - Mechanics, Design &amp; Performance Testing.</i> C. R. Windsor and A. Thompson.	Kendorski
	AUS-330-2 <i>Cement Grouts in Theory and Reinforcement Practice.</i> A. Thompson and C. R. Windsor.	Kendorski
	AUS-806 <i>A Dynamic Cavity Expansion Model for Rocks.</i> H. Alehossein and M. Hood.	Rudnicki
	AUS-919 <i>Application of a Microseismic System in Monitoring E26 Block Cave at Northparkes Mines.</i> D. Chen.	Aimone
	<b>AUSTRIA - 1</b>	
	AST-729 <i>Control System for Tunnel Boring Machines (TBM): A First Investigation Towards a Hybrid Control System.</i> A.H. Zettler and R. Poisel.	Monsees
	<b>BELGIUM - 1</b>	
	BEL-829 <i>Progressive Failure of a Porous Limestone Under Cyclic Loading Revealed by Ultrasonic Attenuation.</i> J. F. Couveur and J. F. Thimus.	Rudnicki
	<b>BRAZIL - 4</b>	
	BRA-829 <i>Effects of Rock Stress on the Extraction of Dimension Stone Granitic Rocks.</i> Aarao de Andrade, Alexandre Buriel, and Tumkur Rajarao.	Haimson
	BRA-830 <i>Effects of Fluid Viscosity, Pumping Rate, Fracture Energy, and Wellbore Diameter in a Leakoff Test.</i> Marcelo Frydman and Sérgio A. B. da Fontoura	Steiger
	BRA-901 <i>Determination of Secondary Roughness of Rock Discontinuities Surfaces by Scanner Devices.</i> José Margarida Da Silva and Lineu Azuaga Ayres Da Silva.	Teufel
	BRA-902 <i>Numerical Modeling of the Pressure Arch in Underground Mines.</i> Eduardo César Sansone.	Agapito

	<b>CANADA - 31</b>	
	CAN-310 <i>Advanced Monitoring and Analysis of Microseismic Activity as an Aid to Mining at Brunswick Mines.</i> B. Simser, D. Peterson, P. Andrieux and T. MacDonald.	Aimone
	CAN-311 <i>S-Wave Attenuation Measurements in a Deep Hard-Rock Mine.</i> S. Talebi.	Aimone
	CAN-314 <i>A 3-D Block-Spring Model for Simulating the Behavior of the Jointed Rocks.</i> G. Li and B. Wang.	Amadei
	CAN-316 <i>An Expert System for the Evaluation of Rockfall Hazards in Highway Rock Cuts.</i> M. Palassi and J. Franklin.	Kranz
	CAN-326-1 <i>Thermo-Mechanical Effects on Borehole Instability.</i> G. Xu and M. B. Dusseault.	Kim
	CAN-326-2 <i>Thermal Conduction and Expansion of Saturated Quartz-Illitic and Smectitic Shales as a Function of Stress, Temperature, and Bedding Anisotropy.</i> D. A. MacGillivray and M. B. Dusseault.	Glaser
	CAN-326-3 <i>Soft Elastic Drive of Fluid Flow and Mechano-Chemical Stability of Shales.</i> M.B. Geilikman and M. B. Dusseault.	Steiger
	CAN-327-1 <i>In-Situ Deformability of Moderately to Highly Stressed Mine Structures in Hard Rock Mines.</i> D. Labrie.	Wade
	CAN-327-2 <i>Rebar Rock Bolting—A Practical Review.</i> D. Gagnon.	Kendorski
	CAN-328 <i>Evaluation of Shotcrete Support Mechanisms as a Function of Joint Dilation Resistance.</i> C. Langille and D. R. McCreath.	Scott
	CAN-331-1 <i>Design, Support, Monitoring and Performance of an Orepass at Depth.</i> S. Seldon, A. Sampson Forsythe, R. Brummer.	Wade
	CAN-331-2 <i>The Mechanical Behavior of Waste Blends for Salt Cavern Disposal.</i> B. Lemieux.	Pariseau
	CAN-331-3 <i>Borehole Stability Monitoring by Combined Natural Seismic and Gravity Methods.</i> B. Xu, M. B. Dusseault and C. Li.	Kim
	CAN-331-4 <i>A Study of Destress Blasting Effects on the Rockburst Potential of an Underground Mine in Hard Rocks.</i> M. Aubertin, R. Simon, L. Auer, D. Gill, H. Mitri and D. Labrie.	Wade
	CAN-331-5 <i>Evaluation of Seismic Strain Rate and Numerical Modelling Derived Stresses Associated with a Sill Pillar Excavation at Depth.</i> T.I. Urbancic, C.I. Trifu, V. Shumila and J. Tod.	Pariseau

	CAN-331-6 <i>Stability Monitoring Around an Underground Opening Using a High-Resolution Seismic Inverse Technique.</i> C. X. Wu and M. B. Dusseault.	Fairhurst
	CAN-331-7 <i>Strength Characterization of a Typical Swelling Shale.</i> J. Fooks and M. B. Dusseault.	Einstein
	CAN-331-8 <i>Three-Dimensional Compaction Testing Equipment.</i> H. Hirst, B. Davidson, B. Lemieux, J. Fooks and M. Dusseault.	Glaser
	CAN-331-9 <i>High Frequency Complex Permittivity of Shales (0.02GHz-1.30GHz).</i> M. Fam and M. B. Dusseault.	Aimone
	CAN-331-10 <i>A Critical Assessment of Semi-Analytical Models for Non-Liner Modelling of Borehole Stresses: Experimental Results and Model Predictions.</i> P. A. Nawrocki, G. Xu, M. B. Dusseault and R. K. Bratli.	Haimson
	CAN-401-1 <i>Evaluation of Openhole Cavity Completion Technique in Coalbed Methane Reservoirs.</i> H. H. Vaziri.	Steiger
	CAN-401-2 <i>Seismic Response of Rock Mass to Blasting.</i> M. Eneva, A. J. Mendecki and G. Van Aswegen.	Aimone
	CAN-402 <i>Optimal Delineation of Joint Sets Using a Fuzzy Clustering Algorithm.</i> R. E. Hammah and J. H. Curran.	Turcotte
	CAN-411 <i>Modelling of Blasthole Expansion and Explosive Gas Pressurization in Jointed Media.</i> A. Mortazavi and P. D. Katsabanis.	Roegiers
	CAN-420 <i>Quantifying Joint Roughness Using Artificial Neural Networks.</i> J. S. Lessard and J. Hadjigeorgiou.	Turcotte
	CAN-422 <i>A Porosity-Gradient Controlled Solid Production Model.</i> L. Zhang and M. B. Dusseault.	Steiger
	CAN-430 <i>Modelling the Cyclic Behaviour of Brittle Materials Using a Bounding Surface Plasticity-Damage Model.</i> P. J. Guo and R. G. Wan.	Rudnicki
	CAN-730 <i>Centrifuge Tests to Identify the Mode of Sand Production and its Effect on Production.</i> H. H. Vaziri and S. Thallak.	Glaser
	CAN-806 <i>Field Testing of a Yielding Support System.</i> E. De Souza and P. Mottahed.	Monsees
	CAN-828 <i>Instrumentation and Backfill Performance in a Narrow Vein Gold Mine.</i> Ferri Hassani and K. Fotoohi.	Wade
	CAN-911 <i>Application of the Miniature Seismic Reflection (MSR) System for Monitoring Dynamic Changes in Mechanical Properties of Rocks.</i> A. Sadri, F. Hassani, and M. Momayez.	Aimone

	<b>CHILE - 1</b>	
	CHI-828 <i>Numerical Modelling for Geotechnical Design and Support Assessment for Main Shaft in Deep Polymetallic Mine in Peru.</i> Carlos A. Soto.	Agapito
	<b>COSTA RICA - 1</b>	
	COS-829 <i>The REX Expert System: A New Alternative for Rock Excavations Design.</i> Marco A. Tapia, Marco Valverde, Bernard Amadei, and Harold Madrigal.	Monsees
	<b>CZECH REPUBLIC - 1</b>	
	RCH-616 <i>The Tensometric Rockbolt for Stress Measuring.</i> R. Snupárek.	Haimson
	<b>DOMINICAN REPUBLIC - 1</b>	
	RED-829 <i>La Piedra Caliza y Sus Aplicaciones como Material de Construcción en la República Dominicana.</i> C. Sánchez.	Einstein
	<b>ENGLAND - 1</b>	
	ENG-827 <i>Elastic Wave Propagation and Fluid Permeability in Rocks with Systems of Aligned Discontinuities.</i> Michael S. King and Shiyu Xu.	Roegiers
	<b>ESCOCIA - 1</b>	
	ESC-0923 <i>Petroleum Geomechanics: Historical Background and Future Challenges.</i> P. Charlez. Keynote Lecture.	
	<b>ESPAÑA - 1</b>	
	ESP-331 <i>FDM Modelling of Subsidence Phenomena Due to Flat Coal Seam Mining.</i> L. R. Alejano, J. Taboada, P. R. Oyanguren, I. Rodríguez.	Wade
	<b>FRANCE - 8</b>	
	FRA-706 <i>Transient Poro-Plastic Response Around a Cylindrical Cavity.</i> I. Benamar and G. Rousset.	Long
	FRA-826-1 <i>Solid Production Prediction in a Highly Heterogeneous Carbonate Formation.</i> A. Onaisi, D. Richard, and Y. Abousleiman.	Doe

	FRA-826-2 <i>Numerical Approach to Design the Support of Galleries at Great Depth.</i> A. Mimoun, A. Thoraval, and J. P. Piguet.	Agapito
	FRA-827-1 <i>Distinct Element Modelling of an Underground Excavation Using a Continuum Damage Model.</i> M. Souley, D. Hoxha, and F. Homand.	Agapito
	FRA-827-2 <i>Evaluation of Drilling Parameters of a PDC Bit.</i> D. Nguyen Minh and H. Geoffroy.	Kim
	FRA-901 <i>Surveillance des Exploitations Minières par des Methodes Numeriques et Sismiques aux Houillères du Bassin de Lorraine.</i> G. Senfaute, M. Al-Heib, J. P. Josien, and E. Sarrault.	Fairhurst
	FRA-912 <i>Modelling of Coupled Elastoplastic Damage in Rock Materials.</i> J. F. Shao and A. S. Chiarelli.	Rudnicki
	FRA-915 <i>In Situ Stress Measurements Based on the Under-Excavation Technique: A Study Case at Mt. Terri.</i> P. Bigarré, P. Cottour, and T. Verdel.	Haimson
	<b>GERMANY - 2</b>	
	ALE-825 <i>Practical Use of Rock Mass Classification for Cavern and Tunnel Support.</i> K. Hönisch and K. H. Nagel.	Monsees
	ALE-829 <i>Investigation of the Long-Term Development of Damaged Zones Around Underground Openings in Rock Salt.</i> Hans-Joachim Alheid and Michael Knecht.	Monsees
	ALE-902 <i>Practical Use of Rock Mass Classification for Cavern and Tunnel Support.</i> Klaus Hoenisch and Karl-Heinz Nagel.	
	<b>HONG KONG - 1</b>	
	HON-830 <i>Rockfall Problems in Hong Kong and Some New Experimental Results for Coefficient of Restitution.</i> K. T. Chau, R. H. C. Wong, and C. F. Lee.	Kranz
	<b>ISRAEL - 3</b>	
	ISR-324-1 <i>The Influence of Bedding Plane Orientation on the Compression Dilation Boundary in Anisotropic Rock Salt.</i> Y. H. Hatzor and E. P. Heyman.	Pariseau
	ISR-324-2 <i>The Influence of Joint Spacing on the Stability of a Laminated Voussoir Beam-Back Analysis of a Roof Failure Using DDA.</i> Y. H. Hatzor and R. Benary.	Amadei
	ISR-829 <i>Tensile Fracturing of Rocks Under 3D Compressive Stress State Due to Stress Amplification in Competent Layers and Inclusions.</i> Ze'ev Reches.	Teufel

	<b>JAPAN - 8</b>	
	JAP-225-1 <i>In Situ Stress Determination Using AE and DRA Techniques.</i> M. Seto, M. Utagawa, K. Katsuyama and T. Kiyama.	Haimson
	JAP-225-2 <i>Fractal Property in Spatial Distribution of AE Induced by Hydraulic Fracturing.</i> M. Seto, M. Utagawa and K. Katsuyama.	Doe
	JAP-401 <i>The Experimental Study on the Determination of Natural Rock Joint Stiffness through the Borehole Jacking Test and Its Application.</i> C. Tanimoto, K. Kishida and H. Fujii.	Fairhurst
	JAP-804 <i>Property of Cracks Generated in Hydraulic Fracturing Depending on Viscosity of Fracturing Fluid.</i> T. Ishida, Q. Chen, and Y. Mizuta.	Long
	JAP-822 <i>Stability Analysis and Design of Reinforcement System in a Progressively Failed Steep Rock Slope by the Distinct Element Method.</i> T. Esaki, T. N. Bhattarai, Y. Jiang, A. Nozaki, and T. Mizokami.	Scott
	JAP-827 <i>Estimation of Rock Mass Deformability by Several Testing Methods.</i> S. Hibino and M. Motojima.	Doe
	JAP-903 <i>Prediction of the Weathering of Cretaceous Granitic Rocks by the Outdoor Exposure Test.</i> I. Hirano, T. Sadahiro, K. Kikuchi, Y. Mito, M. Nishibayashi, and M. Baba.	Banks
	JAP-907 <i>A Finite Difference Scheme for Evaluation of Rate-Sensitive Effect on Wave Propagation in Geomaterials.</i> S. Han.	Pariseau
	<b>KOREA - 5</b>	
	COR-404 <i>Optimization of Rock Slopes Using Reliability Concepts.</i> I. M. Lee and M. J. Lee.	Scott
	COR-806 <i>Application of Anisotropic Traveltime Georadar Tomography to Monitor Rock Physical Property Changes Due to Excavations.</i> Y. Jung, M. Song, and J. Kim.	Teufel
	COR-822 <i>Design and Construction of Hyundai Underground Rock Laboratory.</i> Y. . Lee, Y. H. Suh, D. Y. Kim, K. S. Jue, and J. W. Park.	Samuels
	COR-830-1 <i>Preliminary Study for Determining Water Curtain Design Factor by Optimization Technique in Underground Energy Storage.</i> D. W. Yang, D. S. Kim, I. S. Park, and I. J. Yang.	Scott
	COR-830-2 <i>The Influence of In-Situ Stress on the Tensile Fracture Pattern Induced by Hoop Tests.</i> H. D. Park.	Glaser



	<b>LEBANON - 1</b>	
	LIB-822 <i>An In Situ Test on Near Field of Waste Repositories.</i> Y. Kazan and M. Ghoreychi.	Kranz
	<b>MEXICO - 29</b>	
	MEX-1112 <i>Los Distintos Tipos de Roca, Sus Características y Comportamiento de la Perforación de Pozos en los Campos Geotérmicos de México.</i> R. Maya and J. Vázquez.	Aimone
	MEX-324 <i>Influencia de la Temperatura en Excavaciones Subterráneas y Su Importancia en Mexico.</i> I. Lugo.	Monsees
	MEX-331-1 <i>Resultados de Sondeos de Exploración y Ensayes de Laboratorio en las Rocas. Calizas de la Península de Yucatan.</i> L. Espinosa and A. Sulub.	Einstein
	MEX-331-2 <i>Sobre el Colapso Natural de Fracturas en Rocas con Poco Fluido.</i> M. C. Suárez and F. Samaniego.	Long
	MEX-401 <i>Estudio de Correlación Entre Ensayes de Fluencia y Ensayes de Esfuerzo Desviador Variable en la Roca de Sal Gema del Domo Salino de Tuzandépeil, Ver., México.</i> E. Galván.	Einstein
	MEX-402-1 <i>La Geología de Rocas Blandas y Problemas Constructivos y Fallas Durante la Operación de Presas en Estos Ambientes.</i> C. García.	Scott
	MEX-402-2 <i>Influence of the Tectonic Model of Granite Intrusion on the Stability of Slopes Caved for the Construction of the Luis Donaldo Colosio (Huites) Dam, Fuerte River, Sinaloa.</i> C. Garcia.	Kranz
	MEX-522 <i>Mecánica de la Corteza Terrestre.</i> A. Bello Maldonado.	Turcotte
	MEX-529-1 <i>Estudio Gravimétrico nad Magnetométrico en un Área de Geología Compleja en el Estado de México.</i> J. J. Briones and A. Vázquez Contreras.	Nelson
	MEX-529-2 <i>Modernización de la Central Hidroeléctrica Tuxpango Estado de Veracruz, México.</i> J. M. Alcántara.	Scott
	MEX-529-3 <i>Caracterización de Macizos Rocosos Mediante Imágenes Electronmagnéticas.</i> J. R. Aranda López.	Nelson
	MEX-529-4 <i>Una Nueva Aplicación de los Métodos Geoelectricos para la Investigación de Cavidades Someras.</i> A. Vázquez Contreras and D. Saucedo Quiñones.	Nelson
	MEX-627 <i>Importancia de la Presencia de un Auditor Especialista en Mecánica de Rocas en Auditorías de Aseguramiento de Calidad en Obras Civiles en Roca.</i> D. Yáñez.	Einstein

MEX-721-1	<i>Problemas Amplificados por el Almacenamiento de Aire Comprimido.</i> J. Núñez.	Monsees
MEX-721-2	<i>Los Análisis 3D en una Caverna Lixiviada, ¿Son Indispensables?</i> J. Núñez.	Monsees
MEX-724	<i>Problemas de Deformaciones Laterales en Excavaciones Profundas, Con Rocas Piroclásticas en Zonas Urbanas.</i> A. Menache.	Einstein
MEX-814	<i>Deformational Behavior of Rock Specimens Under Multiaxial Compression.</i> E. Gaziev and J. Alberro.	Glaser
MEX-815	<i>Acueducto Perimetral 3ª Etapa, Ciudad de México.</i> M. Díaz and I. Lugo.	Einstein
MEX-820-1	<i>La Aplicación de Técnicas Geofísicas en el Estudio de Zonas de Riesgo de la Ciudad de México.</i> E. Del Valle.	Aimone
MEX-820-2	<i>Modeling of Osmotic Swelling in Shale.</i> L. De Pablo, C. Avilés, M. Chávez, R. Monsalvo, and M. Miranda.	Einstein
MEX-820-3	<i>Estudio de Caracterización Geoquímica y del Comportamiento Mecánico de Formaciones del Golfo de México.</i> C. Avilés, E. Contreras, and R. González.	Einstein
MEX-820-4	<i>Shale Swelling and Stability.</i> L. De Pablo, M. Chávez, C. Avilés, R. Monsalvo, and M. Miranda.	Einstein
MEX-826-1	<i>Shale Reactivity, Chemical Potential, and Mechanical Properties Testing Under Downhole Conditions.</i> A. Diek, C. Avilés, and A. Díaz.	Einstein
MEX-826-2	<i>New Approach to Therapeutic Remediation in Excavated Rock Slopes.</i> M. Sánchez.	Kranz
MEX-829-1	<i>Estudios de Mecánica de Rocas en el Proyecto del Túnel Carretero "El Novillo," Tamps., México.</i> S. Herrera.	Monsees
MEX-829-2	<i>Reinyección de la Pantalla Impermeable de la Presa "La Angostura," Chis.</i> S. Herrera, J. Bahena, J. Castilla, and O. Pérez.	Kendorski
MEX-901	<i>Geología y Tectónica del Oeste de Panamá y su Relación con el Diseño de un Proyecto Hidroeléctrico.</i> R. Riva and Evert Hernández.	Scott
MEX-903-1	<i>Siete Años de Observación Sísmica con la Red Telemétrica de Zimapán.</i> F. Aguilar, D. Santamaría, and E. Lomas.	Nelson
MEX-903-2	<i>P. H. Zimapán, HGO., México.</i> J. A. Bahena, B. Arana, and J. F. Moreno.	
MEX-912-1	<i>The Rheologic Behavior of the Gema Salt in Underground Storages of Tuzandépetl, México.</i> M. G. López-Aguirre.	Pariseau

	MEX-912-2 <i>Oil Underground Storage in Mexico: State-of-the-Art.</i> M. G. López-Aguirre.	
	<b>NORWAY - 3</b>	
	NOR-401-1 <i>Chalk Solids Production and Effects of Water Weakening.</i> E. Papamichos and R. M. Holt.	Teufel
	NOR-401-2 <i>An Erosion-Mechanical Model for Sand Production Rate Prediction.</i> E. Papamichos, J. Tronvoll, M. Stavropoulou and I. Vardoulakis.	Steiger
	NOR-829 <i>Application of Norwegian Method of Tunnelling (NMT) in Weak Rocks in Western Greece.</i> P. Chryssanthakis, N. Barton, F. Loset, A. Dallas, and K. Mitsotakis.	Kendorski
	<b>POLAND - 2</b>	
	POL-320 <i>Maximum Temperature Memory in Sandstone and Mudstone Samples Observed with Acoustic Emission and Ultrasonic Measurements.</i> W. M. Zuberek, B. Zogala, R. Dubiel and J. Pierwola.	Glaser
	POL-403 <i>On the Validity of the Variogram Method in Fractal Quantification of the Roughness of Rock Joints.</i> M. A. Kwasniewski and J. Wang.	Turcotte
	<b>PUERTO RICO - 1</b>	
	PUR-404 <i>Pressure Tunnels in Fractured Rock. Minimum Cover Criteria from the Stability of Rock Wedges.</i> T. A. Alvarez, E. J. Cording and G. Fernández.	Kranz
	<b>RUSSIA - 2</b>	
	RUS-829 <i>Geophysical Monitoring of Technogene Natural Systems at the Sites of Large Hydro Developments.</i> A. L. Savich, A. M. Zamakhaev, M. M. Ilyin, V. I. Koptev, and J. M. Gorshkov.	Fairhurst
	RUS-922 <i>Mathematical and Physical Modelling for Assessment of Underground Cavity Stability.</i> I. Smirnov, N. S. Khachaturian, and E. M. Shafarenko.	Samuels
	<b>SOUTH AFRICA - 3</b>	
	SUD-616 <i>Stochastic Keyblock Analysis for Slope Support Design.</i> G. S. Esterhuizen and K. A. Ackermann.	Amadei
	SUD-828 <i>Strength of Support Pillars and their Foundations in Hard Rock Tabular Mining.</i> M. U. Ozbay and J. A. Ryder.	Wade
	SUD-830 <i>Spotlight on New Developments in Support of South African Mines.</i> L. Wojno.	Wade

	<b>SWEDEN - 1</b>	
	SUE-918 <i>Influence of Microcracks and Fabric on the Failure Process of Rock.</i> B. Carlsson, E. Nordlund, Y. Andersson, and U. Lindfors.	Rudnicki
	<b>TURKEY - 5</b>	
	TUR-310 <i>An Experimental Study on the Size Effect in Block Punch Index Test and Its General Usefulness.</i> R. Ulusay and C. Gokceoglu.	Glaser
	TUR-313-1 <i>Support and Strata Interaction in Longwall Faces.</i> R. Ozel and E. Unal.	Wade
	TUR-313-2 <i>Selection and Performance-Evaluation Criteria for Shield Supports.</i> R. Ozel and E. Unal.	Samuels
	TUR-829-1 <i>Intact Rock Classification Based on Time-Dependent Deformational Properties.</i> A. Özgenoglu.	Pariseau
	TUR-829-2 <i>Study of Interaction Between Underground and Open Pit Mining by Finite Element Modelling.</i> A. Özgenoglu and G. Reyhan.	Agapito
	<b>U.S.A. - 75</b>	
	USA-210 <i>Ground Control and Design of Deep Mine Openings.</i> B. Amusin.	Wade
	USA-324-1 <i>Experimental Determination of the Relationship Between Permeability and Microfracture-Induced Damage in Bedded Salt.</i> T. W. Pfeifle, N. S. Brodsky and D.E. Munson.	Glaser
	USA-324-2 <i>Mechanism of Pleistocene Rockslides Near Pittsburgh, Pennsylvania.</i> J. V. Hamel.	Kranz
	USA-326-1 <i>Effects of Anistropies on Fluid Flow in Deformable Fractured Media.</i> M. Bai, Y. Abousleiman, S. Ahseek, M. Chen, and J. C. Roegiers.	Long
	USA-326-2 <i>Post-Test Comparision of Thermal-Mechanical Measurements vs. Analyses for the In Situ Single Heater Test, Yucca Mountain Nevada.</i> S. R. Sobolik, R. E. Finley and S. Ballard.	Doe
	USA-326-3 <i>Post-Test Comparison of Thermal-Hydrologic Measurements vs. Analyses for the In Situ Single Heater Test, Yucca Mountain, Nevada.</i> S. Ballard, N. D. Francis, S. R. Sobolik and R. E. Finley.	Doe
	USA-326-4 <i>Numerical Analysis of Dynamic Damage Accumulation in Brittle Rock Based on a Gridless Method.</i> E. P. Chen.	Rudnicki

	USA-327-1 <i>Micromechanics of Failure in Low-Porosity Crystalline Rock Containing a Grain Boundary Second Phase.</i> J. Fredrich.	Rudnicki
	USA-327-2 <i>Matching Simulated Fracture Data with Field Measurements Using Joint Intensity.</i> J. Ehlen.	Einstein
	USA-327-3 <i>Progress on the Development of a Three-Dimensional Capability for Simulating Large-Scale Complex Geologic Processes.</i> J. G. Arguello, C. M. Stone and A. F. Fossum.	Banks
	USA-328-1 <i>Phase Space Characterization of Rock Boring.</i> Leslie Sour Gertsch and Richard Gertsch.	Kim
	USA-328-2 <i>Preliminary Assessment of Particle Flow Code as a Tool to Assess Ore Pass Safety.</i> M. K. Larson, S. R. Iverson, and M. J. Beus.	Amadei
	USA-328-3 <i>Site-Specific Thermal and Mechanical Property Characterizations of In Situ Thermal Test Areas at Yucca Mountain, Nevada.</i> N. S. Brodsky, G. Barker and L. Costin.	Doe
	USA-328-4 <i>Design of the Yucca Mountain Project Drift Scale Test.</i> R. E. Finley, S. C. Blair, W. J. Boyle, R. N. Datta, W. Lin, M. T. Peters, M. Riggins, Y. Tsang, R. A. Wagner and D. J. Weaver.	Long
	USA-328-5 <i>Geomechanical Analysis of Pressure Limits for Gas Storage Reservoirs.</i> M. S. Bruno and M. B. Dusseault.	Roegiers
	USA-328-6 <i>ASRS—A Unified Approach in Reservoir Rock Mechanics.</i> Y. Abousleiman, M. Bai, H. Zang, T. Liu and J. C. Roegiers.	Long
	USA-328-7 <i>Using Three Dimensional Structural Simulations to Study the Interactions of Multiple Excavations in Salt.</i> E. L. Hoffman and B. L. Ehgartner.	Pariseau
	USA-330 <i>A New Peak Shear Strength Criterion for Anisotropic Rock Joints.</i> P. H. S. W. Kulatilake, J. Um and B. B. Panda.	Roegiers
	USA-331-1 <i>Monitoring Mining-Induced Stress Changes with Biaxial Stressmeter.</i> J. Seymour.	Haimson
	USA-331-2 <i>A Neural Approach to Sand Production Prediction in Wells.</i> M. Kanj and J. C. Roegiers.	Steiger
	USA-401-1 <i>Laboratory Investigation of Bit Wear in Water Jet Assisted Cutting of a Continuous Miner.</i> A. W. Khair and V. B. Achanti.	Kim
	USA-401-2 <i>Thermal Mechanical Observations at the Large Block Test.</i> S. C. Blair.	Doe
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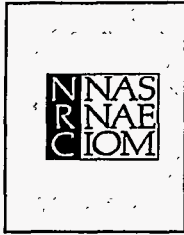
	USA-404-1 <i>Deep-Water Shale Swelling Potential Evaluation.</i> H. Santos, A Diek and J. C. Roegiers.	Einstein
	USA-404-2 <i>Capillary Forces: How Important Are the Effects on Shale Breakage in Laboratory Testing?</i> H. Santos, A. Diek and J. C. Roegiers.	Einstein
	USA-404-3 <i>Hydrological Characterization of the Disturbed Rock Zone Adjacent to Openings in the Waste Isolation Pilot Plant (WIPP) Facility.</i> L. D. Hurtado, F. D. Hansen and T. W. Pfeifle.	Long
	USA-405 <i>A Comparison of Eight Methods for Measuring Grain and Boundary Cracking in Heated Quartzite Samples.</i> J. Kemeny and Z. Zomeni.	Glaser
	USA-407 <i>Use of Thermal Analysis and NMR to Evaluate the Shale Swelling Potential.</i> H. Santos, A. Diek and C. Roegiers.	Einstein
	USA-408 <i>A Solution for Stress Distribution Around an Inclined Borehole in Shale.</i> A. Ghassemi, A. L. Diek and J. C. Roegiers.	Amadei
	USA-411 <i>Micromechanics and Homogenization Techniques for Analyzing the Continuum Damage of Rock Salt.</i> K. L. DeVries, D. H. Allen and L. D. Hurtado.	Pariseau
	USA-414-1 <i>A New Failure Criterion for Transversely Isotropic Rocks.</i> O. Cazaco, N. D. Cristescu, and J. F. Shao.	Amadei
	USA-414-2 <i>Surface Disturbances Resulting from Mass Underground Mining.</i> J. F. Lupo.	Kendorski
	USA-421 <i>Evaluation of Pullout Resistance and Direct-Shear Strength of Grouted Fiberglass Cable Bolts.</i> S. M. Miller and D. C. Ward.	Kendorski
	USA-424-1 <i>Constitutive Behavior of Reconsolidating Crushed Salt.</i> F. D. Hansen, G. D. Callahan and K. D. Mellegard.	Teufel
	USA-424-2 <i>Forensic Pathology of Salt Microstructures.</i> F. D. Hansen.	Teufel
	USA-424-3 <i>Physical and Mechanical Properties of Degraded Waste Surrogate Material.</i> F. D. Hansen.	Teufel
	USA-429 <i>Design and Construction of a Shallow Tunnel Driven Partly in Rock and Backfill of a Quarry with Advancing Jet Grouting (HDI) to Minimize Subsidence.</i> W. Wittke and C. Erichsen.	Samuels
	USA-526 <i>Borehole Stability Analyses in Fluid Saturated Formations with Non-Penetrating Walls.</i> L. Cui, S. Ekbote, Y. Abousleiman, M. M. Zaman, and J. C. Roegiers.	Steiger

	USA-527 <i>Laboratory Investigation of Bit Wear in Water Jet Assisted Cutting of a Continuous Miner.</i> A. W. Khair and V. B. Achanti.	
	USA-601 <i>Study in Fluid Flow in Poroelastic Dual-Porosity Media.</i> M. Zaman, M. Bai, J. Cao and J. C. Roegiers.	Long
	USA-602 <i>Solutions for Hollow Cylinders in Transversely Isotropic Poroelastic Materials.</i> L. Cui, Y. Abousleiman, and J. C. Roegiers	Amadei
	USA-625-1 <i>Investigation of the Influence of Clay Seams in the Vicinity of an Underground Excavation in Rock Salt.</i> S. Kwon and J. Wilson.	Samuels
	USA-625-2 <i>Shear Stress Distribution Around an Excavation in Rock Salt.</i> S. Kwon and J. Wilson.	Roegiers
	USA-714 <i>Three-Dimensional Analysis of Belridge Oil Reservoir Well Failures Due to Rock-Structure Interactions.</i> L. Brun Hilbert Jr., R. L. Gwinn, T. A. Moroney, and G. L. Deitrick.	Roegiers
	USA-716 <i>Use of Block Models for Longwall Shield Capacity Determinations.</i> L. Gilbride and A. Richardson.	Scott
	USA-720 <i>Correlation Between Loading Environment and Stress-Induced Rock Anisotropy.</i> M. Bai, F. Meng, and J. C. Roegiers.	Amadei
	USA-801 <i>Longwall Mining Through a Graben with Anomalous Stresses at the Deer Creek Mine.</i> R. Goodrich, J. F. T. Agapito, C. Polastro, and L. LaFrentz.	Kendorski
	USA-815 <i>Permeability of Natural Rock Salt from the Waste Isolation Pilot Plant (WIPP) During Damage Evolution and Healing.</i> T. W. Pfeifle and L. D. Hurtado.	Doe
	USA-818 <i>Stress-Induced Variations in Acoustic Velocities in Chalk.</i> T. E. Scott Jr., M. Azeemuddin, M. Zaman, and J. C. Roegiers.	Haimson
	USA-820 <i>Evaluation of Mathematical Models for Predicting Efficiency of the Diamond Coring Process.</i> Z. W. Wang and S. L. Huang.	Kim
	USA-822 <i>Design and Performance Issues in a High-Level Nuclear Waste Repository.</i> M. S. Nataraja.	Long
	USA-826-1 <i>A Mathematical Model for Non-Linear Flow in Non-Homogeneous Rock Fractures.</i> B. Amadei	Doe
	USA-826-2 <i>Computer Simulation of Open Pit Bench Blasting in Jointed Rock Mass.</i> Z. Jia, G. Chen, and S. Huang.	Agapito
	USA-827-1 <i>Modeling the Effect of Water and Excavation Sequence on Tunnel Stability.</i> Y. I. Kim, B. Amadei, and E. Pan.	Samuels

USA-827-2	<i>Two-Dimensional BEM Analysis of Anisotropic Half-Plane Problems—Application to Rock Mechanics Problems.</i> E. Pan, B. Amadei, and Y. I. Kim.	Agapito
USA-827-3	<i>Numerical Modeling of Molehole Development.</i> C. Lee, P. Cundall, P. Howard, and S. James.	Agapito
USA-828	<i>Modeling Notch-Formation Mechanisms in the URL Mine-by Test Tunnel Using Bonded Assemblies of Circular Particles.</i> D. O. Potyondy, C. A. Lee, and P. A. Cundall.	Kim
USA-829-1	<i>The Effect of Total Stress and Temperature on Water Activity on Shales.</i> C. F. Fonseca and M. E. Chenevert.	Steiger
USA-829-2	<i>Electromechanical Aspects of Wellbore Stability: Ionic Transport Through Confined Shales.</i> R. Lomba, M. M. Sharma, and M. E. Chenevert.	Steiger
USA-829-3	<i>Reexamination of Fault Angles Predicted by Shear Localization Theory.</i> J. W. Rudnicki and W. A. Olsson.	Roegiers
USA-829-4	<i>Discrete Feature Network Approaches for Enhanced Oil Recovery.</i> W. Dershowitz, T. Eiben, E. Wadleigh, and T. Cladouhos.	Turcotte
USA-829-5	<i>Thermoporoelastic Modeling of Borehole Stability in Non-Hydrostatic Stress Field.</i> X. Li, L. Cui, and J. C. Roegiers.	Haimson
USA-829-6	<i>Derivation of Fracture Spatial Pattern Parameters from Borehole Data.</i> W. Dershowitz, P. LaPointe, and T. Cladouhos.	Turcotte
USA-830-	<i>Interparticle Energy-Stress Relations in Soft Sediments.</i> A. Mese, R. S. Schechter, and A. N. Tutuncu.	Haimson
USA-901-1	<i>In Situ Stress Measurements in the Pre-Excavation Design Stage of the Serra da Mesa Hydroelectric Project, Brazil.</i> B. C. Haimson.	Fairhurst
USA-901-2	<i>Groundwater Response to the Pressurization of Hydropower Tunnels—Case Histories.</i> C. Jaramillo.	Scott
USA-902-1	<i>Prediction of Slope Stability at the Las Encinas Mine.</i> P. Naranjo, S. J. Jung, and F. Cabrera.	Kranz
USA-902-2	<i>Interparticle Energy—Stress Relations in Soft Sediments.</i> A. Mese, R. S. Schechter, and A. N. Tutuncu.	
USA-902-3	<i>Static and Dynamic Moduli of Rock Salt.</i> A. Mese and A. Tutuncu.	Kim
USA-902-4	<i>Fracturing and Failure in Rock Salt.</i> S. Saeb, L. Cherednik, and C. Francke.	Teufel
USA-904	<i>Source Model of Acoustic Emission with Displacement Discontinuities.</i> F. Carvalho and J. Labuz.	Rudnicki
USA-905	<i>Laboratory Technique to Estimate Gas Flow Behavior of Naturally Fractured Reservoirs.</i> S. Harpalani.	Roegiers



	USA-907 <i>Subsidence Prediction Using a Laminated, Boundary-Element Program.</i> K. Heasley and T. Barton.	Agapito
	USA-908 <i>Three-Dimensional Numerical Simulation of Slippage Along Natural Fractures Induced by Earthquakes.</i> P. R. La Point, P. C. Wallmann, A. L. Thomas, and S. Follin.	Aimone
	USA-913 <i>Rock Tunnel Reinforcement Design Using Discontinuities Numerical Methods.</i> M. Y. Ma, Z. Wayne Wang, and B. C. Dorwart.	Kendorski
	USA-919-1 <i>An Experimental Study of Stress Path Dependent Permeability in an Unconsolidated Sand Reservoir.</i> B. Crawford, D. Yale, and R. Hutcheon.	Amadei
	USA-919-2 <i>Laboratory Determination of Elastoplastic Relationships in an Unconsolidated Sand Reservoir.</i> D. P. Yale, B. Crawford, and J. M. Rodriguez.	Rudnicki



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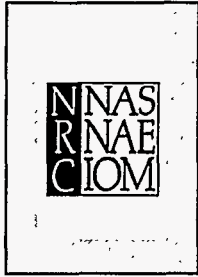
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## Conceptual Models of Fluid Infiltration in Fractured Media

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National Research Council  
Commission on Geosciences, Environment, and Resources  
Board on Earth Sciences and Resources  
U.S. National Committee on Rock Mechanics

Inaugural Meeting of the  
**PANEL ON CONCEPTUAL MODELS OF FLUID  
INFILTRATION IN FRACTURED MEDIA**

Room 110, Cecil and Ida Green Building  
2001 Wisconsin Avenue, N.W., Washington, D.C.  
September 18-19, 1998

## DRAFT AGENDA

### OPEN SESSION

Friday, September 18, 1998

- 8:00 a.m. Continental Breakfast
- 8:30 a.m. Introduction Paul Hsieh
- 9:00 a.m. Rationale for Activity and Expectations
- Nuclear Regulatory Commission Thomas Nicholson
  - Department of Energy, Yucca Mountain Program Office William Boyle
- 10:30 a.m. Break
- 10:45 a.m. Discussion of Task and Methodology to Accomplish Task
- 12:00 noon Lunch
- 1:00 p.m. Discussion on Workshop Papers
- Topics to be Covered
  - Case Studies
  - Possible Authors
- 2:30 p.m. Break
- 2:45 p.m. Discussion of Workshop Organization
- When and Where
  - Goals of Breakout Sessions
- 4:00 p.m. Discussion of Product
- Responsibilities
  - Dissemination
- 5:00 p.m. Adjourn
- 6:30 p.m. Committee Dinner at Local Restaurant

D C I D

<b>CLOSED SESSION</b> <b>Saturday, September 19, 1998</b>
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- 8:15 a.m. Continental Breakfast
- 8:45 a.m. Discussion of Panel Composition, Members' Backgrounds and Perspectives, and NRC Procedures and Concerns Greg Symmes
- 10:15 a.m. Break
- 10:30 a.m. Discussion of Panel Responsibilities and Processes  
(Assignment of Leaders for Specific Tasks)
- Recruitment of White Papers
  - Invitation of Participants
  - Editorial Process
- 12:00 noon Lunch
- 12:45 p.m. Other Issues
- Future Meetings
  - Communication
- 2:00 p.m. Adjourn

# NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING INSTITUTE OF MEDICINE

Office of News and Public Information • 2101 Constitution Avenue, N.W., Washington, D.C. 20418 • (202) 334-2138

Date: July 7, 1998

Contacts: Cheryl Greenhouse, Media Relations Officer  
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[ EMBARGOED: NOT FOR PUBLIC RELEASE BEFORE 5 P.M. EDT TUESDAY, JULY 7 ]

## Publication Announcement

### **Seismic Signals from Mining Operations May Be Confused with Nuclear Blasts**

Seismic signals are generated by natural events, such as earthquakes, and by nuclear explosions, such as the recent tests in India and Pakistan. They also are generated by chemical explosions associated with mining. The detection and processing of these signals form the major basis for monitoring compliance with the Comprehensive Test Ban Treaty. However, the seismic magnitudes and characteristics of some mining-related explosions can be similar to those generated by small nuclear explosions, leading to potential misinterpretation of explosions from routine mining activities as treaty violations.

A new report from a National Research Council committee reviews a draft report by a U.S. Department of Energy (DOE) working group that describes the nature of seismic signals from mining operations and possible measures that could help distinguish between seismic signals from legitimate mining operations and those from covert nuclear tests.

In its report, the DOE working group recommended that the mining industry consider reducing the size of their explosions so that they are not detectable on the treaty's International Monitoring System. Although the Research Council committee found this approach to be valid, it warned that DOE's proposal might greatly increase operating costs to the mining industry.

Instead, the Research Council committee recommended collecting data on the time and location of a few large blasts from each mine. This information, together with monitoring data, could greatly improve the confidence of the monitoring system that the seismic signals are originating from a mining explosion, rather than from a covert nuclear test, the committee said. The mining industry could help avert possible international on-site inspections of their mining operations by a one-time, voluntary submission of such blasting data to the federal agency tasked with compliance of the Comprehensive Test Ban Treaty.

The National Research Council is the principal operating arm of the National Academy of Sciences and the National Academy of Engineering. It is a private, non-profit institution that provides independent advice on science and technology issues under a congressional charter.

(MORE)

**NATIONAL RESEARCH COUNCIL**  
Commission on Geosciences, Environment, and Resources  
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