

# CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

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## TRIP REPORT

**SUBJECT:** Southern California Earthquake Center Annual Meeting and  
Workshop on Extreme Ground Motion  
Project No. 20.06002.01.352  
AI No. 20.06002.01.352.703

**DATE AND PLACE:** September 9–15, 2006  
Palm Springs, California

**AUTHOR:** Alan Morris  
Department of Earth, Material, and Planetary Sciences  
Geosciences and Engineering Division, Southwest Research Institute®

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**SENSITIVITY:** Non-Sensitive

### PERSONS PRESENT:

The conference was attended by approximately 415 researchers, primarily seismologists, but also some structural geologists and engineers; the workshop on extreme ground motion was attended by approximately 40 researchers including seismologists, geologists, and engineers.

### BACKGROUND AND PURPOSE:

Attendance at the Southern California Earthquake Center annual meeting provides an invaluable view of the latest research into a range of topics relevant to Yucca Mountain. This is well exemplified by the Southern California Earthquake Center mission statement.

“The Southern California Earthquake Center is headquartered at the University of Southern California, and was founded in 1991 with a mission to:

- gather new information about earthquakes in Southern California;
- integrate this information into a comprehensive and predictive understanding of earthquake phenomena; and
- communicate this understanding to end-users and the general public in order to increase earthquake awareness, reduce economic losses, and save lives.” [Southern California Earthquake Center. <<http://www.scec.org/aboutscec/>> (October 18, 2006.)]

The Southern California Earthquake Center is funded by the National Science Foundation and the U.S. Geological Survey. Each year the Southern California Earthquake Center hosts a conference which includes talks by invited speakers and a concurrent display of posters authored by a variety of researchers from industry and academia and including many students.

Field trips and workshops are offered prior to the meeting, and in 2005 and 2006 there was a postmeeting workshop on extreme ground motion funded by the Department of Energy (DOE). The primary purpose of these workshops has been to establish a framework for understanding the potential for extreme seismic shaking at Yucca Mountain, Nevada.

The meeting is also used as a forum for setting research priorities for the next round of funding from the National Science Foundation and U.S. Geological Survey, and open discussion sessions were held on the topics listed. Although most topics have some bearing on Yucca Mountain issues of ground motion, those that the author considers to have special relevance to understanding ground motion at Yucca Mountain are highlighted in bold.

- **Improve the unified structural representation and employ it to develop system-level models for earthquake forecasting and ground motion prediction**
- Develop an extended earthquake rupture forecast to drive physics-based seismic hazard analysis
- Define slip rate and earthquake history of southern San Andreas fault system for the last 2,000 years
- Investigate implications of geodetic/geologic rate discrepancies
- Develop a system-level deformation and stress-evolution model
- Map seismicity and source parameters in relation to known faults
- Develop a geodetic network processing system that will detect anomalous strain transients
- Test scientific prediction hypotheses against reference models to understand the physical basis of earthquake predictability
- **Determine the origin and evolution of on- and off-fault damage as a function of depth**
- Test hypotheses for dynamic fault weakening
- Assess predictability of rupture extent and direction on major faults
- Develop statistical descriptions of heterogeneities (e.g., stress, strain, geometry, and material properties) in fault zones and understand the origin and role of these by modeling single ruptures and multiple earthquake cycles
- Predict broadband ground motions for a comprehensive set of large scenario earthquakes
- Develop kinematic rupture representations consistent with dynamic rupture models

- **Investigate bounds on the upper limit of ground motion**
- Develop high-frequency simulation methods and investigate the upper frequency limit of deterministic ground motion predictions
- **Validate earthquake simulations and verify simulation methodologies**
- **Collaborate with earthquake engineers to develop rupture-to-rafters simulation capability for physics-based risk analysis**

#### **SUMMARY OF ACTIVITIES AND PERTINENT POINTS:**

The complete abstracts of posters at this conference are available in electronic form (CD) in the CNWRA library.

The research community at large is concerned with points relevant to ground motion at Yucca Mountain. During the conference, there was a general discussion of the following important research topics:

- Develop high-frequency simulation methods and investigate the upper frequency limit of deterministic, physics-based ground motion predictions. Research areas that will contribute to this includes
  - Improved source representation
  - Velocity model improvement (i.e., better knowledge of subsurface geology)
  - Improved representation of fault geometry
  - Scattering/attenuation studies
- High frequency Greens functions. Current simulations are unable to model above about 2 or 3 Hz because of lack of knowledge about source mechanisms and details of velocity space.
- Non-linear soil response. Better site characterization (e.g., soil type, soil depth, water content, grain size) is needed.
  - Investigate bounds on the upper limit of ground motion
  - Numerical experiments of fault slip and resulting ground motion (see above)
  - Observational constraints such as precarious rocks, shake-down features, and studies of mining-induced earthquakes in South African mines
- Predict broadband (0–10 Hz or higher) ground motions for a comprehensive set of large-scenario earthquakes
- Collaborate with earthquake engineers to develop rupture-to-rafters simulation capabilities for physics-based risk analysis

- Improve characterizations of ground motion for estimating damage and use characterizations in loss and risk calculations

## **CONCLUSIONS:**

There is a general move toward a more deterministic, physics-based approach to both seismic hazard assessment and ground motion. Several groups are attempting to refine the fault geometry and velocity field models of southern California so that the effects of major earthquakes can be modeled with greater confidence. Modeling efforts to this point have highlighted the strong influence that the velocity model has on the propagation of radiated energy, and that local effects, such as those within the Whittier Narrows, as wave guides and generate local anomalies in ground motion. When asked in general conversation what the most important factor in modeling seismic ground motion effects is, Ralph Archuleta (University of California at Santa Barbara) said without hesitation: the velocity model. There are also strong research efforts devoted to understanding heterogeneity in rock damage along strands of the San Andreas fault system. Also relevant to ground motion modeling are efforts to parameterize the effects of the seismic source on ground motion and to understand the nonlinear response of individual engineering sites.

Briefly, the current state of research being conducted both within Southern California Earthquake Center and by contributors to the workshop on extreme ground motion can be summarized thus:

- The broader Southern California Earthquake Center research community recognizes three key areas in which greater knowledge would improve the modeling of ground motion:
  - source parameters, such as fault geometry, dynamic rupture processes, slip-weakening relationships, and broader frequency distribution in modeled radiative energy
  - velocity field, which includes the 3D structural framework model and its associated velocities, and the behavior of fault zones as wave guides
  - site response characteristics, especially the 3D geometry and geotechnical properties of materials that may respond nonlinearly.
- Evidence for unexceeded ground motion at Yucca Mountain and elsewhere in the Basin and Range is being defined and sought by the group at the University of Nevada, Reno, and possibly by John Whitney of the U.S. Geological Survey.
- There is a sparse and seemingly contradictory historical dataset of ground motion records, and this is the primary reason why probabilistic methods have not, thus far, successfully characterized ground motion associated with low probability events.

## **PROBLEMS ENCOUNTERED:**

None.

**PENDING ACTIONS:**

No specific actions are pending.

**RECOMMENDATIONS:**

The Southern California Earthquake Center annual meeting draws scientists from around the world to discuss current research in earthquake seismology. It is an important forum at which there is a free and open discussion of issues. Because of the nature of its mission, much of the work being pursued by the Southern California Earthquake Center community is relevant to earthquake prediction and understanding ground motion and its effects. In addition to the institutional focus on matters relevant to understanding issues at Yucca Mountain, there is a continuing Department of Energy-funded workshop specifically focused on exploring ground motion at Yucca Mountain. Therefore I recommend the following:

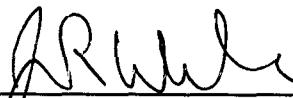
- Attendance at the Southern California Earthquake Center annual meeting should continue, and research developments arising from the Southern California Earthquake Center community should be monitored.
- The workshop on extreme ground motion will meet again on March 19 and 20, 2007, in Las Vegas. Details should be available from Norm Abrahamson ([naa3@earthlink.net](mailto:naa3@earthlink.net)). There will also be another meeting in September 2007 following the Southern California Earthquake Center annual meeting.
- GED staff should stay apprised of developments in understanding ground motion, including research on source parameters, radiative energy and the velocity field, site response, geomorphological analysis of earthquake-prone areas, and methods of treating the historical database of strong motion records.
- There is a strong emphasis on using the geomorphological analysis being pursued by Jim Brune at the University of Nevada, Reno, to constrain unexceeded ground motion at Yucca Mountain. Currently, University of Nevada, Reno, is the only group working on this aspect of the problem, although John Whitney (U.S. Geological Survey) may start work at Yucca Mountain soon. I recommend the work be closely monitored.

**SIGNATURES:**

  
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1 Nov 2006  
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